

IMF STAFF DISCUSSION NOTE

Is the Glass Half Empty or Half Full? Issues in Managing Water Challenges and Policy Instruments

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**Is the Glass Half Empty or Half Full?
Issues in Managing Water Challenges and Policy Instruments¹**

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EXECUTIVE SUMMARY

Water challenges are a growing global concern that could hinder countries' economic prospects. Rising water stress, large supply variability, lack of access to safe drinking water and sanitation, and water pollution are already afflicting many parts of the world. Emerging market and developing countries generally face greater challenges because of their larger populations, lower income levels, inadequate infrastructure, and less developed policy and institutional capacity. But advanced countries are not spared either. Looking ahead, water use is expected to continue to rise with population and income growth, but freshwater resources cannot easily be increased. Climate change is likely to exacerbate water demand-supply imbalances.

Building on extensive literature, this paper examines the role of economic policy instruments and institutions in managing water challenges. It provides three key policy-relevant findings, drawing on cross-country analysis and case studies. Notably, some naturally water-deficient countries have been able to overcome water challenges, thanks to sound policies and institutions.

- Getting incentives right, notably by reforming water pricing, can help rationalize water use, promote needed investment, and protect the poor. Water subsidies provided through public utilities are estimated at about \$456 billion or 0.6 percent of global GDP in 2012. They are also inequitable, disproportionately benefiting upper-income groups.
- The most desirable approach to reform water pricing will vary by country, depending on access of the poor to the existing water network and administrative capacity. Effective and autonomous institutions in charge of water management can also provide credibility and synergize popular support for reforms. In developing countries, reforms should strengthen the finances of public water utilities to promote investment and expand access to water and sanitation for the poor. Ensuring adequate maintenance spending is a priority for all countries. Under the right circumstances, establishing markets for water rights can help allocate limited water to highest-valued uses.
- Achieving sound water management requires an integrated and holistic approach going beyond the water sector itself. Water pricing reforms should be complemented by policies that rationalize water use in areas such as agriculture, trade, and energy, while redirecting achieved gains toward protecting the poor. For example, excessive pumping of groundwater can be discouraged by improving regulations and replacing energy subsidies with targeted social assistance.

The IMF can—and should—play a helpful role in ensuring that macroeconomic policies are conducive to sound water management. Since water challenges increasingly affect economic stability and growth, public finances, and poor and vulnerable social groups, they are of immediate importance to the membership. Key roles for the IMF in line with its mandate and expertise would include: (i) assessing the impact of water challenges on growth and macro-stability in collaboration with institutions that specialize in water; (ii) supporting policies to replace perverse subsidies with targeted social assistance under the right circumstances; and (iii) ensuring fiscal sustainability to support water infrastructure investment and financing.

I. WHY CARE ABOUT WATER?

1. Water resources, which are essential for human development and environmental sustainability, are coming under intense pressure.³ Rising water demand as a result of urbanization and growth in income and population puts increasing strain on the availability, sustainability, and quality of water. At the same time, millions of people still lack access to safe drinking water and sanitation (water access). The water demand-supply imbalance and its consequences, which could be further exacerbated by climate change, are already evident in some regions. For example, Yemen—among the world’s most water-deficient countries—has been in a near-crisis situation for a decade, with growing local conflicts over water rights. And some parts of the United States use as much as 80 percent of their available freshwater resources, meaning that even relatively minor droughts can trigger water shortages. Policies are usually inadequate to address growing water challenges, a situation that contributes to inefficient water use and inadequate investment in water infrastructure. Looking ahead, without an improvement in water demand management, even substantial technological advances and investment are unlikely to close the growing water demand-supply gaps.

2. Failure to manage rising water challenges can impede a country’s economic prospects. Water challenges affect economic growth and stability in numerous ways, although the literature on the aggregate growth impact from such challenges is rather scant (reflecting, among other things, significant data gaps). Because water is a key input in agriculture, energy, and industry, water shortages and variability can lead to food insecurity, raise production costs,⁴ and constrain productivity growth. In some countries in which agriculture is a key source of growth and employment (for example, Burkina Faso, Morocco, and Mozambique), data show a high correlation between GDP growth and average rainfall, with activities affected greatly by droughts and floods.⁵ In addition, lack of water access inhibits development through various channels, including disease, poor health, and low participation of women in education and income-generating activities (women and girls usually are in charge of fetching water in developing countries). Moreover, water quality degradation would lead to reduced activity in sectors that depend on environmental quality (for example, tourism).

3. Managing water resources is a complex policy issue, often complicated by insufficient data and sensitivities related to national sovereignty and social norms. Water is a special

³ The World Economic Forum’s *Global Risks 2015 Report* (WEF 2015) lists water crises as the top global risk in terms of impact and eighth in terms of likelihood.

⁴ As examples at the business level, power plants have cut generation or scrapped plans for expansion in the face of water shortages, and companies have incurred additional costs to build their own desalination or treatment capacity to ensure sufficient water supply.

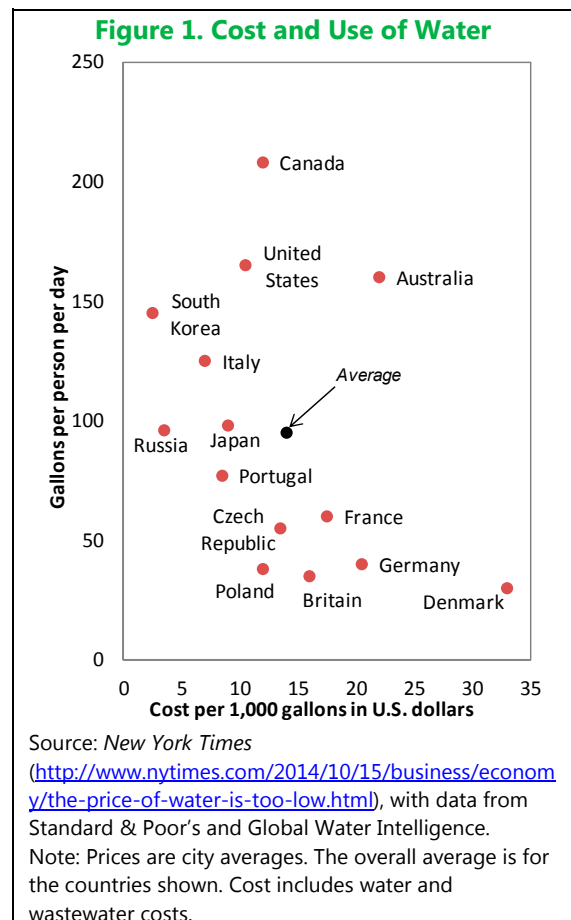
⁵ A World Bank study suggested that GDP growth in Mozambique was reduced by about 1.1 percentage points annually during 1981–2004 due to the impact of water-related shocks (World Bank 2007a).

economic good,⁶ with many unique features that differentiate it from other commodities: it is both a private and public good; it is bulky and difficult to transport; it can be used sequentially and can be recycled; finally, it is a heterogeneous commodity. These factors make it difficult to ascertain water's economic value. Furthermore, water management encompasses political, economic, societal, environmental, and technological considerations. Perhaps most importantly, the right to safe drinking water and sanitation has long been recognized as a human right, and universal access to it is an important policy goal.

4. These complexities notwithstanding, water should not be a free good—the laws of demand and supply tell us that underpricing leads to overuse and undersupply. Water resources are limited and unevenly distributed, and some (like fossil fuels) are nonrenewable. Water use is found to negatively correlate with water cost (Figure 1), suggesting a role for price signals to rationalize water consumption. For example, in the United States, per capita water use in California has declined in recent decades as a result of the implementation of pricing incentives (Kearney and others 2014). Moreover, free water leads to what is known as the “tragedy of the commons,” as evidenced by some regions’ rapid depletion of underground aquifers.

5. Existing price signals are very often off the mark. This paper examines the issue of water pricing through the lens of public utilities. It finds that public utilities in many countries set water prices below the cost recovery level, creating incentives for overuse and underinvestment. This leads to financial losses for public water utilities, underfunding of maintenance, and low investment in new water infrastructure, which in turn results in low water access and quality and large network losses, aggravating water shortages.

6. Water subsidies, defined as the difference between actual water charges and a reference price that covers all supply costs, are inequitable. They benefit mostly upper-income groups in developing economies, as the poor often have limited or no access to piped water and improved sanitation. Even when the poor have access to piped water, lower levels of use mean they capture a smaller share of the benefits compared with other groups. For example, Cabo Verde, India, Nepal,



⁶ Principle 4 of the 1992 Dublin Statement on Water and Sustainable Development states that water has an economic value in all its competing uses and should be recognized as an economic good (<http://www.un-documents.net/h2o-dub.htm>).

and Nicaragua provide the richest households with \$3 worth of subsidized water, on average, for every \$1 worth provided to the poorest households.

7. Getting the price right for water can be an important policy element for managing this essential natural resource and protecting access for the poor. The increasing competition for water resources calls for policy instruments to signal scarcity and create incentives for using water in an efficient, equitable, and sustainable manner. Furthermore, better pricing—especially when it allows for full cost recovery and a normal profit—would help ensure adequate maintenance, attract investment, and promote technological innovation, which in turn will contribute to sustaining or unlocking future water supply and increasing resilience to water supply variability. At the same time, water pricing reforms should be carefully designed to provide affordable water access for the poor through, for example, a progressive tiered tariff structure (see paragraph 44). Importantly, there need not be a conflict between proper water pricing and protecting the poor, not least because only small amounts of water are required to satisfy basic needs for safe drinking water and sanitation. Water pricing reforms should also be complemented by reforms of policies that drive the lion's share of water use, notably agricultural and energy policies.

8. Experiences in some countries with naturally limited water resources have shown that sound water management can be achieved and water challenges are not insurmountable. Examples include low-income countries such as Burkina Faso and densely populated ones such as Singapore, both of which have no natural freshwater resources other than rainfall. In response to early recognition of the various constraints that limited water resources can impose on their economies, both countries have adopted water pricing policies that allow for full or near-full cost recovery and invest aggressively in water infrastructure. One notable innovation in Burkina Faso is the Bagre “growth pole,” in which a huge manmade reservoir supports diverse activities, such as fishing and irrigation for crops. In addition to rigorous water demand management, Singapore has adopted the “Four Taps” strategy—water imports, local catchment water, recycled water, and desalination—to secure its water supply.

9. Lack of proper management exacerbates water challenges, even in countries with abundant water endowment. A case in point is Pakistan, where, despite an abundance of water a few decades ago, lagging policies have raised the prospect of water scarcity that could threaten all aspects of the economy. The bulk of Pakistan's farmland is irrigated through a canal system, but canal water is vastly underpriced, recovering only one-quarter of annual operating and maintenance costs. Meanwhile, agriculture, which consumes almost all annual available surface water, is largely untaxed. The combination of these policies leads to overuse of water. In the Democratic Republic of the Congo (DRC), a country with an extensive system of rivers and lakes, years of poor management, conflicting water sector regulations, and low cost recovery have created a situation in which consumption of drinking water is far below the regional average and only a fraction of agricultural land is irrigated. Meanwhile, the Colorado River Basin in the western United States, which supplies water to 40 million people and irrigates 4 million acres of farmland, is losing water at dramatic rates. Most of the losses are groundwater, the use of which has not been properly regulated.

10. Building on extensive literature on water management, this paper aims to help raise awareness of growing water problems and the need for concerted efforts. The efforts of development organizations (such as the World Bank and the United Nations), specialized institutions (such as the World Resources Institute), local communities, and national authorities have resulted in a wealth of knowledge and experience in how to manage water resources. However, the facts that water is an essential, finite, and mostly renewable natural resource and that its future supply needs to be preserved have not always been properly factored into macroeconomic policymaking. This paper complements other work by summarizing growing water challenges, highlighting their macro-criticality, and examining the role of economic (especially fiscal) instruments and institutions in rationalizing water use and promoting investment. The post-2015 sustainable development goals emphasize economic, environmental, and social sustainability for all. The policies implemented to achieve these goals must be coherent and mutually reinforcing. As water issues become an important policy challenge that affects economic stability, public finances, and growth in many countries, the IMF has a role to play in line with its mandate and expertise.

11. The IMF can play a helpful role in supporting institutions that specialize in water issues by ensuring that macroeconomic policies are conducive to sound water management.

Assessing the impact of water challenges on growth and macro-stability can go a long way in garnering needed political and social support for reforms. Under the right circumstances, supporting policies to replace perverse energy and water subsidies with targeted social assistance will help countries achieve more efficient water use. Finally, ensuring fiscal sustainability to support water infrastructure financing and investment can help developing countries improve water access. This can also help sustain or increase future water supply, and strengthen resilience to supply variability.

12. Several caveats are warranted. The analysis underlying this paper was conducted at the country level and is thus constrained by the availability of comparable data across countries. Because water issues tend to be location-specific even within a country, policy responses must be tailored accordingly. Moreover, since water is essential for economic activities, policies that affect non-water sectors such as agriculture, energy, industry, and trade can have a large impact on water use and supply. Finally, there is an important international dimension to water management, not only reflecting the fact that some water basins cut across several countries⁷ but also the need for policy cooperation among countries to help overcome obstacles to reform.⁸ These important policy issues are beyond the scope of this paper.

⁷ Actual or potential cross-border issues can come into play where water resources are shared among countries. Existing or planned dams for flood control, electricity generation, and irrigation often involve technical, economic, and political aspects. Promoting more efficient water use can alleviate potential conflicts. A consensus among all stakeholders is key to settling issues in the long term.

⁸ Because water is bulky, large-scale cross-border water trading does not exist. To some extent, international trade of agricultural products can be seen as an indirect trade of water (“virtual water”) to substitute for domestic water scarcity. For example, a country that adopts policies promoting less-water-intensive crops needs to ensure that its demand for water-intensive agricultural products can be reliably met with imports.

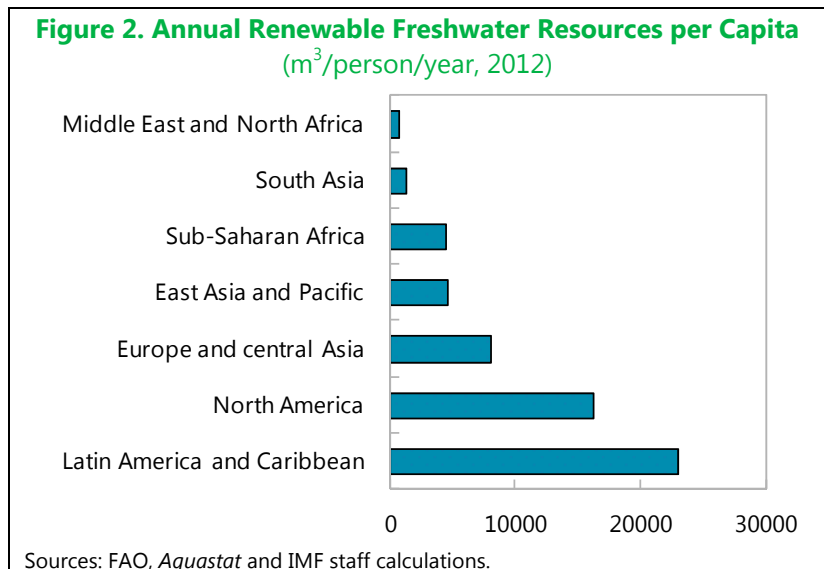
13. The rest of this paper is organized as follows. Section II analyzes cross-country data on water supply and use to determine where water challenges are more pressing and why. Section III estimates country water price subsidies and discusses possible options for pricing reforms. It also reviews country experiences with markets for water rights, which are gaining increasing attention from policymakers.⁹ Section IV presents conclusions. The companion note¹⁰ includes a summary of key water issues in the Middle East, Central Asia, and sub-Saharan Africa, as well as five case studies: Burkina Faso, DRC, Pakistan, Singapore, and Yemen.

