ASIAN INFRASTRUCTURE INVESTMENT BANK

Asian Water Sector Analysis
A Technical Background for the Asian Infrastructure Investment Bank (AIIB) Water Sector Strategy

August 2019

(Prepared with technical support from the International Water Management Institute)

Abbreviations

ADB	Asian Development Bank
AfDB	African Development Bank
AFD	French Development Agency
AIIB	Asian Infrastructure Investment Bank
CDM	Clean Development Mechanism
EIB	European Investment Bank
EPC	Engineering Procurement Construction
GCF	Green Climate Fund
IaDB	Islamic Development Bank
IFC	International Finance Corporation
IFI	international financial institution
IWMI	International Water Management Institute
MDB	multilateral development bank
MIGA	Multilateral Investment Guarantee Agency
NDC	Nationally Determined Contributions
PPP	Public Private Partnership
SDG	Sustainable Development Goal
USAID	United States Agency for International Development
WB	World Bank

Contents

1. Regional Context and Drivers 4
2. Key Water Sector Issues in Asia 7
  2.1. Water Supply and Sanitation 11
    2.1.1. Trends in water supply and sanitation 11
    2.1.2. Performance of water service providers 14
    2.1.3. Trends in Public-Private Partnerships in Water Supply and Sanitation 17
  2.2. Irrigation and Drainage 18
  2.3. Energy 20
  2.4. Water-Related Disasters: Floods and Droughts 21
  2.5. Freshwater Ecosystems 23
  2.6. Navigation 24
3. Cross-Cutting Issues 27
  3.1. Governance 27
  3.2 Nexus 28
  3.3 Gender and Inequality 28
  3.4 Resilience 29
4 Water Infrastructure 31
  4.1 Economic and Financial Characteristics of Water Infrastructure 34
5 Water Infrastructure Investment in Asia 37
  5.1 Investment Trends 37
  5.2 Investment Needs 40
    5.2.1 Overview of infrastructure investment need and gap 40
    5.2.2 Infrastructure investment needs scenarios by sub-region and country 43
  5.3 Financing Strategies and Opportunities 46
    5.3.1 Overview of Water Sector Financing 46
    5.3.2 Financing Challenges 47
6. Water Infrastructure for Development: Lessons Learned 51
  6.1 Strengthen Institutions and Policies 51
  6.2 Promote Financial Sustainability 52
  6.3 Understand Risk-Reward Characteristics 52
  6.4 Improve Long-term Capital Planning 54
  6.5 Consider Public-Private Partnerships 54

6.6 Engage Stakeholders and Beneficiaries 55
6.7 Develop More Incentives 55
Appendix I: Cost of water infrastructure investment by country 57

1. Regional Context and Drivers

Water management and related infrastructure have been crucial for economic growth, food security, public health and trade throughout Asia's history. Harnessing water's productive potential and mitigating its destructive force remain a key priority to achieve better social and economic outcomes in Asia, and beyond. Water investments take place in a complex and dynamic socio-economic and environmental context, characterized by accelerating drivers including population growth, increasing urbanization, rampant ecological and environmental degradation, and climate change.

Sixty percent of the world's population lives in Asia (4.5 billion).[1] This number is set to increase, with UN projections suggesting that Asia's population might grow by another 750 million people over the next 30 years, reaching more than five billion by 2050.[2] Asia's share of urban population, currently at 50 percent[3] is expected to reach about 66 percent by 2050.[4] Two countries in Asia (China and India) alone are projected to add 416 million and 255 million urban dwellers by 2050, respectively.[5] As populations increase and become urbanized, water, energy and food demands grow and governments struggle to keep up. Access to piped water supply, for example, is declining in many urban areas.[6] In addition, food consumption tends to shift towards animal-rich diets, increasing demand for water-intensive food commodities.[7]

Asia has achieved remarkable economic success over the past five decades; however, this has been accompanied by rapid environmental degradation. Degradation of ecosystems and its related services are reported to be significant and growing across the region.[8] Eight of the top ten most plastic-polluted rivers in the world are in Asia,[9] and the continent's freshwater ecosystems are in worse condition than forest, grassland and coastal ecosystems.[10] Scientific estimates show that about 40 percent of Asia's wetlands have disappeared since 1970.[11]

Asia's climate change induced water challenges are as diverse as its physical geography. Asia's mountain systems are a global warming hotspot. Even if global warming is kept to 1.5°C, warming in the Hindu Kush Himalaya mountains will likely be at least 0.3°C higher, and in the northwest Himalaya and Karakoram mountains at least 0.7°C higher[12]. This warming could trigger increased glacial melt, and less predictable water availability impacting the water, energy and food security of more than 1.9 billion people living in the 10 river basins originating in these mountains.[13] Beyond mountain systems, Asia's low-lying coastal areas also face threats from sea-level rise and increased frequency of coastal storms. Under a business-as-usual scenario, sea level may rise by 1.4 meters by the end of the century.[14] While countries with very long coastlines, and low-lying deltas (e.g., China, Vietnam, Bangladesh) are projected to be most affected in absolute terms, small-island states will bear the highest relative impacts from sea-level rise and increasing frequency of tropical cyclones.[15] Finally, Asia's tropical regions might experience more variable and intense seasonal precipitation events, including changes to the pattern of the monsoons.[16]

Asia is already experiencing the negative impacts of increased hydrological variability[17]. Intensification of the hydrological cycle, with attendant increase in the frequency and intensity of extreme events, is expected to accompany climate change. In Asia, the number of record-breaking rainfall events has already increased over the period 1981-2010 across the continent, doubling in Southeast Asia[18]. This trend is expected to continue into the future[19]. More extreme precipitation events have implications for the risk of flooding, in particular for cities and Asia's dry regions which are not well equipped to deal with these events[20]. Asia is also greatly impacted by drought, with severe impacts on economies and population. In China alone, droughts have been estimated to cost the economy an average USD 4.2 billion per year (about 0.25% of GDP)[21]. By the end of the century, droughts are projected to happen 5 to 10 times more frequently in West and Southern Asia[22]. Given Asia's projected economic and population growth, more assets and people will be exposed to water extremes unless mitigating action is taken.

Against this backdrop, investments in water infrastructure become crucial for Asia to be able to reach the goals expressed in global, regional and national policy agendas. At the global level, the Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction provide a framework for investments in the water sector. At the national level, priorities expressed by AIIB client countries include investments in water-related disaster risk reduction[23], reducing water pollution[24], increasing access to water supply and sanitation and expanding irrigation for food security. Investing also in multipurpose water infrastructure for flood control and hydropower development, amongst other uses, is seen as one solution to address the challenges described.

Water is a shared resource, so investments in water infrastructure are also crucial to promote cross-border benefits and connectivity. Asia's international rivers carry a large share of the region's water across national boundaries, and this proportion is even higher if transboundary aquifers are considered. Transboundary freshwater systems create linkages and interdependencies between countries. Across Asia, major transboundary basins where coordinated development and management is recommended include the Mekong, Ganges-Brahmaputra-Meghna, Indus, Kabul, and Syr Darya and Amu Darya River basins. Global experience shows that cooperation among countries in the development of transboundary basins can yield greater benefits than would be achieved through unilateral development[25]. Sharing water's benefits and information across national borders remains a challenge in many parts of Asia.[26]

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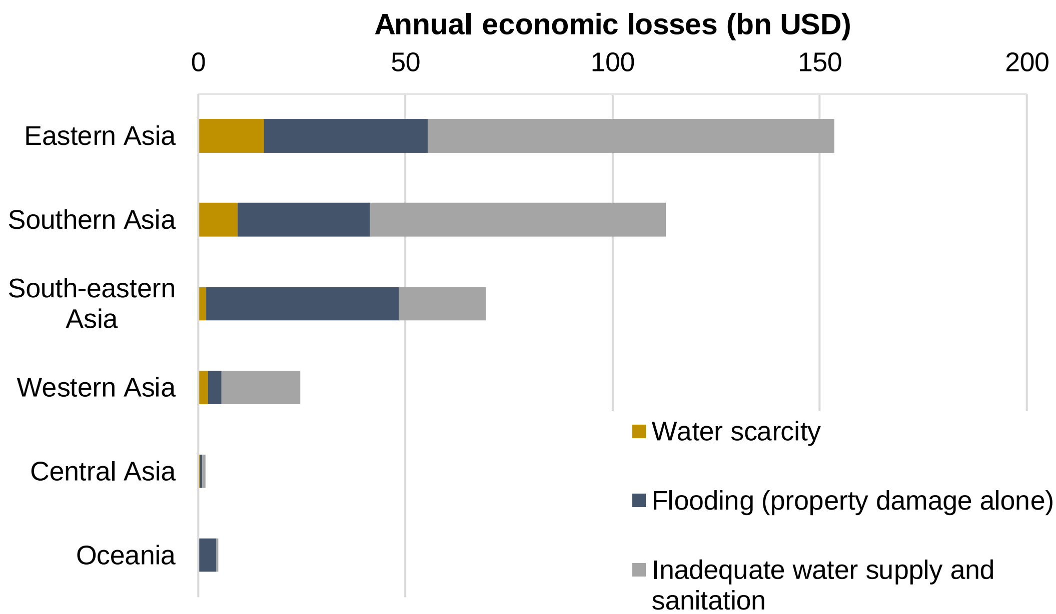
2. Key Water Sector Issues in Asia

The water sector poses significant constraints and opportunities for AIIB clients in their pursuit for improved economic, environmental and social outcomes. When water's destructive potential is not mitigated, economic impacts are significant: at least 360 billion USD are lost annually across Asia due to inadequate water supply and sanitation, water scarcity and flood damage[1]. The largest economic losses in absolute terms are experienced in Eastern Asia and Southern Asia (Figure 2.1). Asia's population also feels the burden of unmitigated water risks, with at least half a billion Asians facing water shortages, and more than a billion not having access to adequate drinking water supply and sanitation services. The greatest number of people exposed to water-related challenges is found in India and China (Table 2.1). When exposure to these water risks is considered in relative terms countries such as Myanmar, Pakistan, Papua New Guinea, and Vietnam have the highest proportions of population at risk (Table 2.1).

Figure 2.1. Annual economic losses from water scarcity, flooding and inadequate water supply and sanitation, by UN sub-regions in Asia[2].



Source: IWMI with data from Sadoff et al. 2015. Securing water, sustaining growth: Report of the GWP/OECD Task Force on Water Security

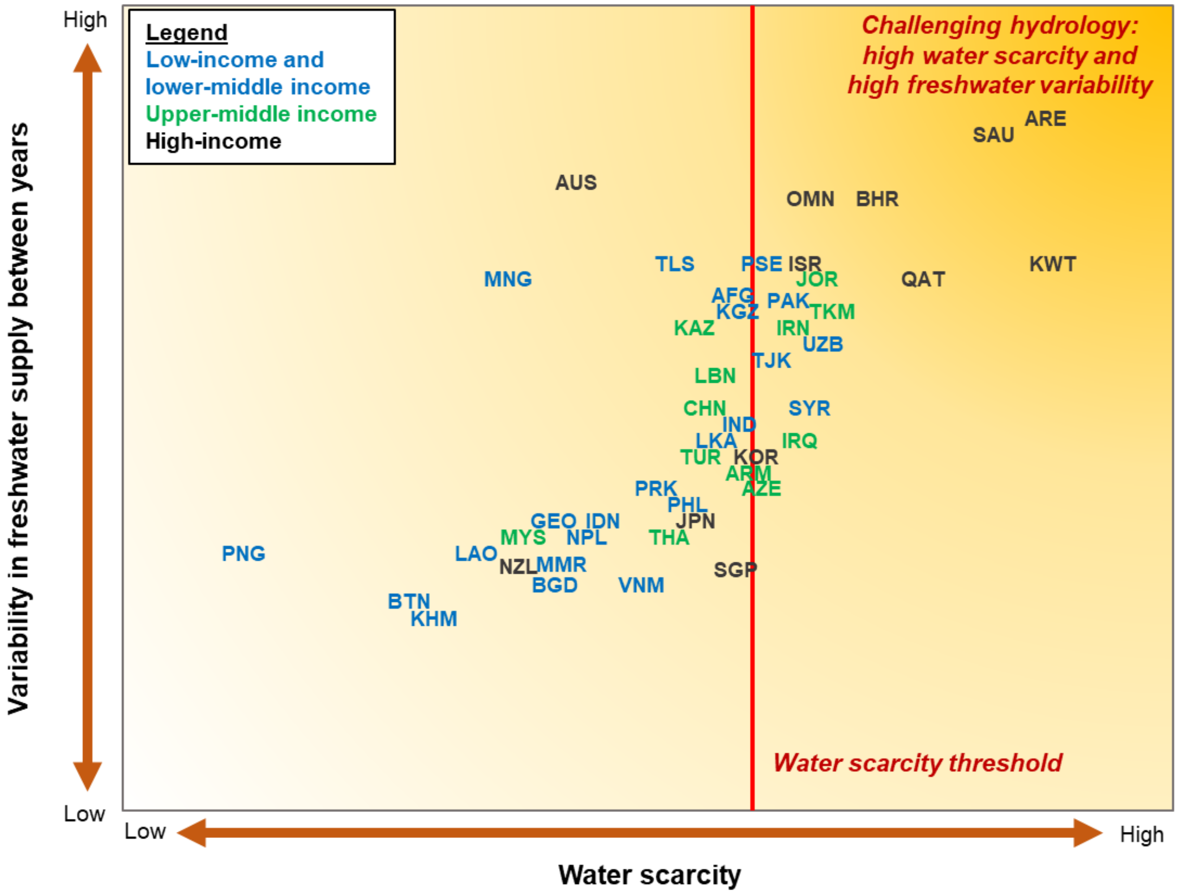
Table 2.1. Top ten Asian countries for total population (left) and proportion of population (right) at risk from water shortages, flooding and inadequate water supply and sanitation.

Top ten Asian countries for total population at risk			Top ten Asian countries for proportion of population at risk		
Total population at risk of frequent water shortages	*Expected population flooded*	*Total population lacking access to sanitation*	*Proportion of population at risk from water scarcity*	*Proportion of population at risk from flooding*	*Proportion of population lacking access to sanitation*
China	India	India	Israel	Viet Nam	Papua New Guinea
Pakistan	China	China	Pakistan	Myanmar	Afghanistan
India	Viet Nam	Indonesia	Jordan	Bangladesh	India
Bangladesh	Bangladesh	Pakistan	Turkmenistan	Lao PDR	Cambodia
Nepal	Myanmar	Bangladesh	Nepal	Cambodia	Nepal
Saudi Arabia	Indonesia	Philippines	Saudi Arabia	Korea DPR	Timor-Leste
Uzbekistan	Pakistan	Viet Nam	Lebanon	Afghanistan	Pakistan
Afghanistan	Thailand	Afghanistan	Uzbekistan	India	Yemen
Israel	Philippines	Nepal	Afghanistan	Iraq	Mongolia
Jordan	Afghanistan	Myanmar	Bangladesh	Thailand	Bangladesh
Turkmenistan	Korea DPR	Yemen	China	Pakistan	Indonesia

Source: IWMI with data from Sadoff et al. 2015. Securing water, sustaining growth: Report of the GWP/OECD Task Force on Water Security.

Where water is reliably available, economic opportunities are enhanced. Where water is scarce and unpredictable, economic and human development are often hampered. Economic output measured as GDP is sensitive to freshwater variability, especially where agriculture accounts for a large share of the economy[3]. Many Asian countries also face the double challenge of both high scarcity (threshold defined where water withdrawals exceed 40% of the available water resources[4]) and high variability (Figure 2.2). This impacts agricultural productivity. Farmers will often respond by expanding cropland at the expense of natural ecosystems[5]. In some countries, water scarcity and variability also affect power generation from hydropower. With growing demands and climate change affecting supplies, investments to manage water variability and scarcity will become even more important.

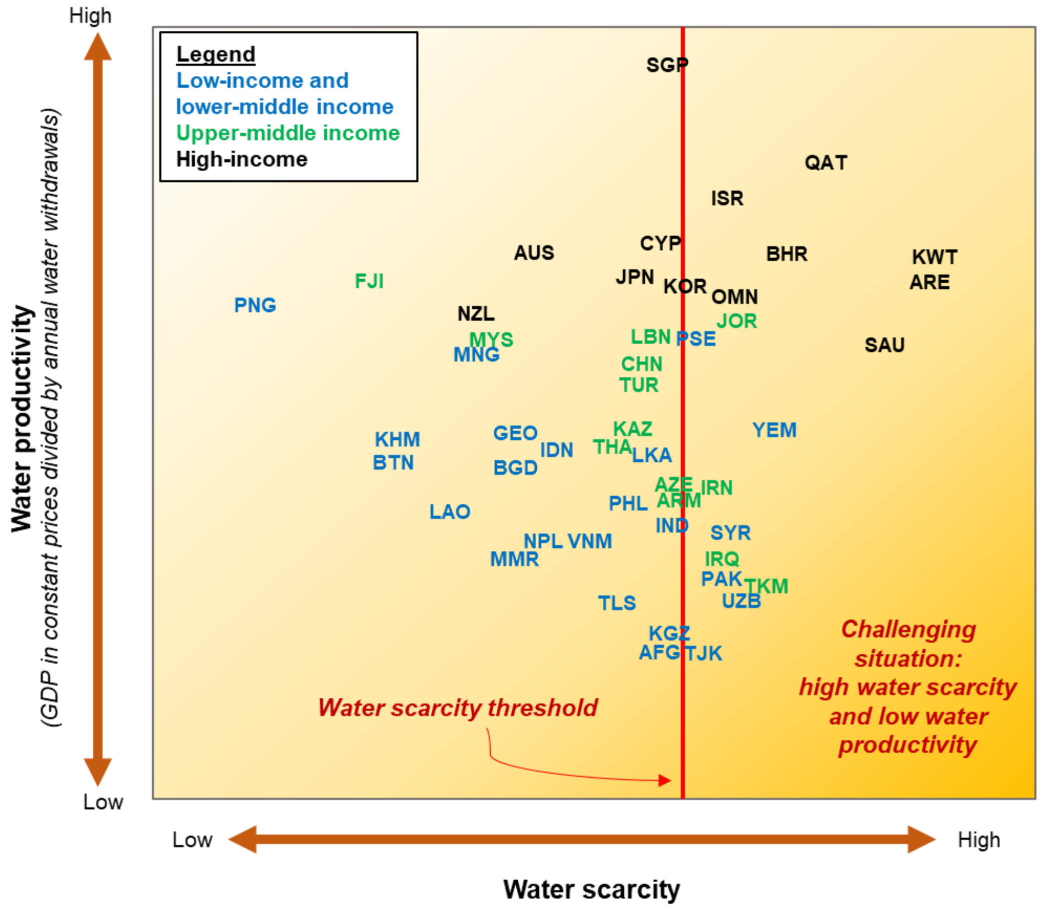
Figure 2.2. Many Asian countries face the double challenge of water scarcity and freshwater variability.



Sources: World Resources Institute for freshwater variability and FAO AQUASTAT database for water scarcity. Freshwater variability is calculated as the standard deviation of annual total freshwater divided by the mean of total available freshwater. Water scarcity is calculated as the ratio of total water withdrawals to renewable freshwater resources (typically referred to as 'water stress' in the hydrological sciences). Country classifications by income levels are based on the World Bank's Gross National Income per capita classification. Country abbreviations are ISO codes.

Many Asian countries are also not making the most of their scarce water resources. The economic value added per water withdrawn (i.e. water productivity) is low in many Asian countries facing water scarcity (bottom right corner in Figure 2.3). This low water productivity is often accompanied by declining water quality. In fact, some of the most polluted waters from nutrient runoff from fertilizers are found in water scarce regions, notably Central Asia, China and South Asia[6]. This suggests that current agricultural water management practices need to be revised in order to enhance water productivity and reduce pollution. Under conditions of scarcity, increasing the productivity of water and ensuring its quality becomes essential to ensure that maximum benefits are obtained with less water and sustainability for future generations and ecosystems.

