The Status of Infrastructure Services in East Asia and the Pacific

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Acknowledgements

This report was prepared by a team of staff and consultants in the World Bank Group Infrastructure, Public-Private Partnerships and Guarantees Team, including Darwin Marcelo (Task Team Leader), Schuyler House, Melania Lotti, Roman Skorzus, Aditi Raina, Deblina Saha, and Iuliia Zemlytska. Cledan Mandri-Perrott (Head, Infrastructure Finance and PPP) provided essential inputs, guidance and oversight. The report also benefited from valuable guidance and support from Jordan Schwartz (Director, GTPD1) and Sudhir Shetty (Chief Economist, EAPCE), whose funding support also allowed the team to undertake the research required for the analysis.

List of Abbreviations

ADB	Asian Development Bank
AHN	Asian Highway Network
ASEAN	Association of Southeast Asian Nations
BNEF	Bloomberg New Energy Finance
BOOT	Build-Own-Operate-Transfer
EAP	East-Asia and Pacific
ECA	Europe and Central Asia
EPI	Environmental Performance Index
DALY	Diarrheal Disability-Adjusted Life Years
FAO	Food and Agriculture Organization
FY	Financial Year
GDP	Gross Domestic Product
GWI	Global Water Intelligence
IBNET	international Benchmarking Network
ICT	Information and Communication Technology
IEA	International Energy Agency
JMP	Joint Monitoring Programme
LAC	Latina America and the Caribbean
Lao PDR	Lao People's Democratic Republic
LCOE	Levelized Cost of Energy
LIC	Low-income countries
MDGs	Millennium Development Goals
MIC	Middle-income countries
NASA	National Aeronautics and Space Administration
NMA	National Mapping Agency
NRW	Non-revenue water
OCCR	Operating Cost Coverage Ratio
OECD	Organization of Economic Cooperation and Development
O&M	Operations and Maintenance
OSM	Open Street Map
PICs	Pacific Island Countries
PLN	Perusahaan Listrik Negara
PPI	Private Participation in Infrastructure
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Public Private Partnership
RAI	Rural Access Index
RANPR	Rural Access to Non-Seasonal Paved Roads

RISE	Regulatory Indicators for Sustainable Energy
ROCKS	Road Costs Knowledge System
SAIFI	System Average Interruption Frequency
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
T&D	Transmission and Distribution
UN	United Nations
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WBG	World Bank Group
WDI	World Development Indicators
WGI	World Governance Indicators

List of Units of Measure

KM	Kilometer
KWh	Kilowatt hour
MWh	Megawatt hour
m^3	Cubic meter
USD	United States Dollar

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Executive Summary

Infrastructure plays an important role in the economic and social development of any country. Access to reliable, high-quality, efficient and affordable infrastructure services is a critical factor for reducing poverty and inequality, promoting economic growth and improving productivity, creating jobs, and promoting environmental sustainability and resilience in the face of major uncertainties including climate change. For a part of the global population, particularly the world's poorest, limited access to basic physical assets such as roads, piped water supply networks, power plants, and electricity distribution networks remains a significant constraint on human health, quality of life, education, and employment.

Over the past decades, the East Asia and Pacific (EAP) region has enjoyed strong and resilient economic growth, accompanied by steady social development. Aggregate growth in the Association of South East Asian Nations (ASEAN) countries is expected to remain at a steady 5% level throughout 2017 and 2018. Nevertheless, governments in the region still face difficulties in meeting the infrastructure development needs required to support sustained economic growth and reduce poverty and income gaps. According to the World Bank, leading up to 2020, the EAP region excluding China will require an additional USD 52 billion for infrastructure in order to keep pace with the current growth levels. The Asian Development Bank (ADB) estimates an infrastructure investment gap of USD 330-459 billion (the latter figure is climate-adjusted) between 2016 and 2020.

To support national, subnational and multilateral efforts related to infrastructure development in the region, a more accurate understanding of the status of infrastructure services across countries is required. Given the World Bank Group's active role in infrastructure development, the EAP regional team has commissioned this report to take stock of the current levels of access, quality, tariffs, and costs associated with infrastructure services. The Infrastructure, Public-Private Partnerships and Guarantees team has led this effort from the Singapore Hub.

This report is largely descriptive and aims to provide an overview of the status of economic infrastructure in several key sectors in the EAP region, particularly for networked infrastructure services such as urban water supply and sewerage, road transport, and electricity distribution. The exercise aims to shed light on the areas of greatest need, as well as to identify which sectors and geographical areas most require focused investments. The report also offers an account of trends and current levels of private sector investment in EAP countries to help inform financing strategies and decisions.

From a development policy perspective, the key questions include: Who receives infrastructure services, and at what level of reliability, quality and affordability? To what degree of efficiency are these services being delivered? And what is required to extend and improve services to meet development goals and sustain growth? These questions can be organized more broadly into three paths of inquiry to assess the status of infrastructure service delivery: access, quality, tariffs and cost of service. Each of these factors is examined across three infrastructure sectors: electricity, water and sanitation, and road transport.

By examining *access to infrastructure,* the study aims to measure who has access to the fundamental infrastructure services critical for economic and social development. Access may be measured in absolute terms or expressed as the proportion of the population receiving (or able to receive) a specific type and standard of service.

Assessment of *quality of infrastructure* intends to build an understanding of variations in reliability and consistency of service provision (e.g., water quality in the case of piped water supply), the user experience (e.g., road surface quality in the case of transport), and the physical state of existing networks (e.g., distribution losses in electricity transmission or water supply) that, in turn, affect consistency of service and efficiency of provision.

Lastly, *tariffs and costs of infrastructure services* include (a) costs of delivering services and (b) tariffs paid by the users of services. Tariffs are key to understanding the affordability of basic infrastructure services. The costs of producing and delivering infrastructure services reflect differences in cost structures as well as the relative efficiency of service provision. These factors in combination determine the levels of cost recovery associated with service provision.

A final section addresses current levels of private sector participation in these key sectors. As in the rest of the world, the government accounts for the vast bulk of infrastructure funding and provision in EAP. However, the estimated infrastructure funding gaps impel an investigation into alternative sources of finance and technical and managerial knowledge to offset deficits in financing and provision.

Methodology

This report draws on descriptive statistical analysis of the aspects of access, quality, and tariffs and costs, as well as private participation in infrastructure at the region-wide and national levels. Geographically, this report assesses the status of infrastructure services in those countries wherein the World Bank Group has an operational presence, namely:

- **China and emerging ASEAN countries**: China, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, Vietnam;

- **Pacific Islands**: Fiji, Papua New Guinea (PNG), Samoa, Solomon Islands, Timor-Leste, Vanuatu; and
- **Regional benchmarks**: Singapore, Brunei, Japan, New Zealand, South Korea.

Japan, New Zealand, and South Korea, as well as high-income EAP countries (Singapore and Brunei) were chosen as benchmark countries to facilitate comparison due to their higher levels of income and infrastructure development. Due to significant data insufficiencies, not all countries in the Pacific Islands were included.

Data for the analysis was obtained from a wide variety of sources, including publicly available data sets maintained by the World Bank Group and other multilateral organizations, subscription data sets produced by industry and market research companies, and government, industry, and company utility reports. Data for road transport access required geospatial modeling and advanced computational techniques to estimate the degree of access to paved rural roads based on open road map data and population data.

Summary of Results

Table 1 presents a summary of data collected on access, quality, and tariffs and costs of service by sector. This snapshot provides an overview of key weaknesses in terms of access and quality (pink-colored fields) as well as the data gaps (identified by the gray-colored empty fields where data is missing) that currently hinder cross-country comparison in the region. For each indicator, results for each country are coded as 'good', 'fair', or 'poor' based on the performance of benchmark countries and lowest performance. Tariff data is coded neutral (white) since no attribution of value can be made without detailed economic review.

This summary offers initial insights into the areas of greatest need with respect to improving access and performance. It also serves as a rough map of where data is most limited. The Pacific Island sub-region shows the most irregularity with respect to data availability: it is in this area that efforts to improve infrastructure data reporting are most needed. With respect to sectors, sanitation is where data is most limited across countries. In ASEAN, Cambodia and Myanmar require the most improvement with respect to extending access to all services. The Pacific Island states – particularly Papua New Guinea, Timor-Leste, and the Solomon Islands – also currently report low levels of access and quality.

Table 1. **Summary of Status Indicators**

Good | Fair | Poor | Neutral | No information

	ACCESS								TARIFFS & COST RECOVERY					QUALITY									
	Electricity			Water		Sanitation		Roads	Electricity			Water		Electricity			Water		Sanitation		Roads	
	Overall	Urban	Rural	Piped Water	Urban Piped Water	Improved Sanitation	Urban Piped Sewerage	Rural Road Access	Res. Tariff	Avg. Tariff	Avg. Tariff – Avg. Cost	Res. Tariff	OCCR	Quality Electricity	T&D Losses	Interruption Frequency	NRW	% Pass Chlorine Test	DALY Index	% WW Treated	Road Quality	% Paved
China	100	100	100	73	87	76.5	85.6	-	0.07	0.10	0.05	0.29	0.76	5.3	5	0.23	20.5	99.9	5	28.8	4.8	-
Cambodia	56.1	82.8	49.2	21	75	42.4	44.8	86.7	0.15	0.19	-	0.16	2.57	3.3	23	19.88	6.7	100	3	0.0	3.4	11
Indonesia	97.0	99.4	94.3	22	33	60.8	-	57.2	0.05	0.07	-0.03	0.46	1.39	4.2	9	1.72	30.4	65.7	3	1.0	3.9	57
Laos	78.1	94.7	68.1	28	64	70.9	1.3	35.3	0.06	0.07	-	0.25	1.07	4.7	-	9.42	20.9	100	1	0.0	3.4	15
Malaysia	100	100	100	96	100	96.0	42.2	48.9	0.07	0.10	0.02	0.14	1.15	5.8	6	0.48	34.4	97.6	5	61.6	5.5	78
Myanmar	52.0	57.9	49.0	8	19	79.6	9.5	58.9	0.04	0.06	-	0.08	-	-	20	-	-	-	2	0.0	-	22
Philippines	89.1	97.3	82.5	43	59	73.9	4.7	84.5	0.20	0.21	-0.11	0.45	2.40	4.0	9	2.71	42.6	93.9	3	40	3.1	81
Thailand	100	100	100	57	76	93.0	8.7	86.7	0.21	0.11	0.02	0.24	-	5.1	6	1.37	-	-	4	44.7	4.2	81
Vietnam	99.2	99.8	98.9	27	61	78.0	3.9	52.9	0.07	0.08	-0.01	0.25	1.51	4.4	9	6.72	22.9	92.4	4	55	3.5	66
Fiji	100	100	76.3	68	96	91.1	-	-	0.08	-	-	0.07	0.59	-	-	8.00	45.4	92.1	4	10	-	-
Papua New Guinea	20.3	76.4	11.9	9	55	18.9	-	21.4	0.25	-	-	0.42	1.78	-	-	134.00	38.4	99.9	1	0.0	-	-
Samoa	97.9	99.2	97.6	85	91	91.5	0.5	-	0.67	-	-	0.50	1.26	-	-	20.00	62.1	94.1	3	-	-	-
Solomon Isl.	35.1	39.4	33.9	26	61	29.8	-	-	0.78	0.90	-	0.73	1.47	-	-	3.20	57.8	89.7	2	-	-	-
Timor-Leste	45.4	63.0	37.0	25	47	40.6	18.2	46.8	0.12	-	-	0.00	-	-	-	-	-	-	1	-	-	-
Vanuatu	34.5	100	11.5	35	61	57.9	6.6	-	-	-	-	-	-	-	-	7.49	18.2	100	2	-	-	-
Brunei	100	100	100	-	-	-	-	92.2	0.01	-	-	0.08	-	5.3	6	0.40	-	-	5	-	4.7	93
Singapore	100	100	100	100	100	100	100	100	0.21	-	-	1.20	-	6.8	2	0.01	3.8	100	5	100	6.3	100
Japan	100	100	100	98	99	100	-	-	0.18	0.24	0.13	1.07	-	6.5	4	0.12	-	-	5	75.8	6.1	-
New Zealand	100	100	100	100	100	100	-	-	0.20	-	-	1.00	1.98	6.3	7	1.84	19.5	-	5	82	4.5	-
South Korea	100	100	100	-	99	100	90.1	94.82	0.05	0.10	-	0.52	2.48	6.20	3	0.08	16.3	-	5	91.5	5.6	-

With respect to coverage and service quality, sanitation is clearly the sector with lowest performance. Urban piped sewerage connection is generally low outside of benchmark countries, as is the percentage of wastewater collected and treated. Gaps in the quality of urban water supply between high-income and emerging economies in the region are closing, though some countries, including Indonesia, Myanmar, and the Philippines, require concentrated effort to improve access to and quality of urban water services. Rural access to paved roads also requires attention in much of developing ASEAN and across the Pacific Islands.

Developments are also required in EAP's middle-income states. Despite their relatively strong economies, Malaysia requires road development in rural areas and extension of urban sewerage services, and Thailand and Fiji show a need for improved water treatment and urban sanitation services. These results reinforce the recognition that in all countries, heterogeneity in urban-rural services and low performance in some sectors, particularly sanitation, requires added analysis to focus improvements on under-served populations.

The following sections provide an overview of results in each section of the report.

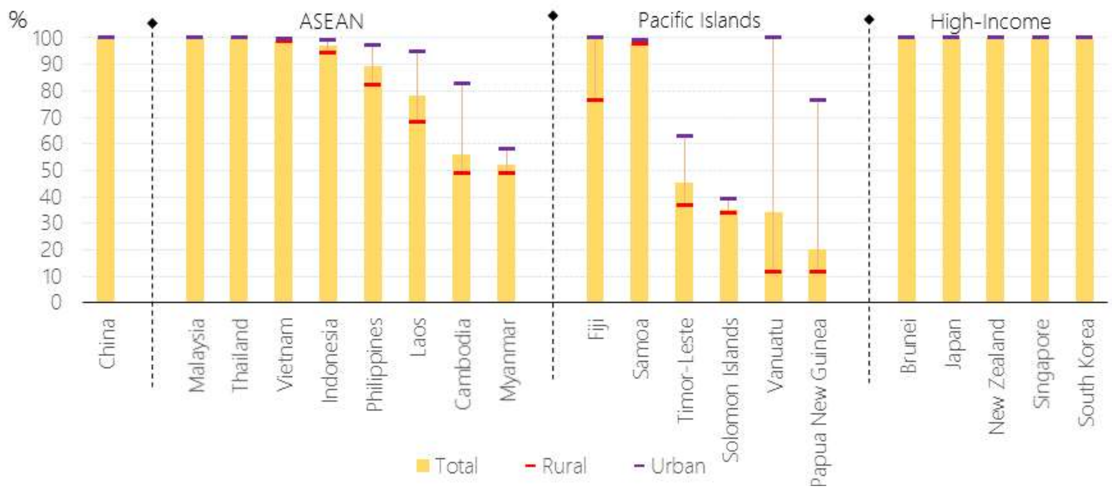
Access to Infrastructure

Overall, access to infrastructure in EAP region is highly fragmented. Countries can be divided into three broad groups with respect to access: highly advanced and well-equipped countries, such as Singapore and South-Korea; a semi-advanced group which includes middle-income countries such as China, Malaysia, Thailand, and Fiji; and a group exhibiting lower access levels, with lower-income countries, such as Myanmar and most of the Pacific Islands, excluding Fiji and Samoa.

Singapore is by far the most developed economy in terms of access to infrastructure services, with 100% access to electricity, piped water, and sanitation. This is not surprising, since Singapore is a highly-advanced economy and a city-state, which eliminates the urban-rural divide observed in other ASEAN and Pacific Islands. Besides Myanmar, the Pacific Islands are among the least developed countries, though Samoa and Fiji are relatively well developed, particularly in urban areas.

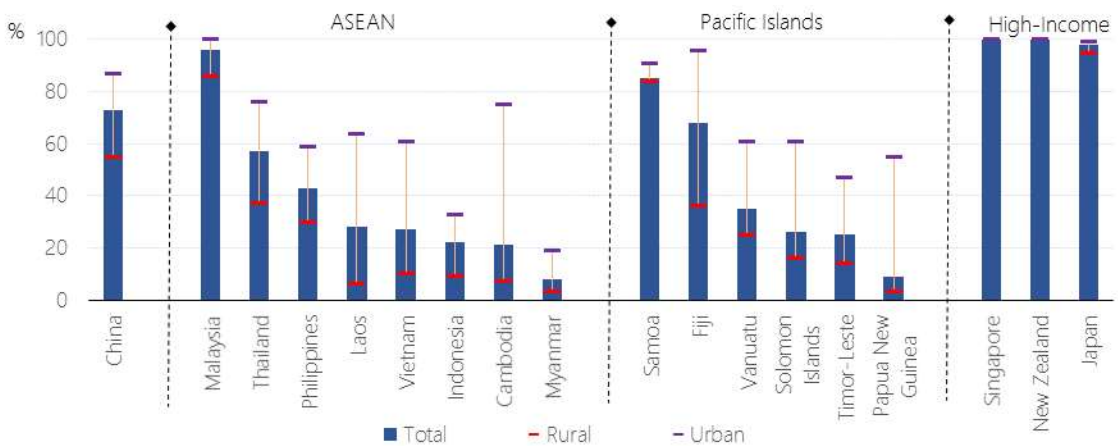
Below are listed the key findings related to access in each of the sectors.

Access to Electricity (% total population)



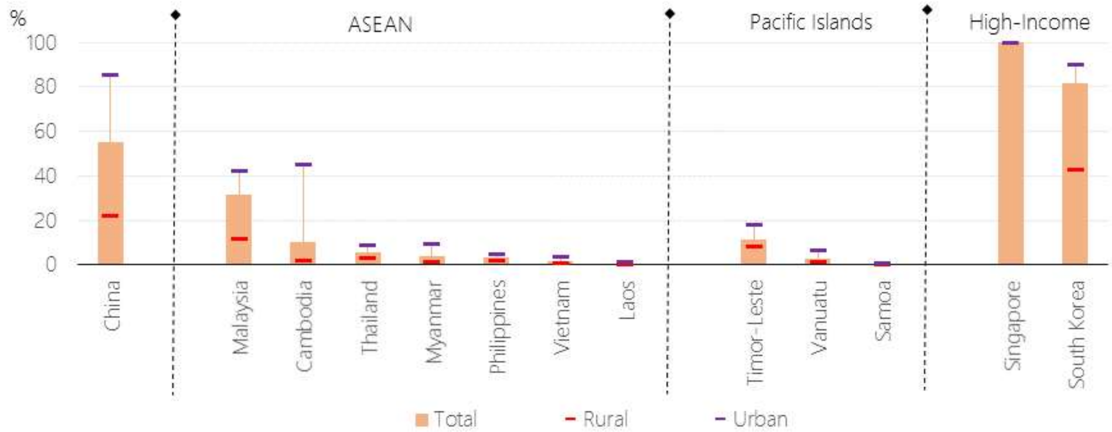
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Development Indicators, World Bank Group (2014)

Household Connection to Piped Water Supply (% total population)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from WHO/UNICEF (2015)

Household Connection to Sewerage (% total population)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from UNICEF-WHO (2015)

Access to Electricity

- Electricity is the most advanced infrastructure service across all countries. Overall, electricity access is relatively high at 96.5%. Still, about 60 million people in the study area lack access.
- Across the region, electrification rates differ between urban and rural populations. Overall, EAP's urban population enjoys high electricity service coverage at a rate of 99.5%, and rural access stands at 94.9%. Most ASEAN countries have a full or near-full coverage of electricity services in rural areas, with the exception of Philippines, Laos, Cambodia, and Myanmar.
- Cambodia and Myanmar have coverage rates of less than 60%. In the case of Cambodia, the electrification rate is marked by a clear urban-rural divide, and access is constrained by high tariffs for consumers.
- Among the Pacific Island countries, access remains below 60% for most countries. Fiji and Samoa, however, are outliers, attaining near-total coverage. The coverage in urban and rural areas is far more differentiated than in ASEAN (e.g. in Vanuatu, urban access rates are as high as 100%, while only 11.5% in rural areas). Low electrification is affected by the archipelagic geography and related challenges to establish efficient and high-quality power grids.

Access to Water and Sanitation

- 93.7% of the EAP population has access to improved drinking water, but household access to piped water supply is relatively low in the region. Household piped access may not be efficient, however, in rural areas. As such, urban rates of household connection are an important indicator alongside the overall measure of access via household connection.
- Only benchmark countries such as Japan, New Zealand, South Korea and Singapore (100%) and Malaysia (96%) have extensive overall access to piped connections at the household level.
- Second tier countries include Thailand (57%), Philippines (43%) and China (73%), as well as Samoa and Fiji, with overall coverage rates of around 70-80%. The third tier includes the low-income ASEAN countries and the other Pacific Islands, with household access levels between 20 and 30%.
- EAP has generally fair urban access levels, however. Cambodia, Laos, Thailand, Vietnam, Solomon Islands, and Vanuatu, for example, have overall piped access levels of less than 60% but significantly higher levels of access in urban areas where economies of scale are present.
- Surprisingly, for a middle-income economy, Indonesia has very low urban rates of access to piped water supply (33%). This could be explained by its dispersed geography and historical reliance on well-water in some major urban areas (including Jakarta) due to issues of water supply reliability.
- Myanmar and Papua New Guinea are at the low-end of household piped access, with only 8% and 9% overall coverage, respectively. Myanmar's urban coverage is also lowest in the region at 19%.
- Access rates to urban piped sewerage in some countries are up to ten times lower than rates of urban piped water connection. In fact, only the high-income benchmark economies enjoy full access to urban piped sanitation systems.
- These countries are followed by Cambodia (44.81%) and Malaysia (42.4%), with fair levels of urban sewerage access, and Timor-Leste, with a 18.2% urban household connection rate. Coverage values elsewhere in the region (even in urban areas) are at single-digit levels.

Access to Rural Transport

- Rural access to roads is estimated using geospatial modelling to capture the population with access within 2km to a non-seasonal paved road.

- In terms of access to rural roads, the selected countries can be broadly sorted into three categories. The highest category contains Brunei and South-Korea, with more than 90% rural access.[1]
- The second category includes Cambodia, Thailand, and the Philippines with access of more than 80%.
- The least advanced countries in terms of access to rural transport are Myanmar, Indonesia, Vietnam, Malaysia and Laos, with access values between 30% and 60%.
- Within the Pacific Islands, where road access is lower, only Timor-Leste is on a comparable level to some of the ASEAN nations, but at the lowest levels of access.

Quality of Infrastructure

Assessing the standards of service is critical to understanding the actual benefits accrued to a country and its people. The assessment of quality examines features such as service reliability, the quality of outputs (e.g., the quality of piped water), and the physical state of networks (e.g., road surface quality and physical network impacts on efficiency).

In general, the data on quality of infrastructure shows that there are three categories in terms of performance. China and benchmark countries are at the top end for all sectors. The mid-tier group are the middle income-economies of Thailand, Philippines, Indonesia and Fiji, though the latter two show low performance in wastewater treatment. Cambodia, Myanmar, Samoa, and Papua New Guinea display the lowest quality levels. A slightly different pattern applies for road infrastructure, where Indonesia and the Philippines both exhibit below-average quality and road condition levels.

Listed below are the key findings related to quality for each sector.

Quality of Electricity

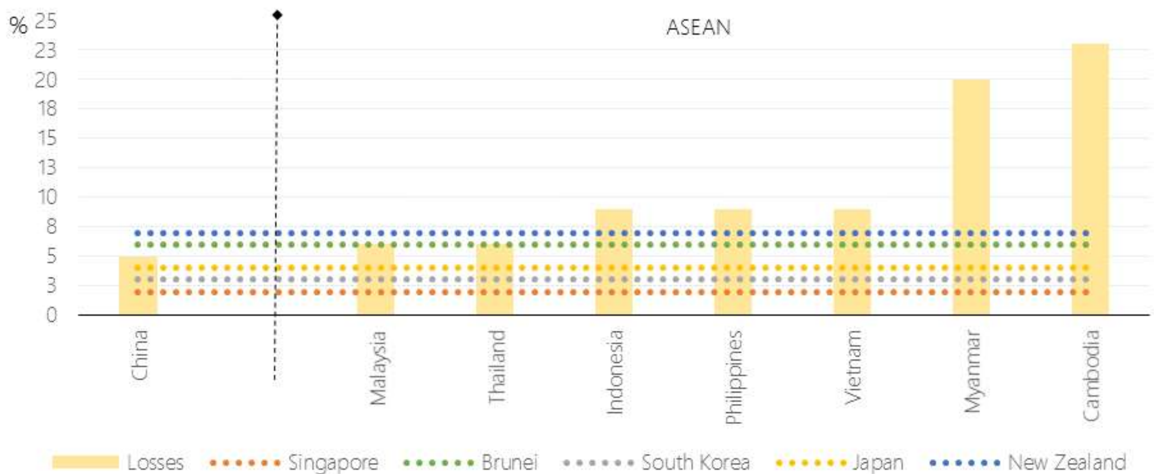
- Survey-based perceptions of the quality of electricity service are the highest in Singapore, Malaysia, Brunei, China, and Thailand, whereas Cambodia is ranked lowest.
- On average, about 8.4% of electricity is lost in EAP economies. Electric power transmission and distribution (T&D) losses range from a low level of 2% in Singapore to over 20% in Cambodia and Myanmar. Cambodia's high losses are due to inefficient

[1] Singapore was not considered because it is a city-state with no rural areas.

electricity supply at lower voltages, whereas losses in Myanmar are caused by outdated kV lines and twisted connections.

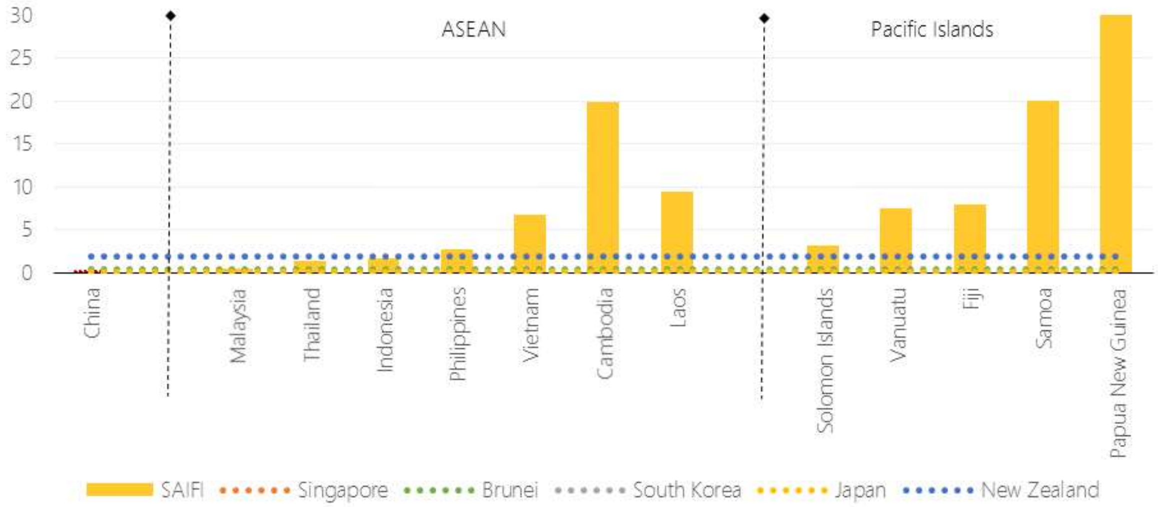
- In Thailand, Malaysia, Brunei, and Singapore, the T&D loss levels match the 6% average of OECD countries. Losses in Indonesia, Vietnam, and Philippines are slightly higher (9%).
- In ASEAN, most countries experience an average of approximately one-hour of outages each per quarter-year, though Singapore experiences almost no power interruptions.
- Cambodia has the lowest figures in the region, with an average of 20 interruptions in the year, followed by Vietnam and Laos. In Laos, interruptions are less frequent than Vietnam and Cambodia, but the average duration is approximately 50 hours a year, per consumer.
- Among the Pacific Islands, Papua New Guinea has the most frequent power outages, with an average 134 per year, far exceeding all other countries in the region.

Electric Power Transmission and Distribution Losses (% output)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank World Development Indicators (2014)

System Average Interruption Frequency Index (SAIFI) (2015)



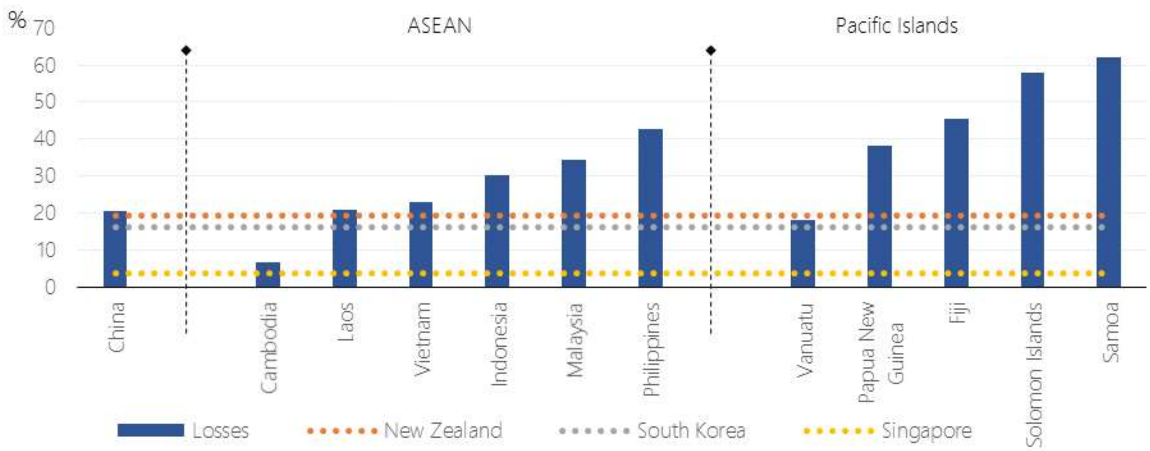
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank Group (2015a)

Quality of Water and Sanitation

- Main utilities in Singapore and Cambodia outperform other countries in the region with respect to the quality of the distribution network, with only 3.75% and 6.74% rates of non-revenue water (NRW), respectively. Select utilities, like East Manila (Manila Water at 11%) also demonstrate low distribution losses, whereas other major regional cities, though much improved, still lose significant amounts of water (e.g., West Manila, Jakarta, and Kuala Lumpur all have NRW rates of at least 30%).
- NRW rates of the cities covered in the EAP region by available data average 32%, with the Pacific Islands having the highest rates, ranging from 38% in Papua New Guinea to 62% in Samoa.
- As per available data in EAP, over 90% of samples of supplied water pass residual chlorine tests that indicate the bacterial contamination of water. This data is available for select utilities, however, mainly in urban areas. Many urban, peri-urban, and rural water utilities still deliver non-potable water to much of the region.
- The wastewater treatment data shows a very low level of treatment across the board. In the Pacific Islands, data is only available for Fiji (10%) and Papua New Guinea (0%). In ASEAN, only Singapore treats 100% of its wastewater. Malaysia, Vietnam, Thailand and Philippines treat between 40% to 60% of collected wastewater. Wastewater treatment in Indonesia, Cambodia, Laos and Myanmar is practically nonexistent.
- Lost days of productivity due to diarrheal illness (measured via DALY scores) are also an indication of overall sanitation and hygiene. In ASEAN, Laos has the lowest DALY score, followed by Myanmar and Indonesia. Comparably low scores are found in Timor-Leste,

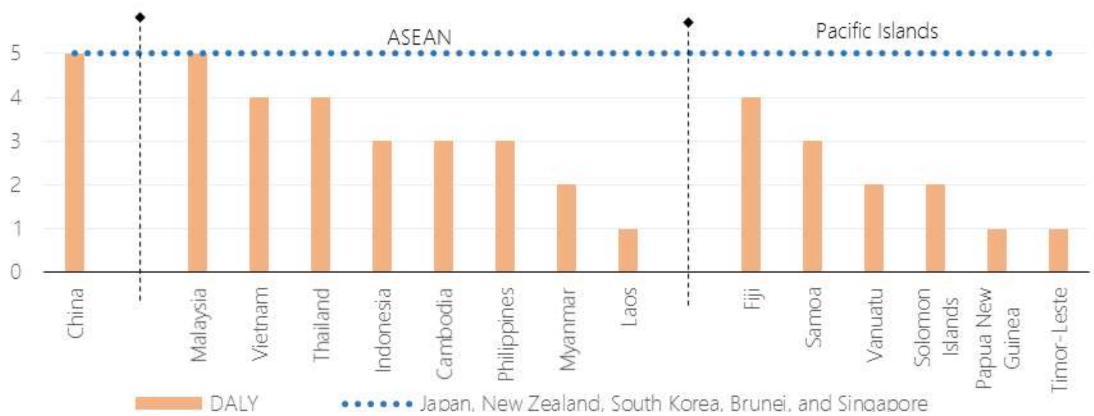
Papua New Guinea, and Vanuatu in the Pacific Islands group. The benchmark countries (including Brunei and Singapore) as well as China and Malaysia perform best.

Non-Revenue Water (%)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET Benchmarking database (various years, see Annex IX)

Disability-Adjusted Life Years Index (DALY)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from WHO (2016)

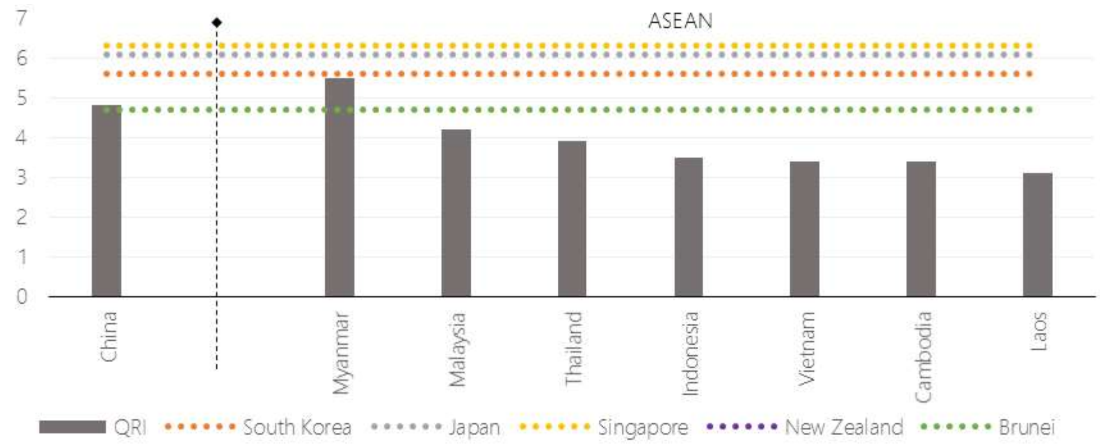
Road Transport Quality

- Singapore is perceived to have the highest road quality, followed by Brunei and Malaysia. The lowest quality roads are reported in the Philippines, Cambodia, and Vietnam.
- The roads within Asian Highway Network (AHN) are reported to be mostly in good condition in Thailand, Myanmar, Cambodia, and Indonesia. Indonesia, Philippines, Laos,

and Cambodia have significant portions of the AHN in need of rehabilitation due to poor surface conditions.

- In ASEAN, Cambodia, Myanmar, and Laos have the lowest ratios of paved roads with respect to their overall road networks.

Quality of Road Infrastructure (1-7, best)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from WEF (2017)

Tariffs and Costs of Infrastructure Services

The status overview in Table 1 summarizes tariff data for the lowest consumption block (subsistence-level consumption) for water and electricity, as well as cost recovery indicators for electricity and water services. Indicators of cost recovery include the difference between average tariffs and average costs for electricity and the operating cost coverage ratio (OCCR) for water supply, which measures to what extent revenues cover operating costs.

A general observation is that electricity and water are always charged in EAP countries (except in Timor-Leste for water, where no tariffs are imposed). Wastewater is generally funded via water service revenues in low-, middle-, and high-income countries in the region.

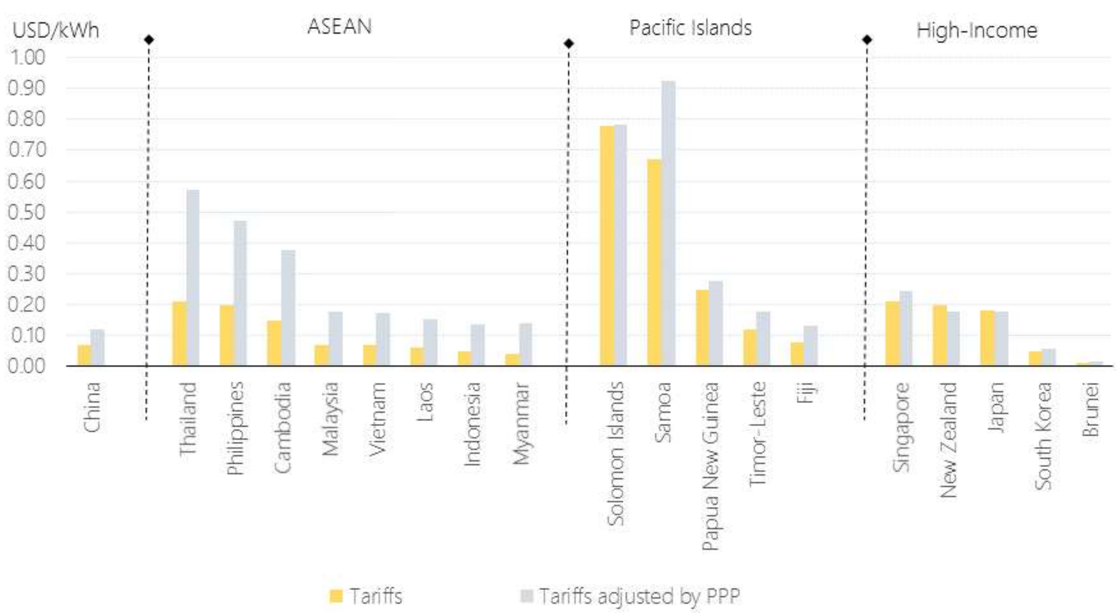
Listed below are key findings related to tariffs and costs, detailed by sector.

Tariffs and Costs of Electricity

- Electricity tariffs for basic levels of consumption are generally highest in Pacific Islands, due to import-dependent energy systems, and in some ASEAN countries (Cambodia, Thailand, and the Philippines) due to a variety of factors that increase production and distribution costs. In Cambodia, higher tariffs are attributable to the challenge of achieving economies of scale due to its relatively small economy, geographic fragmentation of power networks and service provision, relatively high supply costs, and high system losses. Purchasing power parity (PPP)-adjusted tariff levels in these ASEAN countries are even higher than in Singapore.