II. CHARTING WATER CHALLENGES

14. Water challenges are multifaceted. This paper adopts an economic perspective, focusing on challenges arising from water supply, water use, water access, and the availability of water relative to use, today and in the future. Although water quality and pollution are growing and important issues, they are not addressed here.

A. Water Supply and Variability

15. Although water covers approximately 70 percent of the Earth's surface, only a small fraction of it is available for human use. Sources of usable (that is, accessible and renewable) freshwater are mainly ground and surface water, including rivers, streams, lakes, and wetlands. Groundwater, such as wells and aquifers,¹¹ is the largest source of usable freshwater in the world, accounting for 30 percent of the total. In this discussion note, *water supply* will refer to renewable freshwater resources comprising surface water and recharge of groundwater from precipitation.



⁹ In 2014 China selected seven provinces to host pilot markets for trade in water rights; in the United States seven states in the Colorado River system are also starting a pilot program to explore the establishment of a market between farmers and urban water authorities.

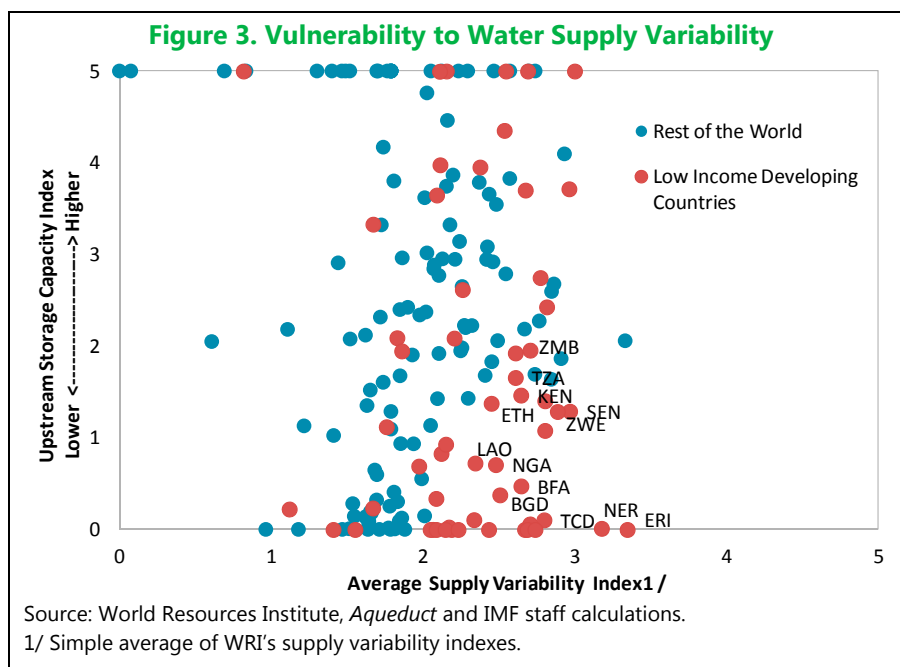
¹⁰ <http://www.imf.org/external/pubs/ft/sdn/2015/sdn1511tn.pdf>.

¹¹ An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials from which groundwater can be extracted with a use of a water well.

16. The global stock of freshwater is unevenly distributed (Figure 2). Over 60 percent of the usable freshwater supply is found in just 10 countries. On a per capita basis, freshwater available in the Middle East and North Africa is only a tiny fraction of that in Latin America. China has roughly the same amount of freshwater as the United States, but it has four times the U.S. population.

17. While technology advances have been used in some advanced countries to help ease freshwater supply constraints, they are expensive. Desalination remains costly because of high reliance on energy and placement of such plants is generally more feasible near coastlines. While recycled water may be a viable long-term alternative, setting up production facilities requires substantial upfront investment, which can be prohibitively expensive.

18. Water supply is also subject to variation, which affects most countries. Four country-level indicators, calculated by the World Resources Institute (WRI) to measure different aspects of water variability,¹² show that out of 179 countries and territories, 119 have at least one aspect of high variability (Annex Table T1). Thirty-four countries—all, except South Korea, developing—are vulnerable to high water variability in at least two aspects.



19. Highly variable water supply adds to the challenge of ensuring that water is available when it is needed. Transportation and storage could mitigate these challenges, but these require building and maintaining expensive infrastructure as well as more sophisticated planning.

¹² *Interannual variability* measures variation in water supply across years; *seasonal variability* measures fluctuation in the water supply in different months; *flood occurrence* is measured by the number of floods recorded in 1985–2011; and *drought severity* is the average length of droughts times their dryness. Each indicator varies from 0 to 5, with 3 and above defined in this paper as “high variability.”

Unfortunately, many countries that face high water variability do not invest enough in increasing water supply resilience and have low storage capacity; this is particularly true for low-income countries such as Eritrea and Niger (Figure 3).

B. Water Use and Intensity

20. Water use is complex to measure, as water is not a homogenous good and is subject to sequential uses. *Withdrawals of water*—total water diverted for human use—are widely used to proxy the reliance of human activity on water.¹³ It is the broadest measure that encompasses domestic, agricultural, and industrial use of water. But water withdrawals do not properly capture the intensity of recycling or the impact on water quality.

21. Global water withdrawals have increased exponentially as a result of rising population and economic growth. Estimates dating back to the year 1700 suggest that global water withdrawals have risen by a factor of 40 (Shiklomanov 2000), far exceeding the 11-fold increase in population over the same period (Table 1). The other primary factor—increasing economic activity and income—is evidenced by a more than hundred-fold increase in global GDP.

Table 1. World: Population, GDP, and Water Withdrawals

Year	Population (in millions of people)	GDP (in billions of international dollars, base 1990)	Withdrawals (in billions of cubic meters)
1700	604	371	100
1820	1,042	694	237
1900	1,564	1,972	579
1950	2,526	5,336	1,382
2010	6,916	53,394	4,104

Sources: Maddison (2010), Shiklomanov (2000), and IMF staff calculations.

22. A country's water withdrawals tend to be highly correlated with the size of its population, economy, and agricultural land (Annex Figure A1). The 10 countries withdrawing the most water include seven out of 10 of the most populous in the world, six of the world's 10 largest economies, and five of the 10 countries with the most land cultivated for agriculture (Table 2). Withdrawals in India, China, and the United States dwarf those of all other countries, given their combination of large populations, economic size, and agricultural sectors.

¹³ Data on and estimates of water withdrawals are available for a wide range of countries and time periods. This paper uses estimates from Gassert and others (2013).

Table 2. Water Withdrawals in 2010: Top 10 Countries

Country	Freshwater Withdrawal (in billions of cubic meters)	Population (in millions)	PPP GDP (in billions of international dollars)	Agricultural Land Area (in thousands of square kilometers)	Withdrawals (cubic meters per capita)	Withdrawals (cubic meters per unit of GDP)	Withdrawals (cubic meters per square kilometer)
India	760	1,206	4,130	3,287	631	18	231
China	627	1,360	10,040	9,597	461	6	65
United States	441	312	14,958	9,629	1,413	3	46
Pakistan	183	179	487	796	1,022	38	230
Indonesia	166	241	1,026	1,905	691	16	87
Iran	89	74	942	1,648	1,202	9	54
Russia	80	144	2,222	17,075	558	4	5
Mexico	80	118	1,603	1,958	676	5	41
Philippines	79	93	365	300	848	22	264
Japan	76	127	4,351	378	596	2	201
World Total	4,104	6,837	73,658	131,077	600	6	31

Sources: United Nations, *World Population Prospects*; World Resources Institute, *Aqueduct*; IMF, *World Economic Outlook*; and IMF staff calculations.

23. Wealthier countries typically use less water per unit of GDP and more of it per person (Annex Figure A2). The relationship between income and water use is affected by two trends that work in opposite directions. Rising per capita income is reflected in increasing water use per person, driven primarily by factors such as more meat-intensive diets and higher consumption of manufactured goods (Flörke and others 2013; Hoekstra and Chapagain 2007). On the other hand, given that agriculture accounts for about 70 percent of total global water withdrawals (Shiklomanov 2000), water use per unit of income declines as income rises and the agricultural sector's role in the economy decreases; thus, for example, water withdrawals in Europe and North America have declined in recent decades (Annex Figure A3).

24. Water intensity, defined as water withdrawals per unit of GDP, is unrelated to the abundance of water in a given location. One would expect water intensity to be positively related to the available supply of water if the economic structure of a country develops along the lines of its comparative advantage. But data suggest no correlation between intensity and water supply or its variability (Annex Figure A4). This could indicate either inefficient use of water resources or a nonlinear relationship, with intensity unrelated to water availability below a certain threshold and strongly related to it once supply constraints become binding. These hypotheses require further investigation.

C. Water Scarcity: Access and Stress

25. Water scarcity is a relative concept that can occur at any level of water use and supply. The scarcity can be economic or physical:

- **Economic water scarcity** is lack of access to or unequal distribution of water. It can be caused by lack of infrastructure investment or poor institutions to satisfy water use even in areas with

abundant water resources. A country's economic water scarcity can be measured by the proportion of the population with water access.¹⁴

- **Physical water scarcity** means insufficient availability of water relative to demand. Arid or dry regions are more likely to face physical water scarcity, but this is not necessarily the case since by definition physical scarcity is *a relative concept* relating water supply to demand. Physical water scarcity can be caused by human activity, such as overuse of water resources, as in the case of Pakistan.¹⁵ It can be assessed by computing water stress, generally defined as the ratio of water withdrawals over the total amount of renewable water supply.

26. Despite recent improvements, economic water scarcity remains a daunting issue for many developing countries. Almost 10 percent of the global population—mostly poor and marginalized—still lack access to safe drinking water sources according to the latest WHO/UNICEF estimates.¹⁶ The situation is even more severe for water sanitation, with more than 2.5 billion people (one out of every three) lacking access to sanitation facilities. At the regional level, sub-Saharan Africa has the lowest coverage of safe drinking water, while Africa and South Asia have the lowest access to water sanitation.

27. A country can experience severe water stress (that is, physical water scarcity) regardless of its stage of economic development (Annex Figure A5). With relatively high population density and low water endowments, the Middle East, the Caribbean, the Pacific island countries, and a few countries in Africa and Asia (for example, Libya, Morocco, and Singapore) are commonly found to face high water stress. The World Resources Institute's Aqueduct project found that 36 countries already face "extremely high" levels of baseline water stress.¹⁷ This means that more than 80 percent of available water resources is withdrawn annually, leaving these countries vulnerable to shortages and variability.¹⁸

28. Benign water stress indicators at the country level can mask considerable variation within the country. Although a country may not face high water stress at the national level, high water stress could be observed at the basin and regional level. Large water variation within a country has the potential to trigger regional disputes over water resources, leading to social instability. Data on the standard deviation of water stress across different water basins within a country show that

¹⁴ The World Health Organization defines an improved drinking water source as "one that, by the nature of its construction, adequately protects the source from outside contamination" and an improved sanitation facility as "one that hygienically separates human excreta from human contact" (http://www.who.int/water_sanitation_health/monitoring/jmp2012/fast_facts/en/).

¹⁵ As another example, overuse of a seemingly abundant water source, the Colorado River basin in the United States, has led to high physical water scarcity downstream (The Water Project 2014).

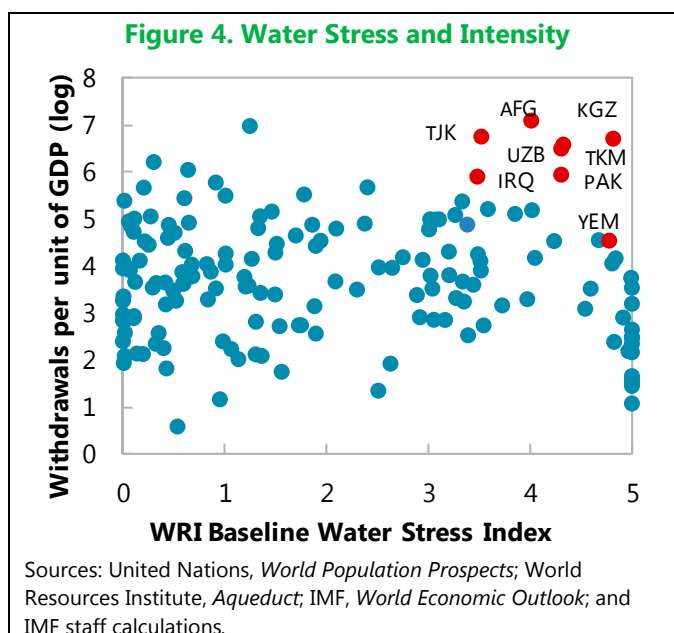
¹⁶ <http://www.wssinfo.org/data-estimates>

¹⁷ This paper uses WRI's "baseline water stress" index to measure physical water scarcity or water stress.

¹⁸ A country is said to face high water stress if more than 40 percent of available water resources is withdrawn annually.

among the 20 countries with the highest regional variation, 15 (including China and the United States) do not face high water stress at the country level (Annex Figure A6).

29. High water stress does not necessarily lead countries to economize on water use. Several countries in Central and South Asia are among the most water-intensive economies despite their high water stress (Figure 4). This suggests that competition for water resources has not led to water being used for activities with more value added. In some cases, groundwater is pumped to supplement surface freshwater supplies, resulting in rapid depletion of underground aquifers. All these underscore the challenges of rationalizing water use and adjusting the structure of economic activity in the face of water stress. For example, the pricing structure of major crops in Pakistan has impeded the adoption of more efficient technology and less-water-intensive crops. Fuel subsidies in Yemen, which were reduced in 2014, contributed to the rapid depletion of groundwater and the distorted production costs that favor water-intensive crops (for example, qat).