Figure 2.3. Some Asian countries are not making the most of scarce freshwater resources.



Sources: World Bank for water productivity and FAO AQUASTAT database for water scarcity. Water productivity is calculated as GDP in constant prices divided by total water withdrawals. Water scarcity is calculated as the ratio of total water withdrawals to renewable freshwater resources (typically referred to as 'water stress' in the hydrological sciences). Country classifications by income levels are based on the World Bank's Gross National Income per capita classification. Country abbreviations are ISO codes.

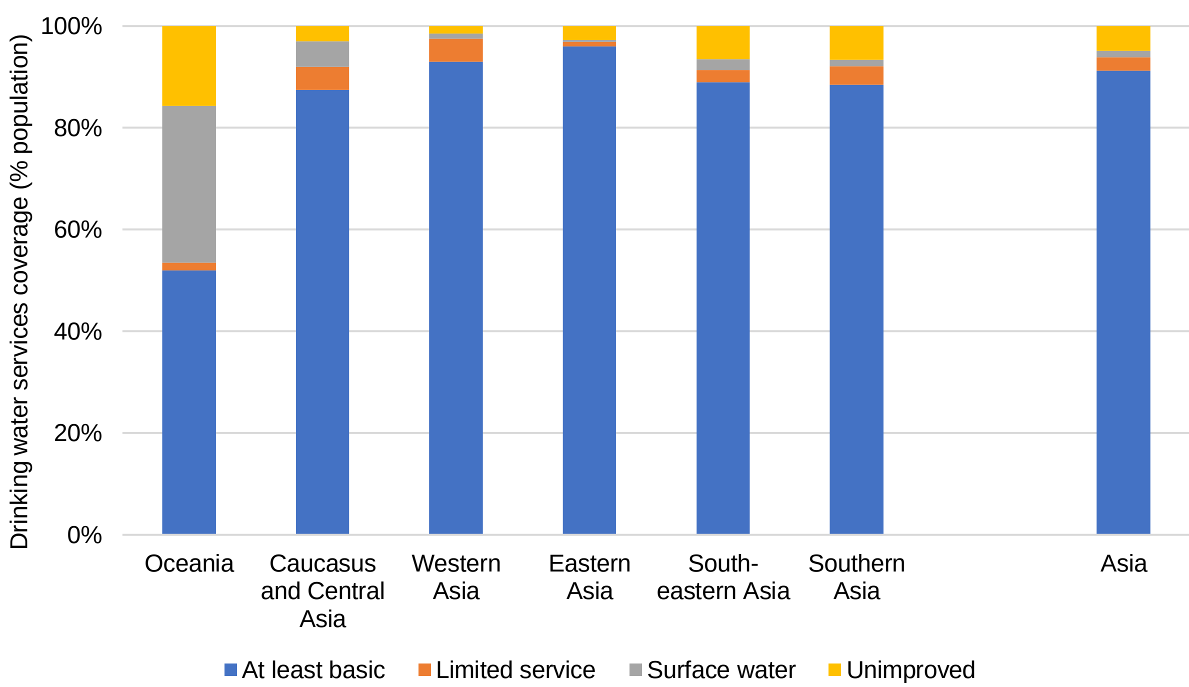
AIIB client countries face two overriding challenges in their efforts to harness water-related opportunities and mitigate water-related risks. First, all countries face the challenge of developing and maintaining water infrastructure. Circumstances and priorities differ, but the need to rehabilitate existing infrastructure assets and develop new ones is high and increasing across Asia[7]. Second, AIIB client countries face the challenge of developing capacity, regulations, laws and institutional arrangements needed to manage water resources and ensure that water infrastructure is sustainable (see Section 3). The remaining part of this section briefly reviews each water subsector in Asia.

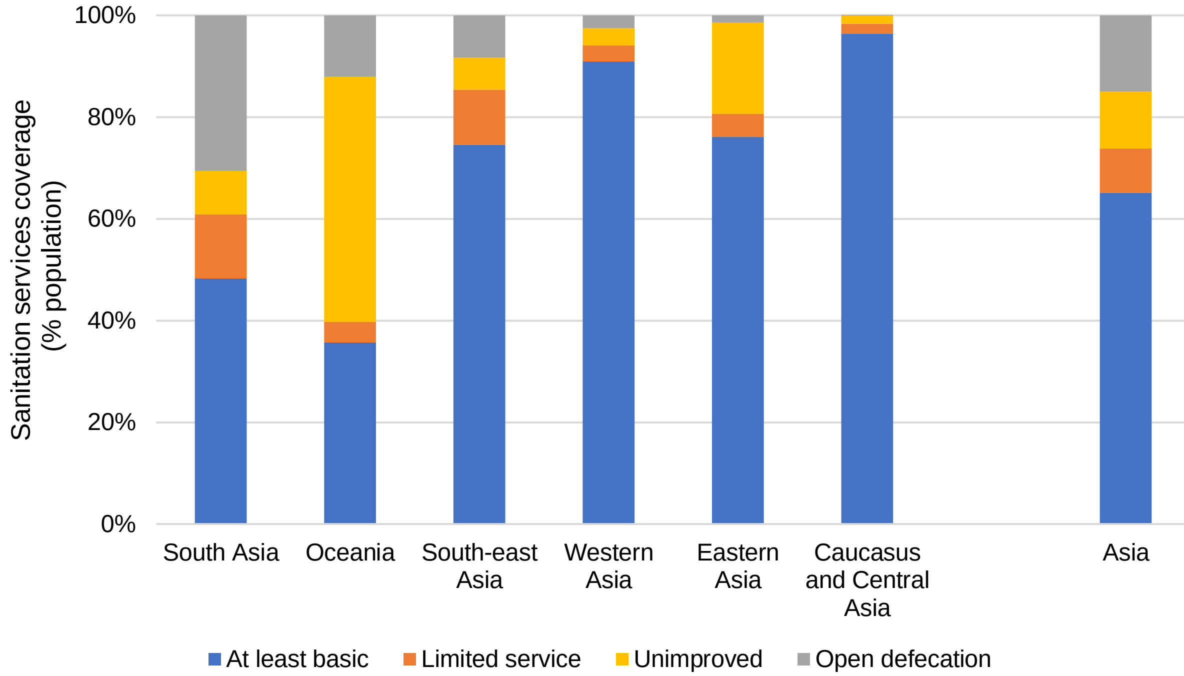
2.1. Water Supply and Sanitation

2.1.1. Trends in water supply and sanitation

Lack of access to drinking water supply and sanitation services remains a key issue and area of infrastructure need. At least 370 million Asians still lack access to basic drinking water services[8]. Of these 370 million, 57% are in south Asia and 19% in south-eastern Asia. Oceania faces the biggest gap in access to drinking water supply as a share of its population, with more than 50% of its population currently lacking basic access to drinking water (Figure 2.4, top panel)[9]. Sanitation also remains a key development challenge throughout Asia, with at least 1.49 billion Asians lacking access to basic sanitation services[10]. Of these, 63% live in South Asia and 24% in Eastern Asia. Oceania and South Asia have the lowest access to sanitation services as a share of their population (Figure 2.4, bottom panel)[11]. These statistics communicate the magnitude of the overall issue but fail to reveal some of the additional challenges faced by vulnerable groups, notably for women and girls.

Figure 2.4. Drinking water supply (top) and sanitation (bottom) coverage by UN sub-region, share of population in 2015.





Source: IWMI with data from WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene (JMP). Available from: https://washdata.org/. The service groups shown in these figures follow the WHO/UNICEF Joint Monitoring Program ladder classification. Drinking water services refers to the accessibility, availability and quality of the main source used by households for drinking, cooking, personal hygiene and other domestic uses. Safely managed: Drinking water from an improved water source which is located on premises, available when needed and free from fecal and priority chemical contamination. Basic: Drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip including queuing. Limited: Drinking water from an improved source for which collection time exceeds 30 minutes for a roundtrip including queuing. Unimproved: Drinking water from an unprotected dug well or unprotected spring. Surface water: Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal. Sanitation services refer to the management of excreta from the facilities used by individuals, through emptying and transport of excreta for treatment and eventual discharge or reuse. Safely managed: Use of improved facilities which are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site. Basic: Use of improved facilities which are not shared with other households. Limited: Use of improved facilities shared between two or more households. Unimproved: Use of pit latrines without a slab or platform, hanging latrines or bucket latrines. Open defecation: Disposal of human feces in fields, forests, bushes, open bodies of water, beaches and other open spaces or with solid waste.

Absent and inadequate approaches to safely managed sanitation, including wastewater treatment capacity, are a key sector issue. About 80% of the region's wastewater is discharged to water bodies without treatment, with consequences for public health, water quality and ecosystems.[12] In many AIIB client countries, including India, Pakistan, Philippines, and Vietnam, this share is even higher, with more than 90% of the wastewater generated receiving no treatment before being discharged into a water body.[13] At the same time, poor sanitation practices lead to unsafe disposal of human waste. Expanding on-site sanitation services, including expanding wastewater treatment capacity, and ensuring the efficient and sustainable operation and maintenance of such facilities is key to providing safely managed sanitation services and avoiding public health risks in Asia's growing cities.

Rapid urbanization has meant that service providers have struggled to keep pace with urban demands. For example, in South Asia access to water supply has reduced from 71 percent in 2000 to 66 percent in 2015[14]. Declines in piped access to water mean that off-grid customers are increasing, typically concentrated in poorer segments of society. An analysis of 75 developing countries in Asia, Africa and Latin America showed that more than 68 percent of these customers come from the bottom two income quintiles. Within these regions, many countries have more than 80 percent such off-grid users from the poor and poorest categories, for example in, Vietnam, Thailand, Cambodia, and Bangladesh.

The water supply sector is faced with increasing demands and limited opportunities to expand supply. Water demands will increase in Asia, with a 65% increase in industrial water use, 30% increase in domestic use, and 5% increase in agriculture use projected by 2030[15]. To respond to growing demands for drinking water, AIIB client countries might increasingly consider 'unconventional' water sources such as desalination and wastewater reuse, as well as more integrated urban water management solutions, to mobilize additional supplies and protect existing ones. Asia already accounts for a significant share of global desalination capacity, and this share is likely to increase[16]. In Western Asia, Saudi Arabia, the United Arab Emirates and Kuwait account for 15.5%, 10.1% and 3.7% of the world's desalination capacity respectively, while Eastern Asia accounts for about 18.4% of global desalinated water[17]. Desalination is not a panacea to address water challenges; however, it will continue to be an option (albeit an expensive one) for urban water infrastructure investment alongside a range of complementary interventions, including leakage reduction, wastewater reuse, and demand management, to meet increasing demands and improve resilience to climate change.

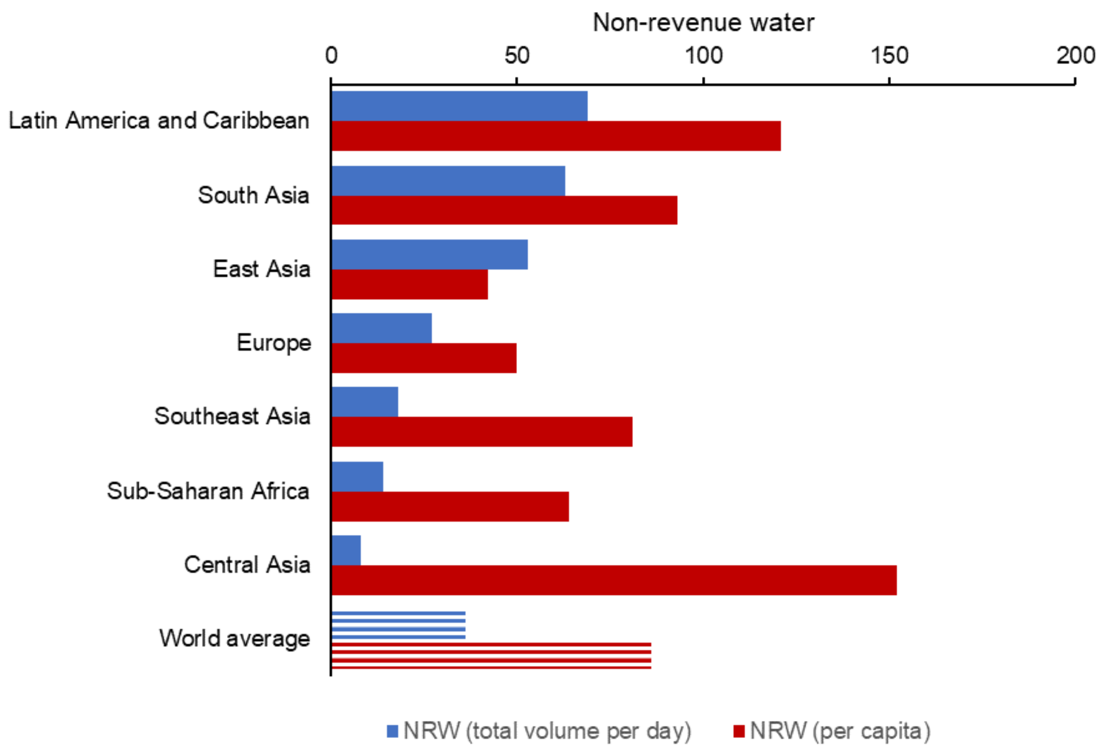
A range of technical solutions – both centralized and decentralized - must be promoted to ensure safely managed drinking water and sanitation for all[18]. Conventional approaches often involve investment-intensive, usually underground, pipe networks that provide single-quality drinking water and evacuate stormwater and wastewater. These systems are often paired with reservoirs and long-distance water conveyance systems which compensate for inadequate local water resources[19]. Alternative approaches that provide locally adapted and resource-efficient solutions are emerging and likely to become more prominent over the coming decades[20]. These solutions include distributed or on-site treatment of wastewater, source separation of human waste and nature-based infrastructure for stormwater drainage (see section 2.5). For these decentralized solutions to work, innovations in organizational and regulatory models are needed, as demonstrated, for instance, by Asia's growing experiences with fecal sludge management[21]. The Citywide Inclusive Sanitation (CWIS) comprehensive approach also shows promise in integrating a range of technical solutions with the financial, institutional, regulatory and social dimensions[22].

2.1.2. Performance of water service providers

Asian water service providers suffer from technical inefficiency, low levels of service, weak governance and poor financial performance. This arises from a complex mix of limited incentives, vested interests that benefit from the low-level status quo, low and politicized tariffs, and weak capacity. In general, such utilities do not possess key characteristics of well-run companies including: (1) financial and managerial autonomy; (2) internal and external accountability; (3) market orientation that would deliver efficiencies and (4) customer orientation. There are exceptions such as Phonm Penh in Cambodia, Manila and Mynilad Water in Manila, and Haiphong water company in Vietnam amongst others. They are, unfortunately, the exception rather than the rule showcasing the "art of the possible" in the region.

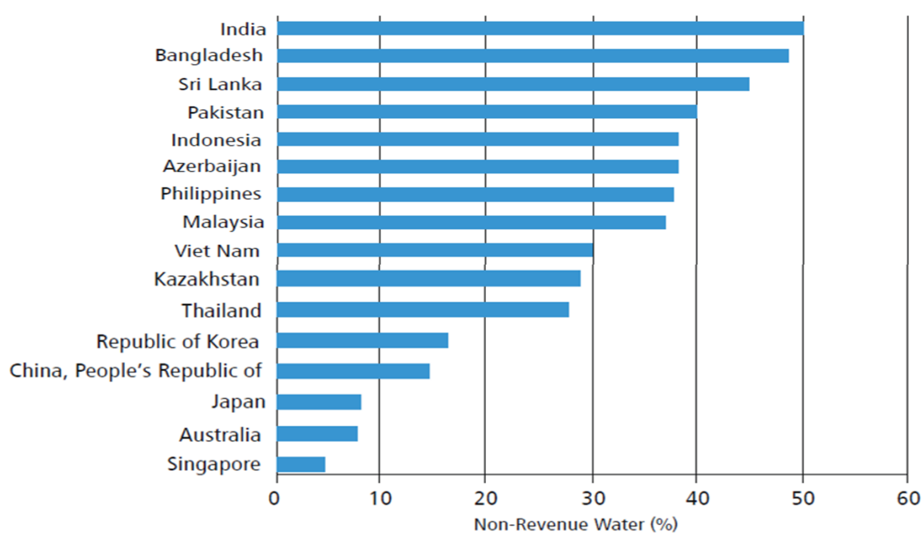
A key indicator of technical performance is levels of non-revenue water, which are high across many Asian countries. Levels of non-revenue water across many Asian sub-regions are higher than global averages both in absolute (cubic meters per day) and relative (volume per capita) terms (Figure 2.5). Non-revenue water is highest in countries in South Asia (India, Pakistan, Bangladesh) and Southeast Asia (Philippines, Malaysia, Indonesia among others), as shown in Figure 2.6. Although costing non-revenue water is notoriously difficult, some estimate revenue losses on the order of USD 12 billion per year across Asia[23].

Figure 2.5. Non-revenue water (NRW) for selected world regions.



Source: IWMI with data from Liemberg, R., Wyatt, A. 2018. Quantifying the global non-revenue water problem. Presented at the Water Loss 2018 conference in Cape Town, South Africa. Available from: http://www.waterloss2018.com/wp-content/uploads/2018/06/08/A24.pdf

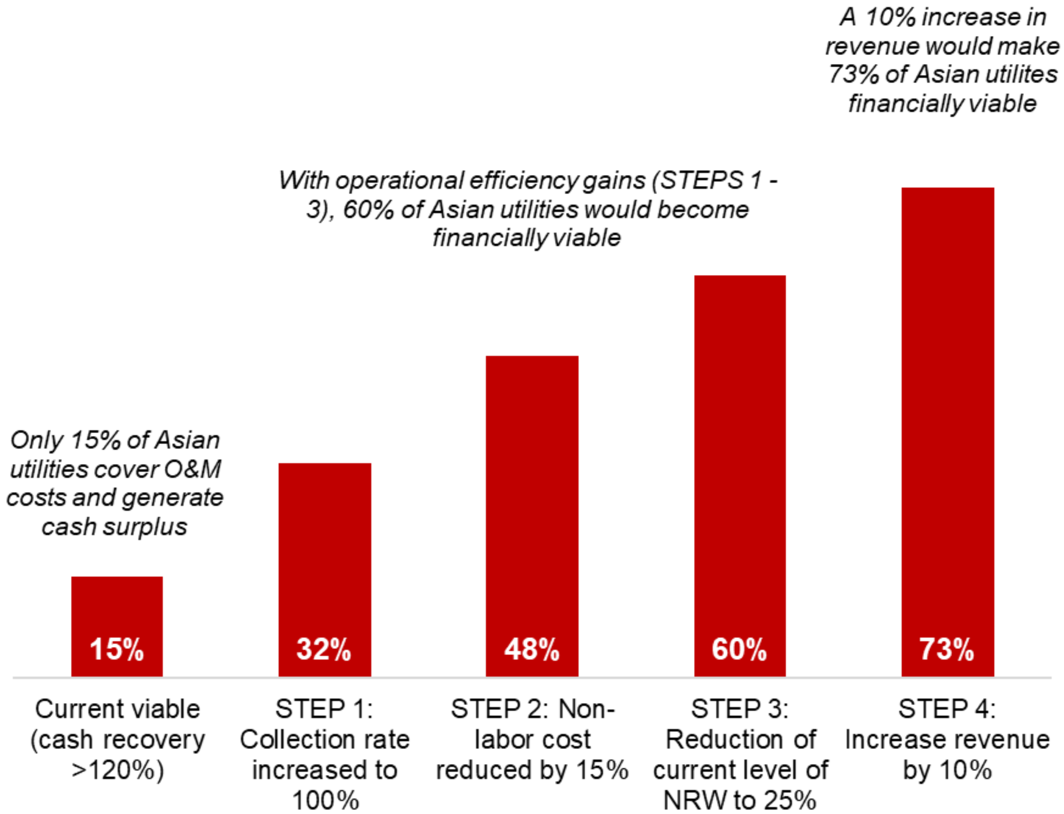
Figure 2.6. Nonrevenue water in selected economies in the Asia and Pacific.