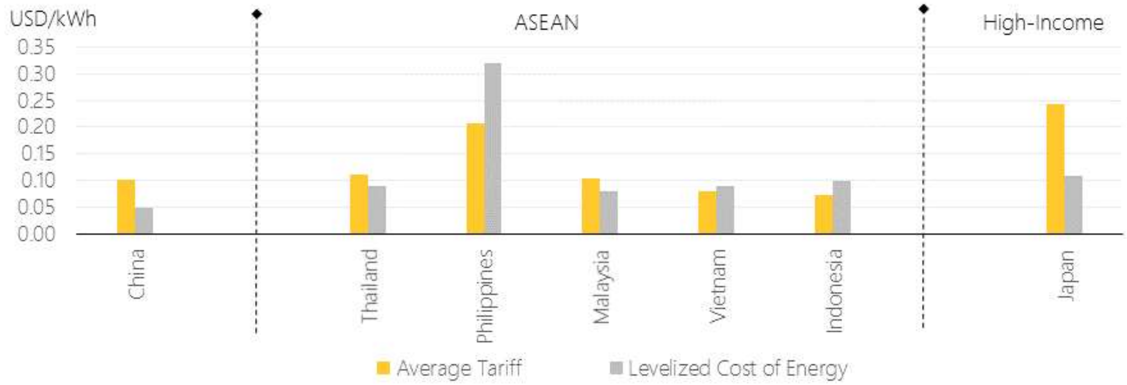
- The lowest subsistence-level electricity tariffs in the region can be found in Brunei, followed by Myanmar, South Korea, and Laos. In Laos, low tariffs are due to the lower costs of hydropower production, whereas Myanmar's tariffs are kept low by policy design (impeding cost-recovery by utilities). In other cases, significant government subsidies (as in Indonesia and Brunei) and user cross-subsidies (as in South Korea) keep subsistence-level tariffs low.
- In the EAP countries for which data is available, China, Malaysia, and Thailand are operating at general cost recovery levels for electricity production. In Indonesia, Vietnam, and Philippines, on the other hand, average unitary revenues from electricity tariffs do not match the marginal costs of generating the same amount of electricity, let alone the costs of distribution and transmission.

Retail Residential Electricity Tariffs (2016 USD/kWh for consumption level of 30kWh/month)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from RISE database (2013 data) for countries where data available; different sources for other countries (complete list in Annex I)

Electricity Tariffs vs Levelized Cost of Energy (2016 USD/kWh)

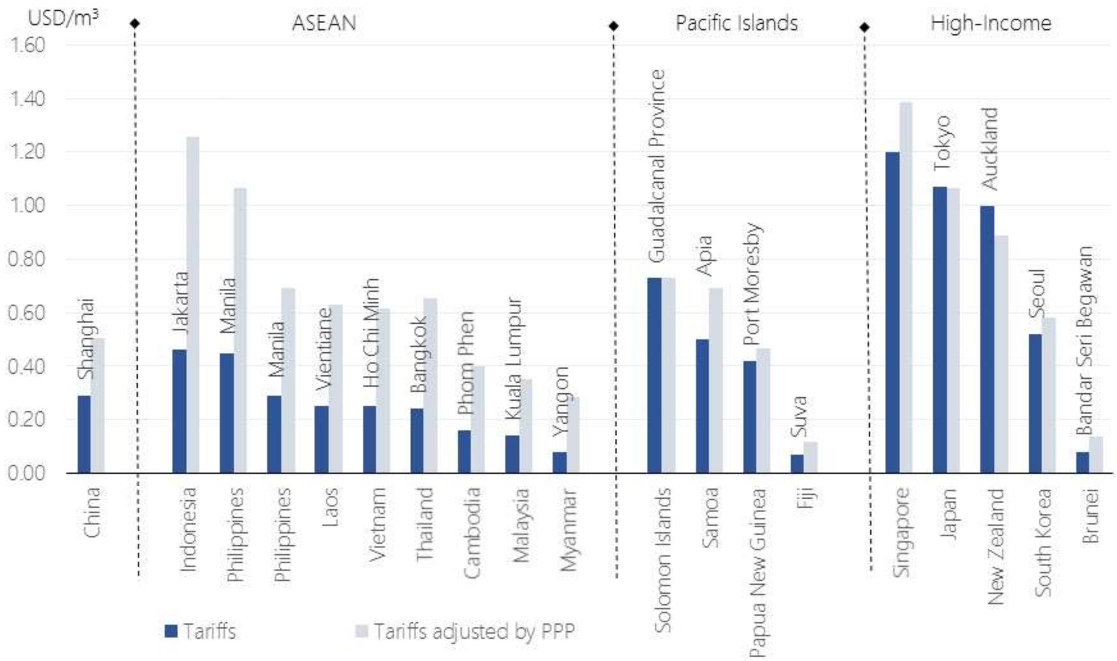


Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on tariffs by RISE database (2013 data) and LCOEs by BNEF (2017) and Lazard (2016). More information in the methodology section

Tariffs and Costs of Water and Wastewater

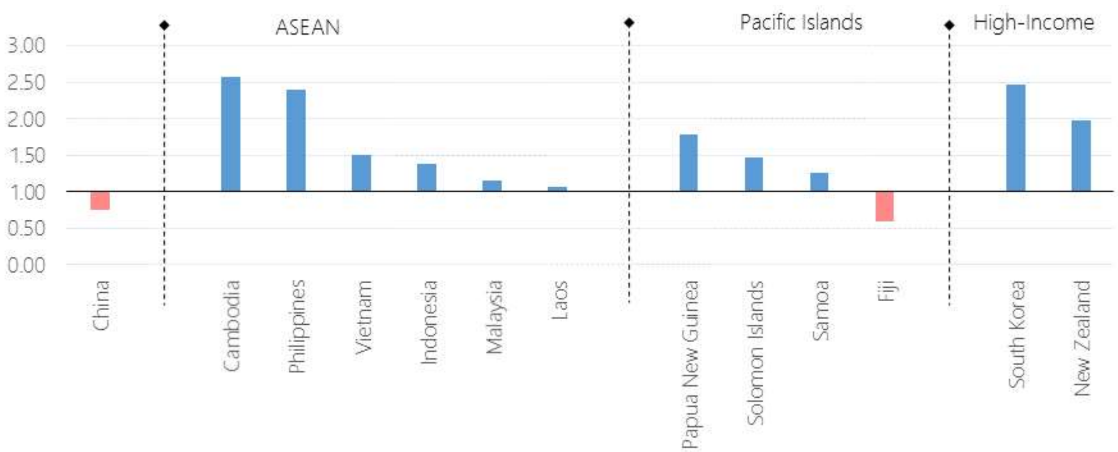
- Higher income countries (Singapore, Japan, and New Zealand) tend to have higher water tariffs, even for basic consumption levels. This is in line with higher ability to pay and commensurate with high coverage and quality. Brunei and Malaysia constitute notable exceptions, as their subsistence-level water tariffs (for monthly consumption of 15 m^3) are very low despite their relatively high incomes compared to neighboring ASEAN countries.
- Once adjusted by PPP, water tariffs in Jakarta are the second highest in the EAP cities under study, at a level close to Singapore, although differences in quality are significant.
- In the Pacific Islands, Fiji, an upper-middle-income country, has the lowest tariffs, significantly below the cost of production.
- In many cases, wastewater costs are covered by a portion of the water tariff. ASEAN low-income countries such as Myanmar, Laos, and Cambodia do not charge tariffs for wastewater collection services, nor does Indonesia. In many cities in these countries, wastewater is not connected to a centralized sewer and, therefore, is not collected by the utilities.
- Where separately collected, PPP-adjusted wastewater tariffs are fairly comparable across ASEAN, the Pacific Islands, and more developed countries in the region. The highest wastewater tariffs in EAP are observed in Papua New Guinea and Samoa, at levels that three times higher than that of Singapore and more than eight times the tariff level in Fiji.
- On average, the utilities studied in all countries except for Fiji and China currently cover their operating costs by tariff revenues. This does not imply, however, that current water revenues are sufficient to cover the capital costs required to expand service or rehabilitate existing infrastructure.

Water Tariffs (2016 USD/m^3 for consumption of 15 m^3 per month), Select Cities



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from GWI database (2016) for countries where available; different sources for other countries (see Annex IV)

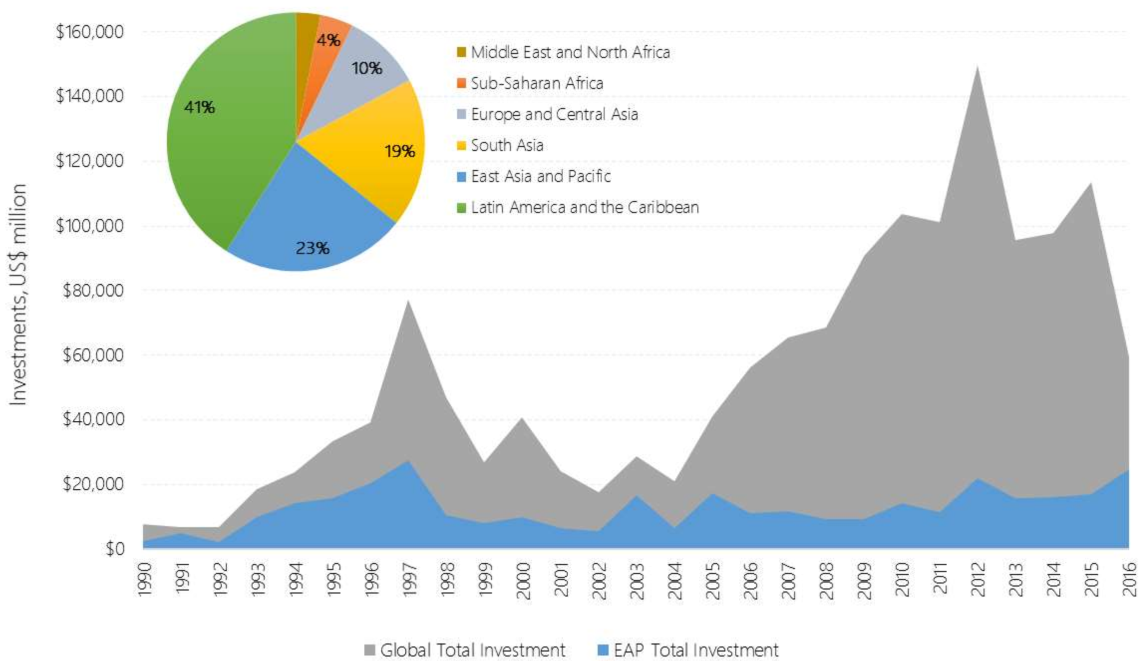
Operating Cost Coverage Ratio, Water Supply



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET Benchmarking database, various years (see Annex VI)

Private Sector Participation in Infrastructure

Overall, during the 27-year period of our study, private sector investments in infrastructure (PPI) in EAP account for 23% of the global investments. All of these recorded PPI projects were located in China and developing EAP. The pace of private participation as a portion of overall global private investments declined sharply following the Asian Financial Crisis, with a slow rebound over a 20-year period, finally nearing pre-crisis levels of investment in 2016. In fact, in 2016, EAP was the only region which saw an increase in investment levels compared to past years.



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

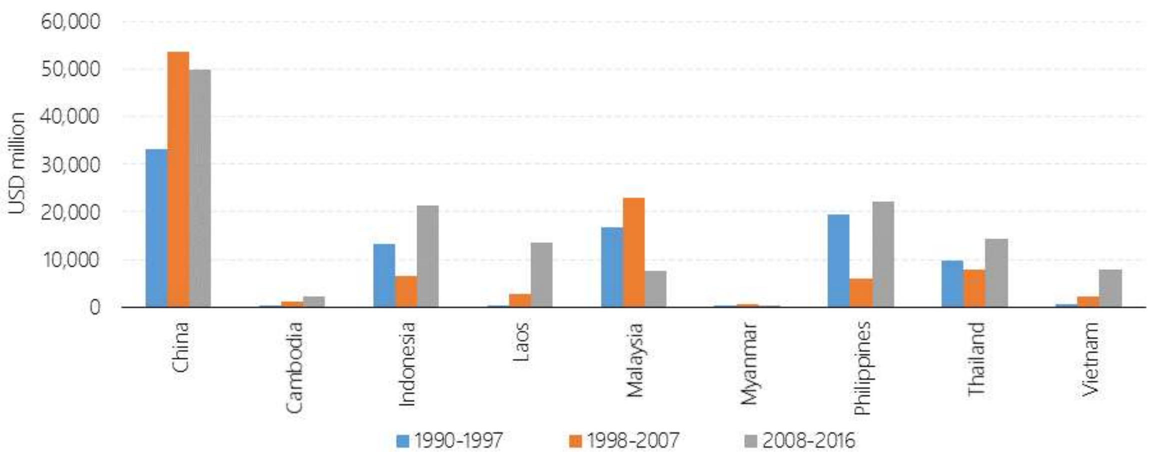
Investments in the energy sector are the highest in EAP, accounting for 56% or USD 213.8 billion of the total EAP investments. This is followed by the transport sector, which received 33% of total investments at USD 125.6 billion. The water and sewerage sector received only 11% of total EAP investments at USD 43.6 billion.

Investments in EAP are led by China, primarily in the transport and energy sectors. From 1998-2007, China accounted for almost half of all EAP investments. Malaysia led PPI investments during the 1990-2007 period, with significant investments in water and sanitation, but its share of investments dropped over the last decade to only 5.43% of EAP's overall PPI investments (from 17.87% and 22% during 1990-1997 and 1998-2007, respectively). Thailand has consistently accounted for between 8-10% of EAP investments over time.

Following the Global Financial Crisis, investments increased in Indonesia (15.35%), Laos (9.7%) and Philippines (15.92%). Investments in Vietnam grew from the level of 0.66% in 1990-1997 to 5.64% in 2008-2016. In the last decade, overall private sector investments increased in all ASEAN countries with respect to1997-2007 levels, except for in Malaysia and China.

In the Pacific Islands, no PPI investments have been recorded in Fiji, Solomon Islands, or Timor-Leste. Vanuatu has seen only two investment commitments in 1994 and 2009, amounting to USD 25 million. Similarly, Papua New Guinea recorded only two investment commitments of USD 205.6 million for two projects in 1996 and 1997.

PPI Investments in EAP Countries by Financial Era



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

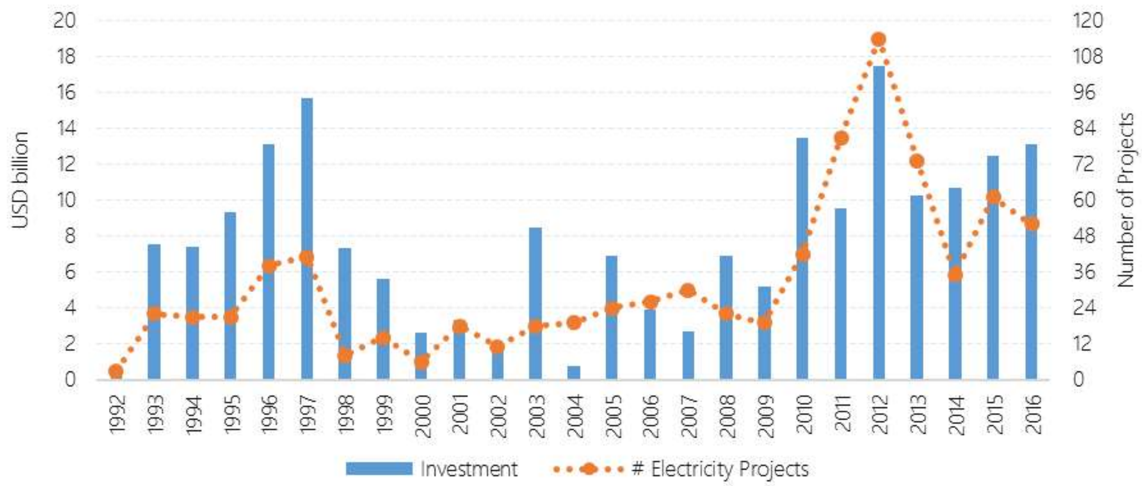
Energy sector investments in EAP account for a quarter of the total accumulated global investments in the sector. China, followed by Philippines, Indonesia, Thailand, and Malaysia, have the highest levels of private sector investments in electricity projects.

In the water and sewerage sector, EAP (mainly China, Malaysia, and Philippines) accounts for 44% of global investments, but levels have declined since 2007. In the past five years, 30% of projects received some form of direct government support. Most investments were made for treatment plants as opposed to water utilities. This reflects country-level needs for wastewater treatment, highlighted earlier.

China's investment rate in the transport sector has grown steadily over the last three decades. Investments in Malaysia's transport sector have been declining, while Indonesia, Philippines and Vietnam have seen a significant upturn in road investments since 2008. Most

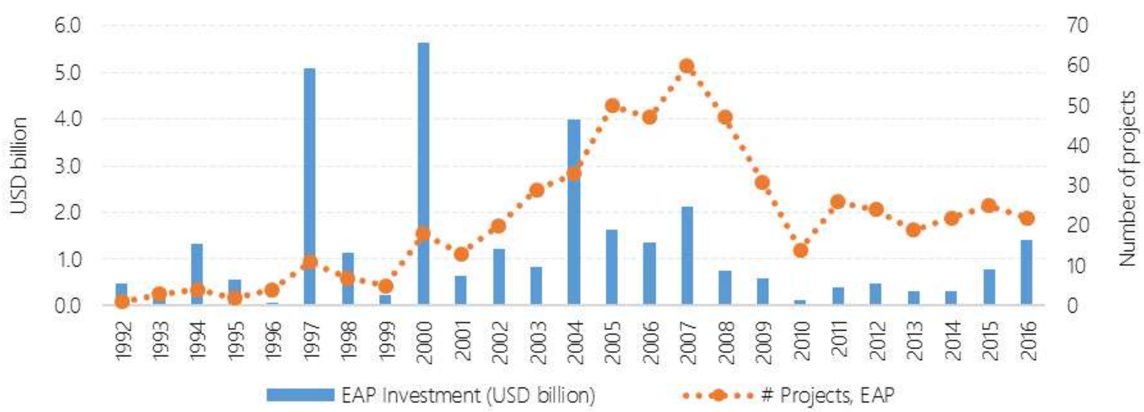
PPI road investments in Thailand were made in the 1990s, and the rest of ASEAN received very limited investments, despite increasing needs for rehabilitation and upgrading. No road investments were recorded in Pacific Island countries.

EAP PPI Investments and Projects in Electricity



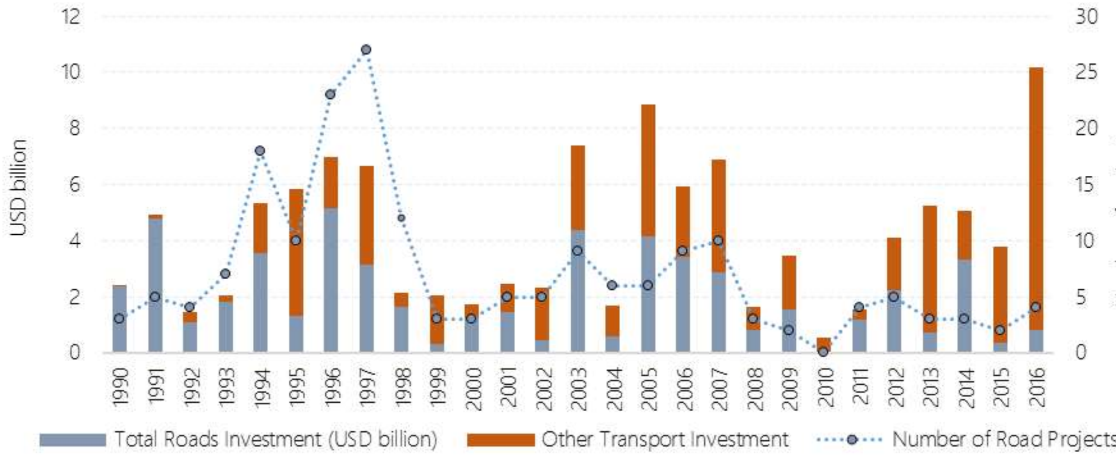
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

EAP PPI Investments and Projects in Water and Sanitation



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

EAP PPI Investments and Projects in Transport



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Increasing participation of private investment is warranted to increase infrastructure service delivery and to help offset unmet demand for infrastructure finance. It is to be noted, however, that PPI investments account for a very small proportion of total investment in infrastructure. For example, in 2015, PPI investments in China were less than 1% of the total investment in transport, energy and water. Moreover, PPI investments are not keeping up with regional growth. In 2016, EAP PPI investments accounted for a meager 0.2% of the GDP, compared with a pre-Asian Financial Crisis level of 8%. As such, PPI investments will continue to be complementary to much higher levels of public sector investment in infrastructure.

Conclusions

This report draws conclusions on key areas of development for improving access, quality, and cost recovery that may inform decisions about the prioritization of infrastructure investments and focal points for private sector participation.

Although infrastructure services in EAP are developing in many locations, there are marked differences in access and quality between low- and high-income ASEAN countries, between ASEAN countries and the Pacific Islands, and between rural and urban areas. Large-scale investments are still required, particularly in water, sanitation, and transport in low-income economies and rural areas. In several middle-income countries, investments are required for water and sanitation.

Moreover, access to and quality of services remains uneven amongst countries and between rural and urban communities. While this report provides a snapshot of comparative performance to help focus regional strategies for infrastructure development, national and local reforms will undoubtedly require more in-depth analysis to deal with sub-national differences in coverage and quality of services.

Among the three sectors considered, the state of electricity provision is the most advanced in the EAP region. Most countries with high coverage rates also have high quality, with a few exceptions. Myanmar and Cambodia, for instance, while fairly well-covered in terms of access, exhibit high transmission losses. Cambodia also has a relatively high rate of service interruptions. Solomon Islands and Vanuatu, on the other hand, have low access levels, but also low incidences of service interruption. Samoa has both low access and high service interruptions.

In the water sector, while overall connection to an improved water source (including piped water, wells, etc.) is high, urban connection to piped household connections is more limited. Further, in many countries, high access rates are not accompanied by high quality service. Many utilities suffer from moderate to high levels of non-revenue water and poor potability. Malaysia, Fiji, and Samoa, for example, have very high levels of urban supply coverage, but with high levels of non-revenue water (NRW). Similarly, Philippines, Papua New Guinea, and Solomon Islands have fair access levels, but also utilities with high system losses.

Indonesia requires special attention with respect to water services, since its access levels are low and NRW is also high. Singapore, on the other hand, is maintaining very high standards with respect to both coverage and efficiency. Interestingly, Cambodia – driven by the success of the Phnom Penh water utility – is also a top performer in municipal water service in the region, alluding the high potential for success even in emerging markets. Overall, a focus for EAP should be on the rehabilitation of existing water networks to reduce inefficiencies and on improving the potability of delivered water.

The results for sanitation access and quality, on the other hand, show that sewerage and wastewater treatment are in most need of extension, upgradation, and rehabilitation. Much of developing urban EAP lacks connectivity to sewerage networks and sufficient wastewater treatment, which can translate to diarrheal illness and water contamination. Few urban areas extend connections to piped sewerage to even half of the country's urban population, and the rates of water treatment after collection are abysmally low.

With respect to rural road transport, the ASEAN countries in most need of attention with respect to extending access to rural areas are Indonesia, Laos, Malaysia, and Myanmar. These countries, along with Philippines and Vietnam, also require significant work for road rehabilitation and upgrading. While access to roads does not necessarily guarantee access to critical social services, low access is nevertheless a recognized hindrance on social development.

Improved data quality is an ongoing need. These include up-to-date comparable cross-country data on per-unit tariffs and costs (capital and operational), since current estimates are limited to urban areas and often, the largest cities. This would also enable a better assessment of cost recovery levels for both electricity and water utilities. Given the importance of water quality to public health, there is a need to collect improved scientific water quality data. In general, there is little information on the costs of road construction, nor is there extensive cross-country data available on road surface quality. Geographically, reliable data is extremely limited in the Pacific Islands.

Finally, according to the economic literature on infrastructure, social and economic development indicators are associated with levels of infrastructure access and quality, which, in turn, are also influenced by a country's quality of governance. The correlations presented in this report show that higher levels of access to piped on-site water are linked to lower rates of infant and child mortality. At the same time, quality of governance and government capacity appear to be related to access levels and quality of services. While these results do not imply causality, as they do not control for variables that may otherwise affect levels of infrastructure service (e.g., income levels, policy factors, geography, etc.), they highlight areas worthy of deeper and more rigorous analysis at regional- and country-levels.

Chapter 1 Infrastructure in East Asia and the Pacific

Infrastructure services form the base of a country's economic and social development. Economic infrastructure – physical assets such as roads, bridges, water treatment plants, piped water supply networks, power plants, and electricity distribution networks – are critical to accelerating economic growth and reducing income disparities.[2,3] These services are also essential to improving access to social services, such as health care and education, reducing poverty, and creating job opportunities.

The enormous importance of economic infrastructure to overall societal well-being, security, quality of life, productivity, economic growth, and the reduction of income disparities is widely accepted.[4] Lack of access to basic services such as drinking water, sanitation, transportation, electricity, and communication networks continue to undermine living standards in low-income countries (LICs), as well as in some regions of middle-income countries (MICs). Furthermore, the under-provision of infrastructure is borne heavily by the world's poorest and is more common in rural areas.[5]

Given the key role of infrastructure to development and the World Bank Group's active role in the infrastructure sector, it is important to periodically take stock of the levels of access, quality, and pricing and costs of infrastructure services in order to inform national, subnational, and multilateral efforts related to infrastructure development. As such, this study aims to evaluate the status of economic infrastructure in the East Asia and Pacific (EAP) region, with a particular focus on electricity supply, water and sanitation, and road transport. The exercise is meant to facilitate a more accurate understanding of the particular infrastructure needs and financing requirements of the region and its constituent countries.

Indeed, a wider range of infrastructure sectors are critical to development. These include water resource and flood management infrastructure, ports and rail networks, and other energy sectors, such as natural gas and renewables. This study focuses more narrowly on the sectors specified above, however, due in part to data availability and in part to their immediate developmental impacts on the lives of the poorest in East Asia and the Pacific.

Therefore, the purpose of this study is to provide a general overview of the status of infrastructure services in the electricity, water and sanitation, and road transport sectors, with a focus on access, quality, costs and pricing, and private participation. While the report

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[2] Agénor and Moreno-Dodson (2006); Estache and Fay (2010)
[3] Fay and al. (2005); Calderón and Servén (2010)
[4] Schwartz et al. (2009); Fay et al. (2005); Hutton and Haller (2004); Dinkelman (2011); Khandkher et al. (2009)
[5] Hutton et al (2004). Findings of this report also confirm a correlation between access and quality of basic infrastructure facilities, such as water and sanitation, and public health outcomes; Dinkelman (2011); Khandker et al. (2009).

intends to provide an overview of the current service levels, it does not immediately diagnose or solve infrastructure challenges at the national or sub-national levels. Sector reforms and development initiatives will require more in-depth and locally-focused analytical work. This study aims to support and focus more extensive sector analyses as well as studies that employ advanced statistical methods to, for example, establish the relationships between pricing, access, and quality of infrastructure services in the region or the impacts of various factors, including governance, on the access and quality of services.

With respect to human development and environmental sustainability, the UN Sustainable Development Goals commit to achieving universal and equitable access to safe and affordable drinking water and sanitation; improving water quality by reducing pollution; and ensuring access to affordable, reliable, efficient, and sustainable energy for all by 2013.

From an economic point of view, infrastructure is not only an important productive input, but also a means to raise overall productivity by reducing transaction costs and promoting more efficient use of other conventional inputs, such as natural and human resources, built systems, and capital. These contributions translate into significant positive impacts on overall economic growth. Estimates suggest that a 10% increase in infrastructure development contributes to 1% overall growth in the long run.[6]

Moreover, the ready availability and reliability of water, energy, transport, and communications services are critical to private sector growth and competitiveness. Infrastructure is closely intertwined with "second-generation" variables like social stability and justice; urbanization;[7] environmental sustainability and climate resilience; [8] energy, water, and food security; and regional and global relations, due largely to the increased importance of trade and human connectivity.

In 2016, World Bank Group (WBG) support to economic infrastructure in the transport, water, energy, and Information and Communication Technology (ICT) sectors accounted for 40% of the WBG's current assistance and lending portfolio. Moreover, the WBG's infrastructure strategy includes an emergent, transformative approach to infrastructure development that employs two major initiatives beyond core sector-specific infrastructure development. First, the WBG is seeking to facilitate transformational projects that include participants and stakeholders across sectors and regions to deal with the complex, second-generation challenges facing client governments. Second, the approach acknowledges the

[6] Irigoyen et al. (2012)
[7] By 2030, 95 percent of the population growth in the developing world will be located in cities, with urban centers contributing up to 70 percent of global GDP.
[8] Fay et al. (2010)

limited availability of public resources and, thus, seeks to leverage capital by engaging partners in the private sector to extend capacity for infrastructure funding.[9]

The study is focused on and organized by three pillars of infrastructure service delivery – access, quality, and tariffs and costs of service – across three sectors: electricity, water and sanitation, and road transport. With an eye to closing the infrastructure financing gap to improve performance along these dimensions, the study also examines the current levels of private participation in infrastructure finance.

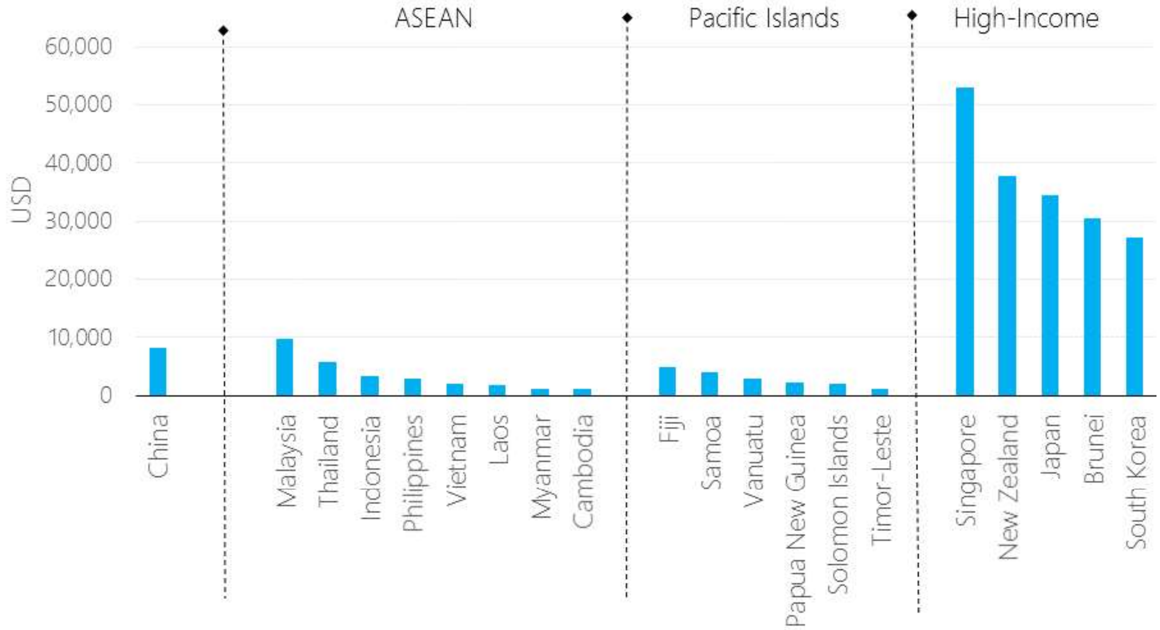
Infrastructure Development in the East Asia and Pacific (EAP) Region

The East Asian and Pacific (EAP) region has enjoyed strong and resilient economic growth accompanied by steady social and infrastructure development over the past decades. Indeed, the region has demonstrated a capacity to learn and rebound from major crises such as the 1997-1998 Asian Financial Crisis, which motivated several reforms and bolstered resilience during the 2008 Global Financial Crisis. The developing economies of EAP are on track to grow at 6.2% in 2017 and 6.1% in 2018, while aggregate growth in the Association of South East Asian Nations (ASEAN) countries is expected to rise slightly from 4.9% in 2016 to 5.0% in 2017 and 5.1% in 2018.[10]

While growth has been steady, there remain high disparities in income both between and within countries. Figure 1 below shows the significant per capita income differences between high-income economies in the region, including Singapore, Brunei, New Zealand, Japan, and South Korea, and the rest of the region, particularly in much of lower-income ASEAN and the Pacific Islands.

[9] Irigoyen et al. (2012)
[10] World Bank projections

Figure 1. GDP Per Capita in 2015, Current USD



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank Group (2015d)

EAP has seen a dramatic decrease in poverty levels over the past twenty years, with the number of people living in extreme poverty falling by over 920 million between 1990 and 2013. Despite these trends, the region's infrastructure poses a significant threat to the pattern of sustained regional growth and an added challenge to regional goals for sustainable development and trade connectivity. Moreover, significant challenges remain with respect to access to basic human services, as well as regional goals for sustainable development and trade connectivity.

A recent ADB report estimated that up to USD 22.6-26 trillion (about USD 1.5-1.7 trillion per year) will be required up to 2030 to sustain economic growth in the region.[11] The demand for infrastructure cannot be met by current levels of funding. A World Bank estimate of the deficiencies currently facing the East Asia and Pacific region up to 2020 amounts to an approximate USD 52 billion (excluding China),[12] while ADB's estimates are USD 330-459 billion (the latter figure for climate-adjusted estimates) over the same time period.[13] McKinsey estimated that the infrastructure investment levels (as a % of GDP) in emerging

[11] ADB (2017)

[12] Ruiz Nunez and Wei (2015)

[13] Climate-adjusted estimates include investment needed for climate adaptation and mitigation.

Asia will have to increase from 4% (the historical level from 2000-2015) to 6% between 2016-2030.[14]

Scarcity of public resources means governments will have to mobilize private sources of finance in order to attain the levels of investment required to sustain growth. Private participation in infrastructure grew steadily up to 1997, with investments in the region of USD27.4 billion in that year, but plunged following the Asian Financial Crisis.[15] Investment levels are only just approaching the pre-crisis range now (USD24.8 billion in 2016), after nearly twenty years of recovery. Therefore, the dual challenge is to extend and improve infrastructure services to support economic growth and to mobilize new sources of finance to close the gap.

Assessing Infrastructure Service Delivery and Development in EAP

Infrastructure services may be assessed and qualified along several dimensions. From a development policy perspective, some of the most important questions include: Who receives infrastructure services, and at what level of reliability, quality, and affordability? To what degree of efficiency are these services delivered? And what is required to extend and improve services to meet development goals and sustain growth? These questions may be organized more broadly into two paths of enquiry to consider what infrastructure stocks and services are available at present, and what infrastructures are required to serve economic and social development goals. This recognizes also that there is a heterogeneity in infrastructure service with respect to access, quality, reliability, pricing, and production cost, both between countries, as well as between rural and urban areas.

What is the current infrastructure stock?

The first broad question – namely, *what is the current infrastructure stock?* – challenges us to assess the current level of infrastructure in EAP, an initiative that comprises the bulk of this report. This stock-taking exercise is organized along three dimensions: access, quality, and tariffs and costs.

Access to Infrastructure

> Access to infrastructure measures who has access to the fundamental infrastructure services critical for economic and social development. Access may be

[14] McKinsey Global Institute (2016)
[15] World Bank Group (2016)

measured in absolute terms or expressed as the proportion of the population receiving (or able to receive) a specified type and standard of service.

Access levels in some networked economic infrastructure sectors such as energy, urban water supply, and information and communication technology (ICT) services are straightforward to measure. These kinds of services are merit goods critical to overall productivity and development, but are not public goods by the strictest economic definition, since they both are excludable and rivalrous. Because service is extended only to those with physical network connections (and therefore measurable by service providers), levels of access may be captured via indicators such as the number of connections to the water distribution supply system, number of users with access to improved sanitation, or number of households with electricity.

Access to non-tolled transport infrastructure networks is often less obvious. In this case, geospatial analysis is a useful approach to estimate the proportion of a population with reasonable access to the country's road network. This study uses the World Bank's Rural Access Index (RAI) methodology.

Quality of Infrastructure

Access is only a partial answer to the question of what infrastructure services a society currently benefits from, since measures of access cannot distinguish variations in the quality of services offered to users. This is also particularly important to economic development, as businesses depend on the provision of reliable services to support productive activities. As such, another important set of measures are those that capture infrastructure quality, including reliability (availability and consistency) and standards of quality related to the product delivered (e.g., cleanliness in the case of water supply) or the experience of use (e.g., road surface quality in the case of transport).

Tariffs and Costs of Infrastructure Service

Infrastructure services are provided at different tariff levels and production costs. While the costs borne by producers and the costs of consumption paid by consumers (i.e., tariffs) may be of equal societal consideration from a social cost-benefit perspective, tariff levels, particularly for subsistence-level consumption, are key to understanding the affordability of key infrastructure services. The costs of producing and delivering infrastructure services (including operational and capital expenditures) are important to understanding the different cost structures associated with various geographies of infrastructure service delivery, the relative efficiency of service provision, and the degree to which costs are recovered from collected revenues.

What is required to extend service, improve quality, and close the infrastructure gap?

A natural follow-up to the exercise of stock-taking is to ask *what more* is required to extend access, improve quality, and increase the efficiency of infrastructure service delivery. The medium- and long-term impacts of investments and infrastructure service gains on sustainable development and economic growth are not directly addressed in this report, though other research has shown how investments in water, energy, and transport are expected to promote social and economic development. Estimates suggest that every USD 1 invested on capital infrastructure projects generates economic returns in the range of 5% to 25%.[16] At the very least, it is given that increased access, efficiency, and quality are desired by nearly all economies and societies.

Closing the global infrastructure gap to attain increased coverage and improved services will require mobilizing alternative sources of finance, including resources from the private sector. Private participation in infrastructure (PPI) is not new to the EAP region. Indeed, public-private partnerships (PPPs) in water, energy, and transport have been active since the early 1990s. Future assessment of the prospects for funding extension and improvement to infrastructure services requires an understanding of current patterns of PPI development.

Private Participation in EAP Infrastructure

Public resources are insufficient to fund the demand on infrastructure improvement and extension over the coming years. Private resources are a source of finance that may be used to help offset the existing funding gap and to improve the efficiency and quality of infrastructure services. To understand the current role of the private sector in developing regional infrastructure, this study analyzes PPI, particularly, the evolution of PPPs over nearly three decades.