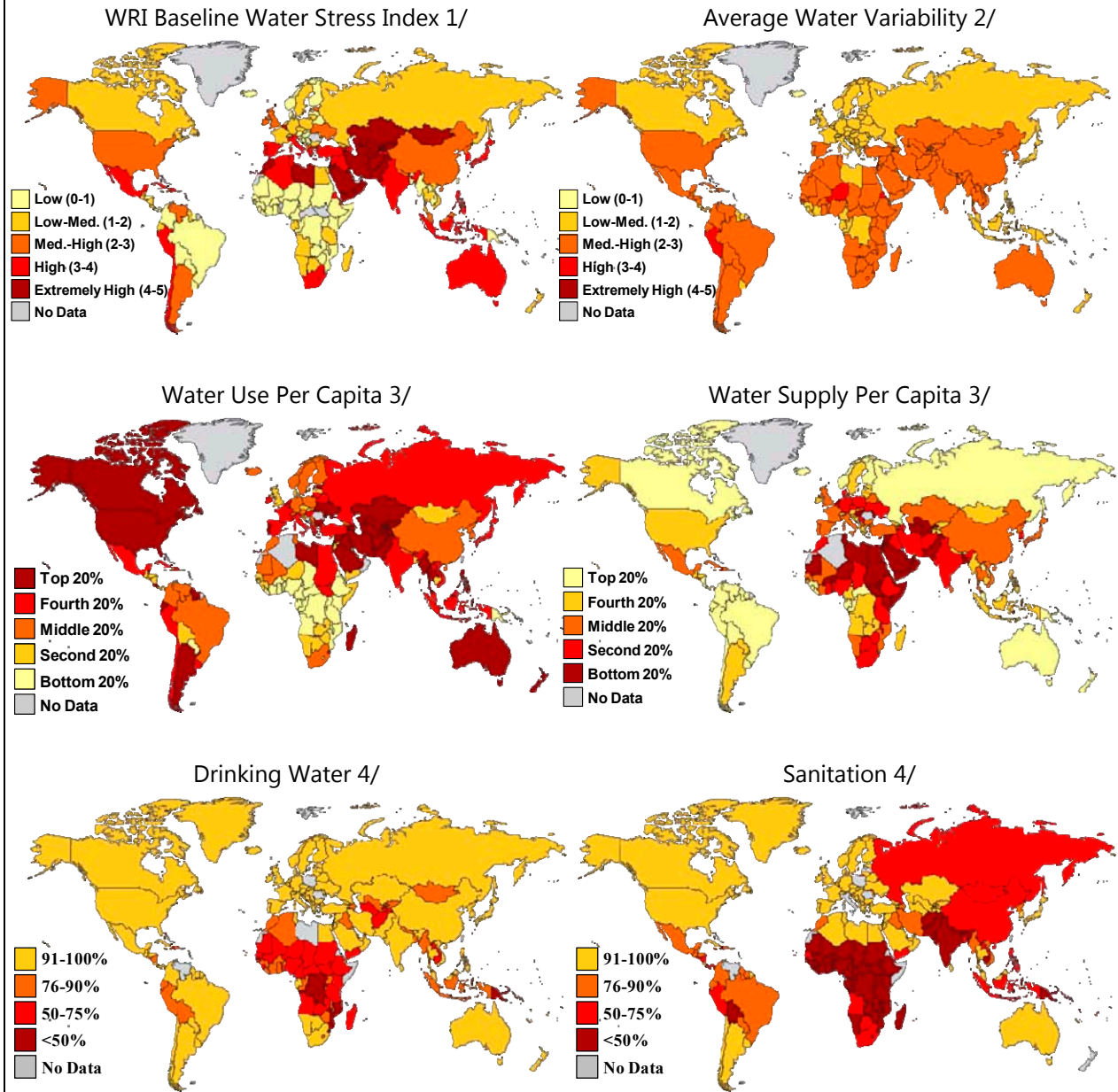
30. Underinvestment in water infrastructure is widespread, and it can exacerbate water scarcity. According to the World Health Organization (WHO) (2014), the financing requirement for developing countries to increase water access and sanitation to 88 percent and 75 percent by 2015 respectively was US\$18 billion per year, and the cost of maintaining water services was US\$54 billion per year. But the actual spending on the sector was only US\$14–16 billion. Many developed countries have aging water infrastructure, with water networks nearing the end of their design lives. For example, 75 percent of urban water networks in the United Kingdom are more than 100 years old. As a consequence of underinvestment, water infrastructure is inefficient, with leakage losses as high as 45 percent in some OECD cities (Gurría 2014).

D. Putting Together Water Challenges

31. No country is spared water challenges (Figure 5). Understanding the causes of water stress (demand factors, supply factors, or both) and examining water access are important because policy responses would differ. Per capita annual water use and supply data are used to investigate causes of stress and access (Annex I).¹⁹

¹⁹ Given the inherent difficulty of defining high or low water use and supply, results shown here should be taken as indicative. In-depth analyses at the country and water basin levels are required to inform tailored policy responses.

Figure 5. Water Heat Maps



Sources: FAO *Aquastat*; WHO/UNICEF, *Joint Monitoring Programme for Water Supply and Sanitation*; World Resources Institute *Aqueduct*; and IMF staff calculations.

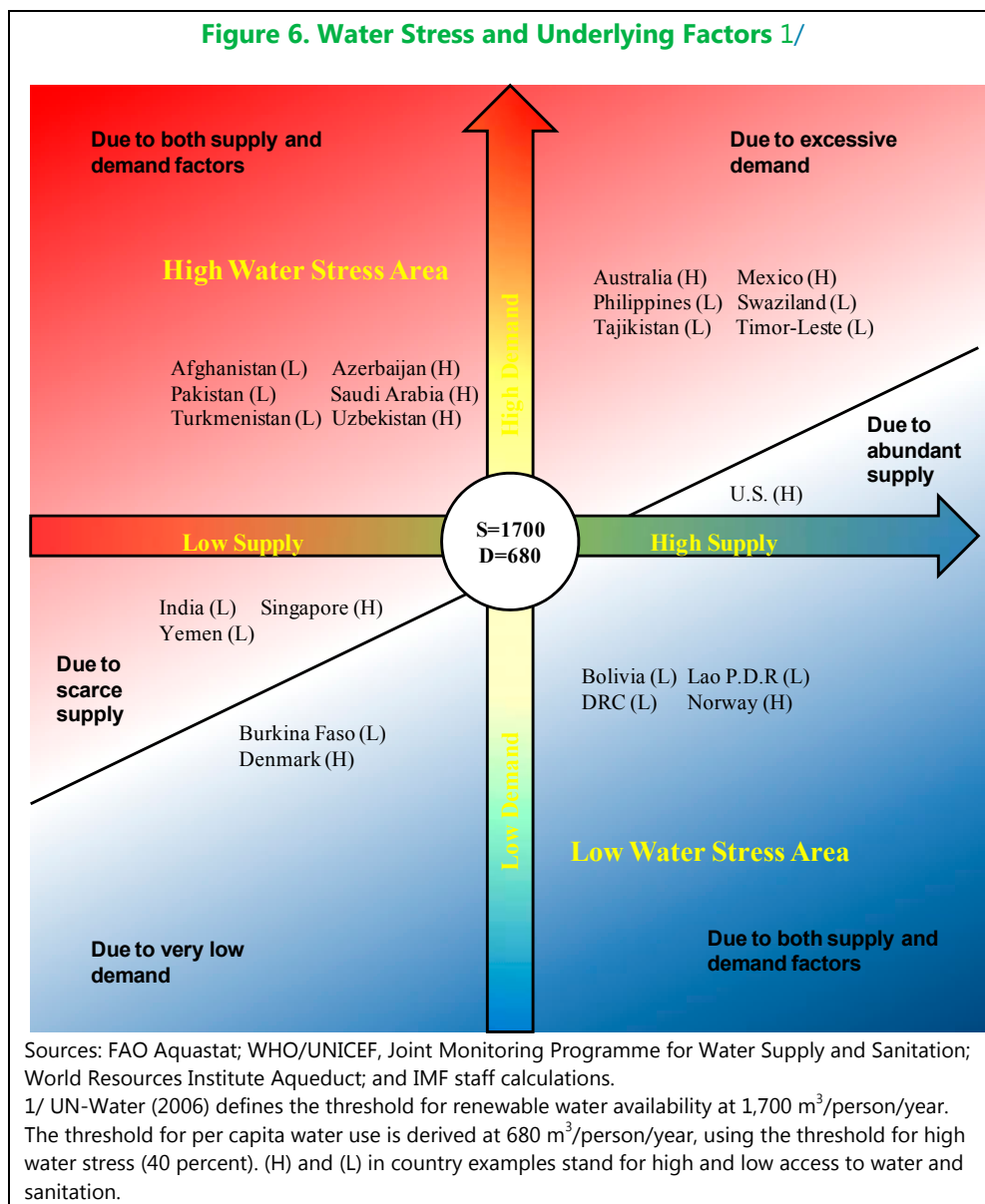
1/ Baseline water stress measures total water withdrawals (2010) expressed as a percentage of the mean available water flows (1950–2008). Countries are scored from 0 to 5, with 0 being the lowest stress and 5 being the highest.

2/ Average variability is a simple average of the scores for interannual (1950–2008), seasonal (1950–2008), flood (1985–2011), and drought (1901–2008) variability. Countries are scored from 0 to 5, with 0 being the lowest variability and 5 being the highest variability.

3/ Countries are ordered from high to low in terms of water use and supply per capita, and divided into threshold quintiles. The sample includes 165 countries. Each threshold is composed of 33 countries.

4/ Percentage of the population with access.

32. Countries facing high water stress need to rationalize water use and/or identify other water resources (Figure 6). High water stress can be attributed to extensive water use (for example, Australia, Mexico, Tajikistan, and Timor-Leste), water resource constraints (for example, India, Singapore, and Yemen), or both (for example, Azerbaijan, Pakistan, Saudi Arabia, and Uzbekistan). Given the difficulty and cost of developing alternative sources of water supply for many countries, the focus should be on policies to better rationalize water use. Some of the countries with high water stress also face economic water scarcity (Annex Figure A7 and Annex Table T2), suggesting that the effect of demand factors may increase as these countries try to improve water access for their populations.



33. Low water stress does not imply an absence of challenges in water management.

Despite high per capita water use, some countries' low stress is explained by their abundant water endowment (for example, the United States), suggesting scope for improving water management to rationalize use. Many other countries with low water stress are low-income countries that currently have low per capita water use and also need to improve water access for their populations (for example, Bolivia, Burkina Faso, DRC, and Lao P.D.R.). As improving water access, urbanization, and growing income are expected to increase water use in these countries, policies need to preempt rising water stress in the future. On a positive note, some countries (for example, Denmark) have been able to rationalize water use, achieve universal water access, and maintain low water stress in the face of water resource constraints.

34. Addressing water challenges is complicated by the fact that policies that affect water use, directly or indirectly, are mostly set according to political or administrative boundaries, such as nations or states. The issue of "tragedy of the commons" and overexploitation of water can arise when two or more countries or states that share the same water basin have policies and management frameworks that lack a holistic understanding of sustainable development across the entire basin. On the other hand, different policies and regulations governing water use may be warranted in a country that has several distinct water basins. An attempt to ensure "equal treatment" within the same country may instead lead to a system that disincentivizes efficient use of water.

E. Water Sustainability

35. Long-term scenarios forecast large increases in water use that, for many countries, cannot be met by existing supplies. With expected growth in population and economic activity, future global water use will far exceed today's level.²⁰ At the same time, freshwater availability is expected to remain more or less fixed in the coming decades. While expecting further improvements in efficiency is not unreasonable, their impact is highly uncertain. The consensus among analysts is that even substantial technological advances and investment would be insufficient to close the projected future gaps between water supply and water use.²¹

36. Closing the gaps will require policy adjustments to better rationalize water use. Since water is bulky and costly to transport, an overabundance in one locality does not translate easily into alleviating shortages in another. There is also a great deal of uncertainty surrounding the ability of international trade of agricultural products to substitute for domestic water scarcity (Liu and others 2014). Furthermore, climate change is expected to exacerbate water sustainability through

²⁰ According to the 2030 Water Resources Group (2009), if no action is taken, growing population, rapid urbanization, and economic growth are estimated to lead to global water demand exceeding the existing water supply by 40 percent in 2030.

²¹ See 2030 Water Resources Group (2009); Alcamo, Flörke, and Märker (2007); Duarte, Pinilla, and Serrano (2011); Erzin and Hoekstra (2014); Hanasaki and others (2013a and 2013b); Hejazi and others (2013); and Schlosser and others (2014).

higher precipitation variability and increased evapotranspiration in areas where temperatures increase (Schlosser and others 2014).

III. GETTING INCENTIVES RIGHT

37. Policies to signal scarcity can be an important part of the solutions to water challenges.

This section analyzes issues in water pricing and discusses options for reforms. Where cross-country data are available, we focus on drinking water and wastewater provided by public utilities. Limited data availability does not permit the inclusion of agricultural water use (which is the lion's share of total withdrawals) in the analysis. However, water pricing by public utilities can serve as a microcosm of the broader problem, which is that underpricing disincentivizes water conservation and investment. We also review the benefits and costs of informal and formal markets for water rights and summarize some general principles in establishing such markets.

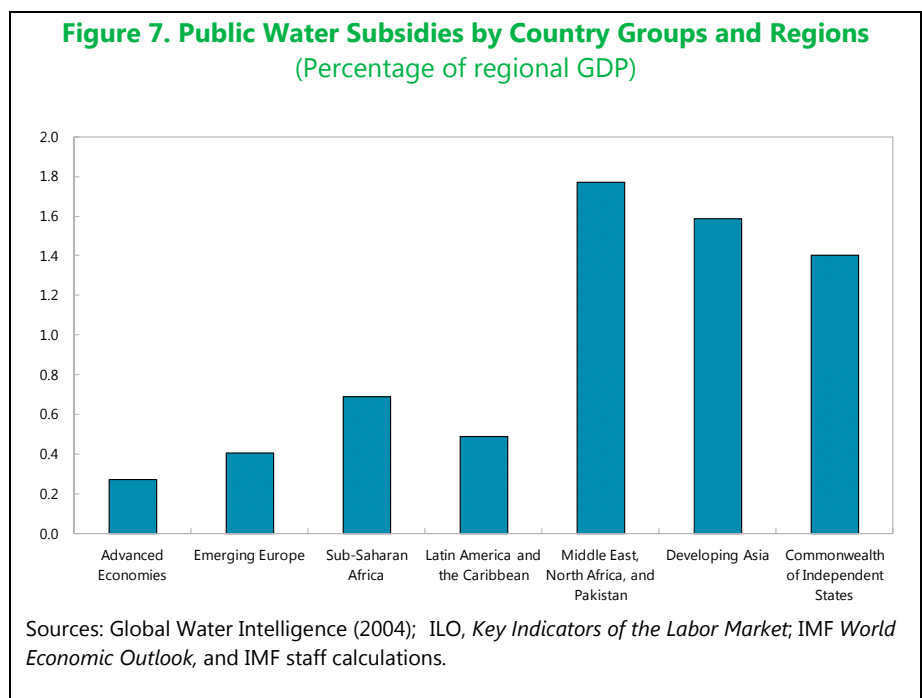
A. Issues in Water Pricing by Public Utilities

38. Through public water utilities, most countries subsidize water, creating incentives for overuse and imposing a substantial fiscal burden.

Subsidies occur whenever a *price gap* exists between the price charged for water and a reference price that covers all supply costs, including depreciation and maintenance of infrastructure. These subsidies are rarely reported or appropriately funded; instead, they are reflected in the underfunding of maintenance, the

deterioration of water infrastructure, and financial losses for public water utilities. This in turn necessitates capital injections or new investment at a future date to maintain the level of services. Ultimately, a large share of the fiscal costs of water subsidies is borne by subnational authorities responsible for providing water. Given the low revenue capacity of these governments, this fiscal burden squeezes their ability to provide other essential public services.

39. The "price gap" approach is widely used to identify and estimate subsidies. This paper follows the price gap approach for estimating water subsidies but adjusts the reference price upward for countries suffering from water scarcity (Annex III). Based on this approach, water

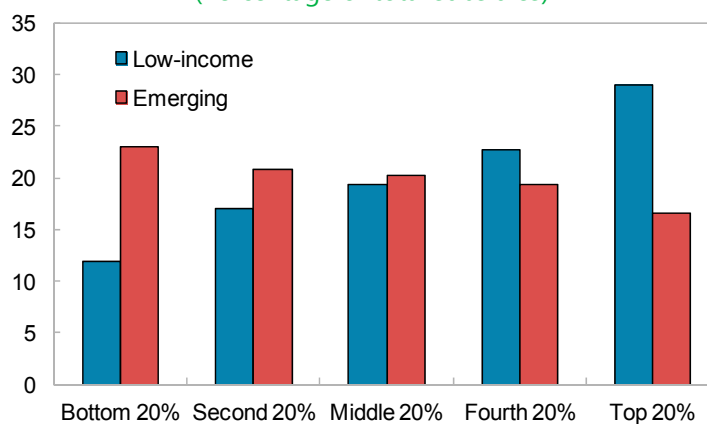


subsidies are estimated at about US\$456 billion, or about 0.6 percent of global GDP in 2012, the latest year for which data are readily available. Across regions, subsidies average between 0.3 percent and 1.8 percent of GDP (Figure 7). Developing Asia has the largest subsidies in absolute terms (US\$196 billion), with China accounting for more than two-thirds of that amount. Cost recovery is particularly low in South Asia despite its higher externalities from groundwater depletion. Subsidies are also substantial at the country level, reaching above 5 percent of GDP in seven countries: Azerbaijan, Honduras, Kyrgyz Republic, Mongolia, Tajikistan, Uzbekistan, and Zimbabwe.²² All of these countries except Honduras and Zimbabwe face high water stress (Annex Figure A8).