Source: Asian Development Bank (2016) Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific. Manila: Asian Development Bank.

There are many opportunities to improve efficiency. And as a result, improve service to customers (e.g. reducing leakage increases both availability of supply and pressure in the network), move providers towards greater financial autonomy, and ultimately improve creditworthiness. Most utilities are far from being creditworthy and are thus unable to borrow domestically from the market. A study looking at the impact of various efficiency improvements (Figure 2.7), shows that 73% of Asian utilities can be made financially viable (i.e., that recover more than 120% of operating costs) by addressing collections and non-labor costs including energy efficiency and leakage. 120% was chosen as a level of financial performance that would provide funds for possible debt service. If this greater operational efficiency and cash surplus can be maintained through good policies, governance and incentives, then Asian utilities could mobilize private finance.

Figure 2.7. Impact of four efficiency improvement steps to reach financial viability (i.e. capable of recovering 120% of O&M costs)



Source: World Bank's International Benchmarking Network for Water and Sanitation Utilities (IBNET). NRW: Non-revenue water. Note: Because of the World Bank regional classification used, estimates include North African and eastern European utilities.

Improving performance of public utilities takes time – up to 10 years to fully embed improved practices and performance improvements. There are many tools now available to support the evaluation of the key challenges facing a utility and guidance on possible solutions. The World Bank's Utility Turnaround Framework[24] is an example. This could provide a foundation for standardized evaluation and project designs by AIIB. There are also opportunities to review the institutional structure of utilities to facilitate progress towards the key desired characteristics mentioned above (e.g. financial and managerial autonomy, accountability, market and customer orientation). This might include at a minimum the ring fencing of accounts or moving towards some form of corporatization of the utility. The introduction of regulatory mechanisms is also possible, but care is needed to ensure that such mechanisms are appropriate for the challenges being faced, the level of regulatory capacity in the country and, critically, the quality and availability of regulatory data in the utilities.

With respect to financing, utilities and potential lenders do not fully understand each other. Utility managers are used to relying on public funding. Once this funding is used, then any further planned activities are put on hold until the next tranche of public finance is provided. Utilities also may not have incentives to invest in efficiency activities – for example, if the state pays for electricity consumption by the utility then there is little incentive for a utility manager to use scarce resources to finance new energy efficiency pumps and motors. At the same time domestic banks are often wary of the sector believing it to be too politicized. As a result, opportunities to stimulate small scale borrowing for high pay back investments are not being exploited.

2.1.3. Trends in Public-Private Partnerships in Water Supply and Sanitation

In the late 1990's, the private sector was viewed as a solution to addressing the endemic performance challenges of public service provision. The approach adopted was generally to seek delegated management of the utility to the private sector to the maximum extent possible – with concessions being the deepest form of privatization. The client bought management expertise from the private sector through a contracting arrangement that facilitated the introduction of the key characteristics noted earlier. This was expected to deliver results quickly and to mobilize private finance

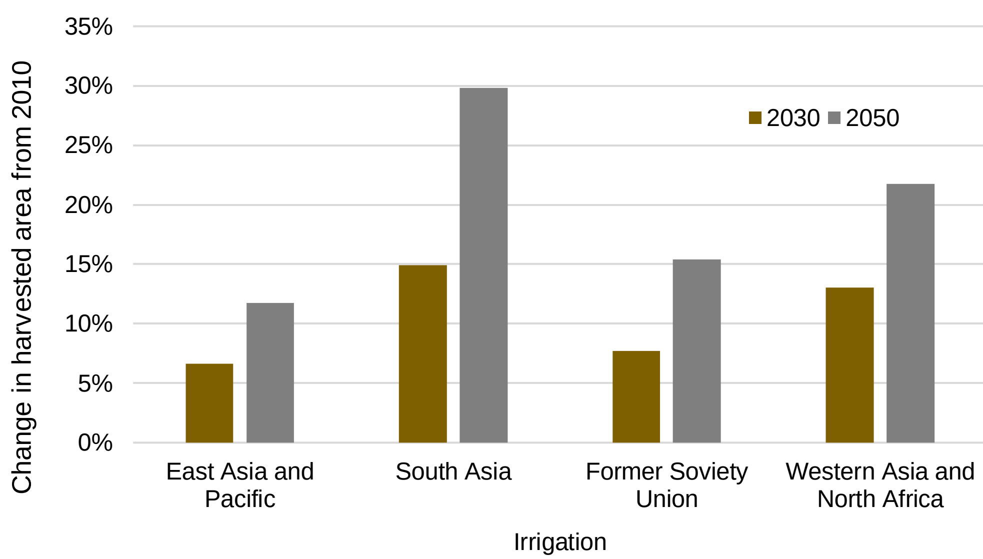
The approach faced many technical challenges. The lack of understanding of the condition and performance of the pipe networks caused delays and led to renegotiation of the contracts with upwards pressure on tariffs. As a result, the high expectations surrounding the process weren't met and political economy challenges became apparent. This led to many failures, some of them high profile.

In recent times the focus has been more on the use of PPPs to deliver improved technical and commercial performance, using public rather than private funds for investment. Greater consideration is also now given to more focused service contracts – particularly those that are performance based such as design-build-operate (DBOs) and performance-based leakage contracts. In the short term, investments in activities that improve collection efficiency, energy efficiency and reductions in leakage are appealing as they have a clear focus, do not involve delegation of management of the whole system, and result in better service and financial performance of the utility.

2.2. Irrigation and Drainage

Asia's irrigation and drainage sector is under pressure to modernize and increase production. Irrigation already plays a key role in Asia's agricultural economy, with recent estimates suggesting that about 2.6 million km^2 of agricultural land in Asia is irrigated (about 70% of the world's total irrigated land)[25]. The largest share of irrigated land is found in South Asia (India and Pakistan) and Eastern Asia (China). In the future, irrigated lands must produce more quantities of food and fiber to respond to the needs and changing consumption habits of Asia's growing population[26]. This growth will partly come from expansion of the area under irrigation. Existing projections suggest that the area under irrigation is set to expand by an additional 57 million hectares by 2050, a 20% expansion from 2010 levels[27] (Figure 2.8). However, irrigation expansion alone will not be enough. Most of the gains from expanding irrigation area will only be realized if it is accompanied by investments to modernize systems and increase water use efficiency[28].

Figure 2.8. Harvested area projections by Asian sub-region (percentage change from 2010).



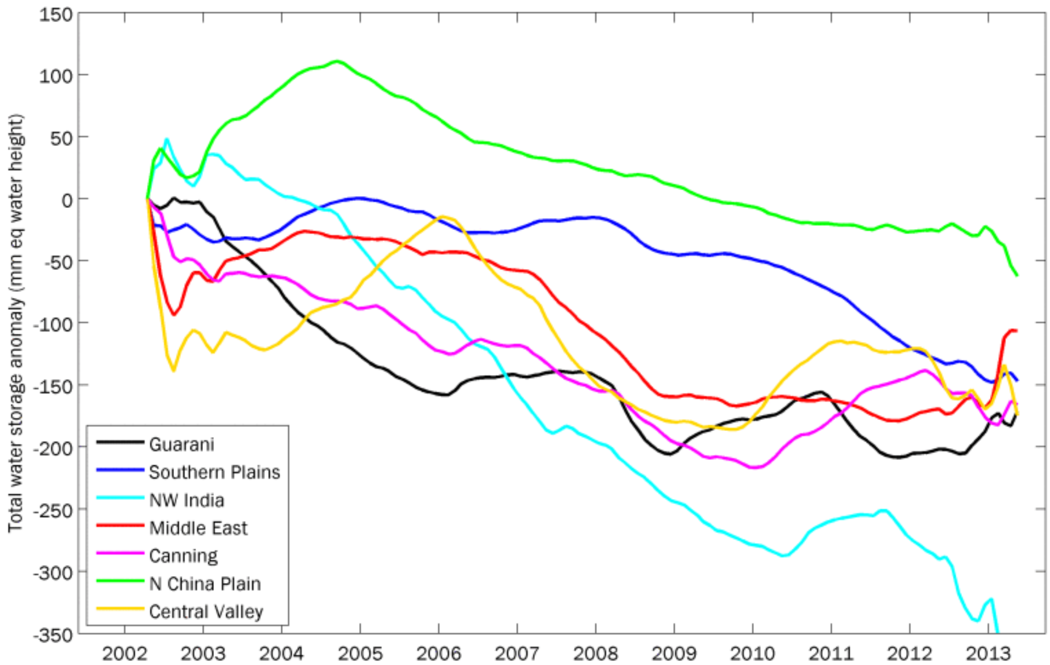
Source: Rosegrant et al., 2017. Quantitative foresight modeling to inform the CGIAR research portfolio. Intl Food Policy Res Inst.

Increased agricultural production must also come from getting more from existing irrigation infrastructure assets. This means that investments in irrigation and drainage infrastructure will have to focus on modernization (both technical and institutional), basin wide efficiency, and improvements to drainage. In particular, underinvestment in drainage has meant that large swaths of agricultural land in Asia, particularly in the semi-arid regions of Central Asia[29] and South Asia[30], have become unproductive or have low productivity as a result of waterlogging and salinity. Modelling suggests that increased investments in water use efficiency will bring the most productivity gains[31].

Underperformance of existing publicly owned surface irrigation schemes is a key sector challenge[32]. Inadequate management, operation and maintenance of irrigation systems initiates a vicious cycle of performance decline (much like in the urban utility sector): poor irrigation service reduces farmers' willingness to pay and hence reduces collected fees. Reduced revenues for the public irrigation agency mean that they lack the financial resources to cover O&M, service debt, and take on new capital investments. This leads to a further deterioration in the performance of the system. Securing adequate funds is a necessary but not sufficient condition to improve sector performance and break this vicious cycle. Institutional and policy reforms are needed, including decentralizing management of lower levels of the irrigation system (e.g. tertiary level canals) to community organized user groups (i.e. irrigation management transfer). Water users' associations (WUAs), for example, can contribute to improving the performance of existing and planned irrigation and drainage infrastructure throughout Asia, alongside other elements such as better use of inputs (e.g., seeds, fertilizers), improved storage and access to markets. WUAs have been promoted, in part, to enhance the collection of local funding for O&M. Nonetheless, ADB's Evaluation Study of Irrigation and Drainage (2009) portrays a very mixed experience with WUAs in 18 projects across Asia, where irrigation management transfer was often ineffective at raising higher funds for O&M[33].

Uncontrolled expansion of groundwater irrigation is not sustainable for many Asian countries. Cheap and subsidized electricity has made groundwater pumping a feasible irrigation option for millions of farmers across Asia[34]. Although this has had positive implications for food security and poverty reduction, it has also led to widespread groundwater depletion (Figure 2.9 – see China and India). Five Asian countries account for more than 50% of global groundwater withdrawals. The Indian subcontinent has some of the highest levels of groundwater depletion in the world, with at least half of the subcontinent's groundwater being extracted faster than it is being replenished[35]. Responding to Asia's groundwater crisis is key to ensure the sustainability of irrigation and agricultural production in the region. This will include, among others, reducing perverse subsidies for groundwater pumping and developing institutional incentives for sustainable and conjunctive use of surface and groundwater resources.

Figure 2.9. Groundwater storage declines in several of the world's aquifers (mm equivalent water height)



Source: Derived from the NASA GRACE satellite mission. The monthly storage changes are shown as anomalies for the period April 2002-May 2013 with 24-month smoothing. JS Famiglietti, The Global Groundwater Crisis, Nature Climate Change, November 2014.

2.3. Energy

Rising energy demand in Asia means that power infrastructure, including hydropower, is high on the agenda. Asia's current installed hydropower generation capacity (including pumped storage) is 613,041 MW[36]. Of this capacity, about 55% is in China and 8% in India and Russia. In 2018, total generation in Asia amounted to 1957 terawatt hours (TWh), with about half coming from China alone[37] (differences between actual generation and installed generation are due to climatic variability, variable performance of facilities, underreporting of actual generation). Asia's technical potential in hydropower is much larger, at about 5980 TWh[38]. This potential is well recognized in Asia, where investments in hydropower have been growing in recent years[39] and where development of hydropower, in an economically, environmentally and socially sound manner could make an important contribution to energy security.

Beyond hydropower, water sector issues can impact other types of power generation. Thermal power generation has been shown to be vulnerable to water scarcity in some parts of Asia as water is required for activities such as cooling[40]. Addressing these vulnerabilities will require not only investments in power plants (i.e., recirculating systems consume less water than once-through systems), but also water resources management interventions to minimize potential conflicts with other users[41]. Given the vulnerability of Asia's energy sector to water-related disruptions, notably flooding and drought, infrastructure investments involving both water and energy will have to take into account the changing frequency and intensity of water-related hazards under climate change.

Water use and energy efficiency are also interlinked. Inefficiencies in the use of one resource have an impact on the other. Pumping plays an important role in Asia's irrigated agriculture and accounts for significant operating costs. In Central Asia, the irrigation sector accounts for a significant proportion of electricity use[42]. Similarly, electricity costs are usually between 5 to 30 percent of total operating costs among water and wastewater utilities worldwide[43]. The share is even higher in some Asian countries, such as India and Bangladesh where it can go up to 40 percent or more[44]. Such high costs translate into often unsustainable operating costs, making energy efficiency improvements a key measure to reduce operating costs and improve the financial health of water utilities and irrigation agencies. Technologies for energy recovery in wastewater treatment plants could also further reduce the total electricity demands of the water sector, reduce operating costs and contribute to meeting carbon emission reduction targets with the potential to mobilize climate funds (e.g. green bonds, see Section 5).

2.4. Water-Related Disasters: Floods and Droughts

Throughout Asia, floods and droughts impact millions of people and cause losses in excess of tens of billions of dollars each year. People living in the Asia-Pacific region are now four times more likely to be affected by natural disasters, mostly floods and droughts, than those living in Africa, and 25 times more likely than those living in Europe or North America[45]. Floods and storms are the most common types of disasters in the region, and these cause the most economic damage (see Table 2.2).

Table 2.2. Recent significant water-related disasters in the Asia and Pacific region

Type of event	Floods	Cyclone	Drought

By number of deaths		By number of people affected		By estimated economic damage	
Event	Deaths	Event	People affected (million)	Event	Estimated damage (billion USD)
Bangladesh (1991)	138987	India (2002)	300	Thailand (2011)	40 (10.8% GDP)
Myanmar (2008)	138366	China (1998)	242	China (1998)	31 (3.1% GDP)
India (1999)	10378	China (1991)	210	China (2010)	18 (0.3% GDP)
Philippines (2013)	7415	China (2003)	155	India (2014)	16 (0.79% GDP)
India (2013)	6453	China (1996)	154	China (2012)	14 (0.17% GDP)
Philippines (2013)	6083	China (2010)	140	Philippines (2013)	10
Bangladesh (2007)	4275	India (1993)	128	Japan (1991)	10
China (1998)	4250	China (2007)	111	Pakistan (2010)	9.5 (5.35% GDP)
China (1996)	4091	China (1994)	88	Japan (2000)	7.4 bn
India (1998)	3471	China (2002)	64	India (2010)	7 (0.34% GDP)

Note: Tsunamis not included. Water-related disasters that took place in Western Asia are not included. Source: IWMI using data from the Asian Development Bank. 2019. Recent significant disasters in the Asia and Pacific Region. Asian Development Bank. Manila.

Droughts have devastating cumulative impacts on human development, as well as economic and environmental impacts including land degradation and decreased agriculture. Agricultural economies in South Asia and South East Asia are particularly vulnerable to droughts. In these regions, eighty percent of the economic impact of drought occurs in the agriculture sector[46]. Under climate change, large-scale reduction in precipitation and more frequent droughts are expected to occur in East Asia[47], South East Asia[48] and in arid Central and Western Asia[49].

The rising costs associated with increases in frequency and severity of flooding drive demand for flood control infrastructure. AIIB client countries face a range of flood hazards from more intense rainfall events, tropical cyclones, storm surges, and sea-level rise. From 1900 to 2012, 1,625 flood disasters (40% of total disasters worldwide) resulted in 6.8 million deaths (98% of deaths worldwide), displaced 3.4 billion persons (95% of affected persons worldwide), and caused at least $330 billion in economic losses in Asia[50]. These flood hazards are perennial. The monsoon periodically claims the lives of thousands of people and causes billions of dollars' worth of damage each year[51]. For example, the 2010 Pakistan floods and the 2011 Thailand floods caused economic losses on the order of USD 9.5 billion (5.3% of GDP) and USD 40 billion (10% of GDP) respectively. Asian countries are also vulnerable to flooding caused by tropical storms (cyclones or typhoons, depending on the geographical location). Typhoon Haiyan in the Philippines in 2013 killed 7415 people and resulted in USD 10 billion in damages (about 3.7% of GDP)[52]. With climate change, the frequency and intensity of tropical cyclones is projected to increase[53].

Coastal zones face heightened risks from climate change and flooding. Asian coastal zones are vulnerable to the confluence of climate change-related hazards, including accelerated sea level rise, intensification of tropical cyclones, extreme waves and storm surges[54]. Tens of millions of people living in Asia's coastal zones must prepare for sea-level rise, with small-island Pacific nations, parts of Bangladesh, China and Indonesia being among the most vulnerable to permanent inundation[55]. Asia's cities located in deltaic settings have been identified as a global hotspot for coastal flooding. Nine of the ten port cities with more than 1 million inhabitants with the highest exposure to coastal flooding in the world by 2070 are in Asia (Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon, and Hai Phòng)[56]. Similarly, many Asian cities also top the world rankings in terms of assets exposed: Guangdong; Kolkata; Shanghai; Mumbai; Tianjin; Tokyo; Hong Kong, China and Bangkok.[57]

Storm water infrastructure will be particularly needed in cities. Exposure to flooding is increasing with urbanization, with a projected 410 million urban Asians at risk of coastal flooding and 350 million at risk of inland flooding by 2025.[58] Most of the large cities in the world classified as having extreme risks of climate vulnerability are in Asia.[59] Many of Asia's megacities, such as Bangkok, Dhaka, Ho Chi Minh City and Tianjin are at risk from both urban and coastal flooding.

Present storm water systems and flood control infrastructure will need to be upgraded and expanded.[60]

In mitigating flood and drought risks, Asian countries also face challenges related to the low coverage of hydrometeorological systems. With low coverage of hydrometeorological monitoring networks (e.g., water level sensors, automated weather stations) and weak hydrometeorological services (e.g., procedures for early warning, hydrological information products), Asian countries have a challenge in preparing for and responding to water-related disasters. AIIB client countries need to improve their flood and drought monitoring and forecasting ability, as well as develop early warning systems for communities.[61] Efforts to strengthen disaster early warning systems and weather services require national level modernization efforts but also have a regional dimension. Given the cross-border nature of hydrological and meteorological issues (e.g., cyclones occurring in the Bay of Bengal affect several countries), these investments will have to be supported by efforts to improve the connectivity of these systems and information sharing.[62]

Unless risk mitigation measures are put in place, economic losses caused by water-related disasters, notably floods, will propagate along regional supply chains and trade networks. Within global supply chain and trade networks, regional production reductions caused by extreme weather and water-related disasters (e.g., floods, heat waves, droughts) can affect economic sectors elsewhere via supply shortages, changes in demand, and associated price signals.[63],[64] The 2011 Thailand floods, for example, not only costed the Thai economy more than USD 40 billion in direct economic losses,[65] but also had a negative impact on the regional economy through supply shortages and increases in the price of goods. This was particularly true for the local disruptions to the automotive and electronics industries, which propagated through Asia and the world economy (e.g., lack of hard disk drives increased the price of desktop HDD by 80-190 percent and mobile HDD by 80-150 percent).[66] Given the level of interconnectedness of the Asian economy, management of water-related risks to reduce the indirect damage of disasters is a priority.

