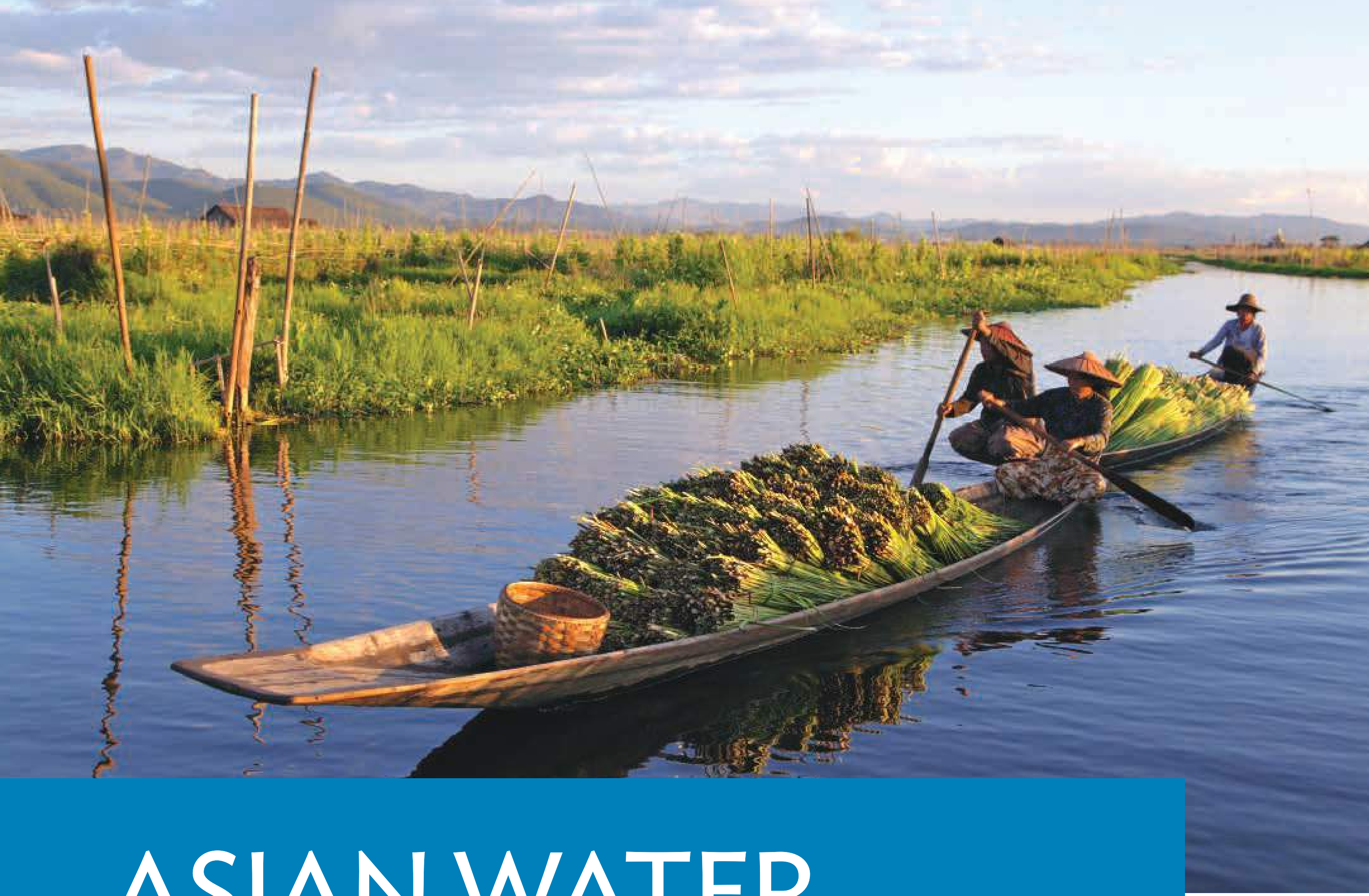

ASIAN WATER DEVELOPMENT OUTLOOK 2016

STRENGTHENING WATER SECURITY IN ASIA AND THE PACIFIC

ASIAN DEVELOPMENT BANK

ASIAN WATER DEVELOPMENT OUTLOOK 2016

STRENGTHENING WATER SECURITY IN ASIA AND THE PACIFIC

ASIAN DEVELOPMENT BANK

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Foreword by the Asian Development Bank

It is a pleasure for me to introduce the Asian Water Development Outlook 2016: Strengthening Water Security in Asia and the Pacific (AWDO 2016), the third edition of the AWDO report. The rigorous analysis undertaken provides a country-wise snapshot of the region's water security status, enabling policy makers, financing institutions, and planners to make more informed decisions on how to improve their performance in the water sector. It is the outcome of a partnership between the Asia-Pacific Water Forum and key contributors, the Asia Pacific Center for Water Security at Tsinghua University, the International Institute for Applied Systems Analysis, the International Water Centre, and the International Water Management Institute.

The rapid growth of the Asia and Pacific region is unprecedented and dynamic. It is a remarkable epicenter of economic and population growth. However, increasing demands from water users place finite water resources into an even more precarious situation. I believe the most daunting challenge is to double food production by 2050 for an increasingly prosperous and growing population, while also providing water for more domestic users and meeting industrial and energy demands. The impacts of climate change as well as increasing climate variability and water-related disasters also culminate in a more challenging horizon than we have experienced in the past.

As you will see, AWDO 2016 undertakes a more rigorous assessment of the indicators that describe the key dimensions of water security using the latest available data. Comparing against the previous edition of the report that came out in 2013, the region shows a positive in strengthening water security, with the number of water-insecure countries falling to 29 out of 48 countries, from 38 out of 49 countries. Despite this progress, we face enormous challenges in water security—especially if we are to meet the targets for the Sustainable Development Goal of universal access to clean water and sanitation by 2030.

There is growing evidence of the link between water insecurity and the drag it places on the economy. AWDO 2016 reminds us of the importance of water as a critical input for sustained economic growth. This is perhaps the most fundamental message for our region's continued progress and one which I would like to elevate to our region's leaders, policy makers, and financiers. Climate change and a dedicated Sustainable Development Goal for water place a greater responsibility on us to rethink how we will secure our region's water future.

I am pleased that this timely publication emphasizes the need to make more concerted efforts in reaching the poorest and providing them the basic building blocks of development, in particular access to water and sanitation. More focus is required in South Asia, which, as the results show, lags behind the rest of the region. Clearly, there is much to be done and I would like to encourage us to consider, first, the need to remove disparities in the provision of water infrastructure and services. Access to drinking water and sanitation requires us to transcend the boundaries of rich and poor and rural and urban. It is important that our developing member countries establish more inclusive policies that not only reach the poorest city dwellers but also rural communities which require equal access to domestic water supply and sanitation.

Bridging gaps is underpinned by having better access to data and knowledge to provide tailored and targeted solutions. I consider this to be a low-hanging fruit, yet a powerful instrument reflecting improved governance. Knowledge of water resources can be easily obtained across entire countries and regions by using technologies like remote sensing. This opens a new doorway to what can be achieved once we have more knowledge. This is the backbone for effective solutions and advancing water governance. It is a basic requirement to understand who is using how much water. This information provides an input to an enabling policy environment in which we can set targets for more productive resource utilization.

There remains much room to make a positive change. The Asian Development Bank recognizes water security as an overarching goal and translates this into development interventions through investment programs to meet the challenges of our region and its future.

AWDO 2016 makes a strong case for strengthening our region's water security through partnerships that include all members of our community in the development process. We can contribute to policy, institutions, and infrastructure development using more knowledge-based solutions and applying the latest technologies.

I look forward to us working together for a more water-secure Asia and Pacific region.

Takehiko Nakao
President
Asian Development Bank

Foreword by the Asia-Pacific Water Forum

Water security continues to be one of the great challenges in Asia and the Pacific. Its impact on human well-being and development is immense and indisputable. Water-related disasters affect a greater number of people in Asia and the Pacific than in all the other regions combined. The cities in the region are growing, and the management of their water and sewerage systems is a matter of concern, as is the health of rivers and water bodies. Climate change and its accompanying uncertainties exacerbate the situation in many ways. While all these challenges are daunting, there are ways to overcome them and develop solutions, provided there is leadership, real commitment, and investment.

The Asian Water Development Outlook 2016 builds on the work of the two earlier editions in analyzing these challenges and suggesting approaches to address these problems. It does not confine itself to a broad approach, but analyzes the water security situation in each country across each of five key dimensions. Such an approach makes it easier to focus attention on the greatest areas of risk and appropriate ways to address them. It attempts to improve on its earlier analysis by using more current information and also by acknowledging more recent areas of concern such as groundwater depletion and by using more rigorous analytical methods.

Apart from the contents, the process in developing the publication is also worthy of emulation in other sectors. It is the work of academic researchers and practitioners across the region working as a team to a common set of standards with the Asian Development Bank and ensuring that the findings are reviewed by peers to exacting standards. The Asia-Pacific Water Forum is privileged to be part of this partnership and this process since its inception.

Such work merits serious attention and it is hoped that leaders in the Asia and Pacific region find the Asian Water Development Outlook useful as a basis for policy development, capacity building, and investment in their drive to make their countries water secure.

Ravi Narayanan
Chair, Governing Council
Asia-Pacific Water Forum

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The following authored the KD reports:

- KD 1 – Household Water Security: Fu Sun, Asia Pacific Center for Water Security, Tsinghua University
- KD2 – Economic Water Security: Jonathan Lautze, Herath Manthrithilake, David Wiberg, Bunyod Holmatov (consultant), and Anil Terway (consultant), International Water Management Institute
- KD3 – Urban Water Security: Eva Abal, Kris Fox, Steve Kenway, and Ka Leung Lam, International Water Centre
- KD4 – Environmental Water Security: Stuart Bunn and Ben Stewart-Koster, Australian Rivers Institute, Griffith University, and International Water Center; Günther Fisher, International Institute for Applied Systems Analysis; Pamela Green, City College of New York; and David Wiberg, International Water Management Institute
- KD5 – Resilience to Water-Related Disasters: Ian Makin, International Water Management Institute; Narciso Prudente (consultant), ADB; and Eelco van Beek, Technical Committee, Global Water Partnership

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Abbreviations

ADB	Asian Development Bank
APWF	Asia-Pacific Water Forum
AWDO	Asian Water Development Outlook
BWSI	Bhutan Water Security Index
CRED	Centre for Research on the Epidemiology of Disasters
DALYs	disability-adjusted life years
GDP	gross domestic product
GWP	Global Water Partnership
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme (WHO/UNICEF)
KD	key dimension
MDG	Millennium Development Goal
NWS	National Water Security
OECD	Organisation for Economic Co-operation and Development
PRC	People's Republic of China
SDG	Sustainable Development Goal
UNESCO-IHE	UNESCO Institute for Water Education
UNICEF	United Nations Children's Emergency Fund
UNISDR	United Nations Office for Disaster Risk Reduction
WASH	water, sanitation, and hygiene
WHO	World Health Organisation

Executive Summary

The Asia and Pacific region has witnessed a remarkable transition in the past 2 decades. From 1990 to 2012, more than 1 billion people in Asia and the Pacific were lifted out of extreme poverty. The region also witnessed rapid economic growth, which is expected to remain stable at a growth rate of about 5.7% for the next 2 years.

Despite these achievements, the region is a global hot spot for water insecurity. It remains home to 60% of the world's population and half of the world's poorest people. Water for agriculture continues to consume 80% of the region's resources. A staggering 1.7 billion people lack access to basic sanitation, and with a predicted population of 5.2 billion by 2050 and hosting 22 megacities by 2030, the region's finite water resources will be placed under enormous pressure. Recent estimates indicate up to 3.4 billion people could be living in water-stressed areas of Asia by 2050.[1]

Coupling demographics with changes in demand adds a further dimension. Industrialization and economic transformation require more power and a shift to more water-intensive diets, thus increasing competition between water users like industry and agriculture. The region's water demand is projected to increase by about 55%, due to the growing needs for domestic water, manufacturing, and thermal electricity generation.[2] Agriculture will need to produce 60% more food globally by 2050, and 100% more in developing countries, using diminishing water resources.

These challenges are compounded by increasing climate variability and water-related disasters that threaten numerous major urban areas, agricultural production, and coastal populations. Poor governance and weak institutional capacity endemic of almost all developing countries in Asia and the Pacific place sustained and inclusive economic development of the region into a very precarious situation.

Water remains pivotal for sustainable development and is linked to a number of global challenges. The advent of the post-2015 development agenda and a dedicated Sustainable Development Goal for water reflects this message and reemphasizes the interlinkages of this finite resource across a range of users.

Asia and the Pacific cannot sustain economic growth unless water is brought into the equation. A recent study by the Global Water Partnership and Organisation for Economic Co-operation and Development indicates that water insecurity costs the global economy about $500 billion annually with a total drag on the world economy of 1% or more of global gross domestic product.[3] Meeting the socioeconomic challenges of the region will require us to go beyond infrastructure-centric solutions and economic growth projections that do not consider the status of water resources and service provision.

1 International Institute for Applied Systems Analysis. 2016. ***Water Futures and Solutions: Asia 2050***. Laxenburg, Austria.

2 Organisation for Economic Co-operation and Development. 2012. ***Environmental Outlook to 2050: The Consequences of Inaction***. Paris: OECD Publishing.

3 C.W. Sadoff, J.W. Hall, D. Grey, J.C.J.H. Aerts, M. Ait-Kadi, C. Brown, A. Cox, S. Dadson, D. Garrick, J. Kelman, P. McCornick, C. Ringler, M. Rosegrant, D. Whittington, and D. Wiberg. 2015. ***Securing Water, Sustaining Growth: Report of the GWP/OECD Task Force on Water Security and Sustainable Growth***. Oxford, UK: University of Oxford.

What Is Water Security?

Providing a more tailored and systematic response to the region's strengths and weaknesses requires a more holistic and quantitative assessment of water resources management and service delivery. This is based on each country's natural resource endowment, stage of socioeconomic development, and vision for its future. In the past decade, water security has increasingly been used to more explicitly state the goals to be achieved with better water management resulting in a range of approaches, definitions, and measurements. Water security is more than just providing sufficient water for people and economic activities. It is also about having healthy aquatic ecosystems and protecting us against water-related disasters.

Asian Water Development Outlook: The Past

In 2007, the Asian Development Bank (ADB) and the Asia-Pacific Water Forum (APWF) prepared the Asian Water Development Outlook (AWDO)—to initiate dialogue on the water security of the region. The report was cautiously optimistic on Asia's water future and pointed out that inappropriate management practices rather than physical scarcity of water were the main cause of water insecurity.

AWDO 2013 provided the first quantitative and comprehensive review of water security in the countries of Asia and the Pacific. It developed a water security framework based on five key dimensions (KDs) for household, economic, urban, environmental, and resilience to water-related disasters. The overall national water security of each country was assessed as the composite result of the five key dimensions, measured on a scale of 1–5, with 1 being a low level of water security and 5 being the exemplary level. AWDO 2013 provided a baseline against which to measure water security and highlighted the urgent need to strengthen the capacity for integrated planning and management of water resources.

Asian Water Development Outlook 2016: The Present

ADB in partnership with APWF and technical inputs from four specialist agencies (see Acknowledgments) has further strengthened AWDO 2013 by refining the key dimension indicators and associated methodologies for ascertaining water security.[4] While maintaining the water security framework and key dimensions, AWDO 2016 aims to probe deeper and provide a more robust set of indicators updated with the latest available data.

Refinements in the key dimensions methodology mean that the results as published in AWDO 2013 are not directly comparable with the results of AWDO 2016. To provide a more meaningful discussion in this document, AWDO 2013 results have been adjusted according to the 2016 methodology to provide a like for like comparison. Some caution is required given the adjustments in methodology and use of other data sources which may impact results.

Performance of the Region

Overall, Asia and the Pacific has shown a positive trend in strengthening water security since 2013. According to the adjusted 2013 data, a total of 38 out of 49 economies (assessed) were found to be water insecure, that is, with a National Water Security Index of 2 or less. This has improved to 29 out of 48 economies being categorized water insecure by 2016.

Advanced economies like Australia, Japan, and New Zealand consistently lead the way, as expected, but are followed by East Asia which has strengthened water security. The remaining regions show mixed performance across the key dimensions, though South Asia remains more challenged. AWDO 2016 also demonstrates the difficulties in using the water security framework for small island nations, for which a more relevant and tailored approach may be appropriate.

KD1 household water security: All regions (except Pacific islands) improved their performance compared with AWDO 2013. South Asia has made slower gains as compared with the rest of the region. There are also disparities in household water security between rural and urban and between rich and poor. While some countries have narrowed this gap (e.g., Armenia and Thailand), others have widened the urban–rural and rich–poor gap of access to piped water supply (e.g., Sri Lanka and Viet Nam).

KD2 economic water security: The overwhelming majority of change in economic water security scores has been positive. Advanced economies (Australia, the Republic of Korea, New Zealand, and Singapore) have the highest scores, with the Pacific islands lagging. There remains potential for improvement in virtually every country, including those already performing well. A limitation of the methodology for KD2 is that water availability and use were not disaggregated by source to allow for specific analysis of the sustainability of groundwater use. This is mainly due to limited data availability.

KD3 urban water security: Many countries in Asia and the Pacific have much scope to meet the vision of vibrant, livable cities and towns. Besides the advanced economies, East Asia has shown remarkable positive progress while South Asia and Southeast Asia have potential for improvement, particularly in countries like Myanmar, Pakistan, and the Philippines. Significant investment and leadership is required to continue many cities in Asia and the Pacific on the path to urban water security and water-sensitive cities.

KD4 environmental water security: There is a wide range of results, with the Pacific islands scoring high due to factors such as limited river flow alteration and good river health. Advanced economies score well due to a strong governance regime to mitigate existing pressures on the environment. An important step forward is to encourage river health monitoring at the country and basin levels, and certainly association with individual infrastructure projects.

KD5 resilience to water-related disasters: Advanced economies demonstrate the strongest performance, whereas the rest of Asia and the Pacific has weak resilience. The results suggest that a minimum level of governance is needed before KD5 can start to increase. Countries like Bangladesh highlight the need for continued support in integrated disaster risk management as well as strengthening governance and investments to increase resilience.

Key Messages

Economic development: Investments in water infrastructure and institutions in developing member countries are crucial for economic development. There is a strong relationship between water management and the economy, and investments in good water management can be considered as longer-term payback for increased economic growth and poverty reduction. Water-related investments can increase economic productivity and growth, while economic growth provides the resources to invest in institutions and capital-intensive water infrastructure. Evidence from KD1 highlights that it is not necessarily the wealth of a nation that determines water security. Rather, the Republic of Korea, Malaysia, Singapore, and Thailand were able to make major progress in drinking water and sanitation while they were still relatively poor countries, proving that this is possible.

The same countries have made remarkable economic progress and might prove to be the

[4] ADB. 2016. AWDO 2016 – Description of Methodology and Data. Manila (available upon request).

evidence in support of the statement that each dollar invested in water and sanitation can provide a return of $5–$46 in reduced health costs and increased economic productivity.

Inclusive water supply and sanitation: Overall, the region has improved access to household water supply and sanitation. Yet, some countries, including Afghanistan, Cambodia, and Timor-Leste, show an increased rural–urban gap in both improved and piped water supply. This suggests a government priority on urban areas over rural areas. Improved sanitation shows a similar picture with the same countries to that for water supply with a widening gap in access to sanitation. Using data presented in the 2015 Joint Monitoring Programme report of the World Health Organization and the United Nations Children's Fund, inequalities are observed between rich and poor in urban and rural areas. Among the 15 Asia and the Pacific economies assessed for AWDO 2016, Thailand shows the lowest inequity between rich and poor. In rural areas, Mongolia has the largest gap between rich and poor and similar high disparities are seen in improved access to sanitation in urban areas in South Asia with gaps of up to 80 percentage points between rich and poor.

There is a need for a more equal and inclusive policy objective without which the Sustainable Development Goal for universal access to drinking water, sanitation, and hygiene cannot be achieved. Solutions will vary across the region depending on a country's stage of economic development and extent of rural–urban integration. The onus will be on planners, policy makers, and financiers to avoid "one size fits all solutions," to identify disparities, and to provide tailored and targeted responses. For inclusive development, the disparities must be narrowed.

Knowledge and information: Analysis also shows that a country's water endowment hardly plays a role in achieving water security. Countries with relatively low water endowment (e.g., Singapore with 107 cubic meters per capita per year and the Republic of Korea with 1,386 cubic meters per capita per year) have been able to achieve high water security, while water-rich countries such as Cambodia and Myanmar still have quite a challenge ahead. This reinforces the continued need for major and fundamental changes in water governance practices in almost all Asian developing member countries. Knowledge and information lead to sound policies to guide proper investments in water management, which subsequently lead to economic growth.

Yet, data and information particularly for groundwater remain weak for making informed decisions on water resources allocation. Data for the strengthened management of water resources at the local, national, and regional levels are essential—where necessary disaggregated to capture inequalities in services. With wider and open source satellite data readily available, the application of remote sensing technologies for water accounting at the national and basin levels provides an ideal opportunity even where physical measurements are absent. For more localized city and town data, data collection and maintenance of databases are urgently needed. Availability of data also provides a sound proxy indicator for water governance. Where governance is high, like in advanced economies, there is generally a solid monitoring program and data accessibility.

What Lies Ahead

There remains a major risk in the overall discussion, "the elephant in the room" which has yet to be effectively tackled. That is the issue of water resource utilization, of groundwater in particular. We have already accessed almost all our available freshwater and surface resources, and overexploited groundwater in many cases (particularly in countries in East and South Asia).

Even if we are able to increase water productivity, there are major challenges ahead. With an increasing population and its welfare, expected spatial and temporal changes in water availability due to climate change, and the need to restore our aquatic ecosystems, we are facing a huge task while the easy solutions are already being implemented.

Business as usual is not possible anymore. While demand is projected to grow by 30%–40 %, in general, existing water resources in many areas in the region can be considered already fully utilized due to rapid groundwater depletion.

The point is that increasing demand cannot be met by simply developing new water resources. Rather, it will be met by a combination of improving water productivity (through water use efficiency in agriculture and significantly reduced urban nonrevenue water), improved water management (such as rainwater harvesting), reuse, and desalination. Overarching is the need to also monitor groundwater resources and actually start managing these more sustainably. This will require more thought beyond the water sector, given that power subsidies also contribute to groundwater overuse.

With increased climate variability, we enter a period of uncertainty. The math tells us that business as usual, even if fully and uniformly implemented across Asia and the Pacific, will simply not suffice due to limited water resources. Strengthening governance is undeniably the major requirement for effective resource management and sustainable development.

The Nam Song River at Vang Vieng, Lao People's Democratic Republic.

Part I.
Introduction

The Asian Water Development Outlook (AWDO) was created by the Asian Development Bank (ADB) and the Asia-Pacific Water Forum (APWF) to highlight important water management issues. The first edition of AWDO was published in 2007 to inform leaders meeting at the first Asia-Pacific Water Summit in Beppu, Japan.

The inaugural edition underlined the need to address water security with a broader perspective than traditional sector-focused approaches. AWDO 2007 highlighted governance as a common factor that has constrained efforts to increase water security in Asia and the Pacific. In response to the two key messages of AWDO 2007 and the Beppu summit, ADB and APWF set out to prepare a second edition of AWDO to answer the implicit challenge facing the leaders at the Beppu summit: that we cannot manage what we do not measure.

Prepared for leaders and policy makers of finance and planning departments as well as for water practitioners and researchers, AWDO 2013 introduced a comprehensive assessment framework for water security as a foundation for the creation of a water-secure future for the people of Asia and the Pacific. Suggestions were received following the launch of AWDO 2013 to further refine the key dimensions for economic, urban, and environment water security.

ADB commenced activities to refine the indicators for the key dimensions in January 2015 with technical inputs from five specialist agencies (see Acknowledgements). Working as a team, these organizations have highlighted their technical strengths and understanding of the challenges faced by the region. AWDO 2016 aims to probe deeper and further strengthen all key dimensions and use the latest available data sets. AWDO 2016 is not intended to present a new approach and retains the fundamental water security framework and key dimensions.

AWDO 2016 remains primarily a communication tool for the Asia and Pacific region and provides a snapshot of the water security status, using refined indicators and the latest data sets. The outcomes provide a baseline reflecting the region's progress in water security, identifying critical subregions and subsectors requiring improvements, and drive toward a vision of improved water resources management within an enabling environment.

Structure of the Report

AWDO 2016 is presented in six parts, of which this introduction is the first. Part II sets the water scene for Asia and the Pacific and describes the water challenges the region is facing. Part III presents the AWDO approach and the five key dimensions of water security. In Part IV, the present status of national water security in the ADB member countries is described, first for the overall National Water Security Index, followed by the results for each of the five key dimensions. The last two parts provide information on how water security can be increased: first in general in Part V and followed up in Part VI on ADB's position and contribution to achieve water security. The appendixes provide basic information on the methodology of AWDO 2016, data sources used, and the actual scores that AWDO 2016 has determined for all ADB member countries.

Cleaning up the *Estero de Paco*, part of a network of drainage canals polluting the Pasig River in Manila, Philippines.

Part II.
Asia and the Pacific: Facing the Water Challenge

High Stakes in a Dynamic Environment

Water Security and Economic Growth

Risks and Global Hot Spots

Managing Water in a Changing Climate

Sustainable Development Goal 6: The Sustainable Development Goal on Water

High Stakes in a Dynamic Environment

Water is fundamental to the post-2015 development agenda and achieving the Sustainable Development Goals (SDGs), in particular the dedicated goal for water. Yet, we face a challenging new horizon, one where the world's population will bulge to almost 10 billion by 2050 and hungry cities will require more energy and drinking water. Global water demand is projected to increase by about 55%, due to the growing needs for domestic water, manufacturing, and thermal electricity generation.[1] Agriculture will need to produce 60% more food globally by 2050, and 100% more in developing countries, using diminishing water resources while the world gets warmer.[2]

By 2050, more than 60% of the Asia and Pacific region's population will be living in cities. Asia is home to 13 of the world's 22 megacities, and the number is expected to go up to 20 megacities by 2025. Yet, we are faced with a staggering 1.7 billion people lacking access to basic sanitation and almost 80% of wastewater being discharged in water bodies (rivers, lakes, and the sea) with little or no primary treatment. In Indonesia, for example, only 14% of wastewater is treated, while in the Philippines the figure is 10%, in India 9%, and in Viet Nam 4%.[3] The water quality-related health risks are immense.

Most precarious are groundwater resources and the balance between abstraction and recharge rates. According to estimates by the Food and Agriculture Organization of the United Nations, more than a third of the world's irrigated area is served by groundwater. Of this, a staggering 70% is in Asia, with India and the People's Republic of China (PRC) being the biggest consumers of this fragile resource, followed by Pakistan (Table 1).[4] The rate of groundwater use remains largely unmonitored, as does its quality and the impacts of overutilization on irrigated agriculture and urban and industrial users.

In many countries, more than half of the groundwater withdrawn is for domestic water supply, and globally it provides 25%–40% of the world's drinking water. Of the world's 15 biggest abstractors of groundwater, 7 are in the Asia and Pacific region. Bangladesh, India, Nepal, and Pakistan use about 23 million pumps with an annual energy bill of $3.78 billion for lifting water.

Preliminary projections to 2050 by the International Institute for Applied Systems Analysis suggest that groundwater use will increase by 30%, with the PRC, India, and Pakistan accounting for 86% of total groundwater abstraction in the region.[5] Such rampant expansion in use and its impact on declining water tables, water quality, and the continued demand for energy will become more pressing as climate variability impacts further on surface water resources. This sounds alarm bells that we are on the verge of a water crisis, with limited knowledge on when we tip the balance.

Superimposed on these stark facts are the challenges to provide sufficient resources to maintain environmental sustainability—within the confines of climate change impacts and increasing climate variability.

Asia and the Pacific has recently experienced some of the most damaging weather- and climate-related disasters, with alarming consequences for human welfare. In the last 10 years alone, it is estimated that 700 million people have died and 1.7 billion

1 Organisation for Economic Co-operation and Development (OECD). 2012. *Environmental Outlook to 2050: The Consequences of Inaction*. Paris: OECD Publishing.

2 N. Alexandratos and J. Bruinsma. 2012. World Agriculture towards 2030/2050: The 2012 Revision. *ESA Working Paper No. 12-03*. June. Rome: Food and Agriculture Organization of the United Nations.

3 ADB. 2012. Wastewater Management and Sanitation in Asia. 19 November. Accessed 30 May 2016 from http://www.adb.org/features/wastewater-management-and-sanitation-numbers

4 National Groundwater Association. 2010. Facts about Global Groundwater Usage. Accessed 30 May 2016 from http://www.ngwa.org/Fundamentals/use/Documents/global-groundwater-use-fact-sheet.pdf

5 International Institute for Applied Systems Analysis. 2016. *Water Futures and Solutions: Asia 2050*. Laxenburg, Austria.

Table 1: Top 15 Countries with the Largest Estimated Annual Groundwater Extractions (2010)

Country	Population in 2010 ('000)	Groundwater Extraction			
		Estimated Groundwater Extraction (km^3/yr)	Breakdown by Sector (%)		
			Groundwater Extraction for Irrigation	Groundwater Extraction for Domestic Use	Groundwater Extraction for Industry
India	1,224,614	251.00	89	9	2
China, People's Republic of	1,341,335	111.95	54	20	26
United States	310,384	111.70	71	23	6
Pakistan	173,593	64.82	94	6	0
Iran	73,974	63.40	87	11	2
Bangladesh	148,692	30.21	86	13	1
Mexico	113,423	29.45	72	22	6
Saudi Arabia	27,448	24.24	92	5	3
Indonesia	239,871	14.93	2	93	5
Turkey	72,752	13.22	60	32	8
Russian Federation	142,985	11.62	3	79	18
Syria	20,411	11.29	90	5	5
Japan	126,536	10.94	23	29	48
Thailand	69,122	10.74	14	60	26
Italy	60,551	10.40	67	23	10

km = kilometer, yr = year.
Source: J. Margat and J. van der Gun. 2013. *Groundwater around the World*. Leiden, Netherlands: CRC Press/Balkema.

have been affected due to serious storms, floods, and heatwaves. Floods have also cost the region about $1.4 trillion.

Water Security and Economic Growth

Water resources are inherently linked to economic development and poverty reduction. Sound management of resources leads to economic growth and social development. There is clear evidence that transitioning toward a more water-secure environment can drive economic growth. This is witnessed in the recent past in countries like the Republic of Korea, Malaysia, and Thailand where strong and high-level leadership and focus on access to sanitation has been a major driver of the economy.

AWDO 2013 already highlighted that water is likely to become a constraint on economic growth in a number of countries unless renewed effort is directed toward ensuring water availability in adequate quantities and quality. More recent studies have further explored the links between economic growth and water security. The Global Water Partnership (GWP) and the Organisation for Economic Co-operation and Development (OECD) estimate that water insecurity costs the global economy about $500 billion annually and is a total drag on the world economy of 1% or more of global gross domestic product (GDP).[6]

6 C. W. Sadoff et al.. 2015. *Securing Water, Sustaining Growth: Report of the GWP/OECD Task Force on Water Security and Sustainable Growth*. Oxford, UK: University of Oxford.

The 2016 United Nations World Water Development Report, Water and Jobs, estimates that three out of four jobs that make up the entire global workforce are water-dependent and that more than 1.4 billion jobs, or 42% of the world's total active workforce, are heavily water-dependent.[7] The report concludes that more efforts are required to adapt to increasing water stress to avoid dramatic consequences for local employment, and possible effects to trade and migration.

Overall access to information, investments in infrastructure, and institutional and policy framework strengthening are essential requirements for improving water security. Failure to invest in water management and improve water security may impede economic growth and job creation. This becomes increasingly relevant as we move into a period of uncertainty linked to climate change and variability.

Risks and Global Hot Spots

Asia and the Pacific is the global hot spot for water insecurity. The International Institute for Applied Systems Analysis has prepared the Asian Water Futures and Solutions 2050 report which provides initial estimates that up to 3.4 billion people could be living in water-stressed areas of Asia by 2050.[8] Further, that Afghanistan, the PRC, India, Singapore, and Pakistan will have the lowest per capita water availability.

Recent similar research by the Massachusetts Institute of Technology on climate change projections and water security reinforces that population growth and industrialization may exacerbate water access problems with climate change further aggravating the problem.[9] The PRC and India will have varying drivers (due to differing paces in industrialization and population growth) for water stress but, inevitably with their massive populations, will be the region's hot spots.

The region is already at highest risk from water-related disasters, including storms, floods, and droughts. Over the past 20 years, Asia specifically has suffered half of the estimated global economic cost of disasters: about $53 billion annually. Countries such as the Philippines increasingly experience more intense rather than more frequent extreme events. Likewise, the number of hot days and warm nights is increasing and projected to continue to do so. Such changes coupled with weak resource management and limited data availability further compound water insecurity.

Over the past 5 years, the World Economic Forum's Global Risks Report has repeatedly highlighted the impacts of a rising global population and growing prosperity placing unsustainable pressure on resources.[10] In 2016, the water crisis was considered the most impactful risk over the next 10 years, reinforcing water security as an urgent political matter.

The next few decades will see an intensification of multiple challenges at the nexus of water, food, and energy. With growing demand for each, these resources will be put under greater pressure by complex interactions, the exhaustion of low-cost options to increase supply, climate change impacts, and institutional barriers that address policies in sector silos.

Bolder steps need to be taken to respond to competing demands and to increase resource management efforts to assure a water- and food-secure Asia and the Pacific. We also need to recognize that population growth and climate

7 United Nations World Water Assessment Programme (WWAP). 2016. *The United Nations World Water Development Report 2016: Water and Jobs*. Paris: UNESCO on behalf of UN-Water.

8 International Institute for Applied Systems Analysis (IIASA). 2016. *Water Futures and Solutions: Asia 2050*. Vienna. (under publication)

9 C. Fant, C.A. Schlosser, X. Gao, et. al. "Projections of Water Stress Based on an Ensemble of Socioeconomic Growth and Climate Change Scenarios: A Case Study in Asia." *PLoS ONE* 11(2016):3, accessed 30 May 2016, doi: 10.1371/journal.pone.0150633

10 World Economic Forum. 2016. *The Global Risks Report 2016, 11th Edition*. Geneva.

variability are already having global and regional impacts on water resources.

The establishment of a global, high-level platform at the World Economic Forum Annual Meeting 2016 is a step forward to forge a united alliance and increase political backing and actions for sustainable water resources development.

Managing Water in a Changing Climate

With an increasing population, Asia and the Pacific faces twin challenges of achieving and sustaining rapid economic growth and meeting the SDGs, with accentuated risks posed by global climate change. Without appropriate management and investment, economic losses in key sectors such as agriculture, energy, transport, health, water, coastal and marine, and tourism are expected to be significant, rendering growth targets harder to achieve. Countries in the region will need support to build resilience against climate change, environmental degradation, and disasters.

Climate variability, including changes in temperature, evaporation, and precipitation, will impact regional water resources and is expected to increase the frequency of floods and droughts and reduce river flows, particularly during low flow periods. Seasonal precipitation changes are already increasing in East Asia, and temperatures, droughts, and flooding are projected to increase in Southeast Asia. Regions that are already socioeconomically and geographically vulnerable (like low-lying, flood-prone areas) will be further impacted by underlying water and food insecurity.