40. On average, water prices in advanced economies for households and industry use tend to be at or close to cost recovery levels. However, some advanced economies continue providing subsidized water for agriculture and electricity generation, contributing directly to the substantial underpricing of water and indirectly to pricing distortions in the agricultural and energy sectors (OECD 2006 and 2010b). For example, a few OECD countries continue to apply no charges to irrigation water abstraction. However, these subsidies are not captured in our analysis owing to the difficulty of obtaining information on the extent of irrigation and energy generation subsidies. Moreover, issues of appropriate management of water resources are important for advanced economies as well, given that prices do not necessarily reflect externalities.

41. Water subsidies are inequitable. Water subsidies mostly benefit upper-income groups in developing economies, as the poor often have limited or no water access.²³ Even when the poor do have access to piped water, lower levels of use mean they capture a smaller share of the benefits compared with other groups.²⁴ In three low-income economies for which data are available, the poorest 20 percent of the population received, on average, less than 11 percent of subsidies incurred by public water utilities, while the

Figure 8. Distribution of Water Subsidies by Income Groups
(Percentage of total subsidies)



Sources: Komives and others (2005) and IMF staff calculations.
Note: The group of low-income countries comprises Cabo Verde, Nepal, and Nicaragua. The group of emerging market economies includes Argentina, Chile, Colombia, Croatia, India, Panama, Paraguay, and Venezuela.

²² The reference price is adjusted for labor costs (downward) and for countries suffering from water scarcity (upward). Data on water prices and water consumption are drawn from Global Water Intelligence *Global Water Market* database.

²³ In many regions where water is scarce and access is limited during the day, middle- and upper-income groups have systems in place that allow them to store water for use throughout the day.

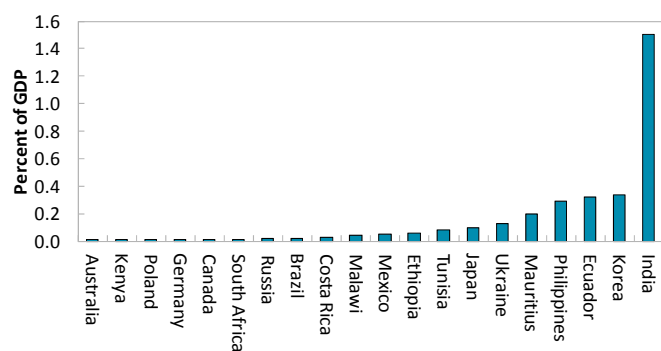
²⁴ In the case of agricultural water use, access to irrigation by poor farmers should be a key consideration in determining the share of subsidies to the poor.

richest 20 percent received over 30 percent of the benefits (Figure 8). Subsidies are less inequitable in emerging market economies, where the poorest received, on average, 22 percent of the subsidies. However, these numbers mask important differences across economies: for example, the poorest receive about 11 percent of subsidies in India and 36 percent in Chile.

42. Prices rarely reflect the externalities associated with water use. These externalities include those linked to the extraction of nonrenewable sources of groundwater²⁵ and the impact of renewable and nonrenewable water use (particularly in agriculture and industry) on water pollution, vulnerable watersheds and deltas, and so on.²⁶ In principle, addressing the depletion externality requires that a scarcity value be reflected in extraction charges that rise over time. These charges should increase (at the rate of interest under some simplifying assumptions) as water resources are exhausted, similarly to what is laid out in the standard Hotelling model for nonrenewable resources (Tietenberg and Lewis 2014).

43. Due to the lack of data, very few empirical studies measure these externalities. To begin with, the practical design of prices to correct for externalities is complex, mainly reflecting the fact that the size of the externality is highly sensitive to local conditions, such as how rapidly the water table is declining. Based on an analysis for the U.S. state of Kansas, Pfeiffer and Lin (2012) suggest that externalities are modest, causing water use to exceed efficient levels by only 2½ percent. But externalities can be much larger in developing economies where water scarcity is more severe and prices charged for its use are significantly lower or nonexistent, compounding the problem of overconsumption. For example, Reddy (2005) finds externalities of about US\$120–US\$200 per rural household in a study covering the Indian state of Andhra Pradesh, with the precise value depending on the degree of water scarcity. A highly crude extrapolation of this result to the entire country would estimate externalities of around 1½ percent of GDP in India. An even simpler extrapolation to other economies (Figure 9) suggests that the annualized depletion externality is generally less costly than for India, partly because agriculture is less dependent on irrigation in most other economies.

Figure 9. Costs Related to Depletion Externality in Selected Economies



Sources: Reddy (2005), World Bank, and IMF staff calculations.

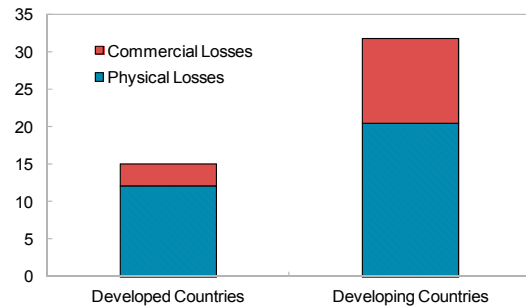
²⁵ Extraction of groundwater can be excessive because users are not charged for lowering the water table, which can raise pumping costs for other users.

²⁶ Water pollution can be severe, especially in developing economies, and can impose costly damages. For example, it is estimated that in China the annualized damage due to water pollution is about 2 percent of GDP (World Bank 2007).

B. Water Pricing Reforms

44. Water pricing reforms are essential to rationalize demand, improve the delivery of services, and unlock additional water supply. Pricing reforms could improve cost recovery in public water utilities, strengthen the fiscal balances of subnational governments, raise investment in water infrastructure, promote efficiency in water use, and incentivize the development of new technologies. Notably, water pricing reforms and, more broadly, strengthening the management of public utilities will help reduce large commercial and physical water losses (Figure 10). However, water pricing reforms will need to be accompanied by reforms of policies that drive water use in agriculture, trade, and energy. Moreover, they will need to consider affordability to ensure water access for the poor. The poor spend a larger part of their income on water than the rich in developing economies (Figure 11), given the poor’s high expenditures on private vendors. Surveys also indicate that the poor are willing to pay even higher prices than current levels, although not enough to fully recover costs (Guha 2007; Halpern and others 2000; Vasquez and others 2009). Targeted income assistance can be provided to ensure that the poor are just as well off as before the reforms.

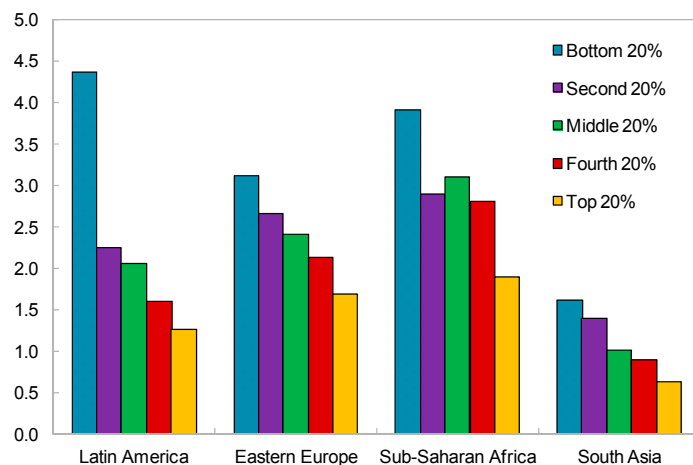
Figure 10. Ratio of Nonrevenue Water (NRW) Losses of Public Water Utilities 1/ (Percentage of urban water supply)



Sources: Kingdom and others (2006) and IMF staff calculations. 1/ NRW is the difference between the amount of water put into the distribution system and the amount of water billed to customers. High levels of NRW reflect huge volumes of water being lost through leaks, not being invoiced to customers, or both.

45. Several options are available for structuring prices to make safe water affordable to the poor. One option is to establish a dual tariff structure that provides a certain amount of water at subsidized prices to everyone and charges a higher tariff beyond that level. For the poor to benefit, this approach requires high levels of access by the poor to the public water network. A second option is to subsidize water at public pumps. This type of subsidy is self-targeted, especially if the pumps are available only in low-income neighborhoods. The third option is to subsidize water connections for the poor, improving their access to water at prices below those charged by private vendors.

Figure 11. Household Expenditure on Water by Income Groups (Percentage of total income)



Sources: Komives and others (2005) and IMF staff calculations.

Empirical evidence of the distributional incidence of these options is limited, though Komives and others (2005) argue that the second option could reach a higher share of the poor.

46. The most desirable approach will vary by country, depending on the access of the poor to the existing water network and administrative capacity. For example, Burkina Faso introduced a progressive tariff grid for drinking water based on the volume of use, with the higher tiers subsidizing the lowest tier as well as part of sanitation activities. In Singapore, there is no subsidized “basic” water consumption; instead, the government provides targeted help for low-income families. Admittedly, full cost recovery can be politically and socially difficult to achieve. In addition, the amount of financing needed to improve water infrastructure can overwhelm the abilities of some developing countries, even if they achieve full cost recovery of public utilities. This situation highlights the need to mobilize financial assistance to help these countries overcome water challenges, including access to financing for water infrastructure.

47. Our country case studies suggest that reforms are much more likely to succeed if there is greater public awareness of water challenges and if water management is left to strong and independent institutions.²⁷ Box 1 summarizes key policy lessons from the five case studies.

- The autonomous Public Utilities Board in Singapore enjoys wide support and is responsible for all aspects of the water cycle (such as collection, production, distribution, and reclamation). It undertakes significant investments and, since 2005, has regularly issued bonds to finance these investments. Similarly, Burkina Faso’s public water utility, l’Office national de l’eau et de l’assainissement (ONEA), charged with water management in urban areas, has been instrumental in achieving a remarkable improvement in the population’s access to drinking water. Performance-based service contracts between ONEA and the government were introduced in the early 2000s, bringing in experienced private management and large infrastructure investments by donors. Elements of the public-private partnership that were essential to its success include arm’s length management contracts, performance benchmarking with independent monitoring, new infrastructure investments based on strict financial sustainability, performance-based compensation for the private manager, and cost recovery tariffs.

- In DRC, where less than half of the population has access to safe drinking water (compared with an average of 73 percent in sub-Saharan Africa), the public water utility for urban areas has been experiencing a steep decline in its operational performance since the 1990s, due to high operating costs, inadequate water tariffs, and low collection rates. The weak water institution is a reflection of the country’s poor institutional environment, which also affects other sectors (for example, mining).

48. Reform priorities will differ among countries depending on their circumstances. For developing economies in which water and sanitation access levels are low, a priority is to expand the water distribution network and raise capital spending, which in turn may require additional fiscal

²⁷ Other examples from various Indian cities and towns can be found in Ahluwalia (2014).

resources. At the same time, it is important that resources mobilized by pricing reforms are in fact used for investment and maintenance spending to boost access to water and sanitation. Many countries—developing or not—whose populations enjoy good access to water and sanitation need to increase capital spending to repair aging infrastructure and sustain future water supply. Ensuring adequate maintenance spending is a priority in all countries.

Box 1. Country Case Studies: Key Policy Lessons

Five case studies in the companion note examine the experiences of Burkina Faso, Democratic Republic of the Congo (DRC), Pakistan, Singapore, and Yemen in dealing with various water challenges. Burkina Faso and Singapore are success cases in which sound water management has eased problems arising from natural water scarcity. Yemen (one of the world's most water-deficient countries), Pakistan (which has one of the world's largest glaciers), and DRC (covered by an extensive system of lakes and rivers) are facing water scarcity that to a large extent reflects years of poor management. The following are some policy lessons from these case studies.

Burkina Faso: Restricted access/high costs for water can bring about homegrown solutions to improve efficiency and reduce per capita use. Resilience to variability of water supply can be improved through aggressive government investment strategies, while public water utilities can achieve cost recovery for drinking water access, provided they focus on independent management, cost recovery, financially sustainable investment, quality of service, and social objectives. Burkina Faso still faces major water challenges—a large infrastructure gap, low access to sanitation, and still-high vulnerability to water shocks—likely to be aggravated further by high population growth, contamination, urbanization, climate change, and structural transformation, and these call for even more aggressive policies.

Singapore: High-level political support for farsighted policy objectives and strong institutions, including an autonomous institution in charge of water management, is among the key factors that enabled Singapore to put in place a comprehensive water strategy. The Singaporean approach is not limited to diversification of water supply sources. It also relies on (i) rigorous water demand management that recovers costs to the fullest extent possible while protecting the poor through targeted social assistance, (ii) continued investment in new technologies, and (iii) involvement of the broad society in water conservation. The rapid improvement in living standards and industrialization of the economy with a significantly reduced role of the agricultural sector may have helped secure broad support for the government's water strategy.

DRC: The water situation in DRC mirrors the weaknesses of other sectors (mining, oil extraction), where delays in the passage of crucial legislation and limited capacities of state institutions such as ministries and administrative bodies are impeding full exploitation of an otherwise abundantly available and diversified natural resource. More broadly, problems with water also reflect across-the-board governance challenges after three decades of internal conflict. The current cross-subsidized system is not working properly, given the very low collection rate. While investment in the water and sanitation infrastructure is a potential channel for enhancing the inclusiveness of growth, there are large regional differences in the allocation of investment. The institutional environment is crucial for adequate management and expansion of the water infrastructure, and a

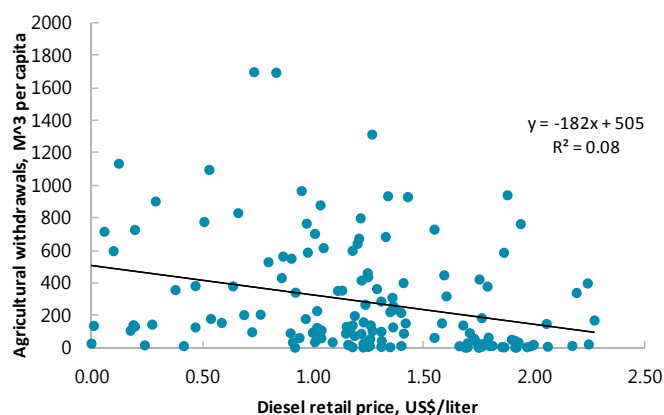
more equitable distribution of funds could reduce the urban-rural gap in access to water and let the most disadvantaged benefit from DRC's recent growth of mining export revenues.

Pakistan: While Pakistan has the necessary natural endowment and the world's most extensive irrigation system, harnessing these assets requires a paradigm shift in water policy and management in a context that would emphasize demand-side measures that promote conservation and control of excessive groundwater exploitation. The thrust of reforms needs to be on improving water-use efficiency in agriculture, which continues to dominate water consumption while escaping taxation at the federal level and bearing a light tax burden at the provincial level. Such reforms would require greater engagement of stakeholders at the local level in water management and capacity building of water management institutions, as well as reforming agriculture taxation systems in the provinces. The nexus between water and electricity is the other area calling for reform of water and electricity subsidies.

Yemen: There is an urgent need for Yemen to improve its water resource management. A broad reform agenda, along with well-coordinated donor support, is needed to boost water supply, rationalize consumption, and improve efficiency. Most important, Yemen needs to implement price-based reforms and to change the legal and social understanding of water rights to reflect the true cost of water resources and minimize inefficient use.