[16] World Economic Forum (2012)

Chapter 2 Analytical Approach

Scope of Analysis: Energy, Road Transport, and Water Infrastructure in ASEAN and the Pacific Island States

The status of EAP infrastructure covers most of the EAP region and three key economic infrastructure sectors: energy, transport, and water and sanitation. Geographically, this report assesses the status of infrastructure services in China, ASEAN and the Pacific Island states, particularly for those countries wherein the World Bank Group has an operational presence (see Figure 2). Due to massive data insufficiencies in some Pacific Island states, not all countries were included in the study.

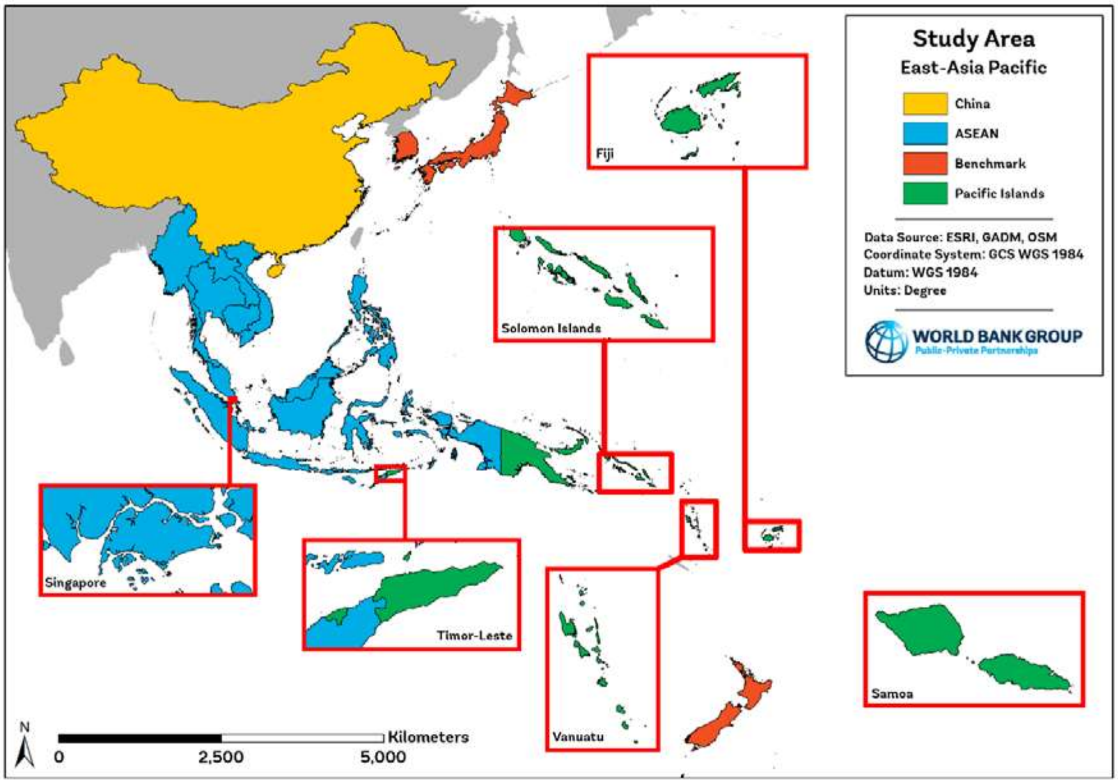
This study covers the following EAP countries:

China and ASEAN	China, Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam;
Pacific Islands	Fiji, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Vanuatu; and
Regional benchmarks	Japan, New Zealand, South Korea.

Brunei and Singapore, while part of ASEAN, are hereafter included in figures and tables alongside the regional benchmarks of Japan, New Zealand, and South Korea, since their levels of development and infrastructure performance are more directly comparable. The benchmark countries were selected as points of comparison due to their higher levels of income and proximity to the EAP countries under study.

With respect to sector scope, the term 'infrastructure' may be used to refer to a wide array of services, including assets that accommodate social services, such as schools, hospitals, and housing developments, as well as economic infrastructure assets that facilitate trade and production, including energy, water, and transport services. This report focuses on the provision of three key economic infrastructure sectors: road transport, water and sewerage, and electricity. For water supply and sanitation, the study focuses largely on urban services, whereas the assessments of road transport access and quality are largely focused on rural areas.

Figure 2. Map of Study Area



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017)

Methodology

The status of infrastructure in EAP is framed by three qualifying aspects of provision – access, quality, and cost and pricing – and one aspect of financing, namely private participation in infrastructure. Analyses are mainly based on secondary sources of information and statistical and geospatial analysis of data drawn from the World Bank, Asian Development Bank, ASEAN, UNESCAP, NASA and country data sets, market intelligence for the energy and water sectors, and open access map data. The data sources and indicators used for each section are detailed below, with further detail provided in the results sections and annexures.

Descriptive statistical analyses of the four aspects are given at the region-wide and national levels. Country comparisons are presented in graphs, maps, and tables for EAP countries, including China, as well as for the three regional benchmark countries, Japan, New Zealand, and South Korea.

Data Sources and Indicators

Data for the analysis was sourced from a wide variety of sources, including from publicly-available data sets maintained by the World Bank Group and other multilateral organizations, subscription data sets produced by industry and market research companies, and government, industry, and company utility reports. Data on access to electricity services and water supply was the most readily available. While the effort to gather and consolidate such data was time-intensive, once available, it allowed direct comparisons across countries and regions.

The data for road transport access was far more complicated to generate, as it required geospatial modeling and advanced computational techniques to estimate the degree of access to paved rural roads based on open road map data and population data. Nevertheless, its comparability amongst countries is robust and offers a direct, well-defined metric by which to assess rural transport access.

Data Challenges

Data for quality, tariffs, production costs, and cost recovery levels was far more challenging, however, due to data deficiencies (both with respect to geographic breadth and timeliness of data), reliance on perceptions survey data over direct measurement in some cases, and the use of different estimation methods, assumptions, and units of measurement, particularly in the case of water and road transport costing and pricing. These are described in the following section in more detail.

Data across countries on capital expenditures was grossly insufficient: no good cross-country, representative data sets exist to capture these kinds of costs. Moreover, they are often not publicly reported via financial reports or government on an extensive basis, nor are they reported in such a way that is consistent with respect to the accounting approach used to determine the value and lifetime of service for the asset to which the capital expenditure applies.

Similarly, data on road costing at the national level was unavailable, outside of data on a few roads constructed via PPP captured in the PPI Database, some project-level data, and some data on road project lending. The estimation of per-km road costs of construction is difficult to undertake. Aggregating average per-kilometer road costs at the national level in a way that is meaningful for comparison is difficult due to a wide array of factors that determine construction cost, including differing regional geographies and topographies, as well as different road widths and technical demands.

Despite these challenges, data was collected for a number of indicators for each pillar and sector. These are described in the following section, organized by pillar (access, quality, tariffs and costs, and private participation in infrastructure), as well as in summary form at the close of this chapter.

Access Data

This study uses multiple databases to retrieve data for the different infrastructure services. Data for access to electricity, water, and sanitation services was retrieved from official databases, whereas the data used to assess rural access to roads was generated with geospatial models.

The following set of indicators were used to evaluate access to essential infrastructure services:

Electricity	Access to Electricity (Total, Rural, Urban)	% Total population	Percentage of population (total, rural, urban) with access to household electricity service (as share of total, rural, urban)
Water Supply	Access to Piped Water on Premise (Total, Rural, Urban)	% Total population	Percentage of population (total, rural, urban) with access to an improved water source via piped water on premise (as share of total, rural, urban)
Sanitation	Access to Sewerage Connection on Premise (Total, Rural, Urban)	% Total population	Percentage of population (total, rural, urban) with access to piped household sewer connection (as share of total, rural, urban)
Roads	Rural Access Index (RAI)	%	Percentage of rural population with access (within 2km) to non-seasonal paved roads

Electricity, Water, and Sanitation and Electricity Access Data

For access to electricity, this study uses 2015 World Bank Development Indicator data. The access data draws on country-level reporting to provide the share of the total, urban and rural populations with access to electricity services. Electrification data is collected from industry, national surveys, and international sources, and is maintained by the World Bank's Sustainable Energy for All (SE4ALL) database.

Data for water and sanitation access is drawn from the UNICEF-WHO Joint Monitoring Programme (JMP) for Water Supply and Sanitation, which collects and publishes an extensive and comprehensive global dataset on access to water and sanitation.[17] The JMP database collects data on access to improved water and sanitation facilities and the share of total, urban and rural populations with access.

Definitions for "access to an improved water source" and "access to an improved sanitation facility" capture services that are broader than those particular to networked infrastructure

[17] WHO/UNICEF (2015)

systems. They include, for example, households with a well, septic tank, or other non-grid-based access. To further narrow the definitions to more accurately reflect the state of infrastructure, this study uses data from the sub-indicators "access to an improved water source, piped on premise" and "access to improved sanitation facility, to piped sewer system" to consider household access to grid-based water supply and sewerage services.

Rural Access Index (RAI)

The Rural Access Index (RAI) was initially created to support the World Bank Infrastructure Action Plan with a transport-related indicator.[18] Its aim was to identify priority strategies for poverty reduction by assessing connectivity gaps and investment needs. The RAI measures the share of the rural population with access to all-seasonal roads, within a walking distance of 20-25 minutes, or approximately two kilometers (2km). All-season roads should be accessible throughout the year, regardless of seasonality or weather events such as intensive rainfall.

While the RAI is considered a key development indicator, there is no regularly updated dataset. The only source with global values is a World Bank database with data from the late 1990s and early 2000s (ROCKS). However, the database contains only national data sourced from models, surveys, and estimations, but with no consistent approach to data collection.

This study uses geospatial data to estimate access to rural road infrastructure by using freely-available population and road network data to calculate the Rural Access to Non-Seasonal Paved Roads (RANPR) indicator, based on the methodology of the RAI. The indicator is termed differently, only because the road inputs to the RAI methodology include only paved roads.

Estimating the RAI with geospatial data requires two kinds of information: the road network and population data. Freely available population data from WorldPop provides geocoded population density data based on land-cover and census data to produce a standardized dataset. WorldPop is a project based at the University of Southampton and comprises population data with a high spatial resolution of 100m. Figure 3 shows a subset of the WorldPop dataset for the Philippines. Areas in red show a high population density, and the green areas are subject to low density. Naturally, areas along roads exhibit higher density, since people tend to live near road infrastructure.

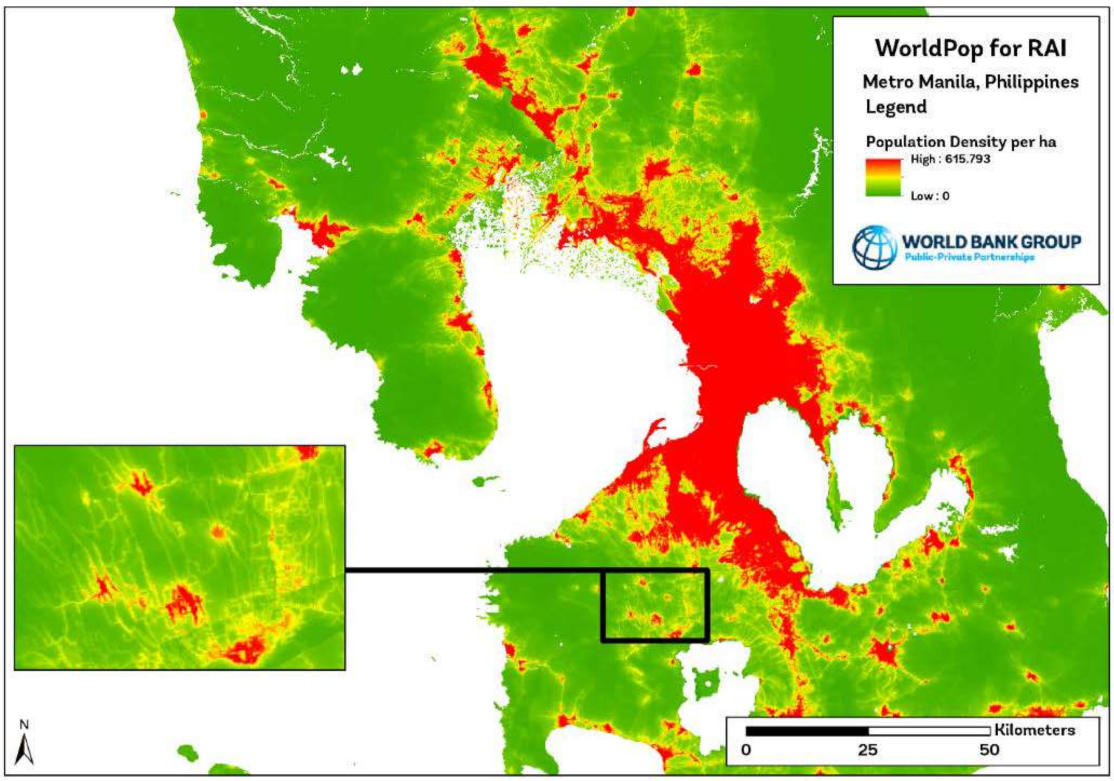
The road network is crucial to estimating the coverage of the accessible area along all-seasonal roads, and high quality data on road infrastructure allows more accurate estimation of the RAI. Acquiring a reliable map of the road network is a complex exercise, however, particularly when dealing with developing countries where official geospatial data is often unavailable. Moreover, many road network datasets do not provide information about road

[18] Iimi et al. (2016)

quality, which challenges the identification of seasonal and non-seasonal roads and may lead to over- or underestimation of the RAI.

To overcome data acquisition and quality challenges, this study uses data from OpenStreetMap (OSM), an open-source geospatial database. OpenStreetMap is a global project to provide user-generated, free, and high-quality geospatial data. The advantage of OSM is the availability of recent and reliable geospatial data for areas where official data from local authorities is either unavailable or challenging to acquire. Particularly in countries or areas where the National Mapping Agencies (NMAs) do not have sufficient data or when commercial services are too costly, OSM data is a strong alternative.

Figure 3. Population Density of Metro Manila



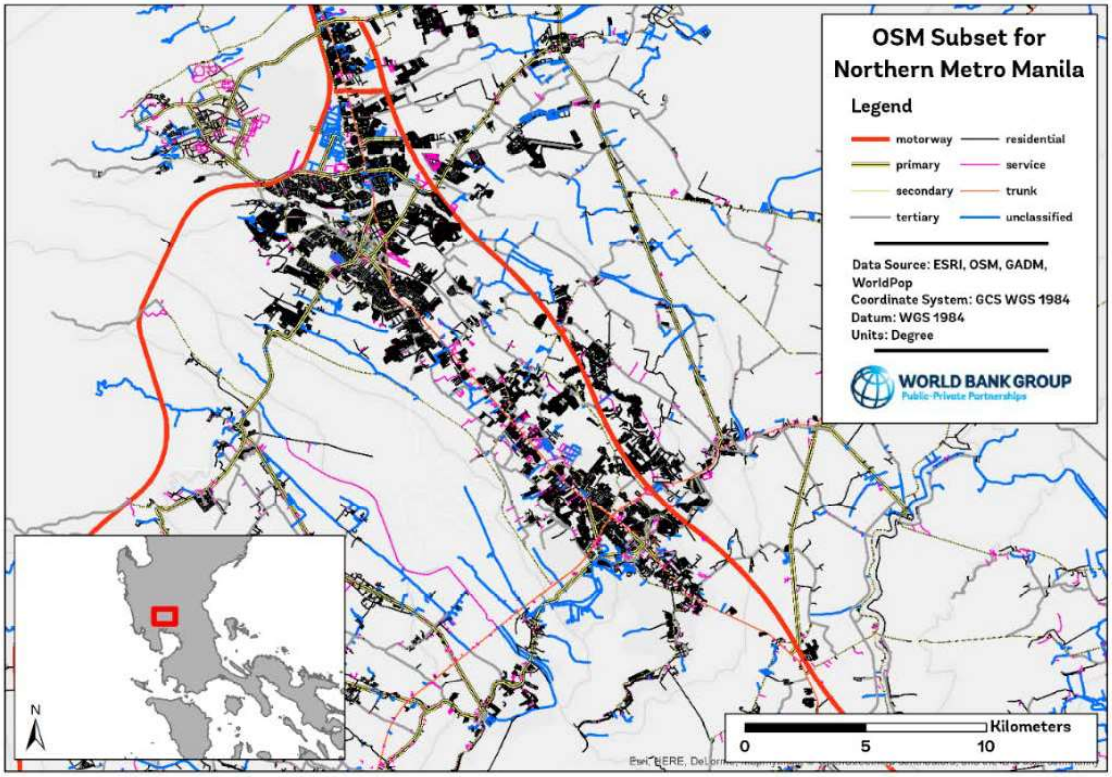
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on WorldPop data

The scientific community concedes that OSM data is relatively accurate, and its transparency outweighs possible risks of manipulation or misinformation. Despite its heterogeneity across the database, Brovelli et al. report that OSM data sometimes provides better quality than proprietary data from official or commercial third-party sources.[19] El-

[19] Brovelli et al. (2016)

Ashmawy has shown that OSM data is even suitable for construction projects, since its positional accuracy is high enough to generate necessary maps for preliminary planning stages.[20] Figure 4 shows an example subset of the OSM extract for RAI estimation.

Figure 4. OpenStreetMap Classes, Subset from Northern Metro Manila, Philippines



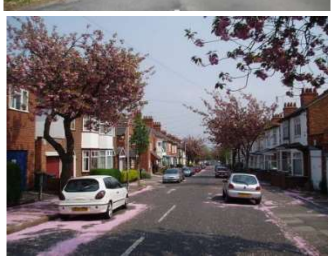
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on WorldPop data

In addition to land-use data, the OSM database contains complex transport infrastructure-related data. For this study, road networks for individual countries were downloaded from OSM, and only relevant roads (according to the definition of the RAI) were extracted. OSM structures its data with attributes such as keys and tags. To avoid overestimation of the access to the road network, roads with the tag "roads" within the key "highway" of the OSM database have been taken into consideration. It should be mentioned that the key "highway" should not be confused with the road type highway.

[20] El-Ashmawy (2016)

Table 2 shows the tags applied for the extracted road network. Among these, the category "unclassified" does not refer to roads without a classification, but is rather an official classification based on the British classification scheme.

Table 2. OSM Tags Used to Extract Road Data

Tag	Example Picture	Tag	Example Picture
Motorway		Trunk	
Primary		Secondary	
Tertiary		Unclassified	
Residential		Service	

Source: OpenStreetMap Wiki (2017)

Since the RAI specifically examines rural areas, spatial separation of urban and rural areas is a crucial issue to prevent over- and underestimation of access. This study uses population density data and excludes areas with population densities above the official urbanization rate (according to the World Bank).

The RAI was then computed by calculating the population within a two-kilometer buffer along the extracted OSM road network and masked with the rural area layer. The final layer, identifying the 2km area around all-seasonal roads in rural areas, was then used to filter and retrieve the population from the population density layer.

Quality Data

Data on the quality of services captures measures of reliability and efficiency of infrastructure services, as well the quality of outputs for some types of service. The following indicators were selected for the purposes of evaluating the quality of infrastructure in the study region:

Electricity	Quality of Electricity Supply	Score (1-7, best)	Perceptions of overall electricity supply
	Electric power transmission and distribution losses	% Total output	Electric power transmission and distribution losses as a % of output to the transmission and distribution system
	System Average Interruption Frequency Index (SAIFI)	Days per year	Average frequency (occurrence) of annual interruptions to electricity services
Water Supply	Non-Revenue Water	%	Percentage of water that enters the piped distribution for which revenues are not collected due to leakages, theft, non-metering, or non-collection; represents the amount of water 'lost' in the supply system
	Quality of Water Supplied (QWS): Samples Passing Residual Chlorine Test	%	Percentage of samples passing the residual chlorine test, which indicates whether sufficient chlorine remains in the water supply after distribution to prevent microbial contamination during transport
Sanitation	Diarrheal Disability-Adjusted Life Years (DALYs)	Number of DALYs per 100,000 persons	The Diarrhea Disability-Adjusted Life Years (DALYs) incorporates both, years of life lost and years lost due to disability caused by diarrhea One DALY can be thought of as one lost year of "healthy" life. A high is a proximate indicator of poor water, sanitation and hygiene conditions.
	Wastewater Treatment Level	%	Percentage of collected wastewater that is treated (2014 data)
Roads	Quality of Road Infrastructure	Score (1-7, best)	Perceptions of overall road quality

Length and Condition of Asian Highway Network Roads	Km	Lengths of Asian Highway Network designated highways classified as good, fair, poor, or unknown
Ratio of Paved Roads to Total Road Length	%	Ratio of paved road to total road length (%)

Data on quality of infrastructure services suffers some common general limitations. First, since it is aggregated at the country level, data does not capture within-country variations, which can be significant. Further, publicly available data on service quality is largely focused on urban areas and each country's largest cities, in particular. Therefore, while the indicators used in this chapter reflect the latest available information on the selected aspects of infrastructure quality in each country, they do not provide granularity with respect to levels of quality at the subnational level, which may range significantly.

Electricity Quality Data

Electricity infrastructure quality is captured by two indicators: electric power transmission and distribution (T&D) losses and average frequency of annual service interruptions for utilities. T&D losses are technical losses that are not observed by households; therefore, they are not a measure of perceived loss of quality by consumers. They are, however, an important indicator of efficiency that is directly affected by the state of the distribution network.[21] The data was drawn from the World Development Indicators, which uses information collected by the International Energy Agency (IEA) from national energy agencies.

The second indicator – the System Average Interruption Frequency Index (SAIFI) - measures the number of interruptions per customer in a year. It is calculated as a ratio between the number of customer interruptions and the number of total customers served, measured over a year. SAIFI data is drawn from the World Bank *Doing Business* report, which in turn sources information from the national regulators for the largest business city of each economy.[22] There are some limitations with respect to representativeness of the data, as the indicators cover only the main economic center of each country (and, additionally, the second largest for countries with populations over 100 million).

Water Quality Data

Data regarding the quality of water infrastructure services comes from the International Benchmarking Network (IBNET) database. IBNET is the world's largest database for water and sanitation utilities performance, gathering data on more than 4,000 water utilities in

[21] ADB (2017)
[22] World Bank Group (2015a)

130 countries. For most countries in the EAP region, the utilities covered by the database account for approximately 75% or more of the urban service coverage in each country.

Two quality indicators of water service have been selected. Non-revenue water (NRW) is a measure of the efficiency of and water losses in a distribution network. NRW represents the water that has been produced by the utility but is "lost" before it reaches the customer, typically due to leakage, theft through illegal connections, or unmetered legal connections. While IBNET is one of the most comprehensive utility data sources, and most utility data in the IBNET database is from the past five years, data for Indonesia (2004), Malaysia (2007), Lao PDR (2008), Singapore (2008), and the Philippines (2009) is outdated. More importantly, IBNET database representativeness at the country level is very low in China (3%), Indonesia (2%), and Laos (3%). Moreover, all data in the IBNET database is self-reported by the participating utilities. These limiting conditions must be acknowledged during the interpretation of comparative results.

The second indicator is a proxy measure of the quality of the water output. The percentage of water samples that pass a residual chlorine test is a proxy for the cleanliness of supplied water with respect to microbial contamination. Chlorine residual is the low level of chlorine that remains in the water at the tap after it was first applied prior to distribution. In cases where water disinfectants are applied to supplied water (as in most countries, including all under study in this report), these additives safeguard water against microbial contamination during transport through pipelines to households. Therefore, the presence of free chlorine residual in piped water reflects the potability of the water, as it indicates that the water is likely to be free of disease-causing organisms.

Sanitation Quality Data

Sanitation quality is proxied by two measures of overall system hygiene (an indicator of waste management and wastewater treatment quality) and the rates of wastewater treatment.

First, the Diarrheal Disability-Adjusted Life Years (DALYs) per 100,000 people, which is a WHO measure that incorporates both, years of life lost and years lost due to disability caused by diarrhea.[23] One DALY can be thought of as one lost year of 'healthy' life. Therefore, a low count of DALY reflects safe water, sanitation, and hygiene conditions in the country. The data is drawn from the 2015 Global Health Estimates by the World Health Organization (WHO).[24] The diarrhea-DALY does not solely capture the prevalence of the disease caused by poor sanitation access or quality, as it may also be affected by cultural or behavioral norms. Nevertheless, the indicator reflects the severity of problems associated with the

[23] WHO (2017)
[24] WHO (2016)

presence of human waste in water supply and the built environment that lead to diarrheal incidences.

Secondly, the report assesses levels of wastewater treatment, i.e., the percentage of collected wastewater that is actually treated. This data from 2014 is reported by Yale University's (2016) Environmental Performance Index (EPI).[25] The wastewater treatment rate captures the percentage of wastewater collected that receives treatment. For the purposes of this report, the variable is taken from the EPI raw data database and reports the 5-year average of the wastewater treatment rate for each country.

The original values used to calculate these variables were been collected using a hierarchy of sources, selected in the following order: (1) country-level statistical data and reports; (2) values derived from the Organization of Economic Co-operation and Development (OECD)'s variable "Connected to wastewater treatment plan without treatment" by taking the inverse of this percentage; (3) the United Nations Statistics Division's "Population connected to wastewater treatment" variable; (4) secondary treatment levels from the Pinsent Masons Water Yearbook;[26] and (5) FAO-AQUASTAT values.[27] This variety of sources may cause discrepancies and inconsistencies in the data due to different measurement methodologies and periods of data collection. Thus, the values for different countries are should be compared cautiously.

Transport Quality Data

Road transport quality data is limited, making cross-country comparisons across all EAP countries very difficult. Nevertheless, the World Economic Forum's *Global Competitiveness Report* (2017) provides national-level perceptions data on the quality of road infrastructure, with measurement from 1 to 7 (best).[28] Data is collected via an extensive survey of industry experts, who were asked, "In your country, how is the quality (extensiveness and condition) of road infrastructure?".[29] Additionally, some information to provide context is available from the UN Economic and Social Commission for Asia (UNESCAP) Asian Highway Database,[30] which records country-reported assessments of the quality of Asian Highway Network (AHN) roads as 'good', 'fair', or 'poor', as well as from the ASEAN-Japan Transport Partnership, which records the percentage of paved roads of the overall road network of ASEAN states. This data is self-reported annually by Member States.

[25] Hsu et al. (2015)
[26] 14th edition, available at http://wateryearbook.pinsentmasons.com
[27] (Total volume of wastewater treated/Total volume of wastewater collected) × 100 for a given year in a given country
[28] Schwab (2016).
[29] [1 = extremely poor—among the worst in the world; 7 = extremely good—among the best in the world]
[30] UNESCAP (2015)

Tariff and Cost Data

Despite data limitations, this report presents information at the national and municipal levels on tariffs, as well as relative costs of production and rates of cost recovery, building upon indicators listed below.

Electricity	Electricity Tariff for Low Consumption Band	2016 USD per kWh	Electricity tariff for retail residential users (USD/KWh) for tariff block for 30KWh monthly consumption, in 2016 USD
	PPP-Adjusted Electricity Tariff for Low Consumption Band	2016 USD per kWh, adjusted for PPP	Electricity tariff for retail residential users (USD/KWh) for tariff block 30KWh monthly consumption in 2016 USD adjusted for purchasing power parity (PPP)
	Average Electricity Tariff	2016 USD per kWh	The average retail electricity tariff across all tariff blocks and consumer types, calculated as total collected revenues divided by total kWh sold
	Levelized Cost of Energy	2016 USD per kWh	Unit cost of 1kWh production, calculated using data from the energy mix for each country (by source for electricity production) and the unitary costs of electricity production by each input
Water	Water Tariff for Consumption Block of 15m^3, Largest City	2016 USD per m^3	Water tariff for a block of monthly consumption of 15m^3 for the largest city in the country
	PPP-Adjusted Water Tariff for Consumption Block of 15m^3, Largest City	2016 USD per m^3, adjusted for PPP	Water tariff for a block of monthly consumption of 15m^3 for the largest city in the country, adjusted for purchasing power parity (PPP)
	Operating Cost Coverage Ratio	Ratio score	Water utilities Operating Cost Coverage Ratio (OCCR) represents the extent to which a utility covers its basic operating and maintenance costs by its revenues. It is a measure of total annual operational revenues divided by total annual operating costs.
Sanitation/ Wastewater	Wastewater Tariff	2016 USD per m^3	Wastewater collection and treatment tariff for a block of monthly consumption of 15m^3 for the largest city in the country, adjusted for purchasing power parity (PPP)

Electricity Tariffs and Costs

For electricity, data on residential tariffs and operational costs (for a selected number of countries) are extracted from the Regulatory Indicators for Sustainable Energy (RISE) database, which is the most comprehensive World Bank database on energy. [31] Electricity tariffs are recorded for a benchmark subsistence electricity consumption of 30 KWh/a

[31] World Bank Group (2013)

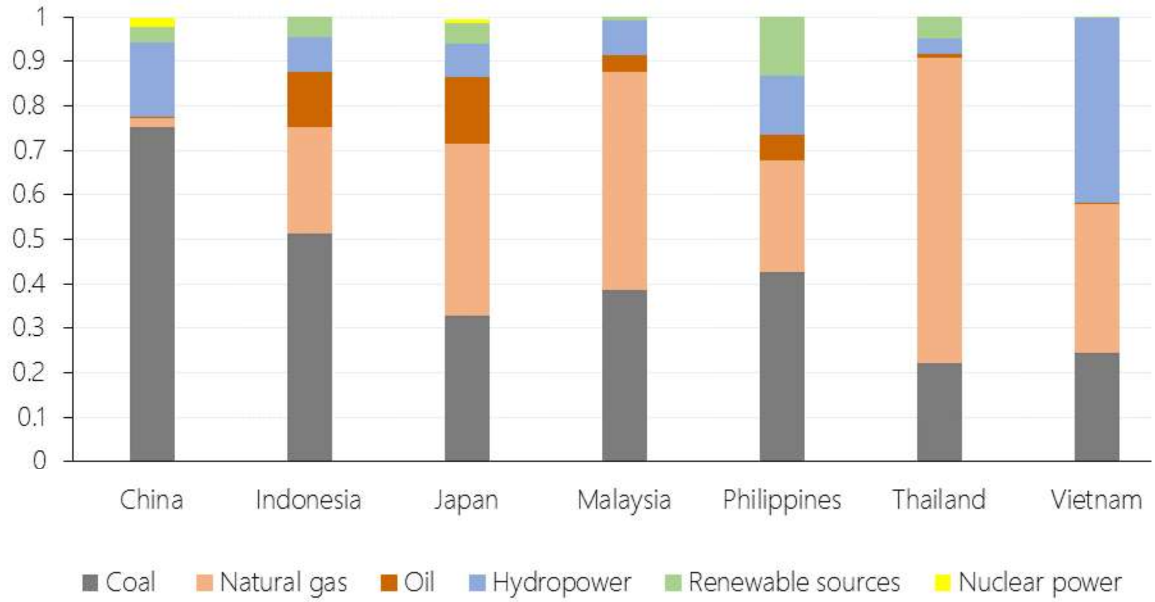
month in 2016 USD. Average unitary operational costs provided by the RISE database are representative of the operational costs for electricity generation in the year 2014, for the largest utility in the largest business city of each country, and they do not include the operational costs of transmission and distribution. For countries whose tariffs and operational costs were not included in the RISE database, country-specific research was carried out to extract relevant data from the publicly available information of the major electricity utility of the country's capital city. The complete list of countries covered by the RISE database and other sources is presented in Annexes I and II for tariffs and operational costs, respectively.

For analysis of cost recovery levels, this report draws on the average retail electricity tariffs for all users (calculated using data from the RISE database as detailed in Annex III) and the 2017 Levelized Costs of Energy (LCOE) as calculated by Bloomberg New Energy Finance (BNEF) and Lazard.[32],[33] The LCOE is internationally recognized as the closest measure of the full cost of producing one unit of energy, and it is defined as the long-term offtake price to achieve a required equity hurdle rate for the project. The LCOE model is based on a pro-forma project finance schedule, which considers the full accounting of the project based on a set of project inputs, including capital expenses, capacity factors, fixed operation and management (O&M) expenses, debt ratio, and cost of equity. BNEF's LCOE data is differentiated by technology and calculated at utility-scale for seven countries: China, Indonesia, Japan, Malaysia, Philippines, Thailand, and Vietnam. For each country, the LCOEs (in 2017 USD/KWh) for each technology are considered to determine a country average cost of producing electricity (per KWh). These technology-specific unit costs are weighted by the share of electricity produced in the overall country electricity mix, as shown as in Figure 5.

The share of renewables has been further adjusted, taking into account the country-specific data on electricity generation by renewables technology from the International Energy Agency (IEA) IEA Energy Atlas.[34] Finally, LCOEs are compared with the average electricity tariff in order to estimate the extent of cost recovery for electricity generation for the six EAP countries where LCOEs were readily available.

[32] For coal, gas and renewables, the LCOE for renewables was calculated as a weighted average of the benchmark LCOEs for the following renewable technologies: wind (onshore and offshore, when available), solar PV, and geothermal; BNEF (2017).
[33] for oil, using the Lazard's LCOE for Diesel Reciprocating Engine; Lazard (2016)
[34] IEA (2013)

Figure 5. Sources of Electricity Production (% of Total)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Development Indicators, World Bank Group (2014)

Water and Sewerage Tariffs and Costs

Data on tariffs, operational costs, and operational cost coverage ratios for water and sanitation were collected separately for water and wastewater (used as a proxy for sanitation). Unfortunately, tariff data is available only for a subset of utilities. Since there are no reliable, up-to-date data sets available that measure average water tariffs at the national level across countries, data are not meaningfully comparable and cannot be extrapolated to represent a country's average rates. It is also important to note that water tariffs do not necessarily give an immediate answer to the relative performance of a utility, as tariff rates are a function of many factors, including production costs (in turn affected by the geography and the cost of inputs), tariff policy, and the efficiency of operations. Taking these limitations into account, this report compares tariffs at the municipal level for the largest cities (by population) for each country for informational purposes.

The main sources of data are the International Benchmarking Network (IBNET) database, supported by the World Bank since 1997, and Global Water Intelligence (GWI), a water market intelligence company. Water supply tariff data is available at the municipal level, with the latest data available from Global Water Intelligence (2016). [35] For EAP countries whose data were not available in the GWI and IBNET databases, country-specific research was conducted to extract the relevant data from publicly available country reports or websites

[35] GWI (2016)

of major water utility companies. Water tariff and cost data also face limitations, due to the age and representativeness of some data. These are detailed in the notes sections of figures presented in Chapter 4.

Water supply tariffs for 2016 are reported for the largest cities in EAP countries, for tariff blocks at the subsistence level of 15m^3 per month, in 2016 USD. Detailed description of data sources in EAP countries in the GWI and IBNET database, dates of data collection, and names and cities of each utility can be found in Annex IV.

Data on wastewater tariffs, operating costs of water and wastewater, and operating cost coverage ratios (OCCR) are gathered from the IBNET tariffs database (for wastewater tariffs) and IBNET benchmarking database (for water and wastewater operational costs). Water and wastewater tariff data is presented both in real terms (2016 USD) as well as in purchasing power parity-adjusted values. Details on the sources are included in Annex VII.

The operating cost coverage ratio (OCCR) represents the extent to which a utility covers its basic operating and maintenance costs by its revenues and is a measure of total annual operational revenues divided by total annual operating costs. While this measure does not account for the extent of full cost recovery (which would require consideration of capital expenditures in addition operational costs), it is still a valuable measure of the extent to which operating costs are met by collected revenues.

The figures for the operating cost coverage ratio are the result of a weighted average of the OCCRs of all water utilities covered by the IBNET Benchmarking Database for the country of analysis (as listed in Annex VI) and can be considered representative of the majority of the urban population in each country. Since the IBNET figures are based on self-reported data from water utilities, the data presented for each country represents different numbers of utilities and population coverage for each country. Most countries have data representing at least 60% of the total urban population in the country, suggesting a relatively high level of representativeness for urban services. Those that do not are noted in results. Detailed description of data sources from the IBNET database, dates of data collection, number of participating utilities, and urban population coverage are found in Annex II.

Private Participation in Infrastructure Data

The primary data source used for the analysis presented in this section of the report is the Private Participation in Infrastructure (PPI) Database, a joint product of the World Bank's Public-Private Partnership Group and the Public-Private Infrastructure Advisory Facility (PPIAF). Its purpose is to identify and disseminate information on private participation in infrastructure projects in low- and middle-income countries.

The PPI Database highlights the contractual forms applied, the sources and destination of investment flows, and information on primary investors. The dataset currently provides information on more than 8,000 infrastructure projects dating from 1984 to the first half of 2016, and contains over 50 fields per project record, including country, financial closure year, infrastructure services provided, type of private participation, technology, capacity, project location, contract duration, private sponsors, debt providers, and development bank support.

PPI information across the electricity, transport, and water and sewerage sectors is studied over a 27-year period from 1990-2016, for almost 1900 projects in EAP. Within EAP, the PPI database has information recorded for seven countries in water and sewerage (China, Indonesia, Malaysia, Papua New Guinea, Philippines, Thailand, Vietnam), 12 countries in energy (China, Indonesia, Lao, Malaysia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Thailand, Tonga, Vanuatu and Vietnam), and nine countries in the transport sector (Cambodia, China, Indonesia, Lao, Malaysia, Myanmar, Philippines, Thailand and Vietnam).

Although divestitures are recorded in the PPI database, they are not included in this study, as the divestiture amounts recorded in the database denote the sale value of an asset (and transition to non-public ownership) and do not necessarily reflect any investment commitment for development of new assets or rehabilitation of existing assets. Merchant projects (wherein a sponsor builds a new facility in a liberalized market with no government guarantees) are also excluded from this study.[36]

The PPI Database should not be seen as a fully comprehensive resource on PPI because some projects — particularly those involving local and small-scale operators — tend to be omitted since they are usually not reported by major news sources, databases, government websites, and other sources used to populate the database.

The indicators described above are summarized in Table 3.

[36] In the EAP region, merchant transactions were recorded mostly for the Information and Communications Technology (ICT) sector, with only six merchant projects with limited information across Energy, Transport, Water and Sewerage sectors in the 27-year period of the study.