According to the Intergovernmental Panel on Climate Change Fifth Assessment Report (2013), water scarcity will be a major challenge for most of the region.[11] Climate change will further compound multiple stresses from rapid urbanization, industrialization, and economic development as Asia and the Pacific has some of the most vulnerable countries to climate change. Combating climate change will require global actions for increased investments in adaptation and mitigation to enhance resilience.

ADB's annual climate finance is expected to increase from the current $3 billion to $6 billion by 2020. Of the $6 billion, $4 billion will be for mitigation and $2 billion for adaptation, bringing support for climate change to about 30% of total lending. This doubling reflects its strategic priorities, with climate change and environmental sustainability central to its operational requirements for sustainable development.

While freshwater scarcity in a warming world is perhaps our most pressing issue, its centrality to critical global dialogue on climate change remains elusive. There needs to be a more concerted effort to incorporate water into climate policy and to reinforce the links between improved water security, sustainable development, and poverty reduction.

Sustainable Development Goal 6: The Sustainable Development Goal on Water

By signing up to the 2030 Agenda for Sustainable Development, 193 member states of the United Nations (UN) General Assembly have set the global agenda for sustainable development. Building on the successes, gaps, and lessons from the Millennium Development Goals (MDGs), this new development agenda sets out 17 SDGs and 169 targets.

[11] Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley, eds. Cambridge, UK, and New York, NY: Cambridge University Press.

AWDO and the SDGs are complementary approaches. AWDO includes all targets of the goal on water (SDG6, Box 1), as well as components of those on agriculture (SDG2), energy (SDG7), sustainable growth (SDG8), and cities (SDG11). As such, AWDO presents a broader picture on water security than SDG6 only.

Box 1: The Water Goal and Its Targets

Sustainable Development Goal (SDG) 6: Ensure availability and sustainable management of water and sanitation for all.

Targets

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and at least doubling recycling and safe re-use globally.

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity.

6.5 By 2030 implement integrated water resources management (IWRM) at all levels, including through transboundary cooperation as appropriate.

6.6 By 2020 protect and restore water-related ecosystems, including mountains, forests, wet-lands, rivers, aquifers and lakes.

Source: United Nations Department of Economic and Social Affairs, Division for Sustainable Development. 2015. Sustainable Development Knowledge Platform. Accessed 20 July 2016 from https://sustainabledevelopment.un.org/sdg6

A view of Ho Chi Minh City, Viet Nam.

Part III. Water Security and the Asian Water Development Outlook Framework

The Vision behind the Methodological Approach

National Water Security

Scoring Approach in this Edition

Changes in Methodology from the 2013 Edition

The Asian Water Development Outlook (AWDO) was initiated by the Asian Development Bank (ADB) and the Asia-Pacific Water Forum (APWF) to highlight important water management issues in Asia and the Pacific. Two editions of the report have been published, in 2007 and 2013, respectively. AWDO 2007 underlined the need to address water security with a broader perspective than traditional sector-focused approaches. AWDO 2013 provided the first quantitative and comprehensive view of water security in the countries of Asia and the Pacific.

AWDO 2013 established the concept of water security by identifying its five key dimensions and developing an approach that quantifies these key dimensions by means of indicators. The approach can be used to score the water security of each country (or river basin) and to compare the scores. This was done for 49 economies of Asia and the Pacific.

This third edition of AWDO refines the analytical framework and associated indicators to provide more detailed analysis and greater confidence in water security assessments. The goal of AWDO 2016 is to refine the indicators developed for AWDO 2013 in order to provide a more reliable assessment of water security in the region. As such, the findings of this report are not directly comparable with those of AWDO 2013; however, they do provide a more complete picture of the region.

The overall aim of each successive AWDO is to provide a country-wise snapshot of the region's water security status and provide guidance on recommended actions. The report is intended to serve as a communication tool and provides a relative, rather than absolute, measure of water security.

The Vision behind the Methodological Approach

Definition of Water Security

The meaning and definition of the term "water security" has developed over time. While in the 1990s the term was mostly used to express a general vision, in the past 10 years it has increasingly been used to explicitly state the goals that we want to achieve with better management. This requires definitions of what water security is and how we can measure water security.[12]

Many definitions of water security exist and most have a certain sector bias. The following definitions are the most comprehensive and most referenced:

1. "The reliable availability of an acceptable quantity and quality of water for production, livelihoods and health, coupled with an acceptable level of risk to society of unpredictable water-related impacts."[13]
2. "The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."[14]

The concept of water security is still developing. The current thinking is largely focused on infrastructure. While the importance of infrastructure is confirmed in the Global Water Partnership (GWP) and the Organisation for Economic Co-operation and Development (OECD)

12 An overview of these developments and use of water security in water management is given in E. van Beek and W. Lincklaen Arriens. 2014. Water Security: Putting the Concept into Practise. *TEC Background Paper No. 20*. Stockholm: Global Water Partnership Technical Committee.

13 D. Grey and C.W. Sadoff. 2007. Sink or Swim? Water Security for Growth and Development. *Water Policy* 9(6): 545–571.

14 United Nations University. 2013. *Water Security and the Global Water Agenda: A UN-Water Analytical Brief*. Ontario: United Nations Institute for Water, Environment and Health.

report *Securing Water, Sustaining Growth*, the report also mentions the need to make water security more risk and opportunity oriented (footnote 6).

Vision of Water Security

In developing the analytical framework for AWDO 2013, the following shared vision of water security was formulated:

> Societies can enjoy water security when they successfully manage their water resources and services to
>
> 1. satisfy household water and sanitation needs in all communities;
> 2. support productive economies in agriculture, industry, and energy;
> 3. develop vibrant, livable cities and towns;
> 4. restore healthy rivers and ecosystems; and
> 5. build resilient communities that can adapt to change.

To quantify water security, this vision was developed into a water security framework with five interdependent key dimensions. These key dimensions are illustrated in Figure 1 and are described in more detail in the next section.

Key Dimensions of Water Security

Key Dimension 1: Household Water Security

The foundation and cornerstone of water security is what happens at the household level. Providing all people with reliable, safe water, and sanitation services should be the top priority of Asia's leaders. Household water security is an essential foundation for efforts to eradicate poverty and support economic development.

Key Dimension 2: Economic Water Security

Water grows our food, powers our industry, and cools our energy-generating plants. The use of water in these sectors must no longer be seen in isolation from each other. Debate about the water–food–energy nexus has begun to raise general awareness about the critical interaction among water uses to support economic activities. Economic water security measures the productive use of water to sustain economic growth in the food production, industry, and energy sectors of the economy.

Key Dimension 3: Urban Water Security

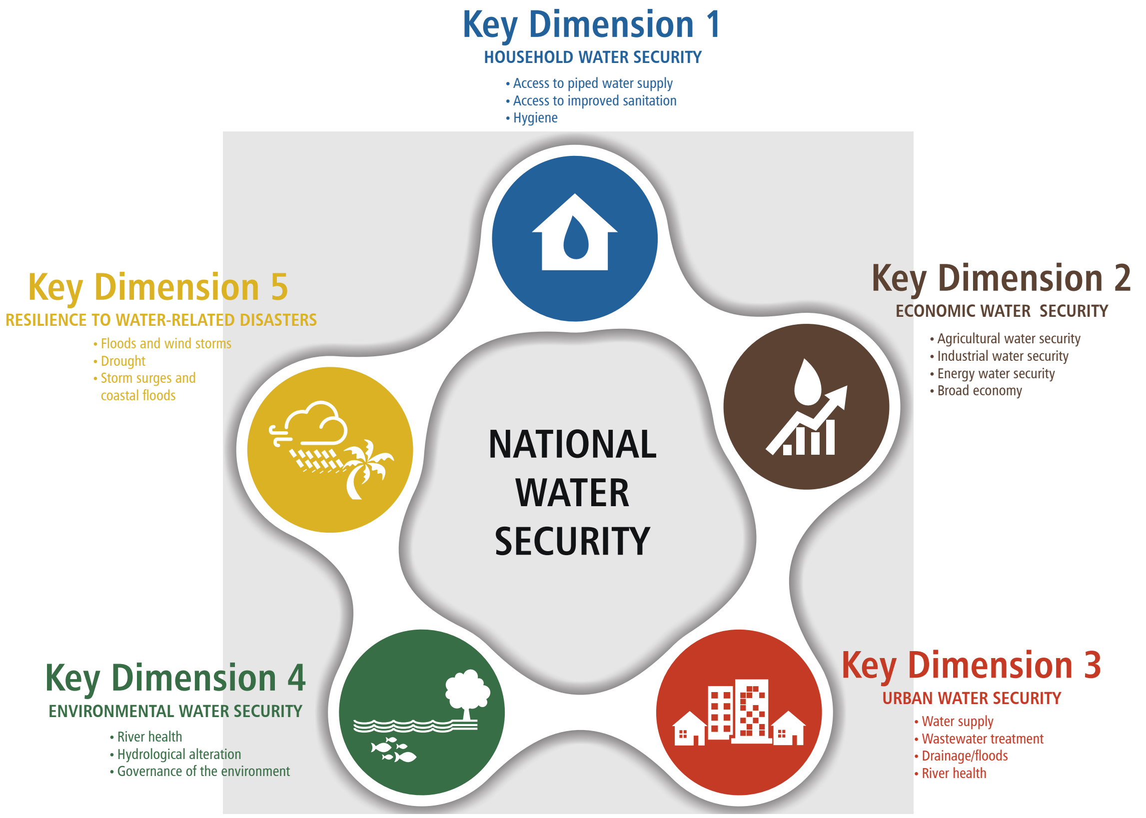
In Asia and the Pacific, about 48% of the population currently lives in urban areas, with this to reach 64% by mid-century.[15] After a century of transformation from agrarian rural societies to urban centers and the creation of the world's largest number of megacities, Asia's cities have become important drivers of the economy. The urban water security indicators measure the creation of better water management and services to support vibrant and livable water-sensitive cities.

Key Dimension 4: Environmental Water Security

Asia's environment and precious natural resources have suffered greatly from decades of neglect as governments across the region prioritized rapid economic growth over environmental objectives. Asia's leaders are now starting to green their economies as a broader focus on sustainable development and inclusive growth gains ground. The environmental water security indicator assesses the health of rivers and measures progress on restoring rivers and ecosystems to health on a national and regional scale. The sustainability of development and improved lives depends on these natural resources.

[15] United Nations Department of Economic and Social Affairs, Population Division. 2014. *World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352)*. New York. https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf

Figure 1: Water Security Framework of Five Interdependent Key Dimensions



Source: ADB.

Key Dimension 5: Resilience to Water-Related Disasters

The region's growing prosperity has involved unprecedented changes in economic activity, urbanization, diets, trade, culture, and communication. It has also brought increasing levels of uncertainty and risk from climate variability and change. The resilience of communities in Asia and the Pacific to these changes, and especially to water-related disaster risks, is assessed with the indicator of resilience to water-related disasters. The building of resilient communities that can adapt to change and are able to reduce risk from natural disasters related to water must be accelerated to minimize the impact of future disasters.

National Water Security

The overall national water security of each country is assessed as the composite result of the five key dimensions, measured on a scale of 1–5. The pentagram of water security (Figure 1) illustrates that the dimensions of water security are related and interdependent, and should not be treated in isolation of each other. AWDO measures water security by quantifying the five key dimensions in terms of clear and measurable indicators. Table 2 describes the five key dimensions, what is measured, and which measurable indicators are used.

The interdependence of the factors that determine water security in each dimension means that increases in water security will be achieved by governments that "break the traditional sector silos"

Table 2: Asian Water Development Outlook Framework Assessing National Water Security

Key Dimension	Index	What the Index Measures	What the Index is Composed of
National Water Security	National water security	How far countries have progressed toward national water security	Combination of the five dimensions of water security measured by the key dimensions
Key Dimension 1 (KD1)	Household water security	To what extent countries are satisfying their household water and sanitation needs and improving hygiene for public health	• Access to piped water supply • Access to improved sanitation • Hygiene index (measured in disability-adjusted life years, DALYs)
Key Dimension 2 (KD2)	Economic water security	The productive use of water to sustain economic growth in food production, industry, and energy	• Broad economic development • Water for agriculture • Water for industry • Water for energy
Key Dimension 3 (KD3)	Urban water security	Progress toward better urban water services and management to develop vibrant, livable cities and towns	• Urban water supply • Urban wastewater collection • Flood and storm drainage • Urban river health
Key Dimension 4 (KD4)	Environmental water security	How well river basins are being managed to sustain ecosystem services	• River health • Flow alteration • Environmental governance
Key Dimension 5 (KD5)	Resilience to water-related disasters	The capacity to cope with and recover from the impacts of water-related disasters	• Floods and windstorms • Droughts • Storm surges and coastal floods

Source: ADB.

to find ways and means to manage the linkages, synergies, and trade-offs among the dimensions. This is the process known as integrated water resources management adopted by world leaders in Johannesburg in 2002 at the World Summit on Sustainable Development, which was reaffirmed at the United Nations Conference on Sustainable Development Rio+20 Summit in 2012 and is now included in the SDGs as target 6.5.

The descriptions of the five stages of national water security (NWS) assessment are summarized in Table 3. At NWS Index 1, the national water security situation is hazardous and there is a large gap between the current state and the acceptable levels of water security. At NWS Index 5, the country may be considered a model for its management of water services and water resources, and the country is as water-secure as possible under current circumstances. The stages and banding of AWDO 2016 are the same as in AWDO 2013.

Scoring Approach of this Edition

The performance of an economy in each of the key dimensions is expressed by scores. How this is done is described in detail in the methodology and data report of AWDO 2016.[16] Appendix 1 contains a short summary. The ultimate scores for all key dimensions are given on a scale of 1–20. The overall national water security score ranges from 1–100 and is the sum of the key dimension scores. The banding over

[16] ADB. 2016. *Asian Water Development Outlook 2016: Description of Methodology and Data*. Manila (available upon request).

Table 3: Description of National Water Security Stages

NWS Index	NWS Score	NWS Stage	Description
5	96 and above	Model	All people have access to safe drinking water and sanitation facilities; economic activities are not constrained by water availability; water quality meets standards for people and ecology; and water-related risks are acceptable and relatively easy to deal with.
4	76<96	Effective	Nearly all people have access to safe drinking water and sanitation facilities; water service delivery is mostly formal and effective to support economic development; water quality is in general acceptable and attention is given to ecological restoration of water bodies; and water-related risks are seriously brought down by infrastructure and warning systems.
3	56<76	Capable	Access to safe drinking water and sanitation facilities is further improving, also in rural and poor areas; water productivity in economic activities has improved; water quality is improving through regulation and wastewater treatment; first measures are taken to restore ecological health of the water bodies; and the most serious water-related risks are being addressed.
2	36<56	Engaged	More than half the people have access to modest drinking water and sanitation facilities; water service delivery is starting to develop, supporting economic activities; first measures are taken to improve water quality; and first attempts are being made to address water-related risks.
1	0<36	Hazardous	Drinking water and sanitation facilities are limited and impose serious health risks; water service delivery is mostly informal and a constraining factor for economic activities and development; water quality is poor and dangerous for people; serious damage to aquatic ecology is present; and droughts and floods drive people into poverty.

NWS = national water security.
Source: ADB.

the five stages of national water security is given in Table 3.[17]

Changes in Methodology from the 2013 Edition

Based on the experience with AWDO 2013, several refinements in the methodological framework of AWDO are introduced in AWDO 2016. These changes are described in detail in an unpublished methodology report which can be provided upon request from ADB. The changes in the key dimensions for economic water security (KD2) and environmental water security (KD4) are considerable.

The following is an overview of all changes:

- KD1—Household water security: adjustment of calculation approach to address the redefinition by the World Health Organization (WHO) of the subindicator measured in disability-adjusted life years (DALYs) (hygiene).
- KD2—Economic water security: inclusion of an additional subindicator (broad economy) and redesign of the calculation approach of the other subindicators, including the use of other data sources.
- KD3—Urban water security: small adjustment of the scoring methodology (less weight to the subindicator river

[17] The same banding is applied for the key dimensions, but as the range of the key dimensions is 1–20, the transfer scores are a fifth of the banding of the national water security scores, i.e., 19.2, 15.2, 11.2, and 7.2.

health) and simplification of the calculation of the wastewater index.

- KD4—Environmental water security: redesign of the subindicator river health and addition of two other subindicators (flow alteration and governance).
- KD5—Resilience to water-related disasters: small adjustments on how the subindicator coastal storm surges is taken into account in landlocked countries.

Important changes in the methodology are also the scoring method and the banding of the 1–5 scale (see Table 3). The scores of the key dimensions are now expressed on a 1–20 scale with the NWS Index being the sum of the key dimension scores. In AWDO 2013, the key dimension scores were first banded on the 1–5 scale before the NWS Index was determined. The banding is now standardized for all key dimensions and NWS Index. In AWDO 2013, each key dimension used an own defined banding that was different from the banding of NWS Index.

The abovementioned changes in the methodology mean that the results as published in AWDO 2013 are not directly comparable with the results of AWDO 2016. To investigate the impacts of the methodological changes, the new methodology was also applied on the data used for AWDO 2013. Comparing the AWDO 2013 results using the old and the new methodologies provide insight on these impacts. This comparison is described in the methodology report and the scores of three cases are given:

- AWDO 2013 as published in the official ADB report,
- AWDO 2013 recalculated using the new methodology with the AWDO 2013 data (AWDO 2013-adj), and
- AWDO 2016 using the new methodology with new data.

The analysis shows that the results are sufficiently comparable to allow drawing conclusions on the difference between AWDO 2016 and AWDO 2013. Some caution should be exercised though; the updated approach and the use of different data sources do have, in some cases, an impact on the results. Comparisons in this report between AWDO 2016 and AWDO 2013 are based on the adjusted 2013 results.

Planting rice within the Casecnan Irrigation scheme in Nueva Ecija, Philippines.

Part IV.
Retaking the Pulse

The National Water Security Index

Key Dimension 1: Household Water Security

Key Dimension 2: Economic Water Security

Key Dimension 3: Urban Water Security

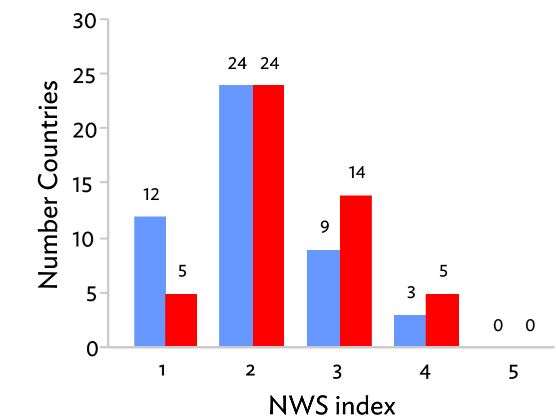
Key Dimension 4: Environmental Water Security

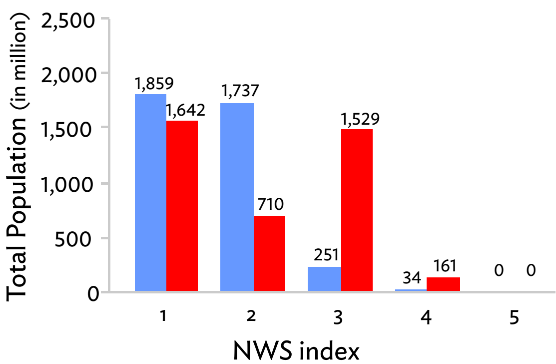
Key Dimension 5: Resilience to Water-Related Disasters

Overlap between Key Dimensions and Indicators

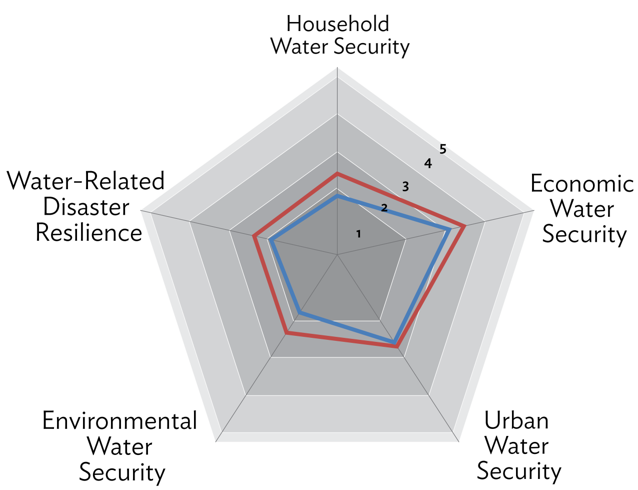
NATION

AWDO 2013 AWDO 2016





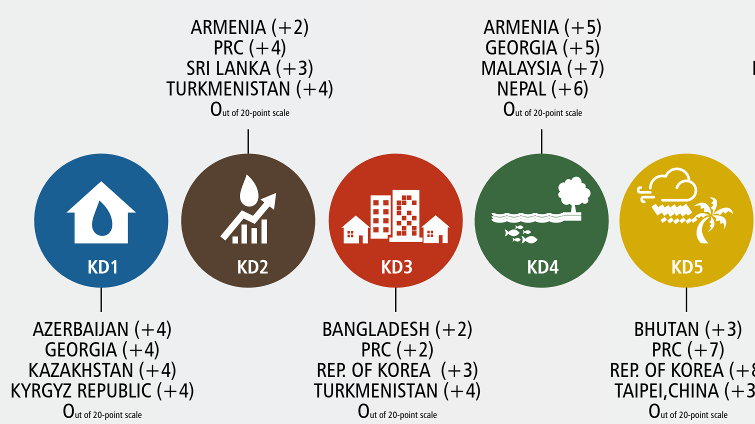
National Water Security Index



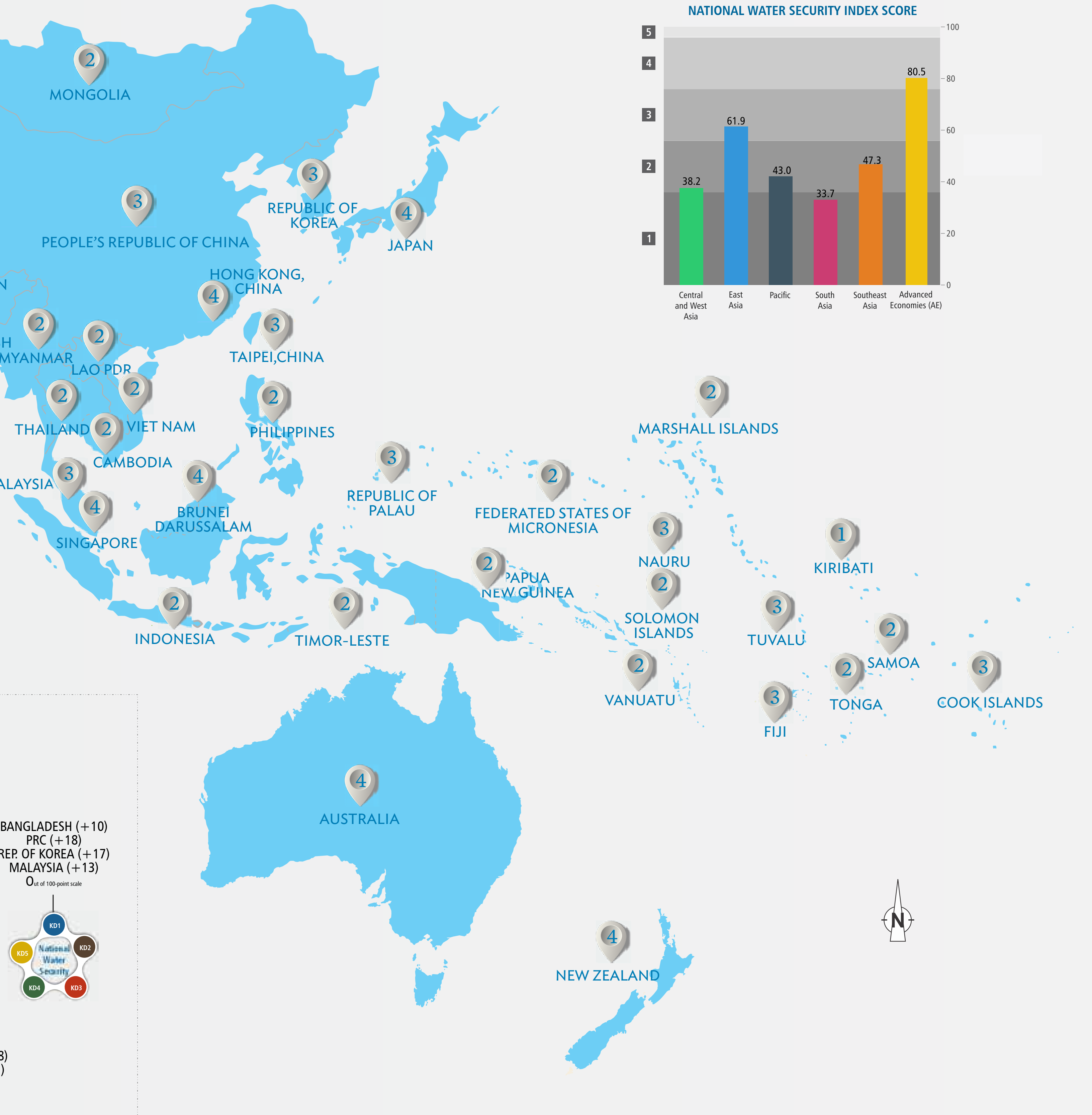
Top Performers

from AWDO 2013 to 2016

(data period 2009–2014 [5 years])



NAL WATER SECURITY INDEX



The Asian Water Development Outlook (AWDO) 2013 presented the water security status of 49 economies in Asia and the Pacific. AWDO 2016 continues the approach of AWDO 2013. The underlying methodologies to quantify the five key dimensions are refined and the most recent data were used.[18] The following sections present the water security for 48 economies in Asia and the Pacific,[19] discuss the results, and offer policy options to increase water security. The actual data (scores) by economy are given in Appendixes 1–6. Appendix 1 provides an overview of the five key dimensions and the national water security (NWS) Index by economy as well as the regional average scores. Appendixes 2–6 present the scores for the five key dimensions (KD1-KD5).

AWDO 2016 is based on the most recent data that were available when the analysis was carried out. The actual data years of the parameters considered in the AWDO editions differ. Appendix 7 includes these data years. For some parameters, recent data could be used; for others, only data of earlier years were available. As a rule of thumb, one might consider that AWDO 2016 describes the situation in 2014, while AWDO 2013 (due to a long publishing process) described the situation in 2009. Hence, comparing AWDO 2016 with AWDO 2013 will show the progress made in 5 years.

In describing the performance of the key dimensions of water security, special attention is given to the relationship between water security on the one hand and gross domestic product (GDP) and governance on the other. Does a country have to be rich to achieve higher water security? Does achieving water security require strong governance? The graphs provided show the relationship between the AWDO results and GDP and governance.[20] The source of the GDP data is the United Nations (UN) database[21] and gives each economy's GDP for 2014. For governance, AWDO 2016 uses the 2014 World Development Indicators of the World Bank (percentile rank data for the government effectiveness category). In this case, a dedicated water governance indicator would have been ideal. Unfortunately, such a water governance indicator is not yet available for all 48 economies considered in AWDO 2016 (see also Box 5 on the work of the Organisation for Economic Co-operation and Development on water governance).

The National Water Security Index: All Key Dimensions Together

The five key dimensions together form the NWS Index. Appendix 1 provides the scores of the five key dimensions for all 48 economies considered. The maximum score of each key dimension is 20. Thus, the maximum score for national water security (i.e., the sum of the key dimension scores) is 100. As illustrated in Figure 2, which sorts the economies based on their national water security score, the range in scores is enormous from 27.5 (Afghanistan) to 91.3 (New Zealand) and rather continuous. No clear groups of countries can be identified.

The regional differences are also clear (Figure 3).[22] The population-weighted score of the advanced economies is 80.5, while for South Asia it is only 33.7. East Asia shows a promising score of 61.9, mainly due to the combined high scores of Taipei,China (67.6) and the PRC (61.8).

Also promising is the increase in scores of all key dimensions between AWDO 2013 (data year about 2009) and AWDO 2016 (data year about 2014), showing the progress in the 5-year period (Figure 4). This result should be interpreted somewhat cautiously as some of the changes between AWDO 2013 and AWDO 2016 will also be due to the updated methodology applied in AWDO 2016.

18 The methodology and data used for AWDO 2016 is described in an unpublished report which can be provided upon request from ADB.

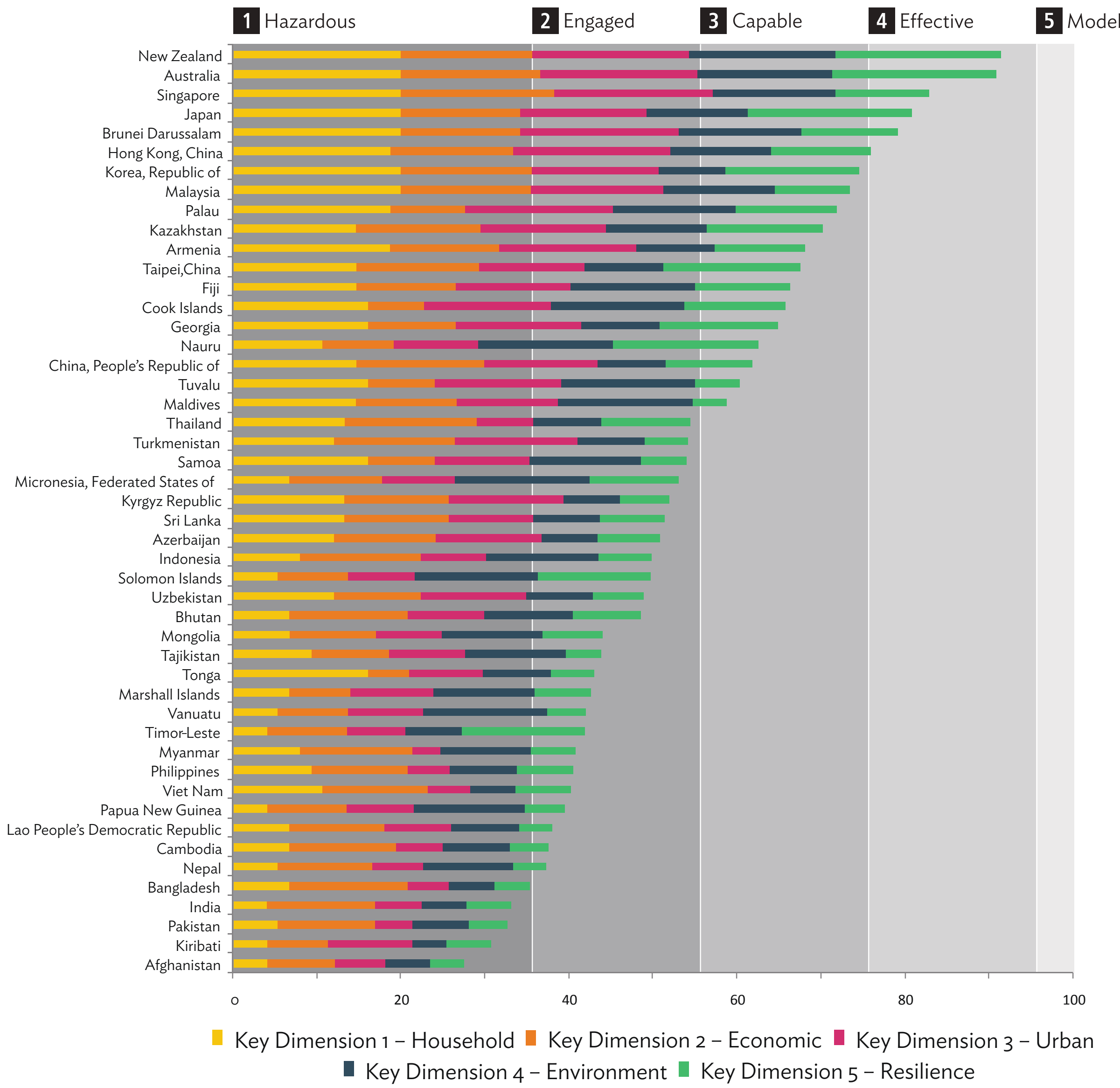
19 Compared with AWDO 2013, the small island country Niue was dropped.

20 The small island nations are not included in the graphs due to the many missing data and the relative small size of the countries.

21 With the exception of Taipei,China, for which World Bank data were used.

22 See Appendix 1 for an overview of the economies included in the six regions.

Figure 2: National Water Security Index Score



KD = key dimension.

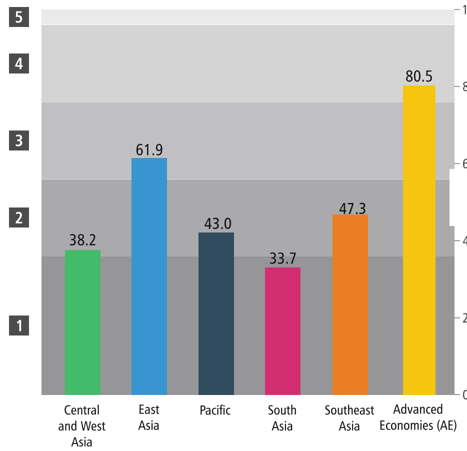
Source: ADB.

In Part II earlier, this report raised two important conditions for achieving water security: financing and governance. The two questions to ask are the following:

- Does a country have to be rich to be able to achieve water security?
- Is good governance needed to achieve water security?

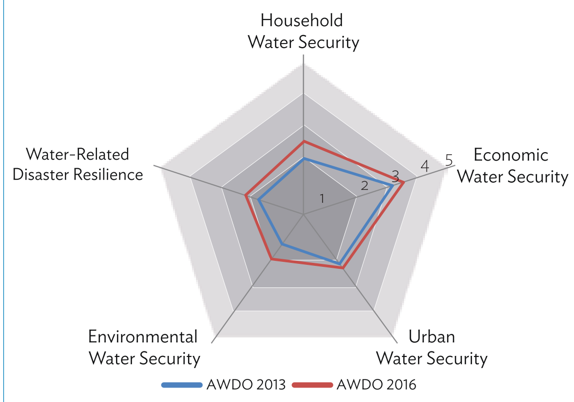
The first question is illustrated in Figure 5. The primary conclusion is indeed that rich countries have higher water security. However, do they have higher water security because they are rich or are they rich because they have higher water security? The Global Water Partnership (GWP) and the Organisation for Economic Co-operation and Development (OECD) Task Force on Water Security and Sustainable Growth has addressed

Figure 3: National Water Security Index by Region



Source: ADB.