49. Regulatory reforms are also important to rationalize demand for water and address externalities. The externalities associated with the overuse of water can only partly be addressed by higher tariffs and taxes that raise the price of water; in many cases, improvements in regulations governing the water sector will also be needed, since water is mostly extracted directly by users from the ground, rather than purchased from public water utilities. Both property rights and regulations will have to be strengthened to help promote the efficient use of water. Regulatory reforms can also help promote greater use of clean technologies, better water management, and the allocation of water to its most productive uses. In this context, some developed countries have made progress in addressing water costs related to externalities, using a variety of fiscal tools (mostly fees and charges) and other instruments such as permits and regulations (OECD 2010). Germany, for example, has introduced water extraction charges, with the dual objectives of decreasing extraction and raising revenue for environmental protection. In Belgium's Flanders region, groundwater charges increase with the total amount of groundwater pumped. In Canada, most provinces levy license fees to major water users.

Figure 12. Water Withdrawal for Agricultural Use and Diesel Retail Price



Sources: World Bank and IMF staff calculations.

50. Achieving greater efficiency in water consumption will require reforms of other policies that drive water use, directly or indirectly. Agriculture uses about 70 percent of all water withdrawn from the ecosystem (FAO 2014). In many countries, the inefficient use of water in agriculture stems from an array of nonwater policies that restrict economic diversification, reducing opportunities for employment outside agriculture and discouraging farmers from diversifying into higher-value crops. These policies include trade restrictions, as well as rigidities in land, real estate, and financial markets (World Bank 2007b). Other policies that encourage wasteful use of water in agriculture are price supports and subsidized credit. Subsidized energy prices also create disincentives for efficient use of water in agriculture, as they reduce the price of pumping groundwater. For example, data suggest that countries with low prices for diesel fuel tend to have greater withdrawal of water for agricultural use (Figure 12).²⁸

C. Markets for Water Rights

51. To the extent that water pricing mechanisms do not exist or inaccurately reflect the economic value of water, allocation of water resources across sectors is likely inefficient. In theory, the development of markets (that is, permitting voluntary, mutually beneficial trades) could result in water moving to its highest-valued uses (Olmstead 2010).²⁹ Such water markets exist both formally and informally. Some countries (for example, Australia, Chile, and Mexico) and the western United States have established formal mechanisms of water trading (that is, in accordance with a set of rules and regulations approved by governments at national or subnational levels). Informal water markets are common in South Asia and also existed in Mexico before a formal mechanism was introduced.

52. Formal water markets can bring sizable net benefits. Key benefits stem from redirecting water toward more productive uses and from reducing price differentials. For example, in Australia, the establishment of markets for water rights has led to a shift toward higher value-added agricultural production and adoption of more efficient irrigation technologies (Bjornlund and McKay 2002). In the United States, multifold differences in prices paid for water by different agents in neighboring areas indicate potential gains from water trading. For example, Brewer and others (2008) found that some farmers in Arizona paid US\$27 per acre-foot while nearby urban customers paid from US\$479 to US\$3,267 per acre-foot. Prompted by the drought in 2014, seven states in the Colorado River system are starting a pilot program to explore a market between farmers and urban water authorities to help maintain water volumes in Lake Powell and Lake Mead.

53. Formal markets for water rights are still rare. Factors holding back development of these markets include legal complexities (pertaining to definition of water rights, mechanisms of their

²⁸ Regression analysis conducted by staff suggests that, after controlling for GDP per capita, a 1 percent increase in the price of diesel would reduce water withdrawal per capita by 0.7 percent.

²⁹ Water marketing is not the only way water can be reallocated across sectors to address inefficiencies in the current allocation of supplies. Other potential allocation mechanisms include administrative transfers and redesign of large-scale water projects to favor different groups of users.

distribution among agents, and establishment of means of monitoring and enforcing contracts), shortage of necessary infrastructure (when distances between potential counterparts are large), and search costs (ability to identify buyers and sellers, especially in areas that are not highly populated). A proper setup requires strong legal, institutional, and accountability frameworks—areas in which many countries may be lagging (World Bank 2007). If they fail to meet these conditions, markets for water rights may do more harm than good, exacerbating water challenges.

54. Informal markets for water rights may result in distortions. For example, in South Asia, farmers who are wealthier and can afford large groundwater wells with pumps sell water to smaller farmers who cannot afford such infrastructure at a high “monopoly” price with payment taking the form of cash, labor, or share farming (Bjornlund and McKay 2002). This lucrative opportunity to sell pumped water with low costs (due to energy subsidies) leads to lower agricultural production, widening of income gaps, and faster depletion of underground aquifers. Although informal markets are, technically speaking, not legal and their functioning may be imperfect, governments tend to turn a blind eye, hoping that these arrangements will solve the problems of water allocation among competing users.

55. Successful establishment of markets for water rights needs to follow some general principles. Building institutions for trading water rights and meeting these principles can be a challenging process even in advanced economies, not to mention developing countries, where institutional and policy frameworks tend to be weaker.³⁰

- *Water rights need to be defined in a clear, socially accepted, environmentally sustainable, and enforceable manner.* This can be difficult because water is a common pool resource—excluding users is costly and consumption is rivalrous, not only at a given point in time but also across generations). One also needs to be mindful of the way the land rights are defined, especially for plots adjacent to water basins.
- *Introduction of formal systems should deal with preexisting practices.* In the absence of well-specified arrangements, water extractors tend to see their current allocations, often reflecting historical practices, as established rights.
- *Establishment of a water rights market requires a sufficiently large number of potential buyers and sellers in proximity to each other.* These buyers and sellers also need to be in an area with a relatively stable water supply, transparent and accepted measurement systems, administrative systems that register and enforce deliveries, well-maintained delivery infrastructure, and judicial systems capable of resolving conflicts and enforcing environmental legislation.

³⁰ The World Bank (2007) finds that if water rights are not clearly defined and withdrawals are not regulated, water trading can lead to overexploitation, as seen in Yemen.

- *Water markets need to be sufficiently flexible.* This reflects the need to accommodate changes stemming from both the demand (for example, new crops that require significantly more or less water, emergence of new or exit of existing agents) and supply (for example, drought) sides.

56. There are limits to what markets for water rights can do. Water markets are unlikely to eliminate, or sometimes even significantly reduce, price differentials because water is a multidimensional (legally and hydrologically) commodity. There may also be market imperfections driven by local factors. Water markets are likely linked to specific water basins and thus limited by existing infrastructure. Such markets tend to have a small number of potential traders of disparate size, and information flows and links could be insufficient.

IV. CONCLUDING REMARKS

57. Given water’s vital role in sustaining life and the rising demand for its use, sound water management is necessary to rationalize use and ensure availability, in particular access by the poor and vulnerable. Water’s unique features and the social, environmental, and political aspects surrounding it have often led it to be managed as if there were no limits to its supply. However, many parts of the world are already experiencing shortages, and the pressures are only expected to rise in the coming decades. In some locations, a low endowment contributes to these shortages, but mismanagement of water—especially the price set on its use—is usually a driving factor, both directly (by maintaining water prices below cost recovery) and indirectly (for example, by subsidizing industries that rely on water, such as agriculture and energy). By contrast, as this paper and the accompanying background note show, some countries have successfully managed these challenges by adopting appropriate pricing mechanisms, strengthening water management institutions, and investing in infrastructure, maintenance, and new water-saving technologies. But even countries that are not facing immediately pressing water challenges should take action or risk doing too little, too late. By focusing mainly on the underpricing of water by public utilities, the analysis in this paper likely only touches the tip of the iceberg. Nevertheless, it flags the issue of how economic policies can help address water challenges and support environmental and social sustainability.

58. The IMF can—and should—play a helpful role in ensuring that countries’ macroeconomic policies are conducive to sound water management. Since water challenges affect economic growth, public finances, and poor and vulnerable social groups, they are of immediate importance to the membership. In collaboration with other institutions such as the World Bank, the IMF can help most directly by assessing the impact of water challenges on growth and macro-stability. In addition, the IMF can encourage macroeconomic policies to “get the incentives right”; for example, replacing perverse energy and water subsidies with targeted social support under the right circumstances. Finally, by designing macroeconomic policies that create fiscal space or catalyze financing, the IMF can help countries increase water-related investment to improve water access and strengthen resilience to supply variability. It can also advise countries on strengthening their public investment management systems, which will contribute to adequate maintenance spending and better prioritization of public investment.

ANNEX I. DATA AND DEFINITIONS

1. **Water withdrawals.** A drop of water, once withdrawn from its natural source, ends up in one of three states: “consumed”—either embodied in a product or returned to the atmosphere through evapotranspiration; “recycled”—employed for additional human use; or “discharged”—allowed to run off, whether into the ground or a body of water. An ideal measure of water use would directly account for the number of times a drop of water is recycled before discharge, but such a measure does not exist. The measure of water withdrawals includes all the three categories.
2. **Data sources.** Data on water supply and withdrawals are from the Food and Agriculture Organization’s Aquastat³¹ and WRI’s Aqueduct database respectively. Building on the databases that are often at the water basin level, the WRI’s Aqueduct database³² also provides comparable water risk indicators at the country level.
3. **Water intensity.** Defined as water withdrawals per unit of GDP, water intensity could serve as a proxy for the efficiency of water use. It allows for identifying potential water issues if analyzed together with other water indicators. For example, high water intensity and water shortages together may be indicative of the need to raise the efficiency of water use and increase recycling efforts (see paragraph 28). However, water intensity provides little information about the efficiency of use without looking at the underlying explanatory factors, as it does not take into account recycling and sequential water use.
4. **High water stress.** A country is said to have “*high water stress*” if WRI (2013) classifies it as either “*extremely high water stress*” or “*high water stress*”. That is, its rate of water withdrawals to supply is equal to or more than 40 percent or the WRI’s water stress indicator is equal to or higher than 3. Otherwise, a country is said to have “*low stress*.”
5. **Low water access.** For evaluating water access we use the latest WHO/UNICEF estimates. A country is considered to have “*low water access*” if less than 75 percent of the population has access to either safe drinking water or improved water sanitation. A country is said to have “*high access*” if the proportion is higher than or equal to 75 percent for both drinking water and sanitation.
6. **High water supply.** According to UN Water (the UN inter-agency coordination mechanism on all water-related issues), when annual per capita renewable freshwater availability is less than 1,700 cubic meters, countries begin to experience periodic or regular water stress.³³ Thus, a country is defined to have “*high water supply*” if its per capita water supply exceeds the UN threshold for

³¹ <http://www.fao.org/nr/aquastat>. Water supply is “internal renewable water resources,” defined as long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation.

³² <http://www.wri.org/our-work/project/aqueduct>

³³ When renewable freshwater availability is below 1,000 cubic meters/person/year, water scarcity begins to hamper economic development and human health and well-being.

renewable water supply of 1,700 cubic meters per person per year. Otherwise, it is considered to have “*low water supply*.”

7. High water use. A country is defined to have “*high water use*” if its per capita water withdrawals exceed 680 cubic meters (i.e., 40 percent of the water supply threshold) per person per year. Otherwise, it is considered to have “*low water use*.” The thresholds for water use and supply are consistent with the water stress threshold of 40 percent.

ANNEX II. FIGURES AND TABLES

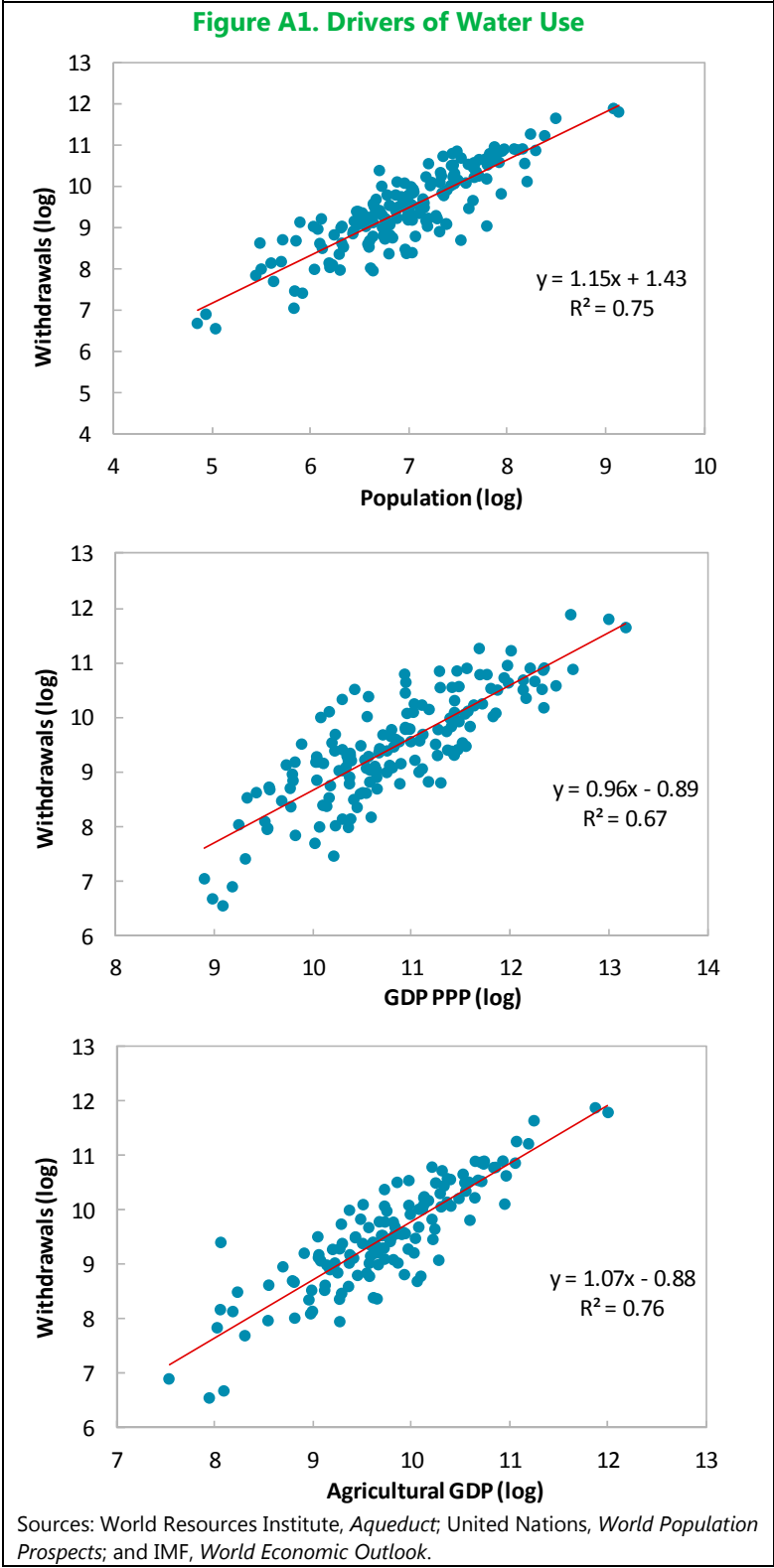
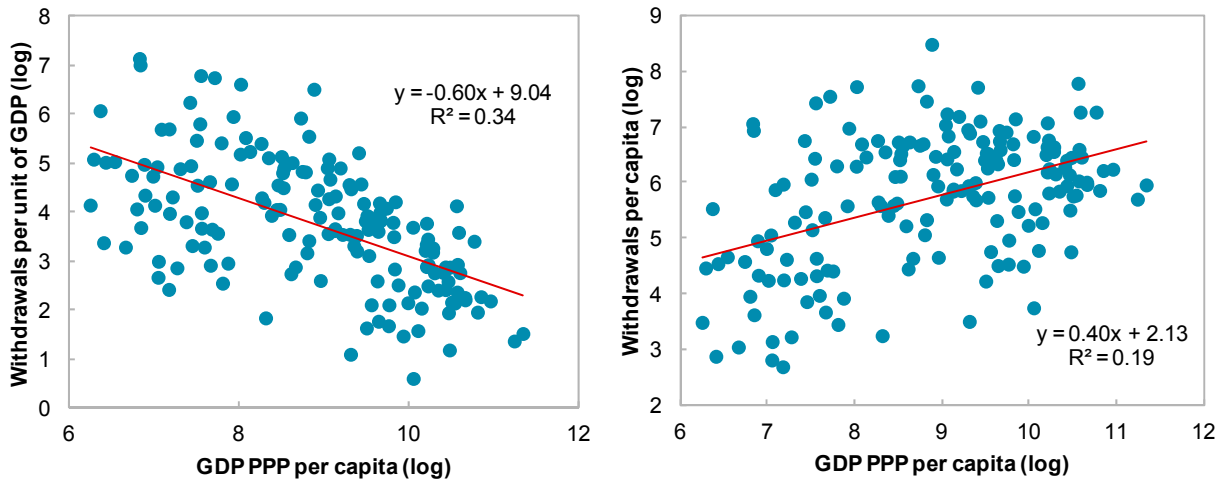
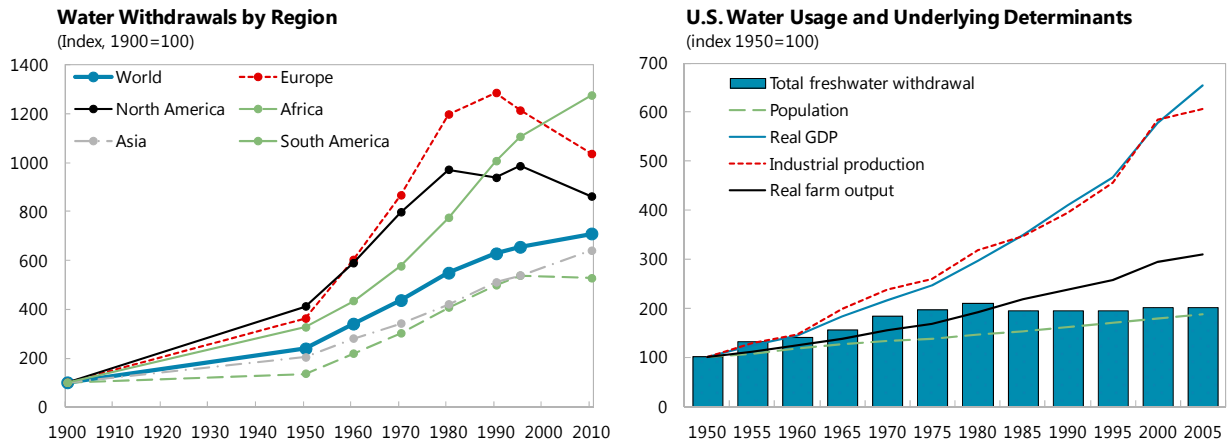