2.5. Freshwater Ecosystems

Water pollution and deterioration of freshwater ecosystems are big challenges in Asia. Freshwater ecosystems are under increasing stress from unsustainable water abstraction, nutrient loads from fertilizer, untreated municipal wastewater, and industrial effluent. South and East Asia show the greatest levels of eutrophication in water bodies among Asian subregions.[67] Changes in precipitation due to climate change are expected to exacerbate eutrophication in India, China and Southeast Asia.[68] Asia's freshwater resources and ecosystems are also under stress from increasing salinity. Salinity is a problem in Central Asia's arid regions as well as many of Asia's coastal areas where saline waters are intruding aquifers and deltas, including the Ganges-Brahmaputra, Mekong and Indus deltas.

Rapid industrialization over the past decades has drastically increased industrial pollutant discharges. This exacerbates water shortages in several parts of Asia. Data from China reveals that about 1/5 of the country's rivers and lakes are too contaminated (from industrial pollution) for any type of water use.[69] Industrial water pollution levels, as indicated by BOD emissions per USD1,000 of GDP, are high across Asia and particularly high in Central Asia (>10 kg BOD/USD1,000 GDP) and South Asia (8 kg), compared to values of <1 kg in countries such as the USA and Japan[70]. Five Asian rivers (Ganges, Yangtze, Yellow, Huai, Indus) top the world's list for the largest number of people exposed to organic pollution.[71] Asia's rivers are also the largest sources of plastic and mercury pollution in the world's oceans.[72]

Freshwater ecosystems provide a range of services that support social and economic outcomes. This includes provisioning services (e.g., fisheries) and regulating services (e.g., flow regulation and flood control, water pollutant assimilation) among others. Protection of ecosystems from further deterioration and maintenance of key ecosystem functions is becoming a priority in water infrastructure planning, in particular given the importance of freshwater ecosystems for climate change adaptation.[73] Asia tops the world for the total volume of investment in watershed protection (about 14.2 billion USD per year), which is just one area of investment in "green infrastructure."[74] Investments in the maintenance and conservation of nature-based or "green" infrastructure also include protection and expansion of mangroves along coastal zones (for instance in Vietnam) and wetlands in urban areas (for instance, in Sri Lanka).[75] Financing for this type of infrastructure that provides socioeconomic as well as environmental benefits requires innovative financial approaches and policies.[76]

2.6. Navigation

Use of inland waterways for trade and improved connectivity is emerging as an option to reduce costs of transport and carbon emissions. Transporting people and goods over inland waterways, such as rivers and canals, can decrease road traffic, accidents and pollution while increasing cross-border trade and in general reduce the overall cost of transport. However, appropriate measures need to be put in place to safeguard ecosystems and benefit riverine populations. The potential of many of Asia's inland waterways has already been tapped in some countries, notably in China, and has been recognized by other national and sub-national governments as a potential area for investment. In India, for instance, where 14,500 km of navigable inland waterways exist but water only carries a mere 0.5 percent of the country's freight traffic, the government is actively working to develop inland waterways as an alternative mode of transport.[77] Similarly, development and restoration of inland waterways transport systems are being considered in Myanmar, Vietnam (25 percent of transport volume by 2020), and Lao PDR (30 percent of transport volume by 2020) among others.[78]

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3. Cross-Cutting Issues

Across the water subsectors, several common themes emerge:

3.1. Governance

The water crisis is often described as a crisis of governance. Water governance refers to the range of political, social, economic and administrative systems that are in place to manage water resources and to deliver water services to different levels of society.[1] It includes the institutions, laws, and regulations but also relates to government policies and actions and its relationships to the private sector and civil society.[2] Each water subsector will have its own governance environment and associated challenges. These are some of the most challenging issues to resolve requiring concerted effort and attention. Decades of experience show that unless an effective governance framework is in place, capable of managing interdependencies and conflicting objectives across policy areas and levels of government, investments in water do not fully achieve the intended outcomes in a sustainable manner.[3] Weak governance can in fact lead to greater water risks. Evaluations of water investments across the world suggest that a minimum level of governance is needed before desired outcomes can start to improve.[4]

The governance challenge relates to the fact that water connects across sectors and people, as well as across geographic and temporal scales. Hydrography (e.g., physical basin, landscape) and administrative boundaries (from national to state to local to city) rarely coincide. This results in interdependencies across levels of government that require coordination to mitigate fragmentation in implementation. Institutional arrangements are needed that support both horizontal coordination (i.e., coordinating water policy with nonwater related sectors such as energy, environment, health) and vertical coordination (i.e., countries have allocated increasingly complex and resource-intensive responsibilities to subnational governments). These characteristics require a multilevel governance perspective,[5] which includes efforts to decentralize and move responsibilities for management and services closer to the local levels. Given the ubiquitous challenge with institutional and policy reform, a "principled pragmatism" approach is needed. That is, "principled pragmatism stresses the importance of economic principles, such as ensuring that users take financial and resource costs into account when using water, and the need to tailor solutions to specific, widely varying natural, cultural, economic and political circumstances."[6]

At the service provider level governance is more localized but typically inadequate. Whether considering the delivery of irrigation water, the treatment and distribution of drinking water or the collection of wastewaters, the characteristics of well-run service providers are similar. They have managerial and financial autonomy, they have internal and external accountability, they are market (i.e., efficiency) oriented and customer-focused. Sadly, most of these characteristics are missing in Asian service providers and this results in suboptimal technical and financial performance. Reforming existing institutions and putting in place the proper policies and regulatory frameworks will be more challenging than the implementation of infrastructure itself.

3.2 Nexus

Water issues faced by countries can often originate from the unmanaged impacts of investments in other sectors. Notable examples include increased risk of flooding due to uncontrolled urban development in floodplains or groundwater depletion due to subsidized electricity for pumping. When the interlinkages between water and other sectors are not considered, progress toward sustainable economic growth and human wellbeing is often hindered in the long-term. These interlinkages between water and other sectors are particularly strong for energy and agriculture (i.e., the water-energy-food nexus). The water sector needs energy to pump, clean and transfer water, while the energy sector generally needs to access water for cooling and power generation. Water is the key factor of production in agriculture, and in turn agriculture affects water quantity and quality for all other users. Identifying synergies and managing trade-offs among sectors (i.e., a nexus approach) is essential to diagnose water sector issues and define strategic directions for water infrastructure investment.

As such, investments to address Asia's water challenges cannot be considered in isolation. Nexus thinking means understanding water and other sectors, notably, energy, food, environment and land and their interrelationships as well as considering the cumulative effects of interventions rather than discrete impacts alone. It also involves thinking across government institutions where responsibilities for each lie. Given the interactions among water and other sectors, there is increasing emphasis on integrated investments capable of exploiting synergies between sectors.[7] Analytical methods have been developed to reveal trade-offs and synergies among sectors[8] and are increasingly being considered by development banks.[9] These can be applied in project appraisal and evaluation to identify multisectoral impacts of water investments.

3.3 Gender and Inequality

Gender plays a crucial role in countries' ability to ensure improved and inclusive water and sanitation services and water resource management for all citizens. There is a growing body of literature around the impacts of poor water and sanitation services on health and educational outcomes (particularly for girls) and on intergenerational impacts that derive from stunting.[10] Droughts and floods also often exacerbate existing gender inequalities or have disproportionate impacts on women and girls. For instance, rainfall shocks are linked to increases in violence against women in India.[11] Similarly, female-led farmers are at greatest risk of not receiving irrigation water and not being represented in user organizations in Central Asia.[12] Achieving equity is a common challenge in water related services. In Pakistan, poor sanitation facilities in schools deter adolescent girls, from education: up to 50 percent of girls do not attend school during menstruation.[13] These examples underscore the complex and multiple relationships amongst water, gender, and inequality. Water infrastructure investments will not deliver their expected benefits and services unless they consider these dimensions and how they interact with other factors such as class, ethnicity and geography.[14,15]

3.4 Resilience

Infrastructure and resilience are closely linked. Resilience is a key objective of infrastructure investment. Infrastructure makes societies and economies more resilient to a range of potential disruptions, notably those due to climate change and related water extremes. Resilience also makes economies more competitive, as investors are more likely to engage and invest in regions that are resilient to the inevitable disruptions occurring in an uncertain world.[16] Resilience also needs to be a key attribute of infrastructure itself. Resilient infrastructure is planned, designed, built and operated in a way that anticipates, prepares for, and adapts to uncertain circumstances, including climate change and water-related disasters, changing consumption patterns and digital disruptions.[17] A range of approaches are emerging and being tested for resilient infrastructure, especially in cities.

City resilience cannot be achieved and sustained without water infrastructure and management. The role that water infrastructure plays is recognized in AIIB's Sustainable Cities Strategy. As people and assets concentrate in cities, demands for services increase as do exposure to water-related disasters and pollution. While the water issues facing Asian cities were discussed in earlier sections, the governance capacity[18] will be important to the sustainability and efficiency of infrastructure investments. At the heart of this is the integrated urban water management (IUWM) approach which emphasizes: (1) coordinated planning of water services (water supply, sewerage and drainage) and other city services (e.g., transport, green spaces); (2) consideration of decentralized options for infrastructure provision (wastewater, stormwater reuse opportunities); (3) diversification of water sources to include unconventional sources (wastewater, sink drainage, other discharges) with traditional (surface and groundwater resources, desalination) sources and (4) explicit consideration and integration of ecosystem protection and "green" infrastructure, including protecting water at its source (see Section 2).[19]

Achieving city resilience requires an investment approach which carefully considers overlaps with other sectors. Water investments can overlap with other sectors' investments in cities (e.g., transport, energy) and also in surrounding areas (e.g., agriculture, environmental conservation). These overlaps generate synergies between sectors, for instance through mutually beneficial material and resource flows. For example, investments in urban wastewater treatment have the potential to benefit the agricultural sector through reuse of wastewater for irrigation in peri-urban areas, as observed in many parts of Asia.[20] Investments in urban greening can also provide stormwater retention, storage and drainage services, as demonstrated by China's sponge cities projects or Colombo's urban wetlands.[21] However, the overlapping nature of urban infrastructure also generates risks, arising for example from the cascading failures in often mutually dependent power and water infrastructure systems (e.g., the power blackout resulting from Hurricane Sandy in 2012, which led to a loss of water supply in New York City[22]).

Opportunities for water infrastructure financing in cities are often limited. Less than 20 percent of the largest 500 cities in developing countries are deemed creditworthy in their local context, severely constricting their capacity to finance investments in water infrastructure.[23] In some developing countries, the market is not yet sufficiently developed to enable the flow of capital into urban infrastructure projects and local government capacity is low. The multisectoral nature of infrastructure investment in urban areas and the need for spatial integration (e.g., town development planning) means that innovative financing opportunities, such as land value capture, can be harnessed to finance some of the required water infrastructure.[24] There is no doubt that to address sector resilience issues in urban areas and attract financing, city governments must ensure that the institutional frameworks are in place to promote integrated urban development.

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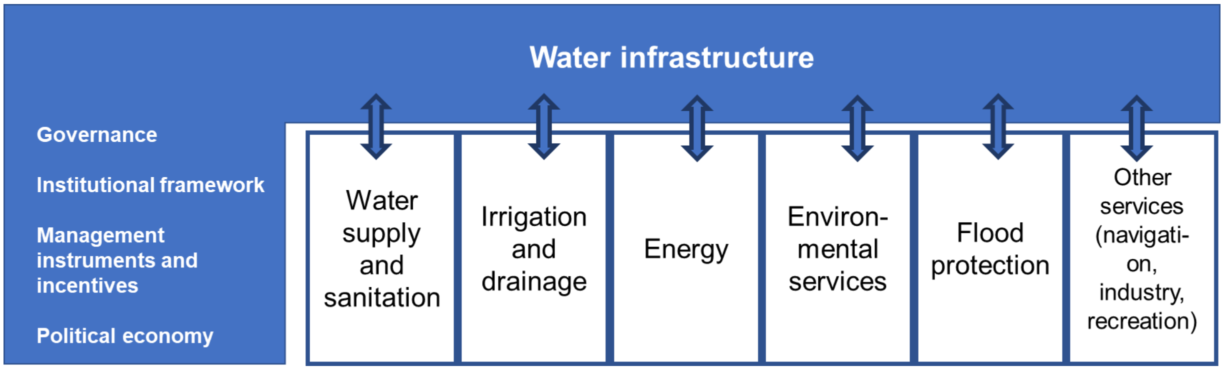
4 Water Infrastructure

Sustained investments in water infrastructure will be critical to meeting the challenges described earlier. Water infrastructure will be an essential pillar for growing economies and central to delivering services, managing the resource, adapting to climate change, and in mitigating cross-border risks. Many countries have already invested heavily in major hydraulic infrastructure such as multipurpose dams, canals, dikes and interbasin transfer schemes, to provide security against climatic variability. All countries will need to be active in both improving management of existing infrastructure and, in some cases, development of new infrastructure. Moreover, not all water problems can be solved with infrastructure alone nor through better management alone—some balance is necessary. Although many argue that some "minimum platform" of infrastructure is needed to achieve water security,[1] this infrastructure is a necessary but not sufficient condition for quality service delivery and broad water resource management.

There is a diversity of water infrastructure making generalizing difficult. No single approach to financing, funding, and sustainability of water infrastructure will be feasible in all circumstances. Recognizing the different "characteristics" of each water infrastructure and the different "cultures" of the subsectors that they support will be critical to understanding the risk-reward tradeoffs of each. Generally, water infrastructure provides services, management, or both (Figure 4.1). Infrastructure can be used to provide strategic functions such as storage, water resources management, bulk water supply to different subsectors, as well as provide for specific services including electricity generation (hydropower and cooling in thermal power stations), irrigation and drainage, municipal and domestic water supply, municipal sewerage and stormwater management, navigation, flood risk reduction (both at the river and city scales), recreation, and assuring sufficient water for ecological services. Such a broad perspective on water infrastructure is required because of the growing needs across a wide range of water-related subsectors and the large backlog for the replacement and modernization of existing infrastructure.

Figure 4.1. Water infrastructure is the enabler, together with institutions and management instruments, of multiple services.

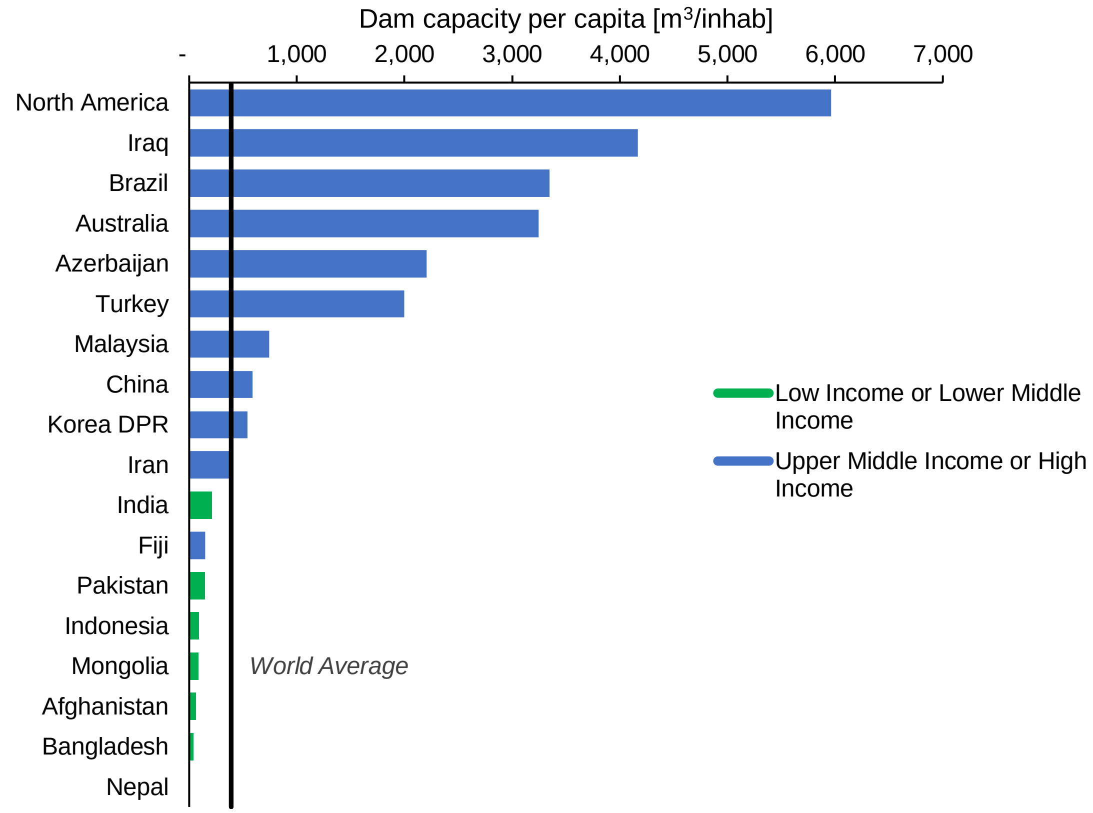


Source: Adapted from: Global Water Partnership, Technical Advisory Committee. 2000. Integrated Water Resources Management. Stockholm: Global Water Partnership.

Water related management and services can be delivered through both "hard" and "soft" interventions." Interventions are not necessarily confined to physical structures such as dams, pipelines, canals, treatment works. "Green infrastructure" (i.e., using land, forests, wetlands, and other natural features) and improved management approaches (e.g. efficiency improvements, demand management) are increasingly part of the response to water risks. These softer initiatives may be more cost effective than physical structures. For example, in New York City, relatively modest investments in conservation in the upstream watersheds supplying the city's drinking water in lieu of the construction of new treatment plant saved the city USD10 billion in construction costs and over USD100 million a year in operating costs.[2] In tackling water risks, countries will have different development agendas and, depending on their economic status, will have different infrastructure endowments. As such, the balance amongst using these different hard and soft combinations will vary by client countries.

Multipurpose water infrastructure (e.g., dams) deserves special attention. In the face of increasing hydrologic uncertainty and competing demands of different user groups, the use of multipurpose water infrastructure will increasingly play an important role in a country's quest towards greater water security. This kind of water infrastructure does present its own unique challenges, in particular with financing given the large sums typically needed. Moreover, many different stakeholders may be affected (e.g., land acquisition and resettlement) and impacts on the environment may be large. Many such large projects may also be on transboundary rivers, thus involving two or more countries. Nonetheless, the contribution that dams can make to development is clear.[3] The ability to store water is essential to matching the uncertain, spatial and temporal distribution of precipitation with changing human demands. Many countries have already invested heavily in storage dams. This is particularly the case for high-income and upper-middle income countries (Figure 4.2, blue bars). In low income and lower-middle income countries, investments in storage are still needed (Figure 4.2, green bars).

Figure 4.2. Dam capacity per capita for selected countries in Asia and the world.



Source: FAO Aquastat database, latest year available. Data for India comes from the [Ministry of Water Resources Water Storage Capacity database].

Finally, water information and communication technologies (ICT), are closely intertwined with infrastructure delivery and performance. Hydrological monitoring networks and metering systems are critical to inform investment decisions and water management, and effectively form part of a country's water infrastructure assets. In many parts of Asia, water information systems are inadequate or poorly maintained, undermining countries' ability to prepare and respond to disasters. Accurate, reliable, timely and relevant water information underpins the design, maintenance, and operation of all water infrastructure and the monitoring and appraisal of investments. In this context, linking investments in water infrastructure with information systems, while also exploiting recent technological advances (see Box 1) can help ensure the effectiveness of water infrastructure investments.