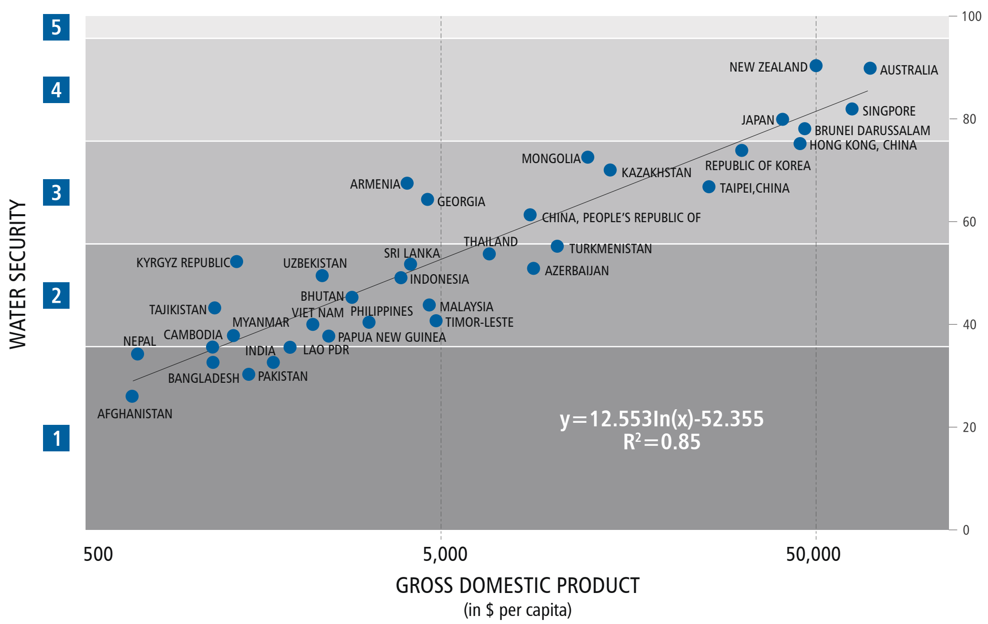
Figure 4: Key Dimensions between Asian Water Development Outlook 2013 and Asian Water Development Outlook 2016



AWDO = Asian Water Development Outlook.

Source: ADB.

Figure 5: Water Security and Gross Domestic Product



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Note: Excludes small island nations.

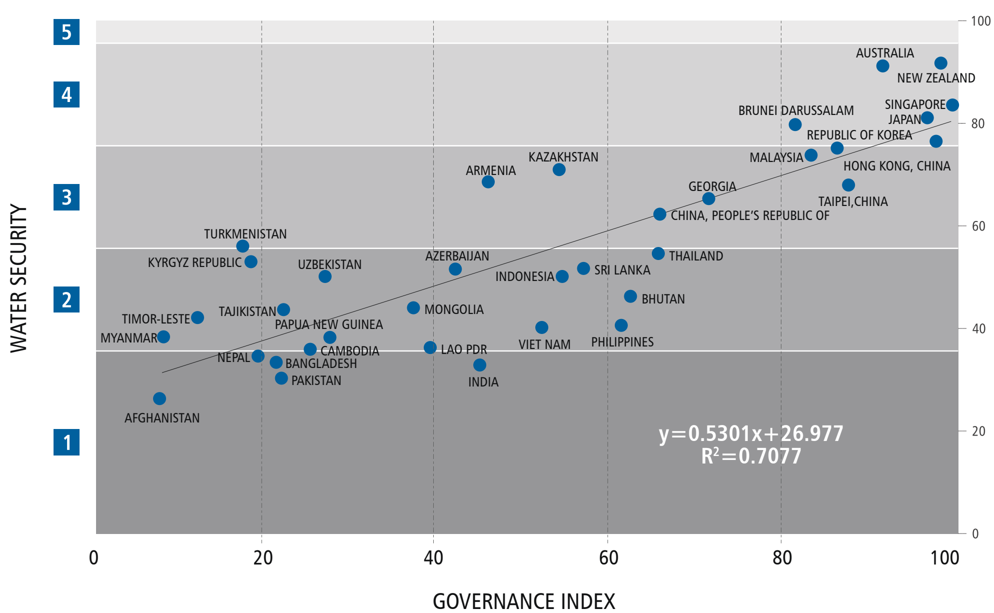
Sources: ADB; World Bank. 2014. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables this from a risk perspective (footnote 6). They related economic growth, hydrological variability, and investment in water security and came to the conclusion that most of the world's wealthy economies face less hydrological variability and have made more investment in water management. They also concluded, however, that the relationship runs in both directions. Water-related investments can increase economic productivity and growth, while economic growth provides the resources to invest in institutions and capital-intensive water infrastructure. Providing hard evidence for the first direction is difficult, although the Republic of Korea, Malaysia, Singapore, and Thailand were able to make major progress in drinking water and sanitation while they were still relatively poor countries, proving that this is possible (see the case described under KD1). The same countries have made remarkable economic progress and might be the evidence to prove the statement that each dollar invested in water and sanitation can provide a return of \$5–\$46 in reduced health costs and increased economic productivity.[23]

The relationship between water security and governance is fuzzier, as illustrated in Figure 6. The deviations from the trend line might be more interesting than the trend line itself. Remarkable is the relative positive scoring of Armenia, Georgia, the Kyrgyz Republic, and Uzbekistan, countries that were part of the former Soviet Union.

Note that Figures 5 and 6 are not population-weighted. Each economy has the same weight in determining the regression line, no matter if it is Brunei Darussalam with a population of only 400,000 people or the PRC with 1.4 billion.

A multiple regression of water security against GDP and governance did not provide an additional explanation of the deviations). Analysis also showed that an economy's water endowment

Figure 6: Water Security and Governance



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Note: Excludes small island nations.

Sources: ADB; World Bank. 2014. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

[23] G. Hutton, L. Haller, and J. Bartram, 2007. Global Cost–Benefit Analysis of Water Supply and Sanitation Interventions. *Journal of Water Health* 5(4): 481–502.

(in terms of cubic meter per capita per year, m^3/cap/yr) hardly plays a role in achieving water security. Countries with a relatively low water endowment (e.g., Singapore with 107 m^3/cap/yr and the Republic of Korea with 1,386 m^3/cap/yr) have been able to achieve high water security, while water-rich countries such as Myanmar and Cambodia still have quite a challenge ahead. The water endowment at the national level is also too simple an indicator in this respect. Temporal and spatial distributions of the water resources play a crucial role in achieving water security. The GWP/OECD Task Force on Water Security and Sustainable Growth also emphasized the importance of the variability of the resource and a country's ability to deal with this variability (footnote 6).

KEY DIMENSION 1 – HOUSEHOLD WATER SECURITY

ADB projects and financing on water and supply and sanitation (2011–2015)

$8.9 billion for **107** projects

Key Dimension 1 provides an assessment of the extent to which countries are satisfying their household water and sanitation needs and improving hygiene for public health in all communities. KD1 is a composite of three subindicators.

1. **Access to piped water supply (%)**
2. **Access to improved sanitation (%)**
3. **Hygiene (age-standardized disability-adjusted life years per 100,000 people for the incidence of diarrhea)**

Linkages to Sustainable Development Goals

SDG 6

Target 6.1

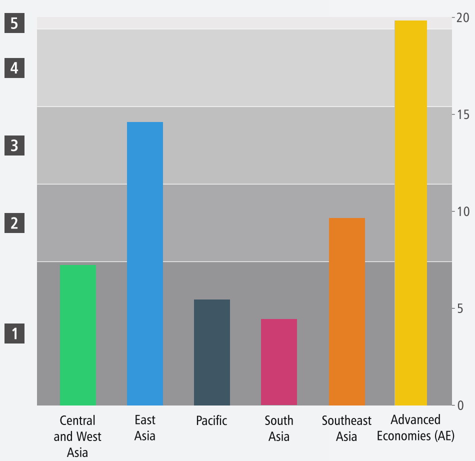
By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

Target 6.2

By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

HOUSEHOLD WATER SECURITY

(POPULATION-WEIGHTED)



Top Performers

(from AWDO 2013 to AWDO 2016)

- **Azerbaijan** (+ 4 POINTS)
- **Georgia** (+ 4 POINTS)
- **Kazakhstan** (+ 4 POINTS)
- **Kyrgyz Republic** (+ 4 POINTS)

Challenged Countries

(No progress from AWDO 2013)

- **India**
- **Sri Lanka**
- **Tajikistan**

Key Dimension 1: Household Water Security

As reported by the World Health Organization and United Nations Children's Emergency Fund (WHO/UNICEF) Joint Monitoring Programme (JMP), Asia and the Pacific has made good progress in reaching the 2015 Millennium Development Goals (MDGs) on drinking water and sanitation.[24] The MDG target for drinking water was met, with the exception of the JMP regions Oceania and Caucasus/Central Asia.[25] The MDG target for sanitation showed considerable improvement in Asia and the Pacific, although the target itself was not met. Most regions reached the MDG target, with the exception of Oceania and Southern Asia.

The AWDO 2016 results confirm these findings. Compared to the JMP, AWDO uses more stringent targets. For water supply, AWDO considers only the access to water "piped on premises" while the JMP also includes other improved supply options (e.g., standpipes). The same is true for sanitation where AWDO only considers the "improved" category of the JMP and not the "shared sanitation" category. Moreover, AWDO applies a nonlinear banding on the scores, with the lowest score of 1 applied for all access to water supply and sanitation less than 60% (see the banding in the figures). Finally, AWDO includes hygiene in its definition of household water security. This makes the JMP and AWDO figures not directly comparable. Nonetheless, AWDO similarly shows promising scores for East Asia, Southeast Asia, and Central and West Asia, and low scores for South Asia and the Pacific.

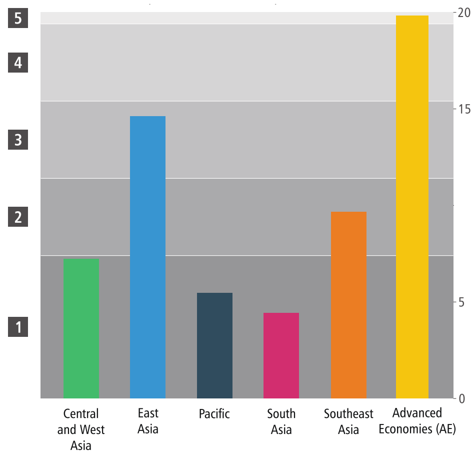
How Does Asia and the Pacific Measure Up?

The scoring approach applied for household water security is described in Appendix 2, which also includes the scores of the individual economies. The figures included in this section are the population-weighted averages of the economy scores.

Overall: Key Dimension 1 Score

The household water security score in Asia and the Pacific on a 20-point scale ranges from 4.5 for South Asia to 20.0 for the advanced economies (Figure 7). Except the Pacific, all regions improved their performance compared to AWDO 2013 by about 2 points. East Asia (up 4.0 points) and Central and West Asia and Southeast Asia (both up 1.7 points) showed a good increase. No significant improvement took place in the Pacific and South Asia also hardly improved its score (up 0.3 points).

Figure 7: Household Water Security by Region



Note: The units on the right axis are the scores (1–20 scale); the ones on the left axis are the stages (1–5 scale from hazardous to model).

Source: ADB.

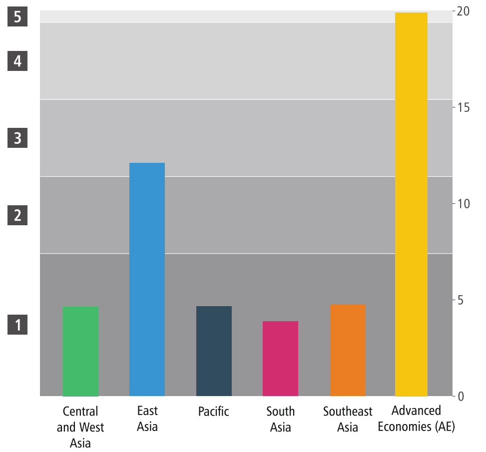
Access to Piped Water Supply

Access to residential piped water supply is steadily increasing. Still, more than half of the 48 economies

[24] United Nations Children's Fund and World Health Organization (UNICEF and WHO). 2015. *Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment*. New York.

[25] The JMP regions differ somewhat from the AWDO regions. For details, see Annex 2 of the 2015 report (footnote 27) and Figure 44 in this report.

Figure 8: Access to Piped Water



Source: ADB.

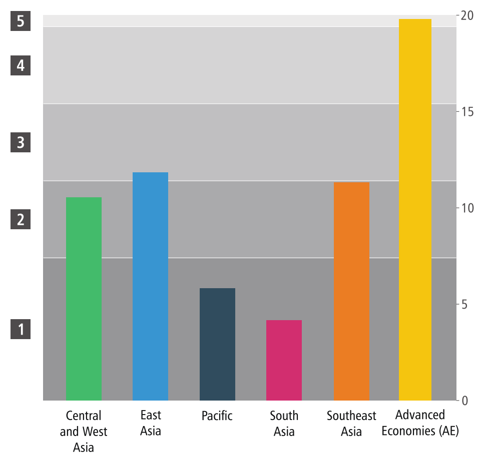
have access rates lower than 50%. The regional data show relatively good results for East Asia (72%) and Central and West Asia (44%). South Asia (28%) and in particular the Pacific (17%) lag behind (Figure 8). At the country level, besides the advanced economies, Armenia (98%) and Malaysia (96%) have performed strongly, also the People's Republic of China (PRC) (already reaching 72%). At the bottom end are Afghanistan (12%), Bangladesh (12%), and Myanmar (8%). It is promising that some of the bottom countries show good progress: Afghanistan (up 8%), Mongolia (up 7%), and Bangladesh (up 6%).

AWDO considers access to piped water supply as the ultimate goal. As intermediate steps, other means of providing safe drinking water are included, such as standpipes and the use of safe groundwater resources. The JMP includes these other means. The scores of the JMP for access to safe drinking water are higher than 90% for most regions in Asia (up to 96% for East Asia), with the exception of the JMP region Oceania (only 56%).

Access to Improved Sanitation

Access to improved sanitation also shows good progress. More than half of the 48 economies have scores of 80% and higher. The regional picture is the same as with the piped supply: low scores for South Asia (45%) and the Pacific (28%) with reasonable to good results in the other regions (Figure 9). At the country level, again apart from the advanced economies, Uzbekistan (100%), Turkmenistan (99%), and Kazakhstan (98%) have very good scores. Most low scores are for countries in South Asia: India (39%), Nepal (44%), Bhutan (50%), Bangladesh (60%), and Pakistan (62%). Papua New Guinea (19%) and Afghanistan (32%) deserve special attention. In sanitation as well, it is encouraging to see remarkable progress in some of the countries in South Asia, in particular Pakistan (up 14%) and Nepal (up 13%). Progress in India (up 3%) and Bangladesh (up 4%) remain slow.

Figure 9: Access to Improved Sanitation

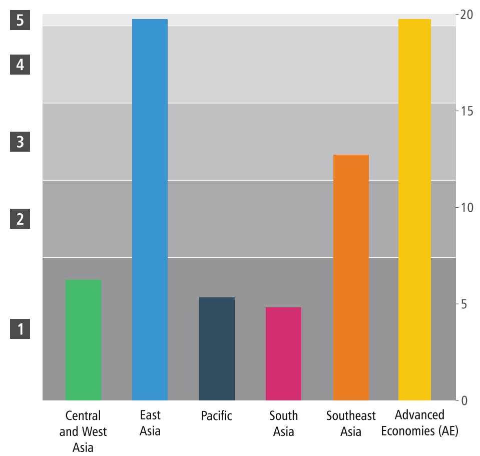


Source: ADB.

Hygiene

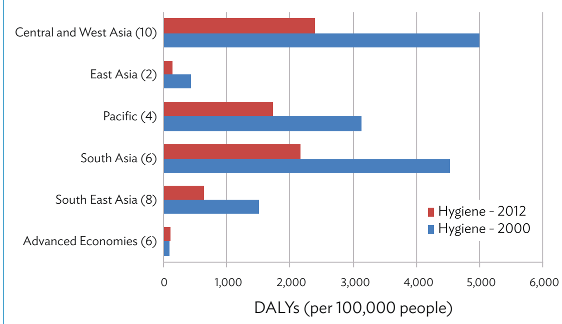
The state of hygiene in the economies is quantified by the disability-adjusted life years (DALYs) per 100,000 people for the incidence of diarrhea. Data issues (missing data and changed estimation method by WHO) are constraining the quantification of this subindicator and comparison with the results

Figure 10: Hygiene in Disability-Adjusted Life Years



Source: ADB.

Figure 11: Comparison of Disability-Adjusted Life Years between 2000 and 2012



DALY = disability-adjusted life year.

Source: ADB.

of AWDO 2013.[26] The general picture is given in Figure 10: East Asia performs very well, while Central and West Asia, the Pacific, and South Asia need to make considerable progress. Figure 11 shows that this progress is indeed being made. At the country level, there are high scores for DALYs in Afghanistan, Pakistan, the Lao People's Democratic Republic, and India (all more than 2,400). Georgia (114), the PRC (150), and Malaysia (150) have good low scores.

Issue: The Inequalities

Besides inequalities between various subregions and countries, and even within countries, there are also major disparities in household water security between rural and urban and between rich and poor populations. With increased overall access, more than half of the developing economies in Asia and the Pacific have narrowed the urban–rural gap in access to piped water supply, e.g., Armenia, the PRC, Georgia, and Thailand. In some countries, such as Bangladesh, Sri Lanka, and Viet Nam, the coverage of improved water supply in rural areas has increased rapidly but the gap in access to piped water supply has been enlarged. This reflects policy choices on how to serve the rural population and might be a practical choice for developing countries. In the next stage, piped water supply can be given higher priority. Some countries show an increased rural–urban gap in both improved and piped water supply, such as Afghanistan, Cambodia, and Timor-Leste. This suggests a government priority on urban areas over rural areas. Improved sanitation shows a similar picture. Two-thirds of the developing economies in Asia and the Pacific have narrowed the rural–urban gap. The same countries as for water supply show a widening gap. A more equal and inclusive policy objective would imply that the policies in these countries should be adjusted.

The WHO/UNICEF 2015 JMP progress report on sanitation and drinking water also highlights the inequalities between rich and poor, both in urban and rural areas. Among the 15 investigated Asia-Pacific countries, Thailand shows the lowest inequity between rich and poor. In terms of improved sanitation in urban areas, India has a gap between rich and poor of 80 percentage points. In rural areas, Mongolia has the largest gap, around 40 percentage points, between rich and poor in access to improved sources of drinking

[26] See Asia-Pacific Center for Water Security, 2016. Final Report Key Dimension 1 of AWDO 2016, March.

water. Thailand, again, scores the lowest in terms of inequality. These data reflect policy priorities which in some countries might be worth reconsidering in light of a more inclusive growth objective.

What Is at Stake?

Low water security in all KDs imposes economic damages and foregone opportunities. The GWP/OECD study states that the greatest economic losses come from inadequate drinking water supply and sanitation, estimated by WHO to be $260 billion per year, more than double the damage of floods ($120 billion per year) and drought ($94 billion per year) (footnote 6). A large portion of this water, sanitation, and hygiene (WASH)-related damage is in the PRC, India, and Indonesia. The economic losses as a percentage of GDP range from 0% to 2% in the PRC, Indonesia, the Republic of Korea, Malaysia, the Philippines, and Viet Nam; from 2% to 4% in Bangladesh, India, and Pakistan; and up to more than 8% in Afghanistan.

And there is a challenge. SDG targets 6.1 and 6.2 aim by 2030 to have universal and equitable access to safe and affordable drinking water and adequate and equitable sanitation and hygiene for all.

What Should Be Done?

The two main ingredients to increase household water security are straightforward: sufficient finance and good governance. Achieving SDG targets 6.1 and 6.2 will require an increase of the budget made available by the governments, in particular for sanitation. Achieving the SDGs in a relatively short period is possible, as experience has shown in several East Asian countries—the Republic of Korea, Malaysia, Singapore, and Thailand.[27] Strong leadership and sustained commitment appeared to be critical, as was a well-coordinated multi-sector approach. These countries developed their vision and strategy for total sanitation coverage before they attained their present levels of national wealth. This included capacity building, continuous monitoring, and raising of standards as goals were achieved.

In order to achieve more inclusive development, special attention should be given to the disparities between urban and rural areas as well as between rich and poor populations (see Box 2 for examples in the PRC). Doing so requires acknowledging the differences in physical, economic, and social conditions and applying appropriate technologies, raising the standards when possible in a later stage.

Household Water Security in Relation to Gross Domestic Product and Governance

The KD1 scores are plotted against GDP and governance in Figures 12 and 13. The link between KD1 and GDP is clearer than the link between KD1 and governance. The direction of the links (the regression line) is as expected. The deviations from the regression line may be more interesting than the regression line itself. Figure 12 shows the high performance of the four countries mentioned earlier (Republic of Korea, Malaysia, Singapore, and Thailand) but also of Armenia and the Kyrgyz Republic. At the same time, several countries are underperforming. Drawing conclusions is challenging as local conditions may play a major role. For example, in Mongolia, the huge nomadic population makes it difficult and not logical to provide the services as specified in the KD1 definition (residential piped water supply).

The link between KD1 and governance is not very clear, as Figure 13 shows. Similar as with the GDP link, it appears that the deviations are the most interesting. Quite a few countries score low compared to their governance capabilities. A striking example is the difference of scores on KD1 between the excellent performer Armenia and India, both at the same governance effectiveness level of close to 50.

[27] H. Northover, S.K. Ryu, and Timothy Brewer. 2015. *Achieving Total Sanitation and Hygiene Coverage within a Generation: Lessons Learned from East Asia*. London: Water Aid. .

Box 2: Integrating the Rural–Urban Divide: Solutions for Water Supply and Sanitation in the People's Republic of China

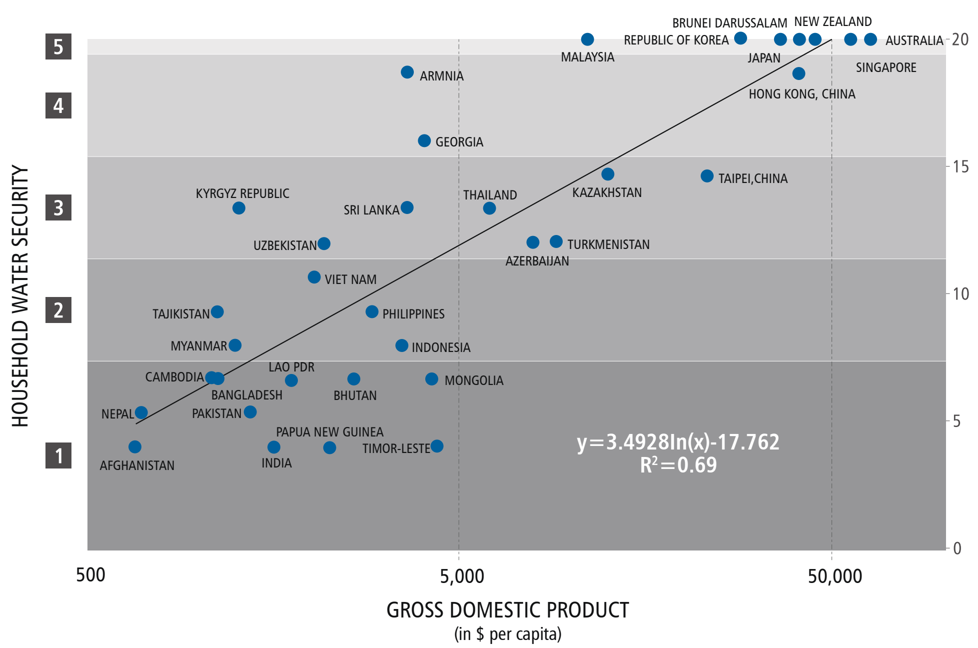
In the People's Republic of China (PRC), improvements in the rural economy have changed communities' water demands beyond just drinking water. They now need water for heating systems, washing machines, and flushing toilets. These all put pressure on rural water supply systems to provide safe, convenient, adequate, and economical water services no different to those of urban residents. Rural–urban water supply integration may be a solution to these problems, in particular for areas close to towns or cities.

The Qinghai Haidong Urban-Rural Eco Development Project financed by the Asian Development Bank (ADB) uses water from two reservoirs (associated facilities) to provide water to poor rural areas first then provides excess water to the urban areas rather than having urban water channeled to rural areas.

Similarly, options considered during the preparation of the ADB-financed Guangdong Chaonan Water Resources Development and Protection Demonstration Project include (i) supplying water to villages and/or small towns by extending the pipelines of existing urban water system; (ii) unifying urban and rural water supply systems by connecting these systems for reliable water sources, water quality, and delivery services; and (iii) integrating operation and management of the systems under a specialized utility, either state-owned entity or private entity. Both projects support the PRC's 13th Five-Year Plan (2016–2020), which recommends a balanced allocation of public resources to promote urban and rural areas and promotes the extension of public services to rural areas.

Source: Adapted from contribution by Y. Zhou, unpublished.

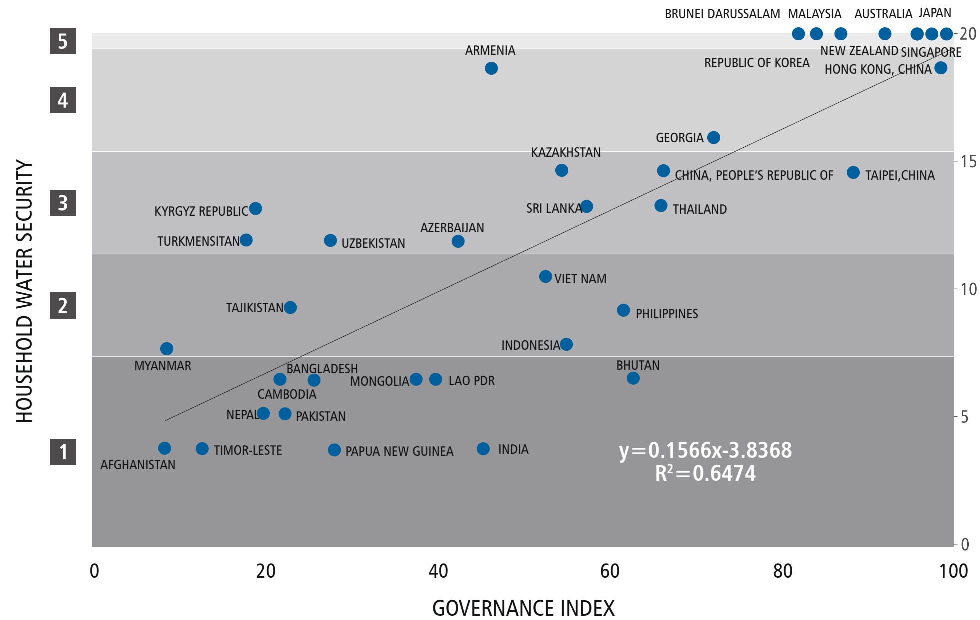
Figure 12: Household Water Security and Gross Domestic Product per Capita



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

Figure 13: Household Water Security and Effectiveness of Governance



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

KEY DIMENSION 2 – ECONOMIC WATER SECURITY

ADB projects and financing on agriculture, hydropower, and irrigation (2011–2015)

$4.8 billion for **55** projects

Key Dimension 2 provides an assessment of the productive use of water to sustain economic growth in food production, industry and energy. KD2 is a composite of four subindicators:

1. Broad economy – describes the general water-related boundary conditions for the use of water for economic purposes
2. Agriculture – water productivity and food security
3. Energy – water productivity and energy security
4. Industry – water productivity in industry

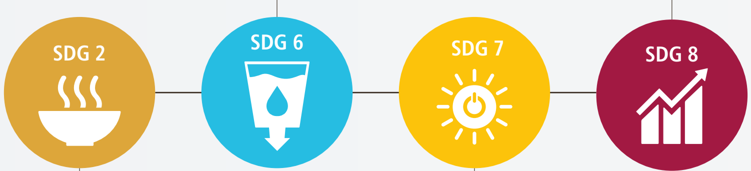
Linkages to Sustainable Development Goals

Target 2.3: By 2030, double the agricultural productivity

Target 6.4: By 2030, substantially increase water-use efficiency across sectors. substantially reduce the number of people suffering from water scarcity

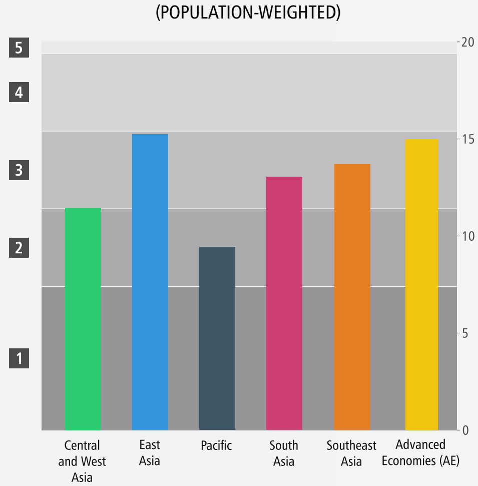
Target 7.2: By 2030, increase substantially the share of renewable energy

Goal 8: Promote sustained, inclusive and sustainable growth, full and productive employment



ECONOMIC WATER SECURITY

(POPULATION-WEIGHTED)



Top Performers

(from AWDO 2013 to AWDO 2016)

- **Armenia** (+2 points)
- **China, People's Republic of** (+2 points)
- **Sri Lanka** (+3 points)
- **Turkmenistan** (+3 points)

Challenged Countries

(No progress from AWDO 2013)

- **Afghanistan**
- **Azerbaijan**
- **Cambodia**
- **Mongolia**

Key Dimension 2: Economic Water Security

KD2 treats economic water security as "assurance of adequate quality and sufficient quantity of water to sustainably satisfy a country's economic requirements." As such, the degree to which economic water security is achieved can be gauged by the level of assurance that water in sufficient quantity is available from different sources (surface, ground, external sources, etc.) relative to present and growing demand from major economic sectors. The framework for assessing economic water security in AWDO has four components: The first component seeks to measure the presence of broad elements that are presumed to enable water's contribution to the agriculture, energy, and industry sectors. The second component examines the degree to which water is secured to enable agricultural production. The third component examines the role of water in energy production. The fourth component explores water's role in industry.

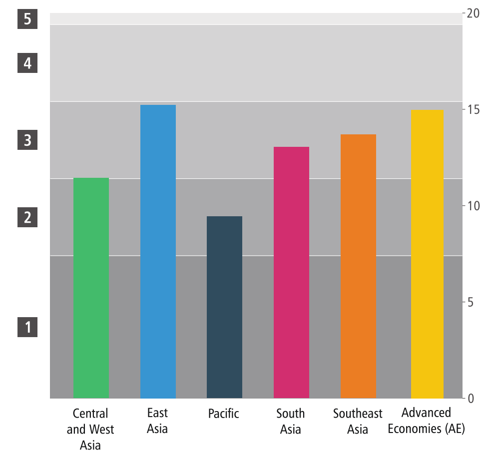
How Does Asia and the Pacific Measure Up?

The scoring approach applied for economic water security is described in Appendix 3, which also includes the scores of the individual economies. The figures included in this section are the population-weighted averages of the economy scores.

Overall: Key Dimension 2 Score

There is diversity in the levels of economic water security in the countries of Asia and the Pacific. The highest-scoring countries are many that one would expect, including Australia, the Republic of Korea, New Zealand, and Singapore (Figure 14). Singapore has the highest score (18.3 out of 20). The lowest scoring group contains many Pacific islands countries. There is room for improvement in virtually every country, including those already performing well. Data availability, particularly for the Pacific islands, constrain the degree to which economic water security in these countries could be assessed. The overall economic water security results show signs of improvement. Nineteen countries increased their score by at least 1 point (on a 20-point scale) in the last 5 years.

Figure 14: Economic Water Security by Region



Note: The units on the right axis are the scores (1–20 scale); the ones on the left axis are the stages (1–5 scale from hazardous to model).

Source: ADB.

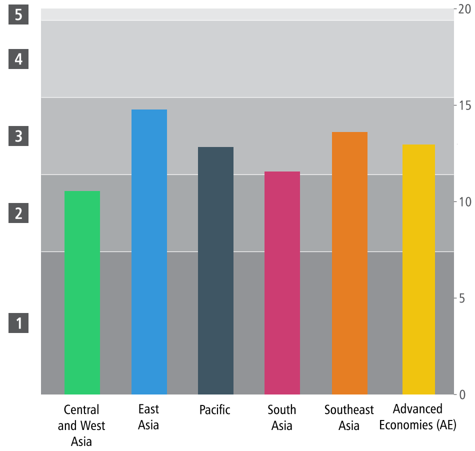
Broad Economy

This subindicator focuses on broad and mostly slow-moving factors relevant to all three major economic sectors. As such, changes in the component score in time would likely indicate (i) an expansion in water storage reservoirs, (ii) a sudden increase in the availability or extraction of water resources, or (iii) improved data availability. Improvements in these areas may require appreciable gestation periods and some elements such as climate variability is strongly externally determined. It is one of the few subindicators in which the advanced economies do not have the highest score.

Agriculture

The strongest performers in this subindicator are Southeast Asian countries such as Thailand and Viet Nam, but South Asian countries such as India

Figure 15: Broad Economy Subindicator



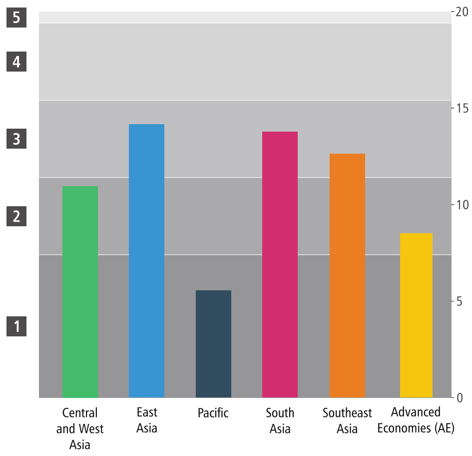
Source: ADB.

and Sri Lanka as well as the PRC have good scores. Compared with AWDO 2013, major improvements have taken place in many countries. Several Pacific island countries as well as Bhutan, Georgia, Japan, and Mongolia have low scores, mainly because of low water productivity.

Energy

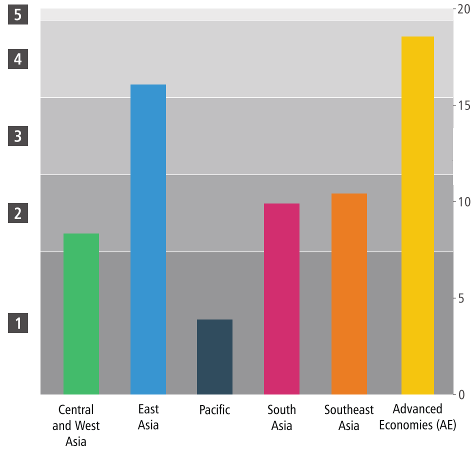
Results for the energy component indicate that certain economies—Hong Kong, China; the

Figure 16: Agriculture Subindicator



Source: ADB.

Figure 17: Energy Subindicator



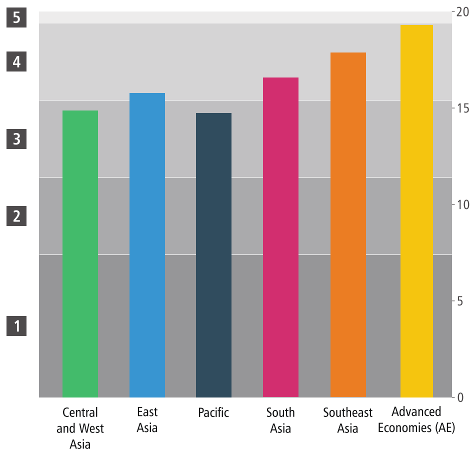
Source: ADB.

Republic of Korea; and Singapore—perform well, as expected. Other economies (Cambodia, Myanmar, and Nepal) demonstrate scope for improvement. Trends in the energy component scores provide mixed signals. In fact, the trends in two countries (Cambodia and Nauru) indicate severe drops. Nonetheless, results in Turkmenistan highlight an improvement that is attributed to increasing electricity generation to meet the minimum requirement.