Figure A2. Water Use per Unit of GDP and per Capita



Sources: World Resources Institute, *Aqueduct*; World Bank, *World Development Indicators*; and United Nations, *World Population Prospects*.

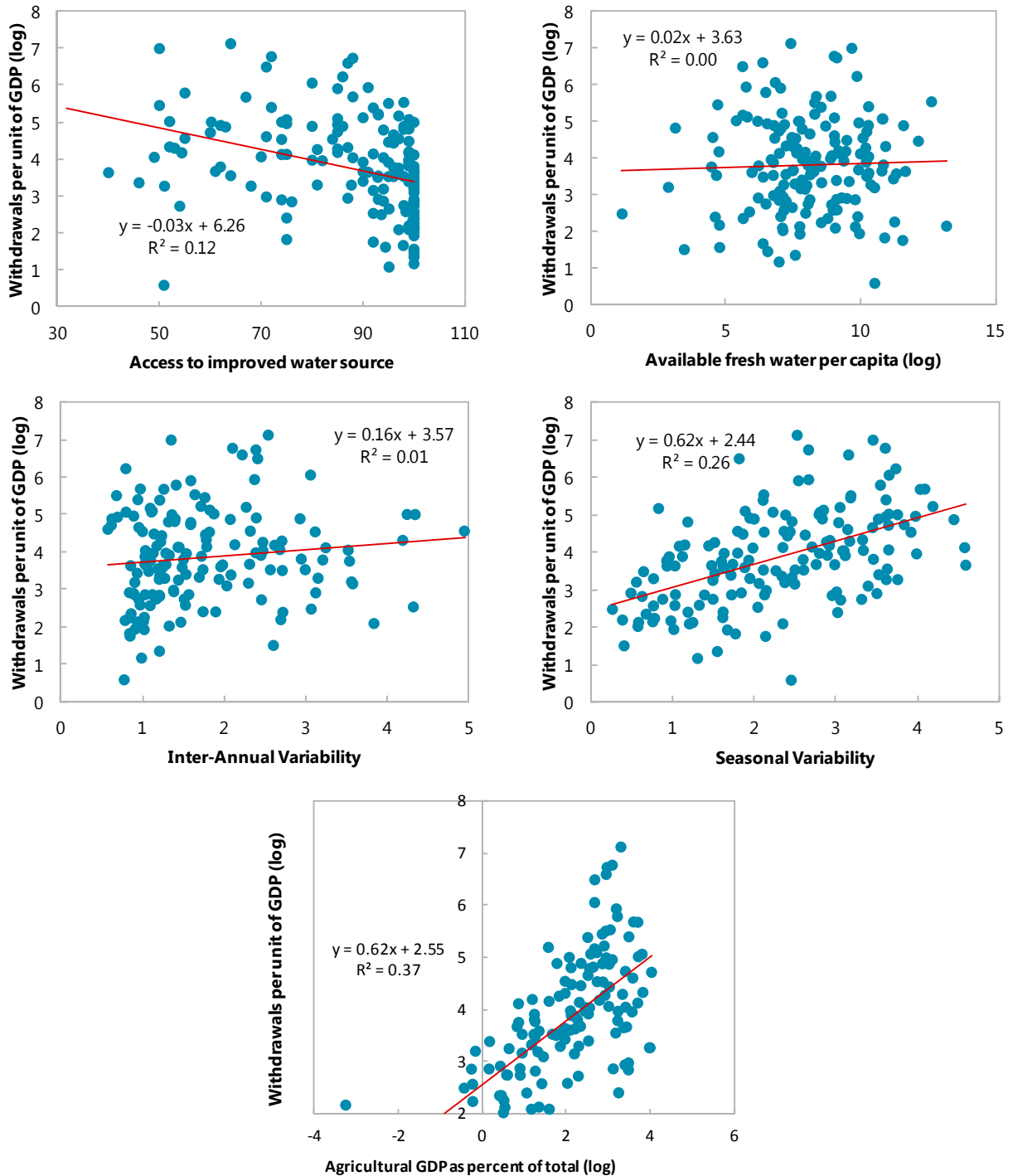
Figure A3. Water Use in Relation to Income and Other Factors



Sources: Shiklomanov (2000); U.S. Geological Survey (2011); World Resources Institute, *Aqueduct*; Haver Analytics; and United Nations, *World Population Prospects*.

Figure A4. Water Intensity and Water Supply

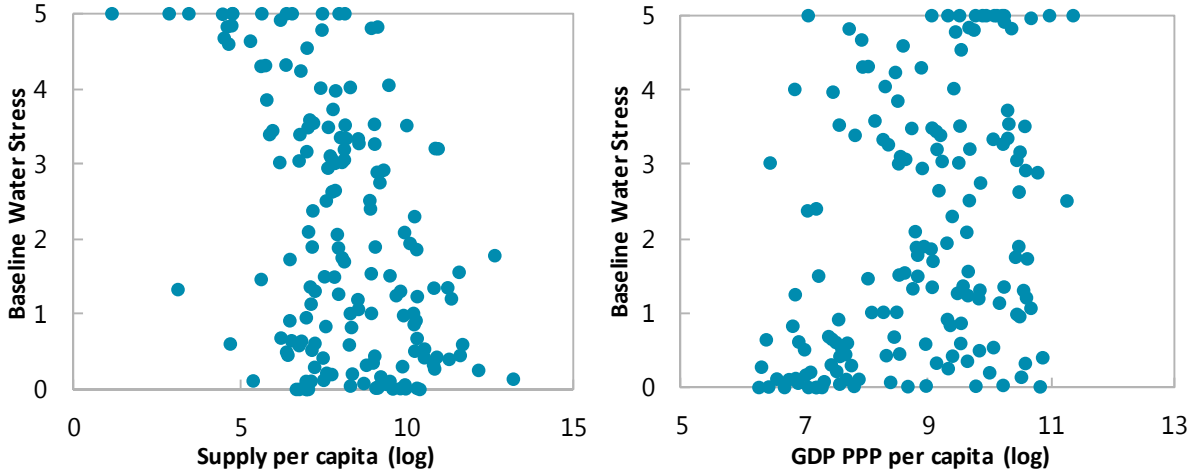
Water intensity across countries is not found to be related to water supply or its variability.



Sources: World Resources Institute, *Aqueduct*; IMF, *World Economic Outlook*; Food and Agriculture Organization; and United Nations, *World Population Prospects*.

Figure A5. Supply, Demand, and Water Stress

Higher supply tends to reduce water stress and higher incomes tend to raise it, but the relationships are not strong.

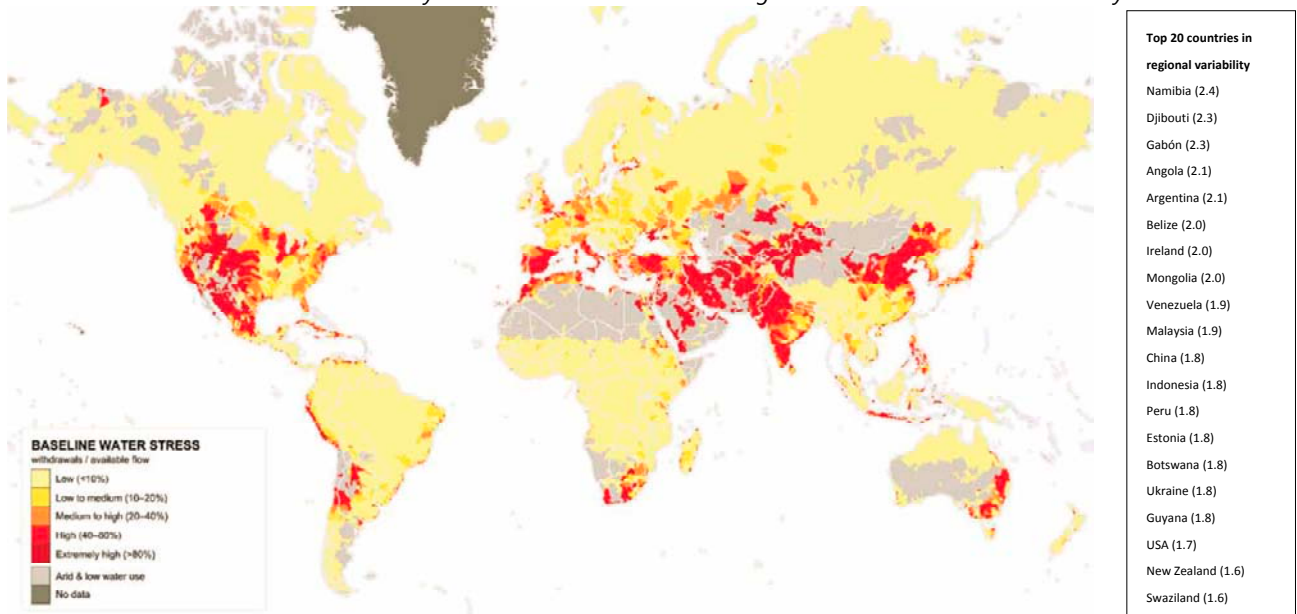


Sources: FAO, *Aquastat*; United Nations, *World Population Prospects*; World Resources Institute, *Aqueduct*; IMF, *World Economic Outlook*; and IMF staff calculations.

Note: Supply is Internal Renewable Water Resources.

Figure A6. Regional Water Variability

Water stress at the country level can mask considerable regional variations within the country.

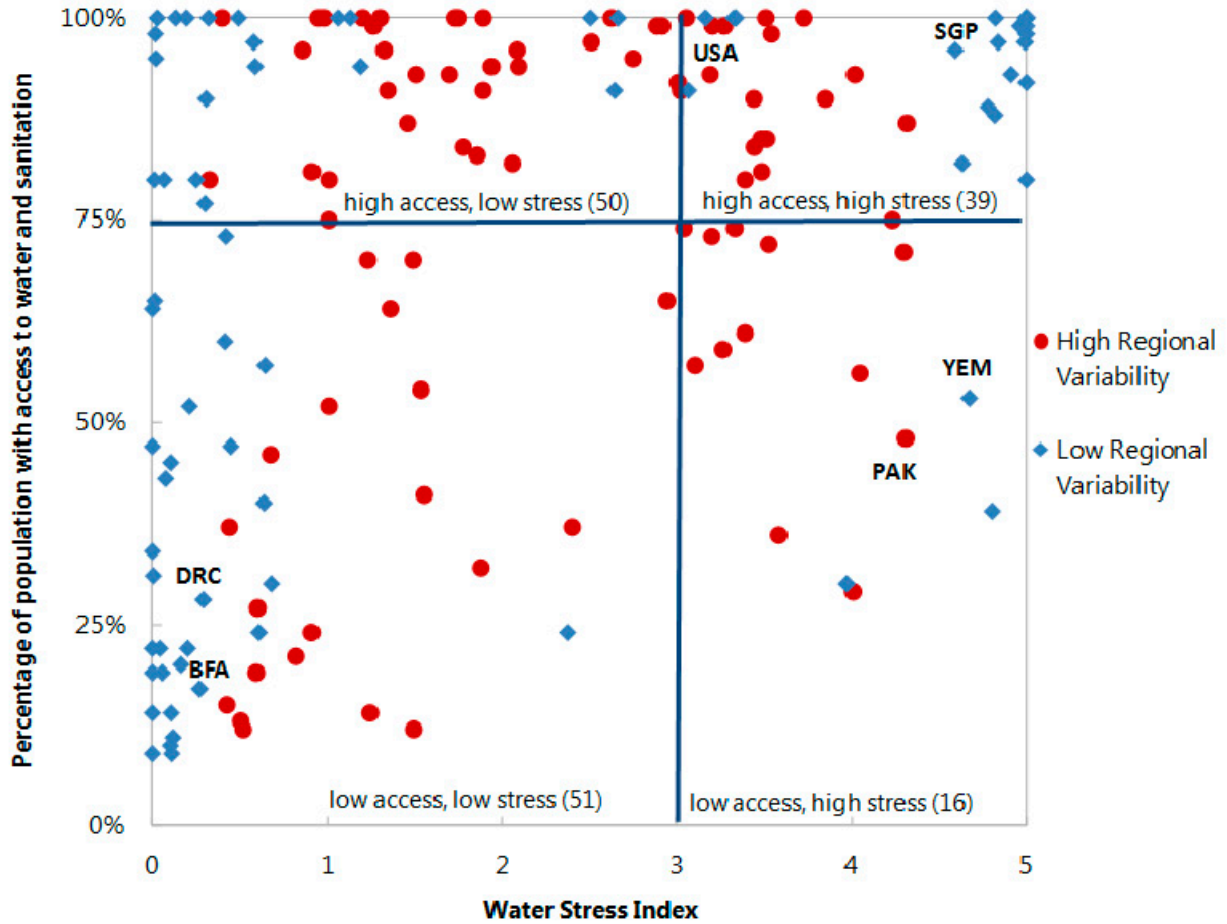


Source: World Resources Institute, *Aqueduct*.