Box 1: Fourth Industrial Revolution (4iR) for Water

The Fourth Industrial revolution is a major transformation marked by a fusion of technologies that is blurring the lines between physical, digital, and biological systems[4]. Technologies driving the Fourth Industrial Revolution (4iR) are numerous including artificial intelligence, robotics, internet of things (IoT), 3-D printing, blockchain, as well as rapid advances in earth observation, nanotechnology, biotechnology, materials science, and quantum computing. These innovations present a major opportunity, if harnessed and scaled effectively, to address the world's most pressing water security challenges: water scarcity, poor water quality, climate change and variability, depletion of groundwater aquifers, floods, water governance, lack of water data.[5]

4iR technologies have the potential to provide information related to water supply and demand at unprecedented temporal and spatial resolution. Data collection is rapidly advancing through satellite imagery and earth observation tools, which are delivering insights on water resources availability, water use and productivity. In-situ sensors and IoT also allow for a more complete picture of water supply and demand to be obtained. Beyond data collection, these technologies also allow for better data management (e.g., cloud services, data cubes) and data analysis and forecasting, through new computing devices, artificial intelligence and machine learning.

The 4iR is allowing for production systems to be redesigned. For water management, this means low-cost approaches to treat water for human consumption, operate water infrastructure and provide access to water supply and sanitation services. Advances in nanotechnology have the potential to lower the costs of producing water through desalination and wastewater reuse, unleashing new water supplies at scales. Additive manufacturing techniques, such as 3D printing, could be used to produce materials to remove water pollutants or provide water-efficient irrigation systems at low costs.

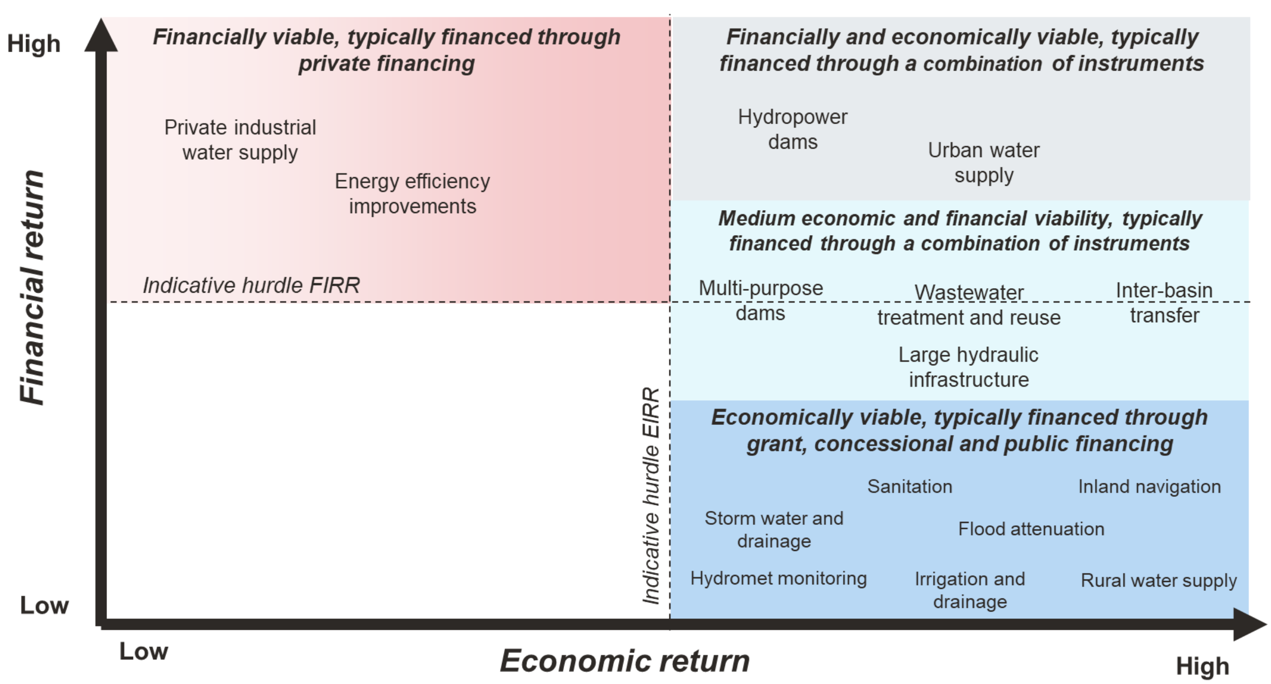
Finally, the 4iR revolution creates new opportunities for interaction. In terms of water service delivery, this offers new channels for cost recovery of water services through mobile payments. With regards to agricultural water management, new interaction technologies can also help to mitigate agricultural water demands, by sharing information about soil conditions and crop water requirements to farmers on their mobile devices in real time or in a daily report. Through improved interaction technologies, multiple stakeholders will also have increased access to data and be able to make better-informed decisions and cost-effective investments.

4.1 Economic and Financial Characteristics of Water Infrastructure

Different infrastructure will have different return profiles; some generating largely private economic benefits (e.g., drinking and irrigation services) while some generating largely public economic benefits (e.g., flood protection, storm water drainage). Some infrastructure, like multipurpose dams, may provide both private and public benefits and both services and management functions. Note that there may be infrastructure that provides, under certain conditions, common pool and club economic goods as well.[6] Understanding this is important in identifying the funding mechanism over the full life cycle (planning, appraisal, implementation, operation, maintenance and replacement) and for determining the opportunity for private financing (Figure 4.3). All infrastructure will undergo a financial and economic cost-benefit analysis (CBA) to determine whether scarce financial resources are best allocated to this infrastructure in comparison to other potential investments in other sectors. Some water infrastructure will have greater opportunities to generate cash flow through user fees, while other water infrastructure will be justified largely on economic grounds (funded through taxes and other sources) and will have limited opportunity to generate financial income streams.

Water services related infrastructure (e.g., WSS, wastewater, irrigation, hydropower) can potentially draw upon on a wider range of financing modalities, from both governments and commercial sources. Financing options for functions generating public goods are more limited. Major large strategic water infrastructure, such as large multipurpose dams, will normally need to be underpinned with public finance, with the projects possibly structured to include participation by private investors and commercial lenders (center-right quadrant in Figure 4.3).

Figure 4.3. Economic and financial return for different types of infrastructure investments.



Source: IWMI. Notes: Figure shows the financing approach most commonly used; however, in reality financing approaches might differ depending on country circumstances. FIRR: Financial Internal Rate of Return. EIRR: Economic Internal Rate of Return.

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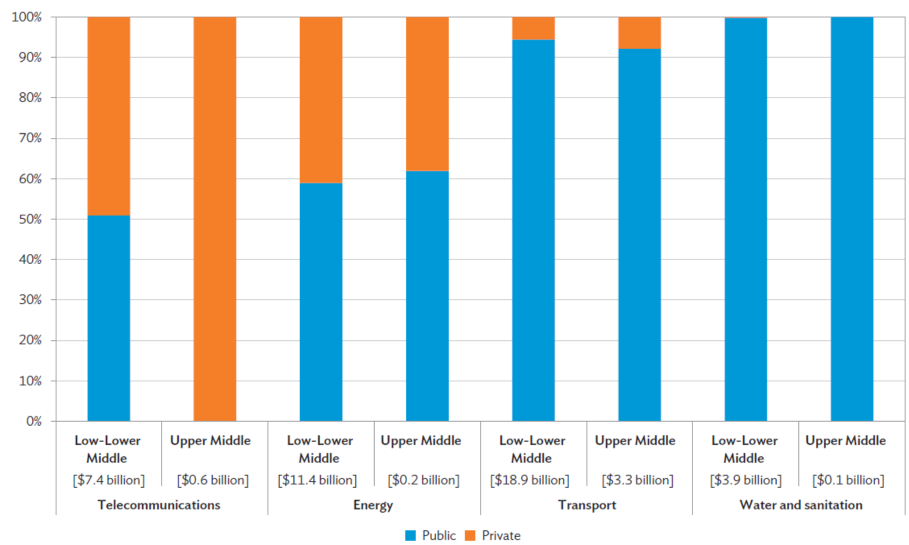
5 Water Infrastructure Investment in Asia

5.1 Investment Trends

Estimates of water infrastructure expenditures are difficult to make due to poor data availability. The ADB estimates that its member countries[1] invested about USD880 billion in infrastructure in 2015. Of these USD880 billion about five percent went to the water sector (which includes water supply and sanitation, dams, irrigation, flood protection and water treatment)[2,3]. These regional estimates hide considerable variation across Asian countries, as most infrastructure investment took place in China and South Asia. Other countries, such as Vietnam and Bhutan have also been investing significantly in infrastructure.[4]

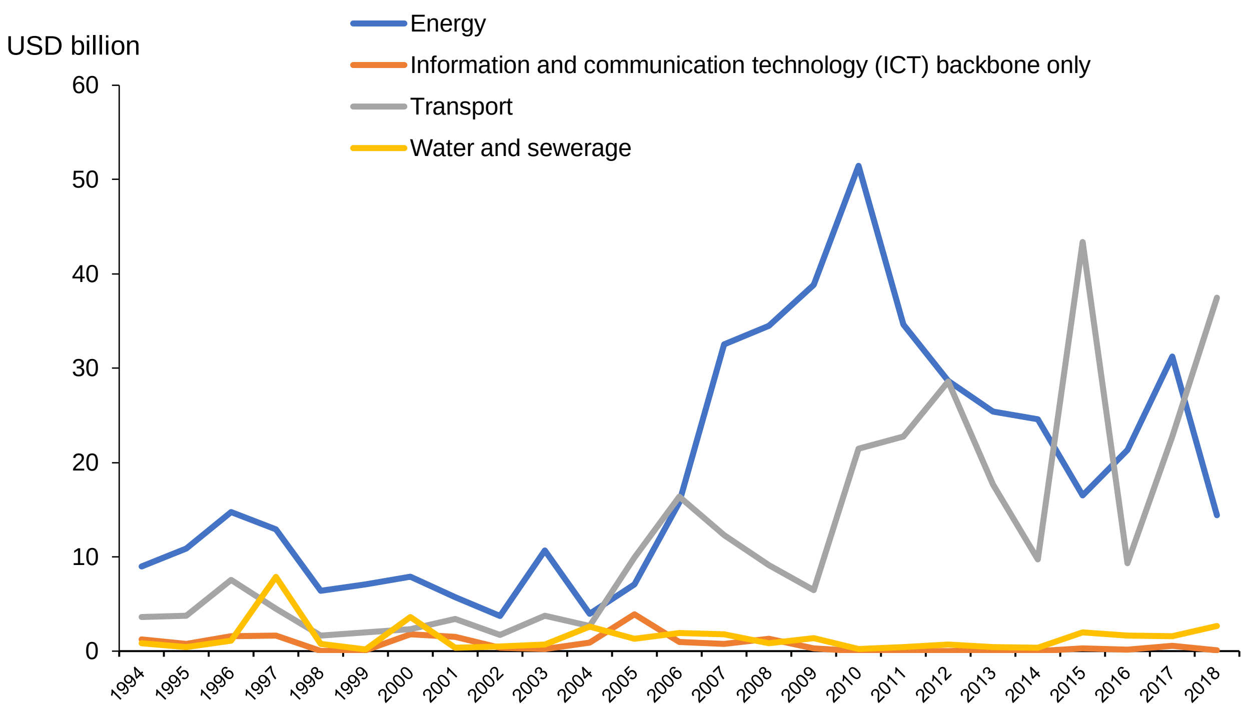
Private investment in water infrastructure in Asia is low. Except for China, where water infrastructure accounts for 10 percent of private sector investment, Asian countries rely almost exclusively on public investment for water infrastructure.[5] Telecommunication and energy infrastructure received much higher shares of private investment in several Asian countries (see Figure 5.1). Private sector investments in the energy and transport sectors averaged 30 and 20 billion USD per year respectively over the least 10 years while that in water supply and sewerage infrastructure averaged USD1 billion per year (Figure 5.2). The higher levels of private investment in energy and telecommunications can be partly explained by the normally favorable returns and predictable revenue streams in the sector, as well as regulation and competition policies favoring private sector engagement.[6] Current levels of private investment in water supply and sewerage are enough to cover just one percent of Asia's WSS infrastructure needs.[7]

Figure 5.1. Public and Private investment in infrastructure, selected countries in Asia, 2011.



Source: Asian Development Bank. 2017. Meeting's Asia infrastructure needs. Manila: ADB.Note: Figures in bracket indicate investment levels in billion (in 2015 prices). Low to lower middle-income countries include Armenia, Bhutan, Cambodia, Indonesia, Kiribati, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, and Vietnam. Upper middle-income countries include Fiji, Georgia, Malaysia, and Maldives. Government budget is for central government only in Armenia, Georgia, Nepal and Philippines. India, China and the Russian Federation are excluded in the chart as they would dominate other economies in their income groups. Adding India back to low-lower middle-income group would not change the pattern much, although adding the PRC back to upper middle-income group would significantly increase the share of public investment across all infrastructure sectors. Water and sanitation include: dams, irrigation and flood control waterworks, local water and sewer mains, local hot-water and steam pipelines, sewage, and water treatment plant.

Figure 5.2. Private investment in infrastructure in Asia, 1994-2018.

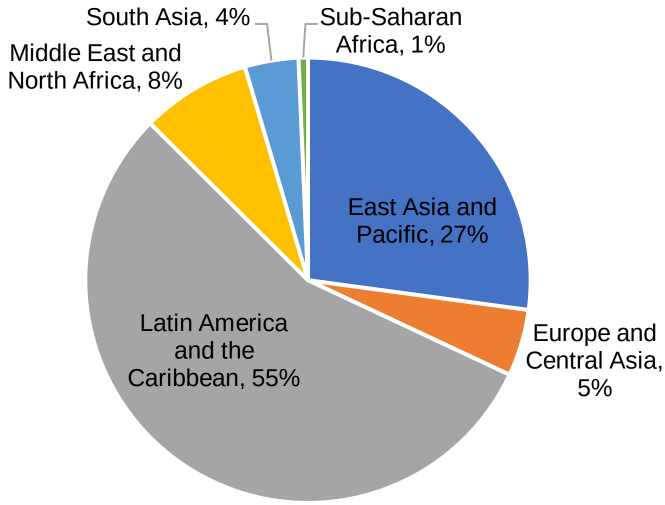


Source: IWMI with data from the World Bank private participation in infrastructure database. Note: these estimates differ from the ones shown in Figure 5.1 because China, India, and the Russian Federation are included here. Estimates for information and communication technology represent ICT-backbone infrastructure (such as fiber-optic cables (land-based/submarine cables), mobile towers, base stations and other hard assets) only.

Private involvement in water and sewerage infrastructure in Asia is almost half that of Latin America. Over the last 10 years, about 55 percent of the total private participation in water infrastructure took place in Latin America and the Caribbean. Investments in East Asia and the Pacific (mostly China) accounted for about 27 percent of global private investments in water infrastructure. Countries in Western Asia and South Asia attracted a lower share of private investments (Figure 5.3).

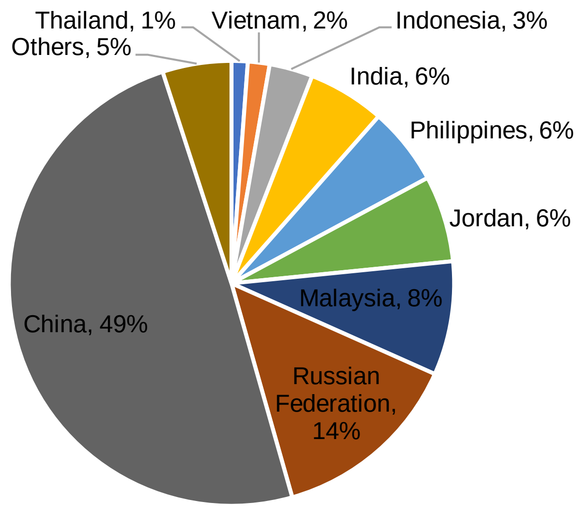
Private investments in water supply and sewerage infrastructure were concentrated in some of Asia's lower risk economies. China, the Russian Federation and Malaysia received the lion's share of private investment in water infrastructure since 2000, with about half of all private investments in water infrastructure directed to China (Figure 5.4). This partly reflects efforts in these countries to expedite and facilitate infrastructure investments, as well as investor appetite to invest in more established economies. Of concern is that little or no private investment is taking place in Asia's smaller countries, where the financing needs are higher and opportunities to raise funds is lower.

Figure 5.3. Private investment in water supply and sewerage infrastructure by world sub-region, share of the total invested globally 2009-2018.



Source: IWMI with data from the World Bank private participation in infrastructure database.

Figure 5.4. Private investment in water supply and sewerage infrastructure in selected Asian countries, (2000-2018).



Source: IWMI with data from the World Bank private participation in infrastructure database. Countries under "Others" include: Papua New Guinea, Turkey, Armenia, Thailand, Bangladesh, Vietnam, Georgia.

Overall, private finance has not been mobilized on the scale needed, and most of the financing has gone to Asia's richer nations predominantly to commercially attractive energy and telecom sector. This picture reflects global trends where low-income countries and water infrastructure have received negligible financing, despite showing some of the highest needs for investment.[8]

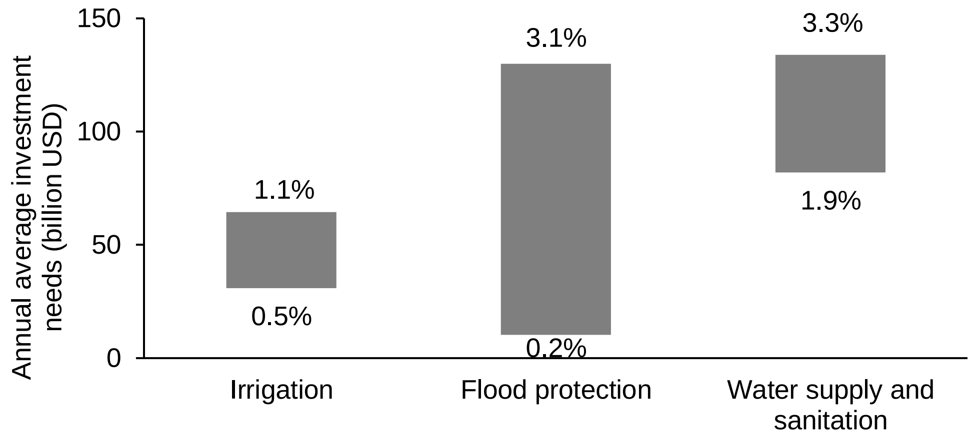
5.2 Investment Needs

5.2.1 Overview of infrastructure investment need and gap

Infrastructure investment needs depend on country goals and the efficiency with which these goals are pursued. Policy goals, including flood risk standards, and types of technologies adopted are some of the factors determining the infrastructure investment needs in Asia. Data from the 2019 World Bank publication *Beyond the Gap*[9] are used to provide a guide on the possible evolution of infrastructure needs based on a common set of policy goals (the SDGs) for lower- and middle-income Asian countries. As with all global assessments, this analysis only provides a strategic, bird's-eye view of future needs and not an accurate projection of national scale investment needs. Moreover, the World Bank data presented here provide ***a lower bound*** as they do not account for multipurpose water infrastructure, hydropower, and urban drainage infrastructure needs.

The water infrastructure investment needs for Asia are in the range of 120 to 330 billion USD per year until 2030. This is for irrigation, water supply and sanitation, and flood protection infrastructure only. Across Asia, this amounts to about 2.5 to 7.5 of regional GDP every year until 2030. The World Bank estimates include both capital and recurrent (operation and maintenance) costs and are developed using consistent policy goals across the scenarios. The substantive investment needed for recurrent costs, almost half of the total, is consistent with the ADB finding that the ratio of new investment to maintenance and rehabilitation is 4:3.[10] The range in the projected investment needs reflects the uncertainty in the estimates coming from the type of policies adopted or a given accepted level of residual risk, in the case of flood protection (Figure 5.5). More ambitious policies to expand access to WSS, irrigation and increase the levels of flood protection would lead to higher investment requirements.

Figure 5.3. Average annual spending needs for water infrastructure in Asia (billion USD), 2015-2030.