Summary of Indicators and Data Sources

Table 3. Summary of Indicators and Data Sources

Pillar	Sector	Indicator	Unit	Definition	Source
ACCESS	Electricity	Access to Electricity (Total, Rural, Urban)	% Total population	Percentage of population (total, rural, urban) with access to household electricity service (as share of total, rural, urban)	World Bank Development Indicators (2014)
	Water Supply	Access to Piped Water on Premise (Total, Rural, Urban)	% Total population	Percentage of population (total, rural, urban) with access to an improved water source via piped water on premise (as share of total, rural, urban)	WHO-UNICEF Joint Monitoring Programme (2015)
	Sanitation	Access to Sewerage Connection on Premise (Total, Rural, Urban)	% Total population	Percentage of population (total, rural, urban) with access to piped household sewer connection (as share of total, rural, urban)	World Bank / WHO-UNICEF Joint Monitoring Programme (2015)
	Roads	Rural Access Index (RAI)	%	Percentage of rural population with access (within 2km) to non-seasonal paved roads	Authors' calculations, based on World Bank RAI methodology (2017)
QUALITY	Electricity	Quality of Electricity Supply	Score (1-7, best)		World Economic Forum (2017), Global Competitiveness Report
		Electric power transmission and distribution losses	% Total output	Electric power transmission and distribution losses as a % of output to the transmission and distribution system	World Bank (2014), World Development Indicators
		System Average Interruption Frequency Index (SAIFI)	Days per year	Average frequency (occurrence) of annual interruptions to electricity services	World Bank (2015), Doing Business database
	Water Supply	Non-Revenue Water	%	Percentage of water that enters the piped distribution for which revenues are not collected due to leakages, theft, non-metering, or non-collection	IBNET Benchmarking database (various years, see Annex IX)
		Quality of Water Supplied (QWS): Samples Passing Residual Chlorine Test	%	Percentage of samples passing the residual chlorine test, which indicates whether sufficient chlorine remains in the water supply after distribution to prevent microbial contamination during transport	
	Sanitation	Diarrheal Disability-Adjusted Life Years (DALYs)	DALYs per 100,000 persons	DALYs incorporates both, years of life lost and years lost due to disability caused by diarrhea. One DALY can be thought of as one lost year of "healthy" life.	WHO (2015), Global Health Estimates
		Wastewater Treatment Level	%	Percentage of collected wastewater that is treated (2014 data)	Yale University (2016) Environmental Performance Index

	Roads	Quality of Road Infrastructure (1-7, best)	Score	Perceptions of overall road quality	World Economic Forum (2017), Global Competitiveness Report
		Length and Condition of Asian Highway Network Roads	km	Lengths of Asian Highway Network designated highways classified as good, fair, poor, or unknown	UNESCAP Asian Highway Database (2015)
		Ratio of Paved Roads to Total Road Length	%	Ratio of paved road to total road length (%)	ASEAN-Japan Transport Partnership (2012)
TARIFFS AND COSTS	Electricity	Electricity Tariff for Low Consumption Band	2016 USD per kWh	Electricity tariff for retail residential users (USD/KWh) for tariff block for 30KWh monthly consumption, in 2016 USD	World Bank Group (2013) RISE database. Different sources for countries with missing data (complete list in Annex I)
		PPP-Adjusted Electricity Tariff for Low Consumption Band	2016 USD per kWh, adjusted for PPP	Electricity tariff for retail residential users (USD/KWh) for tariff block 30KWh monthly consumption in 2016 USD adjusted for purchasing power parity (PPP)	
		Average Electricity Tariff	2016 USD per kWh	The average retail electricity tariff across all tariff blocks and consumer types, calculated as total collected revenues divided by total kWh sold	World Bank Group (2013) RISE database
		Levelized Cost of Energy	2016 USD per kWh	Unit cost of 1kWh production, calculated using data from the energy mix for each country (by source for electricity production) and the unitary costs of electricity production by each input	Author calculations, based on data from Bloomberg (2017) and Lazard (2016)
	Water	Water Tariff for Consumption Block of 15m^3, Largest City	2016 USD per m^3	Water tariff for a block of monthly consumption of 15m^3 for the largest city in the country	Global Water Intelligence (GWI) database (2016) for countries where available; different sources for other countries (see Annex IV)
		PPP-Adjusted Water Tariff for Consumption Block of 15m^3, Largest City	2016 USD per m^3, adjusted for PPP	Water tariff for a block of monthly consumption of 15m^3 for the largest city in the country, adjusted for purchasing power parity (PPP)	
		Operating Cost Coverage Ratio (OCCR)	Ratio score	OCCR represents the extent to which a utility covers its basic operating and maintenance costs by its revenues. It is a measure of total annual operational revenues divided by total annual operating costs.	IBNET Benchmarking database, various years (see Annex VI)
	Sanitation / Wastewater	Wastewater Tariff	2016 USD per m^3	Wastewater collection and treatment tariff for a block of monthly consumption of 15m^3 for the largest city in the country, adjusted for purchasing power parity (PPP)	IBNET Benchmarking database, various years (see Annex VII)

Chapter 3 Access to Infrastructure

Access to economic infrastructure services, including roads, electricity service, and water supply and sanitation promotes human development, improves quality of life, supports enterprises, and fosters increased economic productivity. Moreover, the extension of networked services can directly help alleviate poverty via the creation of new jobs and provision of access to social infrastructure such as education and health services.

The fullest assessment of access should be based on broader developmental goals of delivering clean water, efficient and affordable energy, effective sanitation services, and safe and efficient transport, which may include a variety of technologies and options depending on local conditions. Specific goals and objectives may also vary across regions and countries. More in-depth sector and localized studies should take nationally-defined developmental objectives as the starting point for assessing infrastructure contributions to reaching those particular policy goals. In order to capture the comparative status of physical economic infrastructure in EAP under current data limitations, however, this study focuses more narrowly on access to gridded networks such as electricity services and urban piped water supply.

While access to electricity services is good in much of EAP, some regions still have low rates of electrification, particularly in Cambodia, Myanmar, and many Pacific Island countries. Access to improved piped household water and sanitation is generally lower than access to electricity and exhibits huge disparities between the urban and rural populations.

The urban-rural divide is in part due to the nature of networked services, whose large sunk costs must often be spread over a dense and sufficiently large population in order to make economic sense. In rural areas that lack economies of scale, household connection to a gridded water supply and sewerage system may not be an efficient mode of service provision. As such, results must be viewed with consideration of the concentration and size of the population. In small countries with high population concentrations around one or a few urban centers, extending infrastructure services could be more achievable than extending electricity to dispersed and remote rural populations.

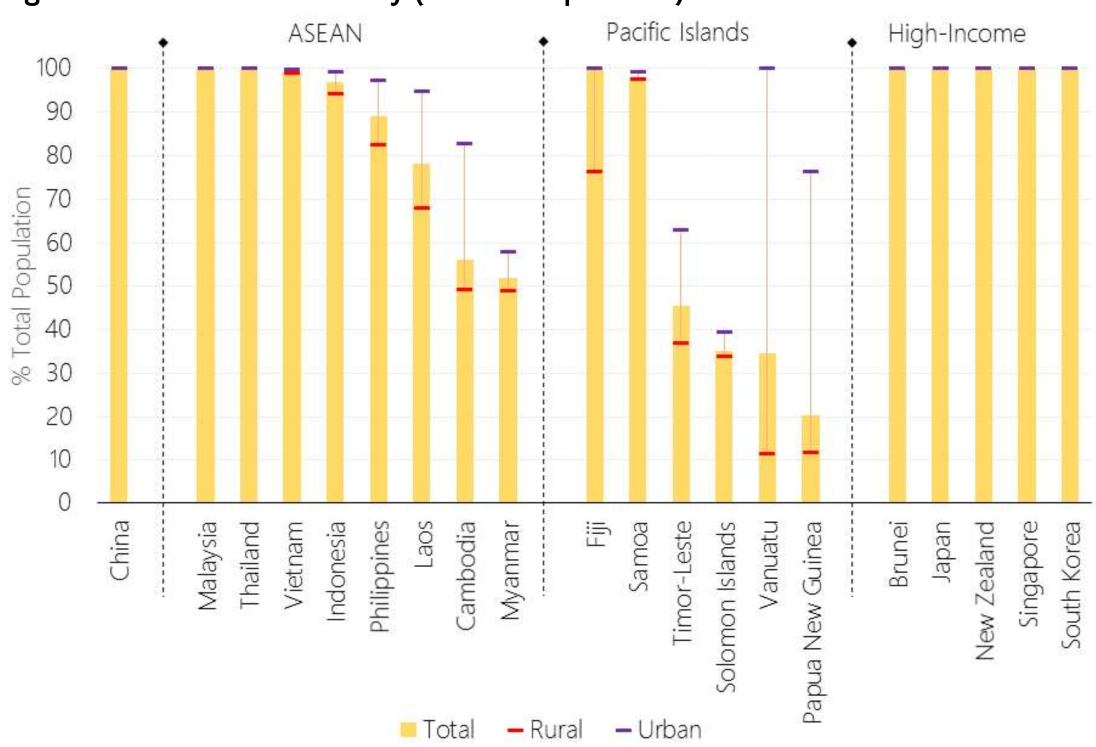
This chapter analyzes the levels of access in EAP to electricity service, piped water supply, sewerage, and rural roads.

Access to Electricity

In EAP, electricity access is relatively high, covering 96.5% of the population overall.[37] Nevertheless, about 60 million people in the study area still lack access to electricity. Some countries in ASEAN – Cambodia and Myanmar, in particular – have coverage rates of less than 60%, and well under half of the populations in many Pacific Island states including Timor-Leste, Solomon Islands, Vanuatu, and Papua New Guinea have electricity access.

Patterns of access are also slightly different between urban and rural populations. Overall, EAP's urban population enjoys high urban electricity service coverage at a rate of 99.5%, and rural access stands at 94.9%. Most ASEAN countries have full or near-full coverage of electricity services in rural areas as well (see Figure 6). Only Philippines, Laos, Cambodia, and Myanmar have lower overall coverage rates of 89%, 78%, 56%, and 52%, respectively. The ADB actually estimates lower electrification rates in Cambodia and Myanmar of 30-40%,[38] whereas rural areas are often not connected at all.[39]

Figure 6. Access to Electricity (% Total Population)



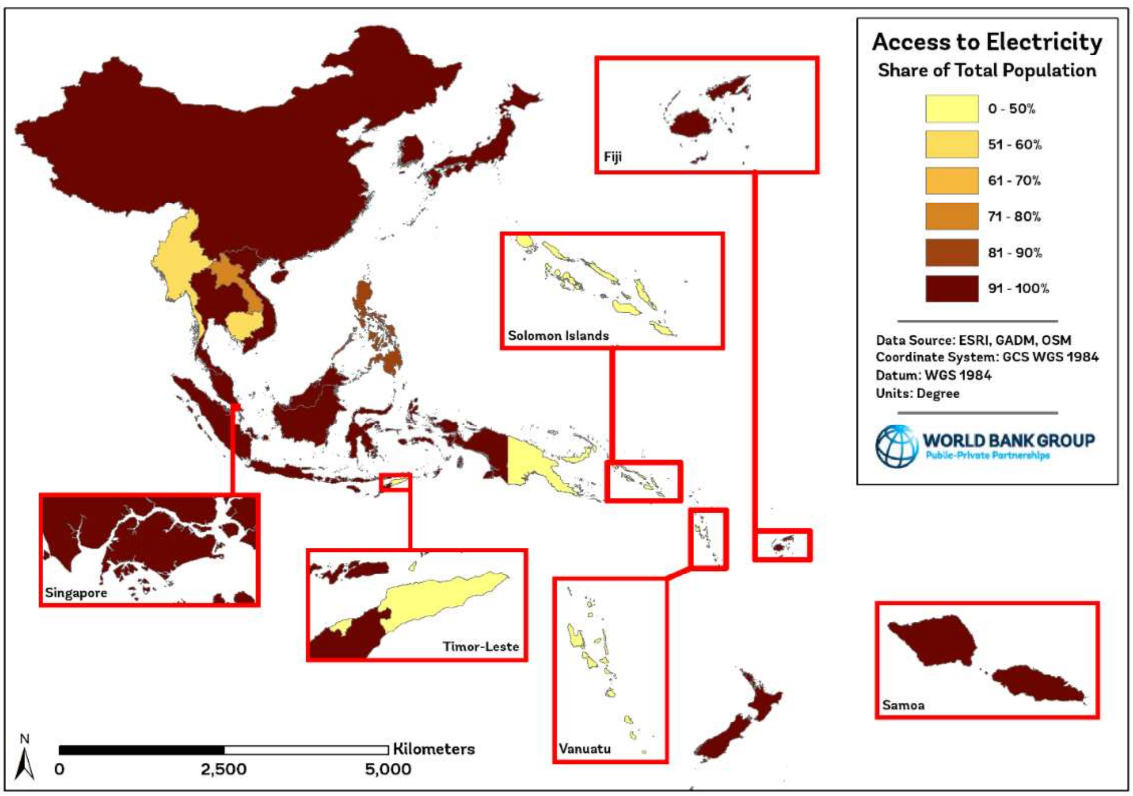
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Development Indicators, World Bank Group (2014)

[37] World Bank Group (2017)
[38] ADB (2014)
[39] World Bank Group (2015)

For the Pacific Island countries, electricity access is far more differentiated and significantly lower, with only Fiji and Samoa attaining near-total coverage. In other Pacific Island countries, less than half of the population has access to electricity. Timor-Leste has only 45% coverage, and lower still are coverage rates in Solomon Islands (35%), Vanuatu (34%), and Papua New Guinea (20%).

Rural electrification is particularly lagging behind in the Pacific Islands. While Vanuatu's urban areas have accessibility rates of 100%, for example, rural coverage is only 11.5%. In Papua New Guinea, urban areas are fairly well connected, but rural coverage is only at 11.9%. Low electrification is undoubtedly affected by the archipelagic geography and challenges to establish a quality power grid.

Figure 7. Map of Electricity Service Coverage, ASEAN and Benchmark Countries



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), rendering based on World Development Indicator data, World Bank Group (2014)

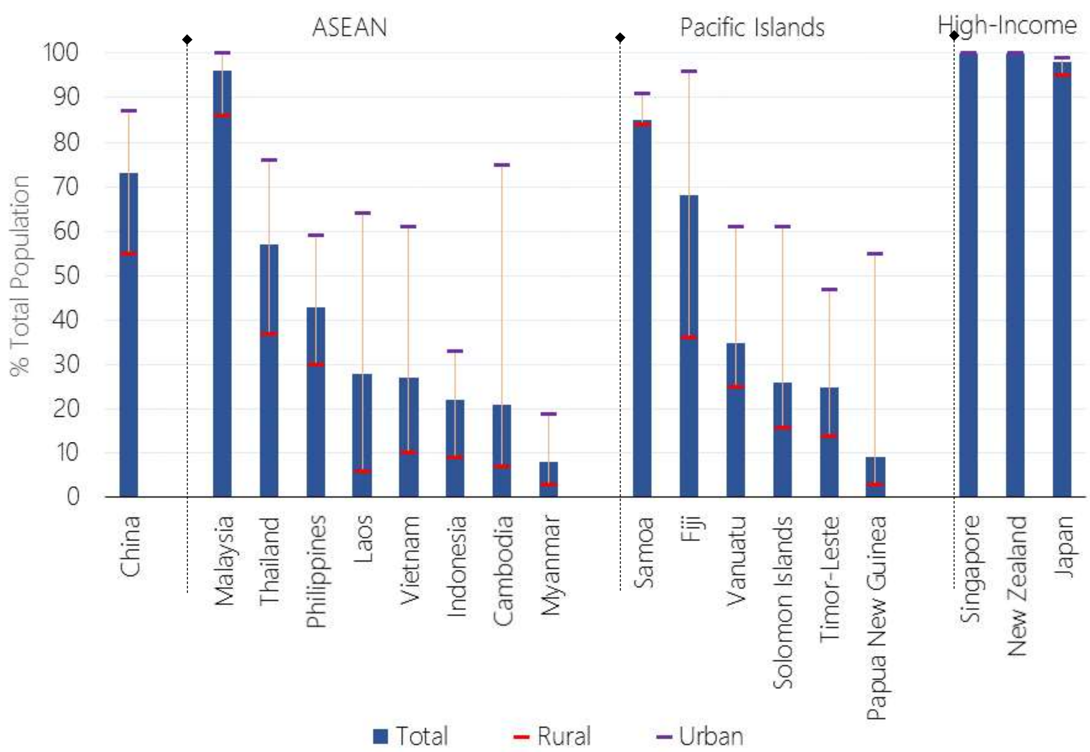
Access to Water Supply

Over 93.7% of EAP's population has access to an improved drinking water source – i.e., service to sources including piped household water, public stands or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection. However, access levels to piped household connections are much lower.[40] Household access to piped water supply – the subset of above services that relates most directly to public infrastructure – is significantly lower in many EAP countries, even in urban areas (see Figure 8).

Among the countries assessed in this study, access to piped household water supply is the highest in Singapore (100%) and Malaysia (96%). The next highest countries in ASEAN have significantly lower overall coverage rates, with Thailand's service coverage slightly over 50% and the Philippines with coverage of 43%. Other ASEAN countries show values between 20% and 30%, whereas Myanmar has low household piped water access of only 8%. Unfortunately, there is no data for Brunei, but considering the relatively small size and wealth, full or near-full coverage is likely.

For the Pacific Islands group, Samoa is the most developed, with more than 80% access to a household piped water source, followed by Fiji with more than 70% and urban area coverage of almost 100%. The other island nations lag behind significantly.

Figure 8. Access to Piped Water on Premise (% Total Population)

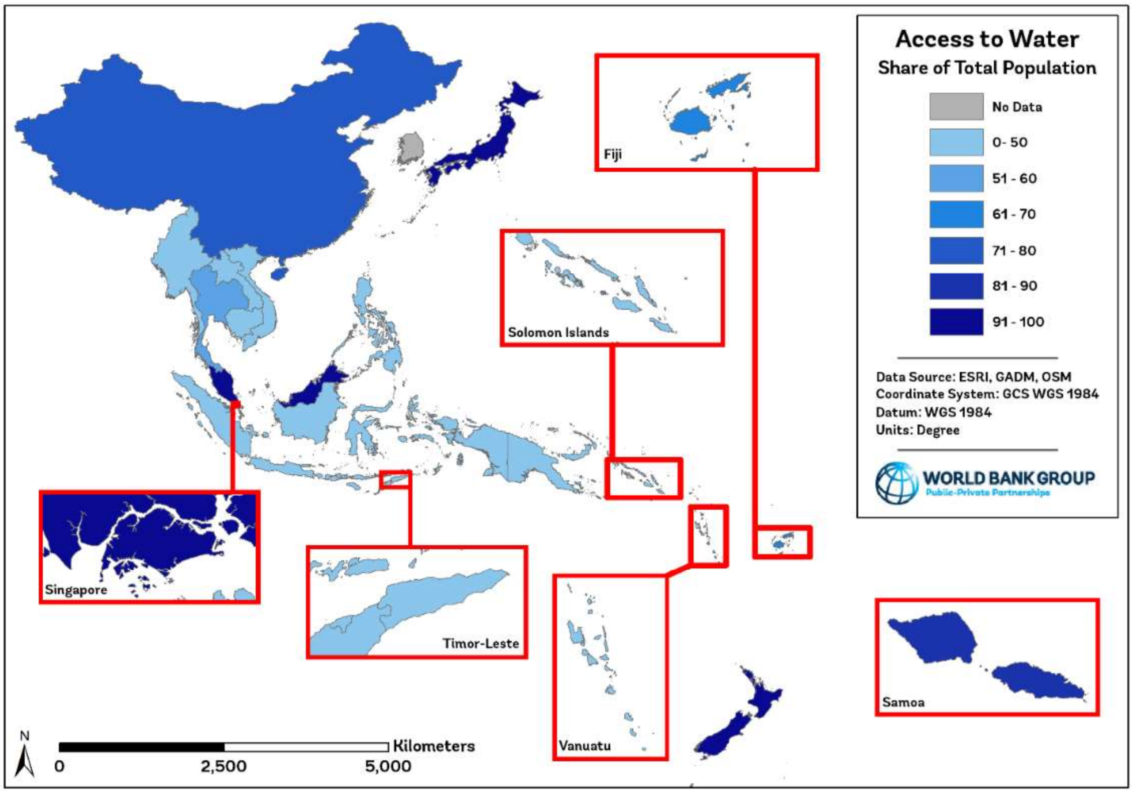


Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from WHO/UNICEF (2015)

40 WHO/UNICEF (2015)

The networked nature of piped water supply and the economies of scale required to capture efficiencies via this mode of supply make assessment more meaningful at the urban level. Indeed, Figure 8 shows that the rural coverage is significantly lower than urban coverage. In some cases, this is because services are underprovided and underdeveloped in general. But in other cases, rural provision of improved water supply is more efficiently attained via non-piped means. As such, this report pays particular attention to urban supply.

Figure 9. Map of Piped Water Supply Coverage, ASEAN and Benchmark Countries



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), rendering based on WHO/UNICEF data (2015)

Outside of Singapore and Malaysia, urban piped access is low in ASEAN, particularly in Philippines (59%), Indonesia (33%), and Myanmar (19%). For instance, in the Philippines, one would expect connectivity to be much higher in urban centers, but huge developmental disparities between larger metropolitan areas such as Manila, Cebu, Davao, and Bacolod and the smaller urban areas offers some explanation for low overall urban coverage.

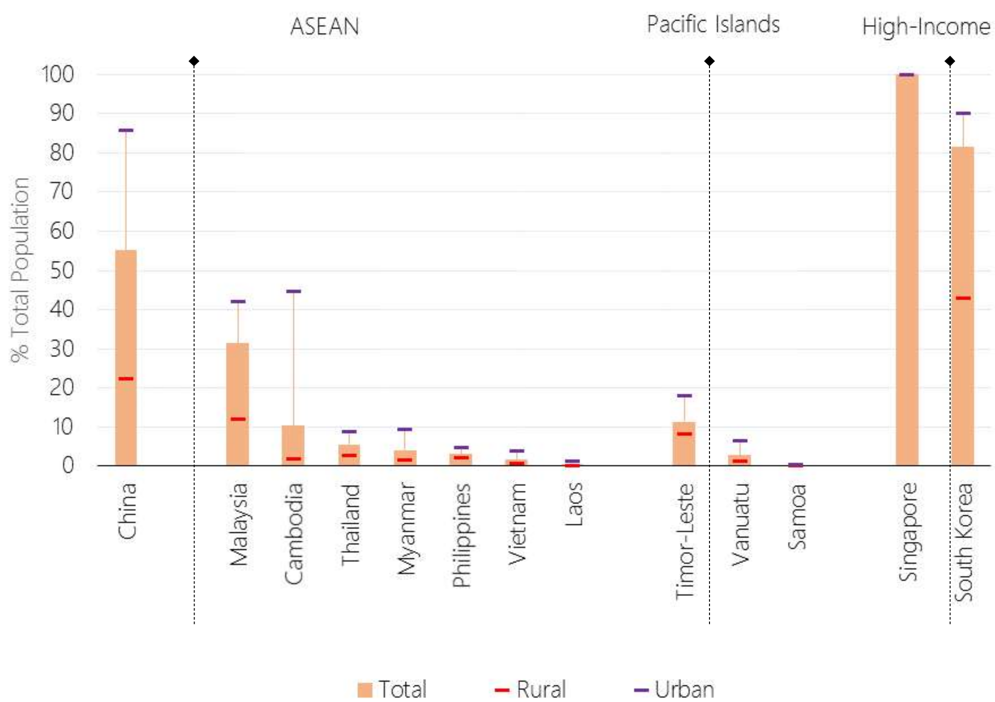
Surprisingly, for a middle-income economy, Indonesia has very low access to piped water supply. Even its urban areas are much less connected than those of the Philippines, Vietnam, and even Cambodia. This is the case, for example, in Jakarta, where residential households rely heavily on wells instead on the piped water system, due to issues of reliability and a historic reliance on privately-owned wells. Moreover, progress has been hindered by low political prioritization of water supply and a decentralized planning system, wherein several ministries have overlapping mandates for planning and implementation in the sector.

In Papua New Guinea and Timor-Leste, urban coverage is measured at 55% and 47%, respectively. While China's total population has only 73% coverage, 87% of its urban population has piped household water supply.

Access to Sanitation

According to the Millennium Development Goals (MDG), access to improved sanitation equates to access to a sanitation facility that hygienically separates human waste from human contact by, for example, flush toilets, piped sewer systems, septic takes, latrines, or composting toilets. In EAP, coverage remains quite low: only 72% of the ASEAN population, 76% in China, and 58% in the Pacific Islands have access to improved sanitation, as opposed to 100% in regional benchmark countries.[41]

Figure 10. Household Connection to Sewerage (% Total Population)



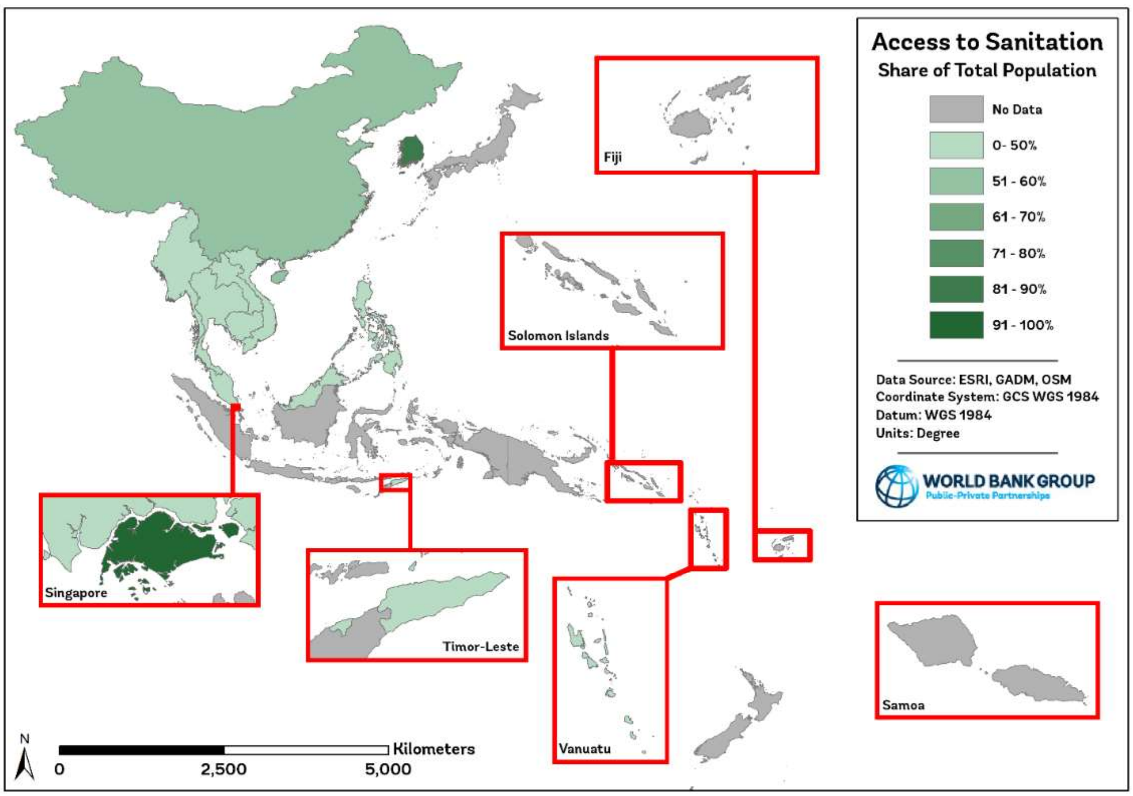
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from UNICEF-WHO (2015)

[41] Calculated from JPM and World Bank population data.

For the purposes of assessing infrastructure status, however, access to sanitation should also be more narrowly considered with respect to access to an on-site piped sewerage connection. While on-site access to a piped water source is relatively low in some EAP countries, access to piped sewerage is considerably worse. Figure 10 shows that, among the selected countries within this study, only the city-state Singapore has 100% coverage of piped sanitation facilities. Within ASEAN, only Malaysia has a considerable level of access to household piped sewerage connection, but this is still only slightly over 30%. For all other countries, coverage percentage values are still single-digit.

Due to the economics of sanitation, sewerage access is also more meaningfully compared in urban areas. In regional benchmark South Korea, access to piped sewerage in rural regions is at only 42.9%, while urban coverage is at 90%.

Figure 11. Household Connection to Sewerage, ASEAN and Benchmark Countries



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), rendering based on WHO/UNICEF data (2015)

While urban coverage is somewhat better, only Singapore (100%) and China (85%) have high levels. These rates are followed by Cambodia (44.8%) and Malaysia (42.4%). In Timor-Leste, urban household connection to sewerage is 18.2%. All other countries for which data is available have urban coverage rates of less than 10%. In Vietnam and Laos, urban piped sewerage access is only at 3.9% and 1.3%. Samoa, while relatively well developed in some other indicators with respect to urban services, has urban access of around 0.5% only.

Access to Rural Transport

The Rural Access Index (RAI) was initially created to support the World Bank Infrastructure Action Plan with a transport-related indicator (see description of methodology in Chapter 2). It identifies priority strategies for poverty reduction by assessing connectivity gaps and investment needs. The concept supporting the RAI is that people without access to roads have neither sufficient access to social services such as health and education, nor access to jobs, apart from their immediate surroundings. Moreover, without access to reliable transport, people must spend a significant amount of time and financial resources to satisfy basic needs.[42]

In practice, the calculation of the RAI is challenging, as it requires detailed road maps, including a distinction between seasonal and non-seasonal roads. This study followed a more conservative approach and estimated, as a proxy to the level of access to rural transport, the percentage of the rural population within a 2km buffer to a paved road. This measure equates to Rural Access to Non-Seasonal Paved Roads (RANPR). In this case, the selection of roads was limited to the class "highway" adopted by the OSM dataset, which includes primary, secondary and tertiary roads as illustrated in the previous section.

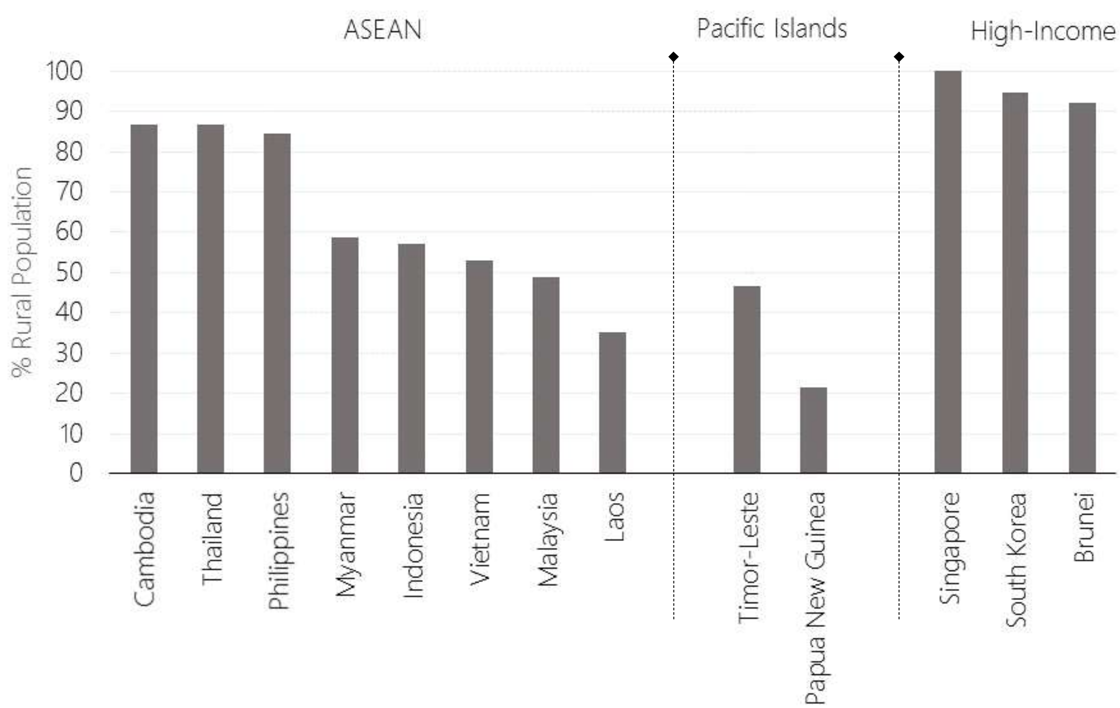
In terms of access to rural roads, the selected countries can be broadly sorted into three categories of access. The highest category contains Brunei for ASEAN and South-Korea for the regional benchmark countries, each with more than 90% rural access. It should be mentioned, however, that Singapore was not considered because it is a city-state with no rural areas. China is also not included due to the huge analytical requirements and time needed to perform geospatial analysis, given the country's size and extensive road network.

The second category includes Cambodia, Thailand, and the Philippines, with RANPRs of more than 80%. The least advanced countries, according to the estimation of rural access, are Myanmar, Indonesia, Vietnam and Malaysia and Laos, with RANPR values between 30 and 60%. Within the Pacific Islands, where road access is lower, only Timor-Leste is on a level comparable level to the ASEAN nations, but at the lowest levels.

[42] Edmonds (1998), Fukubayashi & Kimura (2014), Wong, et al. (2013)

Figure 12 shows that levels of rural access to paved roads are above 80% in most of ASEAN, while levels are lower in Myanmar, Vietnam, Malaysia, and Laos.[43]

Figure 12. Rural Access to Non-Seasonal Paved Roads (% Rural Population)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), estimations based on RAI methodology

Notes: Input to the RANPR methodology includes only paved roads; accordingly, road in the OSM dataset included for estimation was limited to the class "highway".

Interpreting Rural Access

Table 4 compares the estimated Rural Access to Non-Seasonal Paved Roads (RANPR) and the most recent RAI calculations from the World Bank. The differences between the estimated RANPRs and the database calculations are large, except for Cambodia and the Philippines. It is important to keep in mind that the extensiveness of the selected road network is the main defining factor in both the RAI and the RANPR calculations. Since only paved roads from the OSM dataset were selected to calculate the RANPR, it may underestimate the levels of access. This is because part of the rural population may have access to non-paved non-seasonal roads as well.

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[43] Levels in Malaysia are significantly variant between West Malaysia and the less-developed East Malaysian states. This level is also dependent on road classifications taken into consideration (see 'Interpreting Rural Access' discussion below.

It is important, however, to note that mainland countries such as Myanmar, Thailand, Cambodia, Laos, and Vietnam are mostly characterized by a dry winter or monsoon climate, according to the Köppen-Geiger climate classification (Aw and Am classification, respectively). That means that they have a pronounced rainfall seasonality, with dry and wet seasons. During the wet season, the regions experience most of their annual rainfall and, depending on local drainage conditions, non-paved roads may be muddy or easily submerged, which affects the accessibility of the roads.

A few additional points are important with respect to the World Bank RAI calculations:

1. The RAI estimations are from the late 1990s and early 2000s. Many countries have seen tremendous economic growth and infrastructure development during that time. Thus, increased rural access would be expected.
2. The RAI is not subject to a standardized calculation method. It is based on various data sources, including household surveys in some cases, and road maps and spatial models in others.
3. Some values for the RAI are questionable. For instance, Papua New Guinea, one of the least developed countries in the region, has a RAI of 68% compared to 33% of Thailand.

Table 4. Comparison of RAI-based Analysis and Most Recent RAI by the World Bank

Country	Group	RANPR (this study)	RAI WB	RAI Year
Brunei	ASEAN	92.17	81.00*	1991
Cambodia	ASEAN	86.74	81.00**	2003
Thailand	ASEAN	86.73	33.00*	2000
Philippines	ASEAN	84.45	80.00*	2003
Myanmar	ASEAN	58.79	23.00*	1999
Indonesia	ASEAN	57.20	94.00**	2003
Vietnam	ASEAN	52.91	84.00**	2004
Malaysia	ASEAN	48.94	82.00*	2001
Laos	ASEAN	35.28	64.00**	2002
Timor-Leste	Pacific Islands	46.75	90.00**	2001
Papua New Guinea	Pacific Islands	21.36	68.00**	1996
South Korea	Benchmark	94.82	NA	

*based on a not specified model
**based on survey

General Remarks

Overall, access to infrastructure in EAP region is highly fragmented and broadly divided into three groups: highly advanced and well-equipped countries, such as Singapore and South-Korea; a semi-advanced group with middle-income countries such as China, Malaysia and Thailand; and a group exhibiting lower access levels, with less developed countries such as Myanmar and most of the Pacific Islands, excluding Fiji and Samoa.

Singapore is by far the most developed economy in terms of access to infrastructure services, with 100% access to electricity, piped water and sanitation. This is not surprising, since Singapore is a highly-advanced economy and also a city-state, which eliminates the urban-rural divide observed in other ASEAN and Island nations. Besides Myanmar, the Pacific Island nations are among the least developed countries, though Samoa and Fiji have relatively good access levels, particularly in urban areas.

Sector-wise, electricity is the most advanced infrastructure service across all countries. While the emerging economies of ASEAN and the Pacific Island nations are lagging in coverage (particularly Papua New Guinea), access to electricity is still much better than access to quality water and sanitation.

For water and sewerage, extensive access to piped household connections is largely limited to regional benchmark countries and Singapore, followed by Malaysia. Second-tier countries with respect to household piped water supply are Thailand (57%), Philippines (43%) and China (73%), as well as Samoa and Fiji, whose urban areas have piped coverage of over 90%. The third tier contains low-income ASEAN countries and the other Pacific Island nations (showing values between 20 and 30%), with Myanmar at the low-end with only 8% piped household water. Surprisingly for a middle-income economy, Indonesia also has very low access to piped water supply (33%), partly attributable to its dispersed geography.

Access to sanitation services, and particularly household sewerage is by far lower that access to electricity or water supply. In fact, only the high-income economies Singapore, South-Korea, and Japan (likely also New Zealand) enjoy 100% access to piped sanitation systems. Coverage levels – even in urban areas – are far lagging elsewhere in the region.

Chapter 4 Quality of Infrastructure

Of equal importance to the level of access to infrastructure are the quality and reliability of the services provided. Simply put, access offers only a partial understanding of the contribution of infrastructure services to the functionality of a society and the positive effects on productivity, quality of life, human development, and economic participation. Assessing the standards of service is equally important to understanding the actual benefits accrued to a country and its people.

Physical infrastructure assets, whose lifespans often extend over decades, require regular maintenance and timely upgrading to maintain service standards, avoid interruptions and breakdowns, and assure efficient delivery. In the case of road transport, for example, the quality of roads has a significant impact on road safety, travel time, and vehicle maintenance costs.

In many developing and transitioning economies, the expansion of infrastructure services does not necessarily equate to provision of reliable and safe infrastructure. In the case of water supply, for example, households may be connected to a water system with frequent outages and poor water quality. Similarly, in the case of road transport, road density may be high but surface quality poor.

This chapter examines the quality aspects of infrastructure services in EAP countries in terms of electricity provision, water supply, sanitation, and road transportation. To reiterate the discussion in Chapter 2, country-level quality indicators fall short of capturing within-country heterogeneity. Further, publicly available data on service quality issues is largely focused on urban areas. Therefore, while the indicators used in this chapter reflect the latest available information on the overall patterns of selected aspects of quality in the region, they are not accurate measures of the entire within-country situation and local disparities.

