Asian Water Development Outlook 2013

Measuring Water Security in Asia and the Pacific

ADB

Asia-Pacific Water Forum

Asian Water Development Outlook 2013

Measuring Water Security in Asia and the Pacific

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Foreword by the Asian Development Bank

This second edition of the *Asian Water Development Outlook* (AWDO) provides the first quantitative and comprehensive view of water security in the countries of Asia and the Pacific. By focusing on critical water issues *Asian Water Development Outlook 2013* (AWDO 2013) provides finance and planning leaders with recommendations on policy actions to improve water governance and guidance on investments to increase their country's water security.

Bindu N. Lohani

Research to prepare this second edition started soon after the 2007 inaugural Asia-Pacific Water Summit in Beppu, Japan, when government leaders and ministers had discussed issues of "Water Security: Leadership and Commitment." Those discussions were informed by the first edition of the *AWDO*, produced for the occasion by a small group of experts commissioned by the Asian Development Bank (ADB) and the Asia-Pacific Water Forum (APWF). For this second edition ADB and APWF involved a wider team of researchers and practitioners across the region, including several of APWF's regional knowledge hubs. Ten knowledge centers contributed to work on this 2nd edition and were guided by advisers from across the region and ADB staff. This approach has allowed the team of experts to work independently, within a common framework, on innovative approaches to measuring and thinking about water security in the region.

In addition to its important findings and recommendations, this report demonstrates that an inclusive approach for measuring water security is possible. The first *AWDO* sensitized the region's leaders to the importance of water security and the need to improve water governance. This edition provides leaders with a quantitative tool for assessment of water security in the region, with specific recommendations for action. The indicators used to measure the various key dimensions of water security in this second edition will be further refined through continued consultation and regional collaboration.

Preparation of the third edition of the *AWDO* has already started with assistance by the Asia-Pacific Center for Water Security, which was established in Beijing in 2011 by Tsinghua University and Peking University in collaboration with ADB. The center will focus on the water–food–energy security nexus through a regional program for research and development.

ADB's Water Financing Program and Water Operational Plan 2011–2020 supports improved water security by investment in infrastructure and services, capacity development, knowledge sharing, and regional cooperation.

I thank the team of experts for completing this report. May it inspire leaders throughout Asia and the Pacific in their drive to increase water security.

Bindu N. Lohani
Vice-President for Knowledge Management and Sustainable Development
Asian Development Bank

Foreword by the Asia-Pacific Water Forum

The *Asian Water Development Outlook 2013* (AWDO 2013) provides leaders in Asia and the Pacific with information on their national water security situation. This new information should inform and inspire them to lead their countries in developing a national water agenda—one that integrates the needs of various sectors and prioritizes the investments and policies that will advance their country along the path to greater water security.

Tommy Koh

The report highlights two realities that need urgent attention and priority action across the region. First, there is alarming inequality in access to improved water services for households of the rich and poor in urban and rural areas. Second, 80% of Asia's rivers are in poor health. The report's messages are therefore important not only to those charged with the tasks of water services and resource management, but crucially also to leaders of national planning and financial management. We cannot claim to live in a civilized society if our people do not have access to safe drinking water or to basic sanitation.

Water security, together with food security and energy security, is ultimately about human security. Unless we increase water security, we may jeopardize the region's development gains and our currently improving living conditions. While the scale and complexity of this multidimensional challenge are huge, solutions are within reach. They can be realized through well designed policies and smart investments sustained by effective water governance.

Governments should assert their leadership role in guiding solutions for water security, including building stronger coalitions with the private sector and civil society. Government–corporate–society partnerships often result in more innovative solutions better suited to tackle the challenges—especially if supported by timely information and knowledge, which is where *AWDO 2013* makes an important contribution.

In both its content and its process of preparation, *AWDO 2013* puts into practice the approaches and principles that the Asia-Pacific Water Forum promotes for regional leaders. It emphasizes leadership and governance, which are critical to providing momentum and direction for sustainable development.

Strong support by the Asian Development Bank and other lead organizations of the Asia-Pacific Water Forum has made this work possible. I commend the report to our region's leaders. It should guide their decisions and actions to address the burning issues of water insecurity and to build more water-secure and resilient communities, cities, and economies.

Tommy Koh
Chair, Governing Council
Asia-Pacific Water Forum

Foreword by the Global Water Partnership

Water security in Asia and the Pacific is under threat from many sources: population growth, urbanization, increasing water pollution, the over-abstraction of groundwater, water-related disasters, and climate change. Current planning and management have proven insufficient to address the challenges of meeting society's diverse needs for water. Improving agricultural water productivity, achieving energy objectives, satisfying growing industrial water requirements, and protecting water quality and vitally important natural ecosystems are challenges we still face. The social, economic, and political consequences of water shortages are real, as are the effects of water-related disasters exacerbated by climate change.

Mohamed Ait-Kadi

The *Asian Water Development Outlook 2013* (AWDO 2013) is the product of an immense amount of work. It provides a robust, pragmatic, and readily understood framework to assess water security. The care with which water security in Asia and the Pacific is analyzed to develop a composite index is commendable. With its focus on outcomes—a future we want—the framework supports effective decision-making through the analysis of each key dimension of the water security challenge. The basic message is one of urgency, and the recommended policy levers help to elaborate action agendas for water security in each country, river basin, and city.

The Global Water Partnership's vision is for a water-secure world where the dimensions of water security are addressed together through the process of integrated water resources management. The goal is to increase water security by balancing societal requirements with the availability of natural water resources. This requires long-term engagement of governments with private and civil society partners to address usage and wastage, retention and pollution, and balancing today's needs with those of future generations. Hence, understanding the connectivity between the multiple dimensions of water security is a critical step in effective policy design, policy implementation, and consensus building. Political will, as well as political skill, needs visionary and strong leadership to bring opposing interests into balance, to inform policy making with scientific understanding, and to negotiate decisions that are socially accepted.

AWDO 2013 offers countries a helpful framework for collecting and processing data in ways that enable them to track their progress toward national water security. The challenges to increased water security are rooted in political, economic, social, and environmental issues which are becoming more entwined and cannot be solved unless a broader set of stakeholders are involved in long-term collaboration.

Mohamed Ait-Kadi
Chair, Technical Committee
Global Water Partnership

About the *Asian Water Development Outlook*

How the *Asian Water Development Outlook* Started

Water security is both an increasing concern and an imperative critical need for sustainable development in Asia and the Pacific. Increasingly frequent floods and droughts, uncontrolled releases of pollutants to rivers and lakes, and high levels of political dialogue about climate change impacts have brought water issues to the notice of the public across the region. Expanding populations need more water for drinking, hygiene, and food production. Expanding economies require an increased energy supply, which in turn relies on access to more water. Most of the industries that are driving economic growth across the region require reliable supplies of freshwater in some part of their process. At the same time, as communities become wealthier, the demand for protection of ecosystems increases. Competing demands on water resources for these different uses make integrated water resources management essential to enable provision of secure water services.

The *Asian Water Development Outlook* (AWDO) was created by the Asia-Pacific Water Forum (APWF) and the Asian Development Bank (ADB) to highlight important water management issues. The first edition of *AWDO*[1] was published in 2007 to inform leaders meeting at the first Asia-Pacific Water Summit in Beppu, Japan.[2] 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.[3] The 2007 report was well received by leaders, practitioners, and the media and is available in four languages. In response to the two key messages of *AWDO 2007* and the Beppu summit, APWF and ADB 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* introduces 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.

Mobilizing Regional Knowledge

AWDO 2013 draws on the expertise of ten of the leading water knowledge organizations in Asia and the Pacific, with additional guidance from specialists drawn from all five subregions (please see Acknowledgments).[4] Working as a team, these organizations have used their geographic and intellectual diversity to create a shared vision of water security and to develop a practical methodology to measure the region's progress toward that vision. The team included several regional knowledge hubs, established at the request of the region's leaders at the 2007 Beppu summit. The knowledge hubs are intended to help the region navigate toward a secure water future.[5]

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1 ADB. 2007. *Asian Water Development Outlook 2007*. Manila.

2 Asia-Pacific Water Forum. 2007. *First Asia-Pacific Water Summit: Message from Beppu*. Beppu, Japan.

3 *AWDO 2007* also included a proposal for a methodology to measure the region's performance in providing water supply through the Index of Drinking Water Adequacy.

4 The five subregions are Central and West Asia, East Asia, South Asia, Southeast Asia, and the Pacific.

5 The Asia-Pacific Water Forum's Knowledge Hubs initiative includes 17 hubs to address important topics for water security. Each hub connects and serves a network of clients and partners in its specific knowledge domain. Such knowledge networking is helping local leaders adapt better solutions and inform national leaders at subsequent water summits about progress and priorities. See http://www.apwf-knowledgehubs.net.

This edition of *AWDO* presents the findings of empirical studies used to assess the state of water security in Asia and the Pacific. The *AWDO 2013* indicators characterize the complex role of water in human, social, economic, and environmental evolution. Although there may be an appearance of oversimplification of some of the issues in the definition of the indexes used, this simplification is a reflection of the present availability of reliable data on which to base assessments.

The indexes presented here are the last word in measuring water security, and individual key dimensions and composite indicators may be further refined in the preparation of future editions of *AWDO*. Nonetheless, the present indexes are an important initial achievement—the first steps toward creating an objective framework to quantify national and regional water security.

A Vision and Framework for Water Security

The quantitative measurement of water security introduced by *AWDO 2013* lays a foundation for measurement of progress toward a water-secure future for the people of Asia and the Pacific. The country-based findings, rankings, and key messages in the report indicate directions and priorities for increased investment, improved governance, and expanded capacity building. *AWDO* also provides a baseline for the analysis of trends and the impact of policies and reforms that can be monitored and reported to stakeholders through future editions of *AWDO*.

In developing the analytical framework, the team crafted a shared vision of water security:

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.**

This shared vision provided the basis for a new, more comprehensive definition of water security. By measuring water security in five dimensions, *AWDO* provides leaders with new ways to look at their countries' strengths and weaknesses in water resource management and service delivery. *AWDO 2013* includes groundbreaking research undertaken to develop new tools to quantify water security in the region. By explicitly recognizing the tensions that now exist between alternate uses of water, the *AWDO* indicators provide leaders with tools to more confidently and appropriately allocate resources to achieve greater water security.

Taking the Lead

Creating improvements in water security will not happen without committed leadership by politicians, water sector professionals, and leaders of civil society. The data and tools presented in *AWDO 2013* provide a basis for measuring the effect of actions to drive increases in water security for individuals, economies, environments, and nations. Coordinated action requires a shared vision, motivated actors, and creation of momentum fueled by knowledge and determination to achieve a secure water future in Asia and the Pacific. Leaders and civil society will have to take deliberate steps to address areas of poor performance; otherwise, water security will not be increased. *AWDO 2013* indicates the areas in which leaders can initiate action to put their countries on a path to greater water security. The *AWDO* indicators can help leaders choose actions

that will bring about a more water-secure future for all in Asia and the Pacific. Because of the critical role of governance, water security has become as much a choice as a goal.[6]

Continuing the Story

The drive to increase water security in Asia and the Pacific will continue beyond the publication of *AWDO 2013.* In 2011, the Asia-Pacific Center for Water Security was established by Tsinghua University and Peking University, in partnership with ADB. The center will take a leading role in further refinement of the *AWDO* tools and techniques to enable more detailed measurements of water security in the future. In this way, the work of *AWDO* will be transformed from a team project into an ongoing regional program. The work of the Asia-Pacific Center for Water Security will strengthen collaboration among governments, leaders of civil society, water sector professionals, and research partners. Together, these partners will generate new information and knowledge sharing, research, and capacity development, and will support the development of leadership for water security. Work has already begun to downscale the indicators to support more detailed analysis of water security in river basins and administrative regions.

Numbers can never tell the entire story, or at least not very fairly. The assessments of water security presented in *AWDO 2013* must be recognized as a first snapshot, which does not yet measure or show progress and trends. *AWDO 2013* does provide a new baseline for leaders to assess progress toward water security. For all the worrisome stories of water insecurity in the region, there also are inspiring stories of leadership, response, and innovation—and not just in the advanced economies but also in the towns and basins in developing economies across the region.

Supported by collaborative initiatives, subsequent editions of *AWDO* will include analysis of the impact of policy and governance decisions on the status of water security.

Reading the *Asian Water Development Outlook 2013*

AWDO 2013 is presented in three parts. Part I introduces the five key dimensions of water security and presents the combination of indicators for assessment of national water security. The assessments for individual countries are aggregated to provide regional snapshots, with overviews of what the findings mean, identifying regional issues and hot spots where urgent action is required to improve water security.

Part II applies the indicators to demonstrate how countries in Asia and the Pacific measure up against the *AWDO* vision of water security, discusses what is at stake, and introduces policy levers that may be used to increase security in each key dimension. It summarizes the background papers and analyses that underpin this edition of *AWDO.*[7]

Part III presents a summary of policy and strategic actions to increase water security, synthesized as key messages to assist political, water sector, and civil society leaders guide actions on water security nationally, in river basins, and in communities.

6 Water governance may be defined as the range of political, social, economic, and administrative systems that are in place to regulate the development and management of water resources and the provision of water services at different levels of society. See http://waterwiki.net/index.php/Q%26A:_Water_Governance#Most_widely_used_definition.

7 Background papers and additional case studies are available on the *AWDO 2013* supplementary DVD, and the printed edition is available on the APWF website at http://www.apwf.org.

PHOTOS: AFP


Household
Water Security
Key Dimension 1
• Access to piped water supply
• Access to improved sanitation
• Hygiene
Economic
Water Security
Key Dimension 2
• Agricultural water security
• Industrial water security
• Energy water security
National
Water
Security
Urban Water Security
Key Dimension 3
• Water supply
• Wastewater treatment
• Drainage
Resilience to
Water-related
Disasters
Key Dimension 5
• Exposure
• Vulnerability
• Hard coping capacities
• Soft coping capacities
Environmental Water Security
Key Dimension 4
• Watershed disturbance
• Pollution
• Water resource development
• Biotic factors

AFP

Part I

Taking Stock: An Objective Framework for Water Security

Enjoying a public fountain: Countries around Asia and the Pacific are working to develop vibrant, livable cities and towns.

AFP

The Stage and Agenda

At the inaugural Asia-Pacific Water Summit, held in Beppu, Japan, in December 2007, regional leaders of finance, planning, and the water sector gathered to discuss the state of the region's water security and the role of governance. In their *Message from Beppu,* the leaders recognized first and foremost that access to safe drinking water and sanitation is a basic human right (footnote 2). Second, they agreed to substantially increase the allocation of resources to improve water governance, seeking greater efficiency, transparency, and equity. Third, leaders called on the Asia-Pacific Water Forum to establish regional knowledge hubs to research and advise on important water security issues. The intent is to encourage wider knowledge sharing and to connect local leaders with information that will help them develop better solutions.

The world has changed since Beppu. Some countries have succeeded in moving water up the national development agenda and have made progress with reforms and investments. After Typhoon Ketsana devastated parts of Metro Manila in 2009, the Philippines president signed into law the Philippine Climate Change Act of 2009, which is one of the most comprehensive and integrated pieces of legislation in the region so far. When effectively implemented, the law will improve communities' resilience to water-related hazards. In 2011, the People's Republic of China (PRC) Number One Decree, an annual policy paper that details the central government's policy priorities, committed to doubling annual investment in the water sector, reaching CNY4 trillion ($608 billion) by 2020.[8] These significant investments will focus on addressing the country's growing water scarcity, degradation of water resources and water quality, and increased exposure to flood hazards. In 2012, the PRC set performance targets for industry, irrigation, and water quality, supported by institutional measures to drive increased water security as an essential base for a sustainable economy.[9]

8 Central Communist Party Committee and State Council. 2011. *Decision on Speeding up the Reform and Development in the Water Sector*. Beijing.

9 Central Communist Party Committee and State Council. 2012. *Regulation on Implementing the Strictest Water Resources Management System*. Beijing.

AFP

Global and regional events since Beppu have brought the importance of water into the public eye. First, the effect of the global financial crisis on capital markets has constrained investment in water security in many countries in the region. Second, recurring spikes in food prices related to floods and droughts have exposed the vulnerability of national food security. And third, a number of extreme weather events have caused floods and droughts that have been catastrophic. The lives lost, damages, and direct economic losses have put a strain on employment, social services, and infrastructure.

What has not changed since Beppu in 2007 is the need for better governance. As the first edition of *AWDO* (2007) stated, "If some of the Asian DMCs [developing member countries] face a water crisis in the future, it will not be because of physical scarcity of water, but because of inadequate or inappropriate water governance ... Major and fundamental changes in water governance practices are needed in nearly all the Asian DMCs."(footnote 1).

Water scarcity is a historical and geographic reality for some countries, especially in the dry season; however, it also can be an outcome of flawed policies and management systems. It is increasingly evident that water governance remains as relevant today as ever. Good management of both natural and human-induced water problems will contribute to achieving economic, social, and environmental progress and security.

The indicators for each of the five dimensions of water security help governments and civil society assess progress toward national water security.[10] By measuring national water security as an aggregate of the indicators (Figure 1), the interdependent nature of water uses is explicitly recognized. This interdependence means that increasing water security in one dimension may affect security in another dimension while simultaneously increasing or decreasing the indicated overall national water security.

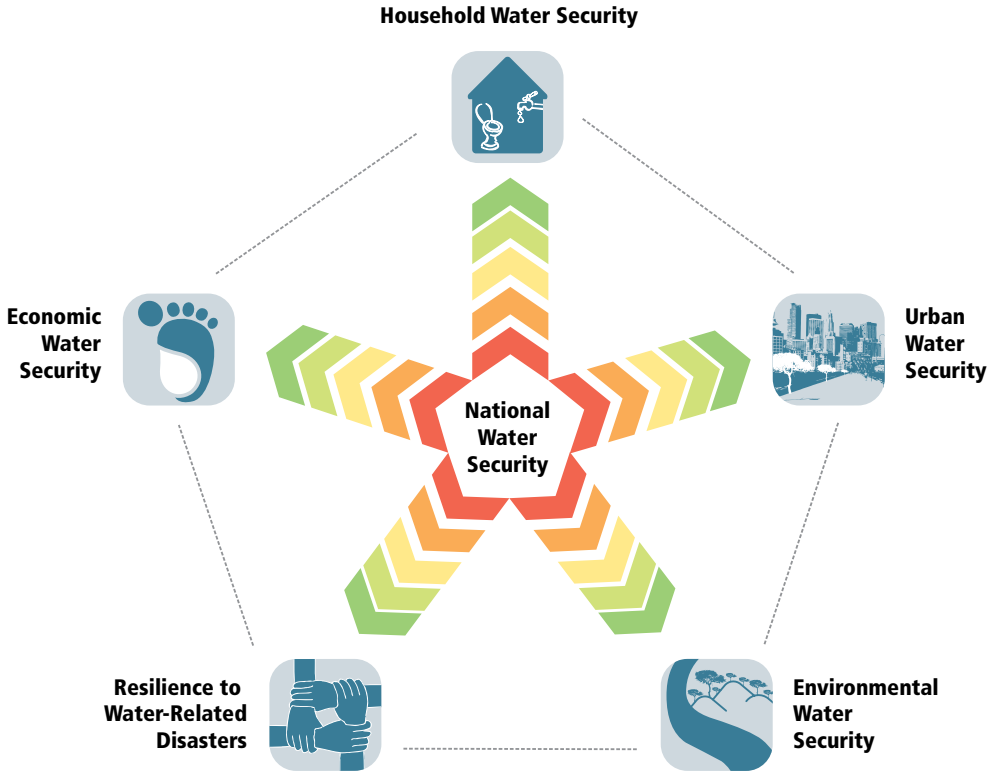
Water Security in Five Dimensions

AWDO measures water security in five key dimensions (Table 1) because a single focus on any one of these is insufficient to guide decisions or assess outcomes in the water sector. The AWDO vision of water security is designed to represent the multiple dimensions of water in people's lives and livelihoods, with poverty reduction and governance as crosscutting perspectives in each of the five dimensions.

10 Further details about the composition of each of these indexes are provided in Part II of this report, in the appendixes, and in the background reports on the *AWDO 2013* supplementary DVD.

FIGURE 1

Water Security Framework of Five Interdependent Key Dimensions



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 43% of the population currently lives in urban areas; however, the urban proportion has risen by 29% over the past 20 years, more rapidly than in any other region.[11] 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.

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.

11 United Nations Economic and Social Commission for Asia and the Pacific. 2011. *Statistical Yearbook for Asia and the Pacific 2011*. Bangkok. Available at http://www.unescap.org/stat/data/syb2011/I-People/Urbanization.asp.

TABLE 1

Asian Water Development Outlook Framework for Assessing National Water Security

Key Dimension	Index	What the index measures
National Water Security	National water security	How far countries have progressed toward national water security. The index combines the five dimensions of water security, measured by key dimensions 1 to 5 (see Appendix 1).
Key Dimension 1	Household water security	To what extent countries are satisfying their household water and sanitation needs and improving hygiene for public health. The household water security index is a composite of three subindexes (see Appendix 2).
Key Dimension 2	Economic water security	The productive use of water to sustain economic growth in food production, industry, and energy. The index is a composite of three subindexes (see Appendix 3).
Key Dimension 3	Urban water security	Progress toward better urban water services and management to develop vibrant, livable cities and towns. The index is a composite of three subindexes (see Appendix 4).
Key Dimension 4	Environmental water security	How well river basins are being developed and managed to sustain ecosystem services. The index is determined by spatial analysis of four subindexes of river health (see Appendix 5).
Key Dimension 5	Resilience to water-related disasters	The capacity to cope with and recover from the impacts of water-related disasters. The index is a composite of three subindexes (see Appendix 6).

Note: Full definitions of the derivation of the indicators and data are provided on the *AWDO 2013* supplementary DVD.

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.

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

The meanings of the five stages of water security assessment are summarized in Table 2. At National Water Security Index (NWSI = 1 or Stage 1), the national water situation is hazardous and there is a large gap between the current state and the acceptable levels of water security. At NWSI Stage 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. No countries in Asia and the Pacific were found to have reached stage 5 by 2012.[12]

12 The following countries have achieved the respective National Water Security Index (NWSI) values: NWSI = 1: Afghanistan,

TABLE 2

Description of National Water Security Stages

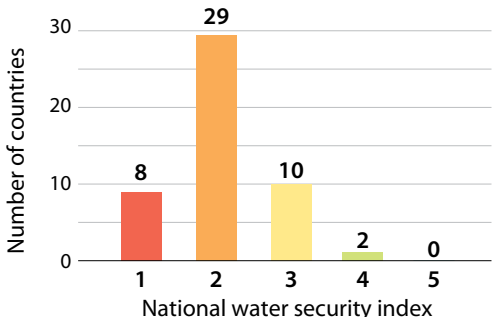
National Water Security Index	National Water Security Stage	Description
5	Model	Sustainable local agencies and services; sustained sources of public financing for water and environmental protection and management; sustainable levels of public water consumption; and government demonstrating new models of water governance, supporting advanced technology, supporting research and development, and initiating or leading international partnerships.
4	Effective	Water security initiatives built into key national, urban, basin, and rural development master plans; high priority on national development agenda; public investment reaching appropriate levels; effective regulation; and public awareness and behavioral change are a government priority.
3	Capable	Continuous capacity building; improving rates of public investment; stronger regulation and enforcement; national development agenda prioritizing water and environment; and focus shifting toward improving local technical and financial capacity.
2	Engaged	Legislation and policy supported by government capacity-building programs; institutional arrangements improving; and levels of public investment increasing (although these rates may still be inadequate).
1	Hazardous	Some legislation and policy on water and environment, and inadequate levels of public investment, regulations, and enforcement.

Note: These descriptions relate the water security stage with various governance factors that are likely to be true of countries at the indicated stage.

Appendix 1 presents the summary of assessments of each key dimension, and the estimated national water security stages are summarized in Figure 2. The underlying causes of 37 of the 49 countries being assessed as remaining at National Water Security Stage 1 or Stage 2 are discussed in more detail in Part II.

FIGURE 2

National Water Security in Asia and the Pacific



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

Vision, Reality, and Hot Spots

Detailed data for each country is given in the appendixes, and fuller descriptions of the development of the indicators are given in the background papers on the *AWDO 2013* supplementary DVD.

The countries and regions[13] with low index values for water security are described as hot spots, where additional efforts and well-targeted investments are required to improve water security. Countries in regions with low levels of water security may be expected to be disproportionally affected by the potential effects of climate change and other stresses on water management. The effect of climate change on livelihoods and economies in these regions could become disastrous unless targeted measures are taken to improve the specific water security dimensions that leave countries especially vulnerable.

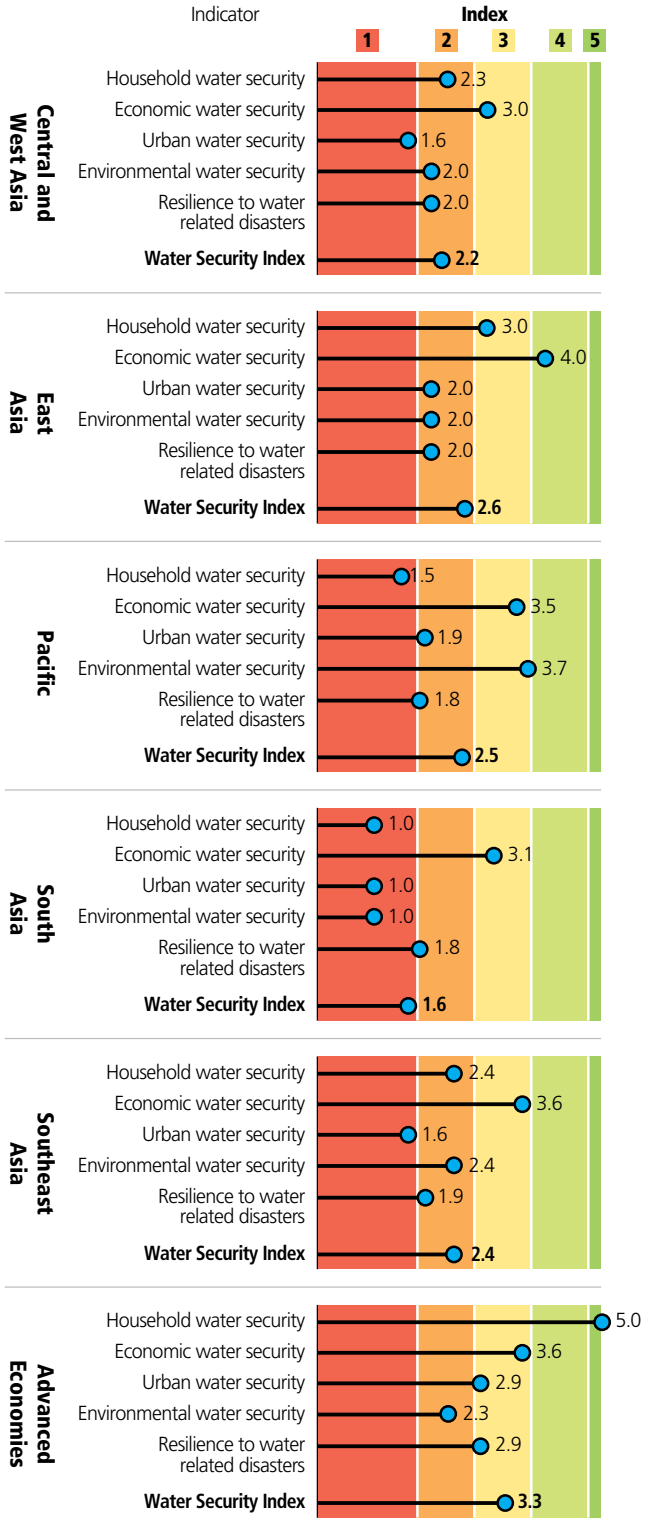
At a regional scale (Figure 3), the Water Security Index confirms South Asia (Water Security Index = 1.6) as a hot spot where populations and economies are being adversely impacted by poor water security. South Asia is less secure than all other regions in terms of its household water security (including sanitation), urban water security, environmental water security, and resilience to water-related disasters. South Asia is slightly more secure in its economic water security than Central and West Asia. Central and West Asia is second lowest-ranked for overall regional water security.

Advanced economies are the most water-secure in the region, as indicated by their higher national water security scores. However, the Great East Japan Earthquake and tsunami in March 2011 and flooding in Thailand in late 2011 have demonstrated that countries are vulnerable to water-related hazards regardless of their economic development. These events also brought into sharp focus the increased connection between economies

13 Central and West Asia: Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. East Asia: People's Republic of China, Mongolia, and Taipei,China. Pacific: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu. South Asia: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Southeast Asia: Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam. Advanced economies: Australia; Brunei Darussalam; Hong Kong, China; Japan; New Zealand; Republic of Korea; and Singapore.

FIGURE 3

Regional Water Security Index by Subregion (population-weighted)



Note: The subregional index values are population-weighted averages of the values for individual countries. The composite National Water Security Index values are the simple averages of the five key dimension index values. To ensure that every country is represented in the index, expert opinions were given in place of missing data.