Industry

Results for the industry component of the water security framework include some surprises. The top-performing countries include Australia, Bangladesh, Bhutan, Cambodia, Fiji, Indonesia, Japan, the Republic of Korea, the Maldives, Myanmar, Nepal, New Zealand, Singapore, Thailand, and Timor-Leste. Relatively high scores in Bhutan and the Maldives may be explained by the lucrative and relatively large contribution of the tourism industry. Countries that may merit the most from a focus on strengthening current conditions appear heavily concentrated in Central Asia—Kazakhstan, the Kyrgyz Republic, Tajikistan, and Uzbekistan. Data constraints preclude the calculation of results for 14 countries, mainly Pacific islands. The industry component scores improved

Figure 18: Industry Subindicator



Source: ADB.

extensively from AWDO 2013 to AWDO 2016. Two Central Asian countries (the Kyrgyz Republic and Uzbekistan) achieved an improvement on their index from 2 to 3 (on the 5-point scale). Eight countries (the PRC, the Lao People's Democratic Republic, Malaysia, Pakistan, Papua New Guinea, Sri Lanka, Turkmenistan, and Viet Nam) improved their scores from 3 to 4, and four countries (Bangladesh, Indonesia, Thailand, and Timor-Leste) progressed from 4 to 5.

Issues

Groundwater

A limitation of the methodology for KD2 is that water availability and use were not disaggregated by source to allow for specific analysis of the sustainability of groundwater use. Though it does not apply only to AWDO, groundwater is missing in many global water resources studies. This is mainly because little information is available about the safe yields of the aquifers (how much can be sustainably withdrawn) and the actual withdrawals.

The scarce data available show that groundwater withdrawals in many countries exceed these safe yields. In particular, in Bangladesh, India, Pakistan, and Turkmenistan, there is major concern whether the present practice of groundwater use can be sustained as the depth of the groundwater level continues to drop. Three of these countries are in South Asia, a region where overall water security is already low.

Excessive groundwater abstraction, exceeding the recharge and safe yield of aquifers, may seriously affect the availability of water for household security (KD1) and urban security (KD3). Groundwater is also vulnerable to geophysical disasters like earthquakes, volcanic eruptions, and landslides, as well as water-induced disasters, particularly droughts.

Water, Energy, and Food

As economies develop, increasing demands will be placed on water for food and water for energy (see Box 3). In Asia, primary energy production is expected to double and power generation to more than triple by 2050.[28] The increased demand for energy will put additional pressure on already constrained water resources. Estimates for Asia predict a 65% increase in industrial water use, 30% increase in domestic use, and 5% increase in agriculture use by 2030. This illustrates the growing and acute competition among principal water users.

Energy use in irrigation is mainly associated with water abstraction and conveyance. As global demand for food and biofuels increases, there will be more intensive irrigation and associated increased consumption of energy. Climate change impacts will further exacerbate the pressures on finite water resources to meet the demands for food, power generation, and domestic supply. According to estimates by the Food and Agriculture Organization of the United Nations, more than a third of the world's 303 million hectares of irrigated

[28] D.J. Rodriguez, A. Delgado, P. DeLaquil, and A. Sohns. 2013. Thirsty Energy. Water Papers 78923. Washington, DC: Water Partnership Program, World Bank.

Box 3: The Water–Energy–Food Nexus and Water Security

Achieving water security requires close linkages between the energy, domestic water use, and agriculture sectors. Energy is the costliest ingredient required to supply safe drinking water and restore water of sufficient quality to ecosystems. Similarly, irrigation and all agricultural processes are highly energy intensive. At the same time, almost all energy generation processes require significant amounts of water. Water, energy, and food are thus intrinsically linked. As economies develop, increasing demands will be placed on water for food and water for energy. And the competition across the various sectors using water will intensify.

Any water security strategy needs to be cognizant of related energy and food security strategies and resource use efficiencies need to be sought across the three sectors. Investments in the food and energy sectors will need to explicitly factor in water needs. Similarly, investors in water development and use should be aware of available energy sources, their costs, and competing demands. More integrated design processes can help identify interventions, technologies, policies, and institutions that increase water security without adversely affecting energy or food security goals. Without such an integrated assessment, water security will remain out of reach for many.

Source: C. Ringler. 2016. ADB. 2016. *Technical Assistance for Knowledge and Innovation Support for ADB's Water Financing Program*. Manila. The above information is from a subproject under this technical assistance—Field-Based Research: Quantifying Water and Energy Links in Irrigation for Improved Resource Utilization implemented by the International Food Policy Institute.

area is served by groundwater. Bangladesh, India, Nepal, and Pakistan annually pump a total of about 210–250 cubic kilometers of groundwater using about 21 million–23 million pumps.[29] The total energy used in these countries for lifting groundwater is estimated to be 68.6 billion kilowatt-hours per year, costing $3.78 billion. Continued expansion of groundwater use, its impact on declining water tables, demand for energy, and the cost to the power sector are highly relevant for the Asian region where energy does not reflect the true cost of supply.

A recent study on energy use on large-scale irrigation projects in Punjab, Pakistan, provides an estimate of the interdependencies of energy, irrigation, and agricultural production for a key agricultural region.[30] It highlights that while total crop production in the province increased by 31% over the past 18 years (since 1998), direct energy intensity for agriculture has increased by 80%. Direct energy use is driven mainly by groundwater pumping (61% of energy used in agriculture) and about 20% of the province's energy (electricity and petroleum products) is used in the agriculture sector.

The study reinforces an Asia-wide message that energy use in conjunctive water management remains unmeasured and poorly monitored. Despite decades of recognition, conjunctive use of water for irrigation remains a neglected area, one that has not been reflected in policy and development interventions and an aspect overlooked in designing solutions.

What Should Be Done?

In sum, the results of this economic water security assessment of economies in Asia and the Pacific reveal some positives aspects and also points for improvement. Chief among the positives is that the overwhelming majority of change in economic water security scores has been positive. Despite these positive developments, it is worth pointing out

29 T. Shah et al. 2003. *Energy–Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability*. Second (Revised) Edition. Research Report 70. Colombo, Sri Lanka: International Water Management Institute.

30 A. Siddiqi and J. L. Wescoat, Jr. 2013. Energy Use in Large-Scale Irrigated Agriculture in the Punjab Province of Pakistan. *Water International* 38(5): 571–586.

that only one country received a score greater than 17 (out of 20) in overall economic water security: Singapore (18.3). In most countries, therefore, there are areas that require attention and investment. Moving forward, the growing water scarcity in Asia and the Pacific will require growing use of nexus approaches to water management—approaches that move beyond silos and sectors to optimize water use and security from a cross-cutting perspective. Three specific messages come forward:

(i) **Understand and build on bright spots.** Positive changes in economic water security in a country call for learning from and building on these examples in order to replicate successes in other countries.

(ii) **Address data gaps.** Data limitations, particularly in the Pacific island countries and on groundwater, constrain our ability to identify and respond to issues. There is, therefore, an opportunity to expand and strengthen data collection so as to enable a more robust assessment of economic water security. Topically, it would seem that the greatest focus might be placed on groundwater and energy-related indicators.

(iii) **Emphasize nexus approaches.** Overall, only a few countries performed well in both agriculture and energy, and few countries showed improvement in these two areas. Fostering sustainable development and achieving economic water security will require concurrent improvements in the agriculture and energy sectors.

As competing demands for water for cities and industry increase, it is no longer possible to neglect the requirement to start considering a more rigorous approach to these links, finding integrated solutions, and defining how much energy and water are used to produce per unit of crop. Energy availability, access, and cost volatility are a growing fraction of farm production costs.

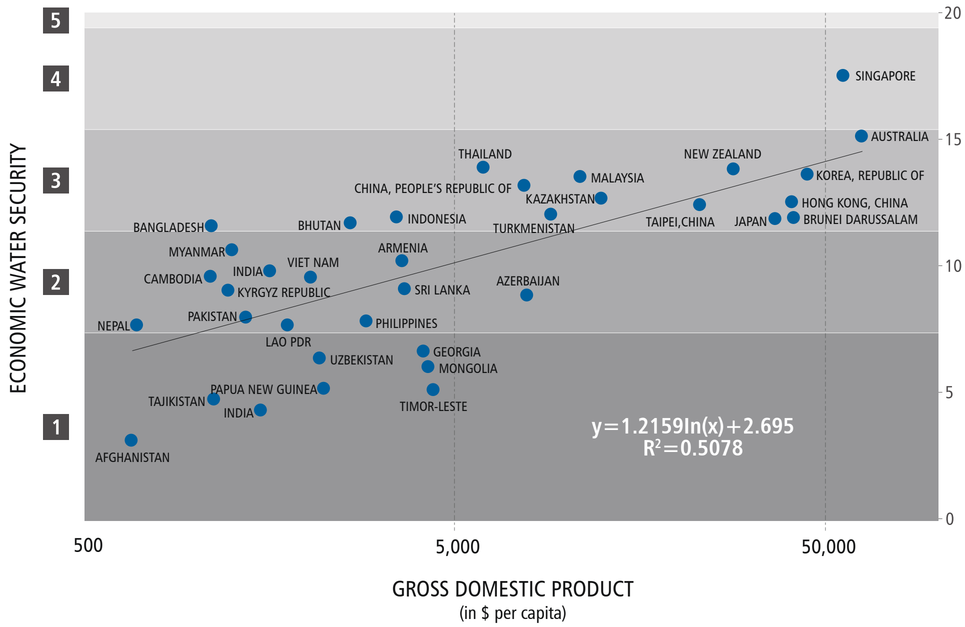
As such, it makes sense to adopt approaches that optimize water security in both agriculture and energy. In particular, integrated governance frameworks can help identify solutions that foster improvements in the two areas. At the operational level, consumption of energy and water productivity in irrigation are largely unquantified. Undertaking energy audits as a component of irrigation interventions would quantify use and solutions to optimize energy consumption.

Economic Water Security in Relation to Gross Domestic Product and Governance

Figures 19 and 20 show the linkages between KD2 and GDP and between KD2 and governance. Similar to KD1, the deviations from the regression line in the figure are more telling than the line itself. Bangladesh, the PRC, Indonesia, Myanmar, and Thailand are above the line, while Afghanistan and Timor-Leste have relatively low scores.

The link between KD2 and governance is not very strong. Bangladesh, Myanmar, and Turkmenistan are well above the line. Afghanistan, Tajikistan, and in particular Georgia are countries that could strengthen their performance.

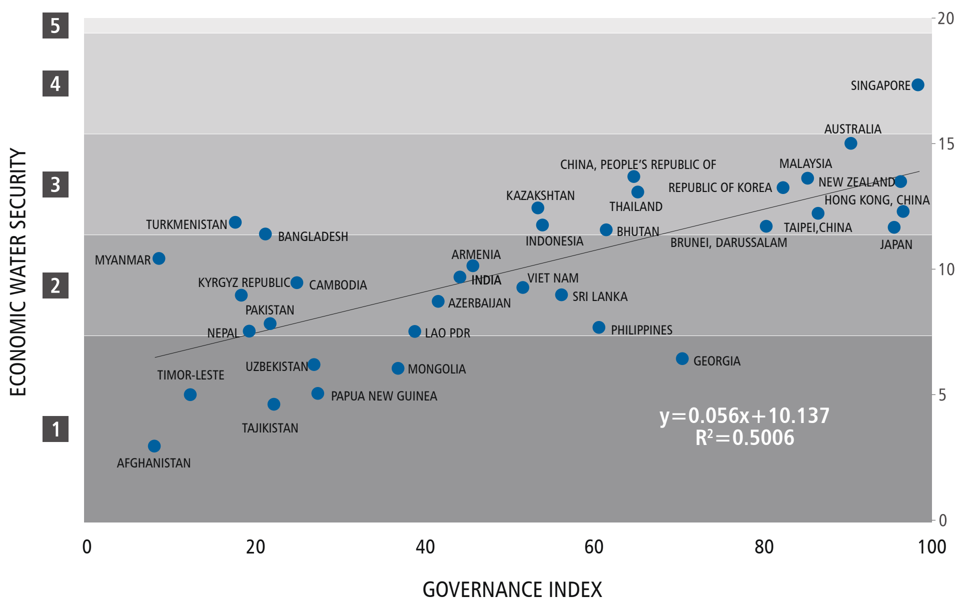
Figure 19: Economic Water Security and Gross Domestic Product per Capita



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

Figure 20: Economic Water Security and Effectiveness of Governance



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

KEY DIMENSION 3 – URBAN WATER SECURITY

ADB projects and financing on sewerage, urban flood management, and urban water supply (2011–2015)

$9.6 billion for **115** projects

Key Dimension 3 describes the progress countries are making to provide better urban water services and management in order to develop vibrant, livable cities and towns. KD3 is a composite of four subindicators:

1. Access to piped urban water supply (% population)
2. Economic damage due to floods and storms (% GDP)
3. Urban wastewater collected (% population)
4. River health (taken from KD4)

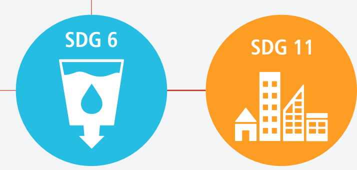
Linkages to Sustainable Development Goals

Target 6.1

By 2030, achieve universal and equitable access to safe and affordable drinking water for all

Target 6.2

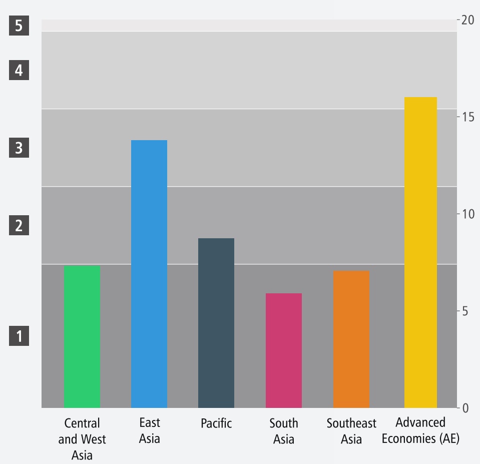
By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations



Goal 11

Make cities and human settlements inclusive, resilient and sustainable

URBAN WATER SECURITY
(POPULATION-WEIGHTED)



Top Performers
(from AWDO 2013 to AWDO 2016)

- **Bangladesh** (+2 points)
- **China, People's Republic of** (+2 points)
- **Korea, Republic of** (+3 points)
- **Turkmenistan** (+4 points)

Challenged Countries
(No progress from AWDO 2013)

- **Thailand**
- **Pakistan**
- **Philippines**
- **Tajikistan**

Key Dimension 3: Urban Water Security

Asia and the Pacific is one of the most rapidly urbanizing regions of the world, with urban populations growing at 1.5% annually. Cities in the region have become important drivers of the economy, enhancing productivity and becoming a major source of economic strength. Water plays an essential role in achieving sustainable, livable cities. However, the explosive growth rates of cities in Asia and the Pacific have not made it possible for a corresponding pace in the provision of infrastructure for water, wastewater, and stormwater management. The urban water security challenges facing cities in Asia and the Pacific will continue to grow in scale and complexity. For example, the International Institute for Applied Systems Analysis forecast that 88% of the Asian population will be living with water scarcity and/or greater complexity by 2050 compared with the present, and that this will be expected to influence economic growth (footnote 5). Consequently, water security must be a development priority, but it is also a major challenge because it intersects with a wide range of sectors, borders, and scales. Consequently, there is a strong need to focus on strong governance, education, innovation, policy development, and adaptability.

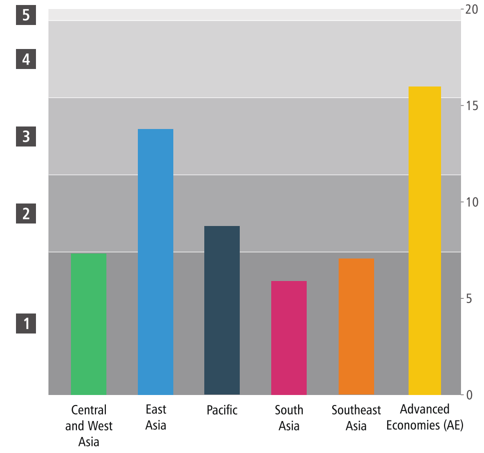
How Does Asia and the Pacific Measure Up?

The methodology to quantify urban water security is based on the Water Sensitive Cities Framework as briefly described in Appendix 4, which also gives the results at the country level.[31] The figures included in this section are the population-weighted averages of the country scores.

Overall: Key Dimension 3 Score

The overall urban water security score takes into consideration the fundamental requirements of a livable city—water supply, wastewater collection, flood management (drainage), and river health. It appears that some economies (Australia; Brunei Darussalam; Hong Kong, China; and New Zealand) are quite advanced in water management and in transitioning toward water-sensitive cities. However, urban centers in many countries in Asia and the Pacific still fall short of the vision of water underpinning vibrant, livable cities and towns. The East Asia region (PRC) is doing comparatively well, while South Asia is lagging behind (Figure 21). The bottom five countries on urban water security are Myanmar (3.4 out of 20), Pakistan (4.5), Viet Nam, Bangladesh, and the Philippines (all 5.0). Comparing AWDO 2016 with AWDO 2013, the overall security index ratings are relatively stable. East Asia shows

Figure 21: Economic Water Security by Region



Note: The units on the right axis are the scores (1–20 scale); the ones on the left axis are the stages (1–5 scale from hazardous to model).

Source: ADB.

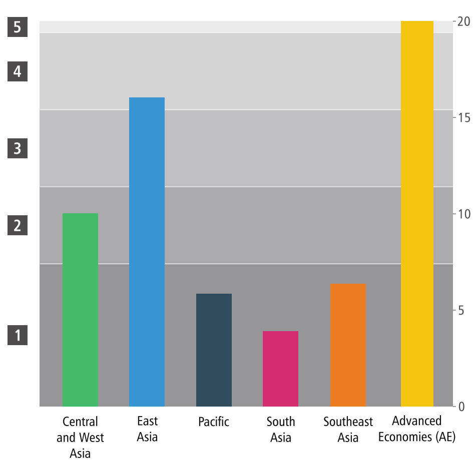
[31] R. Brown, N. Keath, and T. Wong. 2009. Urban Water Management in Cities: Historical, Current and Future Regimes. *Water Science and Technology* 59(5): 847–855.

remarkable positive progress (from 11.3 to 13.5 on a 20-point scale).

Piped Water Supply

The water supply in most countries shows a slight overall change (primarily increases of around 1%–3%), reflecting increased proportions of the population provided with such networks. Nearly half of the economies have piped water supply levels higher than 85% (including the PRC). Afghanistan, Bangladesh, Indonesia, and Mongolia (all about 30%) have low scores, while Myanmar scores less than 20% (see scores by region in Figure 22). With some cities now reaching the limits of sustainable exploitation of water resources, it is crucial to look at a diversity of approaches employed to ensure that there is sufficient supply of clean water for a fast-growing population. The region needs to investigate alternative sources of drinking water and invest in a diversity of centralized and decentralized water infrastructure that promotes a fit-for-purpose approach to matching water usage to water quality standards.

Figure 22: Piped Water Supply

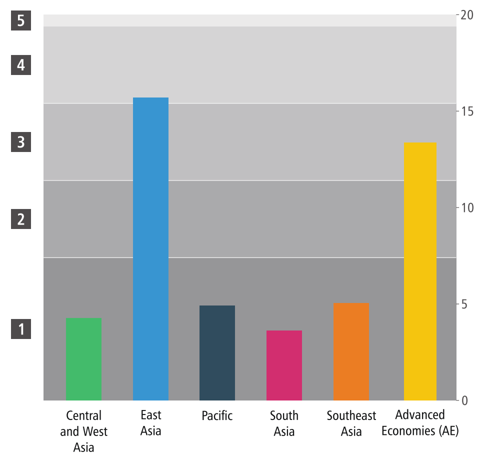


Source: ADB.

Wastewater Treatment

While most cities in Asia and the Pacific have extensive infrastructure for urban water treatment and supply, piped systems often stop short of individual households. In most regions, only a small portion of wastewater is collected through an improved sanitation method (Figure 23). For example, in 16 countries, less than 50% of the urban population have access to improved sanitation. In many areas, the majority of wastewater is discharged to the environment having received little to no treatment. East Asia (PRC) is performing well (82%), but the treatment levels are low particularly in Southeast Asia: Viet Nam (10%), the Philippines (4%), and Indonesia (1%).

Figure 23: Wastewater Treatment

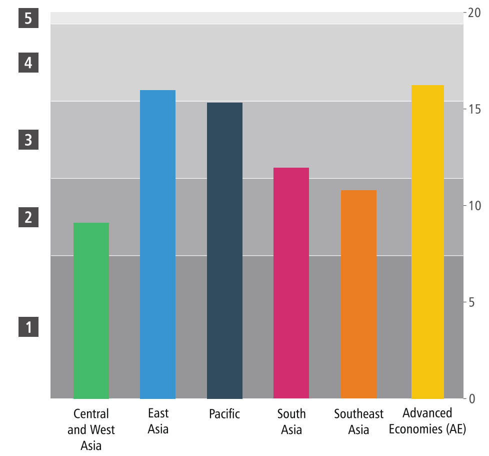


Source: ADB.

Drainage

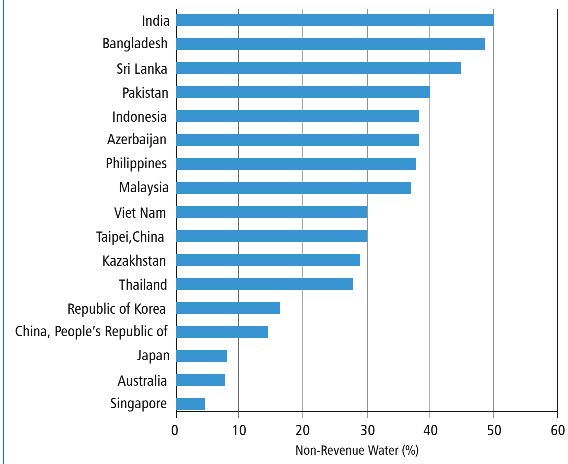
With the rapid urbanization that is taking place in Asia and the Pacific, people—and increasingly valuable economic assets—are being located closer to hazard-prone areas such as riverbanks and floodplains. Many countries in Asia and the Pacific lack adequate flood management measures (for drainage, see Figure 24), which are reflected in the high economic damages due to flood and storm events. The urban water security index needs to be interpreted with caution on the assumption that it is a reflection of conditions in the larger cities and towns in the country and not the smaller urban centers. Moreover, the scores are heavily influenced by events in the particular data period 2000–2015

Figure 24: Drainage



Source: ADB.

Figure 25: Nonrevenue Water in Selected Economies in Asia and the Pacific (%)



Source: Global Water Intelligence. 2014. *Global Water Market 2015: Meeting the World's Water and Wastewater Needs until 2018*. Oxford, UK.

(explaining, among others, the high scores of Samoa and Tonga). Countries with relatively high scores are Cambodia (37%), Thailand (23%), Pakistan (22%), and Myanmar (18%).

Urban Water Issues

Two important issues in urban water management are nonrevenue water and the residential water consumption. Both issues influence the performance of the urban water supply and (indirectly) the sanitation system.

Nonrevenue Water

Nonrevenue water describes water that is not metered or billed. Most is due to leakage, theft, or failed meters, but some may be due to firefighting or other "approved" unmetered uses. Nonrevenue water is a serious impediment to the effective expansion of systems and improvement of delivery as it seriously affects the financial viability of water utilities through lost revenue and increased operational costs. However, the economic cost of reducing nonrevenue water needs to be considered against new supply options. In addition, leakage results in higher chances of drinking water contamination and outbreaks of waterborne diseases, reducing the water service quality and the consumers' willingness to pay. The share of nonrevenue water is high in many places in Asia, ranging from 5% to 50%. This is illustrated in Figure 25 for selected economies.

Water Consumption

Water consumption is highly variable across many Asian cities. It is likely that this is due to issues around current definitions of "urban" populations, including slum areas. Though water consumption is not currently included in the calculation of the urban water security index, water consumption per capita appears high in many cities, ranging from more than 600 liters per capita per day (l/cap.d) in Georgia and 330 l/cap.d in Tajikistan to less than 100 l/cap.d in countries such as Bangladesh, Bhutan, the PRC, and India.[32]

[32] International Benchmarking Network for Water and Sanitation Utilities (IBNET). 2015. Database for Water and Sanitation Utilities. Other data sources provide water consumption rates that are considerably different from the IBNET data, in both directions (India: 205 l/cap.d instead of 84 l/cap.d; Indonesia: 40 l/cap.d instead of 117 l/cap.d). Accessed 20 July 2016 from http://database.ib-net.org/Default.aspx.

What Should Be Done?

Key recommendations in terms of urban water security are the following:

(i) Significant investment and leadership is required for many Asian and Pacific cities to continue on the path toward urban water security and water-sensitive cities.
(ii) For cities to pursue increased sustainability and from the use of waterways as a source of water to management and stewardship of waterways for future generations.
(iii) Future assessments of the urban water security index need to develop detail around forward-looking risks and opportunities. A range of other factors contributes to future water security risks such as management of economic or financial constraints, governance (considering factors well beyond data quality), technological and social factors including political support, public–private partnerships, state of publicly accessible information, and utility ownership and leadership. These have the potential to be incorporated in future AWDO studies.
(iv) The need to progress toward water-sensitive cities is made even more important with climate change. In the face of growing concerns about climate change, energy, and food security, the region's cities must be managed sustainably in the coming decades to ensure that the potential economic and social development arising from urbanization is optimized to create vibrant, livable areas that reduce poverty, protect the environment, and improve the quality of life of all urban dwellers.

Water Supply Security

Improved water supply security is necessary, particularly for the 19 economies that scored either 1 or 2 on the water supply index in the AWDO 2016 analysis (Appendix 4). Improvements could be made by investment in suitable centralized and decentralized water infrastructure to provide cost-effective access to reliable, diversified, raw water sources.

Manage Nonrevenue Water

Incentives should be put in place to encourage utilities to economically reduce nonrevenue water through increased metering and investigations.

Understand Energy Implications

Similarly, it is recommended to further assess the energy risk of water supply options, including the energy trajectory of systems. Such an analysis is likely to require baseline assessment and simulations of future requirements.

Wastewater Security

Improved wastewater security is necessary, particularly for the 31 economies that scored either 1 or 2 on the wastewater security index in the AWDO 2016 analysis (Appendix 4). This may include either

- improving sanitation, both in the percentage of wastewater collected and the proportion of collected wastewater that is treated;
- increasing the coverage of sewerage systems to collect more sewage and wastewater and direct the flows to wastewater treatment facilities;
- increasing investment in wastewater treatment technologies to reduce organic, nutrient, and microbiological loads to appropriate levels for discharge; and
- increasing investment in wastewater recycling to supplement all types of water demand, where appropriate, and also biosolids management to realize the value of wastewater treatment by-products and mitigate associated risks.

Drainage and Flood Security

Improved flood and drainage security is necessary particularly for the 10 economies that scored either 1 or 2 on the drainage index (Appendix 4). Suggestions include

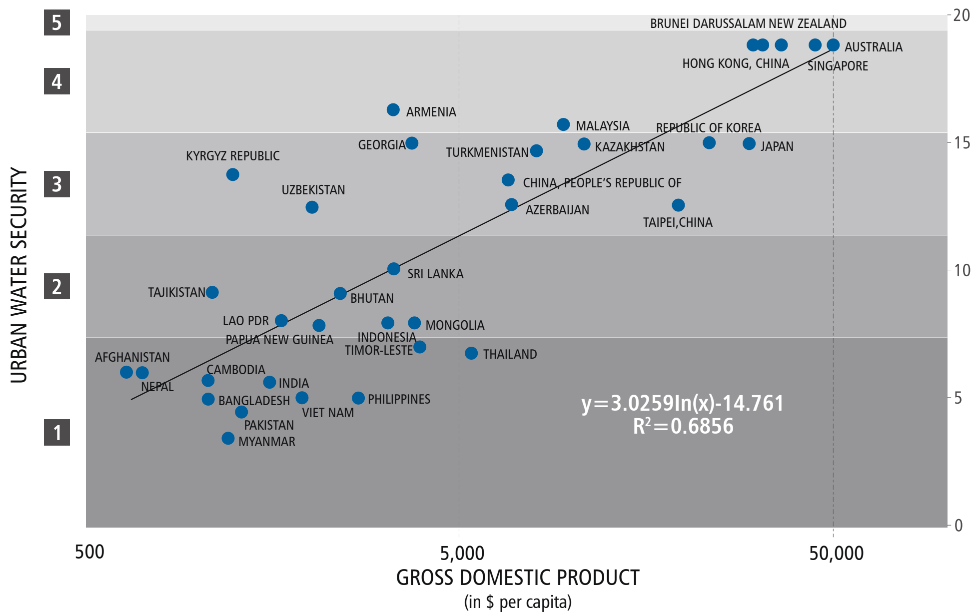
- improved understanding of flood risks in and about urban areas to inform urban land use planning and investment;
- increased investment in catchment management to reduce the deterioration of watersheds and improve raw water quality for drinking water treatment; and
- improved flood mitigation infrastructure and operation.

Urban Water Security in Relation to Gross Domestic Product and Governance

Figure 26 shows that there is indeed a relationship between KD3 and GDP per capita, one that may be expected to strengthen as urban economies become more dominant in the region. Striking in the figure is the relatively good performance of the former Soviet republics, compared with the relatively low performance of countries such as Myanmar, the Philippines, Thailand, and Viet Nam.

Figure 27 shows that there is hardly any relationship between KD3 and the effectiveness of governance.

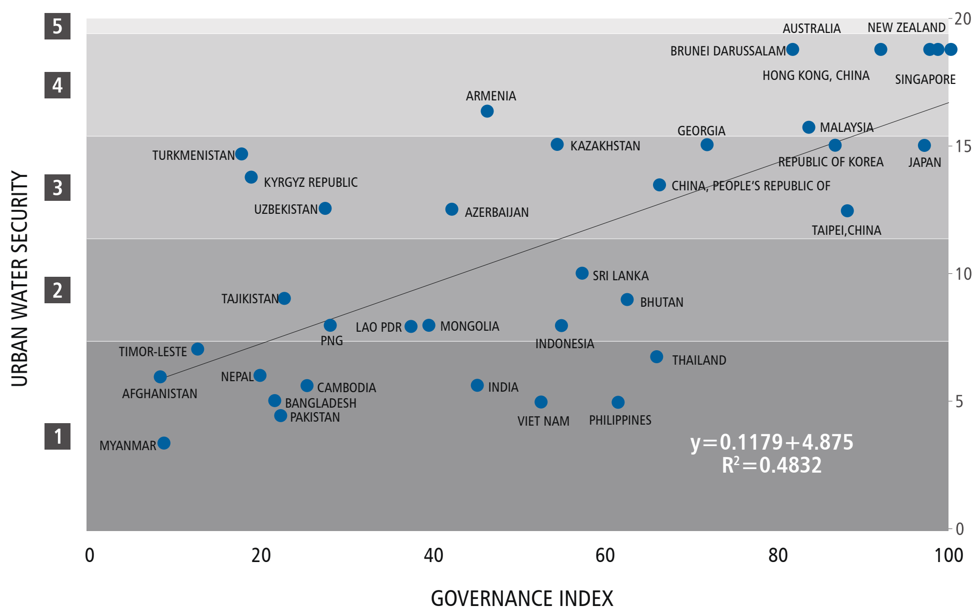
Figure 26: Urban Water Security and Gross Domestic Product per Capita



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

Figure 27: Urban Water Security and Effectiveness of Governance



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

KEY DIMENSION 4 – ENVIROMENTAL WATER SECURITY

ADB projects and financing on water resources management *(including watershed, wetland rehabilitation and water quality)* (2011–2015)

$1.6 billion for **21** projects

Key Dimension 4 describes how well a country is able to develop and manage its river basins with the aim to sustain the ecosystem services the rivers provide. KD4 is a composite of three subindicators:

1. River health
2. Hydrological alteration
3. Governance of the environment

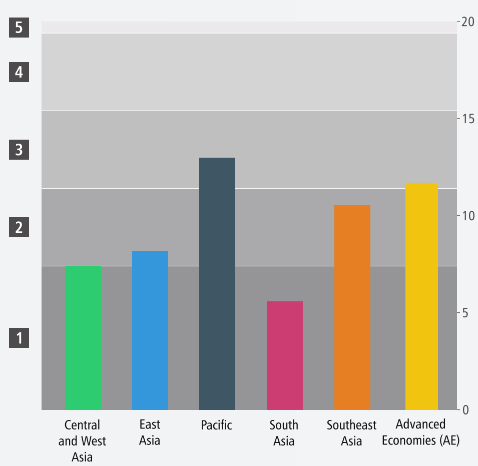
Linkages to Sustainable Development Goals

SDG 6

Target 6.3
By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

Target 6.6
By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

ENVIRONMENTAL WATER SECURITY
(POPULATION-WEIGHTED)



Top Performers
(from AWDO 2013 to AWDO 2016)

- **Armenia** (+5 points)
- **Georgia** (+5 points)
- **Malaysia** (+7 points)
- **Nepal** (+6 points)

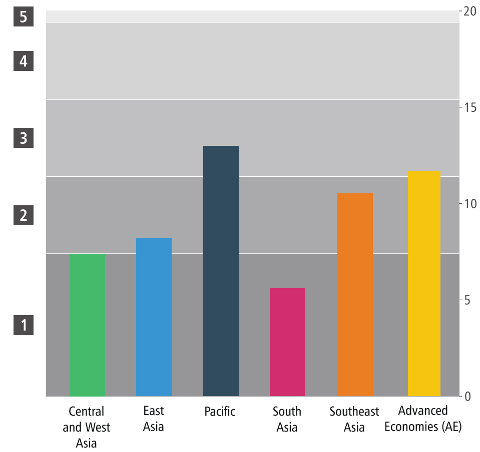
Challenged Countries
(No progress from AWDO 2013)

- **Afghanistan**
- **Kyrgyz Republic**
- **Mongolia**
- **Turkmenistan**

Key Dimension 4: Environmental Water Security

Asia and the Pacific covers one of the fastest-developing areas of the world. Parallel to this unprecedented development, pressures on aquatic systems in the region has been increasing, with the ecological health of several large rivers and many parts of the region considered to be at risk. Consequently, the region faces considerable challenges to maintain economic growth while mitigating and reducing impacts on the aquatic systems upon which much of this growth relies. The index of environmental water security (KD4) quantifies the pressures on the health of flowing surface waters across the region. It includes (i) the river health index (RHI), which is the inverse of a metric of threat to water security, that incorporates the potential impacts of many variables that tend to have detrimental impacts on river health; (ii) flow alteration, which describes the extent to which rivers are changed due to dams, weirs, and direct extractions; and (iii) environmental governance, which expresses the efforts of governments to protect the environment in their country.

Figure 28: Environmental Water Security



Note: The units on the right axis are the scores (1–20 scale); the ones on the left axis are the stages (1–5 scale from hazardous to model).

Source: ADB.

How Does Asia and the Pacific Measure Up?

The scoring approach applied for environmental water security is described in Appendix 5, which also includes the scores of the individual economies. The figures included in this section are the population-weighted averages of the country scores.