Aspects of quality reported herein attend to both the state of infrastructure assets and the quality of the outputs the systems deliver (e.g., in the case of water supply) that depend on asset condition and management. This study attends to facets of quality including reliability, consistent functionality, robustness, and operational efficiency. While matters of efficiency (for example, non-revenue water and electricity distribution losses) do not necessarily affect the quality of the outputs of service, these inefficiencies are often caused by low-quality or deteriorating networks, which, in turn, affect the overall quality of supply.

It is important to note that while this study does not cover some other important aspects of quality, they should not be disregarded. In particular, the impacts of infrastructure on measures of environmental quality such as CO_2 emissions, pollution levels, and water resource quality, as well as the resilience of infrastructure to natural disasters and shocks are critical to the sustainable development agenda. Resilience as a measure of quality requires dealing with both the resistance of infrastructure to various hazards and the redundancy of networks. This is an issue of particular importance to areas that are most vulnerable to the effects of climate change (e.g., low-lying coral islands of the Pacific). While data deficiencies currently limit the ability to measure environmental impacts or the resilience of infrastructure across sectors and countries, these are key areas of future study.

Quality of Electricity Supply

Access to reliable energy is seen as fundamental for economic development, as it enhances productivity from the household to the industrial level. Recent research has corroborated that significant welfare and economic benefits are related to access to higher quality or reliable electricity. This substantiates the need to improve the quality of existing infrastructure in addition to building new assets to extend access.[44]

The World Economic Forum *Global Competitiveness Report* collects survey data from business leaders, including perceptions of the quality of electricity supply, with 7 being the best score assigned to the indicator and 1 the worst. According to 2016-17 data, the perceptions of the quality of the service are highest for Singapore (6.8), Malaysia (5.8), Brunei (5.3), China (5.3), and Thailand (5.1) in EAP. In contrast, Cambodia (3.3) was ranked last. No perceptions data is available for the Pacific Islands states.

In this report, quality of electricity services is directly measured by two indicators that capture efficiency of the transmission and distribution networks within a country and the frequency of electricity service interruptions affecting electricity customers in the country.

Electric Power Transmission and Distribution Losses

The first indicator captures the condition of electricity transmission and distribution systems. Electric power transmission and distribution (T&D) losses are technical losses that are unobserved by households, but are nevertheless indicative of operational inefficiencies associated with lost electricity. T&D losses can be attributed to both technical and non-technical reasons. While technical losses are related to the dissipation of energy in conductors and equipment, non-technical losses are caused by pilferage and meter-related issues.[45]

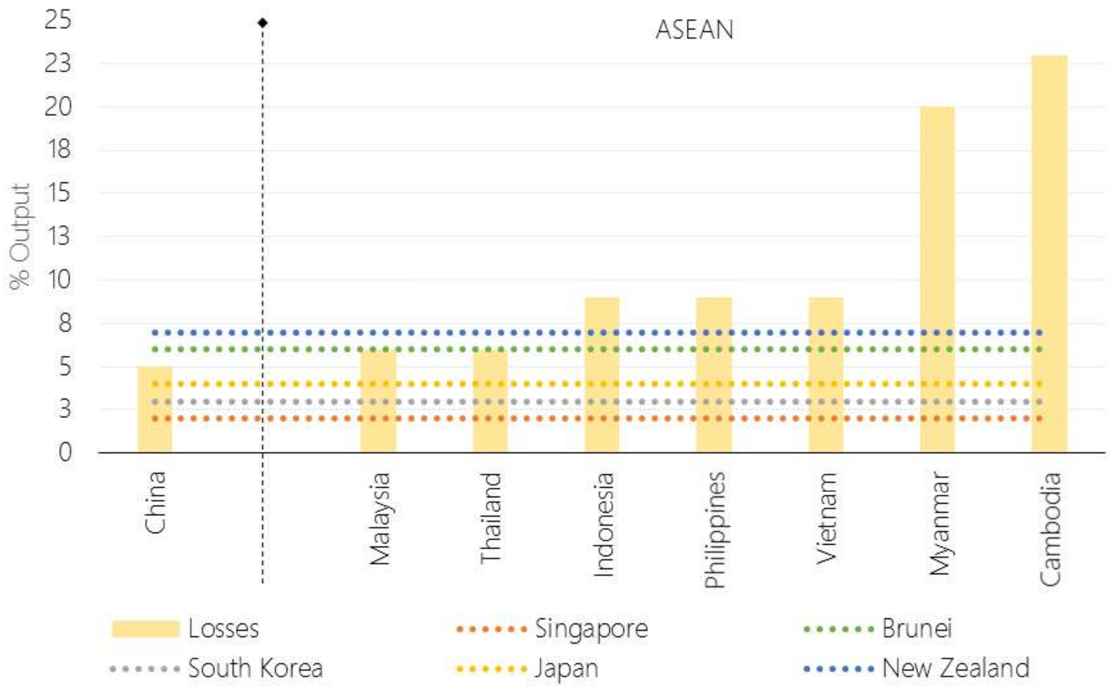
Losses in Myanmar and Cambodia are high, exceeding 20%. Transmission and distribution losses in Myanmar are high because distribution structures, particularly the majority of existing 6.6 kV lines, are largely outdated (built more than 50 years ago) and insufficient for present-day power loads. Many service connections are twisted or in otherwise poor condition, which leads to high resistance connections, high losses, and ultimately, burnout

[44] Alcott et al. (2016); Chakravorty et al. (2013); Gibson and Olivia (2009)
[45] Bhalla (2000)

and failure of conductors. In response to this situation, the Government is planning to upgrade several 6.6 kV lines to 11 kV and expand the 33 kV network.[46]

Cambodia's issue is that supply is largely for lower voltages, which requires the use of more network assets and leads to higher levels of system losses.[47] By contrast, efficiency of the power sector in most other countries, including Thailand, Malaysia, Brunei and Singapore, matched the 6% average of OECD countries.[48] Indonesia, Philippines and Vietnam have slightly higher losses at 9%.

Figure 13. Electric Power Transmission and Distribution Losses (% Output)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank World Development Indicators (2014)

System Average Interruption Frequency

The second indicator captures reliability of electricity services. System Average Interruption Frequency Index (SAIFI) measures the average number of interruptions affecting electricity customers in each country, measured over a year. The data has been taken from the World

[46] Nam et al (2015)
[47] Cambodia Chamber of Commerce (2015)
[48] ADB (2017)

Bank 2016 *Doing Business* report which, in turn, sources information from the national regulators for the largest business city of each economy.[49]

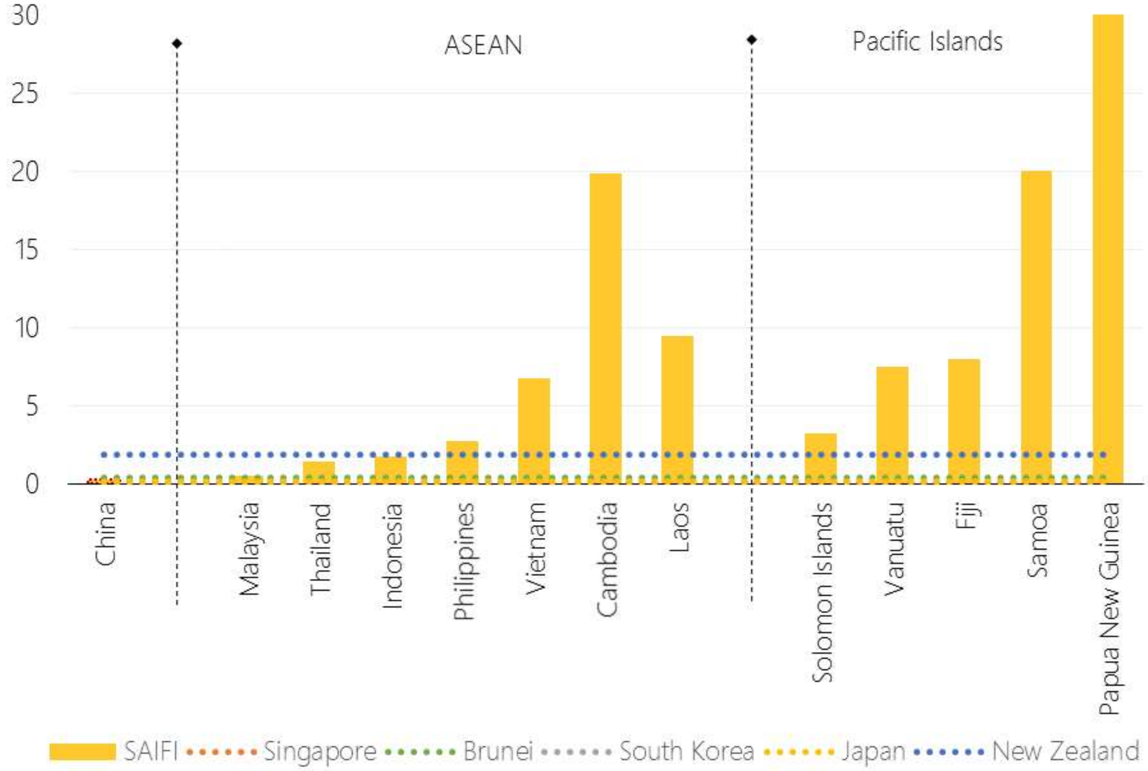
Figure 14 shows that Papua New Guinea has the most frequent power outages, with an average of 134 per year, far exceeding all other countries in the region. The outage rate is excessively high due to a strategy of planned outages scheduled by the national electricity provider, PNG Power, for the purpose of network upgrading and maintenance to increase capacity. Historically insufficient generation, transmission, and distribution capacity is the result of low investment in the electricity subsector. Although installed generation in the private sector has been rising, a substantial part is used to supply power in the mining sector.[50]

Samoa also has frequent power outages that amount to, on average, about 25 hours of electricity service interruption per customer per year. In comparison, other Pacific Islands such as Fiji and Vanuatu experience significantly fewer outages.

In ASEAN, most countries experience outages of approximately one hour each per quarter-year, with Singapore having almost no power interruptions at all. Cambodia has the worst figures in ASEAN, with an average of 20 interruptions in the year, followed by Vietnam and Laos. In Laos, interruptions are less frequent than in Cambodia, but of longer duration. In Laos, the average total duration of outages (averaged for outages recorded over a year) is approximately 50 hours as opposed to 25 hours in Cambodia. While there is no data for Myanmar in the *Doing Business* report, electricity shortages, load-shedding, and blackouts are prevalent across the country. This has been attributed to insufficient and delayed investments in the power sector, an over-reliance on hydropower production that is seasonal in nature, and a sudden surge in electricity demand that the country is unable to meet. All of the benchmark countries perform well, on the other hand. Customers in Singapore, Brunei, South Korea, and Japan experience on average outages equivalent to one hour or less per year.

[49] As noted by the CEER (2016) Report, the SAIDI and SAIFI indicators are not always easily comparable across countries as their aggregation rules may differ (as in Europe). For example, in some countries, all interruptions occurring during a specific defined time period are considered as a single interruption. In the Doing Business Report, information on the interruptions that are included and excluded by the different countries is not available and therefore, could not be verified.
[50] ADB (2012)

Figure 14. System Average Interruption Frequency Index (SAIFI), 2015



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank Group (2015a)

Notes: SAIFI presents the average amount of service interruptions experience by a customer in one year. In this case, the figures above represent the average interruptions within the country (over several utilities) in 2015.

Quality of Water Supply

Data regarding the quality of water services is drawn from the International Benchmarking Network (IBNET) database. IBNET is a large database for water and sanitation utilities performance, gathering data on more than 4,000 water utilities in 130 countries. For the EAP region, the utilities covered by the database account for an average of 63% of the urban service coverage in each of the countries (details on per country coverage of IBNET data are in Annex VI). However, the data for Indonesia, Laos and China reflect a small percentage of the urban population (2%, 3% and 3% respectively), as information was drawn from a limited set of utilities covering the urban population. Further, while most utility data in the database is from the last five years, data for Indonesia (2004), Malaysia (2007), Lao PDR (2008), Singapore (2008) and the Philippines (2009) are from several years before, as indicated in parentheses.

Two indicators have been selected – rates of non-revenue water and the percentage of water samples that meet chlorine testing standards – to capture quality with respect to efficiency of the delivery network and capacity to deliver clean water. Other aspects of the quality of water services include supply continuity and pressure. Continuity of supply is generally high across EAP, with little variance across countries. The only countries (for which data is available) with less than 24-hour water supply are Fiji (20 hours/day), Indonesia (21.67 hours/day), Solomon Islands (22.6 hours/day), Philippines (23.07 hours/day) and Vietnam (23.48 hours/day). There is currently no aggregated information available on average water pressure.

The first indicator of water supply quality in this study, non-revenue water (NRW) provides an indication of the quality of the piping and distribution networks for urban utilities, as it captures the loss of water due to leakages within the system. The second deals with the cleanliness of the water supplied and the capacity of the utility to control the presence of pathogens in the water.

Non-Revenue Water

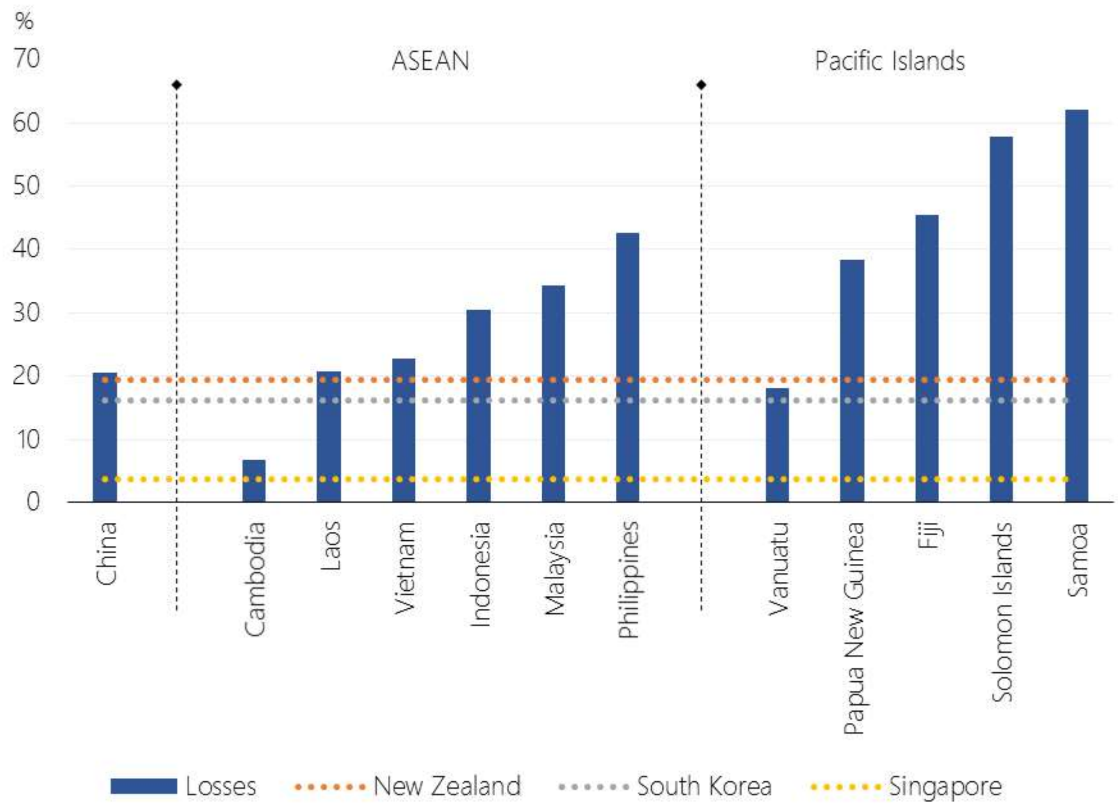
Non-revenue water represents the water that has been produced by the utility but is 'lost' with respect to revenue-generating capacity before it reaches the customer. Similar to T&D losses in electricity, this may be due to technical issues, such as leakages, or through non-technical issues such as theft through illegal connections or unmetered legal connections.

Figure 15 shows that the main utilities in Singapore and Cambodia outperform other countries in the region, with NRW rates of only 3.75% and 6.74%, respectively. The region on the whole has an average of 32% NRW, with the Pacific Islands having the highest rates ranging from 38% in PNG to 62% in Samoa.

While some country's overall NRW rates are not far from those of regional benchmarks, performance at the individual utility level – including for major cities – has been historically poor. Nevertheless, Manila has made great gains reducing NRW, having reduced levels in East Manila (Manila Water) from the range of 63% in the late 1990s to 11% in 2016. Similarly, West Manila (Maynilad) has seen reductions from 60% in 2007, to 30% in 2016. Jakarta is also making gains, having reduced levels in 1997 from 58% by nearly 20 percentage points; nevertheless, NRW is estimated to remain at around 39%. Kuala Lumpur's NRW is around 35%.

High NRW is often linked to low service coverage, as utilities cannot afford the capital expenditures required to extend services. Therefore, in places where water resources are limited, reducing NRW is key to improving service coverage. Moreover, NRW losses can lead to problems of intermittent supply when too much water is lost from the system, leading to a shortfall in capacity to meet demand.

Figure 15. Non-Revenue Water (%)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET Benchmarking database (various years, see Annex IX)

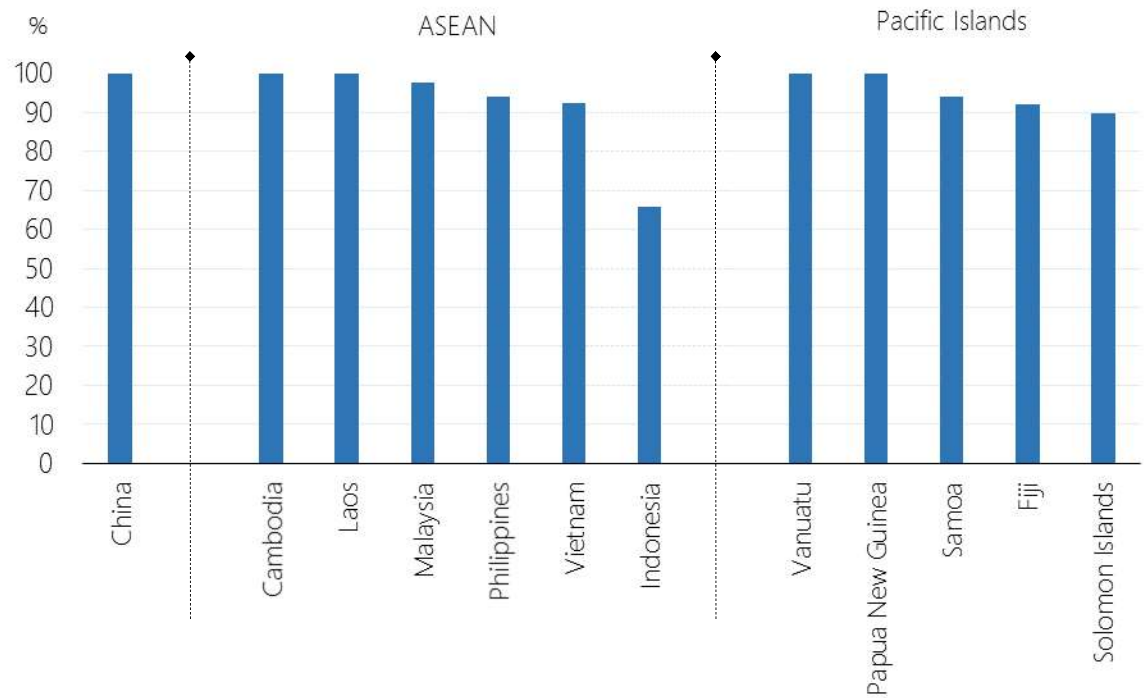
Notes: Non-revenue water is the percentage of water for which revenues are not collected, either due to losses or non-collection / metering.

Information for Indonesia (2004), Malaysia (2007), Laos (2008), and Singapore (2008) is outdated. Moreover, the data for Indonesia, Laos, and China reflect a small percentage of the urban population (2%, 3% and 3% respectively). However, 2012 data for Indonesia from Coordinating Agency for the Development of Water Supply (BPPSPAM) indicates NRW levels remain at an average of 33.1% for the country, with Jakarta having losses of 42.3%.

Tap Water Quality

The second indicator of water supply quality measures the quality of the piped water supplied as the percentage of samples passing residual chlorine test baseline standards. Chlorine residual is the low level of chlorine that acts as a disinfectant for supply and remains in the water after it is first applied. It safeguards the water against future microbial contamination during conveyance through pipelines to households. The presence of free chlorine residual in piped water at the tap indicates that the water is likely to be free of disease-causing organisms, and, therefore, potable.

Figure 16. Samples Passing Residual Chlorine Test (%)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET (various years, see Annex IX)

Amongst EAP countries with available data, Indonesia exhibits the most concerning results, as water samples passed the test only 65% of the time. As mentioned, however, IBNET data on Indonesia is both dated and represents only a small portion of the country's urban population. Three ASEAN countries (Cambodia, Laos, and Singapore) have 100% pass rates for samples tested (Laos' data is limitedly representative at the national level). China and PNG are also near 100%, whereas all others range between 89.72% (Solomon Islands) to 97.56% (Malaysia).

Wastewater and Sanitation

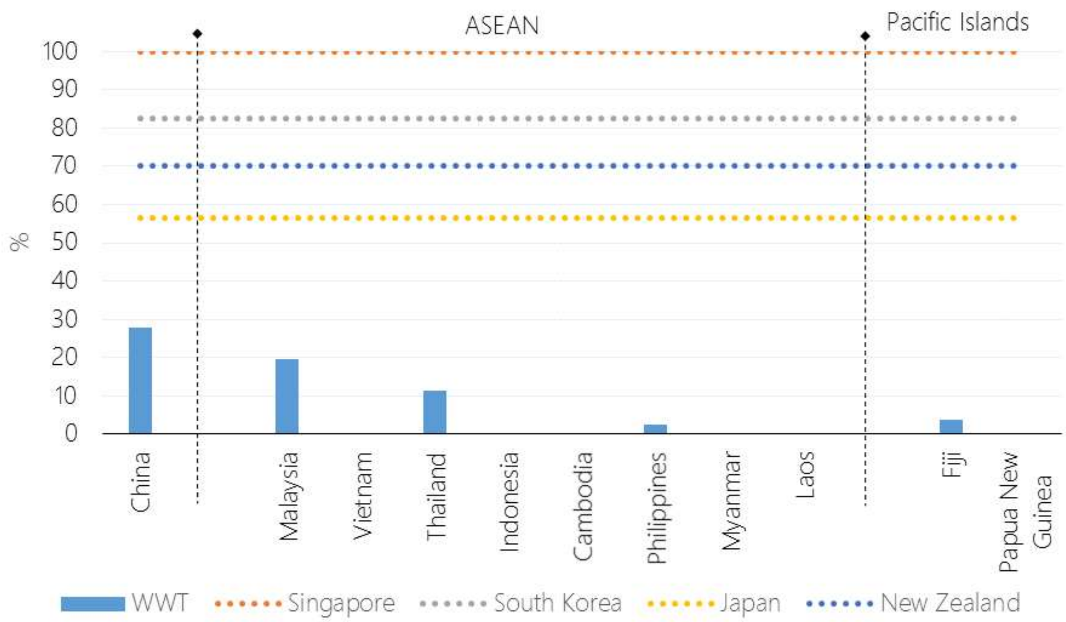
Wastewater refers to water whose quality has been negatively affected by anthropogenic activities. Safely managing sanitation and wastewater treatment are crucial for protecting public health and should form a fundamental part of the infrastructural services provided to households.

Wastewater Treatment

The quality of wastewater services has been analyzed based on the proportion of collected wastewater that is actually treated. The data is drawn from the Environmental Performance Index (2014), a project led by Yale University and launched by the World Economic Forum, which collects data related to environmental health and ecosystem vitality. The project has collected data on the percentage of collected wastewater that is subject to treatment, as opposed to simple conveyance from households.

The results show a very low level of treatment across the board, except for in Singapore, which exceeds even the other benchmark countries. In the Pacific Islands, data is only available for Fiji and Papua New Guinea, both of which have very low percentages of wastewater treated (10% and 0% respectively). In ASEAN, only Singapore treats 100% of its wastewater. Malaysia, Vietnam, Thailand and Philippines treat between 60% to 40% of collected wastewater (see Figure 17), while wastewater treatment in Indonesia, Cambodia, Laos and Myanmar is practically nonexistent.

Figure 17. Percentage of Collected Wastewater Treated (%)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from Hsu et al. (2015)

These results are dismally low, especially when considering that this data does not capture the wastewater that is altogether not collected for removal. Connection rates to wastewater collection are high in Singapore (100%), Thailand (96%), South Korea (91.5%), New Zealand (85.6%), and Japan (76%), but are less than 50% in all other countries in the region. Papua New Guinea (10%), Myanmar (6%), Laos (3.5%), Indonesia (2%), Vietnam (1.8%), and Philippines (1.6%) all have extremely low rates of wastewater collection.[51]

[51] Yale University (2016), Environmental Performance Index (EPI) (data from 2014)

Incidence of Diarrheal Illness

Sanitation quality is proxied by a WHO measure of overall system hygiene, called the Diarrheal Disability-Adjusted Life Year (DALY) indicator, which is an indicator of combined waste management, wastewater treatment rate and quality and water supply. The diarrheal DALY (measured per 100,000 people) incorporates both years of life lost and years lost due to disability caused by diarrhea.[52] One DALY can be thought of as one lost year of "healthy" life. Therefore, a low count of DALY reflects safe water, sanitation and hygiene conditions in the country. The data is drawn from the 2015 Global Health Estimates by the WHO.[53] The diarrhea DALY does not solely capture the prevalence of the disease caused by poor sanitation access or quality; it may also be affected by access to water supply as well as cultural or behavioral norms. Nevertheless, the indicator reflects the severity of problems associated with the presence of human waste in water supply and the built environment that lead to diarrheal incidences.

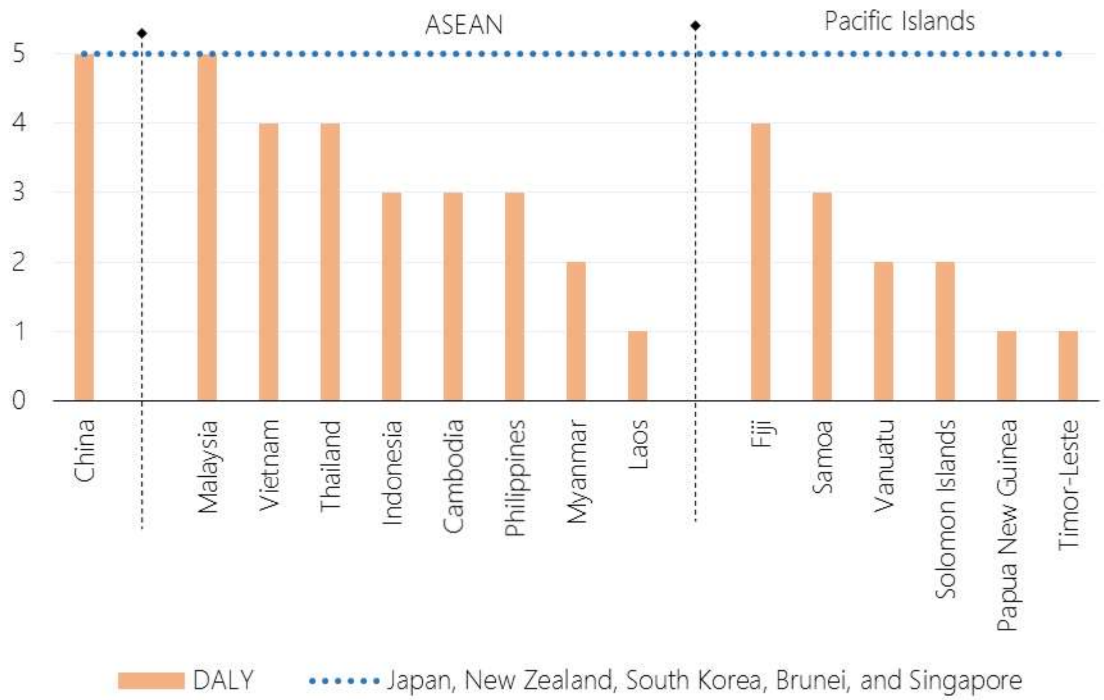
Within the ASEAN countries, Laos has the highest DALY score, followed by Myanmar and Indonesia. In Laos, while sanitation coverage is progressing, over one-third of the population still practices open defecation.[54] Comparably high scores are found in Timor-Leste, Papua New Guinea and Vanuatu in the Pacific Islands group. The benchmark countries, as well as Singapore, Malaysia and Brunei perform best (see Figure 18).

Looking at results of both water and wastewater combined, Singapore ranks highest, with quality indicator scores well above those found in developed states across the world. This is perhaps not surprising given the priority the government has placed on water for decades, including the political willingness to promote sector development and implement cost-recovery pricing to support re-investment into the water system. In addition, it is one of the few countries that has combined institutional responsibilities for water and sanitation and has been at the forefront of recycling wastewater into potable water.

In line with the overall low levels of access to improved sanitation services observed in EAP, and particularly piped sewerage connections in urban areas, the quality of wastewater treatment is a significant area of future development in the region.

[52] WHO (2016)
[53] WHO (2016)
[54] UNICEF (n.d.)

Figure 18. Diarrheal Disability-Adjusted Life Years Index (DALY)

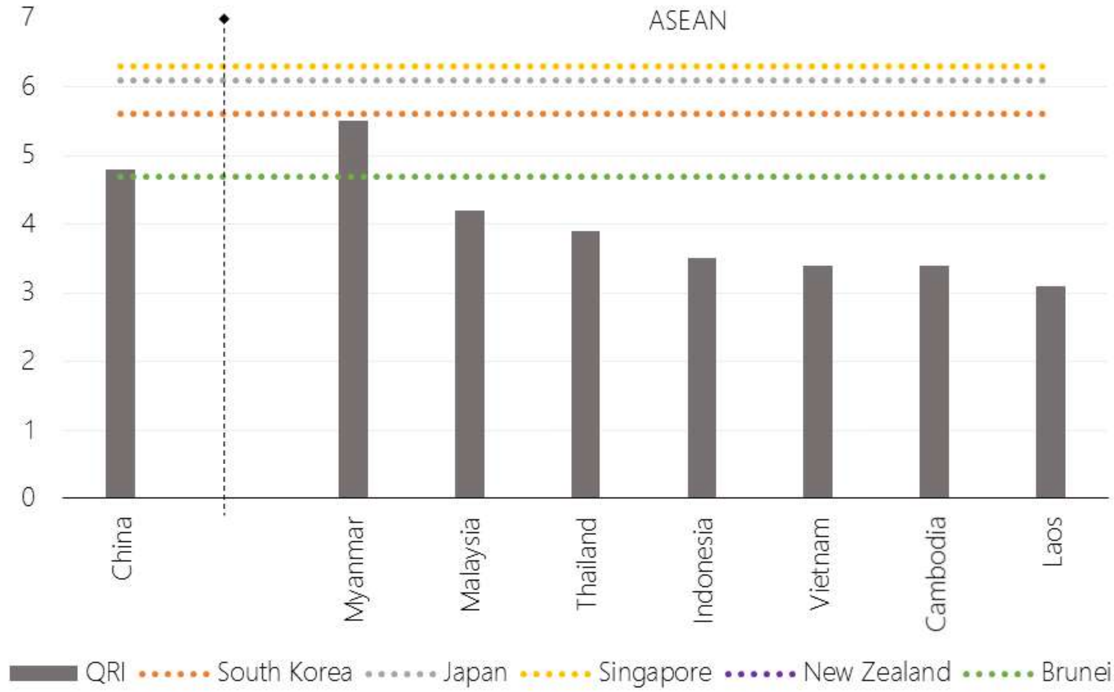


Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from WHO (2016)
Notes: The DALY is a measure that incorporates both, years of life lost and years lost due to disability caused by diarrhea. A high DALY is a proximate indicator of poor sanitation conditions.

Road Transport

Data on the perceptions of road quality from the *Global Competitiveness Report* (2016-17) was used to assess the quality of road infrastructure in the EAP region. It is important to note that this data is based on a survey of perceptions and should, thus, not be interpreted as a strict measure of relative physical quality. Nevertheless, it is one of the only comparative measures of road quality currently available. In this survey of industry experts, respondents are asked, "In your country, how is the quality (extensiveness and condition) of road infrastructure? [1 = extremely poor—among the worst in the world; 7 = extremely good—among the best in the world]". While no data is available for any for the Pacific Islands, within the ASEAN region, Singapore is ranked highest, followed by Brunei and Malaysia. The worst roads are reportedly in the Philippines, Cambodia and Vietnam (see Figure 19).

Figure 19. Quality of Road Infrastructure (1-7, best)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from WEF (2017)

Since information on road quality in EAP beyond this is limited, this report also provides information on the Asian Highway network and self-reported country data from ASEAN Member States to provide some context.

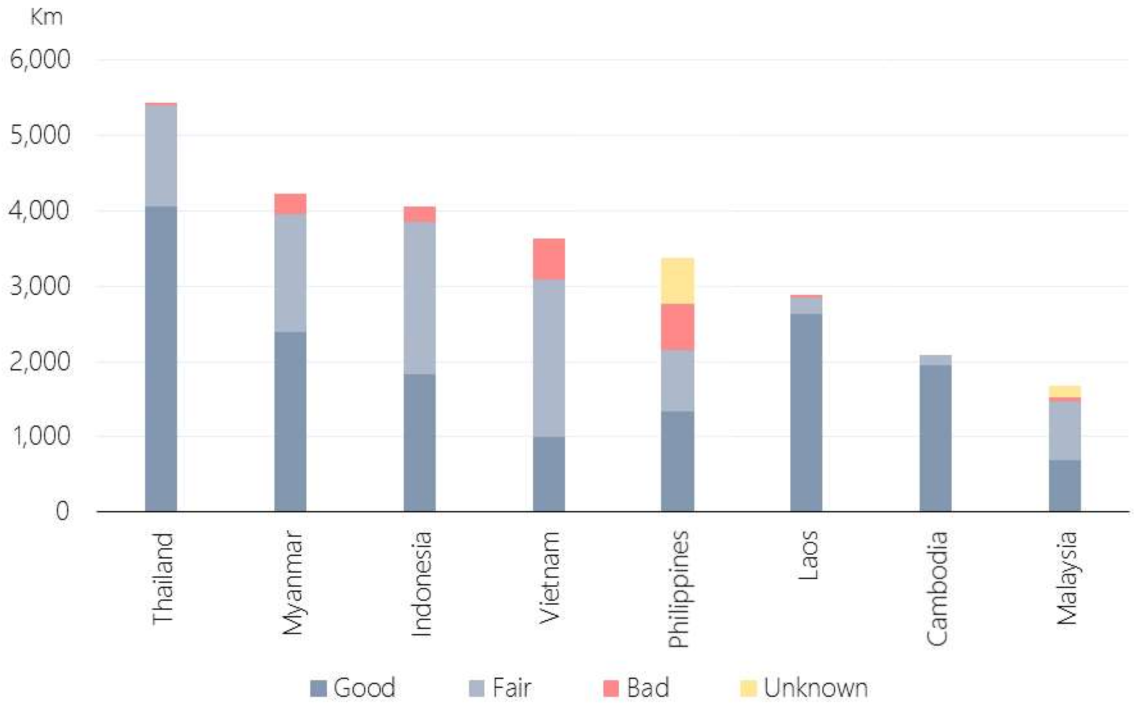
The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) collects data on roads comprising the Asian Highway network (AHN), a regional transport cooperation initiative that has designated a system of priority highways as important transport routes linking Asian countries to each other and to Europe. The Asian Highway network initiative is focused on enhancing road infrastructure development and improving connectivity for landlocked countries. UNESCAP maintains a database on these highways, with information on road lengths, classifications, and surface quality.

Figure 20 shows the current road lengths, by quality assessment, for Asian Highway roads in the countries under study (the AHN does not extend to the Pacific Islands). Data is self-reported by countries, based on common classification and design standards.[55] The figure shows that most of the AHN is in good condition in Thailand, Myanmar, Cambodia, and

[55] UNESCAP (2015)

Indonesia. Only Indonesia, Philippines, Laos, and Cambodia have significant portions of the AHN in need of rehabilitation in order to improve surface conditions to at least fair levels.

Figure 20. Length and Surface Condition of Asian Highway Network Roads (km)

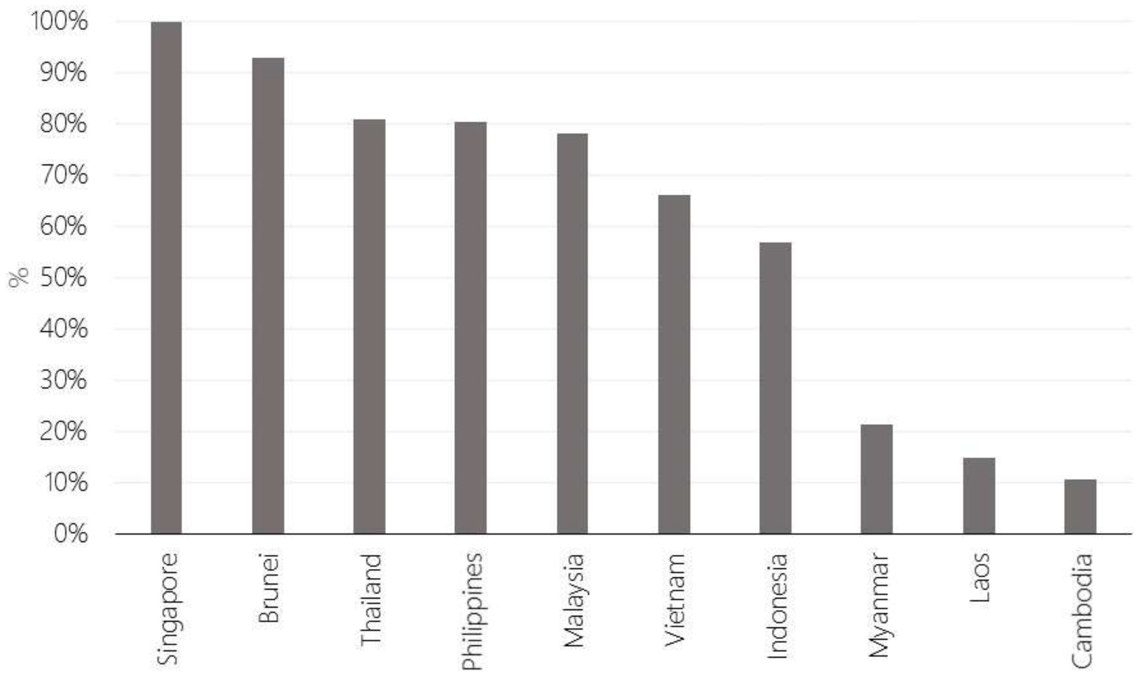


Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from UNESCAP (2015)

ASEAN Member States also report transport data to the ASEAN Secretariat and ASEAN-Japan Transport Partnership (AJTP), a joint project of ASEAN and the Government of Japan. Figure 21 shows the proportion of the overall road network accounted for by paved roads. Singapore's roads are 100% paved, followed closely by Brunei (93%). Thailand (81%), Philippines (81%), and Malaysia (78%) all also have relatively high levels of paving. Myanmar, Laos, and Cambodia have the lowest ratios of paved roads at 22%, 15% and 11%, respectively.