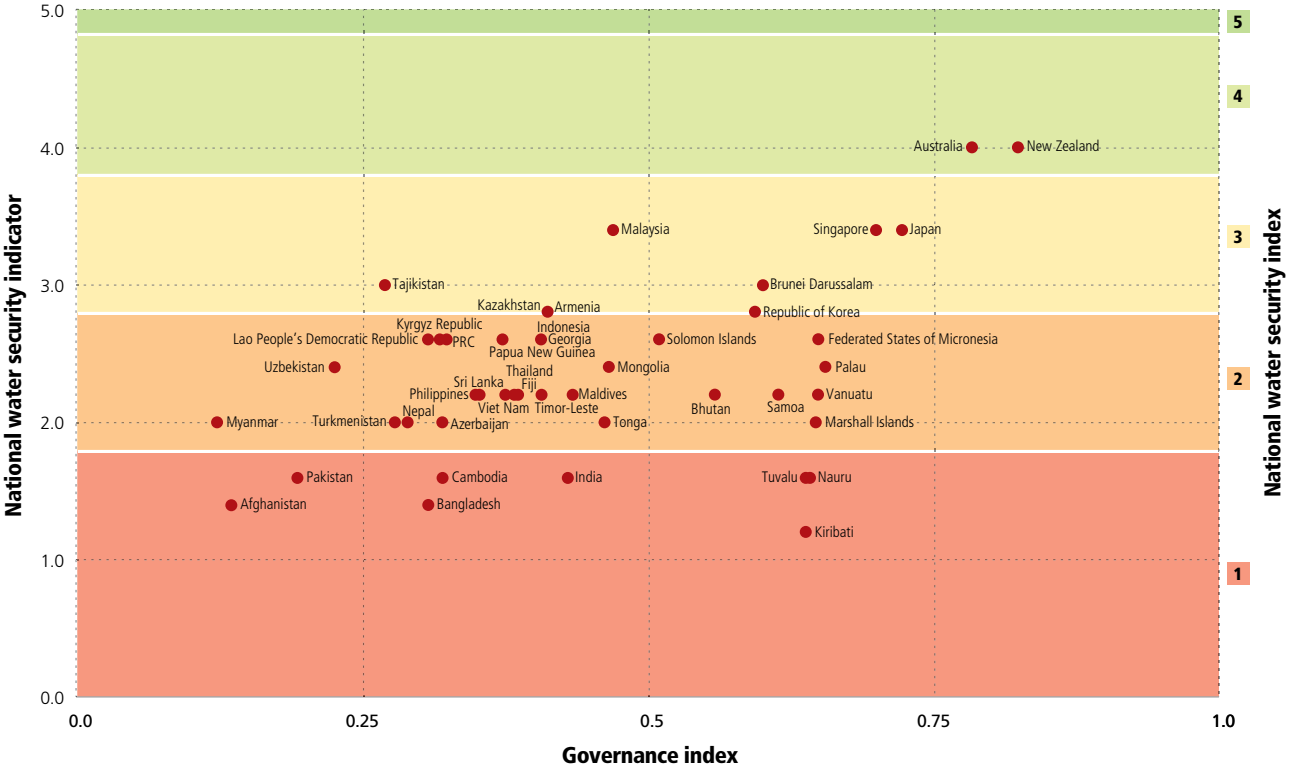
and production chains and the vulnerability of supply chains to disruption by natural events. As a result of increased regional integration, the economic water security of one country can have significant impacts that extend well beyond its own borders.

For each country, the assessment of water security in each key dimension indicates sectors where the allocation of resources for capacity building and focused investments could accelerate the movement toward a secure water future. The indexes also indicate where further effort and investments are required to achieve the vision of a water-secure society that will support inclusive social and economic development. In *AWDO 2007,* the importance of good governance in determining the extent of water security was raised. Combining assessments of national water security with World Bank statistics on governance shows that, with some exceptions, the better the governance assessment the higher the water security assessment (Figure 4).

The *AWDO* water security framework provides the essential foundation for leaders to kick-start transformational changes in management of the water sector. These changes will be essential to drive improvement in how the region's industrial, agricultural, and household users think about and use the precious resource, water. Without clear and committed leadership to guide these changes the full potential to increase water security for all of Asia and the Pacific's multiplicity of water users may be lost. Where leaders make the choice to commit to action, the analysis made possible by *AWDO 2013* will provide the means to measure the impacts of those choices. What is clear is that the progress made so far in the individual water use sectors is no guarantee for a water-secure future for many of the people and economies in Asia and the

FIGURE 4

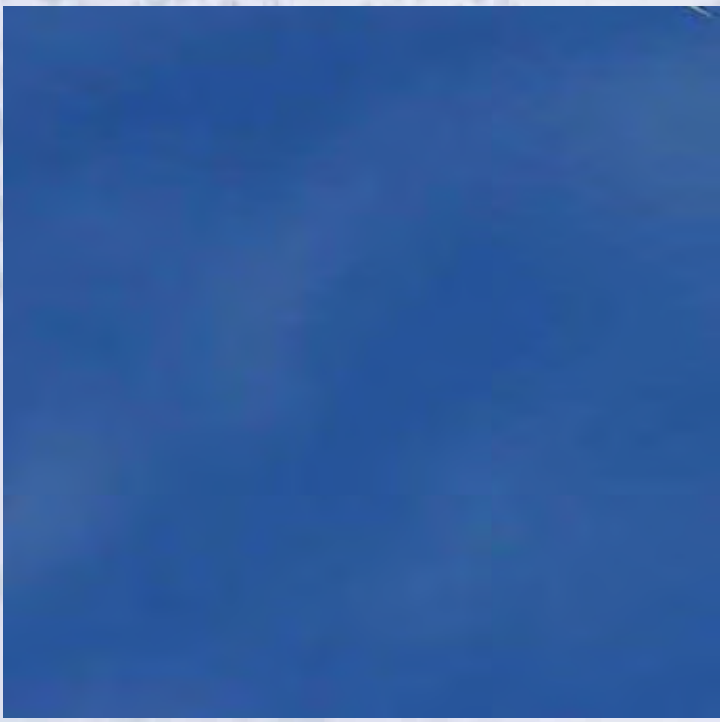
National Water Security and Governance



PRC = People's Republic of China.

Source: World Bank. Worldwide Governance Indicators. http://info.worldbank.org/governance/wgi/index.asp2013.

Pacific. Weaknesses in one key dimension can threaten the progress made in another. *AWDO* will help in determining how to keep the balance between water uses and assess potential trade-offs between competing demands.



AFP

Part II

Taking the Pulse: Measures of Water Security and Policy Levers

Waiting for water in Bangladesh: Providing reliable and safe water is an essential foundation for eradicating poverty.

AFP

The *Asian Water Development Outlook 2013* (*AWDO 2013*) provides political leaders, decision makers, and water sector professionals with a comprehensive assessment of water security in Asia and the Pacific. The first edition of *AWDO*, in 2007, brought together a collection of facts, data, and experiences to provide a comparative overview of water and sanitation in the countries of Asia and the Pacific.[14] This 2013 edition of *AWDO* again brings together a wide array of data on the region and presents new tools for assessing water security that build on the findings of *AWDO 2007*. This is the first step toward a systematic approach to quantifying national, basin, and city water security, bringing together a wide array of data to assess progress toward water security using standardized indexes.[15]

The following sections present assessments of water security for 49 countries in Asia and the Pacific.[16]

A summary of national water security estimates is given in Appendix 1, with further details of the assessment of each dimension of water security given in Appendixes 2 to 6. The implications of low water security are discussed, and policy options enabling leaders to increase water security are offered.

14 *AWDO 2007* introduced an index of drinking water adequacy, developed by Bhanoji Rao and described in ADB. 2007. *Access to Drinking Water and Sanitation in Asia: Indicators and Implications*. Discussion paper on the *Asian Water Development Outlook DVD*. Manila.

15 Detailed descriptions of the *AWDO* vision and analysis of water security in each of five key dimensions are provided on the *AWDO 2013* supplementary DVD attached to this report. Background papers present the underlying assumptions and derivation of the selected indicators. *AWDO 2013* papers and data are also available on ADB's water website at http://www.adb.org/water.

16 Analysis is presented for each country when sufficiently reliable data are available in the public domain. Where data were not available, expert opinion was used to estimate index values.

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An Acehnese woman bathes her baby. There is a widening gap between the rich and poor in urban areas in Asia when it comes to access to secure, clean water. AFP

Key Dimension 1: Household Water Security

To satisfy household water supply and sanitation needs in all communities

Asia and the Pacific is an early achiever of the Millennium Development Goal (MDG) of halving the proportion of people without access to safe drinking water (MDG Target 10).[17] Unfortunately, this commendable achievement has been obtained with extremely uneven results among countries and with a further widening of the divide between rich and poor and between urban and rural populations. Furthermore, the target makes no distinction between secure piped access to households and other forms of improved water supply. And finally, the sanitation target

17 United Nations Children's Fund (UNICEF) and World Health Organization (WHO). 2012. *Progress on Drinking Water and Sanitation—2012 Update*. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. New York.

has not been achieved. The household water security index measures the achievement of a higher standard of services, including piped water supply, access to improved sanitation, and hygiene (Box 1). The estimated household water security in 49 countries in Asia and the Pacific is summarized in Appendix 2.

BOX 1

Key Dimension 1—Household Water Security Index

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. The household water security index is a composite of three subindexes:

- access to piped water supply (%),
- access to improved sanitation (%), and
- hygiene (age-standardized disability-adjusted life years per 100,000 people for the incidence of diarrhea).

See Appendix 2 for more detail.

This index was developed for the *Asian Water Development Outlook* by the United Nations Economic and Social Commission for Asia and the Pacific.

How Does Asia and the Pacific Measure Up?

Access to water supply. Between 1990 and 2010, 18% more households in the region gained access to an improved supply of water (piped and non-piped). This achievement translates into an additional 1.7 billion people gaining access to safe water, confirming, in broad terms, that Asia has achieved the MDG water supply target. However, this achievement masks the wide variation in service provision among and within subregions. According to the MDG figures, the proportion of the region's population with access to improved drinking water sources has increased from 74% to 91%. Progress has been made in all subregions except the Pacific, where access remains low in both relative and absolute terms, at 54%. The Pacific subregion has not yet been successful in reducing the proportion of people without access to safe drinking water.

Clean hands in Myanmar: More than 900 million people in Asia gained access to piped water supply between 1990 and 2010.

AFP

Access to piped water supply. Using the more stringent target of access to safe piped water supply, the data show a significantly different story. Although more than 900 million people gained access to piped water supply between 1990 and 2010, this still means that more than 65% of the region's population does not have what should be considered a secure household water supply. In the Pacific islands, the situation is even less encouraging, with only an average 21% of the population having a piped water supply. As shown in Figure 5, throughout Asia and the Pacific, the number of people with a tap in the house lags significantly behind the overall MDG figures for improved water supply.

Access to sanitation. Sanitation coverage in Asia and the Pacific remains a bigger and still unfulfilled challenge. MDG Target 10—to reduce by half the proportion of people without access to improved sanitation—will not be met in the region by 2015. Although the percentage of people with access to improved sanitation facilities rose from 36% in 1990 to 58% in 2010, 1.74 billion people in Asia and the Pacific continue to live without access to improved sanitation. More than 792 million people still suffer the indignity of practicing open defecation, and more than 631 million of these people live in rural South Asia (footnote 17). By 2010, only around 58% of people had access to improved sanitation, and it is unlikely that sanitation coverage will reach 62% by 2015, the coverage required to achieve the MDG target. There are some bright spots, with Southeast Asia making rapid progress, expanding coverage by 23% between 1990 and 2010, and East Asia expanding coverage by 35% in the same period. However, although South Asia has increased access to improved sanitation by 16%, only about 38% of the population was covered in 2010.

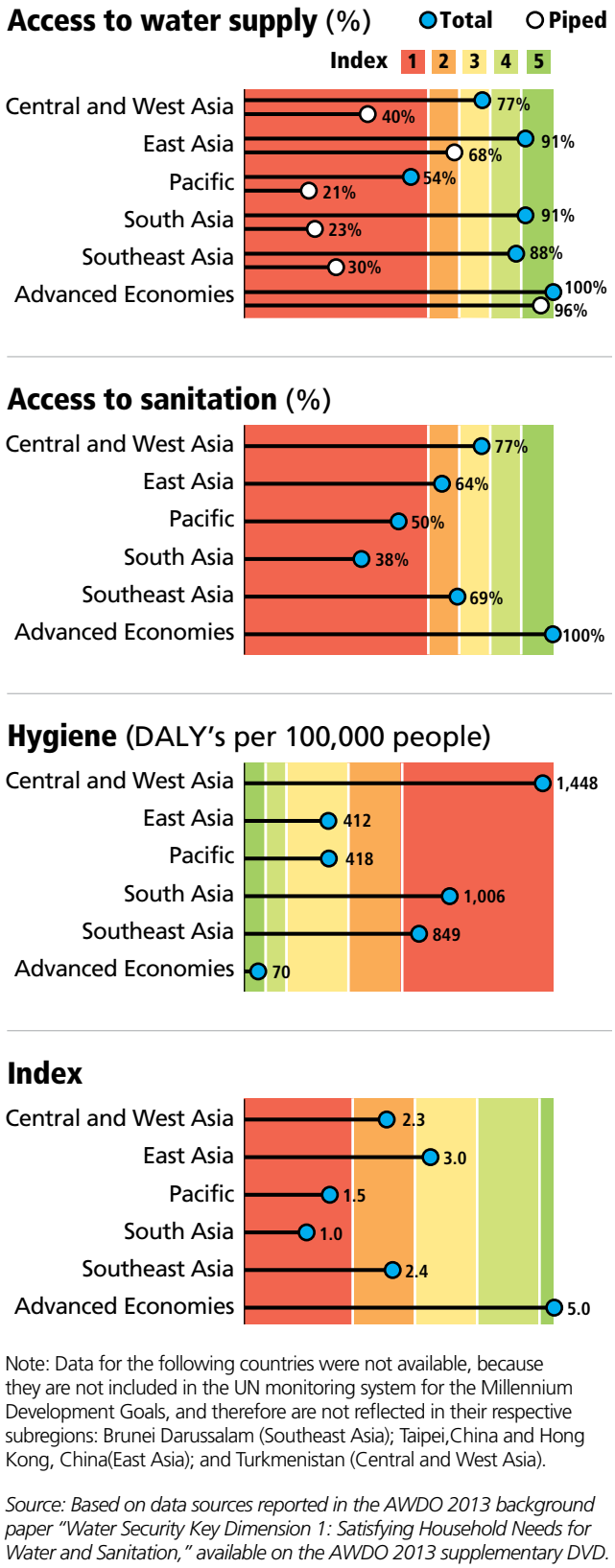
South Asia is a hot spot where urgent efforts are necessary to reverse the stark and alarming inequity of access that persists, particularly in rural areas. It is estimated that 90%–96% of the rural rich have access to sanitation, whereas only 2%–4% of the rural poor have access. Disappointingly, there has been little progress on improving access to sanitation in the Pacific islands (50%).

Hygiene. Diarrheal diseases are caused mainly by the ingestion of pathogens in water.[18] About 88%

18 Poor water quality, inadequate treatment, inadequate sanitation, and poor hygiene are the perfect public health storm, creating a pathway for transmission of pathogens through surface and groundwater into food and drinking water, and through contact with human and animal excreta.

FIGURE 5

Household Water Security by Subregion (population-weighted)

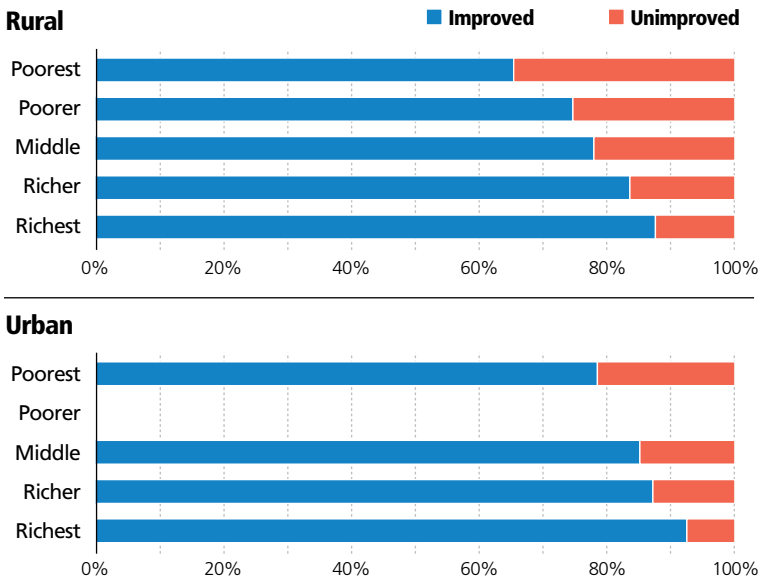


Note: Data for the following countries were not available, because they are not included in the UN monitoring system for the Millennium Development Goals, and therefore are not reflected in their respective subregions: Brunei Darussalam (Southeast Asia); Taipei,China and Hong Kong, China(East Asia); and Turkmenistan (Central and West Asia).

Source: Based on data sources reported in the AWDO 2013 background paper "Water Security Key Dimension 1: Satisfying Household Needs for Water and Sanitation," available on the AWDO 2013 supplementary DVD.

FIGURE 6

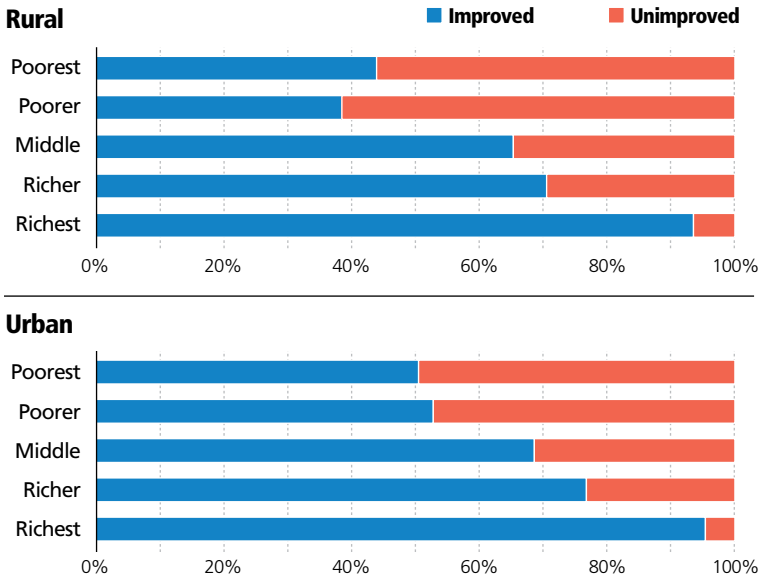
Access to Improved Water Supply—Piped and Non-Piped (%)



Source: United Nations Children's Fund (UNICEF) and World Health Organization (WHO). 2012. Progress on Drinking Water and Sanitation—2012 Update. *WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. New York.*

FIGURE 7

Access to Improved Sanitation (%)



Source: United Nations Children's Fund (UNICEF) and World Health Organization (WHO). 2012. Progress on Drinking Water and Sanitation—2012 Update. *WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. New York.*

of all diarrhea cases worldwide have been attributed to lack of adequate access to water and sanitation.[19]

To measure the health impact of improved access to water supply and sanitation services, *AWDO 2013* assesses hygiene status using the age-standardized disability-adjusted life years (DALYs) index, which measures the diarrheal incidence per 100,000 people.[20]

The hygiene status of people in Central and West Asia and in South Asia is substantially lower than in the other regions, where the monitored DALYs are considerably above 1,000 per 100,000 people (Figure 5).

The inequality calamity. In Asia and the Pacific, the correlation between income and access is unequivocal—the wealthy have better access than the poor to water supply (Figure 6) and sanitation (Figure 7). In addition, the disparity is growing, especially in the burgeoning smaller cities across the region. The most striking inequality is in access to sanitation in smaller cities. Differences between richer and poorer communities amount to 96% in Nepal and 92% in Cambodia, India, and Pakistan. Municipal authorities in rapidly urbanizing towns and small cities often do not have the capacity to meet the demand for housing, leading to a proliferation of slums without, or at best with very poor, public services.

Analysis for the *AWDO 2013* household water security index (Appendix 2) confirmed wide disparities in access, indicating that the region still has substantial investments to make before these critical services are universally available. Surveys undertaken for *AWDO 2013* in four countries revealed further issues of concern behind the MDG figures for water supply and sanitation. These surveys showed that the percentage of facilities in operating condition is lower than the headline statistics of installed facilities recorded in government figures. This suggests that, although the MDGs have prompted great focus on provision of services, the published MDG figures may be

19 A. Pruss-Ustun, R. Bos, F. Gore, J. Bartram. 2008. *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. Geneva: WHO.

20 WHO. Metrics: Disability-Adjusted Life Year (DALY). http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/.

Key Dimension 1

Household Water Security

To satisfy household water supply and sanitation needs in all communities

Household water security is essential to eradicate poverty.

The poorest households in Asia have been left behind, according to results of the *AWDO 2013* household water security index. The richest households have benefited most from investments to increase access to safe drinking water and sanitation.

World

Government leaders are working toward the **2015 target to reduce by half** the proportion of people without safe drinking water and improved sanitation.

Asia and the Pacific

More than **60% of households live without** safe, piped water supply and improved sanitation.

South Asia and the Pacific

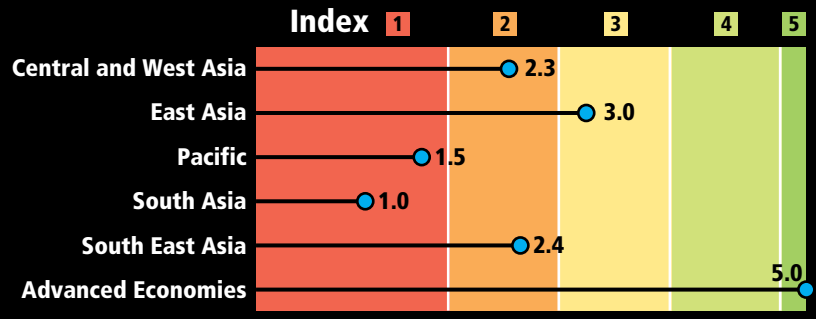
These are hot spots with **lowest coverage** in piped water supply and improved sanitation.

Inequity in access is highest in South Asia.

Vision

Societies can enjoy household water security when they successfully manage their water resources and services to satisfy household water and sanitation needs in all communities.

Household Water Security by Subregion (population-weighted)



Challenges

- Without increased investment and maintenance of facilities, modest **gains over the past 15 years will be lost.**
- Failure to **overcome the inertia in sanitation** investments will cancel out the benefits from increased access to safe drinking water.
- The region needs $59 billion in **investments for water supply** and $71 billion for **improved sanitation.**

Actions to be Taken

- Integrate financing for water and sanitation into national accounts and planning. **Each dollar invested** in water and sanitation is likely to **return $5–$46** in reduced health care costs and increased economic productivity.
- Give agencies and service providers the **autonomy and resources** (financial and technical) to succeed, with accountability.
- **Double the current rates of investment in sanitation.** Just $25 per person will finance basic access to safe drinking water and improved sanitation and hygiene.

presenting a more optimistic picture than reality. The service reliability of improved water supply and sanitation facilities likewise is lower than the headlines suggest. For example, the data for access to piped water supply do not include any indication of whether the service is provided 24 hours per day, 7 days per week, or the service continues to be intermittent. The data also do not indicate whether water is adequately treated and potable at the point of delivery.

Since the first edition of *AWDO* in 2007, food, energy, and economic crises have forced new thinking about the value of drinking water supply and sanitation. More than just a basic need, water and sanitation services are now recognized as a human right by the United Nations and a crucial element in the emergence and survival of small household businesses. These services also are essential keys to protecting households during water-related disasters and extreme weather events that otherwise would put personal investments and public health at risk. New research shows that households—especially the poorest—need water for more than just personal consumption and hygiene. Where they have access to reliable water supply and sanitation services, households put water supplies to productive use in backyard industries, in livelihood actions, and as a strategy for increasing resilience to disasters (Box 2). Countries with greater household water security also tend to have higher per capita gross domestic product (Figure 8).

BOX 2

Going Beyond Basic Water Services to Building Resilience and Supporting Incomes

A combination of diversified income and additional water reserves coming from multiple sources improves household resilience to disasters such as drought, floods, and earthquakes. Diversified income is a key feature of household adaptive capacity in its own right because funds can be used as needed to respond to damage to household or community facilities. For instance, if a well is contaminated by pollutants entering groundwater through flooding, a backyard rainwater harvesting tank can prove to be a reliable source of drinking water (assuming it is well placed and reinforced).

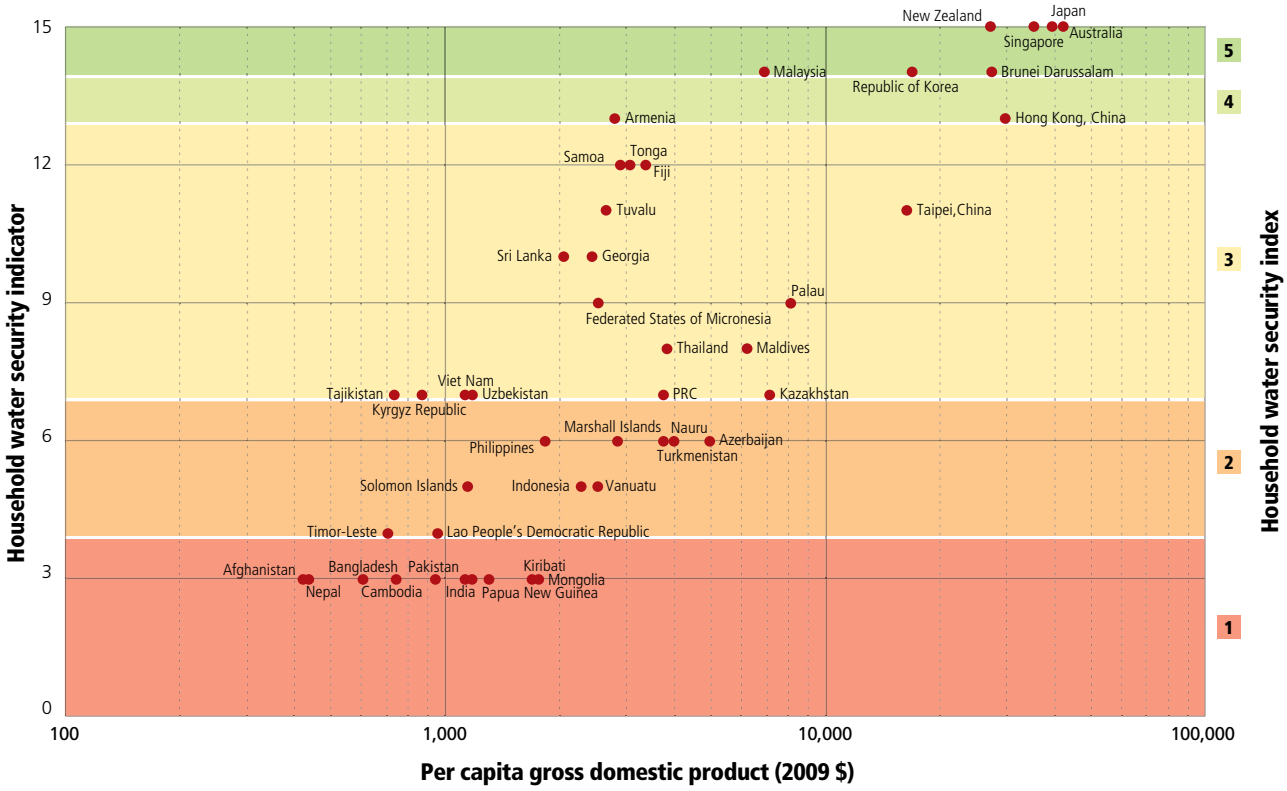
Although multiple-use systems provide additional benefits, it can be difficult to integrate these services into infrastructure plans in large urban settlements. Infrastructure designed for multiple use is likely to be more expensive. However, public financing may be viable where these services are introduced in small, incremental phases. Households and communities that already have diversified coping strategies may be willing to invest in these programs, particularly where projects provide increased reliability of service (van Koppen et al. 2009).

Pilot projects in rural and peri-urban towns in India, Nepal, and Thailand have demonstrated that creative household strategies to alleviate household insecurity may complement official water and sanitation strategies, provided the appropriate institutional, technical, and financial mechanisms are in place. National governments can create incentives for local governments, nongovernment organizations, and development banks to collaborate and integrate these strategies into development planning, and/or can incorporate them into national poverty reduction strategies, using the Millennium Development Goals to measure success.

Source: B. van Koppen, S. Smits, P. Moriarty, F. Penning de Vries, M. Mikhail, and E. Boelee. 2009. Climbing the Water Ladder: Multiple-Use Water Services for Poverty Reduction. *The Hague: IRC International Water and Sanitation Centre and International Water Management Institute.*

FIGURE 8

Household Water Security and Per Capita Gross Domestic Product



Source: For gross domestic product data, World Bank. World Development Indicators. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

What Is at Stake

Access to safe, reliable water supplies and effective sanitation are vital services to improve the lives and livelihoods of the people of Asia and the Pacific. Without progressive financing and more resilient water supply and wastewater disposal systems, the modest gains in access to these services achieved over the past 15 years may be lost. Failure to overcome the persistent inertia that delays the provision of improved sanitation will erode the pro-health, pro-poor benefits achieved by increased access to safe drinking water.

The United Nations Economic and Social Commission for Asia and the Pacific investigated the sustainability of community systems in four countries and found that a reversal of the achievements to date is a real threat. Public utilities responsible for providing water and sanitation services to communities in India and the Philippines were found to lack capacity in all aspects of sustainability, including effective functioning, financing, and demand responsiveness. This is worrisome because these governments are increasing investment to meet the MDGs without committing the necessary investment to building the capacity to adequately maintain existing systems. Without better focused programs to ensure that water services reach—and continue to reach—all communities, poorly designed investments may reinforce existing inequities and exacerbate social injustice.