Overall: Key Dimension 4 Score

The results for environmental water security show that some countries score fairly high while others score quite poorly (see results by region in Figure 28). Countries that show relatively high scores for environmental water security span almost the complete range of economic development. Countries very early on their path toward development, such as Papua New Guinea, have high scores, primarily as a result of higher values for the RHI and limited alteration of river flows. Other countries, such as Australia and Singapore, scored quite high for the entire index because of a strong governance regime that provides the capacity to mitigate existing pressures on the environment.

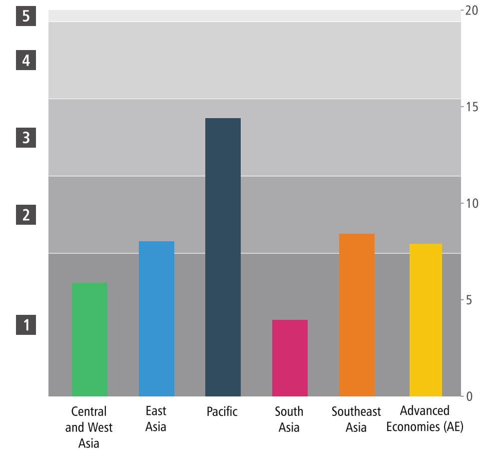
Comparisons between the river health index scores from AWDO 2013 and AWDO 2016 show relatively little change across the period. Those changes that were present tend to be small declines, suggesting ongoing economic development and intensification of agriculture, as generally increasing water demand is expected to result in some declines in river health. There was evidence of substantial declines in the RHI across specific river basins; however, these were not necessarily spatially uniform both within and across basins. It is noted that the KD4 approach does not allow determination of scores for small island countries that do not have flowing surface water. For those countries, expert opinion is used to determine the scores.

River Health

The RHI is the only subindicator in AWDO that is spatially explicit and determined using a model. This allows for locally differentiated results that are combined into country-level results comparable with the other subindicators (Figure 29). Figure 30 shows the results for the years 2000 (the situation described in AWDO 2013) and 2010 (AWDO 2016). There are several patterns that emerge from the mapping of the RHI, such as the concentration of very low river health index values (indicated by the black pixels), in the lower Yangtze River basin in the PRC and the Ganges Basin of India, Nepal, and Bangladesh over the period 2000–2010. Additionally, Northern Viet Nam and the Southern Mekong Delta show widespread reductions in the RHI score.

Despite the black pixels, aggregating the results at the country level shows that the overall score for the RHI at the country level only changes in a few countries.

Figure 29: River Health Index

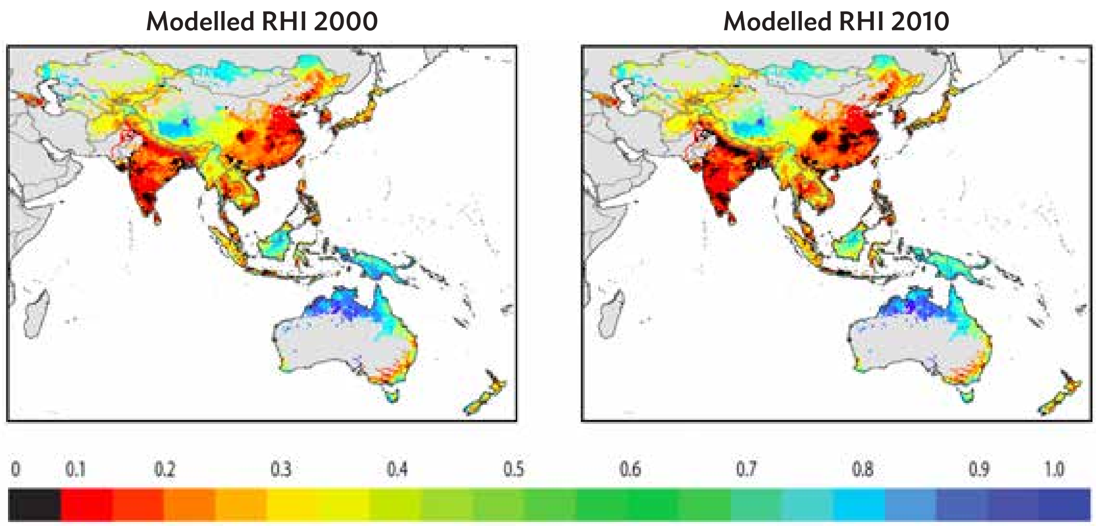


Source: ADB.

Flow Regulation

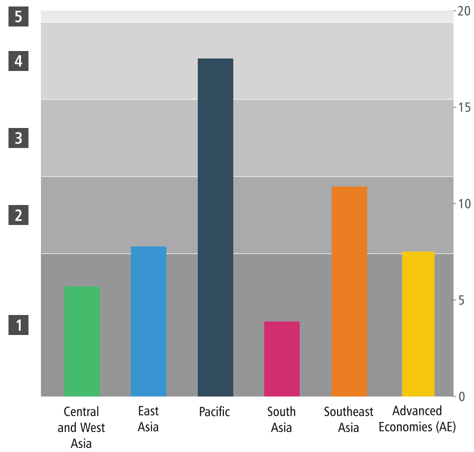
The extent of flow alteration varies a great deal across the region with most countries having some areas with moderate to high levels of flow alteration. Regions with comparatively high levels of flow alteration are spread across Asia and the Pacific (Figure 31). However, because of the relatively

Figure 30: Modeled River Health Index at the Grid Cell Level across the Region



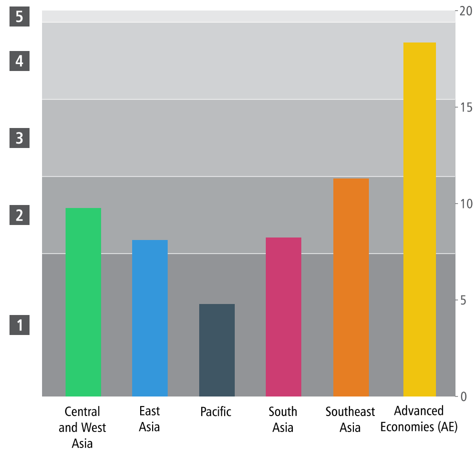
RHI = river health index.
Source: ADB.

Figure 31: Extent of Flow Alteration



Source: ADB.

Figure 32: Environmental Governance



Source: ADB.

localized distributions of flow alterations, even countries with relatively high levels of alteration in some regions, such as Indonesia and Kazakhstan, emerge with comparatively modest scores overall.

Environmental Governance

The results for the governance subindicator show a general trend in line with economic development, wherein more developed countries such as Australia, Japan, and New Zealand tend to have higher scores across all subindicators for governance. In contrast to this general pattern, low- and middle-income countries such as Nepal and Thailand also demonstrate relatively high governance scores. The most obvious pattern that coincides with development among the components is that only relatively developed countries have high scores for wastewater treatment. This provides a clear avenue to improve the governance indicator and produce a positive impact on environmental water security for those countries struggling with this subindicator. There has been considerable progress across the region in regulation of pesticides and even protection of remaining ecosystems. However, the critical step of increasing levels of wastewater treatment remains. The loss of forest cover since 2000 is another component that reflects the stage of economic development. Countries farther down the path of development, such as Australia and New Zealand, and those that are beginning their development, such as Afghanistan and Papua New Guinea, tend to show low levels of forest loss, while those in the midst of rapid economic development, such as Indonesia, Malaysia, and the Philippines, show increasing forest loss.

Issue: Environment versus Economic Growth

An analysis of economic and environmental water security (KD2 and KD4) has identified complex relationships between the two key dimensions with some countries showing synergistic patterns among the subindicators for each dimension and others showing differences among them. Countries with high scores for environmental governance tend to also have higher scores for the energy and, to some extent, agricultural subindicators for the economy. Conversely, countries with higher scores for the RHI tend to have lower scores for agriculture and industry. The case study highlighted opportunities for some countries to achieve a degree of sustainable development and others where restoration and increasing mitigation may be appropriate.

What Should Be Done?

The following actions are recommended:

(i) **Monitoring river health.** An important step forward would be to encourage river health monitoring at the country level—and certainly for infrastructure projects.

(ii) **Developing sustainable infrastructure.** Country and institutional capacities for the development of such infrastructure to improve water security need to be strengthened.

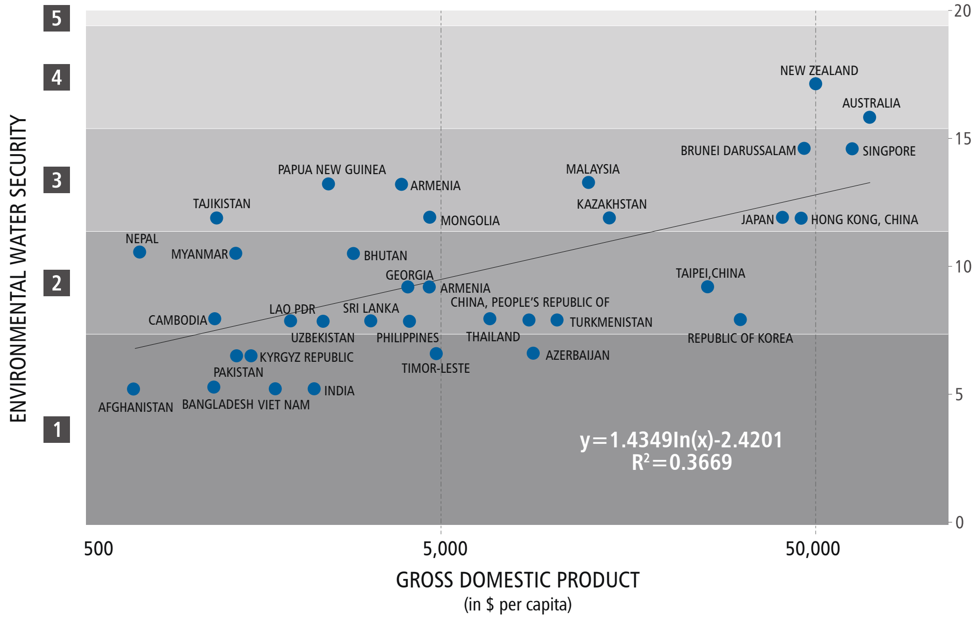
(iii) **Guiding principles of river health.** Guiding principles of river health maintenance for projects based on existing ecological knowledge and generally understood ecological principles should be developed.

It is important that countries work toward identifying synergies between the environmental and human aspects of water security and mitigate environmental impacts where these relationships may not be so clear.

Environmental Water Security in Relation to Gross Domestic Product and Governance

Both Figures 33 and 34 show a huge spread along the general trend from left-bottom to right-top. Somewhat striking are the low scores of the Republic of Korea, a relatively rich and well-governed country. Indonesia and Myanmar are examples on the better side of the trend line.

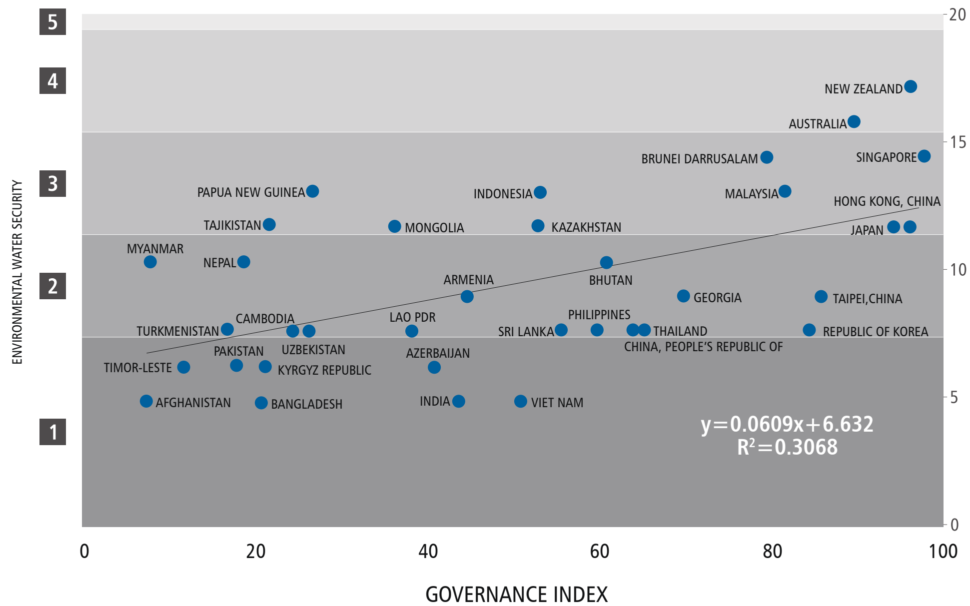
Figure 33: Environmental Water Security and Gross Domestic Product per Capita



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

Figure 34: Key Dimension 4 and Effectiveness of Governance



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

KEY DIMENSION 5 – RESILIENCE TO WATER-RELATED DISASTERS

ADB projects and financing on flood management *(including both structural and nonstructural)* (2011–2015)

$1.3 billion for **18** projects

Key Dimension 5 describes the capacity of a country to cope with and recover from the impacts of water-related disasters. KD5 is a composite of three subindicators:

1. Floods and windstorms
2. Drought
3. Storm surges and coastal floods

Linkages to Sustainable Development Goals

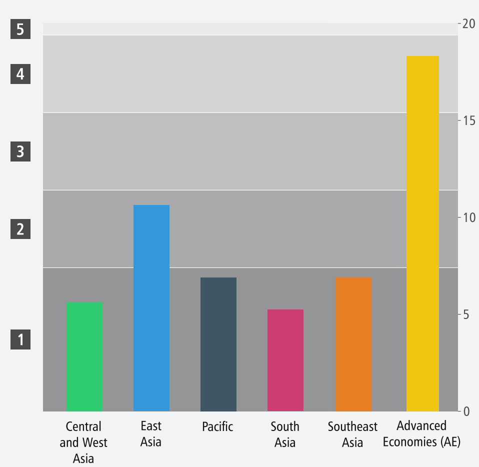
SDG 6

Target 6.4
By 2030, substantially increase water-use efficiency across sectors. Substantially reduce the number of people suffering from water scarcity.

SDG 11

Target 11.5
By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.

RESILIENCE TO WATER-RELATED DISASTERS
(POPULATION-WEIGHTED)



Top Performers
(from AWDO 2013 to AWDO 2016)

- **Bhutan** (+3 points)
- **China, Republic of** (+7 points)
- **Korea, Republic of** (+8 points)
- **Taipei,China** (+3 points)

Challenged Countries
(No progress from AWDO 2013)

- **Kazakhstan**
- **Kyrgyz Republic**
- **Lao, PDR**
- **Tajikistan**

Key Dimension 5: Resilience to Water-Related Disasters

In a recent report, the Centre for Research on the Epidemiology of Disasters (CRED) and the United Nations Office for Disaster Risk Reduction (UNISDR) stated that from 1995 to 2015, 6,457 weather-related disasters were recorded, which claimed a total of 606,000 lives and affected more than 4 billion people.[33] On average, 205 million people were affected by such disasters each year during that period. Weather-related disasters are becoming increasingly frequent, due to a sustained rise in the number of floods and storms. Flooding alone accounts for 47% of all weather-related disasters in 1995–2015, affecting 2.3 billion people, the majority (95%) in Asia. While less frequent than flooding, storms were the deadliest type of weather-related disaster, with more than 242,000 fatalities worldwide since 1995. This is 40% of the global total for all weather-related disasters. The vast majority of these deaths (89%) were in lower-income countries, even though they experienced just 26% of all storms.

Asia bore the brunt of weather-related disasters, with more frequent events and greater numbers of people killed and affected than any other continent. The report mentions that this is mainly due to Asia's large and varied landmass, including multiple river basins, floodplains, and other zones at high risk from natural hazards, plus high population densities in disaster-prone regions. In total, 2,495 weather-related disasters struck Asia between 1995 and 2015, affecting 3.7 billion people and killing a further 332,000 individuals.

These data are largely based on the CRED Emergency Events Database (EM-DAT), which in particular contains information on the human cost of weather-related disasters. AWDO has a slightly different focus, quantifying the capacity of a country to cope with and recover from the impacts of such disasters. Thus, KD5 describes the resilience to water-related disasters. The event itself, the hazard, is not included in the dimension.

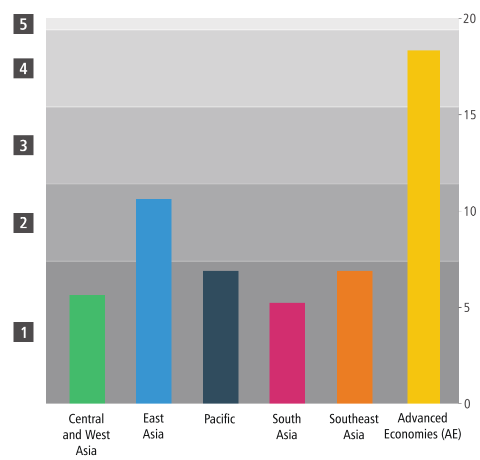
How Does Asia and the Pacific Measure Up?

The scoring approach applied for resilience to water-related disasters is described in Appendix 6, which also includes the scores of the individual economies. The figures included in this section are the population-weighted averages of the country scores.

Overall: Key Dimension 5 Score

The regional picture on resilience to water-related disasters confirms the expected picture of high resilience among the advanced economies and weak resilience in the other regions (Figure 35). South Asia has the lowest score as it includes one of the most vulnerable countries (Bangladesh with

Figure 35: Resilience to Water-Related Disasters



Note: The units on the right axis are the scores (1–20 scale); the ones on the left axis are the stages (1–5 scale from hazardous to model).

Source: ADB.

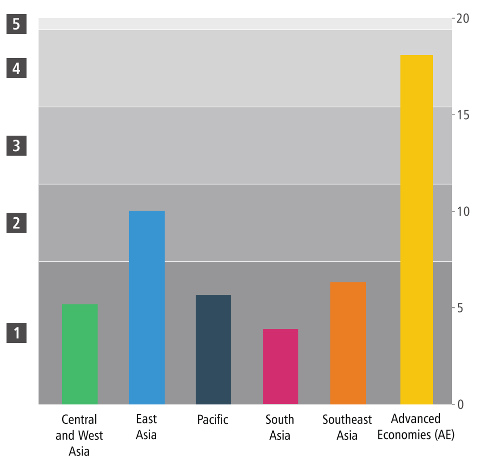
[33] CRED and the UNISDR. 2015. *The Human Cost of Weather Related Disasters 1995–2015*. Geneva, Switzerland.

a score of 4.2 out of 20), and India also has a low score (5.3). Several countries have made strong improvements since AWDO 2013, for example the PRC (up 5 points on the 20-point scale) and the Republic of Korea (up 6 points). The small island states also show good increases, but these results should be viewed cautiously because of the uncertainties in the underlying data.

Flood and Wind Storm Resilience

The resilience against floods and wind storms shows a similar picture to the overall resilience score. The advanced economies have high resilience (Figure 36), as do Armenia, Georgia, and Kazakhstan, which explain the high regional resilience of Central and West Asia. The bottom countries include Bangladesh, the Lao People's Democratic Republic, and Pakistan.

Figure 36: Flood and Wind Storm Resilience

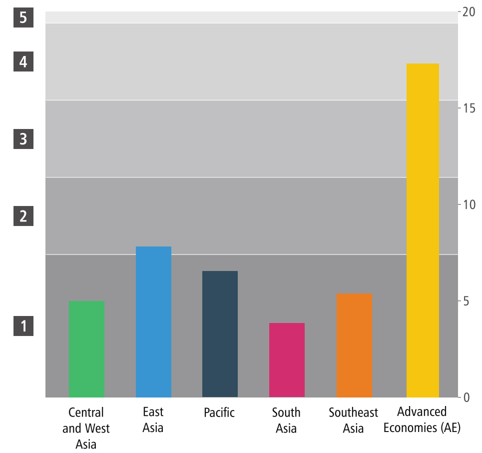


Source: ADB.

Drought Resilience

The drought resilience subindicator is very much determined by the importance of agricultural production in a country and the total reservoir capacity per area. Besides these differences, the scoring for drought resilience follows the same pattern as for floods and the general picture (scores of regions and countries) is the same (Figure 37).

Figure 37: Drought Resilience

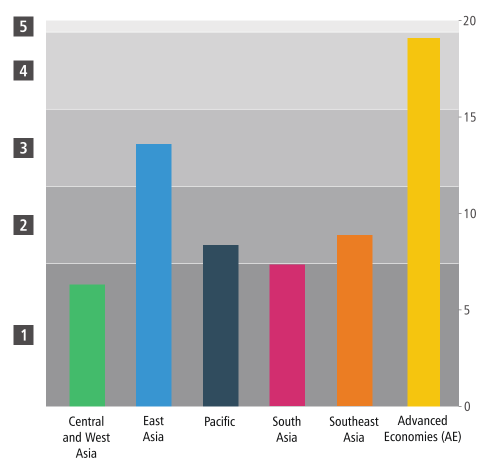


Source: ADB.

Storm Surge and Coastal Flood Resilience

The vulnerability of a country to storm surges is mainly determined by the number of people living in lowland areas and the infrastructure that can be impacted. This explains the relative low scores of the PRC (see results by region in Figure 38).

Figure 38: Storm Surge and Coastal Flood Resilience



Source: ADB.

Box 4: Sendai Framework for Disaster Risk Reduction

On 18 March 2015, after 3 years of consultations, the Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted. The Sendai Framework is the successor instrument to the Hyogo Framework for Action 2000–2015, building on the experiences with the Hyogo Framework and introducing a number of innovations. The most important features of the Sendai Framework are

- a significant shift from *disaster management to disaster risk management*;
- seven global targets for 2020 and 2030;
- the reduction of disaster risk as an expected outcome;
- a goal focused on preventing new risk, reducing existing risk, and strengthening resilience; and
- a set of guiding principles, including primary responsibility of states to prevent and reduce disaster risk, all-of-society and all-of-state institutions engagement, and "build back better."

In addition, the scope of disaster risk reduction has been broadened significantly to focus on both natural and human-made hazards and related environmental, technological, and biological hazards and risks. Health resilience is strongly promoted throughout.

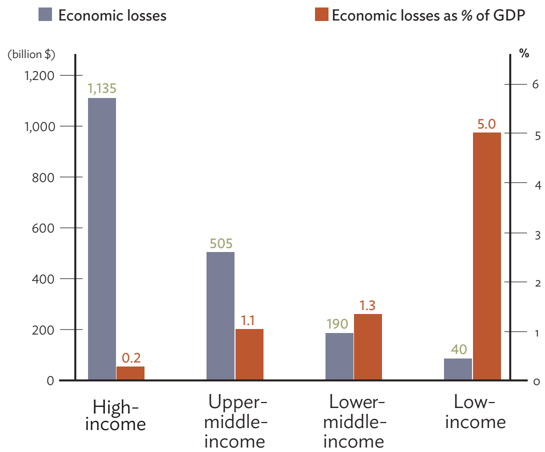
Source: United Nations Office for Disaster Risk Reduction (UNISDR). 2015. *Sendai Framework for Disaster Risk Reduction 2015–2030*. Accessed on 20 July 2016 from http://www.unisdr.org/we/coordinate/sendai-framework

Landlocked countries are excluded from the analysis. Many small island states are extremely vulnerable to storm surges and coastal floods. Because of the lack of data, AWDO uses expert opinion to determine the scores for these small island states.

What Is at Stake?

Floods and droughts have major economic and social impacts on society. The GWP/OECD Task Force on Water Security and Sustainable Growth demonstrated that water resources can play a defining role in economic development (footnote 6). Water insecurity acts as a drag on global economic growth. Monetizing all the impacts of water insecurity is difficult, most notably the risks to the natural environment and the ecoservices they provide. Excluding these environmental risks, the task force report mentions a total in the order of $500 billion annually, of which $120 billion is due to flood damage to urban properties alone (KD3 and KD5), $90 billion due to drought in the irrigation sector (KD2 and KD5), and up to $260 billion due to inadequate water supply and sanitation. CRED and UNISDR report that during 1995–2015, 2.3 billion people were affected by floods (56%), 1.1 billion by droughts (26%), and 660 million by storms (16%), with the remainder (2%) affected by extreme temperatures, landslides, and wildfires (footnote 32). Their estimate of the global economic damage due to weather-related disasters confirms the estimates of the GWP/OECD Task Force. Although these losses in total are less than 0.5% of global GDP, the impacts can be very significant for individual countries or for certain affected groups, as illustrated in Figure 39. Although the chart is based on global data, it can be assumed that the situation in Asia and the Pacific is similar; the economic losses in the non-high-income countries are substantial, up to 5% of their GDP.

Figure 39: Economic Losses from Weather-Related Disasters (1995–2015)



Note: The left axis shows economic losses in absolute values and the right axis as a percentage of gross domestic product.

Source: CRED and the UNISDR. 2015. The Human Cost of Weather Related Disasters 1995–2015. Geneva, Switzerland.

What Should Be Done?

The key to reducing losses due to climate-related events is to follow the Sendai Framework for Disaster Risk Reduction 2015–2030, in particular the four priorities for action:[34]

(i) Understanding disaster risk and striving for a more integrated approach to disaster risk management
(ii) Strengthening disaster risk governance to manage disaster risk
(iii) Investing in disaster risk reduction for increased resilience
(iv) Enhancing disaster preparedness for effective response and to “build back better” in recovery, rehabilitation, and reconstruction

Resilience to Water-Related Disasters in Relation to Gross Domestic Product and Governance

Similar to the previous key dimension, KD5 also shows a wide variance in its relationship with GDP (Figure 40) and governance (Figure 41). The relationship with governance appears significant. Striking are the results of the former Soviet republics Armenia, Georgia, and Kazakhstan and the relatively low scores of Singapore and Hong Kong, China. Figure 41 also seems to suggest that a minimum level of governance is needed before KD5 can start to increase. Kazakhstan and Timor-Leste show positive deviations from the trend line.

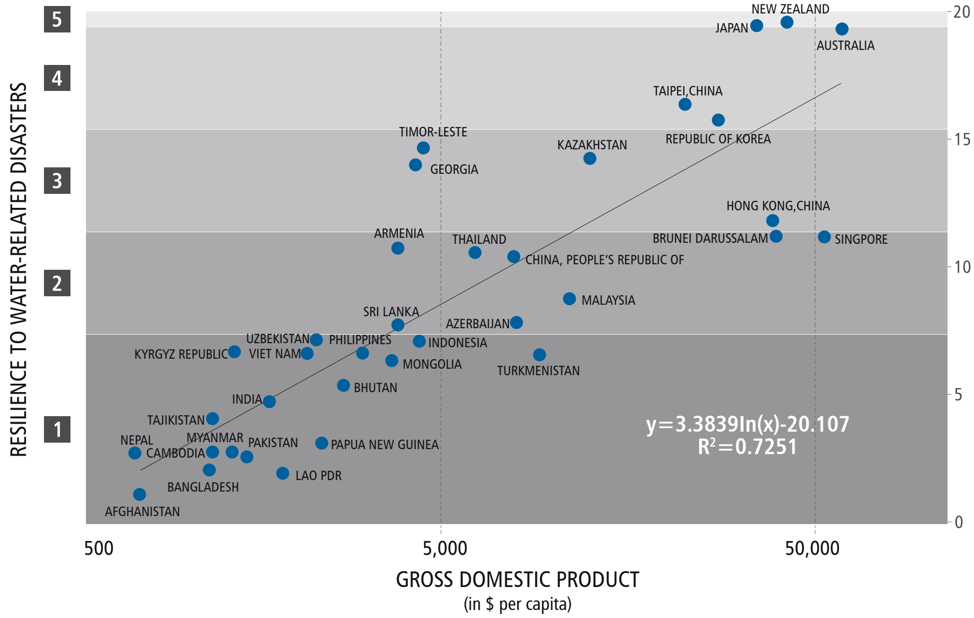
Overlap between Key Dimensions and Indicators

The five key dimensions each represent one of the dimensions of water security. Although the key dimensions seem to be independent, the subindicators used to quantify them are not completely independent. In particular, the four subindicators to describe the case for urban water security (KD3) are also included in other key dimensions—water supply and sanitation (in KD1), floods and storms (in KD5), and river health (in KD4). In a way, this can be regarded as double counting of these subindicators in the overall water security index.

To investigate the extent to which this “double counting” influences the scores, a sensitivity analysis was carried out on the effect of omitting the KD3 scores in the calculation of the National Water Security (NWS) Index on the absolute and relative position of countries. Importantly, AWDO is a communication tool. It communicates the

[34] UNISDR. 2015. *Sendai Framework for Disaster Risk Reduction 2015–2030*. Geneva, Switzerland.

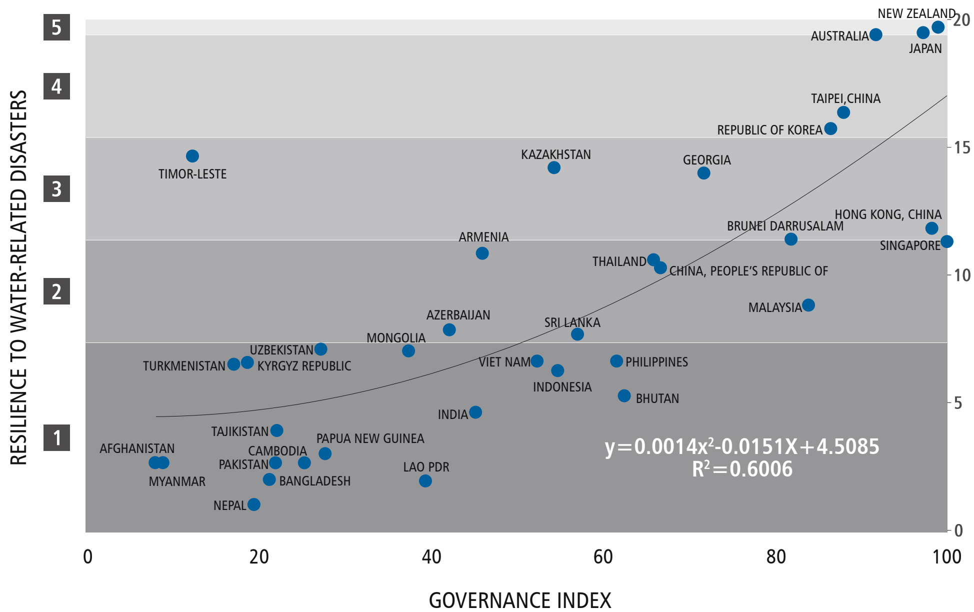
Figure 40: Resilience to Water-Related Disasters and Gross Domestic Product per Capita



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

Figure 41: Resilience to Water-Related Disasters and Effectiveness of Governance



LAO PDR = Lao People's Democratic Republic, R^2 = coefficient of determination.

Sources: ADB; World Bank. World Development Indicators, Government Effectiveness, percentile rank data. Accessed 5 January 2016 from http://wdi.worldbank.org/tables

level of water security (on a scale of 1–100), the relative position of a country compared to other countries, and the progress countries are making. It turns out that the level of water security (on a scale of 1–100) is decreasing on average (by 0.2 points) with a standard deviation of 2.7 points. Countries with a low KD3 score higher (Myanmar, with a maximum increase of 6 points), others score lower (Turkmenistan, with an extreme decrease of 4.8 points). The same applies more or less to the scores of all countries. The same countries as abovementioned are affected and gain positions in the ranking of 48 countries (Myanmar 7 positions higher), or lose positions (Turkmenistan 6 positions lower). In general, the positions of countries stays about the same, with slight movement of 1 or 2 positions up or down. The overall conclusion of this analysis is that the "double counting" has no major impacts on the message that AWDO is conveying.

Elementary students in Harbin, PRC, learn about protecting the health of the Songhua River through art.

Part V.
Achieving Water Security

How to Increase Water Security

Increasing Water Security by Key Dimension

The Sustainable Development Goals (SDGs) as adopted in 2015 by the United Nations (UN) General Assembly set the stage for many development activities in the water sector. Asian Water Development Outlook (AWDO) is strongly related to SDG6, as explained in part II. However, AWDO also links to other SDGs, such as those on food and energy security and livable cities. By increasing water security, we contribute to achieving the SDGs and vice versa. How we can increase water security will depend on country-specific conditions. The lessons learned from previous development efforts in the water sector may provide valuable recommendations on how we can increase water security.

Water security has of late received quite some attention in scientific research. The scientific literature shows a very diverse framing of the concept, from rather narrow and discipline- or sector-oriented to broad and integrative. Two leading approaches have emerged. These are defined by the Global Water Partnership (GWP) as a risk-based approach and a more developmental approach (footnote 12) or by Zeitoun et al. as a reductionist approach and integrative approach.[35] The risk-based or reductionist approach seeks to achieve water security by reducing the uncertainty (risks), while the more developmental or integrative approach seeks to achieve water security in a more integrative way. Both approaches have their merits. AWDO clearly follows the more integrative approach with its specific attention to households and the environment (Key Dimensions 1 and 4 [KD1 and KD4]). KD2, KD3, and KD5 also have strong risk components.

How to Increase Water Security

Over the past 25 years, the concept of integrated water resources management (IWRM) has been promoted as the way to increase water security. The three pillars of IWRM—(i) enabling environment (policies and legislation), (ii) institutional framework, and (iii) management instruments (assessment, information, and allocation instruments)—are strong preconditions for increasing water security.[36] The fourth pillar of IWRM is investments. Experience from developed countries proves that after investing heavily in water information, institutions, and infrastructure systems, the countries are now relatively water secure, facing largely tolerable water-related risks (footnote 6).

Despite important successes resulting from 25 years of IWRM promotion, it must also be concluded that implementation is lagging expectations. While the concept itself is simple, a “one-size-fits-all” approach cannot be followed. Each country has its own unique set of physical, social, economic, political, and environmental circumstances that will determine how it should increase water security. Reviewing IWRM implementation during the last quarter-century, two lessons emerge.[37] The first lesson is that implementation must be gradual and nuanced. The second is that countries at different stages of socioeconomic evolution have different needs and capabilities and it is essential to reflect this in the approach taken. Further, there are four evolutionary stages of water economies (Table 4). These are indicated by the percentage of users in the formal sector: stage I completely informal (< 15%), stage II largely informal (15%–35%), stage III formalizing (35%–75%), and stage IV highly formal water industry (> 75%). The priority actions to be taken to increase water security are different in each stage. Table 4 should be seen as an illustration of the approach only. As stated earlier, each country is different. What is important is to realize that interventions that work well in one stage will not work in another.

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35 M. Zeitoun et al. 2016. Reductionist and Integrative Approaches to Complex Water Security Policy Challenges. *Global Environmental Change* 39: 143–154.

36 GWP. 2000. Integrated Water Resources Management. *TEC Background Paper* No. 4. Stockholm: Global Water Partnership Technical Committee.

37 T. Shah. 2016. Increasing Water Security: The Key to Implementing the Sustainable Development Goals. *TEC Background Paper* No. 22. Stockholm: Global Water Partnership Technical Committee.