Source: IWMI using data from Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. Because of the World Bank regional classification, irrigation estimates for Western Asia also include countries in North Africa and estimates for Central Asia also include eastern European countries. This means that the estimates presented here for irrigation are an upper bound on investment needs for Asia only. Percentages represent percentage of GDP.

Water supply and sanitation is the infrastructure type with the greatest investment need. Universal coverage of water supply and sanitation services (SDG 6.1 and 6.2) could be achieved by 2030 at a cost of about 93 to 153 billion USD per year (about 1.9 percent to 3.3 percent of GDP per year).[11] This is for both urban and rural water supply and sanitation. The goal (basic access versus safely managed access) and the related choice of technology for delivering water supply and sanitation services are the main factors influencing the investment needs and projected range. No matter what goal and technologies are pursued and adopted, operations and maintenance (O&M) costs are expected to account for more than half of the spending needed—and good practice shows that these should be covered from tariffs where possible. The other half is split equally between the capital cost of extending access and the capital investments needed to preserve services for those currently served. New capital spending needs for water supply and sanitation infrastructure exceed replacement costs for existing assets only in South Asia.[12]

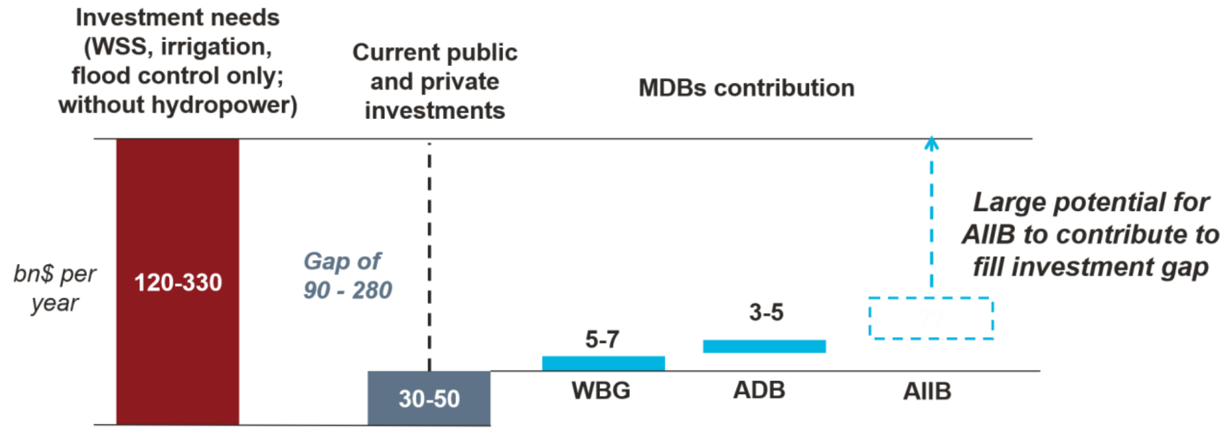
Flood protection needs range between USD12-149 billion, about 0.2 to 3.1 percent of GDP. This estimate is based on several different climate change scenarios and socio-economic development trajectories. Investment costs for protection against both coastal and river floods—and the related projected range—depend primarily on the level of residual risk acceptable to societies and some of the uncertainties related to construction costs.[13] This flood protection needs only include the cost of dike heightening and extension, suggesting that the actual needs might be higher given the likely need to invest more in urban drainage and stormwater systems to reduce flood risk in Asia's growing cities. This also does not include investments in multipurpose dams which often also serve a flood protection role.

Irrigation infrastructure needs range from USD30 to 64 billion, about 0.5-1.1 percent of GDP[14]. This estimate is a lower bound as it only considers capital needs to expand irrigation, without accounting for drainage infrastructure and operation and maintenance costs of existing infrastructure. Nor does this account for rehabilitation costs which in many countries may be substantial. Hence, this investment is the expected cost of transforming rainfed cropland into productive and efficient irrigated cropland, considering constraining factors such as water availability.[15] Depending on the policy goals and investment scenario, between 50 Mha to more than 80 Mha of natural land and forests could be converted to irrigated cropland.[16] Expanding irrigated areas would improve food availability, yet it would also lead to significant impacts on environmental flows and biodiversity of inland waters. Most notably, in South Asia and Western Asia, the share of unsustainable freshwater withdrawals (i.e., freshwater withdrawals compromising environmental flows) could reach 51 percent and 66 percent by 2050 respectively under a scenario of aggressive irrigated cropland expansion.[17]

Water infrastructure needs for hydropower are on the order of hundreds of billions USD over the next decade depending on country energy policies. An increased focus on renewables to achieve Nationally Determined Contributions (NDC) requires globally USD132 billion per year from 2016 to 2030.[18] With annual expenditures on hydropower at around USD60 billion per year, this implies investment more than doubling from current levels at the global level.[19] Also, the development of more intermittent renewable energy sources, such as solar and wind, increases pressure for hydropower storage either in large reservoirs or in pump storage. The need for large storage will increase both the cost and complexity of projects. In South Asia alone, tapping the region's hydropower potential presents a USD107 billion investment opportunity between now and 2030[20] assuming each country will fully meet its NDC and relevant sectoral targets.

Attracting financing from the private sector and from multilateral development banks is critical to meet these investment needs. Current public and private expenditures in water infrastructure are an order of magnitude lower than the expected needs. Analysis from the Asian Development Bank suggests that in 2015 public and private investments in water infrastructure were of the order of USD30-50 billion per year[21]. About 75 percent of this spending took place in China alone, suggesting that investment gap might even be higher in other low- and middle-income Asian countries. In this context, there is a large potential for AIIB to contribute to fill Asia's water infrastructure investment gap (Figure 5.6).

Figure 5.4. The large potential for AIIB to contribute to fill Asia's water infrastructure investment gap.



Source: IWMI using data from Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications for investment needs. Data on current public and private investments are for 2015 and come from Asian Development Bank. 2017. Meeting's Asia infrastructure needs. Manila: ADB. Data on MDBs contributions are for 2018 and come from institutional sources. Note: Data should be considered as indicative only given the large uncertainties surrounding current public and private investments in infrastructure and the lack of comprehensive public expenditure reviews in the sector. WSS: Water Supply and Sanitation. MDB: Multilateral Development Banks.

Closing Asia's water infrastructure gap is not just a matter of spending more, but also spending better. The size of the investment gap (e.g., difference between current expenditures and future needs) shown in Figure 5.6 depends to a large extent on national policy goals and uncertainties (e.g., construction costs, climate change) driving future infrastructure needs. All financiers, including the AIIB, need to avoid just focusing on the financing gap issue (e.g., how much) but to also explore how multiple investments and policy choices contribute to achieve policy goals (e.g., what are we trying to achieve in terms of infrastructure services). Identifying the objectives of infrastructure investment will require close interaction with AIIB client countries and key partners (Section 8).

5.2.2 Infrastructure investment needs scenarios by sub-region and country

In a moderate spending scenario, investment costs are largest in South and East Asia. When investment needs are considered by sub-region (Table 5.1), South Asia stands out as being the sub-region with the highest spending need as a percentage of GDP while East Asia stands out in absolute terms (across all three water subsectors). Western Asia also has significant needs in terms of water supply and sanitation. Results from World Bank analysis show that while capital expenditures are key, so are maintenance requirements.[22]

Table 5.1. Average annual cost of investment, by sector and subregion, 2015-2030 as a share of GDP (top) and in USD billion per year (bottom).

		East Asia and Pacific	**Eastern Europe and Central Asia**	**Middle-East and North Africa**	**South Asia**
Flood protection	**Total**	**0.33**	**0.07**	**0.21**	**0.61**
	Capital	0.25	0.06	0.17	0.54
	Maintenance	0.08	0.01	0.04	0.07
Irrigation	**Total**	**0.13**	**0.04**	**0.10**	**0.27**
	Capital	0.13	0.04	0.10	0.27
Water supply and sanitation	**Total**	**0.43**	**0.57**	**1.20**	**1.10**
	Capital	0.33	0.44	0.90	0.80
	Maintenance	0.10	0.13	0.30	0.30

		East Asia and Pacific	**Eastern Europe and Central Asia**	**Middle-East and North Africa**	**South Asia**
Flood protection	**Total**	**50.0**	**2.2**	**4.6**	**25.9**
	Capital	38.4	1.8	3.8	22.9
	Maintenance	11.7	0.4	0.8	3.0
Irrigation	**Total**	**20.0**	**1.3**	**2.3**	**11.5**
	Capital	20.0	1.3	2.3	11.5
Water supply and sanitation	**Total**	**66.0**	**18.0**	**27.1**	**46.6**
	Capital	50.6	13.9	20.3	33.9
	Maintenance	15.3	4.1	6.8	12.7

Source: Table O.1 in Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. Note: Because of the World Bank regional classification, estimates for Western Asia also include countries in North Africa and estimates for Central Asia also include eastern European countries. This means that the estimates presented here are an upper bound on investment needs for Asia only. These are estimated for a scenario with policies aimed at providing improved access to water services using high-cost technology in cities and low-cost technology in rural areas, at minimizing coastal flood risks and at accepting increased risks from river floods based on cost-benefit analysis, and at subsidizing irrigation infrastructure.

Within these regions, individual countries emerge. Average annual costs to develop and maintain infrastructure (water supply and sanitation and flood protection only – irrigation cost projections by country are not available) are highest in absolute terms in some of Asia's largest economies (Table 5.2). Hence, China and India have the greatest projected costs in absolute terms, followed by Thailand and Indonesia. In the end, how much countries need to spend on water infrastructure depends on their policy goals and on how they choose to pursue these goals (technology choices, construction costs). A full list of countries for which data on infrastructure costs is available is presented in Appendix I.

Small-island nations face the greatest costs of infrastructure investment relative to the size of their economies. If investment needs are estimated as a share of GDP, then a different picture emerges. Spending needs in relative terms are particularly high in small-island nations which face the existential challenge of addressing coastal flood risk (Table 5.3). In terms of water supply and sanitation, many of Asia's most politically fragile countries face some of the greatest costs as a share of their GDP, reflecting the negative impact of conflict and violence on progress towards universal access[23]. In some other countries with already high levels of access to water supply and sanitation (e.g., Thailand), high costs reflect the investment need to reach universal access to safely managed water services whilst maintaining current levels, a challenge faced by many Asian countries.

Table 5.2. Top 10 countries for average annual investment cost of water infrastructure in USD billion per year, 2015-2030

Top ten countries for average annual cost of water infrastructure (bn USD)

Water supply and sanitation		Floods		Total	
China	61.84 (47.73-63.71)	China	18.11 (4.74-53.57)	China	79.95 (52.47-117.28)
India	22.72 (13.05-29.59)	India	8.7 (2.4-25.77)	India	31.42 (15.45-55.36)
Thailand	5.74 (4.38-6.13)	Thailand	2.68 (0.58-5.89)	Thailand	8.42 (4.96-12.01)
Indonesia	5.59 (3.71-7.13)	Myanmar	2.28 (0.39-9.22)	Indonesia	7.4 (4.29-14.28)
Pakistan	5.45 (2.59-6.47)	Indonesia	1.81 (0.59-7.15)	Pakistan	6.03 (2.76-9.18)
Turkey	5.17 (4.37-5.89)	Viet Nam	1.81 (0.34-6.8)	Turkey	5.32 (4.44-6.99)
Philippines	3.95 (2.18-4.85)	Bangladesh	1.32 (0.35-3.94)	Viet Nam	5.12 (2.31-10.32)
Iraq	3.51 (2.25-4.34)	Kazakhstan	1 (0.21-3.59)	Philippines	4.76 (2.41-8.56)
Viet Nam	3.31 (1.96-3.52)	Philippines	0.82 (0.23-3.7)	Bangladesh	4.22 (1.53-7.52)
Malaysia	3.23 (2.55-3.71)	Malaysia	0.7 (0.22-1.63)	Malaysia	3.93 (2.77-5.34)

Upper Middle Income | Lower Middle Income | Low Income

Source: IWMI using data from Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. Details provided in Annex I. Investment cost shown for moderate spending scenario and include capital and maintenance expenditures, with upper and lower bound determined by policy goals and technology choices shown in parentheses.

Table 5.3. Top 10 countries for average annual investment cost of water infrastructure as a percentage of GDP, 2015-2030

Top ten countries for average annual cost of water infrastructure as % of GDP

Water supply and sanitation		Floods		Total	
Timor-Leste	0.05 (0.02-0.07)	Kiribati	0.47 (0.17-0.33)	Kiribati	0.48 (0.18-0.35)
Syrian Arab Republic	0.05 (0.04-0.05)	Vanuatu	0.19 (0.07-0.34)	Vanuatu	0.2 (0.07-0.35)
Yemen	0.04 (0.02-0.04)	Tonga	0.09 (0.03-0.13)	Timor-Leste	0.11 (0.04-0.19)
Nepal	0.03 (0.02-0.04)	Tuvalu	0.06 (0.02-0.07)	Tonga	0.1 (0.04-0.15)
Afghanistan	0.03 (0.01-0.04)	Timor-Leste	0.05 (0.02-0.12)	Tuvalu	0.07 (0.03-0.09)
Iraq	0.02 (0.02-0.03)	Samoa	0.03 (0.01-0.06)	Syrian Arab Republic	0.05 (0.04-0.06)
Pakistan	0.02 (0.01-0.03)	Fiji	0.03 (0.01-0.06)	Samoa	0.05 (0.02-0.07)
Viet Nam	0.02 (0.01-0.02)	Myanmar	0.02 (0.01-0.1)	Fiji	0.05 (0.02-0.08)
Myanmar	0.02 (0.01-0.02)	Mongolia	0.02 (0-0.31)	Afghanistan	0.04 (0.01-0.15)
Thailand	0.02 (0.01-0.02)	Lao PDR	0.02 (0-0.1)	Myanmar	0.04 (0.02-0.12)

Upper Middle Income | Lower Middle Income | Low Income

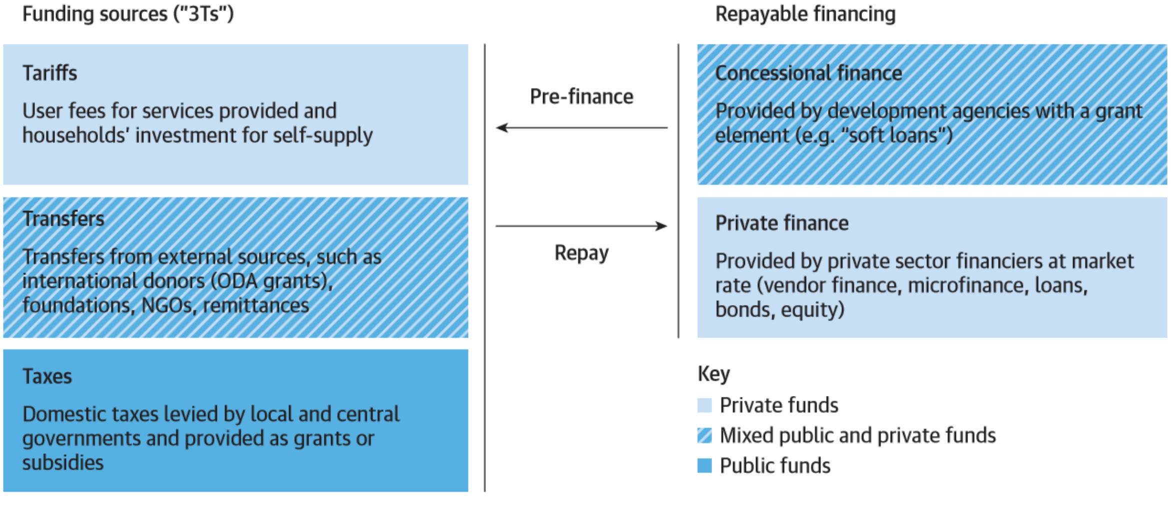
Source: IWMI using data from Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. Details provided in Annex I. Investment cost shown for moderate spending scenario and include capital and maintenance expenditures, with upper and lower bound determined by policy goals and technology choices shown in parentheses.

5.3 Financing Strategies and Opportunities

5.3.1 Overview of Water Sector Financing

Water infrastructure is typically funded by a mix of public and private sources. Tariffs (e.g. user fees), taxes (i.e., funding allocations from the public budget), and external transfers (3Ts) are the three main funding sources available to fund capital and operation and maintenance expenditures (Figure 5.7). These sources are preferred because they do not require repayment, but they are seldom enough to fill the financing gap.[24] As discussed in Section 4.1, only some water infrastructure can generate tariffs (e.g., water supply and sanitation, wastewater, irrigation, hydropower). As such, many Asian countries rely upon repayable financing (i.e., they borrow money on concessional or commercial terms which they need to repay over time) to meet the gap. It is important to emphasize that, in the end, water infrastructure will be paid through one of the three funding sources anyways, as finance needs to be repaid. Finance, however, can provide the incremental resources needed to get the infrastructure in place. When funding sources (e.g., users fees, central government transfers) are uncertain, it will be more difficult to mobilize the finance needed to build water infrastructure and more importantly, use strategically the limited development financing (i.e., concessional) that is available to countries.

Figure 5.5. Funding and finance sources for the water sector.



Note: NGOs = nongovernmental organizations; ODA = official development assistance.

Source: Goksu, Amanda; Trémolet, Sophie; Kolker, Joel; Kingdom, Bill. 2017. Easing the Transition to Commercial Finance for Sustainable Water and Sanitation. World Bank, Washington, DC.

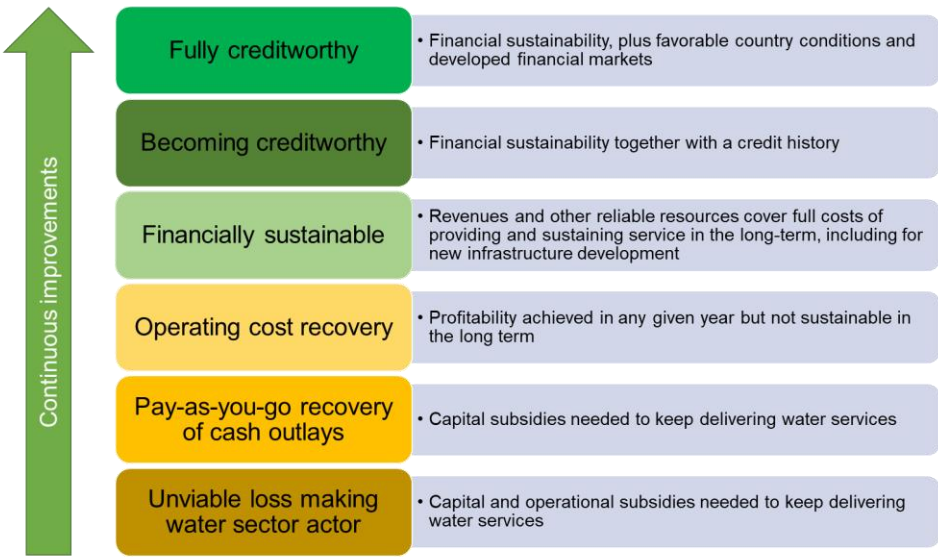
5.3.2 Financing Challenges

Current water sector financing is insufficient to meet the widening water infrastructure investment gap. As discussed in section 5.2, future capital and operating needs for water infrastructure will be higher than current spending levels. Because of this, countries facing lack of funding can only invest in water infrastructure through grants and concessional loans from donors and MDBs. In turn, this creates a stop-and-start mode of investment that does not culminate in long-term sustainable sector improvements[25]. This situation calls for different approaches to the way resources are used in the sector. This also presents significant opportunities for AIIB engagement.

Water sector financing (particularly for WSS and hydropower) needs to transition towards more commercial finance and more strategic use of scarce concessional finance. Increasing the level of commercial finance[26] for the sector would allow service providers to borrow and invest in expanding and improving the quality of water services. The benefits of commercial finance include faster access, more control over investment decisions, and lower transaction costs.[27] For governments and donors, tapping into commercial finance means freeing up scarce public resources for other important public functions (for example, for water infrastructure that does not generate cash flows like flood protection). In addition, expanding commercial finance has the advantage of reducing the implicit costs associated with borrowing in foreign currency (local currency devaluation makes repayment in foreign currency much costlier, often forcing borrowers such as water utilities with unbearable costs).