Pulling the Policy Levers

Governments have a range of policy levers that can be applied to bring accelerated reform to household water supply and sanitation services. These policy options are summarized in four strategic groups in Table 3.

TABLE 3

Policy Levers to Increase Household Water Security

Strategy	Supporting Policies
Financing	Integrate financing for water supply and sanitation into national budget and accounts systems. Internalize connection costs into the tariff or offer long-term installment programs. Explore microfinance for affordable water connections, sanitation facilities, and livelihood generation. Package water supply, sanitation, and wastewater treatment investments together, as benefits increased by a factor of three compared to separate investments in each service alone. Authorize appropriate user fees, with targeted subsidies for the poor.
Management	Simple, transparent, independent regulation to engage the private sector, including small and medium-sized enterprises. Promote demand-side management through water-saving household technologies, industry regulations, and large-scale recycle and reuse technologies. Minimize non-revenue water to potentially increase availability, reserves, and resilience of systems and services in times of shortage and to reduce energy demands. Recognize multiple-use systems to deliver benefits to water users, including improved livelihoods, disaster resilience, and ecosystem protection in peri-urban areas. Promote increased decentralization and financial, technical, and management autonomy for service providers. Expand use of performance management systems, including benchmarking the performance of utilities.
Social	Prioritize demand-driven, community-managed systems for rural water supply. Promote community-led total sanitation programs. Support zero open defecation programs.
Technology	Available technology is adequate for supply and demand over the next 20 years. As an intermediate step, support community-managed sources and services, which need some government support, because they are especially vulnerable to contamination, damage from natural disasters, and the effects of climate change.

As a first priority, governments should integrate financing for water and sanitation into national accounts and financial planning. According to the 2010 *UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water* (GLAAS)[21] survey on financial expenditures and institutions, Asia and the Pacific requires about $59 billion in further investments for water supply, and a further $71 billion is required to provide access at the minimum standard for improved sanitation.[22] Provision of piped water supply will increase the financial resources required. Current rates of investment are far too low to offer any hope of achieving household water security, yet as little as $25 per person will

21 WHO. 2010. *UN-Water Global Annual Assessment of Sanitation and Drinking-Water.* Geneva.

22 United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP). 2010. *Financing an Inclusive and Green Future: A Supportive Financial System and Green Growth for Achieving the Millennium Development Goals in Asia and the Pacific.* Available at http://www.ESCAP.org/66/theme_study2010.asp.

AFP

Collecting household water in India: Though great strides have been made, more than 65% of Asia and the Pacific's population does not have a secure household water supply.

finance basic access to safe water, improved hygiene, and sanitation.[23] There is evidence that each dollar invested in the MDG water and sanitation target can provide a return of $5–$46 in reduced health costs and increased economic productivity.[24]

Second, governments should improve water governance by providing the relevant agencies and service providers with the necessary autonomy and financial and technical resources. In addition, the successful lessons from decentralization, civil society participation, support for small operators, and overall cultural recognition and social awareness programs that have accelerated progress in access to sanitation must be replicated. However, such reforms will fail if they are not backed up with appropriate pricing policies, financial and technical support, and the resources necessary to implement local government plans.[25] Public–private partnership arrangements can help finance the improvement of old and malfunctioning systems and can be instrumental in overcoming inefficient bureaucratic institutions. Appropriately regulated small service providers

23 WaterAid UK. Statistics. http://www.wateraid.org/uk/what_we_do/statistics/default.asp.

24 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.

25 UN ESCAP. 2009. *Institutional Changes for Sanitation*. Bangkok.

STEVEN GRIFFITHS

Building eco-friendly toilets in the Philippines: An estimated 1.74 billion people in Asia and the Pacific continue to live without access to improved sanitation.

can efficiently serve their customers, which often include the poorest, while covering operating costs and generating reasonable returns on investment.

Third, governments should facilitate a doubling of the current rates of investment in improving sanitation. Governments tend to place higher priority on investments to improve access to water supply than on improved sanitation; however, where possible, investments in water supply should be linked with provisions for sanitation and wastewater treatment. Water infrastructure is also more eco-efficient when water supply is offered in conjunction with sanitation services.[26] Although up-front investment requirements are lower for stand-alone water supply than for sanitation, the return on investments in combined water supply and sanitation are three times higher than investments made in either of the services independently.[27]

26 UN ESCAP. 2009 *Emerging and Persistent Issues in Water Resources Management*. Note by the Secretariat, CED paper: E/ESCAP/CED/(2)/5, 16 September. Bangkok. Available at http://www.unescap.org/esd/CED-2/documents/CED2_5E.pdf.

27 United States Agency for International Development. Urban Sanitation and Wastewater Treatment. http://www.makingcitieswork.org.

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Factory beside the river: Water is a critical input for industry, agriculture, energy production, and the tourism and service sectors.

AFP

Key Dimension 2: Economic Water Security

To support productive economies in agriculture, industry, and energy

Just as the reliable supply of good-quality water is vital for members of individual households, water is a critical input for industry, agriculture, energy production, and the tourism and service sectors. These sectors provide employment and contribute to everyone's socioeconomic development and quality of life.

Asia and the Pacific covers about 40% of the earth's land area and is home to about 60% of the world's population. The region faces the paradox of needing to boost food, industrial, and energy production with a decreasing per capita availability of water. The region has a relatively low ecological carrying capacity, partly because the natural resources needed for production are limited and partly because of the persistent use of environmentally debilitating modes of production in the region, including overextraction and/or pollution of basic resources. As a result, countries in Asia and the Pacific have some of the highest proportions of degraded land in the world, vast and expanding arid areas, and the lowest per capita availability of water and arable land. Yet, throughout Asia and the Pacific, the consumption of renewable water resources is increasing.

AWDO 2013 assesses water security in the agriculture, industry, and energy sectors using sector-specific indicators summarized in Box 3.[28] Appendix 3 shows estimates of economic water security for 49 countries in Asia and the Pacific.

BOX 3

Key Dimension 2—Productive Economy Indicators

Key dimension 2 provides an assessment of the productive use of water to sustain economic growth in food production, industry, and energy. The index is a composite of three subindexes:

Agricultural water security subindex

- Productivity of irrigated agriculture
- Independence from imported water and goods
- Resilience (percentage of renewable water resources stored in large dams)

Industrial water security subindex

- Productivity (financial value of industrial goods relative to industrial water withdrawal)
- Consumption rate (net virtual water consumed relative to water withdrawn for industry)

Energy water security subindex

- Utilization of total hydropower capacity
- Ratio of hydropower to total energy supply

Resilience

See Appendix 3 for more detail.

This index was developed for the *Asian Water Development Outlook* by the International Water Management Institute and the Food and Agriculture Organization of the United Nations.

How Does Asia and the Pacific Measure Up?

Economic water security is more uniform across the region than the other key dimensions, although each region has considerable potential to improve water productivity in the three areas of economic activity measured. Overall, agriculture accounts for more than 79% of total water withdrawn in the region and will therefore remain a major determinant of overall economic water security.[29] However, the fastest increase in water demand in Asia is now coming not from agriculture but from the industry sector and urban households, in keeping with the fact that this

28 For a more complete discussion of these indicators and their subindicators for agriculture, industry, and energy, see the background paper "Key Dimension 2: Supporting Productive Economies in Agriculture, Industry, and Energy" on the AWDO 2013 supplementary DVD.

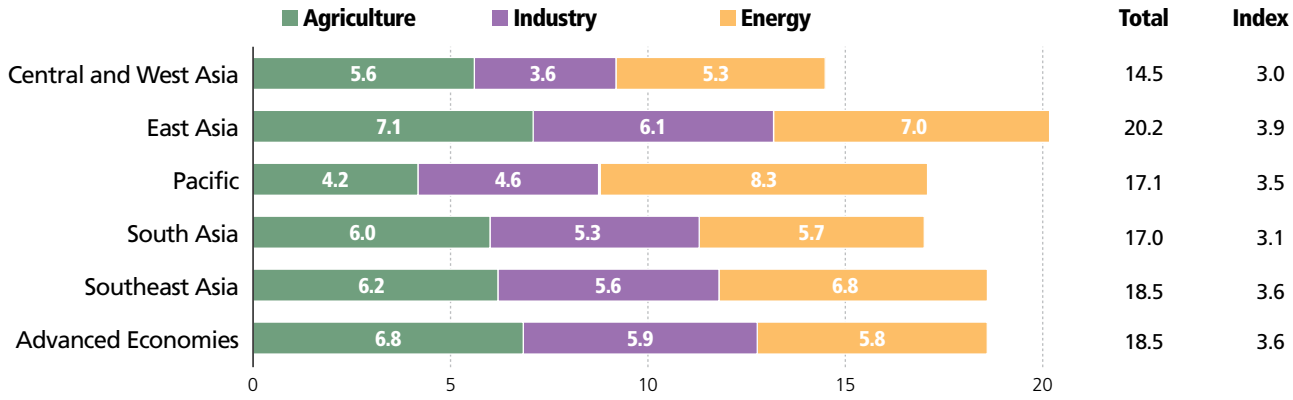
29 UN ESCAP. 2008. *Statistical Yearbook for Asia and the Pacific*. Bangkok.

continent has become the seat of the world's fastest industrialization and urbanization.[30] Indicator values are generally below 7 out of 10 in each of the subsectors (Figure 9), indicating the potential to improve water security through combinations of well-targeted investments in infrastructure and improved management. Only East Asia exceeded an assessment of 20 out of 30. South Asia has the lowest economic water security (17 out of 30).

Figure 9 summarizes the subregional economic water security index. All the subregions are assessed as either *capable* or *effective* (Table 2), with index values in the range of 3–4 (Figure 10). This is unsurprising, as governments, private sector entities, and individuals expend considerable resources to support economic growth. Although these assessments present a generally encouraging view, however, the consolidated regional and national results disguise areas of concern revealed by country statistics (Appendix 3). Water is or is likely to become a constraint on economic growth in a number of countries unless a renewed effort is directed toward ensuring water availability in adequate quantities and qualities. In the People's Republic of China (PRC), for example, an estimated 2.3% of gross domestic product is lost because of water scarcity (1.3%) and the direct effects of water pollution (1%).[31]

FIGURE 9

Economic Water Security Index by Subregion (population-weighted)



Note: The subindicator range is 1–10. No data were available for Taipei,China and Hong Kong, China (East Asia); Maldives (South Asia); Brunei Darussalam and Singapore (Southeast Asia); or Cook Islands, Kiribati, Marshall Islands, Micronesia, Nauru, Palau, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu (Pacific). Estimates for the Pacific region are derived from expert judgment evaluations provided by a range of regional specialists.

Source: Based on various data sources reported in the AWDO 2013 *background paper "Water Security Key Dimension 2: Supporting Productive Economies in Agriculture, Industry, and Energy," available on the* AWDO 2013 *supplementary DVD.*

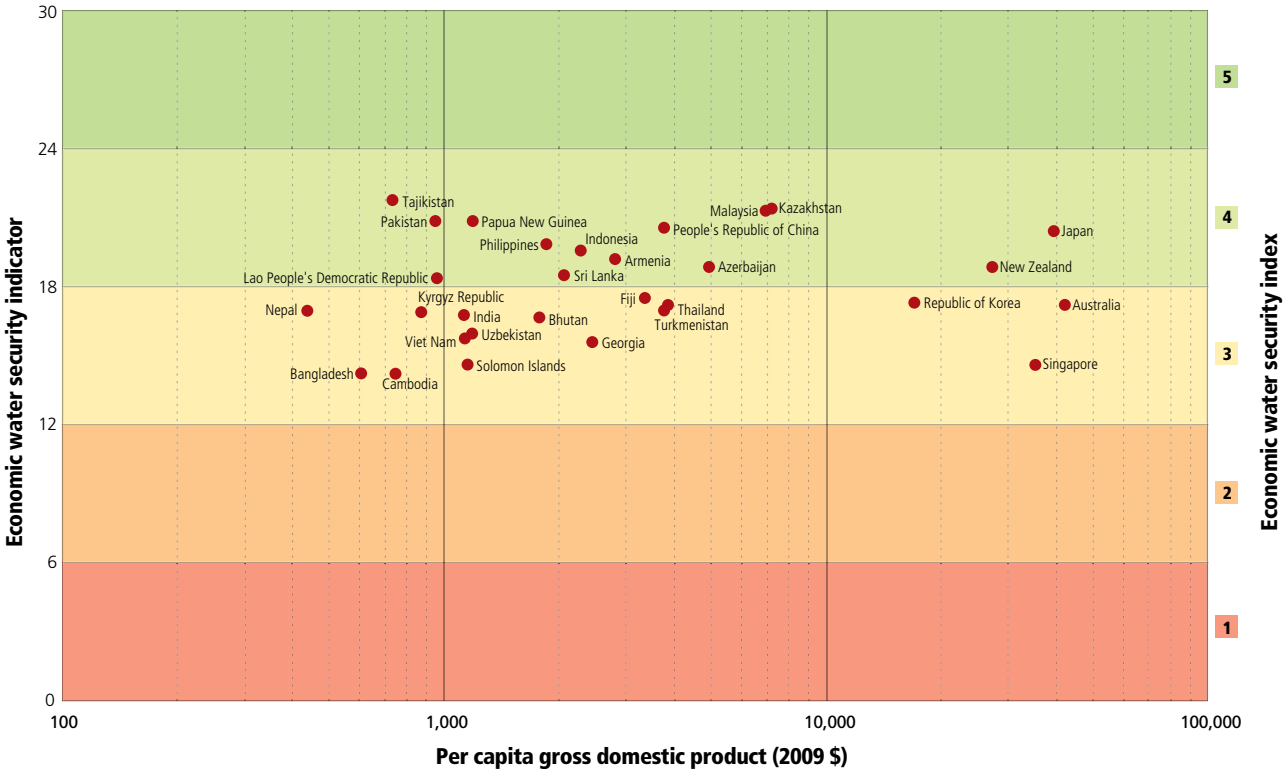
South Asia. South Asia is the poorest and most populous subregion in Asia and the Pacific, with relatively low agricultural water productivity. Although opportunities for improvement are abundant in all three areas of economic activity, attention to agriculture is most critical. The subregion has a low resilience due to low per capita water storage capacity. As a result, South Asia is likely to be particularly vulnerable to the effects of climate variability, including increased frequency and severity of drought or flood events. Large irrigation systems are widely considered to be underperforming in terms of water services provided to farmers and the sustainability of infrastructure, with inadequate investment in maintenance. However, more than 40% of South

30 C. Brahma. 2011. *Water: Asia's New Battleground*. Washington, DC: Georgetown University Press.

31 World Bank. 2007. *Cost of Pollution in [the People's Republic of] China: Economic Estimates of Physical Damages*. Washington, DC.

FIGURE 10

Economic Water Security and Per Capita Gross Domestic Product



Source: For gross domestic product data, World Bank. World Development Indicators. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD.

Asia's arable land is irrigated and is an important contributor to national food security.[32] Agricultural water productivity in South Asia may be higher than the index shows, because the indicator of value added may be distorted as agricultural inputs are subsidized and food prices controlled. It is likely that there is potential to increase agricultural water productivity in South Asia, which has important implications for food and water security in the region.

Increased use of groundwater has been instrumental in increasing agricultural productivity in South Asia and East Asia. The increased availability of low-cost pump sets and generous power subsidies (even with unreliable electricity) has led to high extraction rates and a trend toward faster expansion of groundwater than surface water for irrigation.[33] Unless effective methods are found and implemented to manage the exploitation of groundwater resources, agricultural productivity will become increasingly insecure as water tables fall to levels where it is no longer economic to pump, or where aquifers are damaged. Extensive use of groundwater for agriculture has enabled substantial increases in production and increased resilience. However, *AWDO 2013* has not been able to adequately measure these impacts due to the poor availability of reliable data to enable comparative assessments.[34]

32 A. Mukherji, T. Facon, J. Burke, C. de Fraiture, J.-M. Faurès, B. Füleki, M. Giordano, D. Molden, and T. Shah. 2009. *Revitalizing Asia's Irrigation: To Sustainably Meet Tomorrow's Food Needs*. Colombo: International Water Management Institute and Rome: Food and Agriculture Organization of the United Nations.

33 T. Shah, M.U. Hassan, M.Z. Khattak, P.S. Banerjee, O.P. Singh, and S.U. Rehman. 2009. Is Irrigation Water Free? A Reality Check in the Indo-Gangetic Basin. *World Development* 37(2):422–434.

34 Food and Agriculture Organization (FAO) of the United Nations. 2012. AQUASTAT database. http://www.fao.org/nr/water/aquastat/main/index.stm.

Key Dimension 2

Economic Water Security

To support productive economies in agriculture, industry, and energy

Managing water is critical for modern economies.

Productive economies in agriculture, industry and energy must be secured to eradicate poverty and increase prosperity. Sustained growth requires using more water or using water more productively.

World

Industrial use of water increases as economies develop, from 10% for low- and middle-income countries to 59% for high-income countries.

Asia and the Pacific

Agriculture accounts for **79%** of annual average water withdrawals, and demand for food and animal feed crops is predicted to grow by 70% to 100% over the next 50 years.

South Asia

The poorest and **most populous** subregion has relatively low agricultural water productivity.

Economic Water Security by Subregion

(population-weighted)

Challenges

- The fastest increase in water demand now comes from **industry and cities.**
- **70% of food needs** will be met by enhancing yield and could hasten water depletion and downstream impacts.

Actions to be Taken

- Every $1 invested in the **modernization of irrigation services** improves rural gross domestic product by almost $2.
- Implement appropriate policy measures to **reduce competition** among users and reverse widespread **environmental damage.**
- Actively **manage water demand** and consumption.
- In development planning, take into account climate change projections, potential changes to river flows, and the impacts of reallocation of water on **downstream users,** including wetlands and other land uses that provide environmental services.

Vision

Societies can enjoy economic water security when they successfully manage their water resources and services to support productive economies in agriculture, industry, and energy.

Southeast Asia. This region is using its water resources quite productively, matching the economic water security of the developed economies in the region. However, there is potential to further improve water productivity in agriculture, which would increase food security for its growing population and potentially release water resources for other uses. Improving agricultural soil and water productivity on existing agricultural land is particularly important because land is limited, and expansion to more marginal land should be avoided to minimize environmental degradation. Extensive flooding in Thailand in 2011 and the economic impacts on industry have put water security considerations high on the national agenda. Thailand is an example of a country where economic development is enabling an increased emphasis on the maintenance of water quality and environmental conservation (Box 4). The use of hydropower resources is expanding rapidly to support the increasing energy demands in the subregion. Balancing this expansion with the needs of other subsectors and the environment will be an important determinant of overall water security.

BOX 4

Thailand Enforces Water Quality Standards

The very high level of economic growth in Asia and the Pacific over the past decade explains its current position as one of the most competitive economic regions in the world. Thailand provides a good example of a country in the region that has used agricultural growth and trade to effectively reduce poverty and food insecurity.

Government administrations in Thailand are gradually accepting and accounting for the huge effect that environmental degradation can have on socioeconomic development. Thailand has a relatively high volume of renewable water resources per capita (6,279.5 cubic meters) when compared with other countries in the region, such as the People's Republic of China (2,103 cubic meters) and India (1,592 cubic meters). Nonetheless, water scarcity is an increasing problem in many parts of the country, mostly due to population growth, pollution of existing supplies, and growing competition among the agriculture, domestic, energy, and industry sectors.

The conflicts associated with the Map Ta Phut Industrial Estate demonstrate the often fierce relationship between multiple users of natural resources, and the serious nature of industrial pollution. The case also illustrates the strength of grassroots community groups in Thailand.

The Map Ta Phut Industrial Estate in Rayong Province comprises 117 industrial plants, including 45 petrochemical factories, 8 coal-fired power plants, 12 chemical fertilizer factories, and 2 oil refineries.

Water resources in the Map Ta Phut's neighbourhood contained significant levels of toxic constituents, potentially harming 25,000 people from 25 Map Ta Phut communities and causing genetic changes in local aquatic organisms.

Environmentalists and villagers filed a lawsuit against the government for bypassing constitutional requirements and illegally approving new projects in the industrial park.

The Supreme Administrative Court of Thailand suspended 65 Map Ta Phut projects, and the government issued a new law that separates harmful projects referred to in Section 67 of the 2007 constitution from the existing laws requiring projects to have environmental impact assessments and public hearings. The 65 suspended projects will need to comply with the new law.

Many of the factories have since recommenced operations, but the initial win for the community demonstrates how Thailand's legal system is slowly developing into an institution that can force action and protect citizens. Communities now are able to argue for their constitutional rights against government agencies or businesses that are affecting environmental quality, natural resources, or health.

Source: The International Water Management Institute. 2012. AWDO 2013 *case study.*

In the fields: Agriculture accounts for more than 79% of total water withdrawn in the Asia and Pacific region and is a major determinant of overall economic water security.

AFP

Pacific islands. Assessments for the Pacific island countries have been constrained by a widespread lack of basic data. For the productive economies indicators, 10 of 13 countries lacked the data necessary to evaluate at least two subindexes and therefore the region would not be included in Figure 7 without the inclusion of expert opinion to supplement available data.[35] Few countries in the Pacific have sufficient reliable data to enable computation of the indicator, and it was therefore not possible to make a representative assessment of water security for the Pacific, which will need to improve monitoring and collection of basic data to enable evaluation and tracking of advances in water security as they are achieved. Expert judgment by regional specialists was used to derive the assessment included in Table 6.

East Asia. Agricultural, energy, and industrial water security are relatively high in East Asia. Although irrigated agriculture is the major user, where heavy manufacturing is concentrated, industrial water use already accounts for 22% of demand and municipal supplies take a further 14%. Recognizing the crucial importance of water to sustained advances in poverty reduction and economic growth, the Government of the PRC has initiated a program of water sector investments, referred to as the Three Red Lines. These investments will cap the total national water abstraction at 700 cubic kilometers in 2030, drive improved water productivity and water use efficiency across the economy, and improve water quality in rivers and lakes.[36]

35 The lack of consistent and reliable data on water use for the five key dimensions was a repeated major constraint in the development of the indicators, necessitating a compromise between comprehensive indicators and completeness of coverage. Improving the availability of more comprehensive data is strongly recommended as essential for improvement of water management.

36 People's Republic of China State Council. 2012. *Regulation on Implementing the Strictest Water Resources Management System*. Beijing.

Water use in thermal energy generation is substantial, and with expanding energy demands and diversification of energy sources, water demands will continue to increase. Therefore, improving water use efficiency in the energy sector is essential. However, efforts to improve water use efficiency must reduce consumption of water rather than only reduce withdrawal from the water source. For example, although closed-loop cooling systems reduce water diversions for cooling, the increased consumption in these systems may result in additional stress on the resource. Although many of the best hydropower sites in East Asia are already developed, hydropower makes a relatively small contribution to the subregion's energy generation. The 2012 water resources management regulation has also established clear targets that industry will have to attain by 2030 an added value of CNY10,000 (approximately $1,680) for each 40 cubic meters of water allocated.

Further increases in agricultural water productivity will be required to help ensure food security for the growing population and to enable poverty reduction. By investing heavily in the agriculture sector, the PRC has enabled hundreds of millions of farmers to lift themselves out of poverty. However, more than 100 million people in rural areas of the PRC continue to live in poverty and therefore the PRC continues to pursue a modernization program to ensure that the benefits of increased productivity are realized by all. Notwithstanding these efforts, the indications are that, with the exception of Mongolia, East Asia's ecosystems are already heavily strained and substantial efforts will be required to rebalance water use for socioeconomic activities and the needs of ecosystems to ensure sustainable resource use. The 2012 water management regulations

Iron and steel factories near Beijing: Water resources support critical industries that provide employment and contribute to socioeconomic development.

AFP

include specific water quality targets, reflecting the recognition that water security depends on sustainable access to water in appropriate quantities and of usable quality.

Central and West Asia. Large-scale irrigation systems for production of cotton and wheat were established in the 1930s. Since the 1960s, extractions for the agriculture sector have caused substantial damage to the ecosystem of the Aral Sea. However, as major wheat and cotton producers, Central Asia and the Caucasus are critical to global agriculture and food security. Currently, agricultural water productivity is lower than in the rest of Asia, and the irrigation infrastructure is deteriorating due to a lack of adequate maintenance, resulting from decreasing technical expertise and financial resources. The creation of new independent states has meant that many of the subregion's river basins and some major irrigation canals now span international boundaries, increasing the complexity of management and raising new challenges for water resource allocation and maintenance of infrastructure. There remains room to increase water security through improved productivity by agricultural, industrial, and energy users. However, ecosystem services have been grossly undervalued in Central Asia, and this failure may become a binding constraint on the productive use of land and water resources in the future.

Agricultural productivity in Central Asia is determined by limited rainfall, outdated modes of irrigation, saline groundwater, enforced quotas for wheat and cotton, and the slow pace of reform in land tenure and agriculture. The major irrigation systems in the Central Asian republics are remnants of shared systems developed by the former Soviet Union. The countries now share transboundary systems that are complicated to manage and rehabilitate.

Fishing in the river. The poor are particularly vulnerable to a decline in economic activity related to polluted water sources.

AFP

What Is at Stake

National economies are more secure when the key economic sectors are water-secure and able to depend on reliable water services. By 2050, when today's adolescents are barely middle-aged, Asia and the Pacific will have an additional 1.5 billion people to feed.[37] The region already is a key hub of global agricultural and industrial production. As a result, hundreds of millions of people are exiting poverty and joining an expanding middle class, with corresponding changes in aspirations and diet. In general, these changes demand more energy and, in the absence of improved management practices, more water.

Water scarcity and water pollution are becoming the accepted norm in many river basins in Asia and the Pacific. The Comprehensive Assessment of Water Management in Agriculture[38] concluded that there are sufficient land and water resources to feed the world but that current food production and environmental trends, if allowed to continue, will lead to water and environmental crises in many areas. The Challenge Program on Water and Food has recently confirmed that "while globally there is enough water to sustain human development and environmental needs, water-related conflicts will continue if particular issues like food security and energy production are considered in isolation from one another."[39]

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37 International Water Management Institute (IWMI) and Food and Agriculture Organization of the United Nations (FAO). 2009. *Revitalizing Asia's Irrigation: To sustainably meet tomorrow's food needs*. Available at http://www.iwmi.cgiar.org/SWW2009/.

38 Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. London: Earthscan and Colombo: International Water Management Institute.

39 Challenge Program on Water and Food. 2011. *Major River Basins Have Enough Water to Sustainably Double Food Production in the Coming Decades*. Available at http://results.waterandfood.org/bitstream/handle/10568/10187/FINAL%20-%20Basins%20Release.pdf?sequence=3

Appropriate policy measures must be implemented to reduce competition among users and reverse widespread environmental damage.[40] There already are signs of growing water scarcity and environmental stress in large parts of important agricultural areas in Asia. Groundwater levels are falling in northern India, Pakistan, and the northern plains of the PRC. For extended periods each year, some rivers, such as the Syr Darya in Central Asia, do not discharge into the sea.[41] Increasing environmental stress damages ecosystems and ultimately undermines the production systems that depend on them. For example, the fisheries of the Mekong Basin, which provides a vital source of protein and income for more than 1.2 million people who depend on fishing for their livelihoods in the Tonle Sap Lake in Cambodia, may become stressed by upstream developments in the Mekong mainstream and tributaries.

Just as significantly as lack of water, deterioration of water quality will limit water use, threaten ecosystems, and create a drag on socioeconomic development. Productive economies are sensitive to water quality. For example, irrigation-induced salinization reduces productivity and can ultimately take land out of production. Saline soils are already estimated to affect almost 50% of irrigated areas in Turkmenistan, 23% in the PRC, and 20% in Pakistan. Naturally occurring salinity also limits groundwater use for agriculture, as in Australia, the PRC, and northeastern Thailand. Point source pollution from urban sewage and industrial effluents as well as non–point source pollution from agricultural return flows contaminated with fertilizers and pesticides lead to environmental degradation or may render water bodies unfit, or at best more costly, for use in irrigation, industry, or domestic water supply.

Without concerted efforts to ensure economic water security, the remarkable economic growth and poverty reduction in the region could be jeopardized.

Pulling the Policy Levers

There are essentially three ways to achieve greater economic water security, some of which lie outside the water sector. The first option is the continued expansion of water supply by increasing storage to reduce the variability of natural water resources.[42] A second option is to improve the productivity, including increased reuse of water. A third, more radical, option is to transform the national economic mix by promoting economic activities that are better matched to the available natural resources.

Governments must find and facilitate a sustainable and cost-effective mix of these three options through policy revisions, judicious use of investments, and public awareness and education programs. Growing water scarcity in much of Asia and the Pacific means that countries will need to take rapid action to implement combinations of solutions to avoid water becoming a binding constraint on socioeconomic development. The repeated food price spikes in recent years means that food production is a high priority, calling for investments to revitalize irrigated agriculture to provide affordable food for the region's population. In the medium term, countries will also have to consider assigning new priorities to developments in the industrial and energy sectors, to better match water demands with each country's renewable natural resources. In agriculture, producers will be faced with growing more with current or possibly reduced water supplies, to enable allocation of water for other uses (Table 4). Choosing between these options will require careful assessment of the trade-offs and risks involved and the likely distribution of costs and benefits. Management of the transition from current practices to practices that will

40 J. Alcamo, D.van Vuuren, W. Cramer 2005. Changes in Ecosystem Services and Their Drivers across the Scenarios. In S.R. Carpenter et al. (eds.) *Ecosystems and Human Well-Being, Volume 2: Scenarios, Millennium Ecosystem Assessment*. Washington DC: Island Press. pp. 297-374; D. Seckler, U. Amarasinghe, D. Molden, R. de Silva, and R. Barker. 1998. World Water Demand and Supply, 1990 to 2025: Scenarios and Issues. Research report 19. Colombo, Sri Lanka: International Water Management Institute.