While data is insufficient to provide a definitive assessment of road quality in EAP, from the above information, it can be seen that there are significant spans of highways in need of rehabilitation and upgrading. These are the same countries that also have a low ratio of paved roads – namely Myanmar, Laos, and Cambodia. In addition, Philippines and Indonesia, whose trade routes represent a large proportion of the Asian Highway network in ASEAN (27% in combination), also require rehabilitation of 808 km of poor surface condition highway.

Figure 21. Ratio of Paved Roads to Total Road Length (%)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017) based on data from AJTP (2016)
Notes: These figures are self-reported transport data from ASEAN Member States.

General Remarks

This chapter demonstrates a more nuanced picture of the status of infrastructure in EAP. The data on quality reveals that, in terms of performance, Singapore, China and the benchmark countries are at the top end for energy, water, sanitation, as well as roads. In a mid-tier group are the middle income-economies of Thailand, the Philippines. and Indonesia, though Indonesia exhibits a significant low performance in wastewater treatment. This could also explain why Indonesia's residual chlorine value is so low. At the low end, the study identifies Cambodia and Myanmar in the ASEAN region and Samoa and Papua New Guinea from the Pacific Island nation group, as the countries with the lowest levels of quality in infrastructure.

Chapter 5 Tariffs and Costs of Service

The analysis on infrastructure pricing and costs in East Asia Pacific includes three separate aspects: tariffs, operating costs, and cost recovery. From the user perspective, tariffs are paid by users to access services. Tariffs are calculated using many different structures. Many involve a fixed service price as well as a variable price that takes into account levels of consumption. Tariff structures are also often designed to charge different unit consumption prices to different types of users (for example, residential versus commercial, industrial, and government) and for different levels of consumption (often with higher per-unit prices at higher levels of consumption to cross-subsidize provision at subsistence levels). The level of tariffs affects the affordability of infrastructure services for the poorest and also has an impact on conservation and use patterns.

The cost of providing these services is determined by the costs of building the necessary physical infrastructure assets and the marginal costs of delivering services, including the costs of operation and maintenance. Tariffs are often a major source of revenues to finance the development and maintenance of necessary infrastructure, but many infrastructure services, particularly in developing countries, remain heavily subsidized.[56] Where poverty rates are high, governments may ensure access to the most basic of services through targeted subsidies.

When tariffs levels are set too low to sufficiently recover costs, higher levels of support are required from governments (via the tax base), and the viability of operations relies on public accounts in order to fill budgetary gaps. Moreover, this can sometimes lead to under-provision of services or the provision of low-quality services. Water tariffs, for example, are highly political and are thus often kept low by policy choice, despite the fact that low cost recovery rates often burden the poorest. This is because low coverage leads poorer populations who lack access to depend on considerably more expensive sources, such as private water vendors.[57]

Tariffs are only one side of the cost recovery issue, however. The other aspect is controlling the marginal costs of production, which requires operational efficiency and sound management, both of which are lacking in some contexts.

As such, cost recovery remains a significant issue and challenge with respect to the capacity for governments to extend services and make improvements to existing networks. It is also a challenge for governments to reduce inefficiencies (such as T&D losses, NRW, and manpower-related inefficiencies) in order to control costs and, in turn, bring tariffs down to meet levels of affordability. Indeed, poor levels of quality seen in some countries and sectors

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[56] World Bank Group (2005)
[57] Gomez-Lobo et al. (2014)

– as described in Chapter 4 – are directly related to the inability of utilities to recover costs via tariffs or effectively manage operations.

Despite data limitations, this section provides information at the national and municipal levels on tariffs charged to consumers, the costs of production and the rates of cost recovery. The report is more informational than diagnostic, particularly in the case of water supply, since costs are dependent on local geographic and physical conditions, the availability of water resources, and levels of operational efficiency.

For the electricity sector, a comparison of tariffs for a low consumption level (30 MWh/month) illustrates the comparative rates that users across the region pay to access such services. The average unit costs of producing one kilowatt-hour (kWh) of electricity – estimated for the specific energy mix of each country by weighting the corresponding technology-based Levelized Costs of Energy (LCOEs) – are also presented, alongside the average tariff per kWh to describe levels of cost recovery in electricity provision. For the water sector, this chapter compares residential tariffs for a subsistence consumption band of 15m^3 per month as well as reported operating cost recovery ratios.

Costs related to building roads are excluded in this chapter because data on unit costs for roads (such as a per-km cost of construction or maintenance) is unavailable, aside from limited data from multilateral lending and PPI investment, which are not indicative of overall or comparative road pricing in the region. Road pricing is contingent on numerous variables, including road width, seasonality, and topography. Therefore, it is also difficult to construct a meaningful aggregated estimate of road cost comparable across countries.

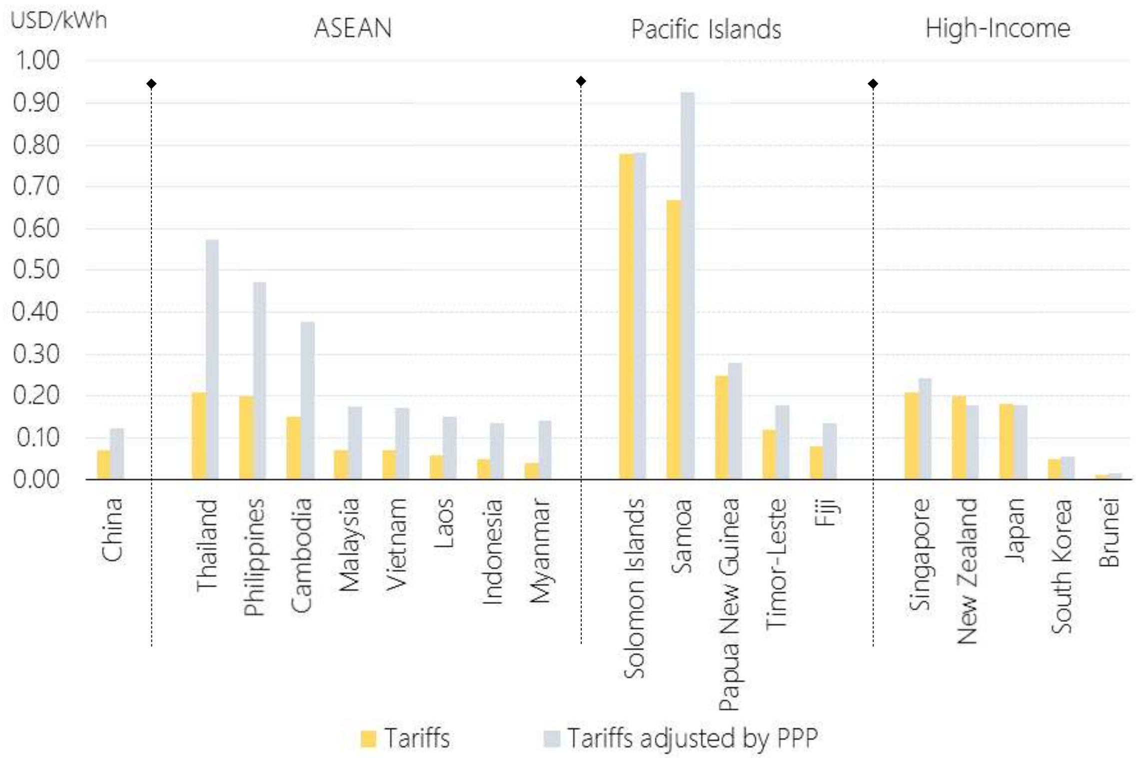
Tariffs

With respect to tariffs in general, all EAP country utilities charge for electricity and water supply services (except Timor-Leste that does not impose a water tariff), but wastewater treatment is not typically charged separately from water tariffs.

Electricity

Electricity tariffs for subsistence consumption (30 kWh per month) vary significantly across EAP countries. The data suggests that almost half of the countries (including most of ASEAN, except for Cambodia, Philippines, Singapore and Thailand) have tariffs below 0.10 USD/kWh, while the remaining countries (except for Samoa and Solomon Islands) have tariffs between 0.10 and 0.30 USD/kWh. While these figures are directly comparable to derive an understanding of the relative prices consumers pay for electricity consumption, adjusting these figures for purchasing power parity presents a more nuanced picture of the relative affordability of electricity services across countries, particularly for the poor.

Figure 22. Subsistence-Level Residential Electricity Tariff, 2016 USD/kWh



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from RISE database (2013 data) for countries where data available; different sources for other countries (complete list in Annex I)

Notes: All tariffs are given in 2016 USD per one kilowatt-hour for a consumption of 30 kWh per month.

Brunei has significant energy subsidies and is the EAP country with the lowest electricity tariff of only 0.01 USD/kWh. In terms of levels of electricity tariffs, Brunei is followed by Myanmar (0.04 USD/kWh), Indonesia (0.05 USD/kWh), South Korea (0.05 USD/kWh), and Laos (0.06 USD/kWh).

With the exception of Laos, where the low tariff is due to the lower costs of hydropower electricity,[58] and South Korea, whose steep progressive pricing system allows higher consumption blocks (with higher tariffs) to cross-subsidize low-consumption consumers, low tariff levels can lead to additional public finance burdens. This is the case for Indonesia, which, like Brunei, has highly subsidized electricity tariffs coupled with a high fiscal transfer to Perusahaan Listrik Negara (PLN), the country's largest power utility. In 2015, subsidies were projected at 0.6 percent of GDP, despite the fact that, since 2013, the Indonesian government embarked upon a tariff rationalization effort aimed at targeting subsidies only

[58] World Bank Group (2017a)

to low income consumers and increasing electricity tariffs for higher-consumption blocks.[59] In Myanmar, government policies have set electricity tariffs so low that it impedes electricity companies from recovering costs, which may lead to a slowdown in investments in the electricity sector.[60]

China, Vietnam, Malaysia, and Fiji charge between 0.07-0.08 USD/kWh. These rates are low compared to most other countries in the region, including Cambodia, Philippines, Singapore, Thailand, and Papua New Guinea, and the regional benchmarks of Japan and New Zealand, all of which charge in the range of 0.15-0.25 USD/kWh. The highest tariffs for electricity are charged in Samoa and Solomon Islands, where the price is 0.67 and 0.78 USD/kWh respectively, more than three times what is paid by users in the ASEAN region and the rest of the Pacific Islands. In small Pacific Island Countries (PICs), high tariffs are related to the high costs of electricity production, which is dependent on imported fuel. Despite relatively low taxes and the fact that the most countries provide lifeline subsidies for low-volume consumers, electricity prices in PICs are above the OECD average.[61]

To understand the relative affordability of these rates, tariffs adjusted for purchasing power parity (PPP) are presented. The PPP-adjusted tariffs are the highest in the Pacific Islands of Samoa and Solomon Islands, where absolute costs are also high, followed by the ASEAN countries of Thailand (0.57), Philippines (0.47), and Cambodia (0.38). This indicates a higher burden on these residents with respect to affordability. Interestingly, adjusted tariff levels in these ASEAN countries are even higher than in Singapore, often referred as one of the world's most expensive cities to live in.

The high electricity tariffs in these countries may be attributable to several factors. For instance, in Cambodia these include the challenge of achieving economies of scale in a relatively small economy, geographic fragmentation of power networks and service provision, relatively high supply costs, and relatively high system losses – as mentioned in Chapter 4. Additionally, the fact that the price of electricity is relatively high compared to neighboring countries may affect also the competitiveness of these economies by increasing the cost of doing business and obstructing the development of value-added production that requires increased mechanization.[62]

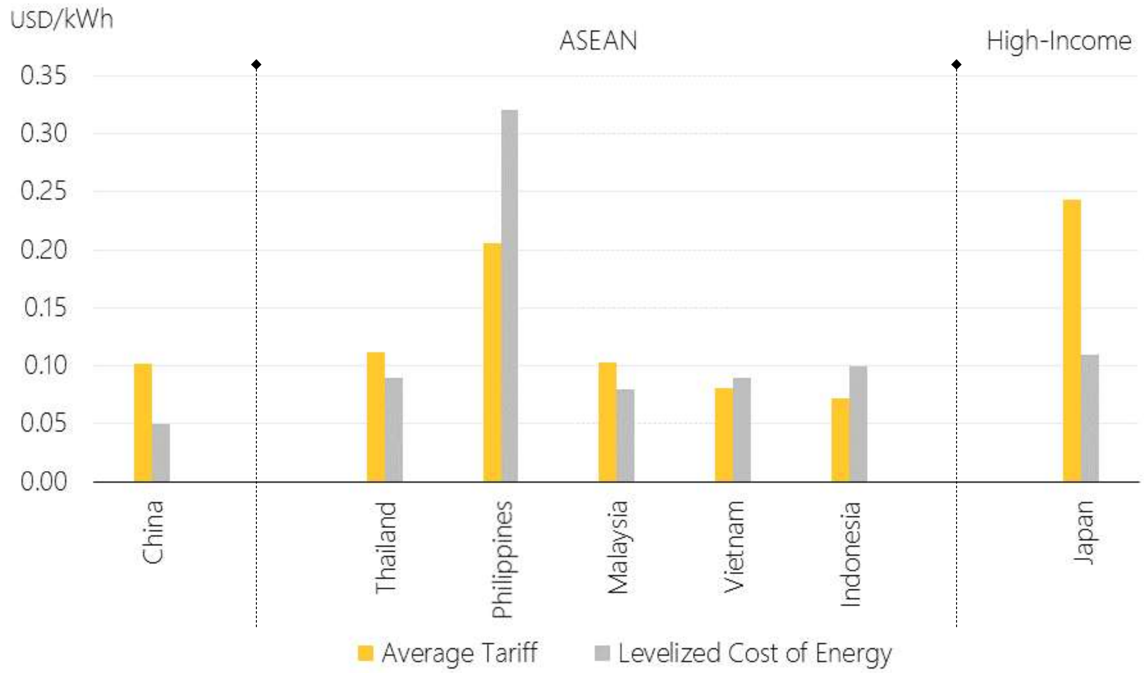
Electricity Cost Recovery

One way to assess whether the tariffs set by electricity utilities are sufficient to recover capital and operating costs is by comparing the average tariffs to average costs of

[59] World Bank Group (2015c)
[60] World Bank Group (2014a)
[61] World Bank Group (2016a)
[62] World Bank Group (2016b)

production. The former corresponds to the average unitary cost across all consumer types and consumption levels. Simply put, it is the sum of all revenues divided by the total energy produced. The average cost of production is based on the Levelized Cost of Energy (LCOE) calculated for five EAP countries (Indonesia, Thailand, Malaysia, Japan and Vietnam), in turn derived from the average costs of production by technology and the distribution of energy sources by technology (see Figure 23).

Figure 23. Average Tariff vs Average Cost of Production, 2016 USD/kWh



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on tariffs by RISE database (2013 data) and LCOEs by BNEF (2017) and Lazard (2016). More information in the methodology section

Notes: All tariffs and costs are for one kWh in 2016 USD/kWh. The average electricity tariff is the average retail rate across all tariff blocks and consumer types, calculated as total collected revenues divided by total kWh sold. The average cost of production is the unit to produce 1kWh, calculated using data from the energy mix for each country (by source for electricity production) and the unitary costs of electricity production by each input

In the EAP countries for which data was available, only China, Malaysia, and Thailand are operating at general cost recovery levels. In the Philippines, on the other hand, the average tariff paid by users for consumption of one kWh is only 65% of the unit cost of producing the same amount of energy. This is due to the relatively high cost of producing energy from the predominant electricity generation technologies used by the Philippines, namely coal (which constitutes 43% of its energy mix) and natural gas (which constitutes 25% of its total energy mix).

Water

With the exception of Timor-Leste, where water supply is not priced, all other EAP countries charge water tariffs. In Figure 24, residential tariffs for a subsistence-level consumption of 15 cubic meters (m^3) per month are presented for the largest cities in each EAP country under study. Water tariff data is not available in a way that can be aggregated at the national level, and rates can vary enormously at the sub-national level. For this reason, this report focuses only on the rates in the largest cities (by population).

As shown in Figure 24, there are high disparities in the water tariff levels across the major cities in EAP. In ASEAN, Bandar Sei Begawan in Brunei and Yangon in Myanmar have the lowest low-consumption tariff rates (0.08 USD/m^3), comparable to those of Suva, Fiji (0.07 USD/m^3) in the Pacific Islands.[63] In contrast, the highest water rates are in Singapore, Manila, and Jakarta in ASEAN, and in the Solomon Islands among the Pacific countries.

High tariffs may be an indicator of appropriate cost recovery, as in the case of Singapore, whose water is priced highest in ASEAN (and whose domestic water resources are also limited, therefore requiring careful management), and where a well-designed policy of cost recovery has allowed the government-owned, corporatized utility to extend full, high quality coverage to the population. Manila's water story, while behind Singapore developmentally, is similarly positive. Jakarta, on the other hand, maintains a high tariff rate despite low (but improving) performance and poor water quality. This example serves to show that immediate judgements about water performance are impossible to make by consideration of tariff levels alone.

By adjusting for PPP, it is revealed that water tariffs in Jakarta are the second highest in the EAP cities under study, at a level that is close to that of Singapore, although important differences in quality persist (see Chapter 4). In Manila, the two main water utility companies have significantly different tariff levels (about 50% more expensive in the case of Maynilad at 1.06 USD/m^3 as compared to Manila Water Company that provides one m^3 of water for 0.69 USD).

In the Pacific Islands, Fiji, despite being the richest country in terms of GDP per capita, has the lowest tariffs, at only a quarter of what is paid in Port Moresby (Papua New Guinea), the city with the second lowest tariff the Pacific Islands. As a result, water supply tariffs in Fiji are significantly below the cost of production. According to an ADB staff assessment, in 2013, revenue generated by water and sewerage charges was equivalent to 44% of operating

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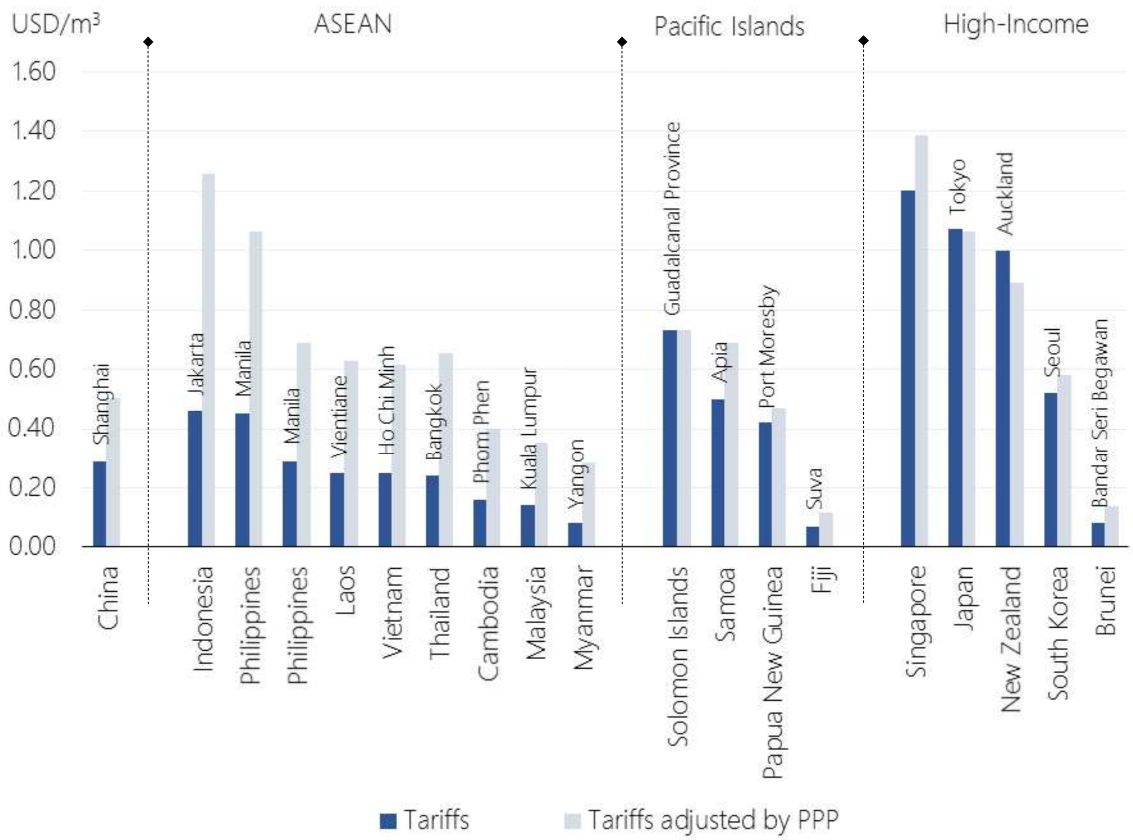
[63] The low water tariff in Myanmar is due to extremely low operational costs. There is a low technical cost of supplying water since low turbidity requires lesser treatment and since intake is gravity-based, thus requiring no electricity. Manpower costs are also low since the majority of operators are not official employees of Yangon City Development Committee (YCDC) but are rather daily wage contract labors. Source: JICA (2014)

costs.[64] Thus, the Water Authority of Fiji is reliant on grants from the government to finance its capital and operating costs.

Figure 24. Subsistence-Level Residential Water Tariff, 2016 USD/m^3



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from GWI database (2016) for countries where available; different sources for other countries (see Annex IV)
Notes: Tariffs are the residential retail rate per cubic meter (m^3) for a consumption of 15m^3 per month for the largest city in the country (city designated in data label above column)

With respect to affordability, the service connection fee is another important aspect to consider. The burden of connection fees compels many households to source expensive water from street vendors, rely on neighbors' taps, or access supply networks through illegal connections that increase the levels of non-revenue water.[65] For example, depending on pipe size, an average household connection charge ranges between USD 145-232 in Bangkok (Thailand),[66] between USD 50-90 in West Jakarta (Indonesia),[67] and up to USD 173 in West

[64] ADB (2014a)
[65] McIntosh et al. (2014)
[66] Metropolitan Waterworks Authority (2017)
[67] Palyja (2017)

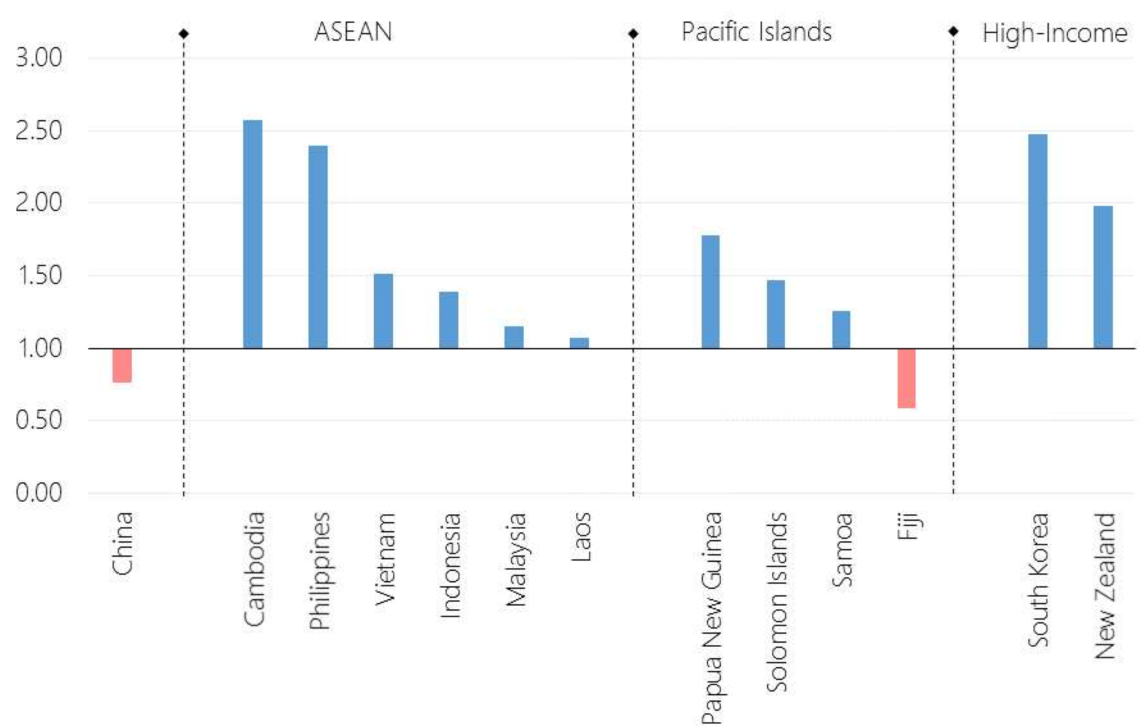
Manila (Philippines).[68] Connection fees are a major constraint to increasing access to service for the poor.

Water Cost Recovery

In the absence of comprehensive data on the capital costs borne by water utilities, the operating cost coverage ratio (OCCR) collected by IBNET is used to understand how extensively utilities are recovering operating costs from revenues. While the utilities included in the IBNET dataset in all countries except for Fiji and China are recovering their operating costs, this does not imply that tariff revenues are sufficient to cover the capital costs of expanding and rehabilitating water supply systems. Given that full asset lifetime costing data across countries is not available, however, the OCCR can provide information about the health of water utility financing and capacity to maintain current levels of service.

Amongst the countries for which information is available, only the Philippines, South Korea and Cambodia have an operating cost coverage ratio above two, which would give the water utilities room to make capital investments to expand and maintain their infrastructure.

Figure 25. Operating Cost Coverage Ratio



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET Benchmarking database, various years (see Annex VI)

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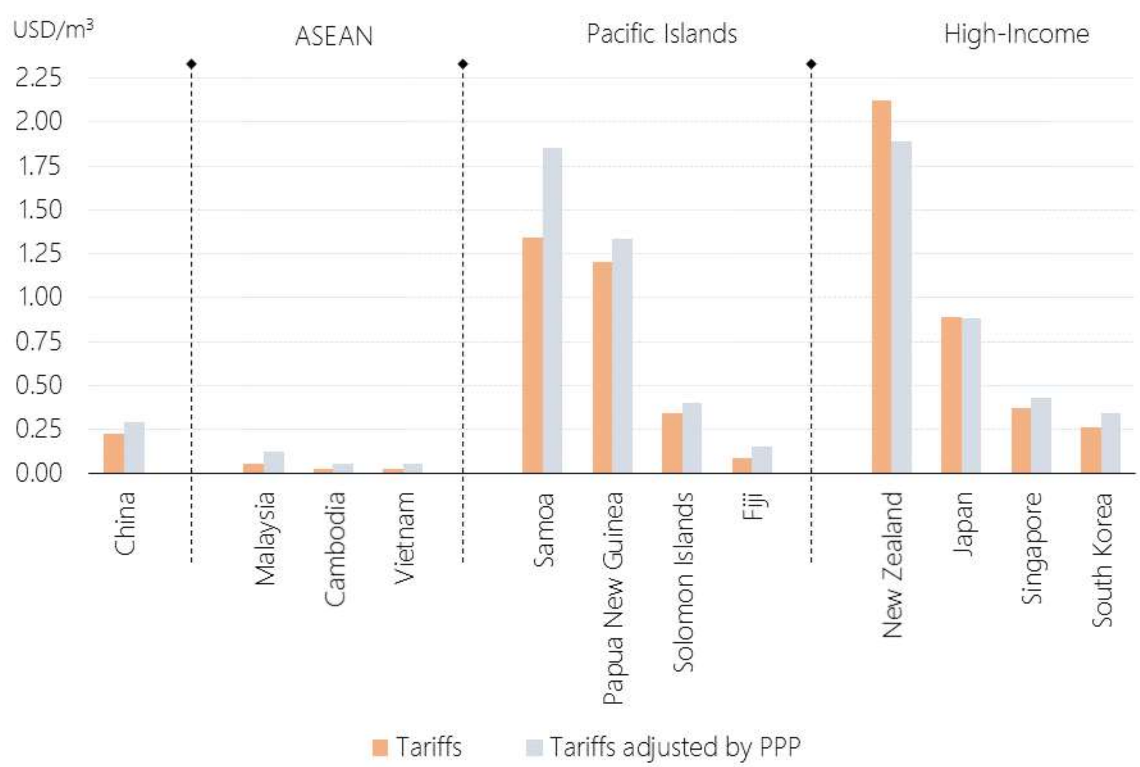
[68] Maynilad Water (2017)

Sanitation

Wastewater collection tariffs are taken as a proxy measure for pricing sanitation services. The number of countries included in the IBNET Benchmarking Database that have tariffs for wastewater collection is significantly smaller than those that regularly impose water tariffs. Of the 18 EAP countries with recorded water tariffs, only 12 have some kind of wastewater tariff.

In many cases, the costs of wastewater treatment are recouped from the water bill. ASEAN low-income countries such as Myanmar, Laos, and Cambodia do not charge tariffs for wastewater collection services, nor does Indonesia. In many cities in these countries, wastewater conveyance is not connected to a centralized sewer and, therefore, is not collected by the utilities.

Figure 26. Wastewater Tariff, 2016 USD/m^3



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET Benchmarking database, various years (see Annex VII)
Notes: All tariffs are for the collection / treatment per one cubic meter (m^3) for the largest city in the country, expressed in 2016 USD.
Data source: IBNET for all countries (see Annex 1) except Myanmar (source in Annex 2)

Even adjusting for purchasing power parity, tariffs for wastewater services are as low as 0.05-0.35 USD/m^3 per cubic meter for several ASEAN countries and Pacific islands (including Cambodia, Vietnam, Malaysia, Fiji, and the Solomon Islands), and also in the same range for more developed countries such as China, Singapore, and South Korea. The highest wastewater tariffs in EAP are observed in Papua New Guinea and Samoa at levels three times as high as in Singapore and more than eight times the tariff level in Fiji.

It is worth noting that the data presented in this section is subject to limitations, particularly with respect to national representativeness. Tariff data are representative of urban realities only, and typically only for the major urban center of each country. With respect to costs of service, capital costs for water are not collected by IBNET and are extremely difficult to extract from financial balance sheets of utilities, because they are project-based and have different lifespans that must be considered to understand the per-year and per-unit capital costs associated with service delivery. Similarly, there is no comprehensive source that accounts for capital costs of electricity production.

There are also a number of data deficiencies that must be recognized. IBNET's dataset for wastewater has many gaps, and the latest RISE data on electricity are from 2013, with many EAP countries missing. Moreover, LCOE data are available only for a very limited number of EAP countries and does not include costs of distribution and transmission, though these are costs are usually quite low in comparison to generation costs.

General Remarks

The costs of delivering services are extremely context-specific, making generalizations difficult: both tariffs and production costs for the three sectors taken into consideration (electricity, water, and wastewater) experience large variations from country to country. A general observation is that electricity and water are always charged in EAP (except for Timor-Leste for water tariffs), whereas wastewater is typically subsumed under the water bill. This is true not only in some ASEAN low income (Myanmar and Laos) and middle income countries (Indonesia, Philippines, Thailand), but also in high income countries, such as South Korea. Financing wastewater services via water tariff revenues is often effective since users generally value water services more than wastewater services. Due to low levels of performance and coverage of urban sanitation service, however, funds for wastewater collection and treatment should be ring-fenced from within water revenues to safeguard financing of sewerage and other sanitation works.

With respect to sectoral trends, electricity tariffs for basic levels of consumption tend to be higher in the Pacific Islands due to import-dependent energy systems. Subsistence consumption level tariffs are also high in Cambodia, Thailand and the Philippines. Lower tariffs in other EAP countries does not necessarily mean that electricity production is more efficient or less expensive, however, as low subsistence-level tariffs may also be attributable to the presence of subsidies (as in Indonesia and Brunei) and/or the structure of cross-subsidies across consumption bands (as in South Korea). In water supply, higher income countries tend to have higher tariffs, even for basic consumption levels (in line with a higher capacity to pay from users), with the notable exceptions of Brunei and Malaysia, whose water tariffs are very low despite their relatively higher incomes due to tariff policy.

Finally, in some EAP countries, tariffs are not sufficient to cover the costs of production. In several ASEAN countries, such as Indonesia, Vietnam, Malaysia and Philippines, average unitary revenues from electricity tariffs do not cover the marginal cost required to generate electricity, let alone to distribute and transmit electricity to users. When it comes to water supply, while only the IBNET utilities in China and Fiji do not cover their operating costs from revenues, it is likely that many utilities in the other EAP countries cannot cover the capital costs of building or expanding water infrastructure to meet developmental goals.

Chapter 6 Private Sector Participation in Infrastructure

While the provision of public infrastructure has historically been considered a core responsibility of government, intensifying demand for alternative sources of infrastructure finance and the recognition of potential technical and efficiency gains via commercialization have spurred continuous development of multiple models of public-private partnership (PPP) and other forms of private sector participation in infrastructure (PPI). Indeed, the private sector is an underexploited source of finance that, if successfully tapped into, could offer support to EAP governments struggling to meet the infrastructure needs due to population growth, urbanization, trade expansion and climate change.

It must be acknowledged that PPI accounts for a mere fraction of overall investment in infrastructure globally, and in many cases (including in EAP), PPI has not kept pace with economic growth. Public expenditures continue to be the primary source of infrastructure funding. Nevertheless, given sustained interest in the potential of the private sector to offset the funding burdens borne by government, this section offers a historical perspective of trends in PPI in order to inform discussions of potential opportunities for mobilizing private finance to close the infrastructure gap.

Forms of private sector engagement in long-term infrastructure contracts can differ based on the level of active engagement in asset development, ownership, and management. This can range from management contracts and design-build arrangements on the lower end of the spectrum of private participation, to build-own-operate-transfer (BOOT) concession arrangements and full divestures (complete private ownership) on the higher end. This report examines committed investments and projects included in the World Bank's Private Participation in Infrastructure (PPI) Database. The analysis in this section provides a historical overview of PPI in EAP as compared to other regions and describes PPI investment patterns in the electricity, water and sewerage, and transport sectors, at the regional and national level.

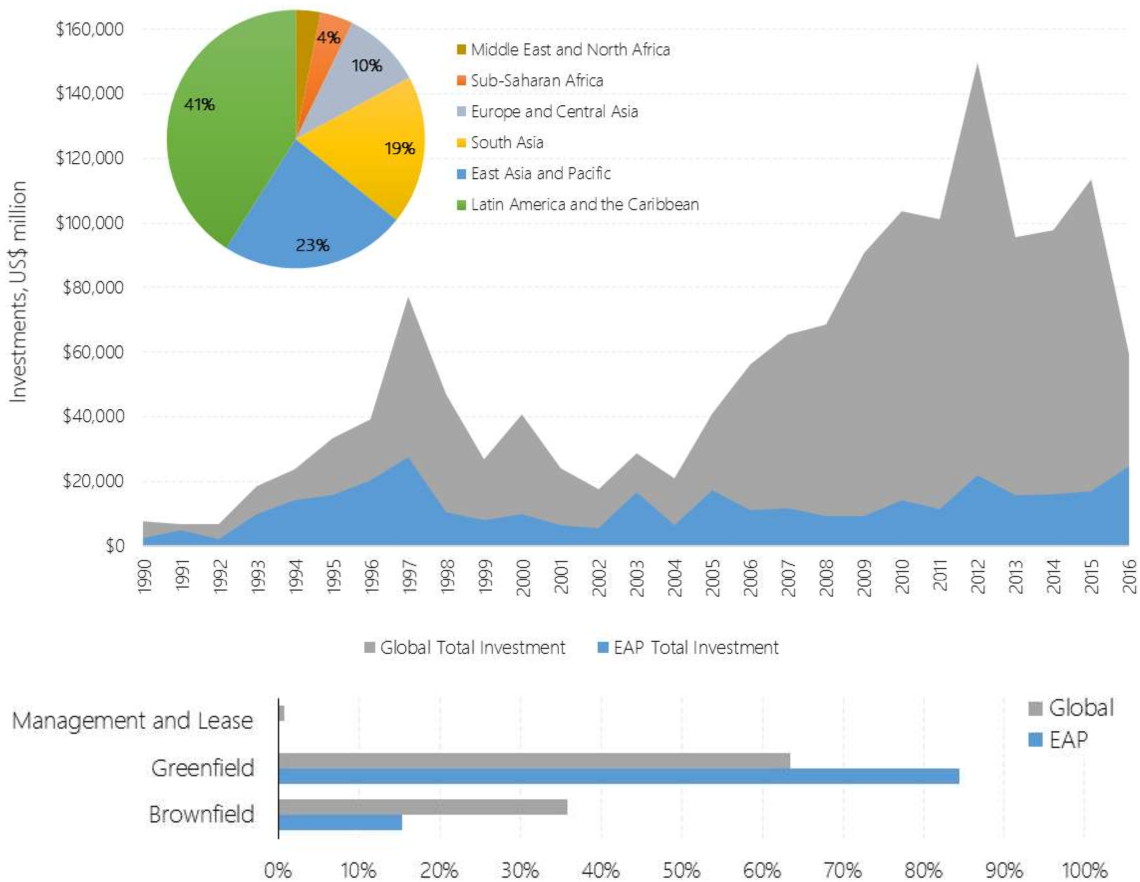
The projects included in the analysis to follow are only those that fall under the energy, transport, and water and sewerage sectors in the PPI Database. The data does not include projects that related to information and communications technology (ICT) or non-electricity energy (i.e., natural gas or renewables). Further, since PPI is discussed with respect to possibilities for the private sector to advance provision of important public infrastructure services, this report includes only those projects that involve both public and private participation (i.e., full divestitures are excluded) and are either operational or concluded.[69]

[69] This includes distressed projects but not cancellations. The rationale is that distressed projects – particularly in EAP – may be operational for many years and/or resolved via arbitration. Cancelled projects were eliminated, as their inclusion would mean overestimation of participation.