Note: WRI's water stress for a country is an aggregated estimate based on water stress at the water basin level. If a country has only one water basin, its regional variability is set at zero.

Figure A7. Country Groups Based on Water Stress and Access

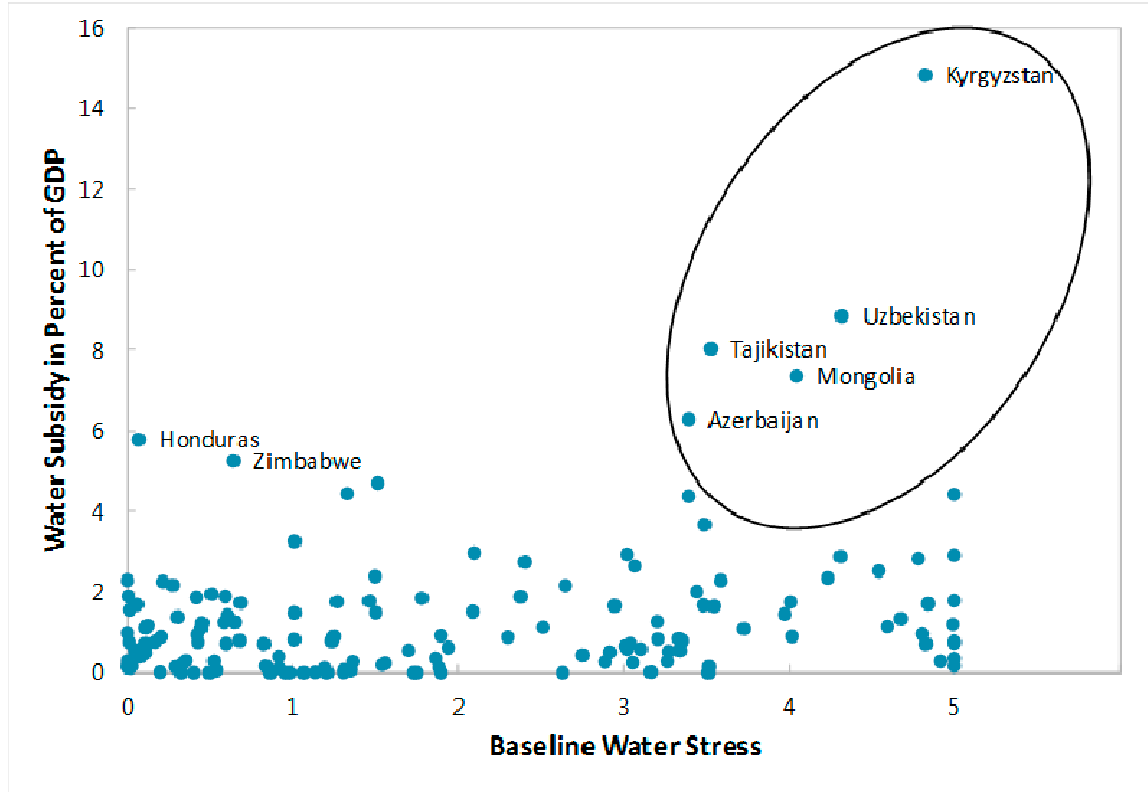
Sixteen emerging markets and developing countries face the dual challenges of improving water access and managing already high water stress.



Source: World Resources Institute, *Aqueduct* and WHO/UNICEF (2014).

Note: Numbers in parentheses refer to the number of countries for each group. A country is said to experience "high" regional variability if its level of regional variability is higher than the global average.

Figure A8. Water Subsidies and Stress



Source: World Resources Institute, *Aqueduct* and IMF staff calculations.

Table T2. Water Stress and Water Access

Group I (Low Stress, High Access)		Group II (High stress, High access)		Group III (Low stress, Low access)		Group IV (High stress, Low access)					
Myanmar	0.3	77	Azerbaijan	3.4	80	South Sudan	0.0	9	Afghanistan	4.0	29
Paraguay	0.0	80	Jamaica	5.0	80	Niger	0.1	9	Lesotho	4.0	30
Honduras	0.1	80	Dominican Republic	3.5	81	Malawi	0.1	10	India	3.6	36
Suriname	0.3	80	Palestine	4.6	82	Togo	0.1	11	East Timor	4.8	39
Colombia	0.3	80	Algeria	3.4	84	Chad	0.5	12	Pakistan	4.3	48
Guatemala	1.0	80	Iraq	3.5	85	Tanzania	1.5	12	Yemen	4.7	53
Brazil	0.9	81	Mexico	3.5	85	Sierra Leone	0.5	13	Mongolia	4.0	56
North Korea	2.1	82	Uzbekistan	4.3	87	Benin	0.0	14	Swaziland	3.1	57
Ecuador	1.9	83	Kyrgyz Republic	4.8	88	Ghana	0.1	14	Indonesia	3.3	59
Guyana	1.8	84	Iran, I. Rep. Of	4.8	89	Madagascar	1.2	14	Djibouti	3.4	61
Moldova	1.5	87	Tunisia	3.4	90	Congo, Republic of	0.4	15	Turkmenistan	4.3	71
Montenegro	0.3	90	Syria	3.9	90	Liberia	0.3	17	Tajikistan	3.5	72
Belize	1.3	91	Turkey	3.0	91	Burkina Faso	0.0	19	Peru	3.2	73
Albania	1.9	91	Armenia	3.1	91	Guinea	0.1	19	South Africa	3.0	74
Macedonia, FYR	2.6	91	Sri Lanka	3.0	92	Papua New Guinea	0.6	19	Philippines	3.3	74
Georgia	1.5	93	Trinidad & Tobago	5.0	92	Guinea-Bissau	0.2	20	Morocco	4.2	75
Thailand	1.7	93	Cuba	3.2	93	Mozambique	0.8	21			
Belarus	0.6	94	Kazakhstan	4.0	93	Central African Republic	0.0	22			
Lithuania	1.2	94	Oman	4.9	93	Cote D'Ivoire	0.0	22			
Costa Rica	1.9	94	Jordan	4.6	96	Mali	0.2	22			
Ukraine	2.1	94	Libya	4.8	97	Ethiopia	0.6	24			
Bosnia & Herzegovina	0.0	95	Saudi Arabia	5.0	97	Sudan	0.9	24			
Estonia	2.8	95	Korea, Republic of	3.5	98	Haiti	2.4	24			
Uruguay	0.9	96	United Arab Emirates	5.0	98	Mauritania	0.6	27			
Egypt	1.3	96	Chile	3.2	99	Nigeria	0.3	28			
Malaysia	2.1	96	Greece	3.3	99	Kenya	0.7	30			
Serbia	0.6	97	Kuwait	5.0	99	Congo, Dem. Rep. of	0.0	31			
Argentina	2.5	97	Bahrain	5.0	99	Namibia	1.9	32			
Croatia	0.0	98	Japan	3.1	100	Uganda	0.0	34			
Bulgaria	1.3	99	Belgium	3.2	100	Cambodia	0.4	37			
United States	2.9	99	Andorra	3.3	100	Nepal	2.4	37			
Ireland	2.9	99	Portugal	3.3	100	Zimbabwe	0.6	40			
Slovenia	0.0	100	Australia	3.5	100	Gabon	1.6	41			
Iceland	0.1	100	Spain	3.7	100	Zambia	0.1	43			
Slovak Republic	0.2	100	Israel	4.8	100	Cameroon	0.1	45			
Austria	0.3	100	Cyprus	5.0	100	Bolivia	0.7	46			
Norway	0.4	100	Malta	5.0	100	Burundi	0.0	47			
Hungary	0.5	100	Qatar	5.0	100	Bhutan	0.5	47			
Denmark	1.0	100	Singapore	5.0	100	Senegal	0.2	52			
Finland	1.0	100				Nicaragua	1.0	52			
Switzerland	1.1	100				Angola	1.5	54			
Czech Republic	1.1	100				Bangladesh	0.6	57			
Canada	1.2	100				Gambia, The	0.4	60			
Sweden	1.3	100				Rwanda	0.0	64			
Netherlands	1.7	100				Botswana	1.4	64			
France	1.8	100				Laos	0.0	65			
Germany	1.9	100				China	2.9	65			
Luxembourg	2.5	100				Russian Federation	1.2	70			
United Kingdom	2.6	100				El Salvador	1.5	70			
Monaco	2.7	100				Panama	0.4	73			
						Vietnam	1.0	75			
Group I	50		Group II	39		Group III	51		Group IV	16	

Source: World Resources Institute, *Aqueduct*; WHO/UNICEF, 2014

Note: The first number refers to water stress score which ranges from 0 to 5, and the second refers to the minimum of the proportion of population with access to safe drinking water and access to sanitation. For most low-income countries, their access to safe drinking water is higher than access to sanitation.

Table T3. Demand and Supply Factors Behind Water Stress

Group I: Low Stress, High Access				Group II: High Stress, High Access			
Low demand outweighs low supply "Demand Effect"	High supply outweighs high demand "Supply Effect"	Low demand and High supply "Combined Effect"	Inconclusive 1/ (High demand and Low supply)	High demand outweighs high supply "Demand Effect"	Low Supply outweighs low demand "Supply Effect"	High demand and low supply "Combined Effect"	Inconclusive 1/ (Low demand and High supply)
Czech Republic (163,1263) Denmark (120,1095) Germany (394,1304) Hungary (562,602) Moldova (308,279) Netherlands (637,661) Serbia (418,858) Ukraine (423,1169)	Argentina (802,7180) Belize (703,48754) Bulgaria (814,2800) Canada (1330,84096) Ecuador (719,32128) Estonia (1344,9485) Guyana (2154,317105) Lithuania (737,4773) Suriname (1278,190385) Thailand (841,3295) United States of America (1518,8872) Uruguay (1097,27359)	Albania (410,8486) Austria (441,6555) Belarus (448,3879) Bosnia and Herzegovina (90,9441) Brazil (297,28968) Colombia (274,49028) Costa Rica (116,24353) Croatia (143,8549) Finland (299,20000) France (504,3193) Georgia (427,13775) Guatemala (243,7594) Honduras (276,11988) Iceland (516,515152) Ireland (257,10675) Korea Democratic People's Republic (363,2793) Luxembourg (116,2041) Macedonia (489,2647) Malaysia (401,20781) Myanmar (658,19861) Norway (597,78601) Paraguay (76,18111) Slovakia (128,2329) Slovenia (464,9243) Sweden (280,18407) Switzerland (342,5323) United Kingdom (210,2342)	Egypt (809,21)	Armenia (938,2220) Australia (2782,22873) Chile (1558,51664) Greece (849,5188) Iran (1245,1712) Japan (709,3386) Kazakhstan (1339,4086) Kyrgyzstan (1441,8816) Mexico (727,3696) Portugal (792,3541) Spain (717,2454)	Bahrain (442,5) Belgium (580,1121) Cyprus (239,886) Israel (268,103) Jordan (145,105) Korea (525,1337) Kuwait (299,0) Libya (657,107) Malta (122,123) Oman (455,481) Palestinian Territory (95,184) Qatar (294,37) Singapore (39,124) Tunisia (275,405)	Azerbaijan (1367,909) Iraq (2097,1119) Saudi Arabia (902,91) Syria (746,317) United Arab Emirates (849,32) Uzbekistan (2015,588)	Cuba (393,3404) Dominican Republic (538,2053) Jamaica (150,3445) Sri Lanka (637,2587) Trinidad and Tobago (171,2866) Turkey (530,2998)
Total countries: 8	Total countries: 12	Total countries: 27	Total countries: 1	Total countries: 11	Total countries: 14	Total countries: 6	Total countries: 6
Group III: Low Stress, Low Access				Group IV: High Stress, Low Access			
Low Demand outweighs low supply "Demand Effect"	High supply outweighs high demand "Supply Effect"	Low demand and High supply "Combined Effect"	Inconclusive 1/ (High demand and Low supply)	High demand outweighs high supply "Demand Effect"	Low Supply outweighs low demand "Supply Effect"	High demand and low supply "Combined Effect"	Inconclusive 1/ (Low demand and High supply)
Bangladesh (253,740) Benn (14,1118) Botswana (96,1212) Burkina Faso (44,767) Burundi (34,1181) Chad (76,1303) Ethiopia (66,1436) Ghana (40,1245) Haiti (118,1277) Kenya (67,507) Malawi (89,1029) Mauritania (416,119) Niger (62,220) Nigeria (82,1306) Rwanda (15,924) Sudan and South Sudan (639,695) Togo (25,1696) Uganda (9,1154) Zimbabwe (333,970)	Madagascar (819,16725) Vietnam (921,4037)	Angola (37,7794) Bhutan (480,109859) Bolivia (259,30259) Cambodia (146,8013) Cameroon (49,13677) Central African Republic (16,31264) China (425,2066) Congo, Republic of (13,59043) Congo, Democratic Republic of (10,13268) Côte d'Ivoire (70,3562) El Salvador (291,2525) Gabon (93,109333) Gambia (51,1714) Guinea (53,21899) Guinea-Bissau (109,9697) Laos (544,29565) Liberia (32,48780) Mali (488,4505) Mozambique (38,4284) Namibia (131,2785) Nepal (318,6640) Nicaragua (240,26838) Panama (259,38917) Papua New Guinea (57,116255) Russian Federation (546,30726) Senegal (173,2006) Sierra Leone (36,27397) Tanzania (115,1865) Zambia (113,603)		Philippines (872,5116) Swaziland (865,2200) Tajikistan (1625,8976) Timor-Leste (1064,7468)	Djibouti (23,341) India (627,1191) Morocco (389,896) South Africa (248,887) Yemen (147,87)	Afghanistan (697,1619) Pakistan (993,298) Turkmenistan (5409,271)	Indonesia (487,8683) Lesotho (19,2514) Mongolia (204,12889) Peru (654,52627)
Total countries: 19	Total countries: 2	Total countries: 29	Total countries: 0	Total countries: 4	Total countries: 5	Total countries: 3	Total countries: 4

Sources: FAO, *Aquastat*; World Resources Institute, *Aqueduct*; and IMF staff calculation.

1/ Inconclusiveness reflects the data discrepancies between WRI and FAO. For example, Egypt is classified as "low stress" according to the WRI classification. However, when using FAO data, it is categorized as "high stress" because it has relatively high water use but low supply. Numbers in parenthesis are annual per capita water use and annual per capital water supply in cubic meters.

ANNEX III. METHODOLOGY FOR ESTIMATING WATER SUBSIDIES

1. The methodology used here is broadly similar to the price gap calculation the IMF has used to estimate energy subsidies.³⁴

2. **Subsidies.** Cost-recovery pricing of water requires that the revenues a utility company receives from consumers cover the costs of operations, maintenance, and capital spending necessary to maintain efficient operations. If revenues are lower than this cost, then utilities make an explicit loss on operations, or they do not maintain their existing capital stock, leading to inefficient operations in the future. In order for the utilities to stay in operation then, they must receive support from the government to make up for this difference between the costs and the actual revenues. This is what is called a *subsidy* in this paper. Subsidies are calculated as:

$$(1) \text{ Subsidy} = \text{Estimated costs} - \text{Actual revenues}$$

This can also be expressed using a per-unit calculation which is then scaled up with national water supply:

$$(1b) \text{ Subsidy} = (\text{Cost per unit} - \text{Average tariff} * \text{Collection rate}) * \text{Water supply}$$

This calculation is done for both drinking water and wastewater supplied by utilities.