41 F. Molle. 2008. Why Enough Is Never Enough: The Societal Determinants of River Basin Closure. *International Journal of Water Resource Development* 24(2): 247–256.

42 Effective increases of water storage may be achieved by improved watershed management, preservation of natural wetlands, and increased recharge of groundwater aquifers, in addition to development of new water impoundments and reservoirs.

TABLE 4

Policy Levers to Increase Economic Water Security

Item	Policy Levers
Financing	Reevaluate current development strategies to ensure that available water resources can sustain them. Adjust economic activities where water use is financially or economically irrational. Maximize the social and environmental value of water when choosing development strategies.
	Adopt financial and market measures that would enable water resources to more aptly meet food demand. Such measures include investing in infrastructure for irrigated agriculture, increasing rain-fed agricultural production, promoting agricultural trade between water-rich and water-short markets, and curbing postharvest losses on farms, in the food processing industry, and in homes.
Governance	Support subnational governments in developing and implementing basin-wide water allocation systems.
	Support the creation and implementation of transboundary institutional frameworks for water resource management.
	Explore potential roles for the private sector in irrigation.
	Support implementation of service-oriented management in irrigation.
Agriculture	Invest in irrigated agriculture.
	Invest in increasing rain-fed agricultural production.
	Promote agricultural trade between water-abundant and highly productive regions and water-scarce areas.
	Reduce overall food demand by reducing postharvest losses, including food industry and household wastes.
	Promote irrigation technologies to increase water productivity.
Industry	Encourage increased reuse of water in processing to minimize effluent discharge.
	Improve energy use efficiency to reduce power demands.
Energy	Encourage demand management and implementation of alternate forms of renewable energy.
	Expand distribution grids and power trading schemes to enable more effective use of generation capacity.
	Minimize consumption of water for cooling in thermal generation plants.

bring about a more water-secure future will require farsighted leadership and the use of adaptive management strategies to enable solutions to immediate challenges and longer-term objectives.

Match economic activities with available resources. This strategy may require policy makers to reexamine the foundations of their country's economy. Does the country have sufficient water to maintain its existing development path, or is a shift in development approach needed to avoid mid- to long-term disruptions that would occur should the natural resource base collapse? Current economic activities may need to be replaced by less water-intensive ones, thus reducing the need to expand water storage or reallocate resources among uses. Countries must consider trade options, possibly increasing agricultural imports to reduce water withdrawals. Within national boundaries, agricultural production may be concentrated in regions better endowed with water resources to provide produce for other, more water-constrained areas.

Unlock water productivity by revitalizing irrigation. Many farmers in Asia and the Pacific are already being affected by water scarcity. Considerable improvements to the productivity of water used in agriculture are expected to come as a result of increasing crop yields with the same allocation

of water, or ideally with reduced water. Strategies will include expansion of the use of wastewater, more effective demand management, improved water delivery services for agriculture, and effective management of multiple-use systems. However, the results of investment in improved irrigation services can be quite deceptive because improved irrigation efficiency may not always lead to net water savings. Nonetheless, if carefully planned, improving water productivity across and within sectors is a valuable tool to increase both food and water security. Increased production from rain-fed agriculture will also contribute to meeting rising food demands. Several assessments of global food production and consumption assume that 70% of food needs will be met by enhancing yield. Increased water productivity in irrigated areas and enhanced agricultural production in rain-fed areas can offset the need for the development of additional water resources but will almost always increase water depletion, with potential impacts on downstream users.[43] Improved agricultural water management will be achieved by better field management practices, including no-till farming, improved soil-water management, improved drainage, use of improved seeds, optimal use of fertilizers, and better management of crop water stress.

Reducing losses in the food supply chain could have a significant impact on improved water productivity. Wastage is occurring at all stages of the supply chain, from field to fork. Improvements in postharvest practices, in food-processing industries, and by households must be promoted to reduce the loss of food and the waste of water used in production of food not consumed.

Actively manage water consumption and water demand. As water becomes a constraint on economic activities, effective water allocation processes are required to facilitate water savings by encouraging improved management of the scarce resource. To offset increased water consumption in water-scarce basins, managers and users may have to adapt to reallocation of water, which may require changes in land use and the reduction of the area provided with irrigation services. Revitalizing irrigation services will be required to produce more with the allocated resources. Producing more food will increase water consumption. However, improved management of irrigation distribution systems may prevent the need to increase water withdrawals. Active management of water will require more accurate measurement of the amount of water depleted by agriculture (consumption) rather than the amount extracted. Achieving water savings outside the agriculture sector may involve restructuring of economic activities at the local and national scale.

Development planning must take into account climate change projections, potential changes to river flows, and the impacts of reallocation of water on downstream users, including wetlands and other land uses that provide environmental services. As societies become wealthier, water saved by changes in land use and improved management practices may be reallocated to maintain minimum downstream flows for environmental and other purposes or may be allocated for other economic uses.[44] Australia has demonstrated that society may choose to reallocate water to support valued ecosystem services and to prevent further environmental degradation of rivers and wetlands. The environment is sometimes referred to as "green infrastructure" because it is being understood more and more as a legitimate and valued water user.

43 A. Keller, R. Sakthivadivel, and D. Seckler. 2000. Water Scarcity and the Role of Storage in Development. Research report 39. Colombo: International Water Management Institute; D. Molden and R. Sakthivadivel. 1999. *Water Accounting to Assess Use and Productivity of Water*. Water Resources Development 15: 55–71.

44 I. Calder, J. Garratt, P. James, and E. Nash. 2008. Models, Myths and Maps: Development of the EXploratory Climate Land Assessment and Impact Management (EXCLAIM) tool. *Environmental Modelling & Software* 23(5):650–659.

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Wastewater treatment in the Philippines: The percentage of people in Asia and the Pacific with access to improved sanitation facilities rose from 36% in 1990 to 58% in 2010.

STEVEN GRIFFITHS

Key Dimension 3: Urban Water Security

To develop vibrant, livable cities and towns

Asia and the Pacific is one of the most rapidly urbanizing regions in the world, with urban populations growing at 2.3% annually—faster than the global average of 2%. Today, more than half of the world's largest cities, including 10 megacities with 10 million or more residents, are found in Asia. By 2015, there will be 12 Asian megacities, and by 2022, the urban population is expected to surpass the rural population.[45]

To enable the urban populations that are the source of economic wealth to enjoy vibrant, livable environments, Asian cities must develop improved water services and management skills as the foundation for sustainable urban economies, employment, and overall quality of city life.[46]

45 ADB. 2008. *Managing Asian Cities*. Manila. Available at http://www.adb.org/publications/managing-asian-cities?ref=themes/urban-development/publications.

46 ADB. Urban Development. http://www.adb.org/themes/urban-development/main.

Cities in Southeast Asia, followed by those in East Asia and South Asia, are growing the fastest. The rate of growth poses serious challenges for water service providers, who must develop new water sources, extend networks, and keep up with the demand for new connections. Expanding sewer networks and maintaining efficient wastewater treatment systems will continue to challenge the resources and commitment of the future leaders of Asian cities and the utilities that provide water and sanitation services.

The rapid growth of Asian cities is making each a source of environmental risk and the potential root of impoverishing conditions for many of their citizens. The challenge for cities is to upgrade current water systems with metered household connections and to expand networks to accommodate the steady influx of job seekers, who typically find housing in settlements not connected to the water supply network. Non-revenue water, including leakage and theft, is a serious impediment to effective expansion of systems and improvement of delivery.

The *AWDO* urban water security index measures how countries are creating better urban water services and management to develop vibrant, livable cities and towns (Box 5). The focus is on water security of cities relative to the first three phases in the water-sensitive cities framework (water supply, sanitation, and drainage).[47] The water security of a city must be considered in the context of the management of the river basin or basins in which the city is located. To reflect this linkage, the urban water security index is adjusted by a factor, between 0 and 1, based on the *AWDO* river health index (key dimension 4), which is added to the urban water security index. The urbanization rate is also taken into account to reflect the challenges to water security faced by rapidly expanding cities.

BOX 5

Key Dimension 3—Urban Water Security

Key dimension 3 assesses the status of urban water-related services to support vibrant, livable cities and towns. The index is a composite of three subindexes:

- water supply (%),
- wastewater treatment (%), and
- drainage (measured as the extent of economic damage caused by floods and storms).

Adjustment factors are included to indicate impacts of the urban growth rate and river health.

There is no attempt to measure the Water Cycle or Water Sensitive City indicators in this version of the *Asian Water Development Outlook.*

See Appendix 4 for more detail.

This index was developed for the *Asian Water Development Outlook* by the International WaterCentre and PUB Singapore.

47 Caution is required in the interpretation of the urban water security index because it is generally an indication of the conditions in the largest/larger cities in the country and rarely an indicator of conditions in the smaller urban centers or towns. The information in *AWDO 2013* should be considered the best-case scenario for the countries in terms of the three fundamental requirements of livable cities.

Key Dimension 3

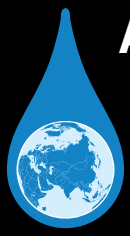
Urban Water Security

To develop vibrant, livable cities and towns

Many of Asia's cities are becoming overcrowded, yet continue to attract more people.
The challenges faced by Asia's cities will therefore grow in scale and complexity. There is underinvestment in areas of public infrastructure and utilities, especially wastewater treatment. In addition, existing water resources are becoming overdeveloped.

World

Cities occupy 2% of the world's land, use 75% of its resources, and generate up to 80% of gross domestic product. More than half the world's slum dwellers live in Asia.



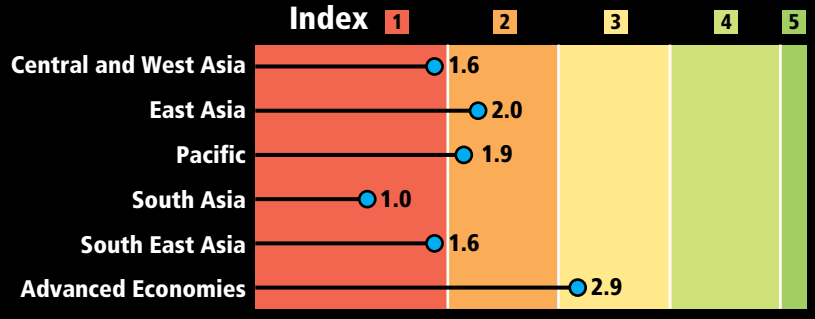
Asia and the Pacific

Wastewater is often released into rivers, lakes and groundwater untreated or only partially treated.

South Asia

As little as 22% of wastewater discharges are treated in South Asia, making it a hot spot for the growth of livable cities.

Urban Water Security by Subregion
(population-weighted)



Challenges

- Increasing urban water security will require investments in **infrastructure, capacity development, and education** about water and wastewater issues in the region's rapidly growing cities and towns.

Actions to be Taken

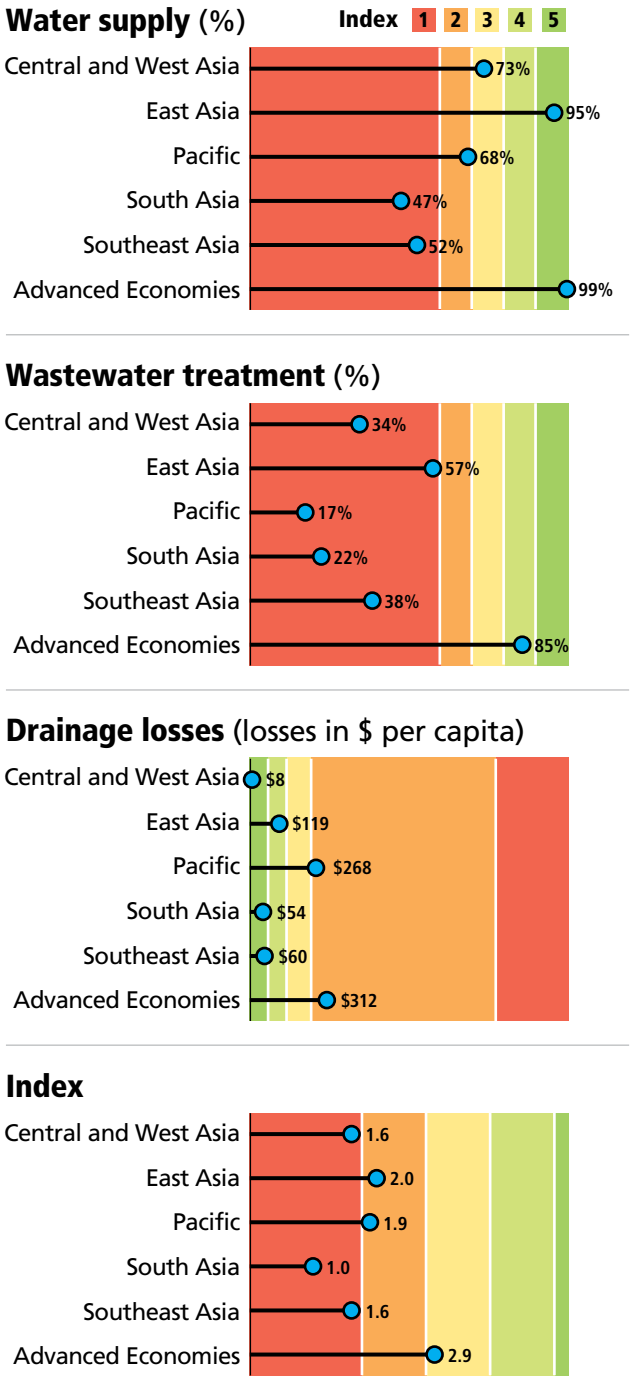
- Adopt **corporate-style governance** to improve urban water and wastewater services.
- Encourage utilities to make urgent investments to **reduce non-revenue water.**
- Increase **wastewater treatment** and control wastewater discharge. Reversing the trends for increasing pollution of water bodies is essential to protect the public health and economic growth.
- Centralize **flood management** and integrate investments in infrastructure with land and water management strategies and comprehensive urban planning.

Vision

Societies can enjoy urban water security when they successfully manage their water resources and services to develop vibrant, livable cities and towns.

FIGURE 11

Urban Water Security by Subregion
(population-weighted)



Note: Urban population–weighted values of the country data.

Source: Based on various data sources reported in the AWDO 2013 *background paper "Water Security Key Dimension 3: Developing Vibrant Livable Cities," available on the* AWDO 2013 *supplementary DVD.*

How Does Asia and the Pacific Measure Up?

Most cities in Asia have extensive infrastructure for domestic water treatment and supply, although piped systems often stop short of individual households, and potable water services are not maintained full-time (24 hours per day, 7 days per week) at the point of delivery (Figure 11).

Unfortunately, the headline statistics for access to piped water supplies hide the wide variation in services available in major cities. Some cities in the PRC and the Republic of Korea provide round-the-clock domestic water service, but in many other cities water is only available at the tap for limited hours. In Jakarta, for example, water is available in most areas for about 18 hours each day, and in Chennai, water is available for an average of only about 4 hours each day.

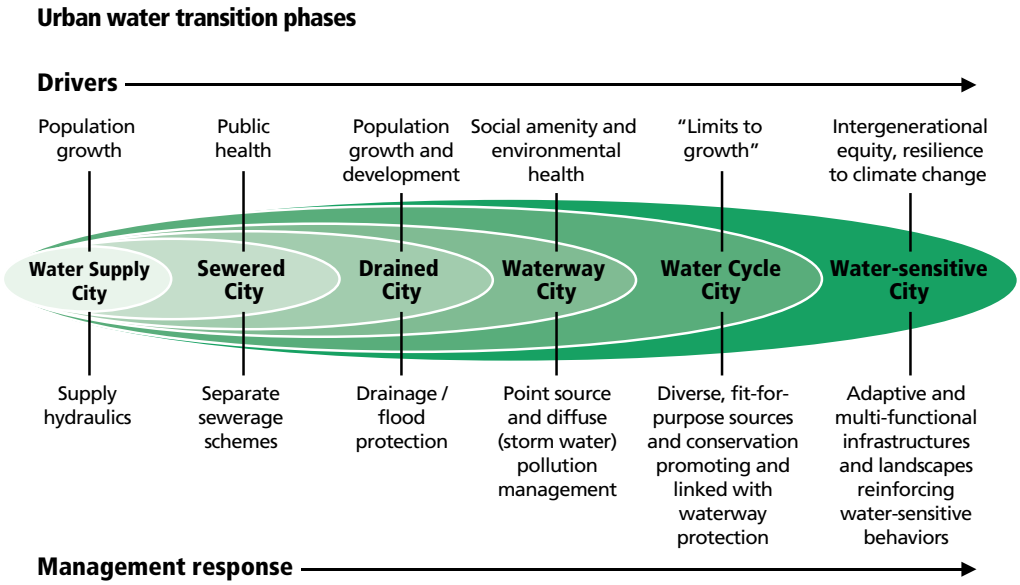
On the other side of the equation, wastewater management is the most evident challenge to the ideal of livable cities and urban aesthetics. Inadequate management of waste leads to persistent visible pollution and foul odors. Poor solid waste management represents an ongoing threat to the health of residents and contributes to the pollution of lakes and the riparian environment. In much of Asia and the Pacific, the majority of sewage discharged to rivers and other receiving water bodies is untreated or only partially treated. In South Asia, as little as 22% of wastewater discharges are treated (Figure 11).

The condition of waterways in cities, including wastewater and storm water systems, is an important determinant of the quality of life for urban populations. Unfortunately, city waterways have for too long been thought of as benign systems, capable of being overloaded and able to cope with any pollutant the community discharges to them. The benefits of investing in water resources protection and cleanup of city water bodies—and the real cost to communities of not doing so—are still a relatively new and rarely applied concept.

Regrettably, too many city administrations still view the water bodies in the city as limitless and endlessly renewable. Policy and management regimes do not yet connect the economic vitality, biodiversity, human health, and livability of their cities with their uses of water and the impact on the hydrologic cycle. Many cities have failed to match collection, treatment, and environmentally safe disposal of wastewater to their expanding population and industry sectors. Wastewater often is discharged to nearby rivers, lakes, or oceans with no treatment, or at best only primary treatment, of these effluents.

FIGURE 12

Water-Sensitive Cities Framework



Source: Based on T. Wong and R. R. Brown. 2009. The Water Sensitive City: Principles for Practice. Water Science and Technology *60(3):673–682.*

The water-sensitive cities framework (Figure 12) is an outline for policy and investment planning, which envisions urban areas progressing along a trajectory from the provision of basic services to increasingly value-added services.[48] More forward-looking city administrations throughout the region are striving to improve water services, with urgent common goals to achieve improved water supplies, separated sewerage schemes, and effective drainage and flood protection. These administrations are increasingly concerned that their policies and programs lead to sustainable advances for their community. Such administrations have recognized that attaining high levels of sustainability will involve changing institutional and public perceptions of waterways as a convenient site for disposal of wastewater, creating a shared commitment to managing waterways as a valuable resource for the present and coming generations.

As a result, many major cities in the region are falling short of the vision of providing their population with water security in a sustainable, vibrant, livable city (Figure 13). Inadequate provision of drainage and flood protection increases the exposure of city dwellers to floods and associated health risk. Many countries that have made progress in providing piped water access and wastewater treatment still have far to go before becoming a drained city. And for the countries with the highest urban growth rates—including Cambodia, Myanmar, and Nepal—the challenges of extending piped water supply, wastewater treatment, and flood management infrastructure for their city populations are substantial.

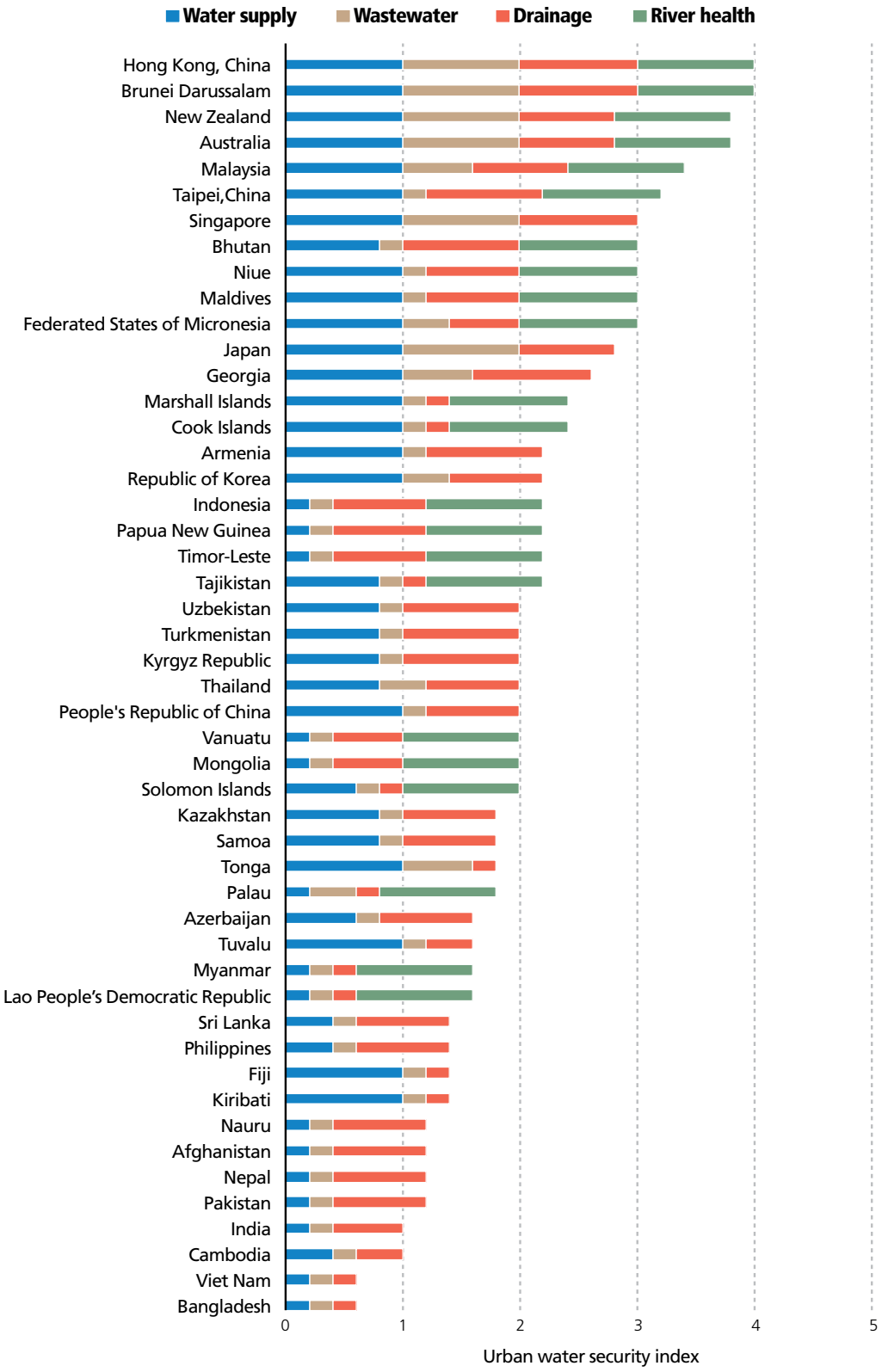
What Is at Stake

Urban water security is an indicator of the livability of towns and cities. For many cities, rapid urban population growth has outpaced the investment capacity of the urban administrations. Moreover, with some cities now reaching the limits of economic exploitation of sustainable water resources, it is becoming crucial to consider a wider diversity of approaches in the water sector in

48 T. Wong and R. R. Brown. 2009. The Water Sensitive City: Principles for Practice. *Water Science and Technology* 60(3):673–682.

FIGURE 13

Urban Water Security—Progress toward Water-Sensitive Cities



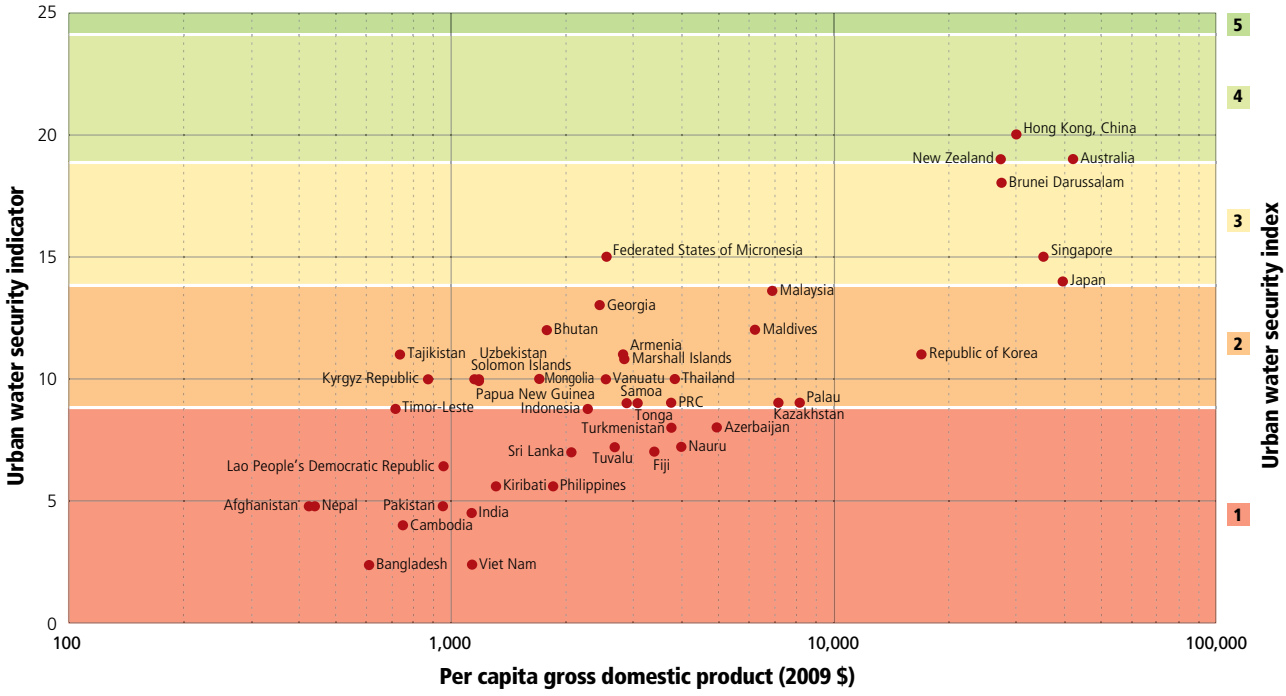
these cities. Emerging approaches being adopted include demand management and development of alternative and novel sources of water, such as recycled water for use as drinking water and increased recycling of water for industrial and agricultural applications. These technologies and approaches will require new infrastructure, including both centralized and decentralized systems, that promotes a fit-for-purpose approach to matching water usage with water quality standards (footnote 48).

It is becoming evident that the more heavily polluted a country allows its water bodies to become, the greater will be the cost to the community in terms of health impacts, economic losses, and treatment costs. In South Asia and East Asia, because of their large populations, expanding cities, and growing industry sector, governments are recognizing the need for better enforcement of pollution control laws and for substantial investment in treatment facilities to reduce pollution loads and to restore river systems. However, progress is slow, and sustained political leadership and commitment of resources will be required to reverse the deterioration of water bodies. Figure 14 suggests a correlation between urban water security and per capita gross domestic product, a relationship that may be expected to strengthen as urban economies become more dominant in the region.

Lack of universal access to potable water, limited capacity of properly functioning waste-water treatment facilities, and lack of adequate flood management measures continue to plague much of Asia. Water bodies are being overexploited, as both sources of water and also as means of wastewater disposal. Rivers have been degraded by overextraction and pollution, and entire ecosystems have been damaged, with negative impacts on biodiversity and the lifestyle of people in the area. In the face of growing concern over climate change, energy and food security, and the sustainability of development advances, managing these issues in the search for livable cities has become more urgent and compelling.

FIGURE 14

Urban Water Security and Per Capita Gross Domestic Product



PRC = People's Republic of China

Source: For gross domestic product data, World Bank. World Development Indicators. *http://data.worldbank.org/indicator/NY.GDP.PCAP.CD.*

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Suzhou Creek in Shanghai. In many cities in Asia, vital water resources have needed rehabilitation after being affected by rapid economic development.

Pulling the Policy Levers

Leaders in the cities of Asia are already recognizing the limitations of traditional water sources to supply ever-growing populations and increasing demands of urban communities and industrial development. Communities are also beginning to recognize that waterways have limited capacity to handle the pollution loads imposed on them. Improved coordination of policies between central and municipal governments is required to ensure the pursuit of well-focused investment strategies and the setting of management objectives that aspire to develop water-sensitive cities.

Strategies designed to enable cities to advance through the water-sensitive cities framework should focus on a mix of three groups of infrastructure investments. First, investment in a balanced network of centralized and decentralized water infrastructure is necessary to provide cost-effective access to reliable water sources. Also, incentives should be provided to encourage utilities to make urgent investments to reduce non-revenue water.

Second, to prevent further pollution of water resources, it is urgent for Asia and the Pacific to increase access to sanitation and invest in control of wastewater discharge. Reversing the trends for increasing pollution of water bodies is essential to protecting the public health of growing urban populations as well as downstream communities that depend on the same river systems. In the long run, investments in improved wastewater management will lead to healthier waterways that underpin sustainable water resources and economic growth.

Third, investment in flood management infrastructure must be better integrated with urban water and land management strategies, and must be included in comprehensive urban and land use planning, to mitigate risks to human lives and to avoid economic impacts from flood events.