Role of EAP in Global PPI

In the 27-year period from 1990-2016, global PPI investment commitments in the electricity, water and sewerage, and transport sectors reached an accumulated amount of USD 1.46 trillion. Of this, USD 383.2 billion have been invested in EAP through 1,868 projects, accounting for 23% of the total global PPI investments. Globally, this investment level is second in value only to Latin America and the Caribbean (LAC) (42%) (see Figure 27).

Figure 27. Global and EAP Investments in PPI



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

With respect to the number of projects (as opposed to committed investments), EAP has maintained pace with other regions. Since 1990, 1,868 projects have reached financial closure in EAP, only slightly fewer than the 1,894 projects in LAC. The difference between the regions is that LAC has seen a concentration of investment in fewer high-value projects, whereas EAP has seen the increase of smaller investment size projects.

Regarding contract type, EAP has seen proportionally more Greenfield (new asset construction) projects as opposed to Brownfield projects (which extend or rehabilitate existing assets), as compared to the rest of the world. Greenfields account for 83% of total investments in EAP, as opposed to 63% of global investments. Conversely, global investments in Brownfields (36%) are much higher than in EAP (17%). This higher proportion of Greenfields in EAP is driven by a regional focus on construction rather than rehabilitation or management, due to increasing demands of urbanization and population growth. This is compounded by a high number of PPIs for new infrastructure assets in developing ASEAN, intended to extend networks and services to underserved regions in Cambodia, Indonesia, Philippines, Myanmar, and Thailand.

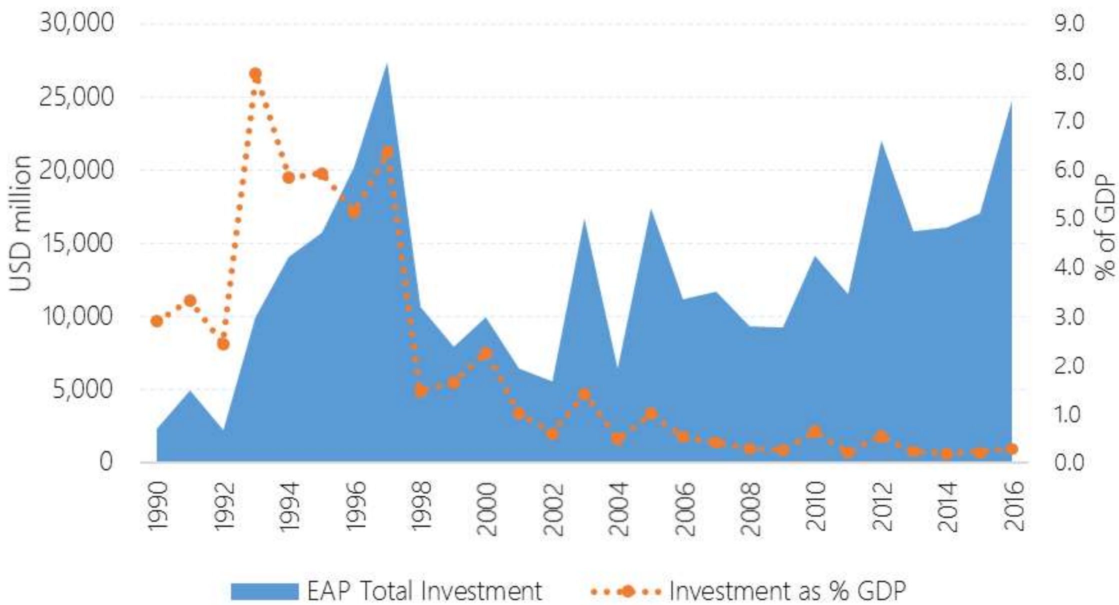
In terms of sector distribution, the EAP trend of higher investments in energy (56%) followed by transport (33%) is consistent with patterns across all other regions, except ECA.

PPI in EAP

PPI investments in EAP peaked at USD 37.0 billion in 1997. Immediately following the Asian Financial Crisis, investment levels declined sharply and decreased until 2002. At this five-year turning point, a period of slow but steady recovery punctuated by a few years of noticeable upturns (e.g., 2003, 2005, and 2012) has brought regional PPI investment levels close to pre-crisis levels. In 2016, EAP received the region's third highest PPI investment commitments in the 27-year period, a total of USD 24.8 billion. Moreover, EAP was the only region which performed well in 2016, having grown 46% from 2015, when all the other regions had declining investments. The surge in 2016 investments was driven largely by Indonesia's investments in two multi-billion USD power plants. Over the 27-year period, investments in EAP have been dominated by China, which accounts for 39% of total EAP investments, followed by Malaysia, Philippines, and Indonesia, with 16%, 14%, and 12%, respectively.

While total investment has returned to 1997 levels, the level of investment has not kept pace with the level of GDP growth (see Figure 28). PPI investment commitments as a percentage of GDP peaked in the 1990s. Leading up to the Asian Financial Crisis, investment as a percentage of GDP was approximately 8%. Following the crisis, this measure exhibited a sharp decline until stabilizing around 2002 at a new low equilibrium. In 2016, EAP PPI investments accounted for a meager 0.2% of GDP.

Figure 28. EAP PPI Investment and Investment as % of GDP



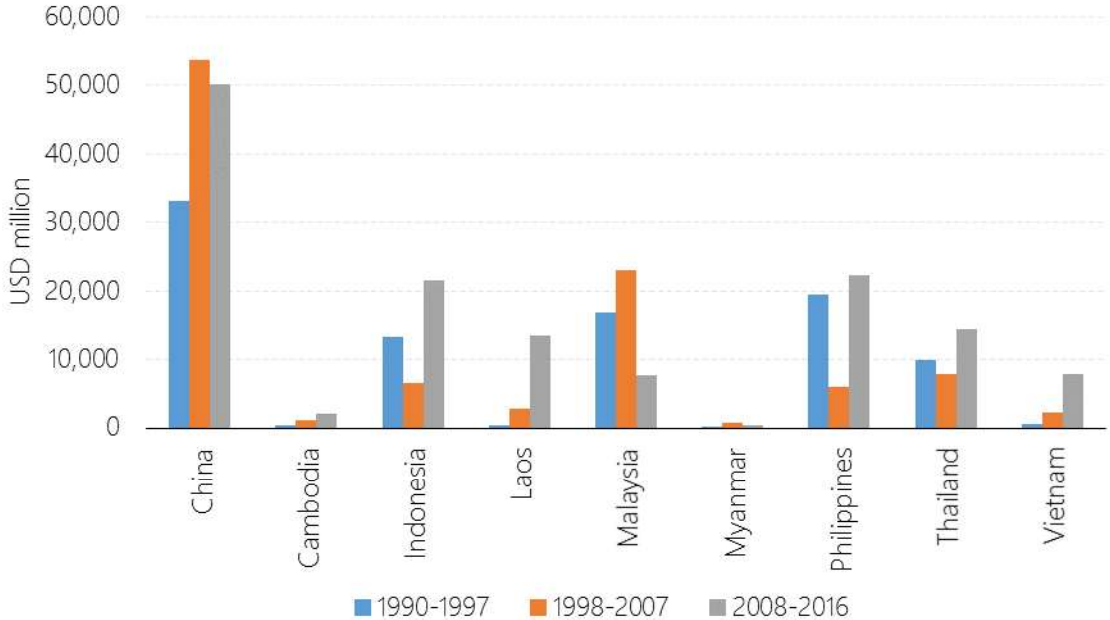
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Country Overview

With respect to investment distributions in EAP, PPI investment commitments have been recorded across sixteen countries: Cambodia, China, Fiji, Indonesia, Lao, Malaysia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Thailand, Tonga, Vanuatu and Vietnam. The distribution of investments in these countries is presented in Figure 29 below, differentiated by three financial eras in order to give some context with respect to major global financial shifts, namely the 1997-1998 Asian Financial Crisis (which divides the first two time periods) and the Global Financial Crisis (which delineates the second from the third time period).

Figure 29 and Table 5 below show that cumulative investments were predominantly made in China in all three eras. In the second period, from 1998-2007, China accounted for almost half of EAP investments. This was also a result of declining investments in Indonesia and Philippines, which regained shares in the last era, accounting for 15.35% and 15.92% collectively from 2008 to 2016. Malaysia's share of investments dropped drastically in the last era to a mere 5.4%, from 22.1% and 17.8% in the first two time periods. Thailand has more consistently accounted for between 8-10% of investments over time.

Figure 29. Total PPI Investments in EAP Countries by Financial Era



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Some countries have also shown recent increases relative to the rest of the region. Laos accounted for only 0.43% of the region's PPI up to 1997, but accounted for 9.7% of investments in the final era. Similarly, Vietnam has grown from 0.66% during the first period to 2.11% and 5.64% over the next two periods, respectively, and Cambodia, while still accounting for only a fraction of overall EAP investment, has nevertheless seen a marked increase in the last decade.

Table 5. Investment and Proportion of EAP Investment by Country & Financial Era

	Period 1: 1990-97		Period 2: 1998-2007		Period 3: 2008-2016	
	%	USD million	%	USD million	%	USD million
China	35.15%	33,140	51.65%	53,686	35.89%	50,090
Cambodia	0.40%	379	1.06%	1,100	1.51%	2,104
Indonesia	14.09%	13,285	6.34%	6,590	15.35%	21,429
Laos	0.43%	410	2.71%	2,812	9.70%	13,540
Malaysia	17.87%	16,845	22.11%	22,981	5.43%	7,580
Myanmar	0.08%	77	0.64%	662	0.27%	375
Philippines	20.63%	19,447	5.83%	6,061	15.92%	22,219
Thailand	10.46%	9,860	7.56%	7,860	10.30%	14,374
Vietnam	0.66%	622	2.11%	2,195	5.64%	7,868
Papua New Guinea	0.22%	206				

Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017)

Investments in the other EAP countries and Pacific Islands have been quite low and have not shown any significant growth. Myanmar's total PPI has accounted for less than 1% in EAP in each decade, accounting to a sum total of USD 1.3 billion.

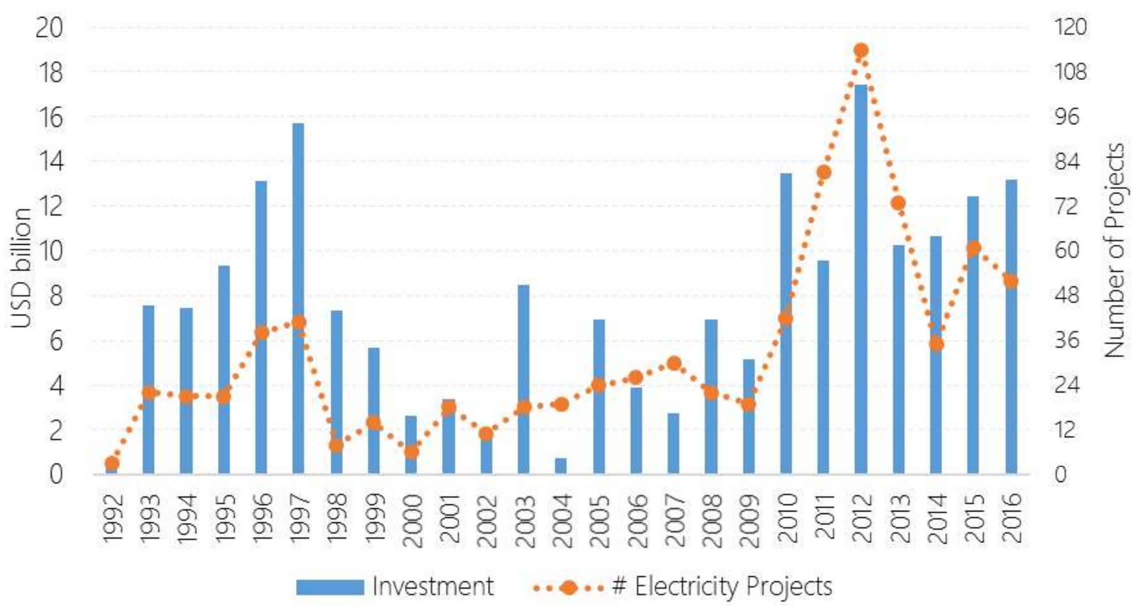
In the Pacific Islands, no PPI investments have been recorded in Fiji, Solomon Islands, or Timor-Leste. Tonga (2000 and 2011) and Vanuatu (1994 and 2009) have seen investments of only USD 16.6 million and USD 25 million, respectively. Papua New Guinea recorded investments of USD 205.6 over only two projects (water and electricity) in 1996 and 1997, and has had no commitments since.

Electricity PPI

In EAP, the energy sector received cumulative investments of USD 213.8 billion, accounting for more than a half of total EAP investments. This volume also represents a quarter of total cumulated global investments in the energy sector, second only to LAC, which contributed 39%.

The investments in the sector saw two crests during the 27-year period, with peaks in 1997 (USD17.4 billion over 45 investment commitments), and more recently in 2012 (USD 17.5 billion across 115 investments). The number of investments per year has increased over the same time frame, indicating smaller project sizes over the period.

Figure 30. EAP Electricity PPI Investments and Projects



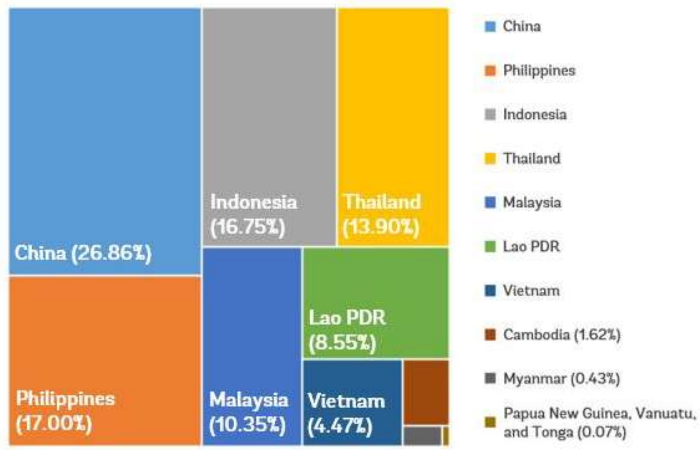
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Country Patterns in EAP Energy PPI

In EAP, China was the highest contributor to electricity investments in the region, accounting for 26.9% of the total sectoral investments, followed by Indonesia and Philippines, each contributing to nearly 17% of the energy investments (see Figure 31).

Investments at the country level are also differentiated by decade. Figure 32 shows that China accounts for most EAP electricity PPI investments, with steady investment over all three financial decades. The Philippines and Indonesia, whose levels are highest in ASEAN, showed a significant contraction following the Asian Financial Crisis, but PPI investments have risen in the latest period to account for about half of all electricity investments in each country.

Figure 31. Investment Distribution in Electricity Projects by Country, 1990-2016

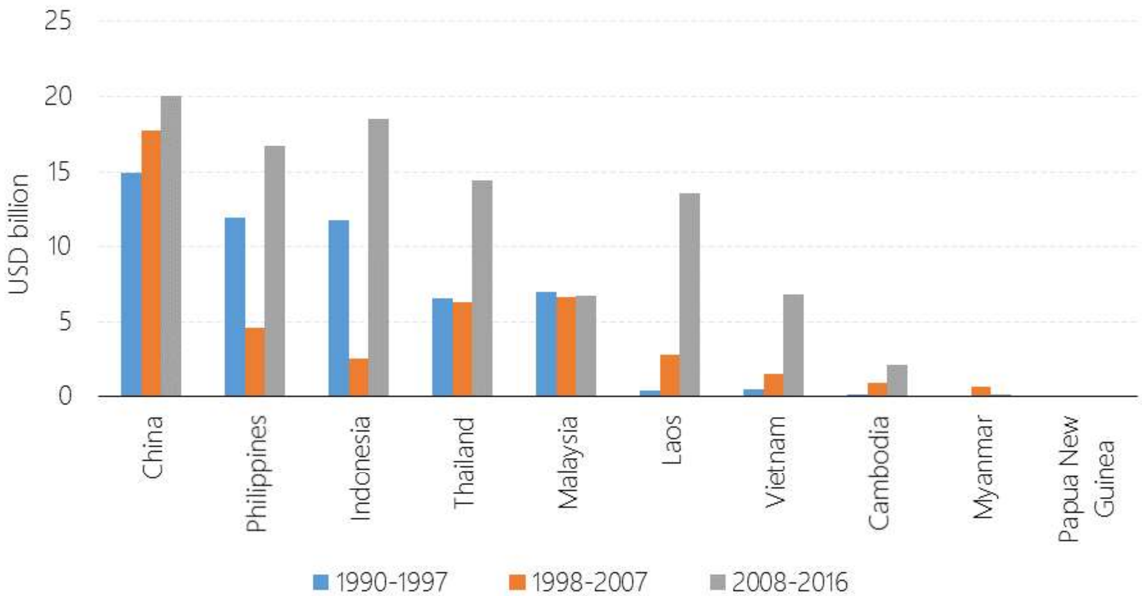


Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Investments in Cambodia, Indonesia, Lao PDR, Thailand and Vietnam are the highest in the current decade, having already surpassed levels in the previous decades. Malaysia saw equal levels of investments in the 1990s and 2000s. The lowest levels of investments were in Myanmar, Cambodia, and the Pacific Island countries. Outside of a USD 99.5 million investment in Papua New Guinea in the early 1990s, there have been no PPI investments in electricity in the Pacific Islands.

Renewable energy has been making inroads in the energy mix of many of the EAP countries, with the share of renewables in the last five years reaching half of the total investments in energy, as compared to only a third of total energy investments in the last 27 years. The major hike in investments in renewable energy is attributable to solar energy, which accounted for 16% of total energy investments in the last five years as compared to only 6% in the last 27 years. China dominated investments in the solar and wind energy space, followed by Thailand. Laos accounted for the bulk of investments in hydropower with USD 12.7 billion out of total hydro investments of USD 29.4 billion, followed by Philippines (USD 4.7 billion).

Figure 32. Total Electricity PPI Investments by Financial Era



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

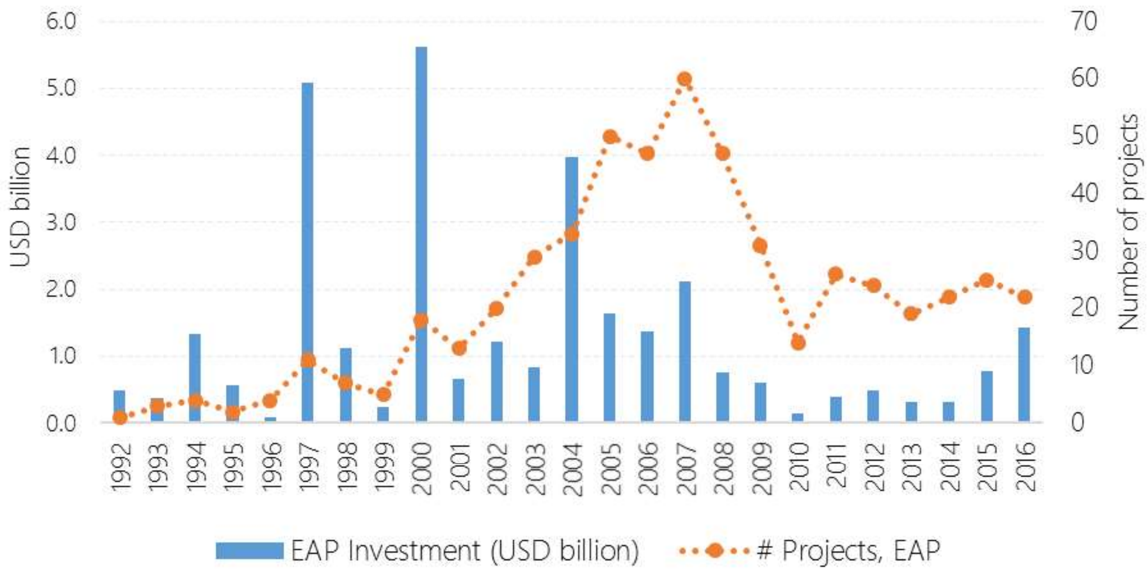
Water and Sewerage PPI

In EAP, the water and sewerage sector received cumulative investments of USD 43.7 billion. While this accounts for only 11% of EAP investments during the period of the study, it represents 44% of global investments in the water and sewerage sector. EAP has been the leader in global water and sewerage investments, followed closely by LAC (43%).

Investments in the sector have varied greatly over different time, peaking in 1997 at USD11.9 billion with the closure of a small number of large concessions arrangements across Southeast Asia (e.g., Jakarta, Philippines, Kuala Lumpur), after which investments declined steeply (aside from moderate spikes in 2000, 2004 and 2007), despite growing numbers of projects. Investments in the sector declined to a 2010 low, at a meager USD 100 million. Investments have since recovered to a new, albeit lower, equilibrium over the past six years, maintaining levels around USD 2 billion per year. The number of investments peaked in the year 2007, with 60 projects receiving investments, after which it continually declined, falling to 22 investments in 2016.

In the past five years, 30% of the projects in the sector received some form of direct government support, all located in China. In contrast to the regional norm of higher shares of investment in Greenfield projects, 77% of the investments in the water and sanitation sector were for Brownfield rehabilitation projects. Further, two-thirds of the regional investments in management and lease contracts were in the water and sewerage sector.

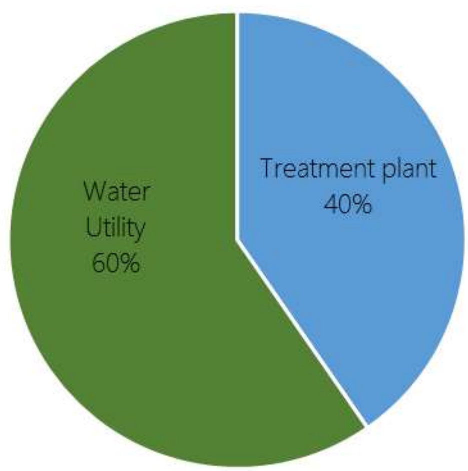
Figure 33. EAP Water and Sewerage PPI Investments and Projects



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Most investment commitments were made for water utilities as opposed to treatment plants. These patterns are reflected of country-level needs and preferences. Papua New Guinea and Vietnam, for example, had no investments recorded for water utilities, but saw USD 106 million and USD 416 million worth of investments in treatment plants, respectively. While China dominated investments in treatment plants, with USD 9.5 billion worth of investments accounting for 68% in EAP, Philippines and Malaysia dominated investments in water utilities, with USD 12.6 billion and USD 11.8 billion in investments.

Figure 34. Investment Distribution in Water & Sewerage PPI by Subsector (1990-2016)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

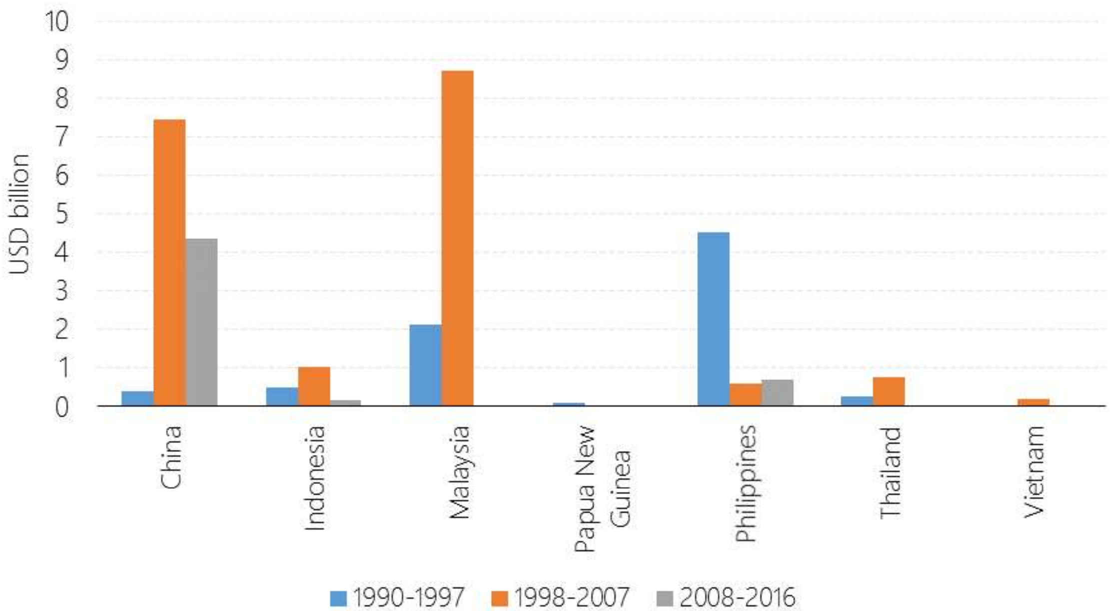
Country Patterns in EAP Water and Sewerage PPI

China, Malaysia, and the Philippines account for 90.5% of investments in EAP's water and sewerage PPI, though historical patterns of private sector participation in water differ. While the Philippines and Malaysia saw a number of very large commitments prior to the Asian Financial Crisis, China has risen to account for 83.4% of investments in the sector since 2008.

While Malaysia accounted for a large proportion of water and sewerage sector investments in the last 27 years, it is notable that there have been no sectoral investments since 2004, due in part to regulatory and tariff difficulties experienced in the state of Selangor. Moreover, growth of sectoral investments in China since 2010 has not kept pace with that of the previous decade.

In the Pacific Islands, Papua New Guinea only had one USD 106 million investment in 1997.

Figure 35. Total PPI Investments in Water and Sewerage by Financial Era

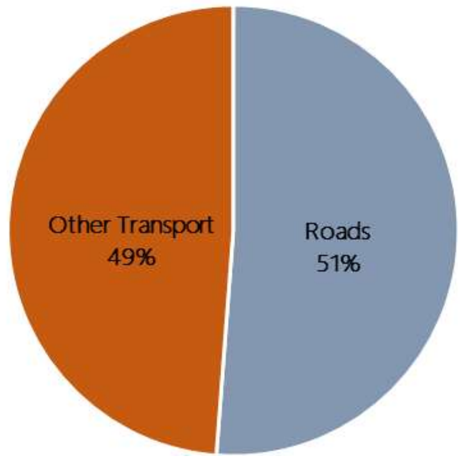


Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Transport PPI

While the PPI database captures data for the road, air, rail, and port transport subsectors, this section focuses on road PPI investments separately from other transport investments. In EAP, road projects account for about half of the investments in the transport sector (51%).

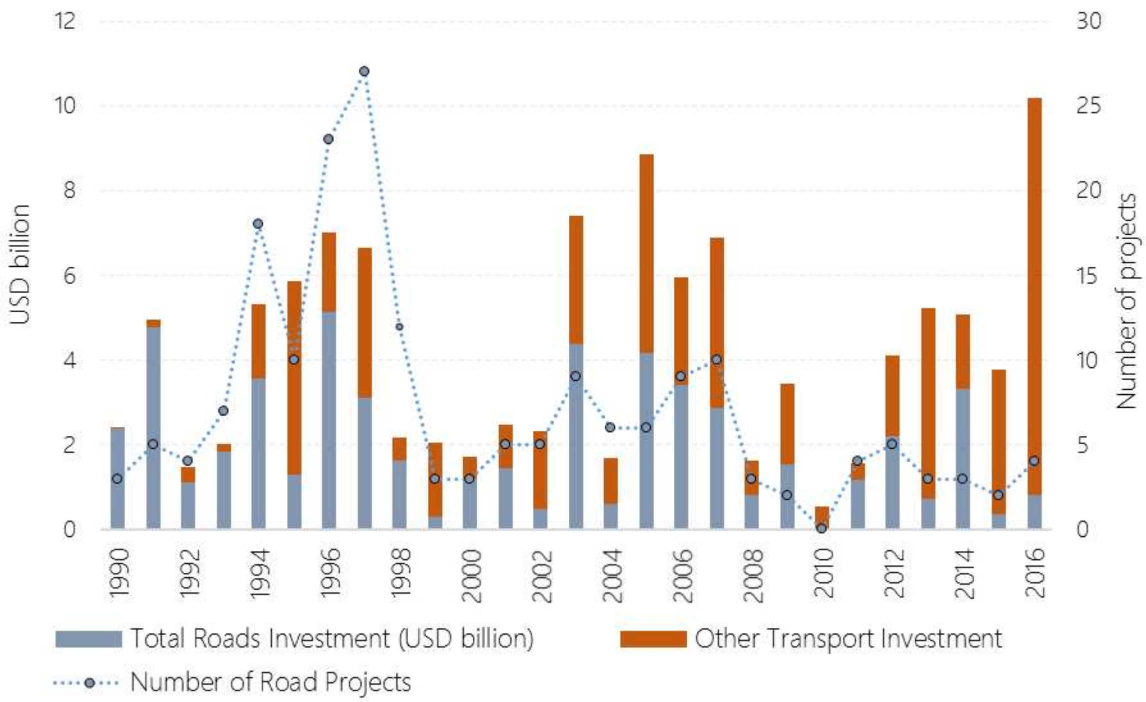
Figure 36. EAP PPI Investment Distribution, Roads versus Other Transport (1990-2016)



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

The EAP transport sector received investments of USD 125.6 billion, a third of total EAP investments between 1990 and 2007, and one-fifth of global investments in transport. Transport investments have seen clear growth and decline cycles around peaks in 1996 (USD 11.5 billion for 35 projects), 2005 (USD 8.9 billion for 22 projects), and 2016 (USD 10.2 billion for 8 projects). Whereas earlier commitments were primarily in the roads subsector, road projects have accounted for much smaller proportions of investments in the sector in recent years.

Figure 37. EAP Transport PPI Investments and Projects



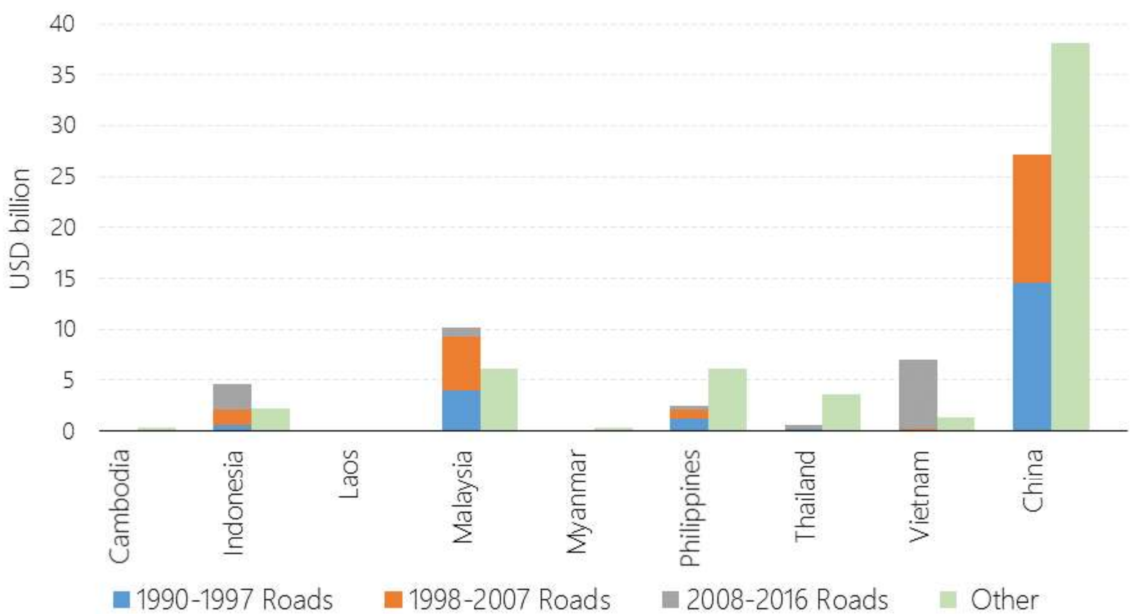
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

Country Patterns in EAP Transport PPI

In EAP, transport sector investments have been dominated by China, with USD 74 billion in investments. China's investment rate has been steadily growing over the past three decades and accounts for 59% of total EAP investments in transport. The second-highest transport investment level was in Malaysia, with investments amounting to USD 24.5 billion, accounting for 20% of the sector totals in EAP. Transport sector investments, however, have been declining in the country, with the highest investments recorded in the 1990s, and only a meagre USD 400 million worth of investments in the current decade.

Only Indonesia and Vietnam have seen a significant upturn in road transport investments since 2008. In fact, almost all of Vietnam's road investment commitments have been made in the last financial decade.

Figure 38. Total Investment in Roads and Other Transport by Financial Era



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on the World Bank PPI database

After a slowdown over the 1998-2007 era, investments in Philippines have gained since 2008. Investments in transport projects in Thailand were mostly made in the 1990s; current levels are extremely low, particularly for the roads subsector. Myanmar, Laos, and Cambodia have received limited investments in their transport sectors, which are all in need of rehabilitation and upgrading. Myanmar and Laos saw no investments in the roads subsector, while Cambodia recorded only USD13 million for small projects in 2002 and 2004.

No investments were recorded for the Pacific Island countries

General Remarks

Overall, during the 27-year period of our study (1990-2016), PPI investment commitments in EAP captured a healthy share of the global investments at 23%, second only to LAC. The share of global investment was higher in the initial years of the study and declined sharply following the Asian Financial Crisis. This was followed by a slow rebound over a 20-year period, finally nearing pre-crisis levels of investment in 2016. In 2016, EAP was the only region which saw an increase in investment levels over the previous year.

Investments in the energy sector dominate EAP, accounting for 56% or USD 213.8 billion of the total EAP investments, followed by the transport sector, which received 33% of total investments at USD 125.6 billion. The water and sewerage sector received only 11% of total EAP investments at USD 43.6 billion.

Investments in EAP are led by China, concentrated primarily in the transport and energy sectors, followed by Malaysia in the water and sanitation sector. Overall, Malaysia, Philippines, and Indonesia are the next biggest contributors to total EAP investments during the entire period of the study. In Malaysia, most investments were recorded over the 1998-2007 period. In the Philippines, Indonesia, Laos, Thailand, and Vietnam, investments all increased following the Global Financial Crisis.

As a share of overall EAP investment, Thailand has consistently accounted for between 8-10% of investments over time. Laos accounted for only 0.43% of the region's PPI up to 1997, but accounted for 9.7% of investments in the last decade. Vietnam's investments in all three sectors have grown from 0.66% to 5.64%, and Cambodia, while still accounting for only a fraction of overall EAP investment, has nevertheless seen a marked increase in PPI during the last decade.

Increased private sector participation can help countries increase infrastructure services to meet a portion of unmet demand. Currently, however, PPI investments account for a very small proportion of the total investments in infrastructure. For instance, in 2015, PPI investment in China was less than 1% of total investment in transport, energy and water. Therefore, PPI investments will continue to be complemented heavily by public sector investments in infrastructure.

Chapter 7 Looking Forward

The following chapter discusses some of the most evident infrastructure development needs in EAP and opportunities for further research. This section also provides a more nuanced picture of the status of infrastructure by examining relationships between quality and access, as well as potential linkages between infrastructure access, human development indicators, and governance. This chapter also discusses informational needs based on the challenges faced in this study, particularly with respect to finding key data for comparison across countries in some sectors and for certain aspects of infrastructure service delivery.

The results of this study suggest that, while infrastructure services are developing in many parts of the EAP, there are marked differences in access to and quality of services between countries (particularly, low- and high-income ASEAN countries and between ASEAN and the Pacific Islands countries) and between rural and urban areas. Large scale investments are still required, particularly in water and sanitation and transport, in several low- and middle-income countries.

In the case of water supply, resources are needed to rehabilitate aging and under-performing urban supply systems and to connect urban users to water supply networks in Cambodia, Laos, Philippines, Papua New Guinea, and Timor-Leste. Urban sanitation requires a step-change in political commitment and strong financial support to address the hugely insufficient urban access levels and quality of sewerage connection and wastewater treatment across the region. Transport networks in some areas need upgrading as well as extension of access to paved roads in most EAP LICs.

There is a clear need to mobilize resources to address some of the high-priority development areas discussed in the following section. Indeed, public finance will remain the largest source of funding for infrastructure development, since PPPs represent only a small share of infrastructure investment and will continue to play a secondary role to government. Nevertheless, they represent an opportunity to both offset the investment burdens on governments and to improve the efficiency of services where quality problems are apparent, especially if contracts and incentives are carefully crafted to promote technological and efficiency gains. The concluding section of this chapter draws linkages amongst aspects of infrastructure and suggests key areas of development for improving access, quality, and cost recovery that may inform decisions about the prioritization of infrastructure projects and private sector participation.

Identifying Key Areas of Development and Informational Weaknesses

Table 6 presents a summary view of the data collected for this study on access, quality, and tariffs and costs, organized by sector. This snapshot gives an overview of areas of weakness in terms of access and quality, as well as the major data gaps hindering cross-country comparison in the region. For each indicator, results for each country are coded as 'good', 'fair', 'poor', or 'neutral' based on the performance of benchmark countries and lowest performers. While these delimiters are somewhat arbitrary, they are intended to give a quick reference to relative performance in the region, both amongst countries, as well as between sectors and pillars of services delivery.

Results on electricity services show that this sector is easily in the best condition in EAP, relative to transport and water and sanitation. The results for sanitation access and quality, on the other hand, show that sewerage and wastewater treatment are the infrastructure systems most in need of extension, upgrading, and rehabilitation. Much of developing EAP is plagued by high rates of diarrheal illness. Few urban areas extend connections to piped sewerage to even half of the country's urban population, and the rates of water treatment after collection are abysmally low.

In the water supply sector, while overall connection to an improved water source (including piped water, wells, etc.) is high, urban connection to piped household connections is patchy. Of perhaps greater concern is the fact that many countries' utilities suffer from moderate to high levels of non-revenue water and poor potability. Aside from high-income countries, Cambodia's capital city utility, Phnom Penh Water, is an outlier with respect to performance, delivering reliable and safe drinking water to an extensive coverage network, particularly considering the country's overall level of development. Overall, a focus for EAP should be on the rehabilitation of existing water networks to reduce inefficiencies due to leakage and theft and to improve the potability of delivered water.

With respect to transport, the ASEAN countries in most need of attention with respect to extension to rural areas are Indonesia, Laos, Malaysia and Myanmar. These countries, along with Philippines and Vietnam, also require significant work for road rehabilitation and upgrading.

Table 6 also shows that many countries lack updated data on access, quality, and tariffs and costs, complicating the ability to compare across the entire region. Cells colored in white, which are associated with tariff data, have no performance attribution. Cells colored in gray are those for which data was unavailable. The most notable data deficiencies are in the Pacific Island, geographically, and in the areas of cost recovery, road costing, and road quality, topically.