Table 4: Indicative Priorities for Increasing Water Security in Water Economies at Different Stages of Evolution

Evolutionary Stage	Stage I Completely informal	Stage II Largely informal	Stage III Formalizing	Stage IV Highly Formal Water industry
% of users in formal water economy	5%–15%	15%–35%	35%–75%	75%–95%
Examples	Afghanistan, Bhutan	Bangladesh, Pakistan	People's Republic of China, Indonesia, Thailand	Australia, Republic of Korea
Capacity building	+++++ Invest in techno-managerial capacities for creating affordable infrastructure and services	+++++ Build capacities for efficient management of water infrastructure and water service provision	+++ Build local capacities for catchment/river basin-level water resources management	++ High-level techno-managerial capacity for water and energy-efficient water economy
Institutional reforms	Make existing institutions equitable and gender-balanced	Create representative and participatory institutions at project and watershed levels	Integrate customary and formal user organizations and territorial agencies into basin organization	Modern water industry with professionally managed service providers
Policy and legal regime	• Effective policies for water for livelihoods and food security • Create a regulatory framework for bulk water users	Establish basic water policy and water law consistent with local institutions and customary law	Introduce policy and legal regime for a transition to basin-level water governance	Policy and regulatory framework for a modern water industry and transboundary water governance
Investment priority	Establish and improve water infrastructure for consumptive and productive use by the poor and women	Invest in infrastructure modernization for improved service delivery and water use efficiency	Invest in infrastructure for basin-level water allocation and management including interbasin transfers and managed aquifer recharge	Technologies and infrastructure for improving water and energy efficiency in water economy
Managing ecosystem impacts	• Create broad-based awareness of aquatic ecosystem • Regulate water diversion and pollution by corporate consumers	• Proactive management of water quality and ecosystem impacts at project level • Invest in low-cost recycling	• Focus on water quality and health management • Urban wastewater recycling • Control of groundwater depletion	• Zero or minimal discharge water economy • Reduce carbon footprint
Water pricing and subsidies	• Minimize perverse subsidies • Make subsidies smart • Rationing to minimize waste	• Volumetric water pricing for bulk users • Partial cost recovery for retail consumers • Targeted subsidies for the poor	• Full financial cost recovery of water services • Metered water supply • 90% population covered by service providers	Full economic cost recovery of water services including the costs of ecosystem impacts

Source: Adapted from T. Shah. 2016. Increasing Water Security: The Key to Implementing the Sustainable Development Goals. *TEC Background Papers* No. 22. Global Water Partnership Technical Committee.

Box 5: Organisation for Economic Co-operation and Development Principles on Water Governance

Coping with current and future challenges requires robust public policies, targeting measurable objectives in predetermined time schedules at the appropriate scale, relying on a clear assignment of duties across responsible authorities and subject to regular monitoring and evaluation. Water governance can greatly contribute to the design and implementation of such policies, with shared responsibility across levels of government, civil society, business, and the broader range of stakeholders who have an important role to play alongside policy makers to reap the economic, social, and environmental benefits of good water governance.

On 4 June 2015, the Organisation for Economic Co-operation and Development (OECD) Principles on Water Governance were endorsed at the ministerial level as a framework, setting the standards for more effective, efficient, and inclusive design and implementation of water policies and encouraging governments to put them into action. The principles were developed in a multistakeholder and bottom–up fashion within the OECD Water Governance Initiative. They aim to enhance water governance systems that help manage water that is "too much," "too little," and "too polluted" in a sustainable, integrated, and inclusive way, at an acceptable cost, and in a reasonable time frame. They consider that governance is good if it can help solve key water challenges, using a combination of bottom–up and top–down processes. It is bad if it generates undue transaction costs and does not respond to place-based needs. The ultimate objective is delivering sufficient water of good quality, while maintaining or improving the ecological integrity of water bodies.

Source: Adapted from contribution by A. Akhmouch, unpublished.

Another important condition for increasing water security is political commitment. The water sector has to engage with society and the private sector to convince policy and decision makers of the importance of good water management for socioeconomic development. The general commitments that governments have made to implement the SDGs have to be translated into practical targets at the national, regional, and local levels.

Increasing Water Security by Key Dimension

All key dimensions are important for water security and in principle have to be addressed simultaneously. Political and societal preferences will determine the budgets that will be made available to the water issues represented in the five key dimensions. The relative AWDO scores might help to set priorities, by asking, for example, why a neighboring economy scores better on a key dimension when conditions are more or less the same.

Key Dimension 1: Household Water Security

Despite having said that all key dimensions are the same, it is easy to argue that the household water security dimension should perhaps receive some kind of priority over the others. Studies have shown that insufficient water, sanitation, and hygiene (WASH) results in high societal damage, higher than for example flood and drought damage. Household water security covers both drinking water (SDG target 6.1) and sanitation (SDG target 6.2), which both have clear targets (100% coverage by 2030). This target can be achieved, or at least come close to, as experience has shown in the Republic of Korea, Malaysia, Singapore, and Thailand. Political will and strong leadership appear to be crucial to reach the high scores of these countries. In order to achieve more inclusive development, special attention might be needed to correct the disparities between urban and rural areas as well as between rich and poor populations.

Key Dimension 2: Economic Water Security

Asia and the Pacific faces a serious water threat, as explained in part II. Water demand in agriculture, industry, and the domestic sectors will increase by 30%–40% in 2050. Sufficient water is important to sustain the high economic growth of the region. Water is already scarce in several countries and strong improvements in water productivity in agriculture and industry are needed to make further economic development possible. This will require a growing use of nexus approaches to water management. Finding smart solutions depends on good data. Data limitations throughout the region but particularly in the Pacific island countries and on groundwater constraing our ability to identify and respond to issues.

Key Dimension 3: Urban Water Security

First of all, a shift in mind-set is needed at the planning and decision-making level to move away from looking at water systems in the city as source of supply (drinking water) and threat (flooding) toward a more comprehensive water-sensitive cities approach. A combination of centralized and decentralized water supply infrastructure can provide cost-effective access to a reliable water supply. Special attention should be given to manage the often high nonrevenue water part of the supply. Infrastructure requirements are high to improve the wastewater and flooding components of the urban water security dimension.

Key Dimension 4: Environmental Water Security

Improved governance is the key word to increase environmental water security. Only good governance can reduce the threats that follow from population and economic growth. Regulations are needed to ensure that land and water systems are managed well and infrastructure decisions (e.g., sewage treatment plants) are taken. Good governance is also necessary to design and manage infrastructure for flow regulation in a sustainable way. To decide where actions are most urgent,

Box 6: A Tailor-Made Approach: Applying the Asian Water Development Outlook in Bhutan

A water security assessment was undertaken by the Asian Development Bank (ADB) in Bhutan in 2015 based on the Asian Water Development Outlook (AWDO) 2013 water security framework. While the AWDO key dimensions were maintained, the underlying indicators were tailored to Bhutan's conditions and readily available and government-collected information. Since the calculation method of the indicators used by AWDO was simplified, the results of the Bhutan Water Security Index (BWSI) cannot directly be compared with the results of the AWDO assessments done in Bhutan or other countries. The lesson derived from this exercise is that the water security dimensions and indicators provide the framework for coordinated planning, implementation, and monitoring efforts to sustainably manage water resources.

The National Water Security Index, as proposed in AWDO, was originally designed to assess water security of countries rather than a (bottom–up) planning tool. The BWSI has been formulated not just as a top–down monitoring tool, but also a basis for planning with dimensions and indicators directly used in a logical framework analysis and river basin planning. This is a major advancement in the application of the water security index. The application and functionality of the BWSI is in its infancy and the system will require constant review and revision to suit the country's needs. With time and a periodic review process, the workability of the present BWSI system will be assessed. This will guide the adjustments to be made to ensure it is more responsive to water management changes over time.

Source: Adapted from contribution by L. Gore, unpublished.

countries should increase their programs for monitoring river health.

Key Dimension 5: Resilience to Water-Related Disasters

Efforts to increase resilience to water-related disasters should be guided by the Sendai Framework for Disaster Risk Reduction 2015–2030. This starts with gaining a better understanding of disaster risk and strengthening disaster risk governance to manage the risk (instead of managing the disaster after it happens). Based on a good understanding of the risks, investments are needed to reduce these risks. Finally, disaster preparedness should be enhanced for effective response actions and the principle to “build back better” should be applied in recovery, rehabilitation, and reconstruction.

Testing effluent from a wastewater treatment plant in Manila, Philippines.

Part VI.
ADB and Water Security

ADB's Water Policy Framework

Water Security: Sustaining Futures

A More Strategic Vision

Expanding Knowledge

Partnering a Way Forward

ADB Contributing to a Water-Secure Asia and Pacific Region

ADB's Water Policy Framework

The Asian Development Bank (ADB) has taken successive steps forward to inform its strategic vision on the water sector. The Water for All policy (2001) considered the linkages between water challenges and poverty reduction, regional development, and the need to manage water both as a resource and as a service. The subsequent Water Operational Plan (2011–2020) established basic principles within an operational context (e.g., adoption of integrated water resources management [IWRM], reduction on nonrevenue water, and outcome targets for water sector interventions). It highlighted a more harmonized approach to river basin planning and incorporating IWRM and demand management.

The increase in disasters in Asia and the Pacific and ADB's engagement in preparedness and emergency response actions led to the dedicated Operational Plan for Integrated Disaster Risk Management 2014–2020.[38] This operational plan included three key objectives: (i) promoting the integrated disaster risk management approach in ADB's operations; (ii) strengthening ADB's integrated disaster risk management capabilities, knowledge, and resources; and (iii) mobilizing additional financial resources for integrated disaster risk management. It paves the way for more concerted efforts linking to the resilience dimension (Key Dimension 5 [KD5]) and improving the region's resilience to water-related disasters.

The policy framework provides firm reference points and sound principles on which to base operational and development interventions. This includes policy actions within a changing scenario of competing demands for water and climate change.

There is a missing link in the chronology of water sector policy in strengthening the outcomes in relation to the Asian Water Development Outlook (AWDO) water security framework. While this is partly due to the sequence of publication (AWDO 2013 was prepared after the Water Operational Plan), the result is that there are no links to subregion-specific recommendations based on water security. With two successive AWDO documents, ADB, its developing member countries, and its partners are well positioned to provide further perspectives on the region's water security status and work toward more tailored recommendations and interventions.

Water Security: Sustaining Futures

With a robust and now globally recognized approach to water security assessment, AWDO 2016 provides an inventory that will enable recommend tailored actions based on subregion specifics and key dimension performance.

Overall, AWDO 2016 demonstrates the following:

- The water security framework provides a sound assessment tool to benchmark the region's and developing member countries' progress.
- Water security and gross domestic product (GDP) are closely correlated and reinforce the point that water should be considered a critical input for sustained economic growth.
- In the face of competing demands and climate variability, water is increasingly an economic good. Its productive use requires an enabling policy framework based on water accounts, users, and targets set for resource utilization.
- Development interventions will increasingly need to consider their impacts on the overall water resource base, which is also essential for a better understanding of the trade-offs across users. This is particularly the case with economic water security (KD2), where water for agriculture continues to be used in isolation of

38 ADB. 2014. *Operational Plan for Integrated Disaster Risk Management 2014–2020*. Manila.

implications on water for domestic use, energy, and the environment.

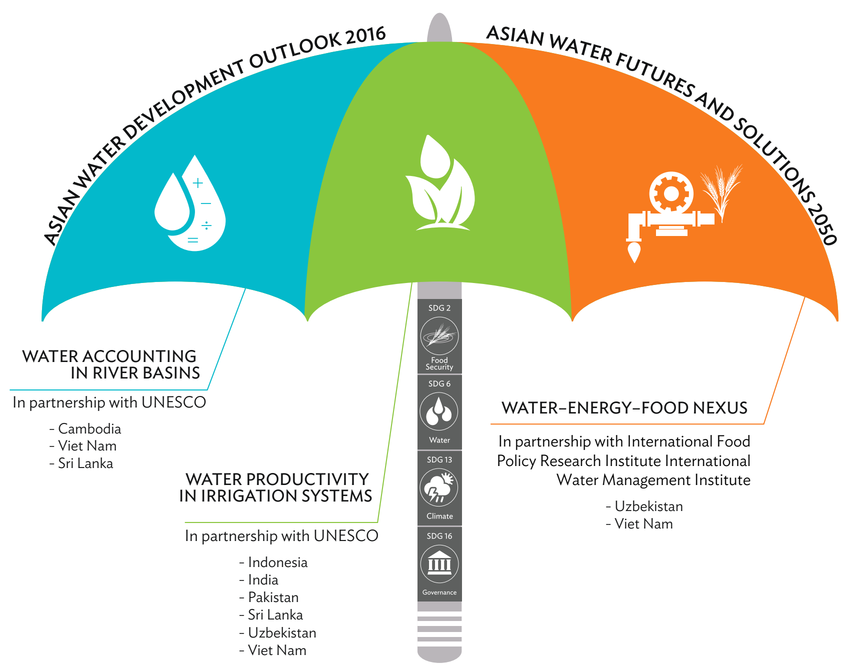
- Continued support—with equal focus on all key dimensions—is required to strengthen water security (investments in infrastructure, institutions, and information). ADB is well positioned as a contributor to the region's targets to meet the Sustainable Development Goals (SDGs) by supporting investments in each key dimension.
- Access to water supply and sanitation reflects a widening gap between rural and urban areas and rich and poor within urban areas. Policies and interventions need to consider these for improved targeting of actions.
- Data constraints remain in describing water security, particularly for cities where data sets require expansion and more rigorous collection. Similarly, for river health, a more comprehensive and measureable set of indicators that can be applied across Asia and the Pacific needs to be developed.

More specifically, Asia and the Pacific displays an overall positive trend in strengthening water security since 2013.[39] Advanced economies consistently lead the way—as expected—but followed by East Asia, which has improved in water security. The remaining regions show mixed performance across the key dimensions, although challenges still remain in South Asia. AWDO 2016 also demonstrates the difficulties in using the water security framework in small island nations, for which a more relevant and tailored approach may be appropriate.

A More Strategic Vision

The advent of AWDO 2016 provides a major turning point for ADB to take a leadership role on water security in the region. A series of actions have been taken for a more coordinated approach

Figure 42: Securing Asia's Water Future



Source: ADB.

[39] This may, however, be in part due to refinements in the calculation methodologies of the key dimensions and changes in data sets.

on operationalizing water security. The umbrella of overarching knowledge studies (Figure 42) is strengthened with ground-level actions to pilot new approaches, tailor approaches for specific situations, and provide capacity building support to strengthen water security.

Water Futures and Solutions Initiative

ADB is supporting the International Institute for Applied Systems Analysis fast-track analysis of the Water Futures and Solutions (WFaS) initiative for Asia and the Pacific.[40] This is part of a global study using multimodel global water scenarios (based on global climate change models and socioeconomic changes). The aim is to analyze the water–food–energy–climate–environment nexus superimposed with climate change projections. It identifies future hot spots of water insecurity and related impacts on food and energy security. Specific data sets generated from the work have been used to inform AWDO 2016.[41]

This will provide a better understanding of the region's emerging water sector trends. It will assist in identifying where and what type of investments will be needed to address potential water crises, and will help identify water use trade-offs required to ensure sustainable water, food, and energy security in Asia and the Pacific. Overall, the study will provide a broad and more strategic approach to identifying investments in the water, agriculture, and energy sectors.

Preliminary results demonstrate the skill of the multimodel integrated modeling approach to water–food–energy simulations. The study also projects a continued increase of 30%–40% in water demand in the agriculture, industry, and domestic sectors by 2050. Although agriculture will continue to account for the largest share of water demand, industrial and domestic demand will grow rapidly. Population growth and economic development are the main drivers determining Asia's water future. Generally, Asian countries with the highest population growth will have the lowest per capita water availability, the key determinant of water stress. Climate change impacts become more overriding after 2050.

The study provides a futuristic understanding at the subregional and national levels and reemphasizes similar hot spots of water insecurity as identified by AWDO 2016 (Central, West, and South Asia). What is more apparent is that the various countries have differing capacities to cope with insecurity and while they may be identified as having low water availability per capita they may have a greater ability to better manage water. One such example is the People's Republic of China (PRC), which is also reflected in AWDO 2016 as having made a positive movement in strengthening water security.

The next stage of the study will consult further on these findings with key stakeholder representatives in Asia and the Pacific as inputs to subsequent detailed simulation modeling. The granularity of results, particularly to demonstrate subnational variation in large developing member countries, has also been acknowledged for further action under a more detailed phase of analysis. This reinforces the overall recommendations of AWDO 2016: to consider the application of the water security framework at the river-basin scale.

Water Accounting in Pilot River Basins

Moving toward better management of finite water resources requires a better understanding of who is using water and how much. This has been challenging to date in Asia and the Pacific where access to hydrological data and diversions for use in industry, agriculture, and drinking water are generally unknown. It is particularly evident in more remote locations where manual measurements and a good data network may be sparse. Thus, a more integrated approach to basin water management to better understand priority uses and how to respond

[40] The Water Futures and Solutions initiative is a broad-based international consortium cooperating with partners such as UN-Water, UNESCO, the World Water Council, the International Water Association, and global scientific research organizations all over the world.

[41] These include data for economic water security (KD2) on cultivated land area from the Global Agro-Ecological Zones model to determine water productivity.

to water-related disasters like floods and droughts cannot be applied.

Water accounting provides comprehensive information on the quantum and users of water resources. These are based on a coherent and consistent methodology that quantifies hydrological processes. It assesses water storage, base flow, distribution of water to various competing sectors, the consumption of water, and the benefits and services that result from consumption and the return flow of non-consumed water.

ADB is adopting the Water Accounting Plus (WA+) framework developed by the UNESCO-IHE Institute for Water Education, the International Water Management Institute, and the Food and Agriculture Organization of the United Nations. The framework provides information on water storage and flows for a variety of land use systems. It focuses on the use of publicly accessible remote sensing data for precipitation, water surface areas, land use, groundwater, and so on. Work already begun in Viet Nam in 2015 on two pilot river basins (the Srepok and Thu Bon) and all basins in Cambodia. Work in additional pilot basins in India (Karnataka and Madhya Pradesh), Indonesia, and Sri Lanka has also commenced.

The pilots will provide a detailed understanding of the overall water resources status, and how much is being used (and returned to the basin) by various users (e.g., industry and agriculture). This provides a more rationalized and informed approach to guide developing member countries on national and basin water security and to plan specific water interventions with a better understanding of the overall resource base. This can then be scaled up to the entire Asian region and will enrich the AWDO data sets that form the basis for computing water scarcity.

Measuring More Crop per Drop

Water productivity is defined as crop yield per cubic meter of water consumed or more popularly "crop per drop." Irrigation investments should lead to increased productivity of water—that is, getting more crop per unit of water. Such investments have historically targeted improved agricultural productivity (how many kilograms of crop are produced per hectare), with little understanding of the volume of water used to produce the crop. This is where water productivity (how many kilograms of crop are produced per cubic meter of water) provides a much better measure of improved water use, or how much "crop per drop."

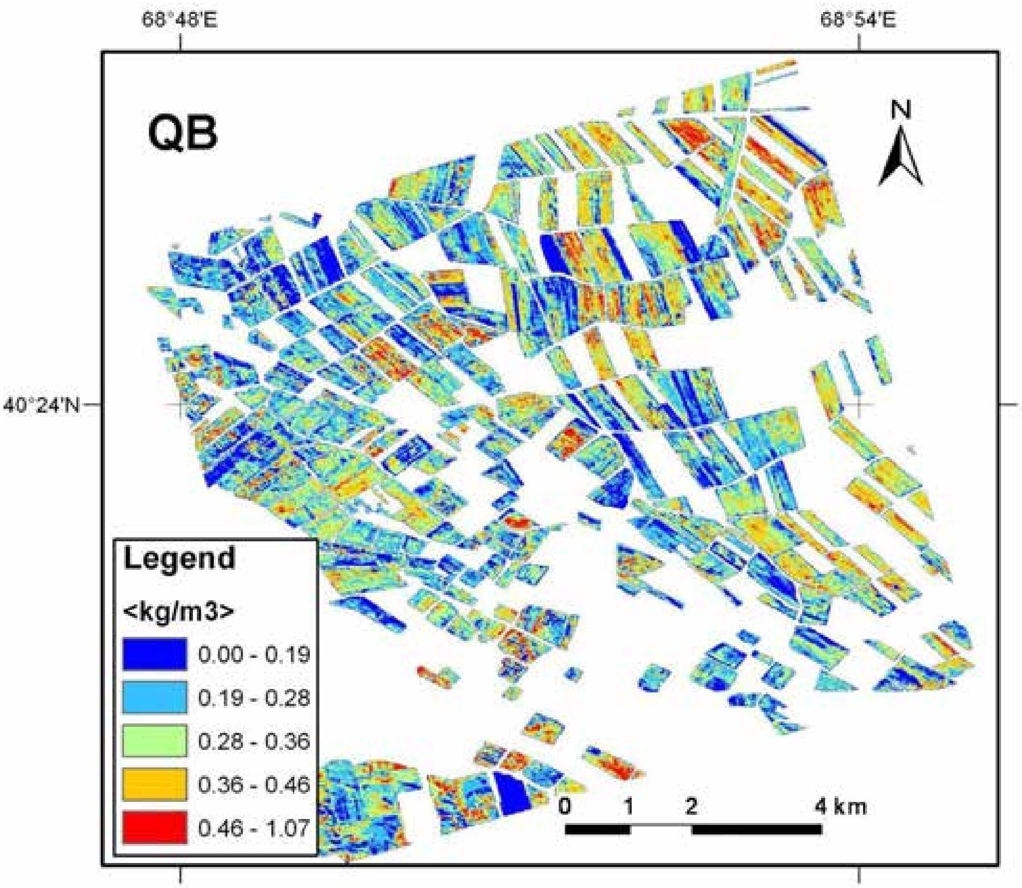
It is critical to know the status of water productivity at the start and at the end of each project. Remote sensing will be used to collect water productivity measurements carried out by ADB and the UNESCO-IHE Institute for Water Education in specific irrigation schemes in India, Indonesia, Pakistan, Sri Lanka, Uzbekistan, and Viet Nam.[42] The assessment forms part of a capacity building program aimed at enhancing the capacity of developing member countries and other stakeholders on the concept of crop water productivity. Developing member countries will also be trained on the use of remote sensing technologies to compute crop water productivity on a field-to-field basis, followed by a diagnosis of good and poor performing fields, and determining target productivity values. This activity will support SDG target 6.4 to increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity. It will be a pioneering step forward in providing a tangible baseline indicator for irrigation investments.

Urban Water

Urban water security needs to markedly progress and accelerate, because risks are increasing. There is a need to focus on strong governance, education, innovation, policy development, and adaptability. It is also important for communities to be informed of their water security scores.

[42] X. Cai, W. Bastiaanssen, and Y. Siddiqi. 2016. *Water Productivity Assessment for Improved Irrigation Performance and Water Security in the Asia-Pacific Region*. Delft, The Netherlands: UNESCO-IHE and Manila: Asian Development Bank.

Figure 43: Remote Sensing-Based Water Productivity Assessment to Identify Hot Spots in Cotton and Rice Fields in Central Asia



QB = Quick Bird.

Note : Remote sensing-based water productivity assessment helps the identification of hot spots. The best practices and most productive fields are indicated in red and poor practices in blue. This is an example of cotton and rice fields in Central Asia.

Source: Cai, X.L., Thenkabail, P.S., Biradar, C., et. al., 2009. Water productivity mapping using remote sensing data of various resolutions to support "more crop per drop." *Journal of Applied Remote Sensing*, 3, 033557.

Guided investment is needed to bring urban water supply security to higher—and more equitable—index levels. Systems or economies with lower scores, or higher risk, should be targeted to provide more information. For example, a risk assessment could identify growing urban populations drawing on stressed water supplies, in areas of projected increasing climatic variability or drying. AWDO could also be used for preliminary risk assessment of issues related to local water pollution, such as areas with generally good water supply coverage but poor coverage of wastewater collection infrastructure.

Further assessment of the energy risk of water supply options, including the energy trajectory of systems, could help inform future cost risks of urban water supply options.

Improved wastewater security is necessary, particularly for countries with lower scores. Improving the percentage of wastewater collected and the proportion of collected wastewater that is treated is necessary, as is increased sewerage covered, improved technologies, and increased investment in wastewater recycling.

The method for assessing water security can also be improved further and provide far greater insight to decision makers and communities. This requires improved data availability, consistency, ease of access, and diversity of analysis. There is a strong need to improve coordination across relevant data sets including water consumption and to improve definitions of what is considered "urban." Similarly, there is a need to support and grow various water data sources including the International Benchmarking Network for Water and Sanitation Utilities (IBNET), WHO/UNICEF Joint Monitoring Programme, and other data sources.

Linking Water and Energy: Theory to Practice

Water and energy are intrinsically linked. Almost all energy generation processes require significant amounts of water. The most straightforward water-related process is hydroelectricity generation, providing 16% of electricity globally, 14% in East Asia and the Pacific, and 13% in South Asia.[43] Biofuels and coal are also well-known water guzzlers, and fracking has joined the list more recently. Water requirements per unit of fossil-fuel-based electricity generation are highest at 75–450 cubic meters per megawatt-hour. Similarly, most water supply activities require large amounts of energy with ranges from 0.4 kilowatt-hour per cubic meter (kWh/m^3) to about 8.3 kWh/m^3 to provide safe water for humans from rivers, lakes, or seawater. This includes water treatment up to a standard so that it can be used for drinking or other purposes as well as treating sewage water and effluents before releasing such water back into water bodies.

Another important use is the pumping of large amounts of water for irrigation—approximately 40% of irrigated areas worldwide receive groundwater, for example. South Asia alone accounts for half of all groundwater used globally. In Asia, primary energy production is expected to double and power generation to more than triple by 2050. The increased demand for energy will put additional pressure on already constrained water resources. Estimates for Asia predict a 65% increase in industrial water use, a 30% increase in domestic use, and a 5% increase in agricultural use by 2030.[44] This illustrates the growing and acute competition among principal water users.

In the irrigation subsector, energy use is primarily for ground or surface water pumping and use of petroleum for farm machinery. Use of agricultural chemicals is a yet further use of energy in the sector. Continued expansion in groundwater use, its impact on declining water tables, demand for energy, and the cost to the power sector are highly relevant for the Asian region where energy does not reflect the true cost of supply.

ADB is working with the International Food Policy Research Institute (for the irrigation subsector) and the International Water Center (for urban water) to develop energy auditing guidelines. These studies aim to develop practical tools for evidence-based assessments of energy consumption in ADB's irrigation, water supply, sanitation, and wastewater management projects. This is intended to help with decisions enabling the optimal and sustainable energy use in ADB water investment projects.

There are three principal objectives, including developing

(i) exemplar guidance (practices) for ADB and its developing member countries in promoting prudent and sustainable energy use in water projects with regard to investments in the sector, covering both lending and nonlending assistance;
(ii) screening methods for use by ADB, and related consultants, governments, and utilities to evaluate projects particularly in the design phase; and
(iii) an energy audit checklist to enable strategic information to be provided on energy use in the proposed investment and energy- and water-efficient design and operations options.

43 Footnote 28, 2013 and 2014 World Bank estimates.

44 2030 Water Resources Group. 2009. *Charting Our Water Future: Economic Frameworks to Inform Decision-Making.* New Delhi.

Expanding Knowledge

A range of conceptual approaches to assess water security exist, each with its own, unique approach. Cross-referencing these alternate assessments and ensuring close coordination with the relevant teams during the development of AWDO 2016 has provided a more broadened view of water security. It also highlights how we jointly contribute to SDG6 to ensure availability and sustainable management of water and sanitation for all.

REACH Improving Water Security for the Poor Research: University of Oxford

REACH is a new global research program to improve water security for millions of poor people in Asia and Africa.[45] It aims to achieve this by applying integrated and innovative approaches in water research using a risk-based approach. The proposed framework will be for policy makers to assess water security risks on the global, national, and individual household scales. The program is led by the University of Oxford and brings together a consortium of global leaders in water science, policy, and practice. The 7-year program financed by the Department for International Development of the United Kingdom will span the full range of relevant disciplines: social, physical, natural, and economic.

The program adopts a risk-based approach addressing the interactions between water security risks and poverty reduction across three intersecting dimensions: resource sustainability, inclusive services, and sustainable growth. It has established regional observatories in Bangladesh, Ethiopia, and Kenya to gain insights from the field. Contrary to AWDO, there is a greater focus on how sustainable water security can be achieved at different scales and with participation of the poor and marginalized in the process.

The project will demonstrate innovation and flexibility that incentivizes cross-disciplinary work and delivers measurable outcomes. A key challenge will be to ensure coherence across themes to develop a body of research evidence, tools, and capacity that helps shape high-level investment and policy choices.

AWDO provides a static snapshot based on measureable parameters, mainly relating to infrastructure development. REACH provides an enhanced understanding of risks faced by the poorest in each developing member country and insights into what is required beyond just infrastructure-based solutions.

Organisation for Economic Co-operation and Development (OECD) Water Governance Initiative

The OECD Principles on Water Governance were developed in a multistakeholder and bottom–up fashion within its Water Governance Initiative. The principles aim to enhance water governance systems that help manage water that is "too much," "too little," and "too polluted" in a sustainable, integrated, and inclusive way, at an acceptable cost, and in a reasonable time frame. They consider governance as good if it can help solve key water challenges, using a combination of bottom–up and top–down processes. It is bad if it generates undue transaction costs and does not respond to place-based needs. The ultimate objective is to deliver sufficient water of good quality, while maintaining or improving the ecological integrity of water bodies.

The abovementioned initiatives each have their own objectives, deliverables, and time lines. The scope of the projects also greatly differs: AWDO is a relatively straightforward approach, more an inventory based on a robust water security framework. Its aim is to create awareness within developing member countries and enable a regionwide presentation of water security.

The Water Futures and Solutions initiative adopts a modeled approach based on global climate

45 REACH – Improving Water Security for the Poor. http://reachwater.org.uk

change projection models. The REACH program is supported by field-based practical applications for poverty reduction and provides a grounded understanding of integrated solutions. The OECD Water Governance Initiative provides a framework for governments to put in place better water policies.

Each of the approaches attempts to increase water security by means of quantitative analysis. Knowledge sharing between these initiatives would contribute to strengthening the understanding of water security and provide solutions or approaches for various levels from practical field-based solutions to policy actions. These may include

- expressing water security indicators and linking these to SDGs,
- harmonizing the global databases that are being used to quantify these criteria,
- highlighting differences and similarities between the various water security initiatives,
- streamlining key messages to reinforce the relevance of water security and implications for Asia's socioeconomic development, and
- providing more downscaled country- or basin-specific results and recommendations for strengthening water security.

Partnering a Way Forward

The strength of partnerships has been a defining factor in the development of AWDO 2013 and AWDO 2016. For AWDO 2016, specialist agencies were engaged by ADB to refine each key dimension. These included the Asia-Pacific Center for Water Security, Tsinghua University for KD1, the International Water Management Institute for KD2, and the International Water Center for KD3 and KD 4. For KD5, the main updating activities were undertaken by ADB with guidance from the International Centre for Water Hazard and Risk Management (ICHARM) and the International Water Management Institute. Cross-cutting support and inputs, particularly to KD2, were provided by the the International Institute for Applied Systems Analysis. The dedicated efforts of each of the teams demonstrates their strengths in the specific areas for refinement. The overall teamwork further highlighted the advantage of a multidisciplinary team that brings broad regional experiences and ties research with operational potential.

In future, having a better vision of the region's progress in water security using the AWDO framework would benefit from a 5-year updating cycle for data alone. This would entail simple data updates and could be undertaken by the agencies contributing to AWDO to date.

ADB Contributing to a Water-Secure Asia and Pacific Region

The region has made remarkable achievements over the past 2 decades with more than 1 billion people lifted out of extreme poverty and most countries have since achieved middle-income status. Yet the region remains home to half of the world's poorest people and, with increasing income inequality, the pace and sustainability of growth could be hampered. Providing access to water and sanitation and feeding a growing population remain critical challenges leaving a huge amount of work to be addressed to achieve the SDGs.

To deliver on this commitment, ADB is scaling up to triple its equity base from about $17.5 billion to about $49 billion with assistance to lower-income countries increasing by up to 70% by 2026.[46] This provides a significant opportunity to increase water security through inclusive development for improved access to water supply and sanitation, boost production from irrigated agriculture, provide environmentally sustainable services in cities, and

[46] ADB. 2016. *Annual Report 2015: Scaling Up to Meet New Development Challenges*. Manila.

ensure resilient infrastructure in a time of increased climate variability.

AWDO 2016 provides practical insights to the region's challenges with a greater subregional understanding; it merits country- or basin-level assessments to draw more tailored conclusions.

Based on the broader results observed, Table 5 summarizes potential actions to overcome water insecurity across the region. It is important to reemphasize that governance must go hand in hand with physical interventions, an element that can be more rigorously tackled by adopting relevant lending modalities (e.g., policy, results based, etc.).

Table 5: Summary of Proposed Interventions

Key Dimension	Aim	Issues	Proposed Interventions
All	Recognize economic value of water	• Population growth and reducing per capita water availability • Increasing and competing demands for water for food, energy, and domestic users • Climate change and increased period of uncertainty	• Initiate country- or basin-level water resources information systems in congruence with physical interventions • Strengthening the knowledge base on water resources using technology and downscaled water security assessments and water accounting to provide details of the resource base and inform water allocations and caps for resource use • Using water productivity measurements in agriculture • Increasing water use efficiency (including water conservation and nonrevenue water reduction measures) • Adopting rigorous cost recovery options (including use of the private sector where feasible)
All	Strengthen governance for inclusive and sustainable development	• Physical investments to be complemented by well-functioning institutions • Wider governance frameworks • Improved information system • Capacity building and skills training required in congruence with infrastructure development • Stakeholder inclusion and communication plan	• Increasing knowledge to support reflective policies, regulatory frameworks, and legislation for sustainable and inclusive development • Emphasizing operation and maintenance strategy, asset inventory, and management plan • Using alternate contract modalities: design, build, and operate; performance-based contracts; etc. • Promoting partnerships/twinning: peer-to-peer learning (e.g., ADB's Water Operators Partnership Program) • Using relevant lending instruments based on desired outcomes
1 and 3	Bridge gaps in water supply and sanitation	To achieve Sustainable Development Goal targets, need to address inequalities in access between rich and poor, rural and urban	• Capturing better (and disaggregated) water supply and sanitation data to identify inequalities and target interventions • Increasing support for water supply and sanitation and integrating it into project design across all regions • Improving water supply and sanitation for urban slum improvements • Considering integrated rural–urban water supply and sanitation systems where relevant • Considering rural water supply and sanitation under rural development and irrigation interventions

continued on next page

Table 5 *continued*

Key Dimension	Aim	Issues	Proposed Interventions
2	Water and energy	• Energy use in water supply and wastewater treatment and irrigation often overlooked, and vice versa • Water use in power generation • Competing demands and water scarcity require assessment of energy use at the operational level	• Mainstreaming energy auditing in all water sector investments, quantifying use and costs • Considering energy and water efficient solutions in project designs • Considering wastewater reuse solutions for water consumption in power generation
1–3	Accounting for groundwater use	• Energy subsidies encourage groundwater use in agriculture • Groundwater monitoring is negligible in water sector projects • Fragmented responsibilities across range of institutions • Planning without accounting and continued drawdown of finite groundwater	• Undertaking policy dialogue and intersector work to consider public finance implications of energy subsidies in the water sector • Undertaking energy auditing for all water sector projects and water auditing for energy projects • Undertaking more rigorous country or basin water security assessments to ascertain groundwater status (using alternate options like remote sensing for measurement)
3	Moving toward water-sensitive cities	• Conventional approach of water supply, wastewater, and flood management in piecemeal interventions • Infrastructure bias in development process	• Considering more multiple uses of water across a longer time frame that considers the future needs of users, river health, and ecosystems • Packaging development to leapfrog the traditional step-by-step provision of services into an integrated approach
1–4	Water quality improvements	• Increasing urbanization and food demand resulting in more point and non-point source pollution • Matter of time before the region's rivers increasingly face constraints on water quality and use • Preemptive management actions in rapidly urbanizing regions	• Considering broader policy and regulatory actions under investment projects • Considering basin approaches for water sector projects (e.g., more urban and peri-urban linked projects and wetland improvements as in the People's Republic of China) • Undertaking country-, basin-, or city-scale investigation to strengthen knowledge • Considering payment for ecosystem services • Considering partnerships with specialist agencies for water stewardship
5	Integrate climate change and disaster risk management for resilient infrastructure	• 90% of recorded major disasters (1995–2015) caused by natural hazards linked to climate and weather including floods, storms, heat waves, and droughts[a] • Require more interlinked approach to assess risks	• Consider investments predicated on the basis of climate change adaptation or climate variability, e.g., investments in drought-prone regions • Integrating approaches to basin dynamics, rather than spatial delineation (e.g., urban flooding to consider broader assessment of subbasin flood routing, etc.) • Using technology like remote sensing particularly in basins lacking hydrometeorological data

[a] United Nations Office for Disaster Risk Reduction. Climate Change Adaptation. Accessed 20 July 2016 from https://www.unisdr.org/we/advocate/climate-change

The great floods in Bangkok, Thailand, 2011.