These investments will require support by programs to develop the technical capacity required to manage the infrastructure and services. In general, there is an urgent need to increase the technical capacity of the water sector to adapt to changing circumstances. Climate change is expected to increase the frequency of extreme drought and flood events, which will require more robust and flexible water infrastructure and management practices. Preparing for these changes requires continued efforts to expand knowledge about climate change in the regions and cities most likely to be affected. Some countries, including Nepal and Tajikistan, are investing in downscaling climate model outputs to provide climate projections for localized planning for climate-resilient infrastructure and management processes. Urban systems can use climate projections to assess risk and highlight where additional investment in climate-proof infrastructure is needed. Adapting to climate change may involve retrofits to current infrastructure and/or revising engineering design guidelines and manuals. Additional training programs will be required for the government, private sector, and education sector to strengthen the current and future core of engineers and related decision makers.

Ensuring sustainable urban water security will require investments in infrastructure, capacity building, and education about water and wastewater issues for the region's population. Funds and financing mechanisms for these investments will involve governments, international financing institutions, and the private sector. However, greater political will and leadership will be required to mobilize adequate resources and to create focused, timely investment programs. Table 5 summarizes some of the policy and investment options that have been effective.

TABLE 5

Policy Levers to Increase Urban Water Security

Item	Policy Levers
Financing	Reprioritize allocation of sufficient funds and appropriate financing schemes for economically and financially feasible water and wastewater infrastructure and integrated water resources management to protect rivers in urban areas.
	Invest in reducing non-revenue water and losses as a highly cost-effective means to improve urban water security.
Management	Explore the potential for corporatizing utilities or introducing private sector management or market-based management practices into utilities to ensure sustainable services.
	Organize or strengthen river basin organizations that will independently manage the river and regulate usage of river water.
Social	Raise public awareness of water as a limited resource that must be conserved for use of future generations and the preservation of natural resources.
	Study and implement, if feasible, an incentive mechanism for those who practice water and environmental conservation.
Environmental	Invest in flood forecasting and other environmental monitoring systems.
	Formulate policies on appropriate water allocation schemes that will consider not only long-term sustainable supply to people but also the long-term environmentally sound condition of urban water sources.
	Shift from managing waterways as a source of water to managing waterways for future generations.

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The Sepik River in Papua New Guinea: Healthy rivers and ecosystems are a vital part of national water security programs. AFP

Key Dimension 4: Environmental Water Security

To restore healthy rivers and ecosystems

Eighty percent of rivers in the region are in poor health, as measured by the river health index.[49] Pollution from cities is only a part of the challenge to the security of the water environment. South Asia and Central and West Asia have rivers assessed as being in the poorest health (Table 6), with selected rivers in India and Armenia having the poorest health ratings. Azerbaijan, Bangladesh, Thailand, Pakistan, and Sri Lanka all have rivers that are in such poor health that environmental water security is threatened in these basins.

Measures of Environmental Water Security

The *AWDO* river health index is a measure of how countries are restoring their river basins and ecosystems to health on a national scale. River health is the capacity of rivers to maintain their natural functions and associated goods and services. Rivers are most commonly threatened by

49 The river health index developed for *AWDO 2013* is based on C. J. Vörösmarty, P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. Reidy Liermann, and P. M. Davies. 2010. Global Threats to Human Water Security and River Biodiversity. *Nature* 467:555–561.

four stress factors: watershed disturbance, pollution, water resource development (increased storage and diversions that alter natural flows), and biotic factors (Box 6).

BOX 6

Key Dimension 4—River Basin Health Indicators

Key dimension 4 assesses the status of the water related environment of river basins using the river health index (footnote 52). The river basin health index is a composite of four indicators and their subindexes:

Watershed disturbance

- Cropland
- Imperviousness
- Livestock density
- Wetland disconnection

Pollution

- Soil salinization
- Nitrogen
- Phosphorous
- Mercury
- Pesticides
- Total suspended solids
- Organic loads
- Potential acidification
- Thermal impacts from power plant cooling

Water resource development

- Dam density
- River network fragmentation
- Relative water consumption compared to supply
- Agriculture sector water stress
- Residency time change downstream from dams

Biotic factors

- Nonnative species
- Nonnative species richness
- Catch pressure
- Aquaculture

See Appendix 5 for more detail.

This index was developed for the *Asian Water Development Outlook* by the International WaterCentre.

TABLE 6

Environmental Water Security by Subregion (population-weighted)

River Health Index	Bad 0–0.22	Poor 0.23–0.36	Moderate 0.37–0.54	Good 0.55–0.71	Excellent 0.72–1	Index
Central and West Asia	2	7	–	–	–	1.9
East Asia	–	1	1	1	–	2.0
Pacific	2	1	5	5	2	3.5
South Asia	4	1	1	1	–	1.0
Southeast Asia	1	3	–	4	–	2.4
Advanced economies	–	3	2	2	–	2.3
Total	9	16	9	13	2	

Notes: The number in each cell refers to the number of countries, according to the ranking of river health condition. Rankings are from *bad* to *excellent* based on the river health index values. Expert opinion was used where data were not available.

Source: Based on various data sources reported in the AWDO 2013 *background paper "Water Security Key Dimension 4: Restoring Healthy Rivers," available on the* AWDO 2013 *supplementary DVD.*

River size. River size was found to be linked to river health; however, the relationship is not statistically significant. Larger rivers are generally in poorer health than smaller rivers, probably due to increased human activities leading to higher pollution loads and greater water extraction.

Proximity to coast. Rivers in proximity to the coast are generally found to have a significantly better-than-average river health index. This is perhaps due to the increased exchange of river and ocean waters in contrast to rivers with greater proportion of inland catchments.

Population density. Population density is a significant determinant of the river health index. At population densities of less than 10 persons per square kilometer, the river health index is significantly higher than catchments with medium population density (10–300 individuals per square kilometer) and high population-density basins (more than 300 individuals per square kilometer). Increasing population density generally puts extreme pressure on rivers.

Agricultural density. River health has a strongly negative correlation with intensity of agriculture in the basin. Basins with less than 25% of the area used for agricultural operations are in better health than catchments with medium- or high-intensity agriculture. Intensive agriculture changes land cover, displaces native vegetation, and introduces monocrop cultivation and the use of greater amounts of agro-chemical and fertilizer inputs. Greater nonpoint pollution from nutrient and sediment loads entering the river and new irrigation diversions are adding stress on the water resources of the basins. Very substantial impacts on river basin health are found in developing countries where, as water extraction increases, the pollution load increases and the resulting deterioration of river health reduces the value and viability of land for planned uses. Pollution also raises the costs of treating water for domestic and industrial supplies.

How Does Asia and the Pacific Measure Up?

The *AWDO* river basin health index reveals the wide range of river conditions across Asia and the Pacific. Notably, the rivers in the Pacific island states of the Solomon Islands and Vanuatu are in the best health. These small, tropical island countries have low population densities, with the

majority of the population living in the coastal zones. The health of these rivers is similar to that of rivers in Australia, Japan, and Singapore.

The rivers of Armenia and India are the least healthy and in urgent need of investment in remedial actions to regenerate ecosystem services as a basis for sustainable economies and better quality of life. The water bodies of Azerbaijan, Bangladesh, Iran, the Republic of Korea, Pakistan, Sri Lanka, and Thailand are also of concern, as many rivers are assessed as being in poor health.

The majority of rivers rated the least healthy are characterized by water resource developments that have substantially changed the flow regime. These changes were found to impact about half the catchment area (48.7% on average). However, pollution is the dominant factor affecting basins in the second-least-healthy group, typically up to 26% of the catchment area in these basins is polluted (Table 7). Two major factors impacting river health are population density and the extent of agricultural production in the river basin.

TABLE 7

Distribution of River Health Index Determinants (% of catchment area impacted)

River Health Determinant	River Health Index Grouping	
	Bad River Health 0.0–0.21 % of area	Poor River Health 0.22–0.35 % of area
Watershed disturbance	13.1	7.9
Pollution	18.9	26.0
Resource development (altered natural flows)	48.7	15.6
Biotic factors	4.3	8.2

Source: Based on various data sources reported in the AWDO 2013 *background paper "Water Security Key Dimension 4: Restoring Healthy Rivers," available on the* AWDO 2013 *supplementary DVD.*

Poor river health is often the result of inadequately planned and poorly executed water resource development. Common problems result from inappropriately developed or poorly managed irrigation systems, inadequately regulated point sources (such as mine tailings and wastewater from industry and municipalities), and uncontrolled nonpoint source pollution (generally agricultural chemicals and pesticide loading from farmlands). Watershed disturbances, including deforestation, road and building construction, and loss of natural wetlands, are all contributing factors in the deterioration of river health (Table 8).

In South Asia, rapid industrial growth is a significant factor driving deteriorating river health in major river basins. Heavy solvents and toxic sludge, among other substances, are reported to be discharged each year into the Brahmaputra, Ganges, and Meghna basins, and this pollution can enter freshwater sources. In the same three basins, about 88% of water withdrawals are used for irrigation, and the return flows to the river systems often are contaminated with agricultural chemicals and pesticides.[50]

50 M. S. Babel and S. M. Wahid. 2008. *Freshwater Under Threat—South Asia: Vulnerability Assessment of Freshwater Resources to Environmental Change*. Nairobi: United Nations Environment Programme and Bangkok: Asian Institute of Technology.

Key Dimension 4

Environmental Water Security

To restore healthy rivers and ecosystems

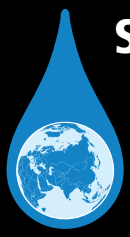
Healthy rivers provide valuable services to economy and society.
Asia's rivers suffer from the pressures of pollution, insufficient environmental flows, watershed deterioration, and increasing population.

World

60% of the world's population lives in Asia, which has the lowest per capita availability of freshwater.

Asia and the Pacific

80% of Asia's rivers are in poor health, jeopardizing economies and the quality of life. $1.75 trillion in ecosystem services per year are threatened.



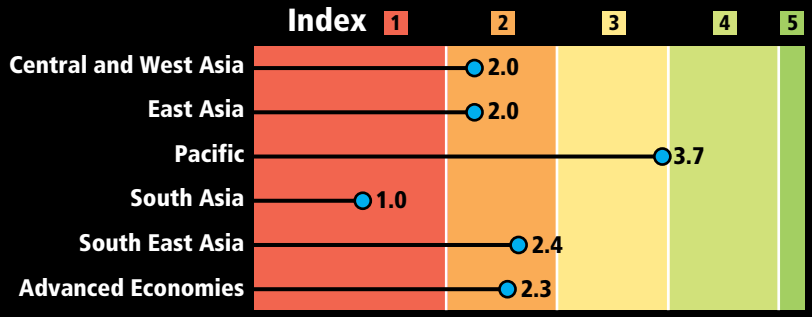
South Asia

This region has the lowest environmental water security, posing huge **challenges for sustainable development.**

Vision

Societies can enjoy environmental water security when they successfully manage their water resources and services to restore healthy rivers and ecosystems.

Environmental Water Security by Subregion (population-weighted)



Challenges

- Improving river health requires **integrated water resources management** (IWRM).
- 50% of irrigated area in Central Asia is **salt-affected, waterlogged,** or both
- Uncoordinated **water resources development** (hydropower, impoundments, flood control, diversions, etc.) negatively affect half of Asia's rivers.

Actions to be Taken

- Accelerating the process of IWRM with all basin stakeholders will increase the return on public investment in **water storage, productivity, and conservation.**
- Public investment, market-based approaches, and support from the private sector can **reduce pollution and finance the restoration of healthy rivers.**
  $1 invested in a river restoration program can return more than $4 in benefits.

TABLE 8

Environmental Water Security in Selected Basins and Countries

Subregion (Country or basin in parentheses)	Watershed Disturbance (% of basin)	Pollution (% of basin)	Resource Development (% of basin)	Biotic Factors (% of basin)	River Health Indicator	River Health Assessment
Central Asia (Aral Sea)	4.2	6.5	74.1	15.1	0.28	Poor
Central Asia (Syr Darya)	0	31.6	68.4	0	0.30	Poor
East Asia (People's Republic of China)	3.4	20.3	71.7	1.3	0.26	Poor
East Asia (Yellow River)	0	29.7	70.3	0	0.19	Bad
Southeast Asia (Indonesia)	21.9	12.5	40.6	0	0.46	Moderate
Southeast Asia (Philippines)	40.1	8.1	27.7	0	0.35	Poor
Southeast Asia (Mekong)	21	3.6	63.8	11.6	0.27	Poor
Southeast Asia (Viet Nam)	38.8	26.7	25.3	4.6	0.27	Poor

Notes: Stressors (catchment disturbance, pollution, water resource development, and biotic factors) developed by C. J. Vörösmarty et al. 2010. Global Threats to Human Water Security and River Biodiversity. *Nature* 467:555–561.

Source: Based on various data sources reported in the AWDO 2013 *background paper "Water Security Key Dimension 4: Restoring Healthy Rivers," available on the* AWDO 2013 *supplementary DVD.*

In Central Asia, agricultural developments have already had major impacts and represent the major stress on the region's rivers. In the Aral Sea basin, for example, irrigation services were expanded during the second half of the last century to convert vast tracts of undeveloped land into productive agricultural systems, leading to a drying up of the Aral Sea. However, the drainage systems to complement the irrigation networks have been inadequate, leading to falling water quality and extensive land degradation in the areas fed by the Amu Darya and the Syr Darya. According to recent estimates, more than 50% of irrigated areas in Central Asia are salt-affected, waterlogged, or both.[51]

The deterioration of rivers in Southeast Asia potentially threatens the livelihoods of tens of millions of people who depend on rivers. Fisheries, which support the livelihoods of about 1.6 million people in the Lower Mekong basin, may be seriously damaged if the migration routes of fish are blocked by dams on the Mekong River.[52] Disturbances of natural wetlands in the subbasins of the

51 M. Qadir, A. D. Noble, A. S. Qureshi, R. K. Gupta, T. Yuldashev, and A. Karimov. 2009. Salt-Induced Land and Water Degradation in the Aral Sea Basin: A Challenge to Sustainable Agriculture in Central Asia. *Natural Resources Forum* 33:134–149.

52 Mekong River Commission. 2010. *Strategic Environmental Assessment of Mainstream Dams*. Available at http://www.mrcmekong.org/about-the-mrc/programmes/initiative-on-sustainable-hydropower/strategic-environmental-assessment-of-mainstream-dams/.

Tonle Sap are causing ecological hot spots, which may lead to the disappearance of indigenous plant and animal species (footnote 50).

What Is at Stake

In 2005, the total value of the world's freshwater ecosystem services (including fish production, recharge of groundwater, and climate regulation) was estimated at about $5 trillion per year. Estimates of the value of ecosystems include the indirect benefits from flood control, groundwater recharge, shoreline stabilization and shore protection, nutrition cycling and retention, water purification, preservation of biodiversity, and recreation and tourism.[53] In Asia, the economic value of the services provided by river ecosystems (including lakes, rivers, tidal marsh, mangrove stands, swamps, and floodplains) is about $1.75 trillion per year, with rivers and lakes contributing about $1 trillion per year. With the river health index revealing that almost 80% of rivers in the region are in poor health, it is clear that the economy and quality of life in large parts of the region may be in jeopardy unless the current trends are reversed.

Youth awareness in the People's Republic of China: Encouraging behavioral changes and disseminating knowledge about rivers is an important part of ecosystem rehabilitation and in Asia and the Pacific.

STEVEN GRIFFITHS

The contribution of the rivers to the economy of the region provides a compelling rationale for maintaining rivers in good health and investing in the restoration of those in poor health. However, it is the failure to adequately recognize the economic value of services provided by rivers and wetlands that has resulted in widespread degradation and loss of ecosystem services. Unregulated and poorly managed development in watersheds is changing runoff characteristics, generally reducing the environmental value of flows, and contributing to pollution and increased sediment loads of rivers.

Misplaced perceptions that river health is a noncritical issue and a widespread assumption that improving wastewater management is not an urgent need are delaying or limiting the investments needed to reverse the trends of deteriorating river health. Increased and well-focused investments are urgently needed to improve wastewater treatment.

Improving management of wastewater is fundamental to improving environmental water security, which underpins sustainable economies, societies, and human health. Failing to accelerate and increase these investments will lead to a continued fall in river health, which will impair growth and limit increased regional prosperity. Industrial and urban growth in Asia is rapid and is driving the swift economic advance of the region. However, the absence of environmentally sound wastewater disposal strategies in the region will threaten equitable growth and prosperity if current approaches are not changed.

53 R. Costanza, R. D'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature 387:253–60.

Information and education campaigns are required that encourage farmers to adopt better management of agricultural inputs to minimize polluting return flows to river systems.

Asia and the Pacific is home to about 60% of the world's population, resulting in the lowest per capita freshwater availability.[54] However, Asia is endowed with substantial freshwater resources and should be able to benefit economically and socially from this advantage. Yet, this will depend on being able to maintain and, where necessary, restore healthy river systems (Box 7).

BOX 7

People's Republic of China: A Case Study of River Health Index

The river health index (RHI) for the People's Republic of China (PRC) is 0.26, ranking it 31 among the 59 countries assessed. Population density and agricultural density are key drivers of RHI in the PRC. The biggest threat to river health in the PRC is water resource development.

Population density. Rivers with a low population density have a much higher RHI (0.48) than rivers with medium density (0.18) and high density (0.06).

Agricultural density. Rivers with low agricultural density are in the best health (RHI = 0.33). Rivers with medium and high density of agricultural operations are in poorer health (RHI = 0.07 in medium-density and RHI = 0.06 in high-density basins).

River size. RHI does not markedly change with river size. Medium-sized rivers have the highest RHI (0.27) and the largest rivers have the lowest (0.14).

Major ecosystem classes. As with the global assessment, rivers in the PRC classified as urban score the lowest RHI. Rivers in forests, mountains, and islands score the highest.

Management Lessons

The leadership of the PRC has recognized the threats that deterioration in river health poses to the economic and social advances made. To mobilize resources to reverse the trend of inadequate attention to environmental values and ecosystem services, the PRC is exploring new policy tools to promote eco-compensation, which is emerging as a valuable economic and environmental policy instrument to address the upstream/downstream trade-offs. The tools are proving to be effective in improving management of water quality. In eco-compensation, which is similar to the better-known international practice of "payment for ecosystem services," a downstream local government pays an upstream local government and community members for environmental services provided by the upstream watershed. The downstream community benefits from the watershed protection efforts of the upstream community. In eco-compensation, the "beneficiary pays principle" applies, rather than the "polluter pays principle," which is usually applied in point-source pollution control.

Still to be included in the country's eco-compensation framework is compensation for those who lose opportunities or access to ecosystem services.

The *AWDO 2013* supplementary DVD presents 10 case studies on RHI in selected river basins and countries of Asia and the Pacific.

54 World Wide Fund for Nature (WWF). 2012. *Ecological Footprint and Investment in Natural Capital in Asia and the Pacific*. United Kingdom: ADB and WWF.

Pulling the Policy Levers

An effective medium-term approach for rehabilitation and protection of rivers will generally involve improved management and additional investments for river cleanups and improved wastewater treatment. This demands supportive policy and regulatory frameworks to encourage long-term rehabilitation and conservation efforts. These frameworks must be supported by enforcement of the regulations, linked with adequate budget resources and, where possible, innovative financing schemes. A number of countries in the region, most extensively the PRC, have experimented with various payment-for-watershed-services schemes, which are providing successful incentive-based approaches that improve local management, increase protection of watersheds, and provide increased funding for wastewater treatment (Table 9).

TABLE 9

Policy Levers to Increase Environmental Water Security

Item	Policy Levers
Financing	Promote payment for watershed services programs to create a funding source for conservation to secure the goods and services that rivers provide to people and the economy.
Social	Expand community awareness campaigns to encourage behavioral changes and disseminate knowledge about rivers as the essential source of water security. Invest in capacity building of the community to expand the use of appropriate management practices, conservation measures, and commitment to the protection of rivers.
Environmental	Adopt integrated water resources management approaches to correct contradictions in sector policies and practices and to promote coordinated investment in basins. Invest in regular monitoring of river health and ensure that management interventions and stewardship of the basin resources are effective.
Technology	Expand deployment of cost-effective technology for wastewater treatment. Promote improved information systems to monitor discharge and water quality in rivers and return flows.

Traditionally, river basin development works have been aimed at increasing water supply for various purposes. Unfortunately, although the various sectors (domestic supplies, agriculture, fisheries, industry, and transport) depend on the same water systems, the different uses have generally been poorly coordinated.[55] The multiple functions of river basins must be better recognized. These include energy production, support for urban environments and water uses, tourism, conservation of biodiversity, maintenance of ecosystem services, and respect for cultural values and traditions. To achieve long-term, sustainable water security for all users, adoption of integrated water resources management approaches are most likely to succeed.

Well-defined water rights (including traditional rights) and effective water allocation systems are essential foundations for any approach to improving the management and protection of rivers and watersheds. Defined water rights are a necessary condition to enable eco-compensation or payment-for-environmental-services schemes to work. The value of river-based ecosystem services, estimated at $1.75 trillion per year in Asia and the Pacific, demands that the environment be considered a legitimate user of water. To preserve the services and economic contributions of environmental uses, these must be included in water rights and allocations in basin development and management plans.

55 P. T. De Jong, J. C. Van Rooy, and S. H. Hosper. 1995. Living with Water: At the Cross-Roads of Change. *Water Science and Technology* 31(8):393–400.

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Concrete dikes serve as a flood wall along the Chao Phraya River in Nakhon Sawan, Thailand: Resilience to disasters is an important aspect of national water security.

AFP

Key Dimension 5: Resilience to Water-Related Disasters

To build resilient communities that can adapt to change.

About 90% of disasters are water-related, including floods, droughts, hurricanes, storm surges, and landslides. Asia and the Pacific is already the most vulnerable to water-related disasters, and the region continues to be inadequately prepared. The impact of water-related disasters is increasing due to increasing exposure of vulnerable populations and infrastructure. The Asia-Pacific Water Forum anticipates that the consequences resulting from climate change will put extra burdens on the already vulnerable countries in Asia and the Pacific, hindering sustainable development, poverty reduction, and other important goals/targets in the region. Although improved forecasting has reduced the number of deaths from water-related disasters, the cost of flood disasters in the region has increased over time, reaching estimated damages of over $61 billion in 2011.[56] Disaster risk reduction strategies are not uniformly or widely implemented in many countries.

56 Swiss Re. 2012. Natural Catastrophes and Man-Made Disasters in 2011 : Historic Losses Surface from Record Earthquakes and Floods. *Sigma* 2/2012. Available at http://media.swissre.com/documents/sigma2_2012_en.pdf.

A country's exposure to disaster-related risks and its capacity to overcome such disasters defines its resilience. Factors that determine a population's vulnerability include demographics and infrastructure. Resilience is the outcome of historical experience and the investments made to cope with water-related hazards, namely floods, droughts, storm surges, and coastal flooding. The danger that a hazard becomes a disaster is reduced as socioeconomic status and infrastructure investments increase.

BOX 8

Key Dimension 5—Resilience to Water-Related Disasters

Key dimension 5 measures progress toward establishing resilient communities that can adapt to change. It is a composite indicator that includes evaluation of three types of water-related shock—floods and windstorms, droughts, and storm surges and coastal floods—by assessing

- exposure (e.g., population density, growth rate);
- basic population vulnerability (e.g., poverty rate, land use);
- hard coping capacities (e.g., telecommunications development); and
- soft coping capacities (e.g., literacy rate).

See Appendix 6 for more detail.

This index was developed for the *Asian Water Development Outlook* by the International Centre for Water Hazard and Risk Management.

TABLE 10

Risk for Water-Related Disasters by Subregion (population-weighted)

Region	Hazard	Exposure	Vulnerability	Hard Coping Capacity	Soft Coping Capacity	Risk Indicator
Central and West Asia	5.24	4.48	6.21	8.36	10.30	32.8
East Asia	7.68	6.82	5.27	10.56	11.20	48.0
Pacific	5.96	6.69	9.87	5.86	5.23	74.4
South Asia	6.98	8.31	8.62	10.97	6.58	72.0
Southeast Asia	5.12	8.16	5.96	10.04	9.73	40.5
Advanced Economies	7.03	5.27	1.17	13.91	12.22	19.0

Note: The National Water Security Index uses a resilience rather than a risk indicator.

Source: Based on various data sources reported in the AWDO 2013 *background paper "Water Security Key Dimension 5: Building Resilient Communities through Water-Related Disaster Risk Reduction," available on the* AWDO 2013 *supplementary DVD.*

Measuring Water-Related Disaster Resilience

Key dimension 5 measures progress toward establishing resilient communities that are able to adapt to change. Resilience is a function of exposure, vulnerability, and capacity (Box 8).[57]

Resilience may be considered a proxy indicator of the national resources allocated to disaster management. However, resilience also reflects the state of the country's socioeconomic development; more advanced economies tend to be more resilient. A community's coping capacity is a strong determinant of its resilience; however, capacity alone is not universally sufficient to guarantee resilience. Some countries have populations that are more exposed to risks, such as in densely populated coastal zones. Well-executed land use planning and control of development in exposed lands lowers risk and increases resilience by limiting the number of people directly exposed to risk. Well-planned and -constructed infrastructure, including flood embankments and levees, seawalls, and early warning systems, reduces the exposure of populations that would otherwise be highly exposed to disasters. Some infrastructure will need to be retrofitted to climate-proof existing investment in the protection of communities at risk.

How Does Asia and the Pacific Measure Up?

Each country's risk from water-related disasters is a result of the degree of hazard, exposure, and vulnerability, as shown in Table 10.

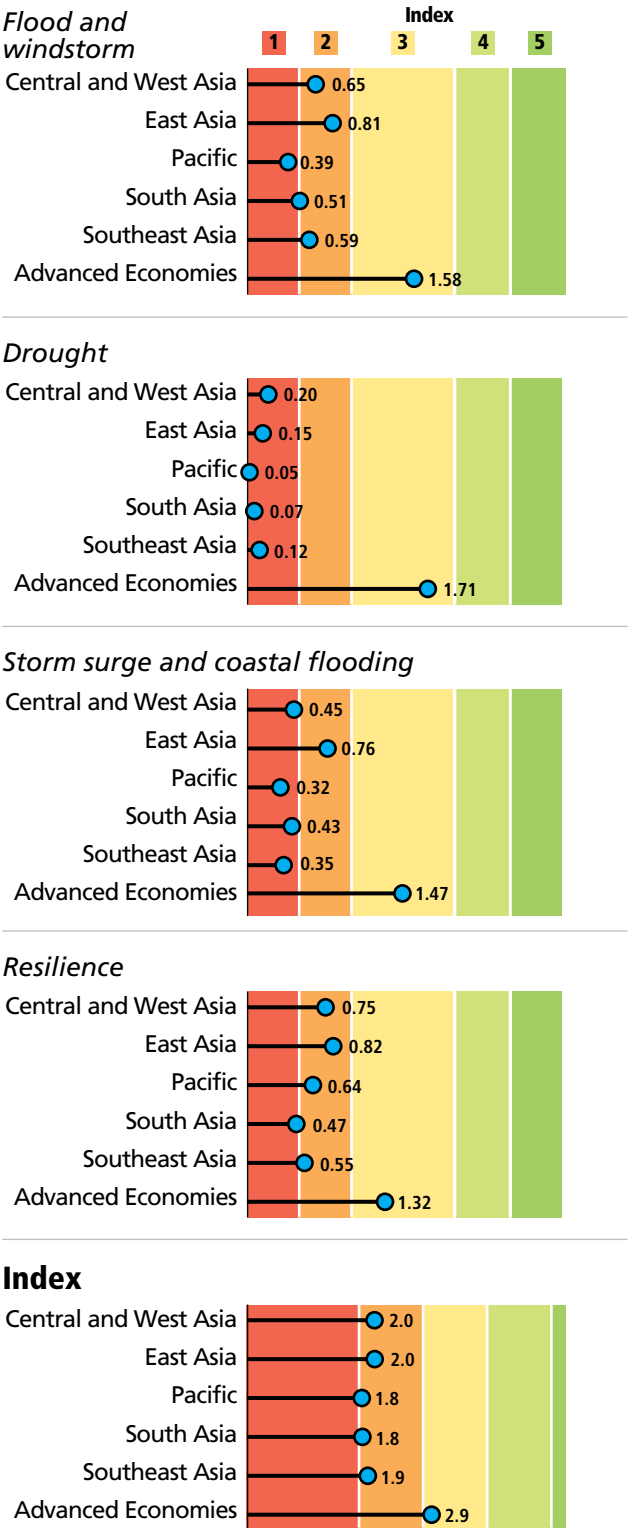
East Asia, the advanced economies, and South Asia are most frequented by hazards. However, the Pacific islands are at the greatest risk of a hazard becoming a disastrous event because of their high vulnerability and low coping capacity, with fragile water resources and a high vulnerability to droughts, cyclones, and storm surges, and significant danger from the impacts of coastal flooding.

South Asia and Southeast Asia are the most exposed, particularly to storm surges and coastal flooding. Although East Asia has the highest frequency of hazards, its extensive investment in hard and soft coping capacity and to lower poverty significantly increases its resilience to water-related disasters (Figure 15). These assessments indicate that natural high exposure to hazards does not automatically impose a high vulnerability.