Mobilizing commercial financing is challenging and requires many intermediate steps (Figure 5.8). Very often, water infrastructure projects do not generate reliable revenue streams, making the sector less attractive to private investors. This is the case for many water utilities and irrigation agencies in Asia, who are unable to generate revenue streams to cover their operation and maintenance costs, let alone a surplus to service repayable finance.[28] In addition, water sector agencies often lack management skills, leadership and corporate structures to enable them to prepare to access private finance. Continuous improvements are needed to reach full creditworthiness.

Figure 5.6. Continuous improvement is needed to mobilize commercial finance in the water sector.



Source: IWMI.

Multilateral development banks like AIIB can leverage their funds to help countries overcome some of these challenges and attract commercial finance. A blended finance approach (i.e., using public or concessional and commercial finance)[29] offers two key advantages. First on the demand side, this approach offers more affordable borrowing rates (i.e. mitigates the costs of full-on market finance) and can accommodate political constraints that sets a ceiling on tariff levels. Second, on the supply side, it reduces lender risk through the participation and due diligence of a MDB or donor. AIIB can employ several instruments to help commercial finance work for its clients and for interested lenders, including grants, concessional loans and equity, and credit enhancements.

Blended finance is increasingly being used across Asia to finance water infrastructure. In Bangladesh, for example, output-based-aid from the World Bank is being blended with microfinance loans to lower the cost of latrines and spread repayment out in weekly installments over an entire year.[30] The blending is expected to leverage USD22 million in household contributions.[31] Similarly, Indonesia's ambitious water supply and sanitation targets are backed by a financial strategy that leverages commercial finance.[32] The urban water supply and sanitation sector is where most blended finance approaches have been tested, with examples from Asia including Manila and Phnom Penh.

Several climate-related sources of financing have also arisen. These include green bonds, the Green Climate Fund (GCF), the Clean Development Mechanism (CDM), and the Adaptation Fund. Green bonds are intended to raise finance for projects that help the transition to low carbon and climate-resilient development. The GCF will become potentially important in funding the creation and adaptation of existing and new water infrastructure to make them more climate resilient and more energy efficient. The CDM allows emission reduction projects in developing countries to earn certified emission reduction credits, each equivalent to one metric ton of carbon dioxide. These credits can be traded and sold and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. In Egypt (where AIIB has already provided water sector financing[33]) the CDM mechanism is being used for an irrigation and drainage pumping stations modernization program where emissions reductions are resulting through energy savings.[34]

Notes and References

[1] Afghanistan, Azerbaijan, Bangladesh, Bhutan, Brunei, Cambodia, Cook Island, Fiji, Georgia; Hong Kong, China; India, Indonesia, Kazakhstan, Kiribati, Kyrgyz Republic, Lao PDR, Malaysia, Maldives, Marshall, Micronesia, Mongolia, Myanmar, Nauru, Nepal, Pakistan, Palau, Philippines, PNG, PRC, Republic of Korea, Samoa,, Singapore, Solomon, Sri Lanka; Taiwan, China; Tajikistan, Thailand, Timor-Leste, Tonga, Turkmenistan, Tuvalu, Uzbekistan, Vanuatu, Vietnam

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[4] Asian Development Bank. 2017. Meeting's Asia infrastructure needs. Manila: ADB.

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[7] IWMI using data from Asian Development Bank. 2017. Meeting's Asia infrastructure needs. Manila: ADB for current investment levels and data from Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications for investment needs.

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[10] Asian Development Bank. 2017. Meeting's Asia infrastructure needs. Manila: ADB.

[11] IWMI using data from Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. Note: Because of the World Bank regional classification, estimates for Western Asia also include countries in North Africa and estimates for Central Asia also include eastern European countries. This means that the estimates presented here are an upper bound on investment needs for Asia only.

[12] Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. (Figure 2.1).

[13] Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications. (Chapter 5).

[14] Because of the World Bank regional classification, irrigation estimates for Western Asia also include countries in North Africa and estimates for Central Asia also include eastern European countries. This means that the estimates presented here for irrigation are an upper bound on investment needs for Asia only.

[15] Rozenberg, J. and Fay, M. eds., 2019. Beyond the gap: How countries can afford the infrastructure they need while protecting the planet. World Bank Publications.

[16] Palazzo, A., Valin, H.J.P., Batka, M. and Havlík, P., 2019. Investment Needs for Irrigation Infrastructure along Different Socioeconomic Pathways.World Bank Background Paper for or the World Bank Group's report: "Beyond the Gap: How Countries Can Afford the Infrastructure They Need While Protecting the Planet."
[17] Palazzo, A., Valin, H.J.P., Batka, M. and Havlík, P., 2019. Investment Needs for Irrigation Infrastructure along Different Socioeconomic Pathways.World Bank Background Paper for or the World Bank Group's report: "Beyond the Gap: How Countries Can Afford the Infrastructure They Need While Protecting the Planet."
[18] IRENA (2016), REmap: Roadmap for a Renewable Energy Future, 2016 Edition. International Renewable Energy Agency (IRENA), Abu Dhabi, www.irena.org/remap. pg. 123
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[21] This estimate is based on Table 5.1 in Asian Development Bank. 2017. Meeting's Asia infrastructure needs. Manila: ADB. Given the uncertainty in estimates of current investments, the data are presented as a range.
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[23] Sadoff, C.W., Borgomeo, E. and De Waal, D., 2017. Turbulent Waters: Pursuing Water Security in Fragile Contexts. World Bank.
[24] Goksu, Amanda; Trémolet, Sophie; Kolker, Joel; Kingdom, Bill. 2017. Easing the Transition to Commercial Finance for Sustainable Water and Sanitation. World Bank, Washington, DC.
[25] Goksu, Amanda; Trémolet, Sophie; Kolker, Joel; Kingdom, Bill. 2017. Easing the Transition to Commercial Finance for Sustainable Water and Sanitation. World Bank, Washington, DC.
[26] Commercial finance refers broadly to various types of finance that are neither concessional finance nor official development finance, and which are usually provided at market rates. In the water sector, this can range from microfinance loans to bonds and can be offered to service providers, local governments, individual users or user groups. Providers of commercial finance may include domestic commercial banks, microfinance institutions or capital market investors (via bonds or equity).
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6. Water Infrastructure for Development: Lessons Learned

The development and management of water infrastructure presents major policy, institutional, technical, financial, environmental and social challenges for most countries. While many lessons learned are common across countries and water subsectors, there is also a high degree of specificity in response to water infrastructure given the local nature of water management. Thus, the most appropriate intervention for a country will depend on the priorities of the stakeholders directly concerned and on the specific economic, political, social, cultural, and historical circumstances. Some general implementation lessons from MDBs are given below.

6.1 Strengthen Institutions and Policies

Well-designed infrastructure only delivers expected outcomes when it is backed by appropriate and effective institutions and policies. Governance matters. This is true across a wide range of sectors but especially true in the water sector where the political economy dominates the ability to effectively govern the resource and associated services. Weak institutional environments are a common denominator across many water subsectors. Reasons for this are many, including general weakening of the public sector, budgetary and staffing declines, and resistance to reform from entrenched vested interests. For example, modernizing large irrigation bureaucracies in South and East Asia to be more service-oriented towards farmers is not easy. Reforming the water utility sector to be more efficient (both technically and financially) and the establishment of effective regulators is a well-known challenge. These are all matters of an institutional and policy nature driven by the binding constraints inherent in the political economy of the country at any given time. Some useful principles for water governance have been developed by the Organization for Economic Development and Cooperation.[1]

It should be recognized that these are deeply difficult operational issues requiring tremendous support and engagement with country clients. Investments in both management improvements and priority infrastructure have complementary roles in contributing to socioeconomic outcomes (e.g., improved services for users, reduction in flood risks, improved water quality). The World Bank[2] finds that institutional reform, institutional strengthening, and capacity building—though they are the most frequent activities in World Bank water-related lending—they have often been less than fully effective. Weak institutions have been identified as responsible for project shortcomings, whilst capacity building has not always resulted in improved performance. Thus, extra care and attention is needed on these aspects.

Projects must be designed with a careful balance between infrastructure and institutional strengthening. Human capacity to manage water infrastructure and undertake long-term strategic planning is weak at all levels (municipal, rural, national, regional, basin) in many low- and middle-income Asian countries. The water sector has proved difficult to attract the needed skills and competencies especially project management, financial and asset management skills. At the entry level, low public salaries do not attract young skilled professionals. In rural areas, this is an even greater challenge. Thus, adequate attention and support must be given to human infrastructure in the design of infrastructure investments. Similarly, investment in the development of management support tools and appropriate IT infrastructure (e.g., decision support tools for water investment planning, flood forecasting, asset management systems, hydrometeorological systems) will complement investments in infrastructure. Ultimately, capacity building and institutional development take time to grow and become internalized in the various subsectors. This means that these changes either must start very early in a project and/or they need nurturing for a period after the investment components have been completed. Typically, a utility turnaround, for example, requires a 10-year horizon, well beyond that of an investment project cycle.

6.2 Promote Financial Sustainability

Irrespective of the source of funds, financial sustainability must be guaranteed to ensure infrastructure sustainability and effective outcomes. For some infrastructure (primarily those related to services such as water supply, wastewater, irrigation), tariffs are important sources of funding for the entire life-cycle of the infrastructure. Tariff setting remains a highly complex and politically charged issue. Though this is true across a wide range of sectors, it is especially true in the context of water where its essentialness to society leads to active political discussions about its provision (both for drinking and irrigation purposes). If tariff levels are set too high, then consumers may face affordability issues and/or reduce water use—leading to reduced revenues for the service provider. On the other hand, if tariff levels are set too low then tariffs do not cover the operational and or capital costs leading to erosion of services. These tariff challenges have a direct influence on the creditworthiness of a utility and public budgets for the irrigation agency. This is a main reason why they are often unable to qualify for debt from both commercial and development banks. According to the World Bank,[3] only 15 percent of water supply and sanitation projects that attempted full cost recovery achieve this goal. Projects that have succeeded have generally done so through improving the collection of fees. For achieving full cost recovery, the key is an institutional framework for making service providers more accountable and efficient.

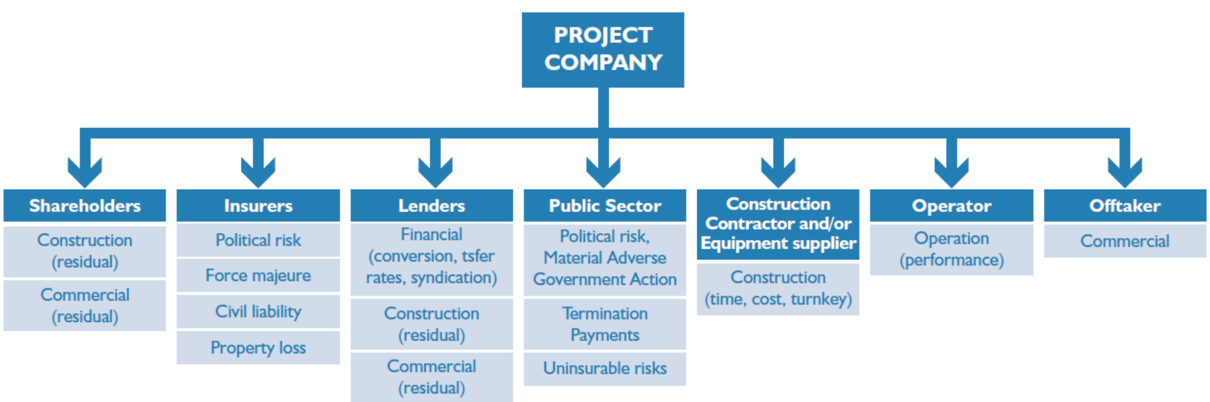
For other infrastructure that do not easily generate cash flows (e.g. flood protection, irrigation), other sources will be needed to ensure that enough funds are allocated for operation and maintenance (O&M). Other sources may include national budgets (e.g. public grants, subsidies), self-financing from water users (e.g., decentralized management of local infrastructure to community user groups), various taxes (e.g., land, pollution) and property developers (e.g., through innovative land value capture techniques). Agency budgets and expenditures need to be reviewed for any new investment in water infrastructure of this type to guarantee proper budgetary allocations will be made after the project is completed. This will be critical to the sustainability of the infrastructure.

6.3 Understand Risk-Reward Characteristics

The risk-reward calculation for water infrastructure is essential to securing financing. Different stakeholders involved with water infrastructure (e.g., governments, public agencies, private water operators, commercial lenders) face a wide range of risks. In comparison to other investments (e.g., oil, gas, minerals) these risks are often not perceived to be accompanied with large rewards. Moreover, these risks may not always be easy to quantify nor minimize. For example, hydrological risks which are inherent to all activities dependent on water may not be easily quantified especially in the context of climate change.[4] This uncertainty threatens the performance of a wide range of activities such as municipal water supply deliveries, stormwater and drainage system of a city, water-intensive industries and agriculture, production of energy (e.g., hydropower, shale-gas production), timing of releases from a dam for flood protection. This has clear implications with respect to the design and planning of water infrastructure. Financial risks, similarly, are ever present both in terms of the commercial side (e.g., revenue and cost recovery risks) and construction side (e.g., site-specific issues, well documented experience of delays and cost overruns in large dams[5]). For some large water infrastructure, environment and social risks are also well documented. Finding ways to share and mitigate risks is critical.

It is commonly accepted that risks should be allocated to those parties best able to bear them most efficiently and at least social cost (see Figure 6.1)**.** Similarly, it is argued that those parties that are in the best position to control these risks should also bear primary responsibility for it.[6] Under some conditions, large engineering, procurement, construction (EPC) and turnkey contracts will make sense in terms of assigning risk. For hydropower, in contrast, it could be more cost effective for public sponsors to retain these risks on their own account rather than devolve them, inappropriately and expensively, to private contractors.[7] Figure 6.1 summarizes the types of risks associated to different parties typically involved in infrastructure development.

Figure 0.1. Coverage of risks: the party that has the greatest control over a risk bears primary responsibility.



SOURCE: World Water Council, Organisation for Economic Co-operation and Development (OECD) (2015) Water: Fit to finance. Catalyzing national growth through investment in water security. Report of the high level panel on financing infrastructure for a water-secure world.

There are opportunities to mitigate these risks in various ways. Financial guarantees can offer coverage on political, contractual, regulatory and credit risks. Many international finance institutions (IFIs) currently offer these products (e.g., World Bank, MIGA and IFC, AfDB, ADB, IaDB, EIB, AFD). Other instruments may be possible (e.g., insurance, currency hedging instruments, use of escrow accounts). Risk sharing mechanisms such as using a geotechnical risk register which allocates risk depending on the severity of the occurrence can also improve project financing.

6.4 Improve Long-term Capital Planning

Investments into water infrastructure may be held back by factors other than the availability of finance. That is, there is generally not a shortage of finance, but a shortage of adequately prepared projects with properly managed risk profiles (also referred to as "bankable" projects). Water infrastructure projects, given their often technical and institutional complexity, require adequate preparation of technical documents (e.g., feasibility studies, design documentation, preliminary bill of quantities), environment and social impact assessments as well as approaches to minimizing impacts during construction, economic cost-benefit analyses, and financial analysis (including evaluation of the entire life-cycle costs of the project). Sufficient project preparation will be necessary before financing can be secured (especially from private sources). Moreover, proper long-term infrastructure planning can help countries avoid "lock-in" where society gets stuck with infrastructure which it does not need.

6.5 Consider Public-Private Partnerships

The private sector is risk averse and will not easily enter the water sector. Political and macroeconomic risks in many low- and middle-income countries often deter investors.[8] Many investors are also not familiar with the investment environment of some low-income countries, and this might increase further their perception of risk.[9]

The lack of bankable and investment-ready projects is a key barrier to private capital mobilization. Efficient governments typically have a pipeline of projects prepared that are viable investments and will be able to communicate this to the market. To create the right incentives for private capital mobilization, the distribution of risks and rewards expressed in project preparation and contractual arrangements needs to incentivize the various potential partners.[10] Most low income and middle-income countries, in contrast, face a shortage of such well-prepared, bankable projects.[11] National and local governments often don't have the capacity, experience, and understanding of private sector needs to prepare bankable projects. In many cases, governments cannot bear the cost of preparing such projects. This highlights the role that project preparation facilities can play. Similarly, investors may find infrastructure projects complex, particularly because of the need to include non-standard financing, and governance and risk mitigation issues.[12]

To date, public-private partnerships (PPPs) in the water sector have been limited to urban water supply provision, wastewater services, and hydropower. PPPs have been explored in the irrigation sector but to date their impact has been limited. PPPs are a viable option in developing countries and have demonstrated success in terms of operational efficiency and service quality although less successful in supplying private finance.[13] These operational improvements can have a major impact on access to financing. By improving efficiency and quality of service, customers become more willing to pay their bills, thereby generating more cash flow from operations which can be used to invest in expansion, which in turn increases the customer base and revenues. As creditworthiness improves, a utility can more easily access market finance and invest in service expansion (see earlier Figure 2.7).

Details matter with the choice of contractual design. The enabling environment and the willingness of both the public and private partners to making it work during implementation are major determinants of the final outcome. Few countries have these necessary conditions. In cases where it worked well, early and sustained engagement and on-the-ground presence (both in terms of local partners and an international financial institution) were critical (e.g. Manilla Water). PPP projects have, however, proved to be complex undertakings that carry strong political risks and large uncertainties as to the magnitude and timing of the expected benefits. Contractual targets are difficult to set and baseline data are seldom reliable which can generate many opportunities for contractual conflict. Private operators do not always deliver the hoped-for benefits as quickly as expected and this can undermine support for the arrangement.

PPPs are not an end in itself. They need to be seen as part of a strategy of interventions that can improve sector performance. There is now greater realism about the strengths and weaknesses of the private sector in WSS service delivery in developing countries. This has led to the use of more targeted service contracts to deliver improved performance in particular activities (e.g. leakage management, energy efficiency, collections), the use of turnkey contracts for treatment facilities with an operational period (such as design build operate wastewater treatment plants) or affermage contracts to deliver better service to customers and improved financial performance to shareholders but drawing on public funding for capital investments. The use of long-term privately financed, concession contracts is now nonexistent.

6.6 Engage Stakeholders and Beneficiaries

By bringing to the table all those who bear the risks associated with different options for water infrastructure, outcomes will greatly improve. Moreover, the development effectiveness of water infrastructure projects improves by eliminating unfavorable projects at an early stage, and by offering as a choice only those options that key stakeholders agree represent the best ones to meet the needs in question. The conditions for a positive resolution of competing interest and conflicts are created.

6.7 Develop More Incentives

The broad water sector is conservative, with few incentives to deliver better financial or technical performance, nor to be efficient in its use of capital. There is a need to provide greater incentives in the sector that will reveal higher levels of capital and operational performance and thus create new benchmarks against which future investments can be compared. There are a number of ways in which such incentives are appearing. These include in the use of output-based financing, program for results lending, the use of performance-based PPPs, and the introduction of staff incentives based on agreed performance improvements. Relying on traditional input-based investments will perpetuate the challenges that the water sector faces without introducing new dynamics which can lead to genuine change and development.

Notes and References

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Appendix 1: Cost of Water Infrastructure Investment by Country

The cost of water infrastructure varies greatly depending on country contexts and development goals. This appendix offers a review of the spending needs (capital and maintenance) needed to close the service gap for two subsectors: water supply and sanitation and flood protection (riverine and coastal). The estimates are based on the 2019 World Bank study 'Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet'. Compared to other infrastructure investment gap studies, the World Bank analysis recognizes the large uncertainty surrounding these estimates and uses scenarios to take this uncertainty into account. Scenarios represent different combinations of policy goals and instruments/choices used to reach these goals. The scenarios considered for each subsector are described in detail below. All scenarios consider historical patterns of development and continued population growth beyond 2030 (last year considered in this analysis) as encapsulated in the Shared Socioeconomic Pathway (SSP) 2.