Appendixes

1. National Water Security Index
2. Key Dimension 1—Household Water Security
3. Key Dimension 2—Economic Water Security
4. Key Dimension 3—Urban Water Security
5. Key Dimension 4—Environmental Water Security
6. Key Dimension 5—Resilience to Water-Related Disasters
7. Overview of Databases Used for the Indicators and Subindicators

APPENDIX 1

National Water Security Index

For each key dimension (KD), a specific scoring approach has been developed, depending on the subindicators that are used for that dimension. This results in score tables that are different for each of the key dimensions. KD1 has a maximum score of 15; KD2 a maximum of 20, KD3 a maximum of 16, KD4 a maximum of 15, and KD5 a maximum is 15. To make these scores comparable, the scores of each KD has been "normalized" to a maximum of 20. The tables in these appendixes list both scores. The graphs presented in part III of the report are all based on the max-20 scores. The national water security (NWS) score is the sum of the max-20 scores. Hence, the maximum of the NWS score is 100.

The NWS Index on a scale of 1–5 is derived from Table 3 in part III. An index of 1 (NWS score < 36) expresses that the water security in that specific country is "hazardous," while an index of 5 (NWS score ≥ 96) means that the country is a "model," that it has achieved water security.

Regional Analysis

The calculations are done and will be presented at the country level. For presentation and comparison purposes, regional summaries will be provided. The regions identified follow the divisions of ADB and are given in Table A1.1.

The total population considered in the 2016 Asian Water Development Outlook (AWDO 2016) is 4.044 trillion (2014 population data). Note that Pakistan is included in the region Central and West Asia and not South Asia. Also note that compared with AWDO 2013, data for Niue are no longer

Table A1.1: Regional Populations

Region	Economies	Total Population (million)
Central and West Asia	Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan	299 (7%)
East Asia	People's Republic of China, Mongolia, and Taipei,China	1,420 (35%)
Pacific	Cook Islands, Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu	11 (0.3%)
South Asia	Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka	1,477 (37%)
Southeast Asia	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam	619 (15%)
Advanced economies	Australia; Brunei Darussalam; Hong Kong, China; Japan; New Zealand; Republic of Korea; and Singapore	218 (5%)
Total Asia and the Pacific		4,044 (100%)

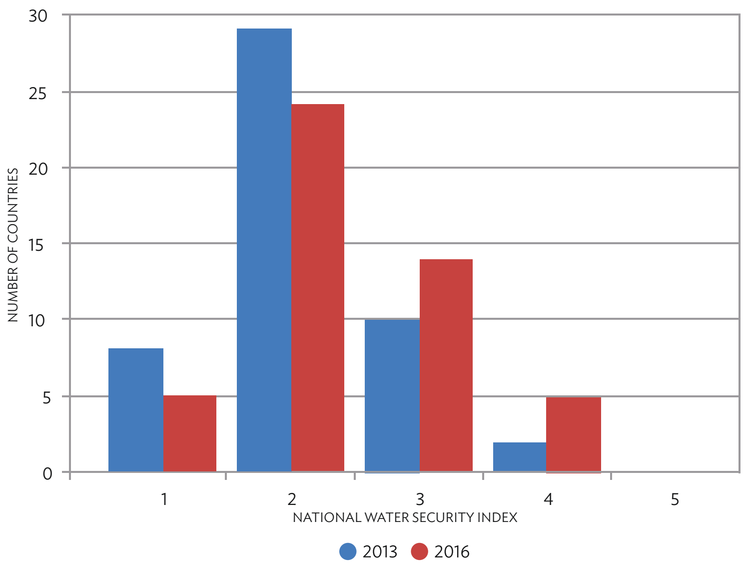
Source: United Nations Children's Fund and World Health Organization (UNICEF and WHO). 2015. *Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment*. New York.

taken into consideration. The regional results are population-weighted averages. This means that the result of East Asia as a region is very much determined by the score of the People's Republic of China and the result of the South Asia region (to a somewhat lesser extent) by the score of India. The Pacific region contains only 0.3 % of the total population.

Comparing the Results of Asian Water Development Outlook 2016 and Asian Water Development Outlook 2013

The results of AWDO 2016 and AWDO 2013 are compared in the regional analysis (Figure A1.1). As explained in part IV, AWDO 2016 presents more or less the situation as existed in 2014, while AWDO 2013 described (also more or less) the situation in 2009. This means that the comparison describes the progress that is made in a 5-year period. Some caution should be exercised in looking at the differences between the AWDO 2016 and AWDO 2013 results. The methodology of some of the key dimensions as well as some data sources have been changed. Although care has been taken to make the results comparable, the change of methodology and data might have some impact on the results of some economies. Still, there is sufficient confidence in the results to include them in this publication.

Figure A1.1: Comparative National Water Security Index for 2013 and 2016



	2013	2016
1	Afghanistan, Bangladesh, Cambodia, India, Kiribati, Lao PDR, Myanmar, Nauru, Nepal , Pakistan, Philippines, Timor-Leste, Tuvalu, and Viet Nam	Afghanistan, Bangladesh, India, Kiribati, and Pakistan.
2	Azerbaijan, Bhutan, People's Republic of China, Cook Islands, Federal States of Micronesia, Kyrgyz Republic, Maldives, Marshall Islands, Mongolia, Nauru, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Tajikistan, Thailand, Tonga, Turkmenistan, Tuvalu, Uzbekistan, and Vanuatu	Azerbaijan, Bhutan, Cambodia, Federated States of Micronesia, Indonesia, Kyrgyz Republic, Lao PDR, Marshall Isalnds, Mongolia, Myanmar, Nepal, Papua New Guinea, Philippines, Samoa, Solomon Islands, Sri Lanka, Tajikistan, Thailand, Timor-Leste, Tonga, Turkmenistan, Uzbekistan, Vanuatu, and Viet Nam
3	Armenia, Brunei Darussalam, Japan, Kazakhstan, Republic of Korea, Malaysia, Palau, Singapore, and Taipei,China	Armenia, People's Republic of China, Cook Islands, Fiji, Georgia, Hong Kong, China, Kazakhstan, Republic of Korea, Maldives, Nauru, Palau, Taipei,China, and Tuvalu
4	Australia, Hong Kong, China, and New Zealand	Australia, Brunei Darussalam, Japan, New Zealand and Singapore
5	None	None

Source: ADB.

Table A1.2: Detailed Scores for the National Water Security Index by Economy

Economy	KD1	KD2	KD3	KD4	KD5	NWS Score	NWS Index
Scale	1–20	1–20	1–20	1–20	1–20	1–100	1–5
Afghanistan	4.0	8.1	6.0	5.3	4.0	27.5	1
Armenia	18.7	13.1	16.3	9.3	10.8	68.1	3
Australia	20.0	16.6	18.8	16.0	19.4	90.8	4
Azerbaijan	12.0	12.2	12.5	6.7	7.5	50.8	2
Bangladesh	6.7	14.1	5.0	5.3	4.2	35.3	1
Bhutan	6.7	14.2	9.0	10.7	8.0	48.5	2
Brunei Darussalam	20.0	14.3	18.8	14.7	11.4	79.1	4
Cambodia	6.7	12.7	5.6	8.0	4.5	37.5	2
China, People's Republic of	14.7	15.3	13.5	8.0	10.4	61.8	3
Cook Islands	16.0	6.8	15.0	16.0	12.0	65.8	3
Fiji	14.7	11.8	13.8	14.7	11.4	66.3	3
Georgia	16.0	10.5	15.0	9.3	14.0	64.9	3
Hong Kong, China	18.7	14.7	18.8	12.0	11.9	76.0	3
India	4.0	12.9	5.6	5.3	5.3	33.1	1
Indonesia	8.0	14.3	7.9	13.3	6.3	49.8	2
Japan	20.0	14.3	15.0	12.0	19.5	80.7	4
Kazakhstan	14.7	14.8	15.0	12.0	13.8	70.2	3
Kiribati	4.0	7.3	10.0	4.0	5.3	30.7	1
Korea, Republic of	20.0	15.6	15.0	8.0	15.8	74.4	3
Kyrgyz Republic	13.3	12.3	13.8	6.7	5.8	51.9	2
Lao People's Democratic Republic	6.7	11.3	8.0	8.0	4.0	38.0	2
Malaysia	20.0	15.4	15.8	13.3	8.8	73.4	3
Maldives	14.7	12.0	12.0	16.0	4.0	58.7	3
Marshall Islands	6.7	7.3	10.0	12.0	6.7	42.6	2
Micronesia, Federated States of	6.7	11.0	8.8	16.0	10.7	53.1	2
Mongolia	6.7	10.3	7.9	12.0	7.1	43.9	2
Myanmar	8.0	13.4	3.4	10.7	5.3	40.8	2
Nauru	10.7	8.5	10.0	16.0	17.3	62.5	3
Nepal	5.3	11.3	6.0	10.7	4.0	37.3	2
New Zealand	20.0	15.6	18.8	17.3	19.7	91.3	4
Pakistan	5.3	11.5	4.5	6.7	4.7	32.7	1
Palau	18.7	9.0	17.5	14.7	12.0	71.8	3

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Table A1.2 *continued*

Economy	KD1	KD2	KD3	KD4	KD5	NWS Score	NWS Index
Scale	1–20	1–20	1–20	1–20	1–20	1–100	1–5
Papua New Guinea	4.0	9.6	7.9	13.3	4.7	39.5	2
Philippines	9.3	11.4	5.0	8.0	6.6	40.4	2
Samoa	16.0	8.0	11.3	13.3	5.4	54.0	2
Singapore	20.0	18.3	18.8	14.7	11.3	82.9	4
Solomon Islands	5.3	8.3	8.0	14.7	13.3	49.7	2
Sri Lanka	13.3	12.4	10.0	8.0	7.7	51.4	2
Taipei,China	14.7	14.7	12.5	9.3	16.4	67.6	3
Tajikistan	9.3	9.3	9.0	12.0	4.3	43.8	2
Thailand	13.3	15.7	6.8	8.0	10.6	54.4	2
Timor-Leste	4.0	9.5	7.0	6.7	14.7	41.8	2
Tonga	16.0	5.0	8.8	8.0	5.2	42.9	2
Turkmenistan	12.0	14.4	14.6	8.0	5.1	54.1	2
Tuvalu	16.0	8.0	15.0	16.0	5.3	60.3	3
Uzbekistan	12.0	10.4	12.5	8.0	5.9	48.8	2
Vanuatu	5.3	8.3	9.0	14.7	4.7	42.0	2
Viet Nam	10.7	12.6	5.0	5.3	6.6	40.2	2

KD = key dimension, NWS = National Water Security.
Source: ADB.

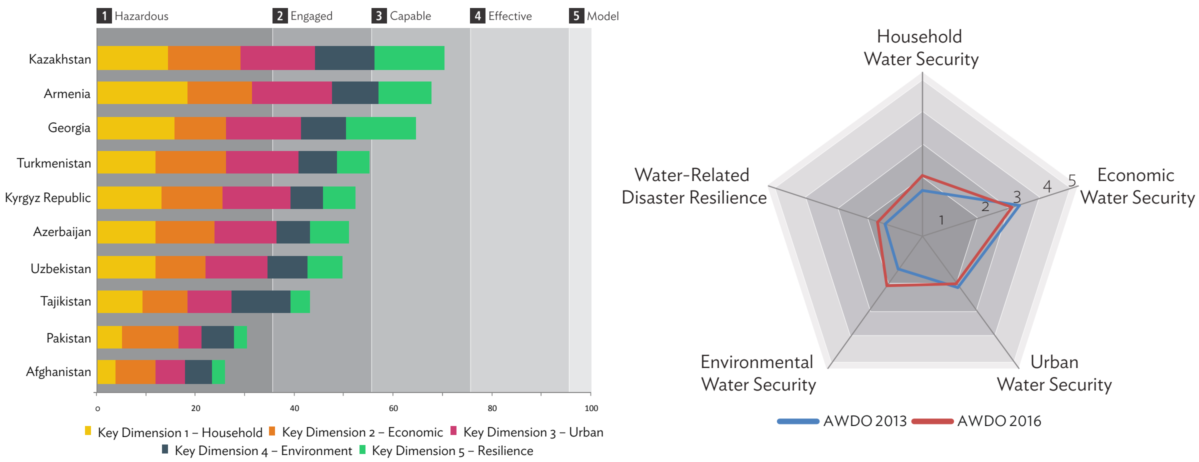
National Water Security Scores by Region

Table A1.3: Central and West Asia

	Population (million)	NWS Score	
		2013	2016
Afghanistan	31.3	27.2	27.5
Armenia	3.0	60.5	68.1
Azerbaijan	9.5	43.0	50.8
Georgia	4.3	55.4	64.9
Kazakhstan	16.6	62.0	70.2
Kyrgyz Republic	5.6	47.8	51.9
Pakistan	185.1	28.8	32.7
Tajikistan	8.4	46.1	43.8
Turkmenistan	5.3	44.8	54.1
Uzbekistan	29.3	44.2	48.8
Average (population weighted)		**34.1**	**38.2**

NWS = National Water Security.
Source: ADB.

Figure A1.2: Central and West Asia



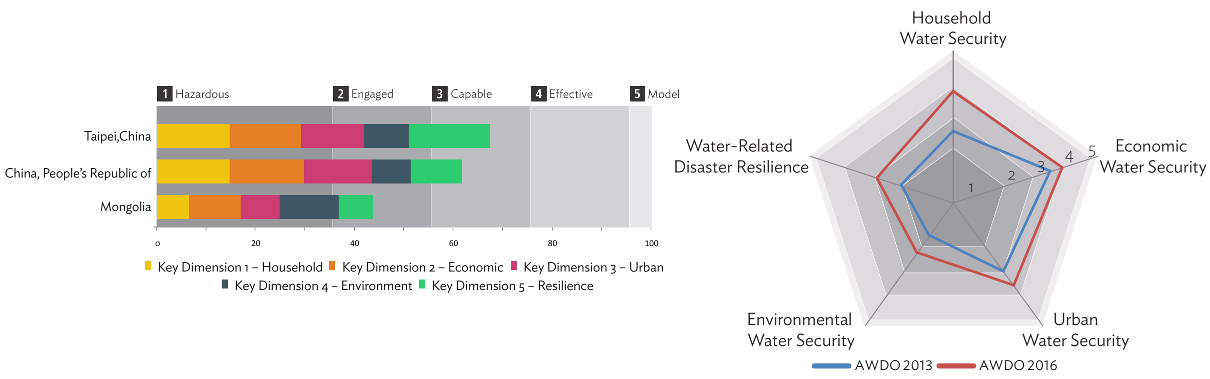
AWDO = Asian Water Development Outlook.
Source: ADB.

Table A1.4: East Asia

	Population (million)	NWS Score	
		2013	2016
China, People's Republic of	1,393.8	44.3	61.8
Mongolia	2.9	38.6	43.9
Taipei,China	23.4	58.2	67.6
Average (population weighted)		44.5	61.9

NWS = National Water Security.
Source: ADB.

Figure A1.3: East Asia



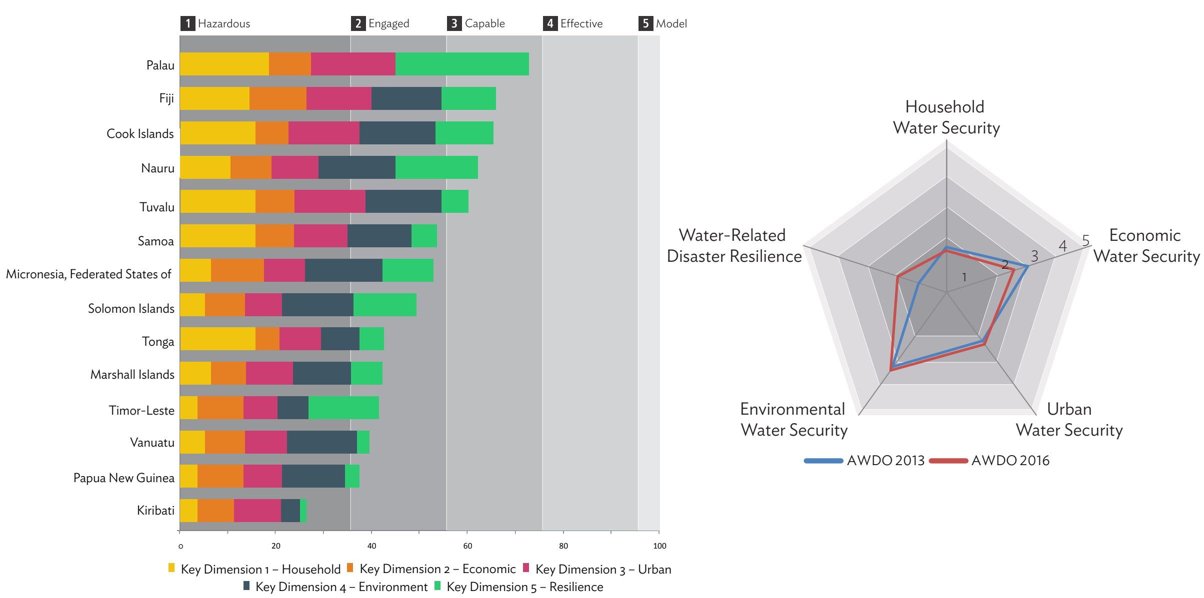
AWDO = Asian Water Development Outlook.
Source: ADB.

Table A1.5: Pacific

	Population ('000)	NWS Score	
		2013	2016
Cook Islands	21	48.5	65.8
Fiji	887	54.7	66.3
Kiribati	104	25.2	30.7
Marshall Islands	58	41.2	42.6
Micronesia, Federated States of	104	40.8	53.1
Nauru	11	45.7	62.5
Palau	21	59.0	71.8
Papua New Guinea	7,476	36.4	39.5
Samoa	192	48.6	54.0
Solomon Islands	573	48.8	49.7
Timor-Leste	1,152	32.7	41.8
Tonga	106	40.4	42.9
Tuvalu	10	50.8	60.3
Vanuatu	258	39.6	42.0
Average (population weighted)		**38.6**	**43.0**

NWS = National Water Security.
Source: ADB.

Figure A1.4: Pacific



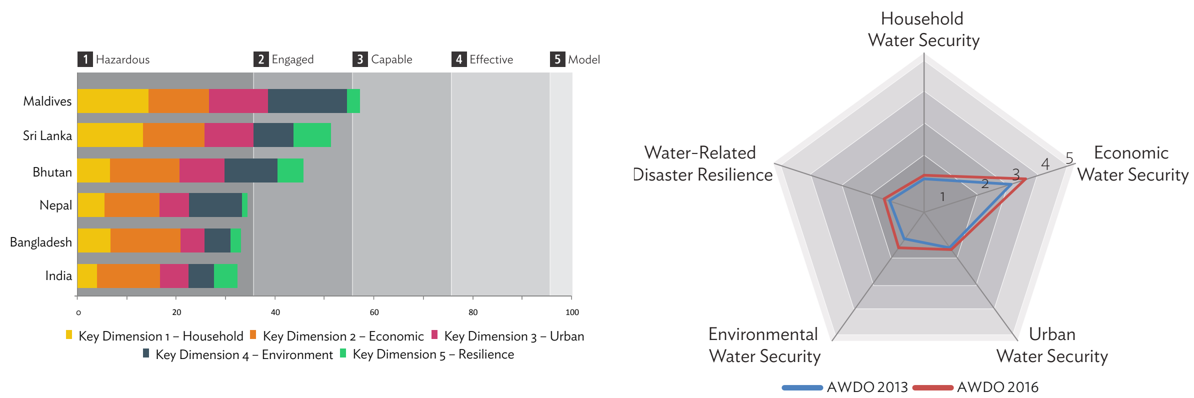
AWDO = Asian Water Development Outlook.
Source: ADB.

Table A1.6: South Asia

	Population (million)	NWS Score	
		2013	2016
Bangladesh	158.5	25.0	35.3
Bhutan	0.8	39.3	48.5
India	1,267.4	29.5	33.1
Maldives	0.4	53.3	58.7
Nepal	28.1	28.0	37.3
Sri Lanka	21.4	44.3	51.4
Average (population weighted)		**29.3**	**33.7**

NWS = National Water Security.
Source: ADB.

Figure A1.5: South Asia



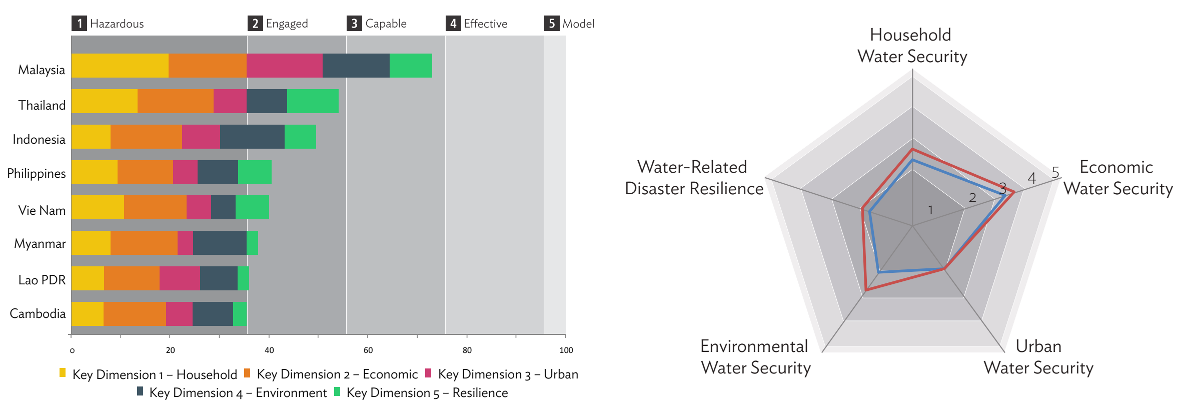
AWDO = Asian Water Development Outlook.
Source: ADB.

Table A1.7: Southeast Asia

	Population (million)	NWS Score	
		2013	2016
Cambodia	15.4	31.6	37.5
Indonesia	252.8	40.9	49.8
Lao People's Democratic Republic	6.9	35.0	38.0
Malaysia	30.2	60.6	73.4
Myanmar	53.7	35.0	40.8
Philippines	100.1	35.0	40.4
Thailand	67.2	47.9	54.4
Viet Nam	92.5	33.9	40.2
Average (population weighted)		39.9	47.3

NWS = National Water Security.
Source: ADB.

Figure A1.6: Southeast Asia



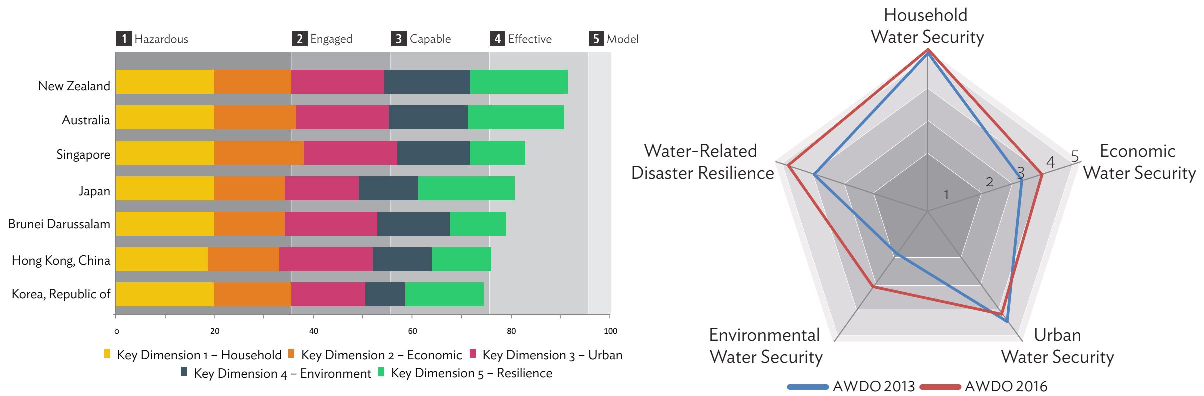
AWDO = Asian Water Development Outlook.
Source: ADB.

Table A1.8: Advanced Economies

	Population (million)	NWS score	
		2013	2016
Australia	23.6	87.5	90.8
Brunei Darussalam	0.4	65.1	79.1
Hong Kong, China	7.3	76.6	76.0
Japan	127.0	74.6	80.7
Korea, Republic of	49.5	57.8	74.4
New Zealand	4.6	82.1	91.3
Singapore	5.5	73.1	84.4
Average (population weighted)		**72.3**	**80.5**

NWS = National Water Security.
Source: ADB.

Figure A1.7: Advanced Economies



AWDO = Asian Water Development Outlook.
Source: ADB.

APPENDIX 2

Key Dimension 1—Household Water Security

The household water security (Key Dimension 1 [KD1]) index is a composite of three subindicators:

(i) access to piped water supply (%)
(ii) access to improved sanitation (%)
(iii) hygiene (number of age-standardized disability-adjusted life years [DALYs] per 100,000 people for the incidence of diarrhea).

Refer to Appendix 7 for an overview of these subindicators, the units applied, the data sources, data years, and data references. Further information is given in the methodology and data report of the Asian Water Development Outlook (AWDO) 2016.

Access to Piped Water Supply

(i) The main data source for this indicator is the *Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment* report by the Joint Monitoring Programme (JMP) of the World Health Organization (WHO) and United Nations Children's Emergency Fund (UNICEF). It is based on statistics provided by the countries themselves.
(ii) The indicator includes only piped water on premises; other improved water supply options are not included.

Access to Improved Sanitation

(i) The main data source is the same as for piped water supply.
(ii) This indicator considers only improved sanitation facilities; shared sanitation facilities are not included.

Hygiene

(i) This indicator is based on official WHO statistics.
(ii) WHO has changed its estimation method for DALYs which makes the DALY data given in AWDO 2013 not directly comparable with the numbers given in AWDO 2016. The given AWDO scores are comparable.

Changes in Methodology Compared with Asian Water Development Outlook 2013

The methodology applied for AWDO 2016 is the same as used for AWDO 2013. Some adjustments have been made to account for the changed estimation method of WHO for the DALYs.

Scoring Methodology

The applied scoring methodology for KD1 is described in detail in the AWDO 2016 methodology and data report. The main characteristics of the scoring methodology are the following:

(i) Each subindicator is scored from 1 to 5.
(ii) For access to piped water and improved sanitation, a score of 1 is given for access less than 60%; for 60% and above, the

scores increase linearly up to a score of 5 for access above 90%.

(iii) For hygiene, a score of 5 is given for diarrhea DALYs less than 190 and a score of 1 for diarrhea DALYs more than 1,800.

(iv) To determine KD1, the three subindexes are summed (maximum sum is 15) and multiplied with 20/15 (to make KD1 comparable with the other key dimension on a 20-point scale).

The KD1 index was originally developed for AWDO 2013 by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The AWDO 2016 application, including an update of the methodology around the DALY parameter, was completed by the Asia-Pacific Center for Water Security in Beijing.

Table A2.1: Detailed Scores for Household Water Security by Economy

Economy	Piped Water Access	Piped Water Index	Sanitation Access	Sanitation Index	Diarrhea DALY	DALY Index	KD1 Score	KD1 Score	KD1 Index
Scale	%	1–5	%	1–5	#	1–5	1–15	1–20	1–5
Afghanistan	12	1	32	1	4,810	1	3	4.0	1
Armenia	98	5	89	4	174	5	14	18.7	4
Australia	100	5	100	5	91	5	15	20.0	5
Azerbaijan	65	2	88	4	574	3	9	12.0	3
Bangladesh	12	1	60	1	759	3	5	6.7	1
Bhutan	58	1	50	1	1,077	3	5	6.7	1
Brunei Darussalam	100	5	96	5	125	5	15	20.0	5
Cambodia	20	1	41	1	970	3	5	6.7	1
China, People's Republic of	72	3	75	3	150	5	11	14.7	3
Cook Islands	77	3	98	5	NA	4	12	16.0	4
Fiji	68	2	91	5	474	4	11	14.7	3
Georgia	79	3	87	4	114	5	12	16.0	4
Hong Kong, China	100	5	100	5	NA	4	14	18.7	4
India	28	1	39	1	2,407	1	3	4.0	1
Indonesia	21	1	61	2	675	3	6	8.0	2
Japan	98	5	100	5	114	5	15	20.0	5
Kazakhstan	61	2	98	5	311	4	11	14.7	3
Kiribati	35	1	40	1	NA	1	3	4.0	1
Korea, Republic of	93	5	100	5	124	5	15	20.0	5
Kyrgyz Republic	58	1	93	5	498	4	10	13.3	3
Lao People's Democratic Republic	28	1	70	3	2,621	1	5	6.7	1

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Table A2.1 *continued*

Economy	Piped Water Access	Piped Water Index	Sanitation Access	Sanitation Index	Diarrhea DALY	DALY Index	KD1 Score	KD1 Score	KD1 Index
Scale	%	1–5	%	1–5	#	1–5	1–15	1–20	1–5
Malaysia	96	5	96	5	150	5	15	20.0	5
Maldives	45	1	98	5	179	5	11	14.7	3
Marshall Islands	3	1	77	3	NA	1	5	6.7	1
Micronesia, Federated States of	37	1	57	1	NA	3	5	6.7	1
Mongolia	24	1	59	1	644	3	5	6.7	1
Myanmar	8	1	80	3	1,295	2	6	8.0	2
Nauru	68	2	66	2	NA	4	8	10.7	2
Nepal	23	1	44	1	1,221	2	4	5.3	1
New Zealand	100	5	100	5	180	5	15	20.0	5
Pakistan	38	1	62	2	2,717	1	4	5.3	1
Palau	95	5	100	5	NA	4	14	18.7	4
Papua New Guinea	9	1	19	1	1,858	1	3	4.0	1
Philippines	42	1	73	3	718	3	7	9.3	2
Samoa	85	4	91	5	NA	3	12	16.0	4
Singapore	100	5	100	5	82	5	15	20.0	5
Solomon Islands	26	1	29	1	1,255	2	4	5.3	1
Sri Lanka	34	1	95	5	353	4	10	13.3	3
Taipei,China	93	5	70	2	NA	4	11	14.7	3
Tajikistan	45	1	95	5	2,066	1	7	9.3	2
Thailand	56	1	93	5	233	4	10	13.3	3
Timor-Leste	25	1	40	1	2,144	1	3	4.0	1
Tonga	78	3	91	5	NA	4	12	16.0	4
Turkmenistan	45	1	99	5	1,195	3	9	12.0	3
Tuvalu	97	5	83	4	NA	3	12	16.0	4
Uzbekistan	47	1	100	5	878	3	9	12.0	3
Vanuatu	34	1	58	1	NA	2	4	5.3	1
Viet Nam	27	1	76	3	414	4	8	10.7	2

DALY = disability-adjusted life year, KD = key dimension.

Notes: NA: data not available; black: based on WHO/UNICEF Joint Monitoring Programme data; blue: data from other sources; green: estimate by the Asian Water Development Outlook team; red: expert estimate by Stephen Blaik, Principal Urban Development Specialist, Pacific Department, ADB.

Source: ADB.

APPENDIX 3

Key Dimension 2—Economic Water Security

The economic water security (Key Dimension 2 [KD2]) index is based on the performance of four subindicators—one general and three specific sector subindicators:

(i) broad economy—describes the general water-related boundary conditions for the use of water for economic purposes
(ii) agriculture—indicates water productivity in agriculture and food security
(iii) energy—indicates water productivity in energy generation and energy security
(iv) industry—indicates water productivity in industry

Refer to Appendix 7 for an overview of these subindicators, the units applied, the data sources, data years, and data references. Further information is given in the methodology and data report of the Asian Water Development Outlook (AWDO) 2016.

Broad Economy

(i) The broad economy subindicator presents the basic water-related elements that should be present in a country to enable a functioning economic sector.
(ii) This subindicator combines information on reliability of supply, water stress, storage (dam capacity), and data availability.

Agriculture

(i) The agriculture subindicator describes the degree to which water is secured to enable agriculture in a country.
(ii) It is a combination of water productivity in agriculture and self-sufficiency of agricultural production.

Energy

(i) The energy subindicator describes the degree to which water security is achieved for the energy sector.
(ii) It is a combination of water productivity in energy and the achievement of a minimum platform for electricity production.

Industry

(i) The Industry subindicator measures the water productivity in industry.

Changes in Methodology Compared with Asian Water Development Outlook 2013

The methodology for KD2 has been redesigned considerably to include a fourth subindicator (broad economy) and uses different sub-subindicators and data sources.

Scoring Methodology

The applied scoring methodology for KD2 is described in detail in the AWDO 2016 methodology and data report. The main characteristics of the scoring methodology are the following:

(i) Each subindicator is scored from 1 to 5, based on data on the components.
(ii) KD2 is the sum of the values of the four subindicators (with a maximum score of 20).

The KD2 index as used in AWDO 2016 was developed and populated by the International Water Management Institute. The Food and Agriculture Organization of the United Nations was involved in the development of the earlier AWDO 2013 version.