AWDO findings suggest that socioeconomic development increases the resilience of communities and the

FIGURE 15

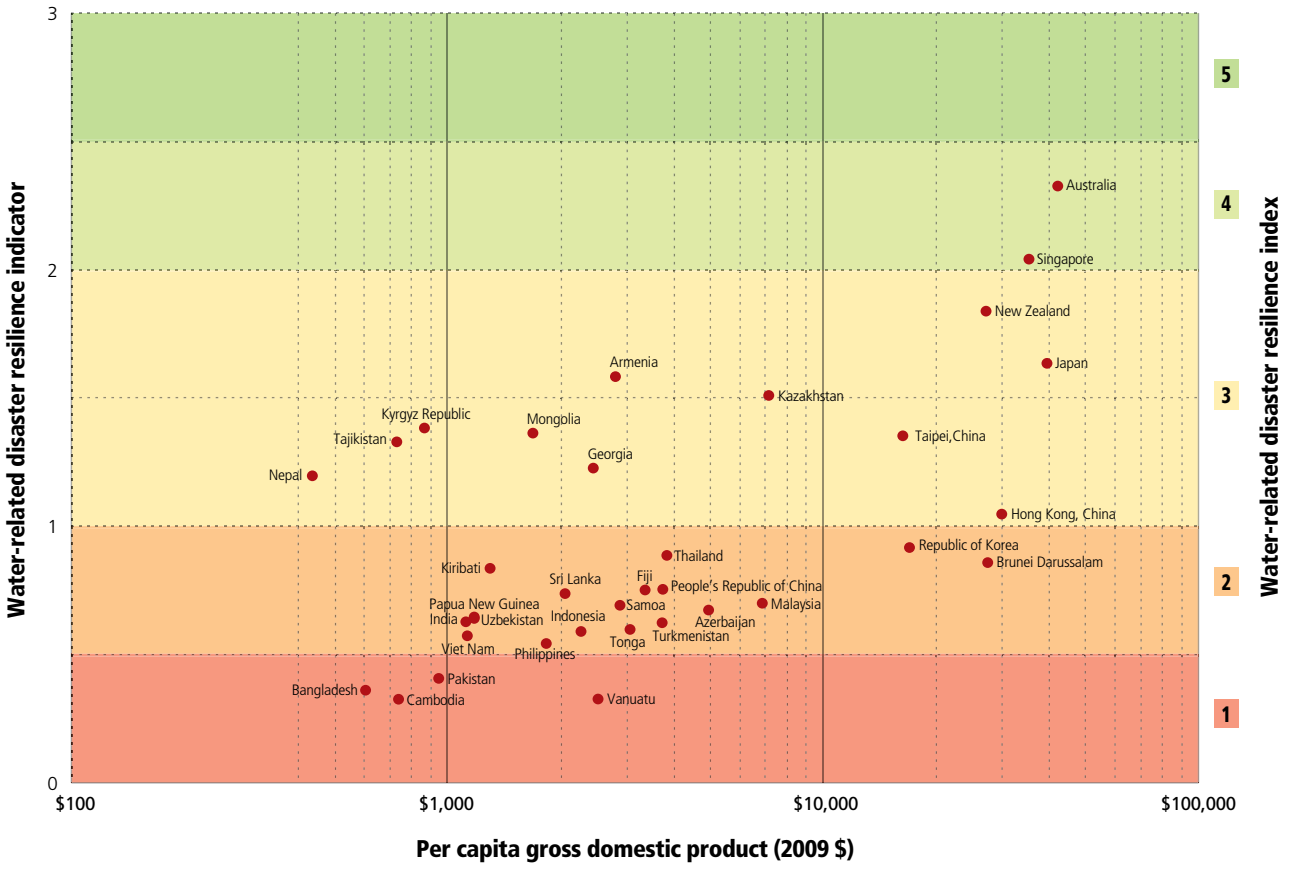
Resilience to Water-Related Disasters by Subregion (population-weighted)



57 Water-related disaster risk is a function of hazards, exposure, vulnerability, and capacity.

FIGURE 16

National Water-Related Disaster Resilience Index Relative to Per Capita Gross Domestic Product



Source: For gross domestic product data, World Bank. World Development Indicators. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

population (Figure 16). However, as illustrated by the recent natural disasters in the region, such as the 2004 Indian Ocean Tsunami, Cyclone Nargis in 2008, extensive flooding in Pakistan in 2010 and again in 2011, the 2011 Great East Japan Earthquake and tsunami, and flooding in Thailand in 2011, the region is vulnerable to major hazard events. These events are of such a scale that they may overwhelm even well-prepared countries, making it impossible to avoid loss of life, significant destruction, and substantial economic losses. These events have also illustrated the economic hazards associated with geographic concentration of specialized production systems and the exposure of international supply chains to disruption by natural events in another country.

The results for the developed economies show that economic advances do increase resilience to water-related hazards. Asia and the Pacific subregions are prone to water-related disasters, but the vulnerability of each country to these hazards is strongly correlated with the country's socioeconomic development. The group of advanced economies has the highest probability of experiencing a water-related hazard event, but because of their relatively low population growth, well-planned and -managed settlements, higher economic status, and high-quality infrastructure, they are more resilient and better able to mitigate losses, minimize damage, and/or recover from events faster (Figure 16).

Key Dimension 5

Resilience to Water-related Disasters

To build resilient communities that can adapt to change

Resilience to water-related disasters secures lives, livelihoods, and economic assets.
Urbanization and climate change pose unprecedented challenges to sustainable development in Asia and the Pacific. The region is the most vulnerable to water-related disasters, yet continues to be inadequately prepared.

World

90% of the world's disasters are water-related, including floods, droughts, hurricanes, storm surges, and landslides.

Asia and the Pacific

Disasters related to water have sharply increased, particularly floods. 90% of the people affected by water-related disasters live in Asia.

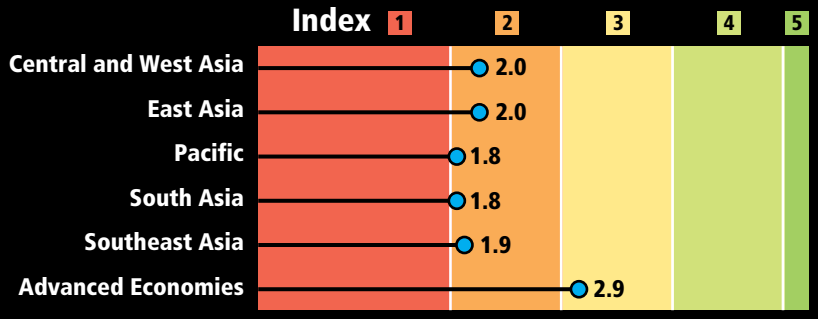
South Asia and the Pacific

These two subregions face the **highest risk** for water-related disasters and have the **lowest resilience.**

Vision

Societies can enjoy water security when they successfully manage their water resources and services to build resilient communities that can adapt to change.

Resilience to Water-Related Disasters by Subregion (population-weighted)



Challenges

- **Most countries in the region** have yet to incorporate disaster risk reduction into their public investment planning.
- **75% of vulnerable urban populations** in coastal zones live in Asia.
- **Although improved forecasting has reduced the number of deaths** from water-related disasters, the costs of flood disasters in the region have increased over time, reaching estimated damages of over $61 billion in 2011.

Actions to be Taken

- **Save lives and economic losses** by investing in modern flood forecasting, effective early warning systems that reach local communities 'the last mile', and by sharing information across national boundaries.
- **Reduce the cost of rehabilitation** after disasters by investing more in risk reduction and preparedness through a combination of structural and nonstructural solutions.

Nearly 46% of water-related disaster fatalities and 90% of people affected by such disasters from 1980 to 2006 lived in Asia.[58] From the mid-1990s to 2006, and in recent years, Asia has experienced a sharp increase in water-related disasters, particularly floods. Although South Asia is prone to droughts, most of the countries in East, South, and Southeast Asia are subject to frequent floods resulting from typhoons, cyclones, and monsoon rainfall. The Pacific region is prone to floods, windstorms, and storm surges and is more vulnerable than other subregions to rising sea levels. The developed economies of the region, including Australia, Japan,[59] the Republic of Korea, and Singapore, are just as exposed as their neighbors to the region's natural hazards. However, these countries generally suffer fewer losses, less damage, and fewer fatalities as a result of investments in durable infrastructure, their skilled leadership, and effective use of forecasting systems to warn and mobilize their populations in advance of storms.

Each subregion includes one or more countries assessed as having low resilience (Figure 17). Cambodia is shown as being the least resilient due to its very low coping capacities, characterized by poor disaster preparedness. Although Cambodia is less exposed to water-related disasters, the exposure of a large proportion of the relatively poor population makes the country vulnerable to these hazards. Vulnerability and exposure are expected to increase with climate change, due to increased incidence and severity of floods or drought events. Furthermore, as the floods in Thailand in 2011 demonstrated (Box 9), even slow-onset events can disrupt the lives of millions and impact economic activities beyond the immediate flooded area.

BOX 9

2011 Flooding in Thailand

Beginning at the end of July, triggered by the landfall of Tropical Storm Nock-ten, flooding soon spread through the provinces of northern, northeastern, and central Thailand, along the Mekong and Chao Phraya river basins. In October, floodwaters reached the mouth of the Chao Phraya and inundated parts of the capital city of Bangkok. Flooding persisted in some areas until mid-January 2012 and resulted in a total of 815 deaths (with 3 missing) and 13.6 million people affected. Of Thailand's 77 provinces, 65 were declared flood disaster zones, and over 20,000 square kilometers of farmland was damaged. The disaster has been described as "the worst flooding yet in terms of the amount of water and people affected." The World Bank estimated $45.7 billion in economic damages and losses due to flooding, as of 1 December 2011.

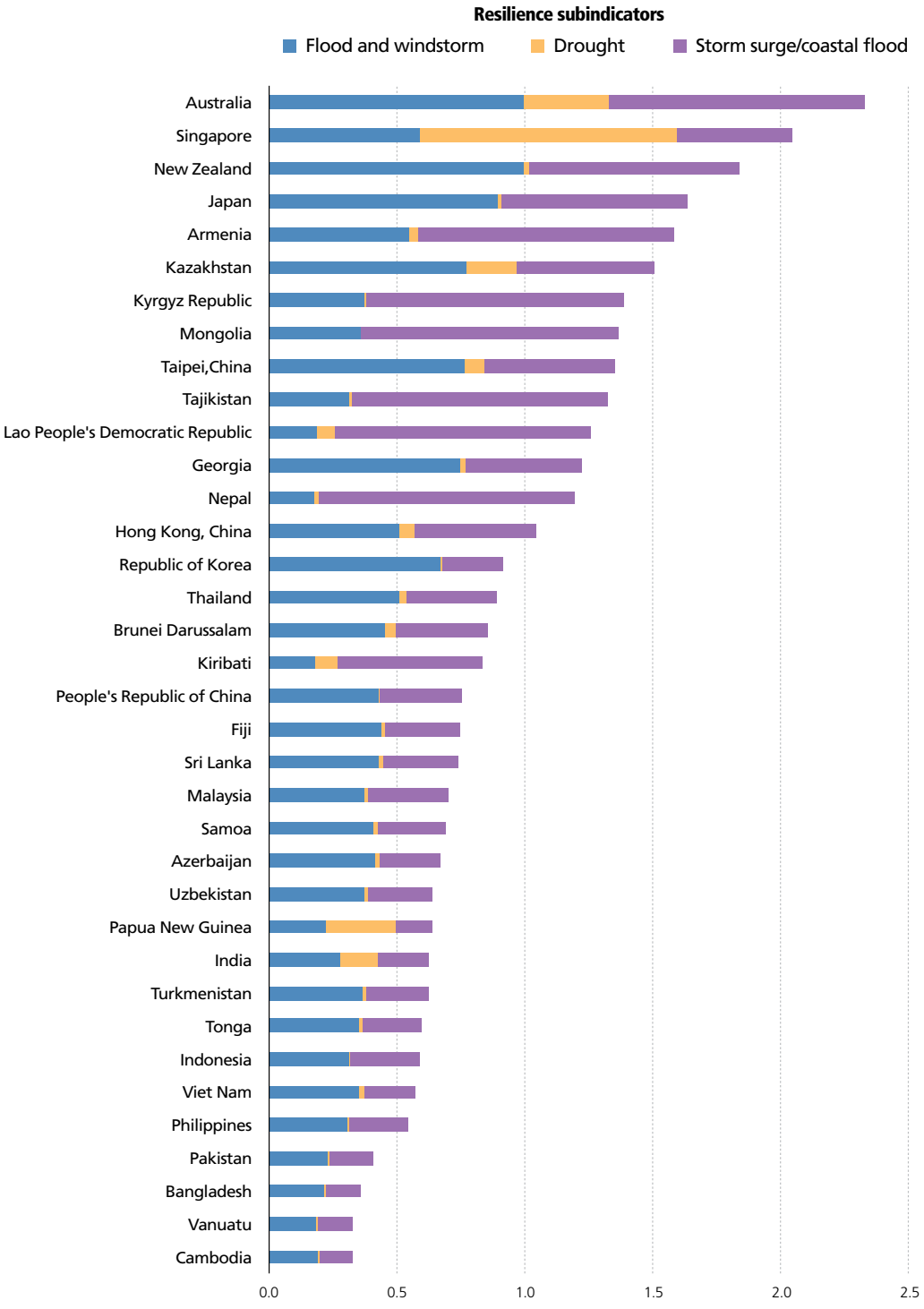
Most countries in Asia and the Pacific are still in the early stages of making strategic investments to increase climate resilience. Investments include urgent efforts to improve early warning systems, formulate improved drought management plans, and implement upgraded data collection and monitoring systems. Some countries have made substantial advances in their disaster preparedness and response and are now looking to reduce their exposure to risks by incorporating disaster risk reduction and management into policies, development plans, and design manuals. Improved protection of infrastructure is being complemented by better training of community leaders, community members, and staff responsible for vulnerable sectors. Screening tools are making their way into the planning process to ensure that new investments are designed with climate and disaster resilience as standard attributes. Local, traditional adaptation practices are getting less attention than international best practices, yet that knowledge is valuable, and some

58 Y. Adikari and J. Yoshitani. 2009. Global Trends in Water-Related Disasters: An Insight for Policymakers. Available at http://unesdoc.unesco.org/images/0018/001817/181793E.pdf?bcsi_scan_97e98328e2b67804=0&bcsi_scan_filename=181793E.pdf (accessed 1 February 2013).

59 The Great East Japan Earthquake and tsunami in March 2011 revealed that well-prepared countries with established emergency procedures and skilled disaster management capacity are also vulnerable to extreme natural events.

FIGURE 17

Water-Related Disaster Resilience Index



governments, such as that of Nepal—a highly vulnerable country—are designing and implementing government- and donor-funded programs to document local practices and develop local adaptation plans of action (Box 10).

Figure 18 summarizes national vulnerability as measured by resilience and the incidence of water-related hazards. The most vulnerable are the countries with the highest exposure to hazards and the lowest resilience, plotted in the red-shaded upper left quadrant. This quadrant includes

BOX 10

Local Disaster Preparedness in Chitral District, Pakistan, and Eastern Nepal Plains

National and international development agencies frequently disregard local knowledge, as it is considered unscientific or as "just myths or beliefs." The International Centre for Integrated Mountain Development conducted rapid rural appraisals in the Chitral District of Pakistan and the eastern plains (*terai*) of Nepal, documenting local knowledge on flood preparedness.

The case study reveals the potential for local knowledge and practices to improve disaster management. Generations of living with risks have created knowledge of the local environment and effective strategies to minimize negative outcomes from floods. Local people often have the ability to interpret the local landscape and to monitor local environmental signals of upcoming flood events. Locally adapted house construction includes strategies such as raising the house plinths and consolidating and protecting walls and fences with mud. Construction of elevated food stores and platforms keep small items, food, livestock, and people above flood levels.

Many communities have strategies for natural resources management, including communal regulations on grazing and deforestation, revision of cropping patterns and landholdings, and introduction of new cropping strategies, such as planting trees and/or vegetables on riverbanks to reduce the effect of flood. Communities learn from past mistakes and flood events due to social mobility and a tradition of oral communication (e.g., local songs) about past floods, which retains the memory of past flood events. They have also established early warning systems (e.g., whistling, shouting, or running downhill).

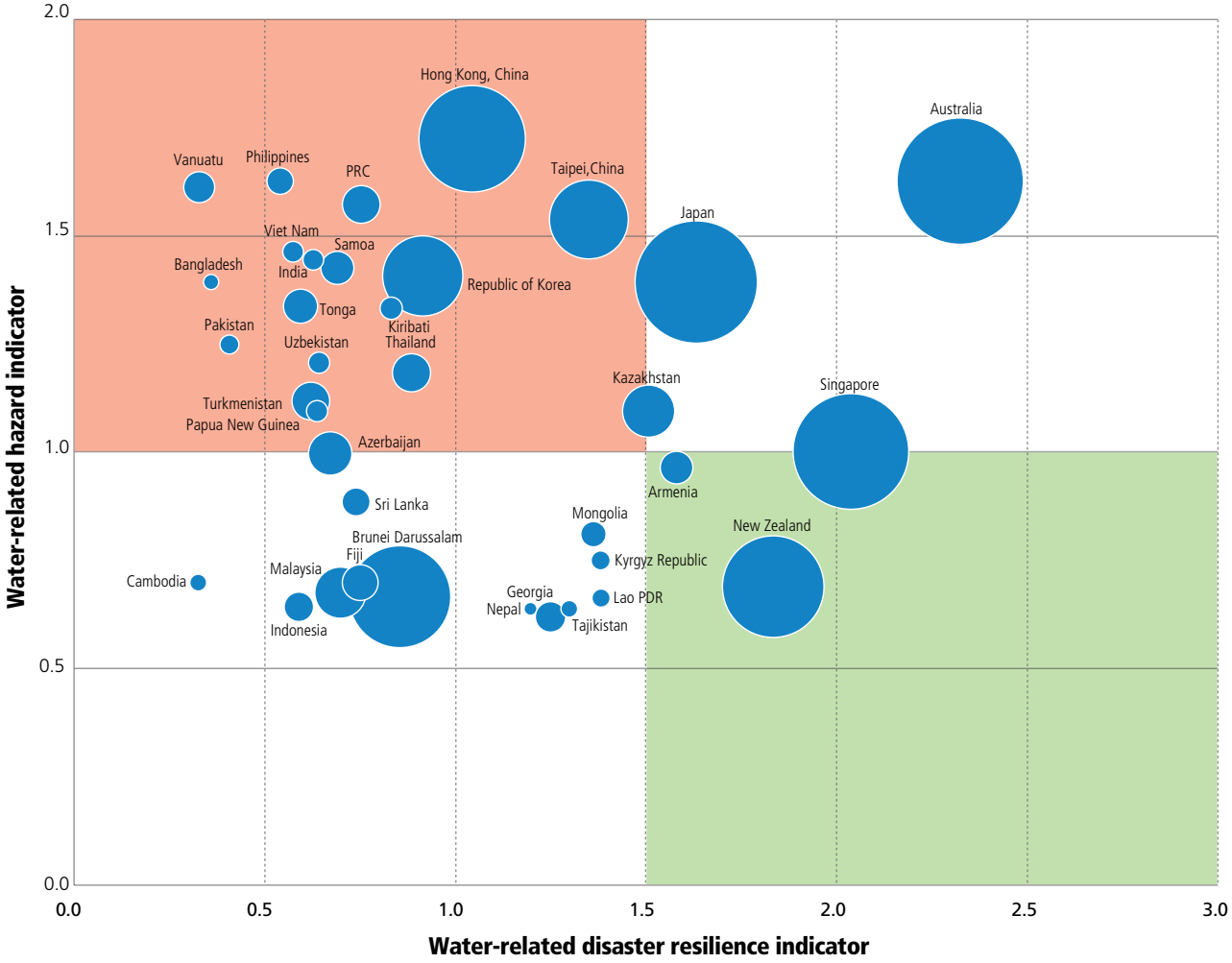
Accessing local knowledge can contribute to better formulation and implementation of disaster preparedness. External agencies should recognize the diversity and complexity of local knowledge and practices to better understand local contexts and needs. Better training in participatory design is required. Documenting local knowledge should become more systematic and should be undertaken before starting new activities. Rapid rural appraisal is a simple tool to collect and understand local knowledge about disaster preparedness. Documentation of local knowledge on disaster preparedness should collect information on how people observe, anticipate, communicate about, and adapt to natural hazards. Local knowledge alone is not sufficient, however, due to climate and other factors making some existing strategies less relevant or effective.

Improving disaster preparedness should replace unsustainable practices and beliefs, strengthen existing sustainable practices, and avoid introducing new practices that are not in tune with the local context. Great benefit can be obtained by seeking local advice on safe locations for construction of new buildings, roads, and so forth, and by adapting communication strategies to better fit local understanding and perceptions.

Source: Nepal case study, available on the AWDO 2013 *supplementary DVD.*

FIGURE 18

Water-Related Hazard Relative to Resilience



Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China

Note: Bubble size is proportional to per capita gross domestic product (2009 $)

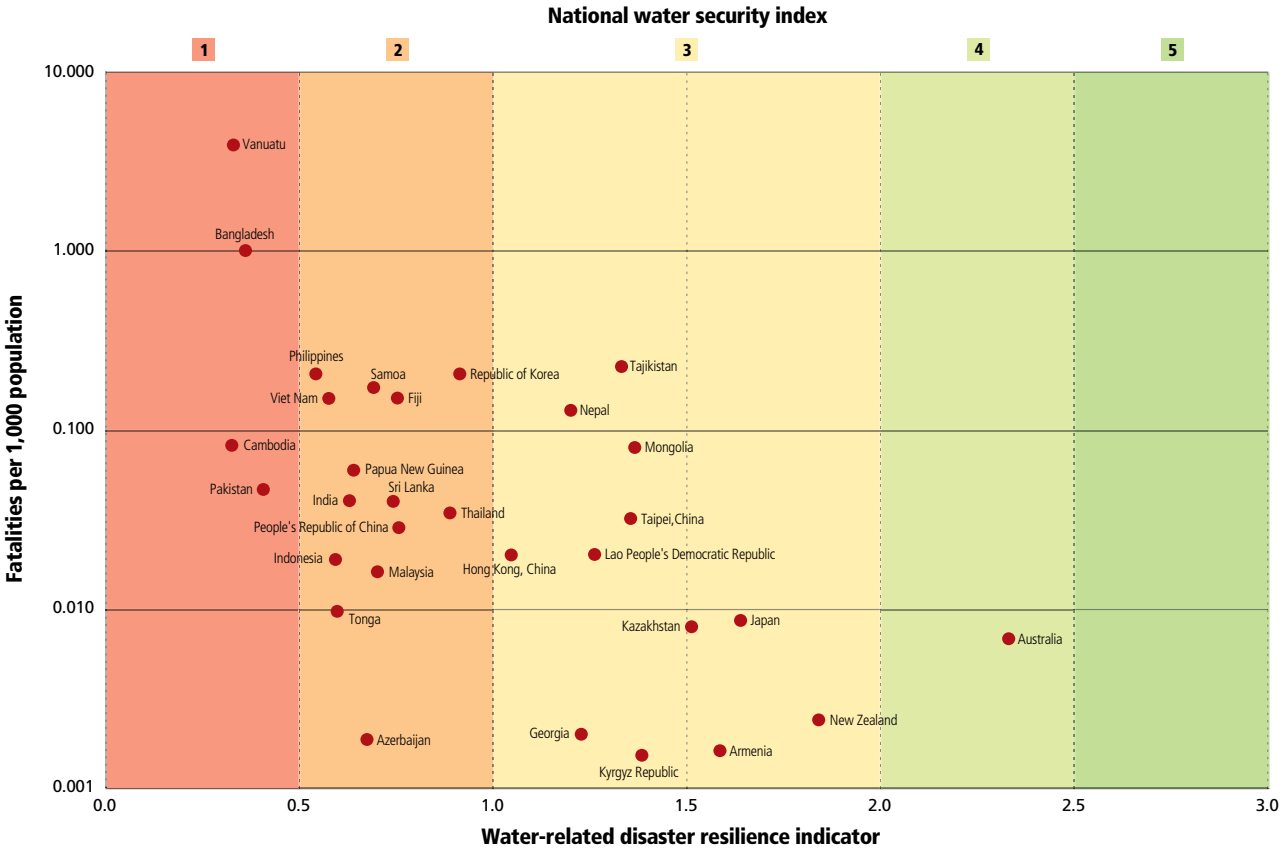
Source: For gross domestic product data, World Bank. World Development Indicators. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

Kiribati and Vanuatu, which have limited internal capacity to respond to major disasters and often require external assistance to facilitate recovery. The least vulnerable, with relatively high resilience and low exposure to hazards, are in the bottom right quadrant. Armenia and New Zealand, in the lower right quadrant, are the only countries with low exposure to hazards and high resilience. Those in the upper right quadrant are exposed to frequent water-related hazards but have stronger capacity to cope with such disasters when they occur.

Bangladesh is vulnerable to water-related hazards due to the exposure of its densely populated coastlines to frequent floods, storm surges, and rising sea levels. Several island countries in the Pacific also have low resilience, resulting from a lack of adequate infrastructure, governance, and social organization to prevent, respond to, and recover from extreme events. Each of these countries has high fatality rates when water-related disasters occur (Figure 19). The countries with the highest rates of water-related fatalities, notably Bangladesh, Nepal, the Philippines, Tajikistan, and Vanuatu, should be encouraged to increase investments in disaster risk reduction. Increased

FIGURE 19

Water-Related Disaster Fatalities Relative to National Resilience



Source: For data on fatalities, International Disaster Database. www.emdat.be/database

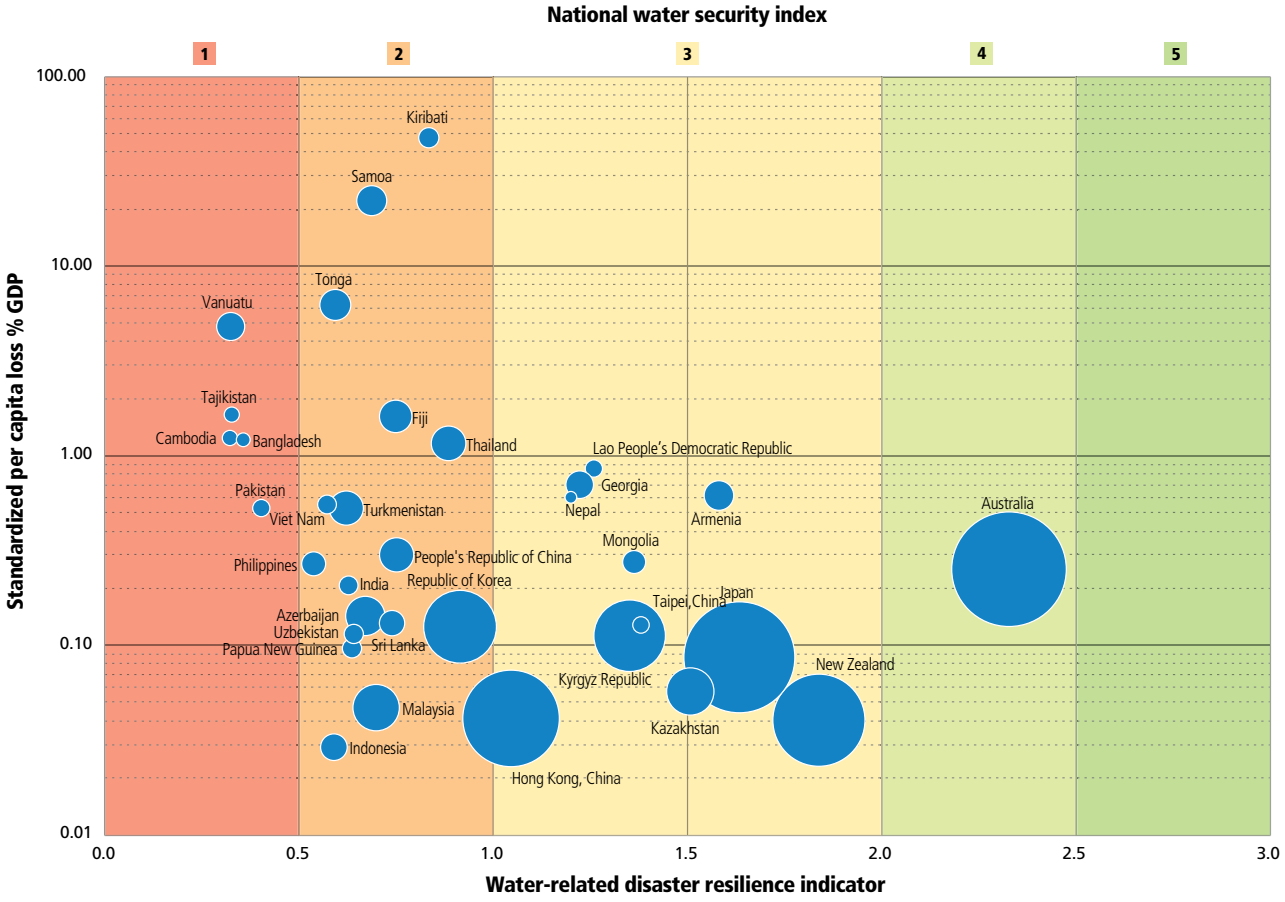
TABLE 11

Policy Levers to Increase Water-Related Disaster Resilience

Item	Policy Levers
Financing	Prepare appropriate funds for disaster risk management and response that are proportionate for the level of risk. Incorporate disaster risk management and climate adaptation into the national planning and budget process of the relevant line ministries. Develop and provide catastrophe insurance, including coverage for damages resulting in crop loss.
Social	Increase investments in early warning systems, including last-mile coverage to communities. Raise awareness about disaster preparedness and response as well as collective and individual adaptation measures to increase resilience. Revise school curricula to include information about climate change, mitigation and adaptation measures, and disaster preparedness and response.
Environmental	Invest in environmental, natural resource, and climate monitoring, data storage, forecasting, and warning systems.