Table 6. **Summary of Status Indicators**

Good | Fair | Poor | Neutral | No information

	ACCESS								TARIFFS & COST RECOVERY					QUALITY									
	Electricity			Water		Sanitation		Roads	Electricity			Water		Electricity			Water		Sanitation		Roads		
	Overall	Urban	Rural	Piped Water	Urban Piped Water	Improved Sanitation	Urban Piped Sewerage	Rural Road Access	Res. Tariff	Avg. Tariff	Avg. Tariff – Avg. Cost	Res. Tariff	OCCR	Quality Electricity	T&D Losses	Interruption Frequency	NRW	% Pass Chlorine Test	DALY Index	% WW Treated	Road Quality	% Paved
China	100	100	100	73	87	76.5	85.6	-	0.07	0.10	0.05	0.29	0.76	5.3	5	0.23	20.5	99.9	5	28.8	4.8	-
Cambodia	56.1	82.8	49.2	21	75	42.4	44.8	86.7	0.15	0.19	-	0.16	2.57	3.3	23	19.88	6.7	100	3	0.0	3.4	11
Indonesia	97.0	99.4	94.3	22	33	60.8	-	57.2	0.05	0.07	-0.03	0.46	1.39	4.2	9	1.72	30.4	65.7	3	1.0	3.9	57
Laos	78.1	94.7	68.1	28	64	70.9	1.3	35.3	0.06	0.07	-	0.25	1.07	4.7	-	9.42	20.9	100	1	0.0	3.4	15
Malaysia	100	100	100	96	100	96.0	42.2	48.9	0.07	0.10	0.02	0.14	1.15	5.8	6	0.48	34.4	97.6	5	61.6	5.5	78
Myanmar	52.0	57.9	49.0	8	19	79.6	9.5	58.9	0.04	0.06	-	0.08	-	-	20	-	-	-	2	0.0	-	22
Philippines	89.1	97.3	82.5	43	59	73.9	4.7	84.5	0.20	0.21	-0.11	0.45	2.40	4.0	9	2.71	42.6	93.9	3	40	3.1	81
Thailand	100	100	100	57	76	93.0	8.7	86.7	0.21	0.11	0.02	0.24	-	5.1	6	1.37	-	-	4	44.7	4.2	81
Vietnam	99.2	99.8	98.9	27	61	78.0	3.9	52.9	0.07	0.08	-0.01	0.25	1.51	4.4	9	6.72	22.9	92.4	4	55	3.5	66
Fiji	100	100	76.3	68	96	91.1	-	-	0.08	-	-	0.07	0.59	-	-	8.00	45.4	92.1	4	10	-	-
Papua New Guinea	20.3	76.4	11.9	9	55	18.9	-	21.4	0.25	-	-	0.42	1.78	-	-	134.00	38.4	99.9	1	0.0	-	-
Samoa	97.9	99.2	97.6	85	91	91.5	0.5	-	0.67	-	-	0.50	1.26	-	-	20.00	62.1	94.1	3	-	-	-
Solomon Isl.	35.1	39.4	33.9	26	61	29.8	-	-	0.78	0.90	-	0.73	1.47	-	-	3.20	57.8	89.7	2	-	-	-
Timor-Leste	45.4	63.0	37.0	25	47	40.6	18.2	46.8	0.12	-	-	0.00	-	-	-	-	-	-	1	-	-	-
Vanuatu	34.5	100	11.5	35	61	57.9	6.6	-	-	-	-	-	-	-	-	7.49	18.2	100	2	-	-	-
Brunei	100	100	100	-	-	-	-	92.2	0.01	-	-	0.08	-	5.3	6	0.40	-	-	5	-	4.7	93
Singapore	100	100	100	100	100	100	100	100	0.21	-	-	1.20	-	6.8	2	0.01	3.8	100	5	100	6.3	100
Japan	100	100	100	98	99	100	-	-	0.18	0.24	0.13	1.07	-	6.5	4	0.12	-	-	5	75.8	6.1	-
New Zealand	100	100	100	100	100	100	-	-	0.20	-	-	1.00	1.98	6.3	7	1.84	19.5	-	5	82	4.5	-
South Korea	100	100	100	-	99	100	90.1	94.82	0.05	0.10	-	0.52	2.48	6.20	3	0.08	16.3	-	5	91.5	5.6	-

Notes
Good >90%; Fair 61-90%; Poor <60% coverage
Good >90%; Fair 61-90%; Poor <60% coverage
Good >80%; Fair 51-80%; Poor <50% coverage
Good >80%; Fair 61-80%; Poor <60%
Tariffs: Poor > USD0.4/kWh, otherwise Fair Difference between Average Tariff and Cost of Production: Good (+) value; Poor (-) value
Tariffs: Fair OCCR: Good >=1.98 (NZ Benchmark); Poor <1
QES: Good >6; Fair 4.1-6; Poor <4 T&D Losses: Good <7% (NZ Benchmark); Fair 8-15%; Poor >15% Average Frequency of Interruptions: Good <2 (NZ Benchmark); Fair 2.1-10; Poor >10
NRW: Good <20% (NZ benchmark); Fair 20-40%; Poor >40% Samples Passing Test: Good >98%; Fair 95-98%; Poor<95%
DALY: Good 5; Fair 3-4, Poor 1-2 % WW Treated: >75% Good (South Korea benchmark); 60-75% Fair; <60% Poor
QRI: Good >5; Fair 4.1-5; Poor <4 % Paved Roads: Good >80%; Fair 60-80%; Poor <60%

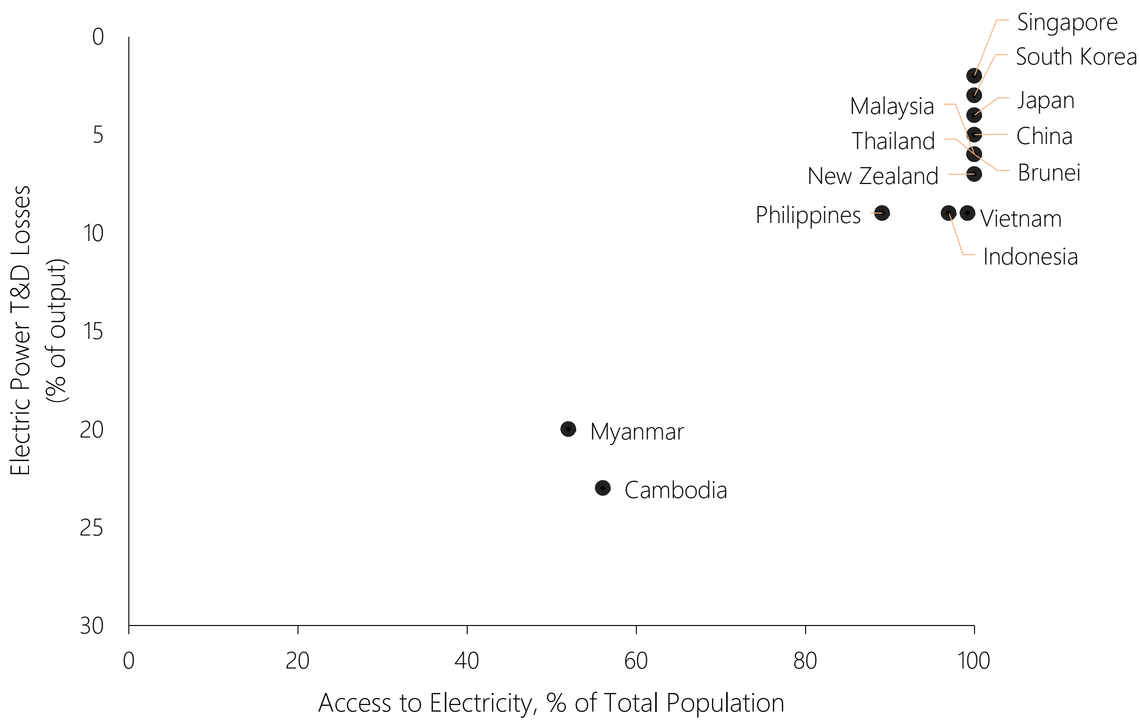
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017)

Relating Aspects of Infrastructure Status: Quality and Access

This section illustrates that access levels and quality, while naturally related as aspects of healthy utilities, are nevertheless not always correlated. In some countries, people have high levels of access, but to relatively poor services. In others, quality is fair, but service coverage is limited.

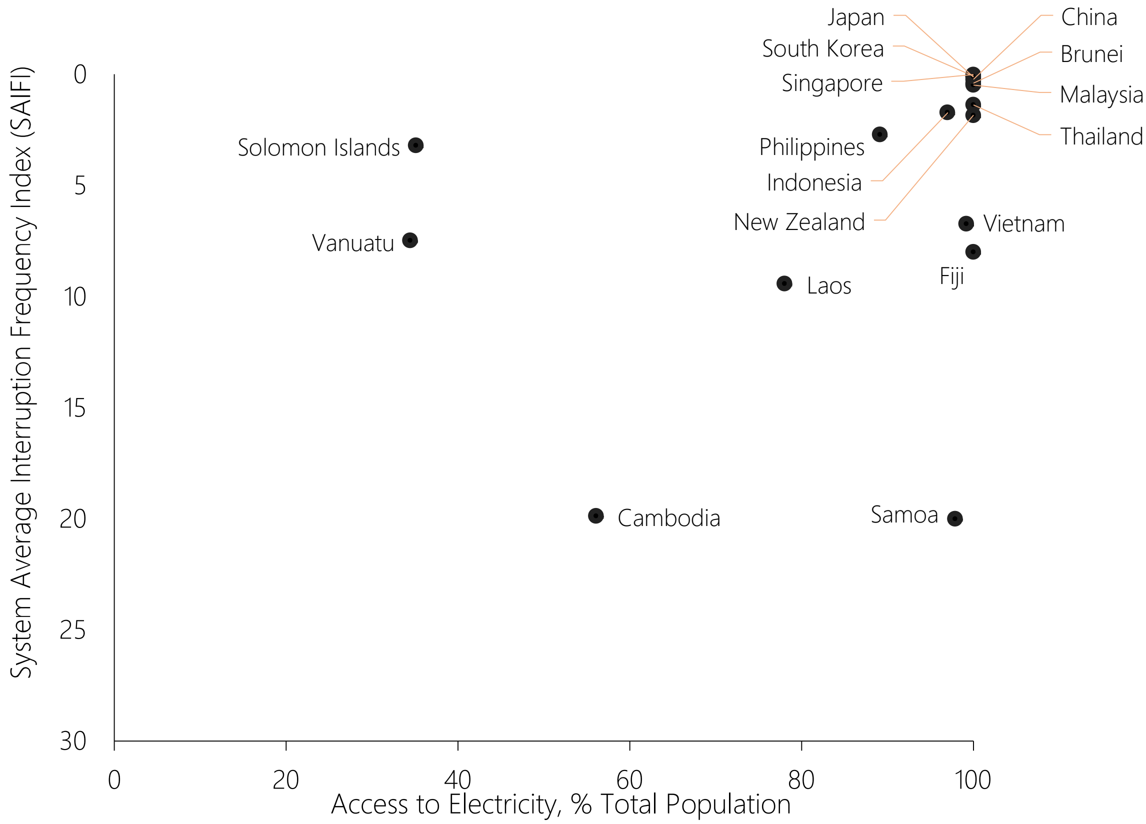
In the case of electricity, most countries with high coverage rates also have high quality. Myanmar and Cambodia, however, are well-covered but continue to suffer problems associated with high transmission losses (see Figure 39). Cambodia also has a high rate of service interruptions. Solomon Island and Vanuatu, on the other hand, have low access levels, but also low incidences of service interruption. Samoa has both low access and high service interruption (see Figure 40), highlighting the significant need in the country to extend services and upgrade production and distribution networks.

Figure 39. Electricity Access vs T&D Losses



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank Group (2015d) and World Bank Group (2015a)

Figure 40. Comparing Electricity Access and Frequency of Service Interruptions



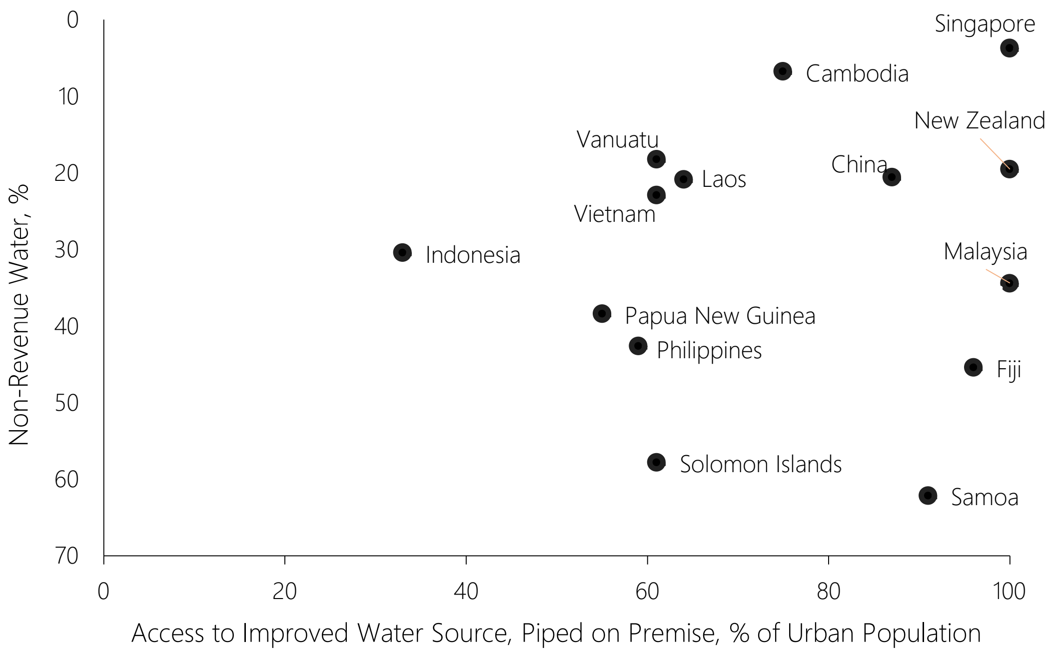
Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank Group (2015d) and World Bank Group (2015a)

Water supply services show more variation between access and quality. Figure 41 shows that Malaysia, Fiji, and Samoa have very high levels of urban supply coverage, but also record high levels of non-revenue water. Philippines, Papua New Guinea, and Solomon Islands have fair access levels, but again, to utilities with high system losses. These losses represent major operational inefficiencies that lead to resource wastage and also limit the collection of revenues needed to cover operational costs and re-invest in capital projects.

This is an important issue to address, because the lack of cost recovery impacts the viability of private participation. That said, there have been several successful stories with respect to NRW-reduction via PPP. Manila Water and Maynilad in the Philippines, for example, have made enormous strides in decreasing levels of NRW, driven largely by the contractual incentives to improve operational efficiencies that, in turn, increase revenues.

Indonesia requires special attention since its access levels are low and NRW is also high. Singapore, on the other hand, is maintaining its strong lead with respect to both coverage and efficiency. Cambodia, driven by the success of the Phnom Penh water utility, is also a top performer in municipal water service in the region.

Figure 41. Urban Access to Piped Water vs Non-Revenue Water



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from IBNET (different years, see Annex IX) and WHO/UNICEF (2015)

Service Performance, Development Outcomes, and Governance

Data suggests an association between governance and health and infrastructure service indicators, though these results must be cautiously interpreted and should not be used to make causal inferences, since they do not isolate the effects of omitted independent variables that may otherwise affect levels of infrastructure service (e.g., income levels, policy factors, geography, etc.) Nevertheless, literature shows that access to and high-quality of infrastructure has positive impacts on human development and quality of life.[70] Further, levels of access and quality are influenced by quality of governance. The simple correlations presented here support this research.

First, increased access to infrastructure is correlated with public health indicators in EAP, particularly in the case of water supply and sanitation. There is an evident relationship between higher levels of access to piped on-site water and lower rates of infant and child mortality.

High-income countries such as Singapore, New Zealand, and Japan have high levels of access and low levels of child mortality, whereas countries like Papua New Guinea, Myanmar, Laos, Vanuatu, Timor-Leste, Cambodia, Indonesia, Solomon Island, Vietnam, and the Philippines

[70] Mauro, P. (1998), Montgomery, M. & Elimelech, M. (2007), Rajkumar, A. & Swaroop, V. (2008).

have low levels of piped water supply and high rates of infant and under-5 mortalities due to diarrhea.

Second, quality of governance and government capacity appear to be related to access levels and quality of services. Good public management and budgeting, as well as the control of corruption, are known to be important factors in infrastructure development.[71] Again, while the following figures do not attribute causal relationships between measures of governance and infrastructure performance, particularly since they do not control for other factors, strong correlations between performance and governance are worth noting.

Figures 42 to 45 show apparent linear correlations between access to electricity, improved household water supply, and rural roads and government effectiveness. These relationships support research that suggests the importance of transparency, accountability, and sound principles and practice of public management to effective infrastructure development. Issues surrounding contract inflation, non-competitive procurement, and procurement fraud are rife in infrastructure development. Since government capacity to assess the quality of bid data is often weak and contracts often large, even small-percentage skimming can be highly lucrative. For this reason, efforts to support capacity building and the imposition of clear and transparent procurement processes is key to promoting development in the region.

Figure 42. Access of Piped Water and Public Health

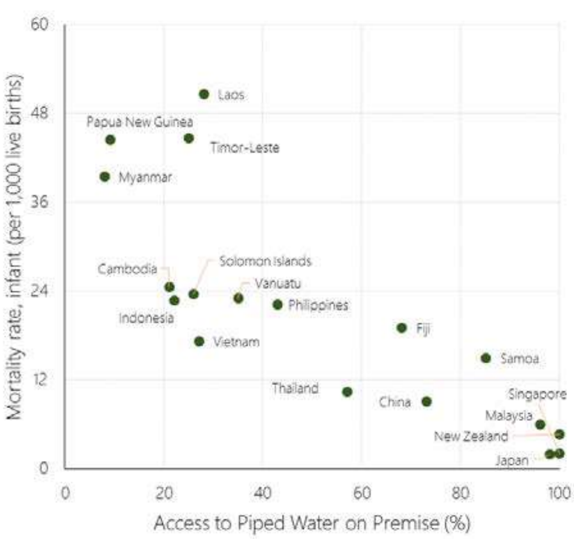
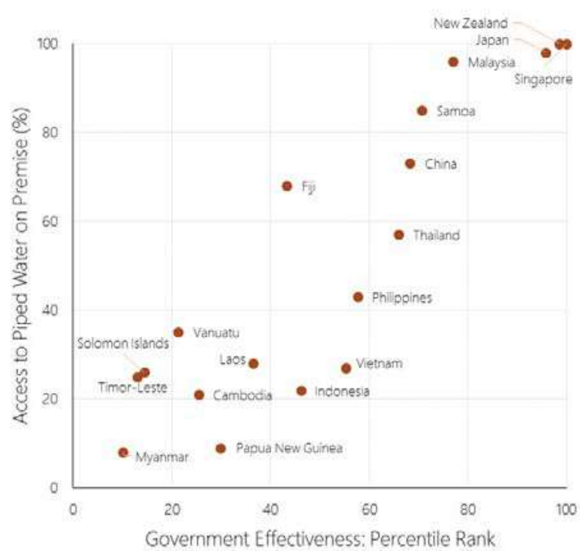


Figure 43. Access of Piped Water and Governance



71 Tanzi, V., Driscoll, D., & Davoodi, H. (1998), Gillanders, R. (2014)

Figure 44. Quality of Electricity Supply vs Government Effectiveness

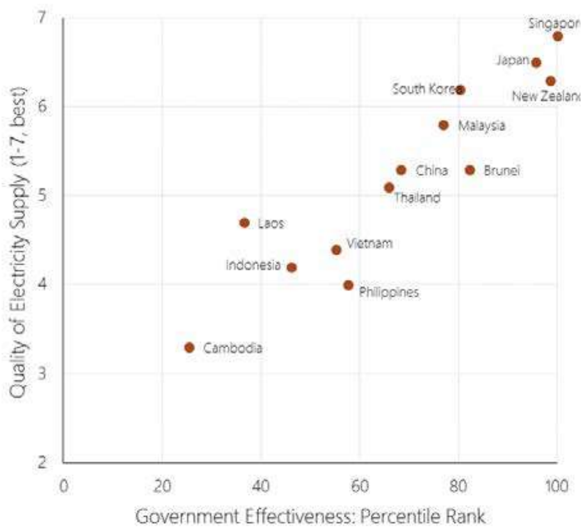
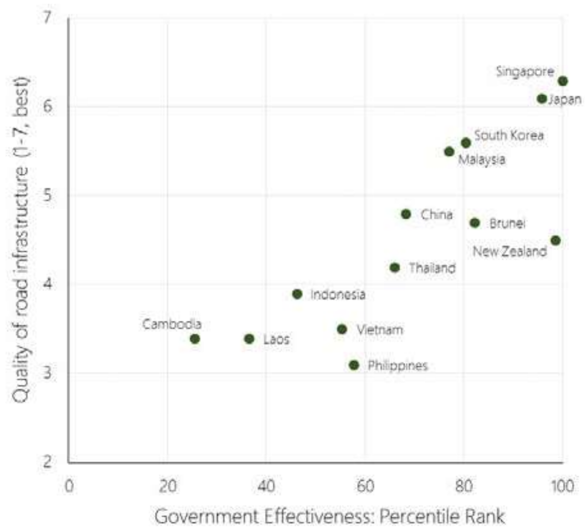


Figure 45. Road Quality vs Government Effectiveness



Source: World Bank Infrastructure, PPPs & Guarantees (IPG) Group, Singapore (2017), based on data from World Bank Group (2015d)

Conclusions on Developing EAP Infrastructure

Infrastructure services are essential to the development of the EAP region. The reliable provision of economic infrastructure to both rural and urban populations is a critical barrier to the attainment of sustainable development goals and the sustenance of current levels of economic growth. This analysis has presented the status of infrastructure in the region with respect to access, quality, and tariffs and costs. It has also provided an overview of the current participation of the private sector in infrastructure provision.

The provision of sanitation and urban access to piped household sewerage is the sector in greatest need of attention. Evident impacts on health and productivity underscore the importance of good sanitation. Development of this sector will depend on strong political will, as demand for sanitation is typically lower than the levels expected by rational choice economics. Moreover, capacity for effective water treatment must be expanded, particularly in developing ASEAN and the Pacific Islands.

In water supply, urban connections to the piped network remain low in Indonesia, Myanmar, Philippines, and Papua New Guinea, where the poor are most burdened by reliance on expensive sources of water, such as private water vendors. Moreover, supplied water remains non-potable in many places, contributing to high incidences of diarrheal illness. This is compounded by the extremely low rates of wastewater treatment.

While electricity coverage is high, there are areas of developing ASEAN (Cambodia and Myanmar) and several Pacific Island countries – particularly amongst rural communities – where service extends to less than half of the population. Road access is also fairly good, but many roads in developing ASEAN and the Pacific Islands are in need of upgrading, particularly those that are components of critical trade routes marked for development to improve regional connectivity.

Private participation has resumed pre-crisis investment levels in the energy and road sectors, but the appetite for water PPP is greatly diminished in EAP. Issues of cost recovery, tariff levels, and NRW are critical barriers to mobilizing resources for water PPPs. Governments may have to invest in initial improvements (such as NRW reduction and increased metering and collection) and address tariff ceilings and subsistence subsidization plans to increase the bankability of potential PPPs in the sector.

Lastly, improved data quality is an ongoing need. These include up-to-date comparable cross-country data on per-unit tariffs and costs (capital and operating), since current estimates are limited to urban areas and often only the largest cities. This would also enable a better assessment of cost recovery levels for both electricity and water utilities. Given the importance of water quality to public health, there is a need to collect scientific water quality data (such as presence of coliforms, etc.) in piped water systems. In general, there is little information on cost of road construction, nor are there consistent and objective quality assessments available. Geographically, reliable data is extremely limited in the Pacific Islands; thus, analysis of several indicators in this report was limited to ASEAN countries.

Aspects of infrastructure service delivery are highly interrelated and often difficult to compare across countries, not only due to data issues, but also due to high variation in developmental priorities, physical geographies, the availability of natural resource inputs, and complexities in measurement of concepts like efficiency. Nevertheless, this report provides an overview of the status of infrastructure services in EAP and highlights priority areas on which scarce public resources should be focused and for which opportunities for private-sector participation should be explored and supported. Moreover, the analysis provides focus for the World Bank with respect to the areas where both lending and technical assistance may result in the most significant developmental impacts.

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Annexes

Annex I. List of sources for electricity tariff for retail residential users (USD/kWh) for tariff block 30 kWh monthly consumption

Country	City	Utility	Source/Year
Brunei Darussalam	National Tariff	National Regulation	Brunei Department of Electrical Services (2012). "Electricity Tariff".
Cambodia	Phnom Penh	Electricite du Cambodge	RISE database (2013)
China	Beijing	Municipal Regulation	Beijing Municipal Commission of Development and Reform (2016)
Fiji	National Tariff	Fiji Electricity Authority	Fiji Electricity Authority (2016). "Annual Report 2015." Suva, Fiji.
Indonesia	Jakarta	Perusahan Listrik Negara	RISE database (2013)
Japan	Tokyo	TEPCO	TEPCO (2016). "Customer Communication – Rate Calculation"
Lao PDR	Vientiane	Electricite du Laos	RISE database (2013)
Malaysia	Kuala Lumpur	Tenga Nasional Berhad	Tenaga Nasional Berhad (2014). "Tariffs rates".
Myanmar	Yangon	Yangon Electricity Supply Corporation	RISE database (2013)
New Zealand	National tariff	National Regulation	Ministry of Business, Innovation and Employment, New Zealand (2016) "Electricity Prices - Data Table."
Papua New Guinea	National Tariff	PNG Power	PNG Power (2013) "Schedule of 2013 First & Second Quarter Electricity Tariffs."
Philippines	Quezon City	MERALCO	RISE database (2013)
Samoa	National Tariff	Electricity Power Corporation	Electricity Power Corporation (EPC). (2017) "Electricity Rates."
Singapore	National Tariff	SP Group	SP Group, Singapore (2017) "Electricity Tariff Rates."
Solomon Islands	Honiara	Solomon Islands Electricity Authority	RISE database (2013)
South Korea (Rep of K.)	Seoul	KEPCO	Korea Electric Power Corporation (KEPCO) (2016). "Electric tariffs calculation".
Thailand	Bangkok	Metropolitan Energy Authority (MEA)	Metropolitan Electricity Authority (MEA) (2015) "Temporary tariff"
Timor Leste	National Tariff	National Regulation	Ministry of Finance, Timor-Leste, and World Bank (2015) "Timor-Leste Public Expenditure Review: Infrastructure - A Joint Ministry of Finance and World Bank Review of the Quality of Infrastructure Spending in Timor-Leste, Focusing on Roads, Irrigation and Electricity."
Vietnam	National Tariff	Vietnam Electricity Corporation	Vietnam Electricity Corporation. 2016. "Retail Electricity Tariff".

Annex II. List of sources for electricity operating cost (USD/m^3) average

Country	City	Utility	Source/Year
Cambodia	National Average	ADB report	ADB (2015). "Renewable Energy Developments and Potential in the Greater Mekong Region"
China	Beijing	Huadian Energy	Huadian Energy (2016). "Financial Report 2016"
Fiji	National Average	Fiji Electricity Authority	Fiji Electricity Authority (2015). "Annual Report"
Indonesia	National Average	PWC report	PricewaterhouseCoopers (2013). "Power in Indonesia"
Japan	Tokyo	TEPCO	RISE database (2013)
Lao PDR	Vientiane	Electricite du Laos	RISE database (2013)
Malaysia	Kuala Lumpur	Tenga Nasional Berhad	RISE database (2013)
Myanmar	Yangon	Yangon Electricity Supply Corporation	RISE database (2013)
New Zealand	National Average	New Zealand Electricity Authority	New Zealand Electricity Authority (2013)
Papua New Guinea	National Average	PNG Power	Independent Consumer and Competition Commission (ICCC) (2012). "The Proposed Draft Report on PNG Power Limited's Electricity Regulatory Contract Review".
Philippines	Quezon City	MERALCO	RISE database (2013)
Samoa	National Average	Electric Power Corporation	Electric Power Corporation (2015). "Annual Report 2015"
Singapore	Singapore	SP Group	SP Group (2017). "Billing – Tariff Rates"
Solomon Islands	Honiara	Solomon Islands Electricity Authority	RISE database (2013)
South Korea (Rep of K.)	Seoul	KEPCO	RISE database (2013)
Thailand	Bangkok	Electricity Generation Authority (includes MEA and PEA)	Electricity Generation Authority (2014) "Action Plan and Budget FY 2014"
Timor Leste	National Average	Joint report WB and Timor Leste Ministry of Finance	Ministry of Finance and World Bank (2015). "Timor-Leste Public Expenditure Review: Infrastructure".
Vietnam	Ho Chi Minh City	Ho Chi Minh Power Corporation	RISE database (2013)

Annex III. List of sources for average retail electricity tariff for all end-users

Country	City	Utility	Source/Year
Cambodia	Electricite du Cambodge	Phnom Penh	RISE database (2013)
China	State Grid Power Corporation	Shanghai	RISE database (2013)
Indonesia	Jakarta	Perusahan Listrik Negara	RISE database (2013)
Japan	Tokyo	TEPCO	RISE database (2013)
Lao PDR	Vientiane	Electricite du Laos	RISE database (2013)
Malaysia	Kuala Lumpur	Tenga Nasional Berhad	RISE database (2013)
Myanmar	Yangon	Yangon Electricity Supply Corporation	RISE database (2013)
Philippines	Quezon City	MERALCO	RISE database (2013)
Solomon Islands	Honiara	Solomon Islands Electricity Authority	RISE database (2013)
South Korea (Rep of K.)	Seoul	KEPCO	RISE database (2013)
Thailand	Bangkok	Metropolitan Electricity Authority	RISE database (2013)
Vietnam	Ho Chi Minh City	Ho Chi Ming Power Corporation	RISE database (2013)

Annex IV. List of sources for water tariff (USD/m^3) for a 15m^3 monthly consumption

Country	City	Utility	Source/Year
Brunei Darussalam	Bandar Seri Begawan	Jabatan Perkhidmatan Air	GWI database (2016)
Cambodia	Phnom Penh	Phnom Penh Water Authority	GWI database (2016)
China	Shanghai	Shanghai Water Supply Company	GWI database (2016)
Fiji	Suva	Water Authority of Fiji	IBNET database (2015)
Indonesia	Jakarta	Palyja	GWI database (2016)
Japan	Tokyo	Bureau of Waterworks Tokyo	GWI database (2016)
Lao PDR	Vientiane	Nampapa Nakhoneluang	Vientiane Water Supply Enterprise (Nampapa Nakhoneluang) (2016) "Water prices and how to calculate"
Malaysia	Kuala Lumpur	SYABAS	GWI database (2016)
Myanmar	Yangon	Water Supply and Sanitation Department of Yangon City Development Committee	UNESCAP (2014) "Yangon's Water Supply Treatment Issues." presented at the Training Course on Capacity Building in Urban Water Management, Yangon, Myanmar
New Zealand	Auckland	Watercare	GWI database (2016)
Papua New Guinea	Port Moresby	Eda Ranu Water and Sewerage Company	GWI database (2016)
Philippines	Manila	Maynilad Water Service Inc	GWI database (2016)
Philippines	Manila	Manila Water Company	GWI database (2016)
Samoa	Apia	Samoa Water Authority (SWA)	Samoa Water Authority (SWA) (2016) "Tariffs"
Singapore	Singapore	Public Utility Board (PUB)	GWI database (2016)
Solomon Islands	Guadacanal Province	Solomon Islands Water Authority	IBNET database
South Korea (Rep of K.)	Seoul	Arisu	GWI database (2016)
Thailand	Bangkok	Metropolitan Water Authority	GWI database (2016)
Timor Leste	Dili	National Directorate of Water Supply	World Bank and WSP (2015). "Water Supply and Sanitation in Timor-Leste: Service Delivery Assessment–Turning Finance into Services for the Future"
Vietnam	Ho Chi Minh	Ho Chi Minh City Water Company	GWI database (2016)

Annex V. List of sources for water utility average operating cost (USD/m^3)

Country	No of Utilities in the IB-Net database	% of population covered by IB-net utilities as% of Total Urban Population	Source/Year
Cambodia	1	66%	IBNET Benchmarking database (2013)
China	42	3%	IBNET Benchmarking database (2012)
Fiji	1	100%	IBNET Benchmarking database (2016)
Indonesia	7	2%	IBNET Benchmarking database (2004)
Japan	N/A	N/A	Japan Water Works Association (2016). "Water Supply in Japan 2016." Tokyo, Japan.
Lao PDR	2	2%	IBNET Benchmarking database (2008)
Malaysia	7	83%	IBNET Benchmarking database (2007)
Myanmar	N/A	N/A	JICA (2014). "The Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City, in the Republic of the Union of Myanmar - Vol VI." Sewerage and Drainage System Master Plan. Japan International Cooperation Agency.
New Zealand	47	90%	IBNET Benchmarking database (2016)
Papua New Guinea	1	78%	IBNET Benchmarking database (2016)
Philippines	25	38%	IBNET Benchmarking database (2009)
Samoa	1	100%	IBNET Benchmarking database (2014)
Singapore	N/A	N/A	Public Utilities Board (2016). "Annual Report and Financial Report FY 2015." Singapore: PUB, Singapore's National Water Agency
Solomon Islands	1	54%	IBNET Benchmarking database (2016)
South Korea (Rep of K.)	161	100%	IBNET Benchmarking database (2014)
Thailand	N/A	N/A	Metropolitan Waterworks Authority (2015). "Saving Water Together - Annual Report 2015." Bangkok, Thailand.
Vietnam	86	98%	World Bank (2016). Investment Consultancy and Technology Transfer Limited Company (InvestConsult Group). 2016. "Vietnam Urban Water and Sewerage Sector Performance Database for Year 2013 and 2014 - Assessment Report (Final Report)." 2016: World Bank and Ministry of Construction, Vietnam.

Annex VI. List of sources for water utility operating cost coverage ratio

Country	No of Utilities in the IBNET database	% of population covered by IBNET utilities as % of Total Urban Population	Source/Year
Cambodia	1.00	66%	IBNET Benchmarking database (2013)
China	42.00	3%	IBNET Benchmarking database (2012)
Fiji	1.00	100%	IBNET Benchmarking database (2016)
Indonesia	7.00	2%	IBNET Benchmarking database (2004)
Lao PDR	2.00	3%	IBNET Benchmarking database (2008)
Malaysia	7.00	83%	IBNET Benchmarking database (2007)
New Zealand	47.00	90%	IBNET Benchmarking database (2016)
Papua New Guinea	1.00	78%	IBNET Benchmarking database (2016)
Philippines	25.00	38%	IBNET Benchmarking database (2009)
Samoa	1.00	100%	IBNET Benchmarking database (2014)
Solomon Islands	1.00	54%	IBNET Benchmarking database (2016)
South Korea (Rep of K.)	161.00	100%	IBNET Benchmarking database (2014)
Vietnam	86.00	98%	IBNET Benchmarking database (2014)

Annex VII. List of sources for wastewater tariff (USD/m^3)

Country	City	Utility	Source/Year
Brunei Darussalam	Bandar Seri Begawan	Jabatan Perkhidmatan Air	GWI database (2016)
Cambodia	Phnom Penh	Phnom Penh Water Authority	GWI database (2016)
China	Shanghai	Shanghai Water Supply Company	GWI database (2016)
Fiji	Suva	Water Authority of Fiji	IBNET database (2015)
Indonesia	Jakarta	Palyja	GWI database (2016)
Japan	Tokyo	Bureau of Waterwoks Tokyo	GWI database (2016)
Malaysia	Kuala Lumpur	SYABAS	GWI database (2016)
New Zealand	Auckland	Watercare	GWI database (2016)
Papua New Guinea	Port Moresby	Eda Ranu Water and Sewerage Company	GWI database (2016)
Philippines	Manila	Maynilad Water Service Inc	GWI database (2016)
Philippines	Manila	Manila Water Company	GWI database (2016)
Samoa	Apia	Samoa Water Authority (SWA)	IBNET database (2016)
Singapore	Singapore	Public Utility Board (PUB)	GWI database (2016)
Solomon Islands	Guadacanal Province	Solomon Islands Water Authority	IBNET database (2016)
South Korea (Rep of K.)	Seoul	Arisu	GWI database (2016)
Thailand	Bangkok	Metropolitan Water Authority	GWI database (2016)
Vietnam	Ho Chi Minh	Ho Chi Minh City Water Company	GWI database (2016)

Annex VIII. List of sources for wastewater operating cost (USD/m^3) average

Country	No of Utilities in the IB-Net database	% of population covered by IB-net utilities as% of Total Urban Population	Source/Year
Cambodia	1	0.66	IBNET Benchmarking database (2013)
China	42	0.03	IBNET Benchmarking database (2012)
Fiji	1	1	IBNET Benchmarking database (2016)
Indonesia	7	0.02	IBNET Benchmarking database (2004)
Lao PDR	2	0.03	IBNET Benchmarking database (2008)
Malaysia	7	0.83	IBNET Benchmarking database (2007)
New Zealand	47	0.9	IBNET Benchmarking database (2016)
Papua New Guinea	1	0.78	IBNET Benchmarking database (2016)
Philippines	25	0.38	IBNET Benchmarking database (2009)
Samoa	1	1	IBNET Benchmarking database (2014)
Solomon Islands	1	0.54	IBNET Benchmarking database (2016)
South Korea (Rep of K.)	161	1	IBNET Benchmarking database (2014)
Vietnam	86	0.98	IBNET Benchmarking database (2014)

Annex IX. List of sources for water quality indicators (non-revenue water, continuity of service, and quality of water supplied)

Country	No of Utilities in the IBNET database	% of population covered by IBNET utilities as% of Total Urban Population	Source/Year
Cambodia	1	66.00%	IBNET Benchmarking database (2013)
China	42	3.00%	IBNET Benchmarking database (2012)
Fiji	1	100.00%	IBNET Benchmarking database (2016)
Indonesia	7	2.00%	IBNET Benchmarking database (2004)
Lao PDR	2	3.00%	IBNET Benchmarking database (2008)
Malaysia	7	83.00%	IBNET Benchmarking database (2007)
New Zealand	47	90.00%	IBNET Benchmarking database (2016)
Papua New Guinea	1	78.00%	IBNET Benchmarking database (2016)
Philippines	25	38.00%	IBNET Benchmarking database (2009)
Samoa	1	100.00%	IBNET Benchmarking database (2015)
Singapore	1	100.00%	IBNET Benchmarking database (2008)
Solomon Islands	1	54.00%	IBNET Benchmarking database (2016)
South Korea (Rep of K.)	161	100.00%	IBNET Benchmarking database (2014)
Vanuatu	1	48.00%	IBNET Benchmarking database (2015)
Vietnam	86	98.00%	IBNET Benchmarking database (2014)