Table A3.1: Detailed Scores for Economic Water Security by Economy

Economy	Economic (broad)	Agriculture	Energy	Industry	KD2 Total	KD2 Score	KD2 Index
Scale	1–5	1–5	1–5	1–5	1–20	1–20	1–5
Afghanistan	2.1	1.0	1.0	4.0	8.1	8.1	2
Armenia	3.1	3.0	3.0	4.0	13.1	13.1	3
Australia	4.1	3.0	4.5	5.0	16.6	16.6	4
Azerbaijan	3.7	2.5	3.0	3.0	12.2	12.2	3
Bangladesh	3.1	3.0	3.0	5.0	14.1	14.1	3
Bhutan	3.2	1.0	5.0	5.0	14.2	14.2	3
Brunei Darussalam	3.2	2.5	5.0	NA	10.7	14.3	3
Cambodia	3.2	3.0	1.5	5.0	12.7	12.7	3
China, People's Republic of	3.8	3.5	4.0	4.0	15.3	15.3	4
Cook Islands	1.8	NA	1.0	NA	2.8	6.8	1
Fiji	3.3	2.5	1.0	5.0	11.8	11.8	3
Georgia	4.0	1.5	2.0	3.0	10.5	10.5	2
Hong Kong, China	1.0	5.0	5.0	NA	11.0	14.7	3
India	2.9	3.5	2.5	4.0	12.9	12.9	3
Indonesia	3.3	3.0	3.0	5.0	14.3	14.3	3
Japan	3.3	1.5	4.5	5.0	14.3	14.3	3
Kazakhstan	4.3	3.0	4.5	3.0	14.8	14.8	3
Kiribati	1.5	3.0	1.0	NA	5.5	7.3	2
Korea, Republic of	3.1	2.5	5.0	5.0	15.6	15.6	4
Kyrgyz Republic	3.8	2.5	3.0	3.0	12.3	12.3	3
Lao People's Democratic Republic	3.3	3.0	1.0	4.0	11.3	11.3	3
Malaysia	3.9	3.0	4.5	4.0	15.4	15.4	4
Maldives	3.0	3.0	1.0	5.0	12.0	12.0	3
Marshall Islands	2.3	3.0	NA	NA	5.3	7.3	2
Micronesia, Federated States of	1.0	4.0	NA	NA	5.0	11.0	2
Mongolia	3.3	1.0	3.0	3.0	10.3	10.3	2
Myanmar	3.9	3.0	1.5	5.0	13.4	13.4	3

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Table A3.1 *continued*

Economy	Economic (broad)	Agriculture	Energy	Industry	KD2 Total	KD2 Score	KD2 Index
Scale	1–5	1–5	1–5	1–5	1–20	1–20	1–5
Nauru	1.5	NA	3.0	NA	4.5	8.5	2
Nepal	2.8	2.5	1.0	5.0	11.3	11.3	3
New Zealand	4.6	2.5	3.5	5.0	15.6	15.6	4
Pakistan	2.5	3.0	2.0	4.0	11.5	11.5	3
Palau	2.0	3.0	NA	NA	5.0	9.0	2
Papua New Guinea	3.6	1.0	1.0	4.0	9.6	9.6	2
Philippines	2.9	3.0	2.5	3.0	11.4	11.4	3
Samoa	1.5	3.5	1.0	NA	6.0	8.0	2
Singapore	3.3	5.0	5.0	5.0	18.3	18.3	4
Solomon Islands	2.3	3.0	1.0	NA	6.3	8.3	2
Sri Lanka	2.9	3.5	2.0	4.0	12.4	12.4	3
Taipei,China	1.0	5.0	5.0	NA	11.0	14.7	3
Tajikistan	3.3	2.5	1.5	2.0	9.3	9.3	2
Thailand	3.7	3.5	3.5	5.0	15.7	15.7	4
Timor-Leste	2.5	1.0	1.0	5.0	9.5	9.5	2
Tonga	1.8	1.0	1.0	NA	3.8	5.0	1
Turkmenistan	2.4	3.0	5.0	4.0	14.4	14.4	3
Tuvalu	2.0	4.0	NA	NA	6.0	8.0	2
Uzbekistan	2.4	3.0	2.0	3.0	10.4	10.4	2
Vanuatu	2.3	3.0	1.0	NA	6.3	8.3	2
Viet Nam	3.6	3.5	1.5	4.0	12.6	12.6	3

KD = key dimension.

Notes: NA: data not available; black: based on data; blue: score determined by omitting the missing subindicator; red: score determined 50% based on data and 50% on expert judgment (Stephen Blaik, Principal Urban Development Specialist, Pacific Department, ADB).

Source: ADB.

APPENDIX 4

Key Dimension 3—Urban Water Security

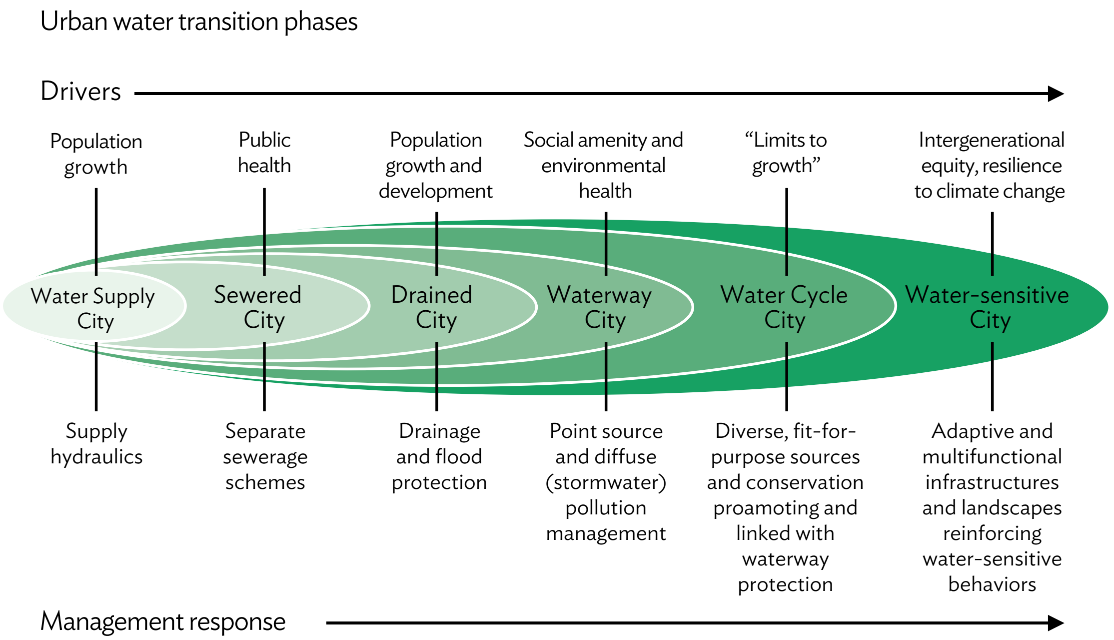
The urban water security (Key Dimension 3 [KD3]) index describes the progress the countries are making to provide better urban water services and management in order to develop vibrant, livable cities and towns. The concept behind KD3 in the Asian Water Development Outlook (AWDO) is based on the Water Sensitive Cities Framework illustrated in Figure A4.1.

The urban water security indicator is based on the performance of the first four stages (drivers) in this framework and is expressed by four subindicators:

(i) piped urban water supply access (% of population)
(ii) urban wastewater collected (% of population)
(iii) economic damage due to floods and storms (% of gross domestic product [GDP])
(iv) river health (taken from KD4).

The framing of urban water security in KD3 focuses predominantly on the state of water infrastructure assets and development within the first three stages. In doing so, it aims to assess the conditions of that infrastructure.

Figure A4.1: Water Sensitive Cities Framework



Source: R. Brown, N. Keath, and T. Wong. 2009. Urban Water Management in Cities: Historical, Current, and Future Regimes. *Water Science and Technology* 59(5): 847–855.

Refer to Appendix 7 for an overview of these subindicators, the units applied, the data sources, data years, and data references. Further information is given in the methodology and data report of AWDO 2016.

Piped Urban Water Supply Access

(i) This subindicator is the same as the one used for KD1, but only for urban areas.
(ii) The main data source for this indicator is the *Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment* report by the Joint Monitoring Programme (JMP) of the World Health Organization (WHO) and UNICEF. It is based on statistics provided by the countries themselves.
(iii) Only piped water supply to premises is taken into account.

Urban Wastewater Collected

(i) This subindicator describes the percentage of the population that has access to a sewerage collection network.
(ii) It is partly based on empirical data and on estimates resulting from a calculation of the percentage of wastewater that is collected.

Economic Damage due to Floods and Storms

(i) This subindicator is calculated based on data of flood and storm damage in cities, the urban population, and gross domestic product.

Changes in Methodology Compared to Asian Water Development Outlook 2013

The methodology for KD3 in AWDO 2016 is the same as in AWDO 2013, with the exception that the maximum value for the river health subindicator is now set at 1 instead of 5.

Scoring Methodology

The applied scoring methodology for KD3 is described in detail in the AWDO 2016 methodology and data report. The main characteristics of the scoring methodology are the following:

(i) Each subindicator is scored from 1 to 5, based on data on the components; the river health subindicator is given a value of 0 or 1 depending on the score of KD4.
(ii) The KD3 score is determined by summing the values of the four subindicators (maximum of 16), multiplied by (i) a factor (between 0.8 and 1) to account for urban growth and (ii) a factor 20/16 (to make KD3 comparable with the other key dimension on a 20-point scale).

The KD3 index was developed by the International Water Centre in Australia who also performed the population of the index and the analysis of the KD3 results.

Table A4.1: Detailed Scores for Urban Water Security by Economy

Economy	Piped Water Supply	Water Supply Index	Waste-water	Waste-water Index	Stand. Loss (% of GDP)	Drainage Index	Urban Factor	River Health Index	KD3 Score	KD3 Score	KD3 Index
Scale	%	1–5	%	1–5	%	1–5	0.8–1	0 or 1	1–16	1–20	1–5
Afghanistan	31	1	17	1	0.5	4	0.8	0	4.8	6.0	1
Armenia	99	5	82	4	0.9	4	1	0	13.0	16.3	4
Australia	100	5	92	5	1.7	4	1	1	15.0	18.8	4
Azerbaijan	88	4	45	1	0.1	5	1	0	10.0	12.5	3
Bangladesh	32	1	26	1	9.6	3	0.8	0	4.0	5.0	1
Bhutan	80	3	51	1	0.0	5	0.8	0	7.2	9.0	2
Brunei Darussalam	100	5	90	5	0.0	5	1	0	15.0	18.8	4
Cambodia	72	3	39	1	36.7	1	0.9	0	4.5	5.6	1
China, People's Republic of	87	4	82	4	2.8	4	0.9	0	10.8	13.5	3
Cook Islands	77	3	74	3	0.0	5	1	1	12.0	15.0	3
Fiji	96	5	71	3	12.3	2	1	1	11.0	13.8	3
Georgia	96	5	76	3	1.1	4	1	0	12.0	15.0	3
Hong Kong, China	100	5	93	5	0.0	5	1	0	15.0	18.8	4
India	54	1	33	1	7.2	3	0.9	0	4.5	5.6	1
Indonesia	32	1	1	1	1.2	4	0.9	1	6.3	7.9	2
Japan	99	5	71	3	1.0	4	1	0	12.0	15.0	3
Kazakhstan	91	5	54	1	0.2	5	1	1	12.0	15.0	3
Kiribati	67	2	39	1	0.0	5	1	0	8.0	10.0	2
Korea, Republic of	99	5	72	3	1.0	4	1	0	12.0	15.0	3
Kyrgyz Republic	88	4	63	2	0.1	5	1	0	11.0	13.8	3
Lao People's Democratic Republic	64	2	65	2	4.9	4	0.8	0	6.4	8.0	2
Malaysia	100	5	94	5	0.5	4	0.9	0	12.6	15.8	4
Maldives	99	5	63	2	0.0	5	0.8	0	9.6	12.0	3
Marshall Islands	4	1	64	2	0.0	5	1	0	8.0	10.0	2
Micronesia, Federated States of	42	1	65	2	0.7	4	1	0	7.0	8.8	2
Mongolia	33	1	38	1	0.9	4	0.9	1	6.3	7.9	2
Myanmar	19	1	50	1	18.7	1	0.9	0	2.7	3.4	1
Nauru	68	2	50	1	0.0	5	1	0	8.0	10.0	2
Nepal	50	1	25	1	2.0	4	0.8	0	4.8	6.0	1
New Zealand	100	5	96	5	0.2	5	1	0	15.0	18.8	4
Pakistan	61	2	45	1	21.6	1	0.9	0	3.6	4.5	1

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Table A4.1 *continued*

Economy	Piped Water Supply	Water Supply Index	Waste-water	Waste-water Index	Stand. Loss (% of GDP)	Drainage Index	Urban Factor	River Health Index	KD3 Score	KD3 Score	KD3 Index
Scale	%	1–5	%	1–5	%	1–5	0.8–1	0 or 1	1–16	1–20	1–5
Palau	97	5	76	3	0.0	5	1	1	14.0	17.5	4
Papua New Guinea	55	1	43	1	1.3	4	0.9	1	6.3	7.9	2
Philippines	58	1	4	1	13.8	2	1	0	4.0	5.0	1
Samoa	91	5	71	3	87.2	1	1	0	9.0	11.3	3
Singapore	100	5	100	5	0.0	5	1	0	15.0	18.8	4
Solomon Islands	61	2	62	2	9.5	3	0.8	1	6.4	8.0	2
Sri Lanka	73	3	57	1	4.9	4	1	0	8.0	10.0	2
Taipei,China	96	5	48	1	0.6	4	1	0	10.0	12.5	3
Tajikistan	83	4	55	1	11.6	2	0.9	1	7.2	9.0	2
Thailand	76	3	67	2	23.0	1	0.9	0	5.4	6.8	1
Timor-Leste	47	1	48	1	0.0	5	0.8	0	5.6	7.0	1
Tonga	73	3	74	3	82.9	1	1	0	7.0	8.8	2
Turkmenistan	81	4	75	3	0.0	5	0.9	1	11.7	14.6	3
Tuvalu	97	5	66	2	0.0	5	1	0	12.0	15.0	3
Uzbekistan	85	4	49	1	0.0	5	1	0	10.0	12.5	3
Vanuatu	60	2	49	1	0.0	5	0.8	1	7.2	9.0	2
Viet Nam	61	2	10	1	12.3	2	0.8	0	4.0	5.0	1

GDP = gross domestic product, KD = key dimension.

Notes: black: based on main source data; blue: estimate made by the International Water Centre based on other sources; green: assumed no change compared to Asian Water Development Outlook 2013.

Source: ADB.

APPENDIX 5

Key Dimension 4—Environmental Water Security

The environmental water security (Key Dimension 4 [KD4]) index is based on the performance of three subindicators:

(i) river health, under a number of driving forces (climate, population, water demand, and industrial and agricultural activities);
(ii) flow regulation, representing the proportion of grid cells in a country where observed monthly discharge is more than 20% different from pristine discharge at least once per year; and
(iii) governance of the environment.

Refer to Appendix 7 for an overview of these subindicators, the units applied, the data sources, data years, and data references. Further information is given in the methodology and data report of the Asian Water Development Outlook (AWDO) 2016.

River Health

(i) The river health subindicator is calculated using a grid-based model of the driving forces (treats) of climate, population, water demand, economic development, and agricultural land use and production change.
(ii) The grid-based results are added up and averaged to determine the country score.

Flow Regulation

(i) The flow regulation subindicator describes the changes in flow regime due to abstractions, return flows, dams and weirs, etc., compared to the pristine situation.
(ii) This subindicator counts the number of months per year where the total discharge differs more than 20% from pristine levels.

Governance of the Environment

(i) The governance subindicator describes the institutional capacity and willingness of each country to reduce and prevent environmental degradation.
(ii) It includes governmental measures to treat wastewater, regulate pesticides, reduce forest loss, and protect terrestrial ecology.

Changes in Methodology Compared with Asian Water Development Outlook 2013

The methodology for KD4 for AWDO 2016 has been redesigned considerably compared with AWDO 2013. The model used to determine the river health has been simplified. KD4 in AWDO 2013 described only river health, while in AWDO 2016 the flow regulation and governance are also included.

Scoring Methodology

The applied scoring methodology for KD4 is described in detail in the AWDO 2016 methodology and data report. The main characteristics of the scoring methodology are the following:

(i) All three subindicators are scored on a scale of 1 to 5. The score for river health is determined by a model, summarizing the pixel results up to the country level.

(ii) The KD4 score is the sum of the three subindicators (maximum of 15), multiplied by a factor 20/15 (to make KD4 comparable with the other key dimension on a 20-point scale).

The KD4 index has been developed by the International Water Centre in Australia who also undertook the population of the index and the analysis of the KD4 results.

Table A5.1: Detailed Scores for Environmental Water Security by Economy

Economy	RHI	RHI Index	Flow	Flow Index	Governance	KD4 Total	KD4 Score	KD4 Index
Scale	0–1	1–5	0–100	1–5	1–5	1–15	1–20	1–5
Afghanistan	0.32	2	88	1	1	4	5.3	1
Armenia	0.14	1	100	1	5	7	9.3	2
Australia	0.61	4	44	3	5	12	16.0	4
Azerbaijan	0.15	1	89	1	3	5	6.7	1
Bangladesh	0.01	1	90	1	2	4	5.3	1
Bhutan	0.27	2	23	4	2	8	10.7	2
Brunei Darussalam	0.25	2	0	5	4	11	14.7	3
Cambodia	0.30	2	70	2	2	6	8.0	2
China, People's Republic of	0.26	2	60	2	2	6	8.0	2
Cook Islands	0.57	4	NA	NA	NA	12	16.0	4
Fiji	0.54	4	0	5	2	11	14.7	3
Georgia	0.24	2	48	3	2	7	9.3	2
Hong Kong, China	0.00	1	NA	NA	NA	9	12.0	3
India	0.07	1	87	1	2	4	5.3	1
Indonesia	0.42	3	22	4	3	10	13.3	3
Japan	0.27	2	62	2	5	9	12.0	3
Kazakhstan	0.40	3	31	4	2	9	12.0	3
Kiribati	NA	NA	NA	NA	2	3	4.0	1
Korea, Republic of	0.06	1	95	1	4	6	8.0	2
Kyrgyz Republic	0.32	2	74	1	2	5	6.7	1
Lao People's Democratic Republic	0.31	2	61	2	2	6	8.0	2
Malaysia	0.27	2	14	5	3	10	13.3	3
Maldives	NA	NA	NA	NA	NA	12	16.0	4

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Table A5.1 *continued*

Economy	RHI	RHI Index	Flow	Flow Index	Governance	KD4 Total	KD4 Score	KD4 Index
Scale	0–1	1–5	0–100	1–5	1–5	1–15	1–20	1–5
Marshall Islands	NA	NA	NA	NA	NA	9	12.0	3
Micronesia, Federated States of	NA	NA	NA	NA	NA	12	16.0	4
Mongolia	0.58	4	43	3	2	9	12.0	3
Myanmar	0.36	3	51	3	2	8	10.7	2
Nauru	NA	NA	NA	NA	NA	12	16.0	4
Nepal	0.20	1	50	3	4	8	10.7	2
New Zealand	0.36	3	9	5	5	13	17.3	4
Pakistan	0.14	1	86	1	3	5	6.7	1
Palau	0.53	3	NA	NA	3	11	14.7	3
Papua New Guinea	0.62	4	0	5	1	10	13.3	3
Philippines	0.15	1	59	2	3	6	8.0	2
Samoa	0.23	2	NA	NA	NA	10	13.3	3
Singapore	0.20	1	0	5	5	11	14.7	3
Solomon Islands	0.93	5	0	5	1	11	14.7	3
Sri Lanka	0.13	1	95	1	4	6	8.0	2
Taipei,China	0.16	1	62	2	4	7	9.3	2
Tajikistan	0.39	3	32	4	2	9	12.0	3
Thailand	0.15	1	90	1	4	6	8.0	2
Timor-Leste	0.17	1	67	2	2	5	6.7	1
Tonga	0.32	2	NA	NA	2	6	8.0	2
Turkmenistan	0.37	3	57	2	1	6	8.0	2
Tuvalu	NA	NA	NA	NA	NA	12	16.0	4
Uzbekistan	0.33	2	51	3	1	6	8.0	2
Vanuatu	0.67	4	0	5	2	11	14.7	3
Viet Nam	0.09	1	78	1	2	4	5.3	1

KD = key dimension, NA = not available, RHI = river health index.

Notes: black: based on data; green: assumed same value as 2013; red: expert estimate by Stephen Blaik, Principal Urban Development Specialist, Pacific Department, ADB.

Source: ADB.

APPENDIX 6

Key Dimension 5—Resilience to Water-Related Disasters

The resilience to water-related disasters (Key Dimension 5 [KD5]) index describes the capacity of a country to cope with and recover from the impacts of water-related disasters. It is based on the performance of three subindicators that describe the resilience of the country against

(i) floods and windstorms,
(ii) drought, and
(iii) storm surges and coastal floods.

Refer to Appendix 7 for an overview of these subindicators, the units applied, the data sources, data years, and data references. Further information is given in the methodology and data report of the Asian Water Development Outlook (AWDO) 2016.

All three subindicators are based on processing of data on exposure, vulnerability, and coping capacity (hard and soft).

Exposure

(i) Describes the population density and growth rate (urban and rural).
(ii) For storm surges and coastal flooding, the proportion of the population in lowland areas is considered.

Vulnerability

(i) Describes general vulnerability characteristics such as percentage of the population with consumption below $1 per day, governance and corruption, development assistance, and infant mortality rates.
(ii) For floods and windstorms, the deforestation rate is included.
(iii) For drought, the agricultural gross production is included.

Coping Capacity

(i) Soft coping capacity parameters included are literacy rate, education, information (TV and mobile), and economic growth.
(ii) Hard coping capacities include potential investment density, total reservoir capacity, and paved road density.

Changes in Methodology Compared with Asian Water Development Outlook 2013

The methodology applied for KD5 in AWDO 2016 is the same as used for AWDO 2013. Some minor adjustments have been made in how coastal floods and storm surges are (not) taken into account in the scores of landlocked countries.

Scoring Methodology

The applied scoring methodology for KD5 is described in detail in the AWDO 2016 methodology and data report. The main characteristics of the scoring methodology are the following:

(i) The data on the components (exposure, vulnerability, and coping capacity) of each subcomponent are standardized to between 0 and 1.

(ii) Based on these values, the resilience of each subindicator is calculated and normalized between 0 and 1. Resilience indicates the ability of the system to recover from the effects of a hazard.

(iii) The KD5 score is the sum of the three subindicators (maximum 3), multiplied by a factor 20/3 (to make KD5 comparable with the other key dimensions on a 20-point scale)

The KD5 approach was originally developed for AWDO 2013 by the International Centre for Water Hazard and Risk Management in Japan. The AWDO 2016 application was performed by ADB.

Table A6.1: Detailed Scores for Resilience to Water-Related Disasters by Economy

Economy	Flood and Windstorms	Drought	Storm Surge/ Coastal Flooding	KD5 Total	KD5 Score	KD5 Index
Scale	0–5	0–5	0–5	max 15	max 20	1–5
Afghanistan	1.0	1.0	NA	3.0	4.0	1
Armenia	2.9	2.5	NA	8.1	10.8	2
Australia	4.6	5.0	5.0	14.6	19.4	5
Azerbaijan	1.9	1.8	1.9	5.6	7.5	2
Bangladesh	1.0	1.0	1.2	3.2	4.2	1
Bhutan	2.0	2.0	NA	6.0	8.0	2
Brunei Darussalam	2.8	2.6	3.3	8.6	11.4	3
Cambodia	1.0	1.0	1.4	3.4	4.5	1
China, People's Republic of	2.5	1.9	3.4	7.8	10.4	2
Cook Islands	3.0	4.0	2.0	9.0	12.0	3
Fiji	2.9	2.3	3.4	8.5	11.4	3
Georgia	3.8	3.2	3.5	10.5	14.0	3
Hong Kong, China	3.1	2.2	3.56	8.9	11.9	3
India	1.0	1.0	1.9	3.9	5.3	1
Indonesia	1.3	1.1	2.3	4.7	6.3	1
Japan	4.9	4.7	5.0	14.6	19.5	5
Kazakhstan	3.5	3.4	NA	10.4	13.8	3
Kiribati	1.0	2.0	1.0	4.0	5.3	1
Korea, Republic of	3.9	3.6	4.4	11.9	15.8	4
Kyrgyz Republic	1.7	1.2	NA	4.4	5.8	1
Lao People's Democratic Republic	1.0	1.0	NA	3.0	4.0	1
Malaysia	2.0	1.8	2.9	6.6	8.8	2
Maldives	1.0	1.0	1.0	3.0	4.0	1
Marshall Islands	2.0	2.0	1.0	5.0	6.7	1

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Table A6.1 *continued*

Economy	Flood and Windstorms	Drought	Storm Surge/ Coastal Flooding	KD5 Total	KD5 Score	KD5 Index
Scale	0–5	0–5	0–5	max 15	max 20	1–5
Micronesia, Federated States of	2.0	3.0	3.0	8.0	10.7	2
Mongolia	1.9	1.7	NA	5.3	7.1	1
Myanmar	2.0	1.0	1.0	4.0	5.3	1
Nauru	4.0	4.0	5.0	13.0	17.3	4
Nepal	1.0	1.0	NA	3.0	4.0	1
New Zealand	5.0	4.8	5.0	14.8	19.7	5
Pakistan	1.0	1.0	1.5	3.5	4.7	1
Palau	4.0	2.0	3.0	9.0	12.0	3
Papua New Guinea	1.0	1.0	1.5	3.5	4.7	1
Philippines	1.6	1.3	2.1	5.0	6.6	1
Samoa	1.1	1.0	2.0	4.1	5.4	1
Singapore	2.9	2.4	3.2	8.4	11.3	3
Solomon Islands	2.0	4.0	4.0	10.0	13.3	3
Sri Lanka	1.8	1.6	2.4	5.8	7.7	2
Taipei,China	4.8	3.3	4.3	12.3	16.4	4
Tajikistan	1.1	1.0	NA	3.2	4.3	1
Thailand	2.5	2.1	3.3	7.9	10.6	2
Timor-Leste	3.0	4.0	4.0	11.0	14.7	3
Tonga	1.0	1.0	1.9	3.9	5.2	1
Turkmenistan	1.01	1.5	NA	3.8	5.1	1
Tuvalu	1.0	2.0	1.0	4.0	5.3	1
Uzbekistan	1.7	1.3	NA	4.5	5.9	1
Vanuatu	1.0	1.0	1.5	3.5	4.7	1
Viet Nam	1.4	1.6	1.9	5.0	6.6	1

KD = key dimension.

Notes: black: based on data; Not applicable: score not given for land-locked countries; red: expert estimate by Stephen Blaik, Principal Urban Development Specialist, Pacific Department, ADB; green: expert estimates by other ADB staff.

Source: ADB.

APPENDIX 7

Overview of Databases Used for the Indicators and Subindicators

	Subindicator	Sub-subindicator	Unit	Data Source	Year of Data	Where Available
KD1	Access to piped water supply	None	%	WHO/ UNICEF (JMP)	2014	http://www.wssinfo.org/data-estimates/tables
	Access to improved sanitation	None	%	WHO/ UNICEF (JMP)	2014	http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html
	Diarrhea disability-adjusted life years (DALYs) per 100,000 people	None	#	WHO	2012	http://www.wssinfo.org/data-estimates/tables
KD2	Broad economy	Coefficient of variation rainfall and storage/ TRWR		FAO AQAUSTAT Literature	2012	Harris et al. (2014) FAO AQUASTAT (2015)
		Total freshwater withdrawal/ TRWR	%	FAO AQAUSTAT World Bank	2013	World Bank (2015) FAO AQUASTAT (2015)
		Storage drought duration		FAO AQAUSTAT World Bank Literature	2000, 2007, 2013	Eriyagama et al. (2009) New et al. (2002) FAO AQUASTAT (2015) World Bank (2015)
		Data availability; # points	#	ADB FAO AQUASTAT IEA USEIA Literature	2010, 2013	ADB (2015a, 2015b, 2015c) FAO AQUASTAT (2015) Harris et al. (2014) Hoekstra and Mekonnen (2012) IEA (2015) USEIA (n.d.) World Bank (2015)
	Agriculture	Total agriculture production/ total agriculture water depletion	$ million/ km^3	IIASA FAO MODIS (NASA) World Bank	2013	ADB (2015c) FAO (n.d.) IIASA and FAO (n.d.) MOD 16 (n.d.) http://modis.gsfc.nasa.gov/data/dataprod/dataproducts.php?MOD_NUMBER=16 World Bank (2015)
		Agriculture good consumption/ agriculture good production	ratio	ADB World Bank Literature	2013	ADB (2015a; 2015b; 2015c) Hoekstra and Mekonnen (2012) World Bank (2015)

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Table *continued*

	Subindicator	Sub-subindicator	Unit	Data Source	Year of Data	Where Available
KD2	Energy	GWh production/ water consumption	GWh/km^3	IPCC IEA Literature	2006, 2010, 2013	Gerbens-Leenes et al. (2008) IPCC (2012) IEA (2015) Mekonnen et al. (2015)
		Present per capita elec. prod. and add. capacity needed	KWh/cap	ADB USEIA	2013	ADB (2015a; 2015b) USEIA (n.d.)
	Industry	Industry GDP/ Industry withdrawal	$ million/ km^3	World Bank	2013	ADB (2015c) World Bank (2015)
KD3	Piped urban water supply access	None	%	WHO/ UNICEF (JMP)	2014	JMP (2015)
	Urban wastewater collected	Empirical data – wastewater collected	%	GWI	2014	GWI (2014)
		Derived data: slum population	% of urban population	United Nations	2014	UN (2015)
		Derived data access to improved sanitation	% of population	JMP	2014	JMP (2015)
	Flood and storm damage	Monetary damage due to flood and storms	$	EM-DAT	2000-2014	EM-DAT (2015)
		Urban population	#	JMP	2014	JMP (2015)
		GDP per capita	% GDP	EM-DAT World Bank	2014	World Bank (2015) UNESCAP (2015)
	River health index		–	ADB	2010	AWDO (2016)
	Urban growth rate	None	%/yr	UNESCAP	2014	UNESCAP (2015)
KD4	River health index	Based on model results	0–1		2010	Manuscript in preparation
		Threat to environmental water security	0–1		2000	Vörösmarty et al. (2010) http://riverthreat.net/data.html
		Total annual runoff	km^3		2000 2010	Warszawski et al. (2013) Contact Balazs Fekete, CUNY Environmental CrossRoads Initiative, bfekete@ccny.cuny.edu
		Population (per grid cell)	# people	CIESIN	2000	CIESIN (2011) (gridded data) http://sedac.ciesin.columbia.edu/data/collection/grump-v1
				IIASA	2000 2010	IIASA, SSP database v1.0 (country population growth) https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about

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Table *continued*

	Subindicator	Sub-subindicator	Unit	Data Source	Year of Data	Where Available	
KD4	River health index	Water demand (water withdrawn from grid cell flow)	km^3		2000 2010	Flörke et. al. (2013) Warszawski et al. (2013)	Center for Environmental Systems Research
		GDP (per grid cell)	$ (billion)		2000	Nordhaus et al. (2006) (gridded data)	http://gecon.yale.edu (World Bank data for each country provide the basis for this spatially distributed data)
				SSP	2000 2010	SSP database v1.0 (country GDP change)	https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about
		Agriculture land use (cultivation/livestock	% area of grid cell	IIASA	2000 2010	Manuscript in preparation	Guenther Fischer, IIASA
		Agriculture production (cultivation/livestock)	Gross value ($)	IIASA	2000 2010	Manuscript in preparation	Guenther Fischer, IIASA
	Flow alteration	Proportion of undisturbed pixels where disturbed flow is defined as monthly discharge being within a 20% difference from natural discharge, at least once per year	%	Lit.	2010	Warszawski et al. (2013) Contact Balazs Fekete, CUNY Environmental CrossRoads Initiative, bfekete@ccny.cuny.edu	
	Environmental management	Wastewater treatment	%	Yale	2014	Yale Environmental Performance Index (2014) http://epi.yale.edu/	
		Pesticide regulation	%		2014		
		Forest loss since 2000	%		2014		
		Terrestrial protection	%		2014		
KD5	General (for all three subindicators)	Exposure population density	#/km^2	UNESCAP	2012	UNESCAP Online Statistical Database	
		Exposure urban growth rate	%	UNESCAP	2012	UNESCAP Online Statistical Database	
		Exposure population growth rate	%	UNESCAP	2012	UNESCAP Online Statistical Database	
		Vulnerability governance (corruption)	index	Transparency International	2014	Transparency International https://www.transparency.org/cpi2014/results	

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	Subindicator	Sub-subindicator	Unit	Data Source	Year of Data	Where Available
KD5	General (for all three subindicators)	Vulnerability % people below $1.25/day	%	UNESCAP	2013	UNESCAP Online Statistical Database
		V. % Net ODA to gross net income	%	World Bank	2012	World Bank Database (World Development Indicators)
		Infant mortality rate / 1,000 births	#	UNESCAP	2013	UNESCAP Online Statistical Database
		CH. pot. investment density		World Bank	2014	World Bank Database (World Development Indicators)
		CS. literacy ratio	%	CIA	2015 est.	CIA World Fact Book
		CS. education (enrolment ratio)	%	UNDP	2014	UNDP Human Development Report
		CS. information (TV/1,000 inh.)	#	NationMaster	2003	NationMaster.com Australia
		CS. Information (mobile/100 inh.)	#	UNSD	2013	Millennium Development Goals Database (United Nations Statistics Division)
		Soft coping capacity econ. growth/gross domestic saving		World Bank	2013	World Bank Database (World Development Indicators)
	Flood and windstorms	Deforestation rate	%	FAO	2005-2010	FAO Global Forest Resources Assessment 2010
		Reservoir capacity per area	m^3/km^2	World Bank GWSP	2012	Total Dam or Reservoir Capacity: Global Reservoir and Dam (GRanD) Database Land Area: World Bank (World Development Indicators)
	Drought	Agricultural part of GDP	%	World Bank	2014	World Bank Database (World Development Indicators)
		Reservoir capacity per area	m^3/km^2	World Bank GWSP	2012	Total Dam or Reservoir Capacity: Global Reservoir and Dam (GRanD) Database Land Area: World Bank World Development Indicators
	Storm surge and coastal flooding	Population proportion living in area below 5 meters	%	World Bank	2000	World Bank Database (World Development Indicators)
		Infrastructure (paved road density)		CIA	2006-2015	CIA World Fact Book

ADB = Asian Development Bank; AQUASTAT = name of database, not an abbreviation; CIA = Central Intelligence Agency; CIESIN = Center for International Earth Science Information Network; EM-DAT = Emergency Events Database; FAO = Food and Agriculture Organization; GDP = gross domestic product; GWh = gigawatt hour; GWI = Global Water Intelligence; GWSP = Global Water System Project; IEA = International Energy Agency; IIASA = International Institute for Applied Systems Analysis; IPCC = Intergovernmental Panel on Climate Change; JMP = Joint Monitoring Programme; KD = key dimension; km^2 = square kilometer; km^3 = cubic kilometer; m^3 = cubic meter; MODIS = Moderate Resolution Imaging Spectroradiometer; NASA = National Aeronautics and Space Administration; SSP = Shared Socioeconomic Pathways; TRWR = total renewable water resources; UN = United Nations; UNDP = United Nations Development Programme; UNESCAP = United Nations Economic and Social Commission for Asia and the Pacific; UNICEF = United Nations Children's Fund; UNSD = United Nations Statistics Division; USEIA = United States Energy Information Administration; WHO = World Health Organization.

Building her own toilet in rural Sri Lanka.

Asian Water Development Outlook 2016

Strengthening Water Security in Asia and the Pacific

The Asian Water Development Outlook charts progress in water security in Asia and the Pacific over the past 5 years. This 2016 edition of the report uses the latest available data to assess water security in five key dimensions: household access to piped potable water and improved sanitation, economic water security, providing better urban water services to build more livable cities, restoring healthy rivers and ecosystems, and resilience to water disasters. The region shows a positive trend in strengthening water security since the 2013 edition of the report, when 38 out of 49 countries were assessed as water-insecure. In 2016, that number dropped to 29 out of 48 countries.

This study was supported by ADB's Water Financing Partnership Facility.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to half of the world's extreme poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

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