FIGURE 20

Estimated Mean Annual Standardized Water-Related Disaster Damages
(per capita % per capita gross domestic product)



Note: Bubble size is proportional to per capita gross domestic product (2009 $).

Source: For gross domestic product data, World Bank. World Development Indicators. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

community-based disaster risk management is likely to be a cost-effective measure to make communities more resilient and to reduce fatalities.

Over the past 20 years, countries have incurred damages broadly inversely proportional to the estimated national water-related disaster resilience index (Figure 20). Countries such as Kiribati, Samoa, Tonga and Vanuatu each assessed with low resilience (< 1.5), have experienced comparatively high levels of damage. Conversely, Indonesia and Malaysia, also classified with low resilience (≈ 1.0), and Hong Kong, China, only moderately more resilient (> 1.75), have experienced low levels of losses from water-related disasters.

However, the majority of countries are only in the early stages of incorporating disaster risk reduction into their sector development planning process. Progress can be seen in stronger institutional systems and improved legislation for disaster preparedness and response. Good foundations are being laid for disaster risk reduction in many countries. Now, investments must be made to build effective infrastructure and organizations to reduce the risks faced by people in exposed communities.

Pulling the Policy Levers

Water-related disaster risk reduction and management, including more community-based approaches and climate change adaptation measures, must be more deeply incorporated into development of national policies, investment planning, and annual budget allocation processes (Table 11). These measures will reduce economic and social losses more effectively than confining disaster management as an isolated responsibility within a single ministry. Better coordination of efforts to mitigate disasters and damages can be built into many projects and development activities, including roads, water supply, and bridges, and irrigation, education, and health investments. Screening proposed infrastructure investments for climate risks will enable not only mitigation of disasters but also improved adaptation to the expected impacts of climate change.

What Is at Stake

Asia is the world's most populous continent, home to more than 60% of the world's 7.06 billion people.[60] More than 634 million people (one-tenth of the global population) live in coastal areas that lie 10 meters or less above sea level. Of the total global urban population, 13% lives in low-

60 UN ESCAP. 2012. Data Explorer - Annual Data. http://www.unescap.org/stat/data/statdb/DataExplorer.aspx .

The skyline of Johor Bahru, Malaysia.

elevation coastal zones; of these, about 75% reside in Asia. In 21 nations, more than half of the population lives in such coastal zones, and 16 of these countries are small island states. More than 40% of the land area of Bangladesh, a highly populated country, lies below 10 meters above sea level. In addition to the hydrometeorological extremes that can cause frequent droughts and floods, glacial retreat in the Himalayas is increasing the risk of potentially disastrous glacial lake outburst floods. The demographic and geographic vulnerability of Asia and the Pacific to water-related disasters highlights the urgent need to create capacity for disaster risk reduction.

Economic development and resilience are correlated. As long as a country's level of resilience remains low, the probability of sustainable economic and social development also remains low. Decades of economic development can be undone by a single disaster.

Investment in disaster risk management reduces a community's risk of loss of critical infrastructure. It reduces reconstruction costs and loss of development opportunities, which lowers the overall cost of reducing poverty and helps ensure that development is sustainable.

AFP

AFP

Part III

Taking the Lead: Key Messages to Increase Water Security

Swimming in the Buriganga River in Dhaka: About 43% of the population in Asia and the Pacific live in urban areas, putting pressure on water resources.

AFP

Improving Water Governance

Leaders of government, the increasingly dynamic private sector, and the region's diverse and resourceful civil society are the gatekeepers of a water-secure future in Asia and the Pacific. They set the pace of reforms and signal the urgency of the transformation through their own leadership styles and visions for a water-secure society. They have the proven potential to drive and expedite changes in the water sector—changes that have profound effects on the lives and livelihoods of millions of individuals and on the economies of Asia and the Pacific. These leaders must raise the standard and demonstrate their confidence and their commitment to taking on the challenge of maintaining water security. The skills and the resources they command are in demand, and the needed changes are critical. Water resources must be developed and managed in environmentally and socially responsible ways.

The *Asian Water Development Outlook 2007* (*AWDO 2007*) highlighted water governance as a potent source of present and future water insecurity, and as a key to increasing water security. Combining the *AWDO 2013* water security indicators with the World Bank governance indicators[61] confirms a strong relationship between measures of national governance and water security outlined in the 2007 edition of *AWDO.*

Parts I and II of this report presented the background on the search for objective measures of water security that would enable leaders in the region to propel changes that would transform the lives of the people in Asia and the Pacific. Part II used indicators developed for *AWDO* to illustrate the diversity of water security status among subregions and discussed the status of key dimensions of water security in various countries. Selected policy levers that could be used to initiate changes that would increase water security are presented for each of the five key dimensions that, together, determine the level of national water security. This final section summarizes opportunities and strategic choices that are available to leaders in government, the private sector, and civil society to

61 World Bank. Governance Indicators. http://databank.worldbank.org/Data/Views/VariableSelection/SelectVariables.aspx?source=Worldwide%20Governance%20Indicators#.

bring about improvements in water security that will positively affect the lives and livelihoods of the almost 4 billion people of Asia and the Pacific.

Water governance plays a central role in boosting water security in each of the five key dimensions, and also in managing the trade-offs between the dimensions. It is an intersectoral process that requires leaders to break through silos, to span boundaries, and to create a positive nexus among water, food, and energy security. This process is known as integrated water resources management (IWRM), and most countries in the region have already adopted policies and legislation to support its implementation. There are, however, no one-size-fits-all solutions across the region. Rather, the appropriate solutions in each country will reflect the country's resource endowment, economic development, culture, and chosen development path. As the national water security assessments in *AWDO 2013* demonstrate, there is an urgent need to strengthen the capacity for integrated planning and management nationally as well as in river basins and cities.

Building on the findings of parts I and II, Part III offers 12 key messages for leaders that will bring substantive improvements to water security for households, productive economies, cities, rivers, and communities confronting serious risks from climate change and increasing demands on available water resources, using an intersectoral approach, effective water governance, and smart sharing of knowledge and resources that are available in the region. Together, they offer a ready prospect for increasing water security that will directly improve quality of life and prosperity in the region.

Not all of the choices suggested are easy or obvious. Nonetheless, clear leadership, with the commitment to make appropriate investments in capacity development and infrastructure, can accelerate the work of turning the vision of a water-secure future into a reality.

Key Messages for Leaders

Message 1: Make the best use of already developed water resources by investing in and incentivizing "reduce, reuse, recycle" systems.

Setting and implementing policies for demand management can unlock more benefits from existing urban and rural water services, and will reduce, and in some cases avoid, substantial public investment in developing new water sources, which should become the option of last resort.

The mantra "reduce, reuse, recycle" is an urgent message and a principle of water use that must be fully supported by policy and programs. This will require an acceleration of efforts to reduce demand, including reducing water withdrawals by industry and energy producers. Municipalities should routinely promote actions to lower domestic water consumption, thereby reducing or delaying the need to develop new water sources. Cities should require water-saving fixtures in all newly constructed homes, offices, and public buildings and should offer incentives to those who retrofit with these technologies. Well-designed tariff structures with effective information, education, and communication programs can reduce water demand substantially. Cities should increase investment in reducing non-revenue water, consider the potential to improve water services by establishing autonomous and accountable providers, increase price signals to users by improving metering and collection of service charges, implement tariff structures to support financial sustainability, and invest in inclusive public awareness programs to highlight water issues.

Public reluctance to consume safe "used" water can be overcome through communication programs, as Singapore's PUB has shown through its successful resale of treated wastewater.

STEVEN GRIFFITHS

Water awareness program in Sri Lanka: Public information, education, and communication programs can mobilize communities to protect water resources.

Message 2: Unlock the performance of water utilities through corporatization.

Helping water utilities to corporatize will increase their autonomy and accountability. These are key success factors for improving performance through better water governance and for attracting much-needed financing to expand networks and improve the quality and sustainability of water services.

Adoption of corporate-style governance and procedures, referred to as "corporatization," is a key for success in unlocking utility performance to deliver better water services for customers, with tariffs supporting cost recovery. In the many variations of government–corporate–society partnerships, there are ample opportunities for governments and regulatory agencies to adopt corporate forms of governance and to improve management and performance. There also are opportunities for civil society to monitor the quality of services from the providers and to demand that the poor receive the service they deserve as part of contractual arrangements.

Corporatization will not automatically improve efficiency and productivity unless the corporate entity allocates substantial resources to reorient internal organization, processes, and operations to satisfy customer needs. Investment in public information, education, and communication campaigns will be required to focus utility leaders and their partners on the search for ways to manage existing supplies more effectively. Cambodia's Phnom Penh Water Supply Authority is an example of an independent water utility that operates as a public enterprise and has been able to provide world-class, efficient water services to the entire city of Phnom Penh, with full cost recovery.[62]

62 Phnom Penh Water Supply Authority was the first initial public offering on the Phnom Phenh stock exchange on 18 April 2012. http://www.ppwsa.com.kh/

In support of corporatization, the private sector and market-based approaches may provide new sources of infrastructure investment and financing. The development of domestic capital markets, especially local currency bond markets, can help raise money for investments. There is no one-size-fits-all form of private sector participation. The differences among the various approaches are defined according to who has responsibility for capital investment and how the burdens of commercial risk are shared between the public and the private sector.

Message 3: Invest in better sanitation to boost health, productivity, and the economy.

Investing $1 in clean water and comprehensive sanitation from toilet to river can unlock as much as $8–$12 dollars in health and economic benefits.

Innovative arrangements should be encouraged to find ways to develop sanitation into the viable business it can be. These arrangements may include new roles for community-based or private sector entities. There is potential in many places for low-cost, decentralized treatment plants, sewerage, and septage management systems that would be viable, self-sustaining business models. Policies, incentives, and institutional arrangements are needed to attract more private sector and public utility investments.

The financial viability of sanitation investments would be strengthened by including health benefits in the cost–benefit analysis of projects. Such benefits often are cited in project rationales but rarely are accounted for in economic analysis[63].

Message 4: Mobilize rural communities for equitable and just access to water and sanitation.

Make water everybody's business by promoting local collective action in rural communities to reverse an alarming trend of widening inequitable access to safe drinking water and improved sanitation. Social justice for poor and vulnerable groups will enable such groups to benefit from investment in water and sanitation projects.

Access to water supply and sanitation improves health and increases the productivity of people. Demand-led, community-based approaches to water delivery are particularly effective in increasing access in rural areas. Even so, unequal access to services may persist, as the poorest in the community are often the first to be excluded from benefiting from improvements. To promote social justice, personnel working in these communities must take active roles to avoid cases of social exclusion. Information, education, and communication campaigns are essential to mobilize communities and service providers to a common cause. Communities should be encouraged to implement social mobilization initiatives and collective action to ensure social inclusion. Strategies may include social marketing to convince individuals and entire communities of the benefit of investing in improved sanitation; increased investments in early social mobilization to ensure pro-poor features in project design; improved affordability for households through innovative payment structures, including subsidized cash contributions and output-based aid; and introduction of third-party monitoring of project implementation by civil society organizations to verify that benefits accrue to the intended poor and vulnerable groups.

Message 5: Embrace the challenge of the water–food–energy nexus.

Water, food, and energy are inextricably linked. Setting clear productivity targets will reduce withdrawals by food and energy producers.

63 ADB. 2011. *Accounting for Health Impacts of Climate Change*. Manila.

Energy production is a large user of water resources, and in turn, the water sector is a large user of energy. Strategies to promote increased water productivity may include those to control pumping by charging appropriate tariffs for electricity used to pump groundwater for irrigation or investing in separate grids to enable power rationing for agricultural uses. Other strategies may include provision of incentives to encourage investment in reducing leaks in water delivery infrastructure; promote installation of energy-efficient pumps; introduce modern technology for water application, such as drip and sprinkler irrigation; and use new biotechnical innovations, including development of crops modified to better withstand moisture stress.

Message 6: Start managing groundwater as a valuable and limited resource.

Introducing groundwater regulation and self-management can prevent a costly crisis resulting from groundwater overdraft and pollution.

Groundwater is a vital common-pool resource for millions of people. However, the focus of groundwater management must transition from resource development to better resource management and control of water consumption. This transformational change may involve regulation of withdrawals through the registration of user permits, increased energy tariffs, or energy rationing, introduction of incentives to encourage effective conjunctive management of surface and groundwater resources, or introduction of modern irrigation and water-saving agricultural technologies. However, without increased promotion of self-management by informed and trained community groups supported by civil society organizations, unsustainable exploitation of groundwater resources will lead communities to continue the current slide into environmental and economic crisis due to overextraction.

Democratic self-management of groundwater resources by informed users has been shown to be effective in some types of aquifers. Self-management may be the best strategy to promote sustainable use. Where this approach has been applied, the keys to success include appropriate training of community members in the concepts and methodology of hydrogeology, and involvement of locally grounded and respected nongovernment organizations as facilitators of the management changes, to increase the effectiveness of new management strategies. Changes often require use of informal education approaches, making groundwater users the primary custodian of the resources and transferring responsibility for implementing management measures in a collective manner. The full support of government agencies responsible for groundwater regulation is also essential for such innovations to be effective.

Although groundwater is a vital resource for millions of people, the availability of accurate information on groundwater resources, its quality, and current withdrawals is inadequate. New investments are required to improve monitoring and management systems to provide regulators and users the information required for sustainable management of water use.

Message 7: Revitalize irrigation institutions for transformation of irrigation services.

Adopting service-oriented irrigation will deliver better results from public investments in medium- to large-scale irrigation systems. Improved irrigation performance in small to medium-scale systems may be better achieved through collective management by system users. It is time to implement more responsive institutional models in irrigation operations, maintenance, and management.

Investment in irrigation has a positive effect on the rural economy. Studies have shown that every $1 of investment in irrigation infrastructure can improve rural gross domestic product by almost $2. However, these returns are realized more quickly where appropriate institutions are in place to deliver services to farmers. It is also clear that the institutions appropriate for small systems may differ from the ones suitable for medium and large systems.

For medium-sized and large surface water irrigation systems, a comprehensive irrigation modernization strategy designed to provide service-oriented management can resolve the deficiencies that otherwise limit the impact of participatory irrigation management models. Innovative management systems to provide responsive irrigation services may enable irrigation systems to operate as a viable business.

Small to medium-sized irrigation systems in Nepal and elsewhere have been managed successfully through collective action and provide models of well-managed common-pool resources that rely on strong, locally crafted rules. However, as water scarcity increases, these local management institutions must evolve to provide responsive services and to minimize the tendency for farmers to invest in unregulated access to irrigation from groundwater or surface waters.

Message 8: Make integrated water resources management a priority.

Implementing a process of IWRM in river basins is required to increase national water security. Investing in IWRM processes will increase the return on public investment in water storage, productivity, and conservation.

Competition for water is intensifying in river basins. Balancing the demands of different sectors requires an increasingly comprehensive understanding of the issues and options. IWRM approaches enable basin managers to better allocate resources among sectors and users to support economic development, ecosystem services, and biodiversity critical to river basin health. Strategies include introduction of new institutional arrangements, such as river basin organizations to coordinate the interests of different sectors and administrative units. With IWRM as a core organizing principle, such organizations can facilitate investments to improve

A farmer and his bull in Indonesia: Many people in Asia and the Pacific who are engaged in agriculture are affected by water scarcity.

AFP

water management, including developing new water sources in reservoirs or enhancing groundwater recharge. In addition, the basin-scale focus of these organizations can provide strong incentives to promote increased water productivity in all sectors and to promote investments to reduce water withdrawals. Water accounting linked with effective land use monitoring should be introduced to provide the basis for evaluation of water productivity of all abstractions and depletion by different uses.

Message 9: Mobilize additional resources to clean up rivers.

Of the region's rivers, 80% are classified as being in poor health. Public investment, supplemented by increased involvement of private sector entities and market-based approaches, can promote reduced pollution and finance the restoration of rivers to good health.

Experience in the region has shown that $1 invested in a river restoration program can return more than $4 in benefits.[64]

If necessary, public funds should be used to pay for the health benefits of improving the water quality of river systems. In many cases, river quality has deteriorated due to the discharge of untreated wastewater from cities and industrial units. In many countries, cities have built sewer lines first and then built wastewater treatment plants only when they could no longer afford to put off the investment required.

Effective control of pollution and healthy freshwater ecosystems provide multiple goods and services essential to life and livelihoods. Governments should include the economic benefits of treatment plants and good water quality to upstream and downstream residents when doing cost–benefit analyses on projects, to guide investment decisions.

Strategies for improving river quality may include increasing public investment for the early construction of wastewater treatment plants in combination with, rather than after, the installation of sewer lines. Governments should introduce pollution discharge trading that encourages polluting companies to evaluate the real cost of pollution abatement relative to the costs of buying discharge credits on a trading market. Active regulation of wastewater discharges can mobilize private sector resources to bring about substantial improvements to river water quality and the riparian environment. These improvements can unlock new value for riverside properties and improve the quality of life for residents in cities.

Payment for ecosystem services can provide the means to improve watershed protection and management in order to satisfy water resources for economic uses downstream. Such payment schemes may also provide a sustainable financing mechanism for management and protection of natural resources, including river restoration efforts.

Message 10: Forewarned is forearmed.

Implementing integrated structural and nonstructural approaches for disaster risk management improves preparedness and can significantly reduce the cost of rehabilitation after disasters. Investing in flood forecasting and early warning systems that reach the last mile helps save lives. It also reduces economic impacts when supported by modern technology and information sharing.

Asia and the Pacific is experiencing increasingly frequent and severe water-related disasters that cause loss of life and disrupt economies. Fostering communities that can better cope with such events by being better prepared, through a combination of appropriate infrastructure, effective early warning systems, and community-based responses, will reduce the cost counted

64 E. Abal. 2010. Presentation to Payment for Ecosystem Services Conference. Ya'an, Sichuan Province, People's Republic of China. 23–24 October.

in lost lives, damaged property, and interrupted economic activities. Helping communities be better prepared is a cost-effective investment. Integrated approaches to disaster preparedness are particularly effective when risk management is viewed as an integral part of the larger IWRM objectives within the river basin.

Although investment in flood protection works and channel improvements can reduce the effects of extreme events, an important strategy for the immediate future is to make long-overdue investments in the development and maintenance of up-to-date, comprehensive disaster risk assessments, with supporting database systems for the basins, communities, and industries at risk. Linking these databases to efficient forecasting, early warning, and disaster management systems, and with well-practiced institutional responses and teams of disaster management specialists, will reduce the risk of catastrophic events and associated losses.

These systems require adequate funding, continued political support, and frequent training and simulation exercises to ensure effective forecasts, dissemination of timely warnings, and implementation of risk mitigation strategies. Where necessary, these systems must operate across jurisdictional boundaries within countries or between riparian countries. Sharing real-time hydrological and meteorological data is a key to success. Warning messages must be conveyed to communities and people in a timely fashion and must be understood all the way to the individual at the end of the last mile of the system.

Message 11: Create insurance mechanisms to minimize reliance on disaster relief.

Creating insurance facilities to provide immediate funding after disasters can help countries jump-start the rehabilitation and recovery process.

Post-disaster humanitarian aid can provide much-needed relief in the immediate aftermath of a disaster. However, risk management programs established before a disaster occurs can combine prevention and risk transfer. Increased access to international reinsurance markets will help diversify and offset risk. These approaches can enable governments to rapidly access the additional liquidity required after a disaster occurs, in order to combine this with humanitarian relief resources. For example, since 2007, the Caribbean Catastrophe Risk Insurance Facility has provided participating governments with rapid access to funds following hurricanes and earthquakes. A similar initiative for the Pacific is being considered as a sovereign risk facility to meet governments' post-disaster liquidity requirements. Having funds immediately available to jump-start the rehabilitation and recovery process will reduce the potential for disasters to derail development progress.

Message 12: New problems demand institutions crafted for current challenges.

Revisiting the institutional arrangements for water management is overdue. Governments must ensure that the institutions and organizations responsible for water resources and services are best matched to the emerging challenges of increasing water scarcity and the growing uncertainties due to increasing population, changing lifestyles, and climate change.

In many countries, water governance institutions were developed to build infrastructure that would deliver water-related services and did not assume any scarcity in supply. These governance structures worked quite well until the drivers of change, such as population growth, accelerating economic growth, urbanization, and climate change, led to the current situation in which water is becoming a scarce resource. The changing scenario has created the need to manage water both as a scarce resource (on the supply side of the equation) and as a critical service (on the demand side). As a result, it has become necessary to consider whether the existing institutions and organizations are best matched to the governance needs in the water sector (Box 11).

Adopting IWRM as the core approach has been a critical decision to initiate the revitalization of the water sector. Transformational changes are now required in many water institutions to respond to the new challenges that the sector must address in infrastructure development and water allocation. These may include rationalization of institutions and increased capacity development to better manage both supply and demand sides of the water equation. In many countries there is a need to provide better oversight and stronger regulation of uses and users and to resolve the growing water–food–energy nexus in basins.

National policies will need to take a holistic approach to water governance so that socioeconomic goals can be achieved. Revised and updated legislation, including the necessary regulations to enforce such legislation, will help to implement these policies. Subsectoral policies, laws, and regulations will have to fall in line with holistic national policy.

In some cases, new organizations may have to be developed for national coordination of the activities of the subsectors and for basin-level coordination of the supply of and demand for water resources. The functions of the national water apex bodies would include raising awareness of the need for a comprehensive approach to water allocation, developing policies for water allocation to be incorporated into law, and promoting innovative ways to encourage water conservation through the licensing system. The functions of the river basin organizations would include enhancing the technical and institutional capacity of the regulatory agencies evaluating license applications and making water allocation decisions, facilitating cross-agency and cross-sector coordination, and developing capacity for water allocation and dispute resolution.[65]

BOX 11

Pulling Policy Levers through Regional Cooperation

To increase water security, leaders can invest in the smart use of a wide range of regional collaboration opportunities:

- knowledge sharing and networking (including the Asia-Pacific Water Forum's regional water knowledge hubs);
- capacity development through practitioner networks (including the Network of Asian River Basin Organizations);
- regional technical assistance projects, such as the regional research and capacity development program initiated by the Asia-Pacific Center for Water Security;
- performance benchmarking services;
- regional public goods (such as models and data) to support water and climate change adaptation;
- transboundary water resources management (both within and among countries);
- regional funds (partnership facilities at ADB, cofinancing, and various climate funds); and
- insurance facilities, food grain storage and trade facilitation, and more.

65 J. D. Bird, W. Lincklaen Arriens, and D. Von Custodio. 2009. *Water Rights and Water Allocation: Issues and Challenges for Asia*. Manila: ADB.

Community-based organizations for local water governance should be promoted to help attain a sustainable equilibrium between water supply and demand through better planning and management at the local level with the active participation of well-informed water users.

Making Smart Use of Regional Cooperation

As shown in several policy levers in parts I and II, water security impacts often transcend national boundaries, as do the opportunities to increase water security. The scope for regional sharing of knowledge, capacity, and institutions is significant. Risks can be reduced by proactive sharing of information on hazards such as floods, droughts, and pollution, and by increasing risk-pooling insurance facilities. Capacity can be strengthened cost-effectively by investing in regional professional networks and associations (such as for utilities, river basin organizations, and regulators), and by using benchmarking and proficiency certification.

Investing in the creation and use of regional public goods can involve regional climate models to support planners and decision makers in adaptation. Regional funds, technical assistance projects, and partnership facilities, including those administered by ADB, can be further extended to support innovation in projects.

Managing the water and related natural resources of Asia's great transboundary river basins for mutual benefit and sustainable development is still an unfinished agenda. With the effects of climate change becoming clear, many of these rivers are increasingly referred to as Asia's water towers, calling for judicious collective stewardship among all riparian users, who are now essentially all "downstream." The use of widely available remote-sensing data and information offers great potential to enhance such transboundary collaboration.

Leadership in Increasingly Connected Economies

Across the increasingly connected economies of Asia and the Pacific, leaders can draw on unprecedented resources to tackle water security with an integrated approach. Their smart choices for water management policies, reforms, and investments will make it possible to simultaneously satisfy household needs, support productive economies, create livable cities, restore the environment, and build resilience.

Programs to increase water security will benefit from government decisions to adopt integrated and inclusive approaches. To succeed, programs typically start off with a comprehensive and quantitative assessment and then build a coalition of partners that can work together with a shared vision. Particular attention is given to ensuring that every move forward is knowledge-driven and supported by research. Australia, the People's Republic of China, and Singapore—each in their different circumstances—have demonstrated that when policy decisions at the highest level are combined with innovation and sustained reform, supported by public investment, they do deliver results.

Leaders in Asia and the Pacific today have unprecedented access to information, knowledge, technology, and funding resources to tackle water security with an integrated approach and to support development paths that are appropriate to local conditions. It is imperative and urgent that renewed efforts are applied to address immediate water challenges while balancing today's needs with those of future generations. Adopting an inclusive strategy that draws on all sectors of society will enable all, including poor and vulnerable communities, to benefit from a water-secure future.

Embedding IWRM in public investment planning will increase water security and sustainability. It will also enable leaders to reduce unnecessary expenditures that result from fragmented plans and investments in each water-using sector. Today's leaders can demonstrate the right choices and nurture a new generation of water leaders to deliver solutions. To that end, Australia,

Singapore, and the Network of Asian River Basin Organizations have already initiated new water leadership programs. More such programs are needed in countries across the region.

Looking to the Future

Preparing *AWDO 2013* has revealed bright spots where innovations are improving water security. It has also revealed hot spots where greater efforts must be directed to achieve greater water security for people, industry, and river ecosystems. The assumption that water is an inexhaustible resource that can be overlooked or abused at will is now recognized as a fallacy. The decisions made about water will determine the quality of life for billions of people in Asia and the Pacific; however, the path to a water-secure future is not easy. Political and economic choices will determine the speed at which the path is traversed. *AWDO* has presented new tools that are available to assist leaders in making critical decisions about the route of the path toward water security. Whether the next edition of *AWDO* will find positive improvements in the water security of the countries of Asia and the Pacific will be determined by the efforts of leaders in government, civil society, and the private sector, and ultimately by the actions and efforts of every individual in the region, through the lifestyles they choose.

STEVEN GRIFFITHS

Painting a clean river in the People's Republic of China. Public awareness programs promoting water security start at a young age.

AFP

Appendixes

Measuring Progress toward Water Security

Appendix 1: National Water Security Index

	KD 1 Rating	KD 2 Rating	KD 3 Rating	KD 4 Rating	KD 5 Rating	Total	National Water Security Indicator	Index
Afghanistan	1	***2***	1	2	***1***	7	1.40	1
Armenia	4	4	2	1	3	14	2.80	3
Australia	5	3	4	4	4	20	4.00	4
Azerbaijan	2	4	1	1	2	10	2.00	2
Bangladesh	1	3	1	1	1	7	1.40	1
Bhutan	1	3	2	3	***2***	11	2.20	2
Brunei Darussalam	5	2	3	3	2	15	3.00	3
Cambodia	1	3	1	2	1	8	1.60	1
People's Republic of China	3	4	2	2	2	13	2.60	2
Cook Islands	5	2	2	***3***	*1*	13	2.60	2
Fiji	3	3	1	***2***	2	11	2.20	2
Georgia	3	3	2	2	3	13	2.60	2
Hong Kong, China	4	***4***	4	3	3	18	3.60	3
India	1	3	1	1	2	8	1.60	1
Indonesia	2	4	2	3	2	13	2.60	2
Japan	5	4	3	2	3	17	3.40	3
Kazakhstan	3	4	2	2	3	14	2.80	3
Kiribati	1	1	1	***1***	2	6	1.20	1
Republic of Korea	5	3	2	2	2	14	2.80	3
Kyrgyz Republic	3	3	2	2	3	13	2.60	2
Lao People's Democratic Republic	2	4	1	3	3	13	2.60	2
Malaysia	5	4	3	3	2	17	3.40	3
Maldives	3	1	2	***4***	***1***	11	2.20	2
Marshall Islands	2	1	2	4	***1***	10	2.00	2
Federated States of Micronesia	3	2	3	***3***	***2***	13	2.60	2
Mongolia	1	2	2	4	3	12	2.40	2
Myanmar	2	3	1	3	***1***	10	2.00	2
Nauru	2	1	1	2	***2***	8	1.60	1
Nepal	1	3	1	2	3	10	2.00	2
New Zealand	5	4	4	4	3	20	4.00	4
Niue	3	***1***	3	***4***	***1***	12	2.40	2
Pakistan	1	4	1	1	1	8	1.60	1
Palau	3	2	2	***3***	***2***	12	2.40	2
Papua New Guinea	1	4	2	4	2	13	2.60	2
Philippines	2	4	1	2	2	11	2.20	2
Samoa	3	2	2	***2***	2	11	2.20	2
Singapore	5	3	3	2	4	17	3.40	3
Solomon Islands	2	3	2	5	***1***	13	2.60	2
Sri Lanka	3	4	1	1	2	11	2.20	2
Taipei,China	***3***	***3***	3	3	3	15	3.00	3
Tajikistan	3	4	2	3	3	15	3.00	3
Thailand	3	3	2	1	2	11	2.20	2
Timor-Leste	2	3	2	3	***1***	11	2.20	2
Tonga	3	***1***	2	***2***	2	10	2.00	2
Turkmenistan	2	3	1	2	2	10	2.00	2
Tuvalu	3	1	1	***2***	***1***	8	1.60	1
Uzbekistan	3	3	2	2	2	12	2.40	2
Vanuatu	2	1	2	***5***	1	11	2.20	2
Viet Nam	3	3	1	2	2	11	2.20	2

KD = key dimension.

Note: KD1=Household Water Security. KD2=Economic Water Security. KD3=Urban Water Security. KD4=Environmental Water Security; KD5=Resilience.