The cost of achieving safely managed access to water supply and sanitation services is much higher than just achieving universal access. Three scenarios of the cost of water supply and sanitation investment were considered:

- Minimum spending: universal access to basic water, sanitation and hygiene services by 2030.
- Moderate spending: achieve universal access to safely managed water and sanitation services and end to open defecation by 2030 using a low-cost technology and a direct strategy (Assumes that countries go directly to providing safely managed services for all citizens).
- Maximum spending: achieve universal access to safely managed water and sanitation services and end to open defecation by 2030 using high cost technology and an indirect strategy (assumes that countries first deliver universal access to basic water and sanitation services to all of their citizens, before working to upgrade everyone to safely managed services).

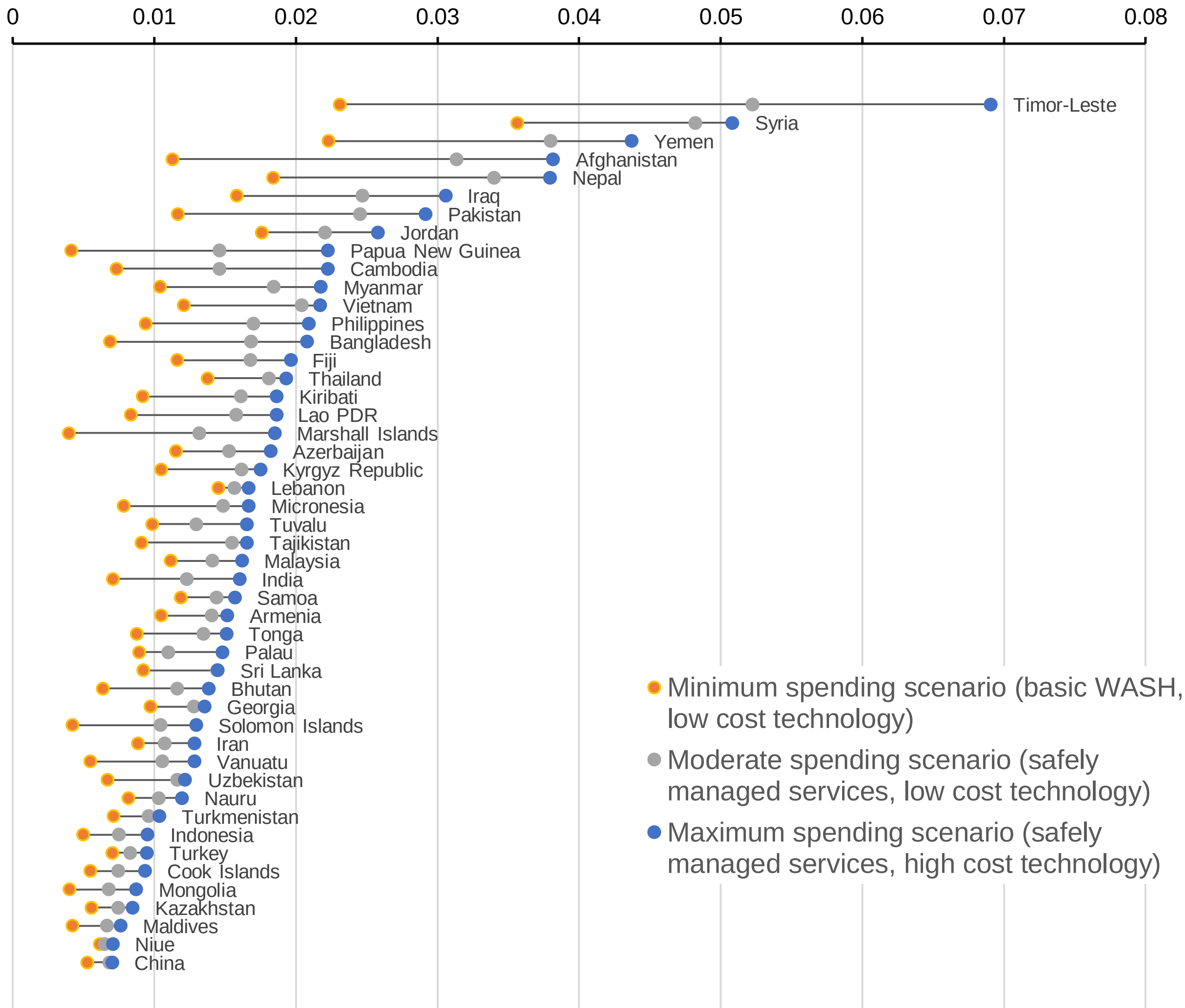
Investment costs for protection against both coastal and river floods depend primarily on the level of risk acceptable to populations and construction costs. For both river and coastal floods, we consider a scenario of continued carbon emissions (RCP 4.5) and medium ice melting. For coastal protection, we considered three flood protection strategies and related spending scenarios:

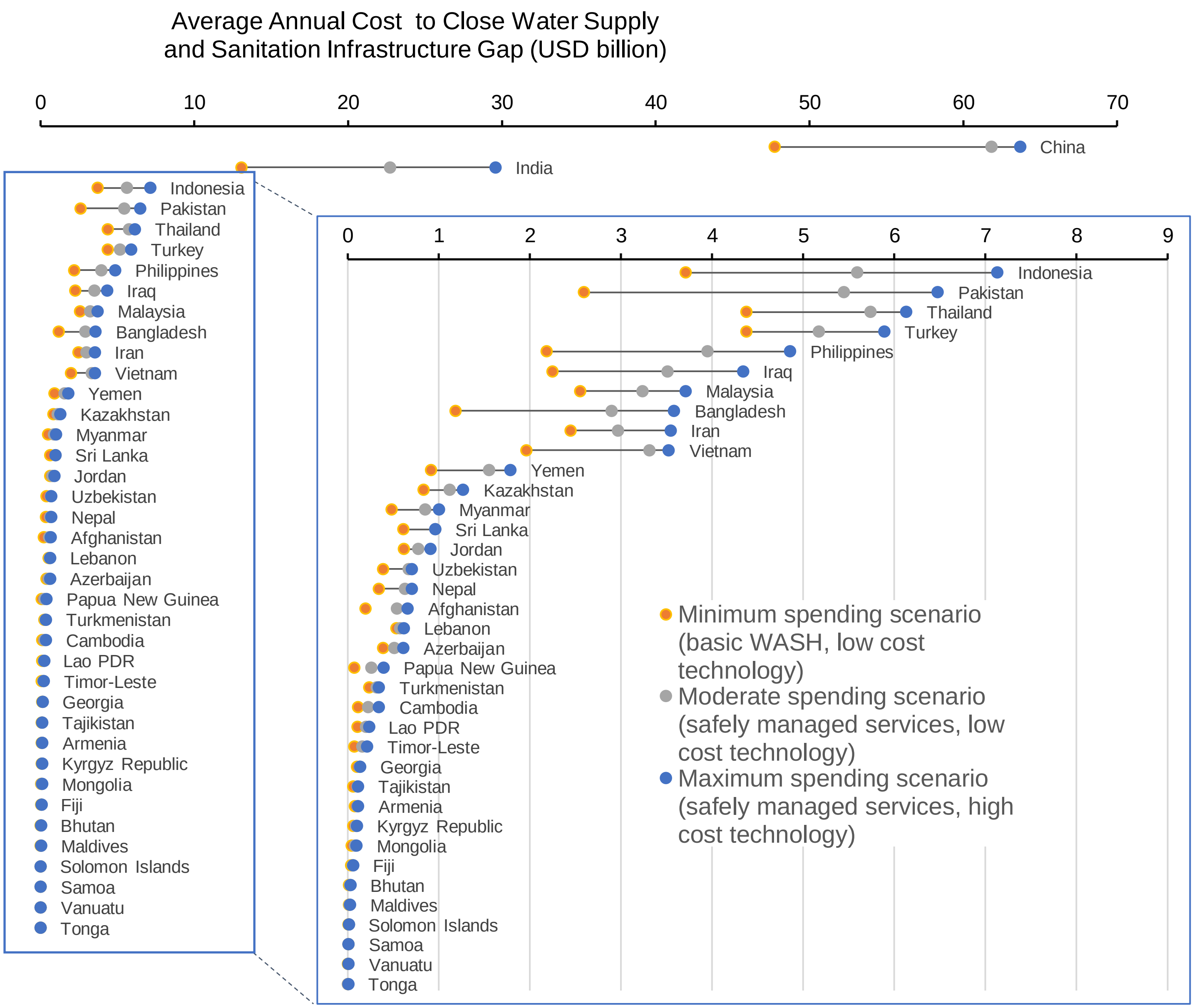
- Minimum spending: this strategy maintains the current (2015) average annual losses constant in monetary terms for protected (constant absolute risk).
- Moderate spending: this strategy maintains relative average annual losses constant in terms of percentage of local GDP for protected areas (constant relative risk).
- Maximum spending: this strategy keeps average annual losses below 0.01 percent of local GDP for protected areas and entails a low risk tolerance, similar to the level of flood risk accepted in the Netherlands (low risk tolerance).

For river floods, we considered three flood protection strategies and related spending scenarios:

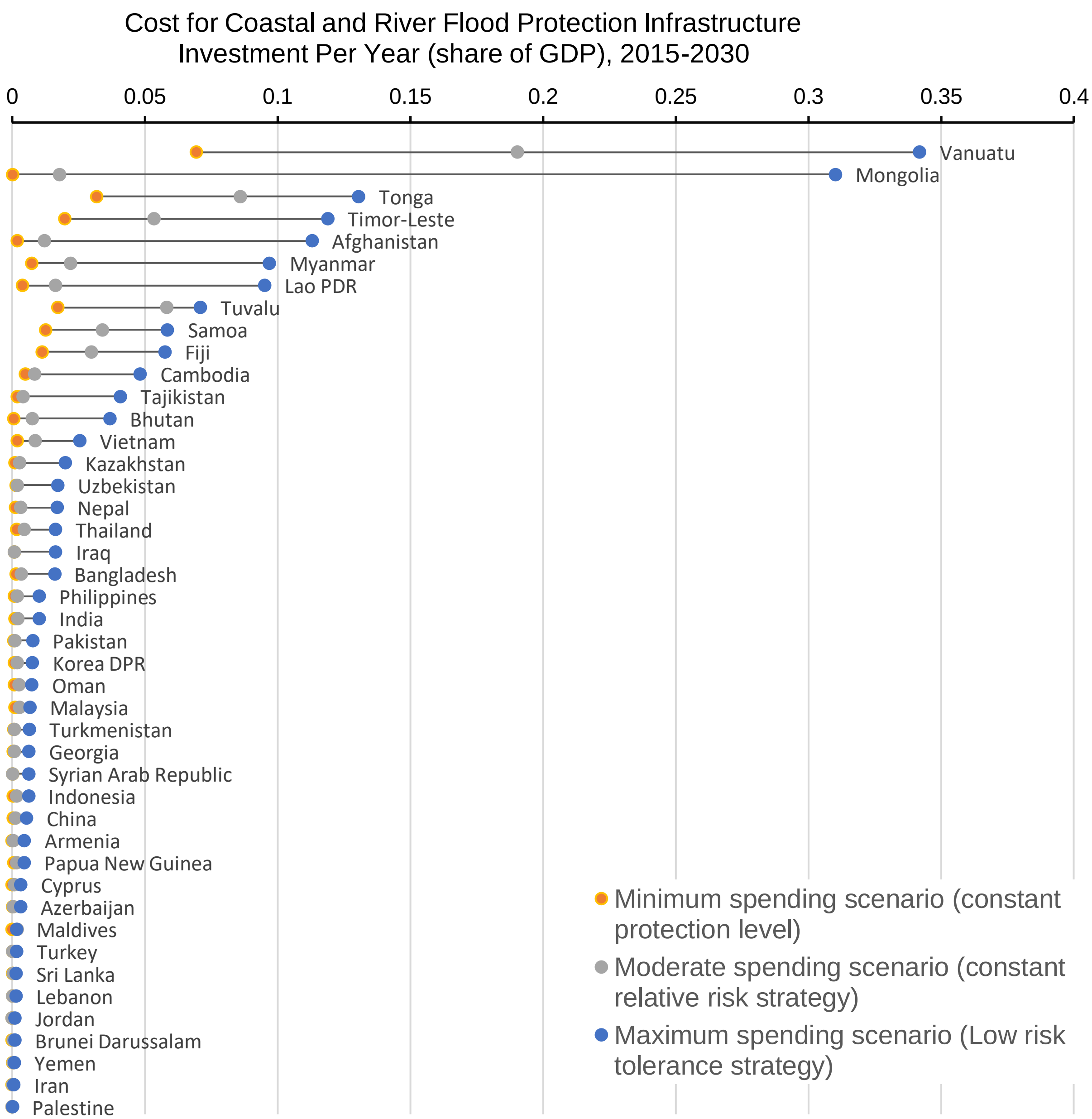
- Minimum spending: achieving an optimal level of protection based on cost-benefit analysis (optimal protection).
- Moderate spending: this strategy maintains the current (2015) average annual losses constant in monetary terms (constant absolute risk).
- Maximum spending: this strategy maintains relative average annual losses constant in terms of percentage of local GDP for protected areas (constant relative risk).

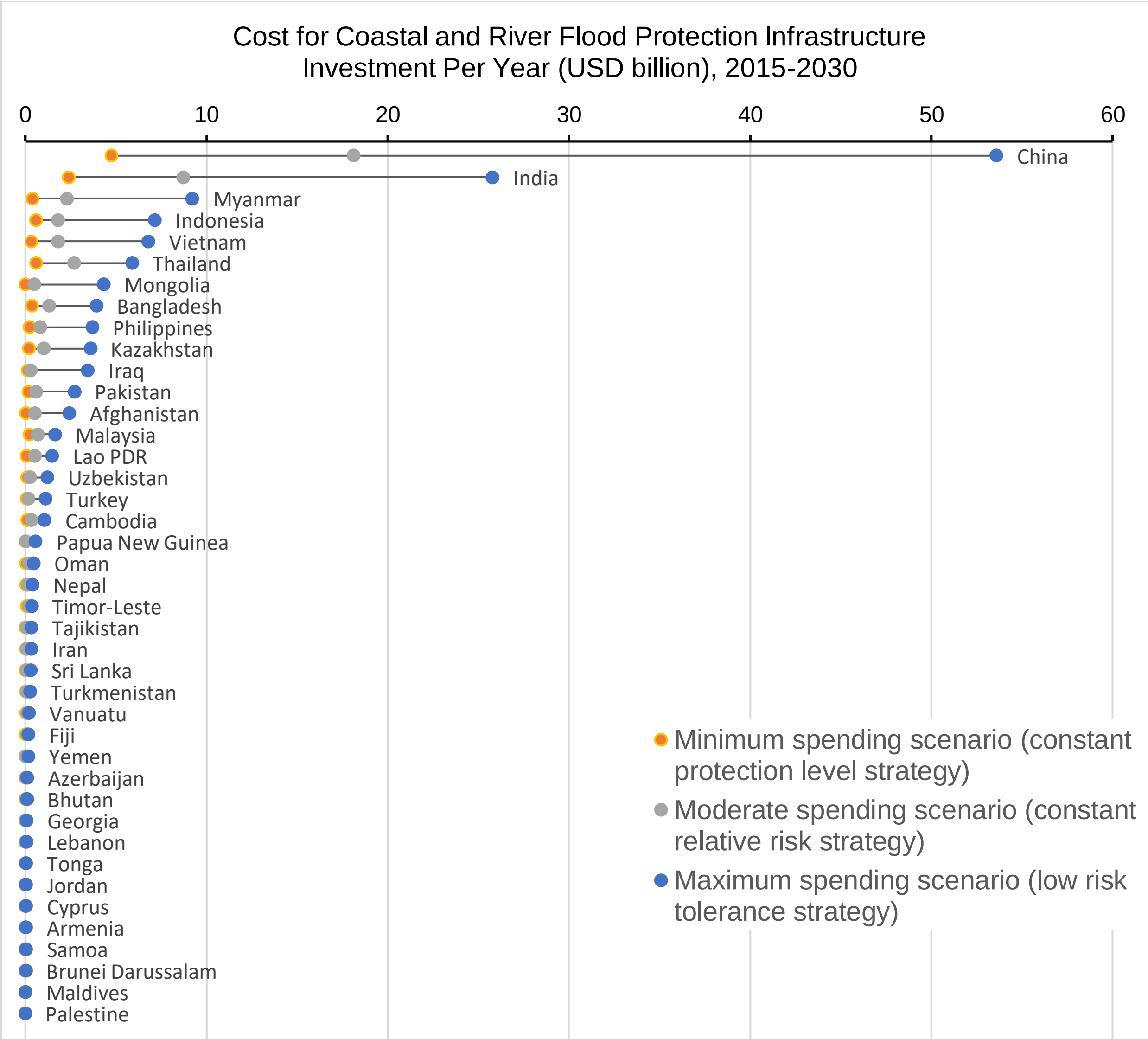
Annual Share of GDP Needed to Close Water Supply and Sanitation Infrastructure Gap





Average Annual Cost to Close Water Supply and Sanitation Infrastructure Gap (USD billion)
0
10
20
30
40
50
60
70
China
India
Indonesia
Pakistan
Thailand
Turkey
Philippines
Iraq
Malaysia
Bangladesh
Iran
Vietnam
Yemen
Kazakhstan
Myanmar
Sri Lanka
Jordan
Uzbekistan
Nepal
Afghanistan
Lebanon
Azerbaijan
Papua New Guinea
Turkmenistan
Cambodia
Lao PDR
Timor-Leste
Georgia
Tajikistan
Armenia
Kyrgyz Republic
Mongolia
Fiji
Bhutan
Maldives
Solomon Islands
Samoa
Vanuatu
Tonga
0
1
2
3
4
5
6
7
8
9
Minimum spending scenario (basic WASH, low cost technology)
Moderate spending scenario (safely managed services, low cost technology)
Maximum spending scenario (safely managed services, high cost technology)


Cost for Coastal and River Flood Protection Infrastructure Investment Per Year (share of GDP), 2015-2030
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Vanuatu
Mongolia
Tonga
Timor-Leste
Afghanistan
Myanmar
Lao PDR
Tuvalu
Samoa
Fiji
Cambodia
Tajikistan
Bhutan
Vietnam
Kazakhstan
Uzbekistan
Nepal
Thailand
Iraq
Bangladesh
Philippines
India
Pakistan
Korea DPR
Oman
Malaysia
Turkmenistan
Georgia
Syrian Arab Republic
Indonesia
China
Armenia
Papua New Guinea
Cyprus
Azerbaijan
Maldives
Turkey
Sri Lanka
Lebanon
Jordan
Brunei Darussalam
Yemen
Iran
Palestine
Minimum spending scenario (constant protection level)
Moderate spending scenario (constant relative risk strategy)
Maximum spending scenario (Low risk tolerance strategy)



Cost for Coastal and River Flood Protection Infrastructure Investment Per Year (USD billion), 2015-2030
0
10
20
30
40
50
60
China
India
Myanmar
Indonesia
Vietnam
Thailand
Mongolia
Bangladesh
Philippines
Kazakhstan
Iraq
Pakistan
Afghanistan
Malaysia
Lao PDR
Uzbekistan
Turkey
Cambodia
Papua New Guinea
Oman
Nepal
Timor-Leste
Tajikistan
Iran
Sri Lanka
Turkmenistan
Vanuatu
Fiji
Yemen
Azerbaijan
Bhutan
Georgia
Lebanon
Tonga
Jordan
Cyprus
Armenia
Samoa
Brunei Darussalam
Maldives
Palestine
Minimum spending scenario (constant protection level strategy)
Moderate spending scenario (constant relative risk strategy)
Maximum spending scenario (low risk tolerance strategy)