Note: Numbers in ***bold italic*** type reflect a rating by expert opinion (no data available).

The national water security index is a composite of the five key dimension indexes of water security. It is calculated as the populated-weighted average of the five key dimensions of water security. Where insufficient data are available to compute the key dimension indicator, a value has been estimated through discussion with experienced regional experts.

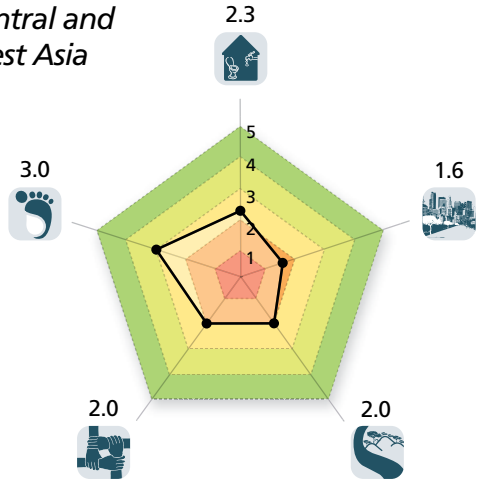
The water security index for each of the subregions is presented in the following pages.

Water Security Index by Subregion

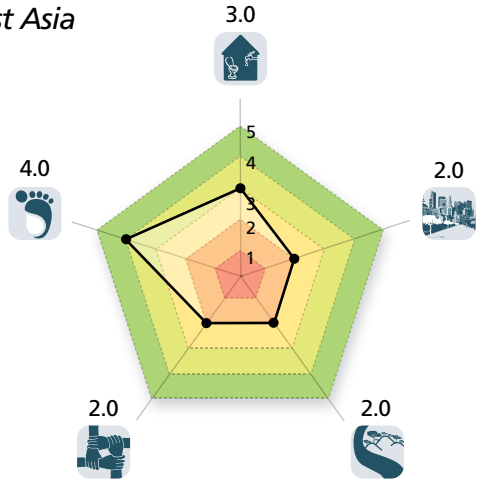
Legend

- Household Water Security
- Economic Water Security
- Urban Water Security
- Environmental Water Security
- Resilience to Water-Related Disasters

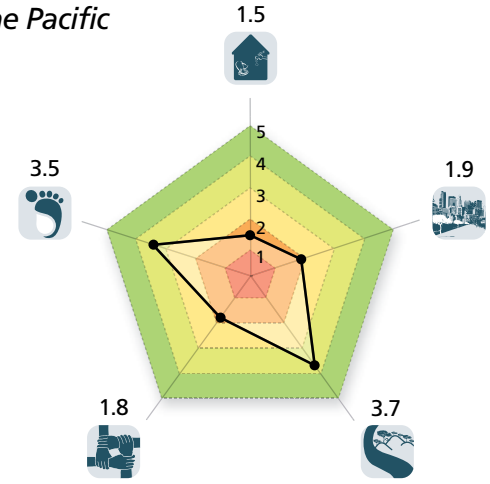
Central and West Asia



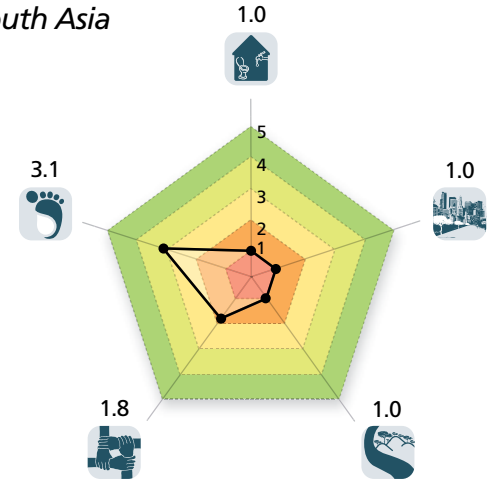
East Asia



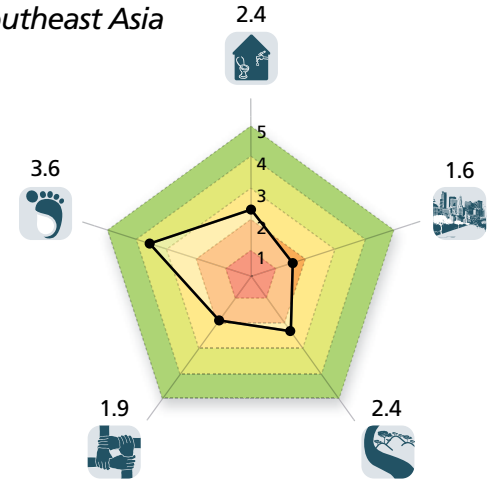
The Pacific



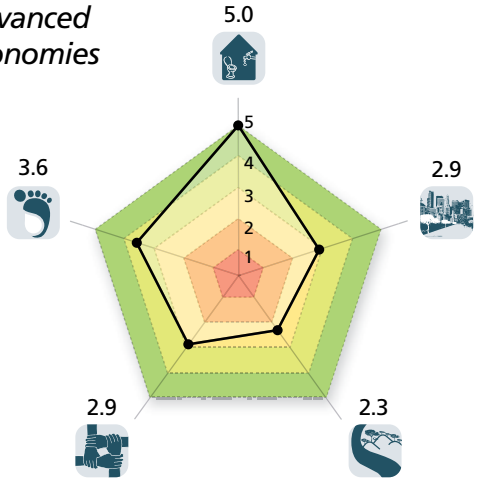
South Asia



Southeast Asia



Advanced Economies



Appendix 2: Key Dimension 1—Household Water Security Index

	Piped Water Access	Piped Water Index	Sanitation Access	Sanitation Index	DALY[a]	DALY Index	Indicator	Index
Afghanistan	4%	1	37%	1	5,289	1	3	***1***
Armenia	93%	5	90%	5	345	3	13	***4***
Australia	***90%***	5	100%	5	30	5	15	***5***
Azerbaijan	50%	1	82%	4	1,166	1	6	***2***
Bangladesh	6%	1	56%	1	1,217	1	3	***1***
Bhutan	57%	1	44%	1	1,399	1	3	***1***
Brunei Darussalam	100%	5	80%	4	94	5	14	***5***
Cambodia	17%	1	31%	1	2,170	1	3	***1***
People's Republic of China	68%	2	64%	2	324	3	7	***3***
Cook Islands	100%	5	100%	5	192	4	14	***5***
Fiji	82%	4	83%	4	169	4	12	***3***
Georgia	73%	3	95%	5	597	2	10	***3***
Hong Kong, China	***80%***	4	***93%***	5	***100***	4	13	***4***
India	23%	1	34%	1	1,246	1	3	***1***
Indonesia	20%	1	54%	1	483	3	5	***2***
Japan	98%	5	100%	5	34	5	15	***5***
Kazakhstan	58%	1	97%	5	880	1	7	***3***
Kiribati	36%	1	42%	1	769	1	3	***1***
Republic of Korea	93%	5	100%	5	130	4	14	***5***
Kyrgyz Republic	53%	1	93%	5	905	1	7	***3***
Lao People's Democratic Republic	20%	1	63%	2	1,078	1	4	***2***
Malaysia	97%	5	96%	5	181	4	14	***5***
Maldives	39%	1	97%	5	609	2	8	***3***
Marshall Islands	1%	1	75%	3	751	2	6	***2***
Federated States of Micronesia	***94%***	5	30%	1	253	3	9	***3***
Mongolia	17%	1	51%	1	811	1	3	***1***
Myanmar	8%	1	76%	3	1,551	1	5	***2***
Nauru	***30%***	1	65%	2	435	3	6	***2***
Nepal	18%	1	31%	1	1,345	1	3	***1***
New Zealand	100%	5	93%	5	30	5	15	***5***
Niue	***20%***	1	100%	5	67	5	11	***3***
Pakistan	36%	1	48%	1	1,072	1	3	***1***
Palau	43%	1	100%	5	206	3	9	***3***
Papua New Guinea	10%	1	45%	1	1,128	1	3	***1***
Philippines	43%	1	74%	3	528	2	6	***2***
Samoa	81%	4	98%	5	227	3	12	***3***
Singapore	100%	5	100%	5	73	5	15	***5***
Solomon Islands	14%	1	37%	1	408	3	5	***2***
Sri Lanka	29%	1	92%	5	153	4	10	***3***
Taipei,China	***91%***	5	***60%***	2	***100***	4	11	***3***
Tajikistan	40%	1	94%	5	1,944	1	7	***3***
Thailand	48%	1	96%	5	504	2	8	***3***
Timor-Leste	21%	1	47%	1	556	2	4	***2***
Tonga	***80%***	4	96%	5	297	3	12	***3***
Turkmenistan	***72%***	3	***62%***	2	812	1	6	***2***
Tuvalu	97%	5	85%	4	583	2	11	***3***
Uzbekistan	47%	1	100%	5	1,096	1	7	***3***
Vanuatu	26%	1	57%	1	236	3	5	***2***
Viet Nam	23%	1	76%	3	296	3	7	***3***

[a] Age-standardized disability-adjusted life years (DALY) is a measure of the diarrheal incidence per 100,000 people.

Note: Missing data provided by expert judgment shown in ***bold italics*** type.

The household water security index is a composite of three subindexes:

- access to piped water supply (%),
- access to improved sanitation (%), and
- hygiene (age-standardized disability-adjusted life years per 100,000 people for the incidence of diarrhea).

Appendix 3: Key Dimension 2—Economic Water Security Index

Country	Agriculture	Industry	Energy	Indicator	Index
Afghanistan	5.22	–	–	–	***2***
Armenia	6.56	5.56	7.11	19.22	4
Australia	5.89	5.56	5.78	17.22	3
Azerbaijan	5.56	5.56	7.78	18.89	4
Bangladesh	4.89	5.56	3.78	14.22	3
Bhutan	4.67	4.67	7.33	16.67	3
Brunei Darussalam	–	–	4.44	–	***2***
Cambodia	3.56	4.22	6.44	14.22	3
People's Republic of China	7.22	6.22	7.11	20.56	4
Cook Islands	–	–	5.56	–	***2***
Fiji	5.56	4.89	7.11	17.56	3
Georgia	6.78	–	8.89	15.67	3
Hong Kong, China	–	–	–	–	***4***
India	6.11	5.11	5.56	16.78	3
Indonesia	6.89	5.56	7.11	19.56	4
Japan	7.78	6.44	6.22	20.44	4
Kazakhstan	6.11	6.44	8.89	21.44	4
Kiribati	–	–	3.56	–	***1***
Republic of Korea	6.67	5.33	5.33	17.33	3
Kyrgyz Republic	5.56	4.22	7.11	16.89	3
Lao People's Democratic Republic	5.00	4.67	8.67	18.33	4
Malaysia	6.67	6.67	8.00	21.33	4
Maldives	–	–	1.33	–	***1***
Marshall Islands	–	–	1.33	–	***1***
Federated States of Micronesia	–	–	5.56	–	***2***
Mongolia	2.11	1.78	4.89	8.78	2
Myanmar	4.89	4.22	8.44	17.56	3
Nauru	–	–	1.33	–	***1***
Nepal	5.67	4.00	7.33	17.00	3
New Zealand	4.89	5.56	8.44	18.89	4
Niue	–	–	4.00	–	***1***
Pakistan	6.22	6.89	7.78	20.89	4
Palau	–	–	1.33	–	***2***
Papua New Guinea	5.56	5.56	9.78	20.89	4
Philippines	6.56	6.89	6.44	19.89	4
Samoa	–	–	6.22	–	***2***
Singapore	–	8.89	5.78	14.67	3
Solomon Islands	–	8.89	5.78	14.67	3
Sri Lanka	6.56	5.56	6.44	18.56	4
Taipei,China	–	–	–	–	***3***
Tajikistan	6.44	5.78	9.56	21.78	4
Thailand	5.89	6.22	5.11	17.22	3
Timor-Leste	–	–	4.00	–	***3***
Tonga	–	–	1.33	–	***1***
Turkmenistan	5.00	5.33	6.67	17.00	3
Tuvalu	–	–	1.33	–	***1***
Uzbekistan	5.33	4.67	6.00	16.00	3
Vanuatu	–	–	6.67	–	***1***
Viet Nam	5.11	4.44	6.22	15.78	3

Note: Expert opinion was used to estimate values for countries with insufficient data to compute the subindicators. Values based on expert opinion are presented in ***bold italics*** type.

The economic water security index developed for the *Asian Water Development Outlook (AWDO)* measures how countries are ensuring the productive use of water to sustain their economic growth in food production, industry, and energy. The *AWDO* team[66] developed subindexes for each of the three sectors, using three main indicators that characterize water security. Each subindex is evaluated on a scale of 1–10, with 1 being *insecure* and 10 being *secure*. The mean scores for each subindex give the total economic water security of the country's economy. The maximum score for the index is 30 (10 points for each of the 3 subindexes that make up the index). A factor for resilience is incorporated into each of these subindexes to indicate the intra- and inter-annual rainfall variability and water resources storage.

66 Comprising the International Water Management Institute and the Food and Agriculture Organization of the United Nations.

Appendix 4: Key Dimension 3—Urban Water Security Index

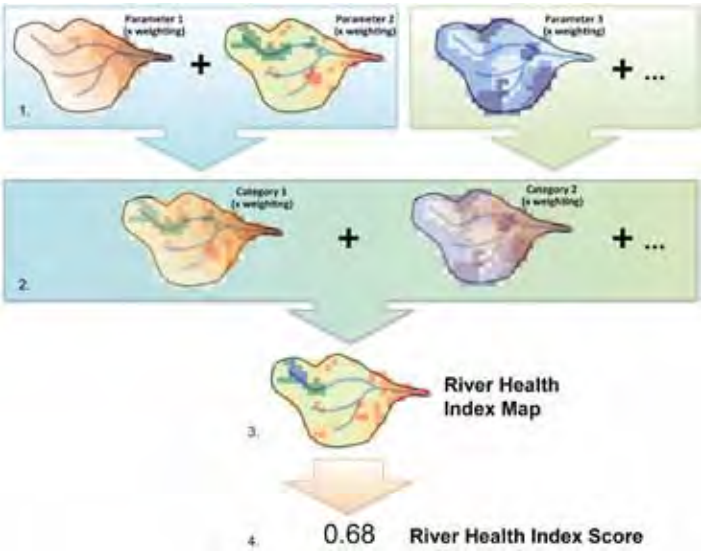
	Piped Urban Water Supply Access	Water Supply Index	Wastewater Treatment	Wastewater Index	Flood Damage Losses ($ per capita)	Drainage Index	Urban Factor	River Health Index Factor	Indicator	Index
Afghanistan	16%	1	***0%***	1	3.83	4	0.8	0	4.8	1
Armenia	98%	5	***30%***	1	1.50	5	1.0	0	11.0	2
Australia	100%	5	96%	5	338.76	4	1.0	1	19.0	4
Azerbaijan	78%	3	21%	1	12.20	4	1.0	0	8.0	1
Bangladesh	20%	1	17%	1	127.64	1	0.8	0	2.4	1
Bhutan	81%	4	***10%***	1	0.00	5	0.8	1	12.0	2
Brunei Darussalam	100%	5	***90%***	5	0.00	5	0.9	1	18.0	3
Cambodia	63%	2	9%	1	56.14	2	0.8	0	4.0	1
People's Republic of China	95%	5	58%	1	119.58	4	0.9	0	9.0	2
Cook Islands	100%	5	***0%***	1	***1,500.00***	1	1.0	1	12.0	2
Fiji	97%	5	***30%***	1	***675.00***	1	1.0	0	7.0	1
Georgia	92%	5	74%	3	0.95	5	1.0	0	13.0	2
Hong Kong, China	***100%***	5	93%	5	***2.50***	5	1.0	1	20.0	4
India	48%	1	21%	1	49.18	3	0.9	0	4.5	1
Indonesia	36%	1	34%	1	13.78	4	0.8	1	8.8	2
Japan	99%	5	96%	5	397.84	4	1.0	0	14.0	3
Kazakhstan	82%	4	47%	1	15.44	4	1.0	0	9.0	2
Kiribati	100%	5	***0%***	1	***1,000.00***	1	0.8	0	5.6	1
Republic of Korea	99%	5	61%	2	270.59	4	1.0	0	11.0	2
Kyrgyz Republic	89%	4	48%	1	1.46	5	1.0	0	10.0	2
Lao People's Democratic Republic	55%	1	6%	1	74.70	1	0.8	1	6.4	1
Malaysia	99%	5	78%	3	52.82	4	0.8	1	13.6	3
Maldives	96%	5	0%	1	51.00	4	0.8	1	12.0	2
Marshall Islands	***100%***	5	***0%***	1	***1,200.00***	1	0.9	1	10.8	2
Federated States of Micronesia	***100%***	5	***60%***	2	***200.00***	3	1.0	1	15.0	3
Mongolia	26%	1	21%	1	53.29	3	1.0	1	10.0	2
Myanmar	19%	1	***10%***	1	247.80	1	0.9	1	7.2	1
Nauru	***50%***	1	***0%***	1	***50.00***	4	1.0	0	6.0	1
Nepal	53%	1	12%	1	13.87	4	0.8	0	4.8	1
New Zealand	100%	5	96%	5	91.37	4	1.0	1	19.0	4
Niue	100%	5	***0%***	1	***50.00***	4	1.0	1	15.0	3
Pakistan	58%	1	34%	1	36.43	4	0.8	0	4.8	1
Palau	43%	1	***65%***	2	***1,000.00***	1	1.0	1	9.0	2
Papua New Guinea	57%	1	***15%***	1	***20.00***	4	0.9	1	9.9	2
Philippines	61%	2	43%	1	37.63	4	0.8	0	5.6	1
Samoa	84%	4	***5%***	1	36.59	4	1.0	0	9.0	2
Singapore	100%	5	92%	5	0.00	5	1.0	0	15.0	3
Solomon Islands	76%	3	***30%***	1	***200.00***	1	1.0	1	10.0	2
Sri Lanka	67%	2	32%	1	11.60	4	1.0	0	7.0	1
Taipei,China	***96%***	5	48%	1	***26.70***	5	1.0	1	16.0	3
Tajikistan	83%	4	12%	1	51.79	1	1.0	1	11.0	2
Thailand	80%	4	62%	2	30.31	4	1.0	0	10.0	2
Timor-Leste	45%	1	***0%***	1	***20.00***	4	0.8	1	8.8	2
Tonga	***100%***	5	78%	3	1,973.08	1	1.0	0	9.0	2
Turkmenistan	***85%***	4	35%	1	0.00	5	0.8	0	8.0	1
Tuvalu	97%	5	***0%***	1	***200.00***	2	0.9	0	7.2	1
Uzbekistan	85%	4	45%	1	0.00	5	1.0	0	10.0	2
Vanuatu	52%	1	***0%***	1	***100.00***	3	1.0	1	10.0	2
Viet Nam	59%	1	19%	1	198.61	1	0.8	0	2.4	1

Note: Expert opinion was used to estimate values for countries with insufficient data to compute the subindicators. Values based on expert opinion are presented in ***bold italics*** type.

The urban water security index is a composite of three subindexes and adjustment factors representing urban growth rate and river basin health:

- water supply (%),
- wastewater treatment (%),
- drainage (measured as extent of economic damage caused by floods and storms), and
- adjustment factors for urban growth rate and river health.

Appendix 5: Key Dimension 4—Environmental Water Security Index

	River Health Input Data, Processed in GIS Spatial Analysis	Indicator	Index
Afghanistan		0.33	2
Armenia		0.08	1
Australia		0.59	4
Azerbaijan		0.13	1
Bangladesh		0.16	1
Bhutan		0.39	3
Brunei Darussalam		0.52	3
Cambodia		0.29	2
People's Republic of China		0.26	2
Cook Islands		–	***3***
Fiji		–	***2***
Georgia		0.26	2
Hong Kong, China		–	***3***
India		0.11	1
Indonesia		0.46	3
Japan		0.23	2
Kazakhstan		0.35	2
Kiribati		–	***1***
Republic of Korea		–	***2***
Kyrgyz Republic		–	***2***
Lao People's Democratic Republic		0.38	3
Malaysia		0.41	3
Maldives		–	***4***
Marshall Islands		–	***4***
Federated States of Micronesia		–	***3***
Mongolia		0.57	4
Myanmar		0.39	3
Nauru		–	***2***
Nepal		0.26	2
New Zealand		0.54	4
Niue		–	***4***
Pakistan		0.12	1
Palau		–	***3***
Papua New Guinea		0.64	4
Philippines		0.35	2
Samoa		–	***2***
Singapore		0.27	2
Solomon Islands		0.92	5
Sri Lanka		0.20	1
Taipei,China		–	***3***
Tajikistan		0.36	3
Thailand		0.16	1
Timor-Leste		0.37	3
Tonga		–	***2***
Turkmenistan		0.35	2
Tuvalu		–	***2***
Uzbekistan		0.28	2
Vanuatu		0.90	5
Viet Nam		0.27	2

GIS = geographic information system.

Note: Expert opinion was used to estimate values for countries with insufficient data to compute the subindicators. Values based on expert opinion are presented in ***bold italic*** type.

The river health index measures

- pressures/threats to river systems from watershed disturbances and pollution; and
- vulnerability/resilience to alterations to natural flows by water infrastructure development and biological factors; this may be intrinsic (vulnerability of river/river basin to pressures) or extrinsic (level of degradation of ecosystems).

Appendix 6: Key Dimension 5—Hazard and Vulnerability Indicators (Risk)

	Hazard	Exposure	Vulnerability	Hard Capacity	Soft Capacity	Indicator	Risk
Afghanistan	–	–	–	–	–	–	–
Armenia	4.82	1.99	4.27	6.28	6.93	8.41	0.21
Australia	8.14	3.64	0.98	9.67	13.31	5.94	0.15
Azerbaijan	4.99	5.86	6.71	9.92	9.97	11.28	0.28
Bangladesh	6.96	10.19	9.88	10.74	4.23	30.95	0.77
Bhutan	–	–	–	–	–	–	–
Brunei Darussalam	3.32	8.61	2.82	11.18	12.21	6.37	0.16
Cambodia	3.49	10.24	11.44	7.47	6.55	17.45	0.43
People's Republic of China	7.68	6.85	5.32	10.52	11.18	16.19	0.40
Cook Islands	–	–	–	–	–	–	–
Fiji	8.80	4.92	5.92	8.74	9.55	18.89	0.47
Georgia	3.10	2.22	4.68	9.54	10.22	3.96	0.10
Hong Kong, China	8.62	8.51	0.87	11.48	11.47	12.84	0.32
India	7.22	7.99	8.60	11.28	7.19	23.80	0.59
Indonesia	3.22	7.89	6.12	9.76	9.65	8.63	0.21
Japan	6.96	5.17	1.26	14.83	12.04	5.84	0.14
Kazakhstan	5.48	1.57	4.77	8.12	12.44	5.90	0.15
Kiribati	6.66	8.92	11.81	2.96	5.81	37.57	0.93
Republic of Korea	–	–	–	–	–	–	–
Kyrgyz Republic	3.75	3.38	5.06	5.34	5.82	10.00	0.25
Lao People's Democratic Republic	–	–	–	–	–	–	–
Malaysia	3.38	9.23	3.68	10.88	10.68	7.67	0.19
Maldives	–	–	–	–	–	–	–
Marshall Islands	–	–	–	–	–	–	–
Federated States of Micronesia	–	–	–	–	–	–	–
Mongolia	4.06	2.62	5.60	3.17	7.06	10.97	0.27
Myanmar	–	–	–	–	–	–	–
Nauru	–	–	–	–	–	–	–
Nepal	3.19	8.15	7.12	5.29	2.66	17.92	0.44
New Zealand	3.45	4.55	0.69	10.81	12.83	2.83	0.07
Niue	–	–	–	–	–	–	–
Pakistan	6.23	9.24	8.29	9.90	4.71	25.51	0.63
Palau	–	–	–	–	–	–	–
Papua New Guinea	5.47	6.91	10.47	5.71	4.51	24.20	0.60
Philippines	8.14	9.31	6.30	10.50	9.58	23.10	0.57
Samoa	7.13	4.65	5.59	4.24	8.44	17.07	0.42
Singapore	5.01	10.62	0.57	15.89	12.48	6.82	0.17
Solomon Islands	–	–	–	–	–	–	–
Sri Lanka	4.42	5.62	5.81	10.79	9.21	9.45	0.23
Taipei,China	7.70	6.02	2.12	13.68	12.47	8.68	0.21
Tajikistan	3.20	4.01	5.51	5.52	4.96	9.92	0.25
Thailand	5.92	6.12	4.20	10.84	11.15	10.43	0.26
Timor-Leste	–	–	–	–	–	–	–
Tonga	6.68	5.26	6.36	4.97	7.77	18.33	0.45
Turkmenistan	5.59	5.83	7.20	7.55	10.46	14.45	0.36
Tuvalu	–	–	–	–	–	–	–
Uzbekistan	6.02	6.24	7.35	8.90	10.87	15.94	0.39
Vanuatu	8.06	8.02	10.92	2.69	6.49	40.38	1.00
Viet Nam	7.30	8.61	6.40	9.84	9.19	20.96	0.52

Appendix 6 (continued): Key Dimension 5—Resilience to Water-Related Disasters Index

	Flood Indicator	Drought Indicator	Coastal Indicator	Indicator	Index
Afghanistan	–	–	–	–	***1***
Armenia	0.57	0.85	–	1.58	3
Australia	1.03	8.25	1.49	2.33	4
Azerbaijan	0.43	0.47	0.35	0.67	2
Bangladesh	0.23	0.13	0.20	0.36	1
Bhutan	–	–	–	–	***2***
Brunei Darussalam	0.47	1.02	0.54	0.86	2
Cambodia	0.20	0.11	0.19	0.32	1
People's Republic of China	0.44	0.43	0.48	0.75	2
Cook Islands	–	–	–	–	***1***
Fiji	0.45	0.52	0.43	0.75	2
Georgia	0.77	1.63	0.68	1.22	3
Hong Kong, China	0.52	3.75	0.71	1.05	3
India	0.29	0.21	0.29	0.63	2
Indonesia	0.32	0.33	0.41	0.59	2
Japan	0.92	4.98	1.08	1.64	3
Kazakhstan	0.80	2.32	0.80	1.51	3
Kiribati	0.19	0.13	0.83	0.83	2
Republic of Korea	0.69	1.64	0.34	0.91	2
Kyrgyz Republic	0.39	0.36	1.00	1.38	3
Lao People's Democratic Republic	–	–	–	–	***3***
Malaysia	0.39	0.53	0.46	0.70	2
Maldives	–	–	–	–	***1***
Marshall Islands	–	–	–	–	***1***
Federated States of Micronesia	–	–	–	–	***2***
Mongolia	0.37	0.41	1.00	1.36	3
Myanmar	–	–	–	–	***1***
Nauru	–	–	–	–	***2***
Nepal	0.18	0.09	1.00	1.20	3
New Zealand	1.03	6.80	1.22	1.84	3
Niue	–	–	–	–	***1***
Pakistan	0.24	0.16	0.25	0.41	1
Palau	–	–	–	–	***2***
Papua New Guinea	0.23	0.15	0.21	0.64	2
Philippines	0.31	0.28	0.34	0.54	2
Samoa	0.42	0.45	0.39	0.69	2
Singapore	0.61	25.15	0.67	2.04	4
Solomon Islands	–	–	–	–	***1***
Sri Lanka	0.44	0.51	0.44	0.74	2
Taipei,China	0.79	1.94	0.76	1.35	3
Tajikistan	0.32	0.27	1.00	1.33	3
Thailand	0.53	0.74	0.52	0.89	2
Timor-Leste	–	–	–	–	***1***
Tonga	0.36	0.37	0.34	0.60	2
Turkmenistan	0.38	0.35	0.36	0.62	2
Tuvalu	–	–	–	–	***1***
Uzbekistan	0.39	0.31	0.38	0.64	2
Vanuatu	0.19	0.12	0.21	0.33	1
Viet Nam	0.37	0.45	0.30	0.57	2

Note: Expert opinion was used to estimate values for countries with insufficient data to compute the subindicators. Values based on expert opinion are presented in ***bold italic*** type.

The water-related disaster resilience index is a composite of subindexes based on type of hazard (floods and windstorms, droughts, and storm surges and coastal flooding) measuring

- exposure (e.g., population density, growth rate);
- basic population vulnerability (e.g., poverty rate, land use);
- a country's hard coping capacities (e.g., telecommunications development level); and
- a country's soft coping capacities (e.g., literacy rate).

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Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific

This 2nd edition of the *Asian Water Development Outlook* (AWDO) provides the first quantitative and comprehensive view of water security in the countries of Asia and the Pacific. Prepared for leaders and policy makers of finance and planning departments, *AWDO 2013* introduces a comprehensive framework to measure water security as a foundation for creating a water-secure future for the people of Asia and the Pacific.

AWDO 2013 was prepared by a team of ten leading water knowledge organizations in Asia and the Pacific, guided by specialists drawn from all five subregions. Part I introduces the five key dimensions of water security and presents indicators for assessment of national water security. Part II demonstrates how countries measure up against the *AWDO* vision of water security, discusses what is at stake, and introduces policy levers to increase security. Part III presents key messages for political, water sector, and civil society leaders to guide actions on water security nationally, in river basins, and in communities.

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Created in 2006, the Asia-Pacific Water Forum (APWF) is an independent, not-for-profit, nonpartisan, and nonpolitical network dedicated to improving sustainable water management by championing best practices, boosting investments, building capacity, and enhancing cooperation throughout the Asia-Pacific region. Developing knowledge and lessons is central to the APWF approach.

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