3. **Costs.** Since data on actual costs for utilities are not widely available, they are estimated using a reference cost-recovery price, and scaled up by the level of utility water supplies for the country.

$$(2) \text{ Estimated costs} = \text{Reference price} * \text{Water supply}$$

This price is taken from work done by the Global Water Intelligence in 2004 (GWI 2004). According to the GWI \$1 US was the price per m³ in 2004 necessary to recover the costs of operations, maintenance and capital in most high-income cities. This cost is assumed to be the same for drinking water and wastewater. Costs in developing countries would be lower due to lower costs of labor. In order to produce a reference price for this paper, the price used in the GWI's report is adjusted to account for three factors: (i) general price inflation that occurred between 2004 and 2012; (ii) lower labor costs in developing countries; and (iii) varying levels of water scarcity:

$$(3) \text{ Reference price} = \$1 * \text{Inflation adjustment} * \text{Labor adjustment} * \text{Scarcity adjustment}$$

³⁴ See Clements and others (2013).

The **inflation adjustment** for all countries was calculated as the ratio of GDP deflator in the USA in 2012 to GDP deflator in the USA in 2004. This raised the reference price about 18 percent to \$1.18.

The **adjustment for labor costs** was applied only to the portion of costs that labor accounts for. According to the 2014 GWI Water Market report (GWI 2014), labor costs accounted for about 24 percent of water operating costs. We also assume a similar ratio for non-operating labor costs. Thus, 24 percent of the reference price is adjusted for differences in the level of wages. Data on wages are taken from the ILO's Key Indicators of the Labor Market database, and are converted into US dollars using market annual-average exchange rates from the WEO database.

The **water scarcity adjustment** takes into account that the economic value and reference price for water should be higher where water is scarce. To undertake this adjustment, we use estimates of water scarcity published by Gassert and others (2013) of the World Resources Institute (WRI), which assigns a score to each country based on the level of current water extraction and remaining water supply. High stress countries have higher scores, since they extract or consume more water than required to maintain supplies stable over time. The WRI study considers scores below two to be low to medium levels of stress. In this light, the stress adjustment is calculated as the ratio of the country's stress score to two. The cost recover price is then scaled up by this factor.

As an example, using equation (3) and these adjustments, the reference price for a developing economy with a high stress score of 5, can be calculated as:

$$(4) \text{ Reference price} = (\$1.18) * \left(\frac{5}{2}\right) * (0.8 * 0.24 + 0.76) = \$2.81$$

4. Revenues. Data on utility revenues are also estimated for this paper. While the GWI did estimate total national utility revenues in 2008 (GWI 2008), this calculation has not been updated since then by the GWI or other organizations. However, data on utility drinking water and wastewater tariffs in 2012 are available for a large sample of over 80 countries in 2012 from the GWI. Using this and data on water supply, a series can be constructed to estimate utility revenues at a national level according to the following equation:

$$(5) \text{ Revenues} = \text{Average tariff} * \text{Water supply} * (100\% - \text{Non revenue water})$$

where non-revenue water represents the share of water on which utilities do not receive revenue, either because of distribution losses, theft, or inadequate collection of revenue. These data are taken from GWI (2014).

In practice, tariffs are frequently differentiated according to household consumption level, through block tariffing. However, since consumption data is not available at a household level, an average tariff is used. This tariff is taken as the average cost for a household consuming 15 m³ per month. Data on tariffs are taken at a utility level from GWI (2014), and correspond to 2012. A national tariff is calculated as the population-weighted average of these observations using UN urban population data.

Since some countries have data on total national revenues in 2007 reported in the GWI 2008 report, but do not have data on prices in 2012, we perform the subsidy calculation using 2007 data, and assume that subsidies represent the same share of nominal GDP in 2012. For costs we calculate the reference price using the GDP deflator in 2007 rather than 2012 for the adjustment.

5. Water supply. For the purpose of these calculations, water supply data are taken from the GWI 2008 report, the last year that it is available. It is then scaled up to 2012 by assuming a growth rate equal to that of real GDP.

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June, 2015

ISSUES IN MANAGING WATER CHALLENGES AND POLICY INSTRUMENTS: REGIONAL PERSPECTIVES AND CASE STUDIES

Prepared by an IMF Staff Team

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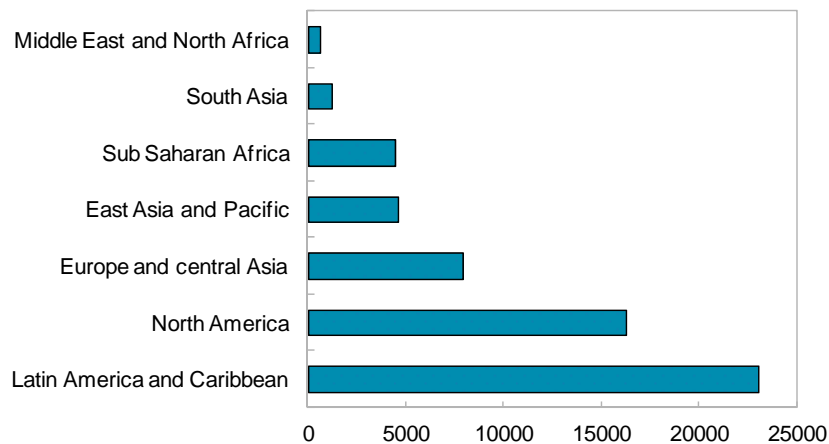
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REGIONAL PERSPECTIVES

A. Key Water Issues in Sub-Saharan Africa¹

1. Sub-Saharan African (SSA) countries are characterized by highly variable water resources, with relatively low per capita supply on average. Countries in the western Sahel, eastern horn, and southern tip have scarce access to watersheds and highly variable rainfall (e.g., Burkina Faso, Kenya, Niger, Zimbabwe), with relatively abundant resources in the middle of the continent (Angola, Cameroon, Democratic Republic of the Congo (DRC), Republic of Congo). On average, SSA countries have relatively limited water resources compared to other regions of the world (Figure 1).

Figure 1. Annual Renewable Freshwater Resources per Capita (m^3 /person/year)



Source: FAO, *Aquastat*.²

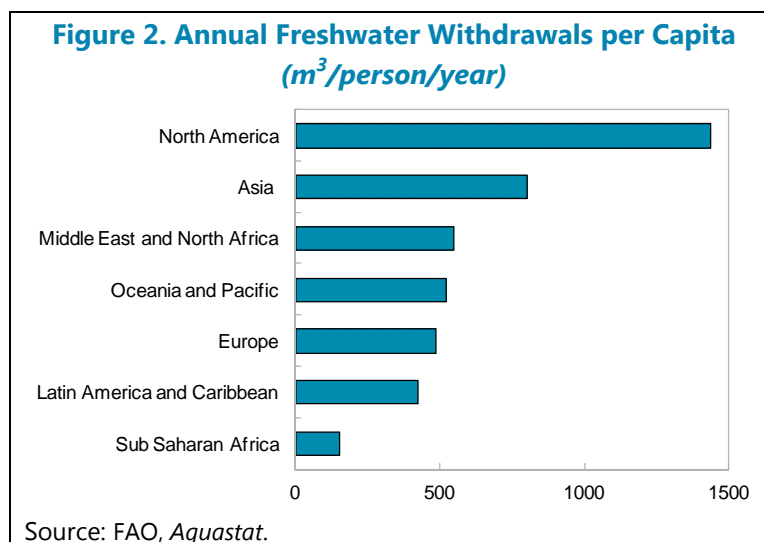
2. Despite low per capita supply of resources, “water stress” (as defined elsewhere in this exercise) is tempered by low annual withdrawals, reflecting both low access rates and low depth of access to water. On average, SSA countries withdraw the lowest annual volume per capita of all regions (Figure 2) and display the lowest rate of access to drinking water (64.5 percent), except for Oceania (55.2 percent).³ Chief among the reasons for this low access is a deficit of infrastructure (including energy), reflecting insufficient, outdated, or poorly maintained water storage, distribution, and treatment facilities. The annual infrastructure investment gap in Africa’s water sector is estimated to be \$22 billion (Foster and Briceño-Garmendia 2010). The infrastructure deficit is magnified by poor management, including through poor maintenance, waste, below-cost-recovery tariffs, and low collection rates. Ironically, such problems seem more pronounced in some countries with relative water abundance. Particularly acute examples are DRC and Angola, gifted with some of the most ample supplies of water resources in the world, yet with some of the lowest rates of access

¹ Contributors: Laure Redifer and Samba Mbaye.

² Aquastat is a global water information system, developed by the Land and Water Division of the Food and Agriculture Organization (FAO) of the United Nations, <http://www.fao.org/nr/water/aquastat/main/index.stm>. The main mandate of the program is to collect, analyze, and disseminate information on water resources, water uses, and agricultural water management, with an emphasis on countries in Africa, Asia, Latin America, and the Caribbean.

³ The concept of “access” masks large discrepancies across regions in the amount of access per person.

to drinking water in SSA (46 and 54 percent, respectively). On the other hand, other SSA countries have been successful in expanding access through large-scale investment and sound management strategies. These countries have often been able to achieve full recovery of costs for drinking water, partly through the application of a progressive tariff grid (Burkina Faso, Lesotho, Mozambique, and Seychelles).



3. There is a pronounced lag in the rate of access of rural vs. urban areas. On average in SSA countries, there is a 28 percentage point gap between urban and rural rates of access to drinking water.⁴ In several countries, the responsibility for operating rural water systems has been decentralized and transferred to local communities, as opposed to urban areas, where the responsibility generally falls to a publicly owned water utility. Increasing access to drinking water in rural areas and the efficiency of their operations is one of the main challenges in most African countries and the object of numerous ongoing initiatives by development partners. To improve rural access and irrigation, the authorities have often invested in smaller-scale mechanisms, such as wells, small reservoirs, and rainwater collection schemes.

4. In general, access to improved sanitation in SSA lags far behind drinking water access. As of 2012, average access to improved sanitation was 35 percent, with a 20 percentage point gap between urban and rural access rates.⁵ There are numerous factors responsible for this: cultural, difficulties in charging for access, lack of maintenance, and hoarding.

5. Water challenges in SSA put significant constraints on growth, but these are difficult to quantify. Water in most SSA countries is concentrated on agricultural and household use, followed by energy generation and industrial uses. Because agriculture is a key component of growth, employment, and subsistence in most SSA countries, water supply and variability are key

⁴ WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation, <http://www.wssinfo.org/data-estimates/>.

⁵ WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation.

determinants of growth, agricultural productivity, and food security. Variations in GDP growth are highly correlated with rainfall, with growth affected strongly by drought and flood events. A World Bank study (for period 1981–2004) suggested that GDP growth in Mozambique is reduced by about 1.1 percentage points annually due to the impact of shocks typically occurring every five years (World Bank 2007a). The vulnerability of agriculture to consistent water supplies also leads to risk-minimizing strategies that favor low-return, low-risk crops over those with high returns and high risk. Finally, in many countries, low or difficult-to-access water supplies negatively impact women’s participation in income-generating activities and education, as women and girls are usually in charge of fetching water. The costs of gaps in improved sanitation are numerous, including disease, water contamination, violence, lost time, etc. Sharing access of water across country borders does not seem to be a large source of stress in SSA, with a few exceptions.

6. Water stress will become more acute going forward, due to high population growth, urbanization, structural transformation, climate change, and contamination. Currently, most SSA countries are not classified as “water stressed,” since per capita withdrawals remain lower than per capita supplies. However, with an average population growth rate of around 2.5 percent, per capita supplies will quickly diminish. Many countries report that increased urbanization and the development of more water-intensive activities have put stress on existing infrastructure. Several countries report that the quality of water resources is deteriorating due to contaminants, ranging from fertilizers to mining activities. Almost all SSA countries have extensive infrastructure development strategies for the water sector, many with support from development partners.

B. Key Water Issues in Middle-Eastern and Central Asian Countries⁶

7. Middle-Eastern and Central Asian countries face important water challenges. Many countries are faced with high water stress, given limited renewable water resources. Much of the Middle-Eastern and North African (MENA) region already faces difficulty meeting current water demand, and per capita water availability in the MENA region is projected to fall by half by 2050 (World Bank, 2007b). Some economies, particularly countries in Caucasus and Central Asia (CCA), as well as Afghanistan, are highly water intensive while facing significant water stress. Countries in both the MENA and CCA regions share significant water resources across international borders, adding an additional layer of complexity to their water management challenges.

8. While past water policy has led to some successes, important challenges remain. Countries have a long history in implementing water policy, including, over the last few decades, large public investment programs. As a consequence, the MENA region’s proportion of surface freshwater resources stored in reservoirs is by far the highest in the world. Overall access to improved water and sanitation is relatively widespread. However, it has been uneven, with rural populations in oil-importing countries at particular disadvantage. In addition, individual well drilling has led the MENA region to use more of its renewable and non-renewable water resources than

⁶ Contributor: Harald Finger with inputs from the country teams.

other regions, with regulators having insufficient capacity to control the extraction. There remains ample scope for improving resource management, in light of continued allocation of water to low-value uses, significant service outages, vulnerability to droughts and floods, overextraction of groundwater, and water-related environmental problems.

9. In addition to natural water scarcity in often arid climates, three sets of issues are important in Middle-Eastern and Central Asian countries:

- **Subsidies or lack of metering.** The prevalence of water subsidies and/or the failure to properly meter and bill for water use—both for domestic use and in agriculture—encourages overconsumption and can imply sizable costs for the public sector (often outside of budgets). For example, costs are estimated at around 2 percent of GDP in the Gulf Cooperation Council (GCC) countries, in part reflecting the high costs of desalinating water, which are not passed on to consumers; and 1 percent of GDP in Algeria and Jordan. Issues of subsidies or lack of metering are prevalent in Algeria, Armenia, Djibouti, Egypt, the GCC countries, Iraq, Jordan, Kyrgyz Republic, Lebanon, Mauritania, Pakistan, Sudan, Tunisia, and Turkmenistan. Tajikistan faces water-related financial sector issues linked to ailing utilities' defaulted bank loans. In Yemen, subsidized diesel encourages overconsumption because it makes pumping of groundwater relatively cheap.
- **Infrastructure issues and water management.** Aging infrastructure or general lack of adequate infrastructure lead to low water quality and large network losses in many countries, reinforcing water shortages. Examples include Afghanistan, Armenia, Azerbaijan, Iraq, Kyrgyz Republic, Pakistan, Sudan, Turkmenistan, West Bank/Gaza, and Yemen. In a number of cases, water supply is rationed (e.g., Jordan, Lebanon), leading the private sector to step in with more reliable but also more expensive ways to supply water (such as with water trucks). The estimated cost of infrastructure needs to address these issues can be sizable (for example, in Djibouti, Kyrgyz Republic, and Lebanon).
- **Potential for cross-border coordination issues.** Actual or potential cross-border issues can come into play where water sources are shared among countries. These are often linked to existing or planned dams for flood control, electricity generation, and irrigation. Examples of cross-border sharing of significant water resources include Egypt/Sudan/Ethiopia, Jordan/Israel/West Bank, Iraq/Turkey/Syria, Afghanistan/Iran/Uzbekistan/Turkmenistan/Pakistan, India/Pakistan, Uzbekistan/Tajikistan/Kyrgyz Republic.

10. Water challenges in Middle-Eastern and Central Asian countries can have important macroeconomic implications. Reliance on, and high variability of rainfall can have a sizable impact on economic growth, as agricultural output directly depends on it (for example, Morocco). More broadly, water scarcity constrains productivity of agriculture and, to some extent, industries, thereby depressing economic growth potential. In some countries, underpricing of water and/or lack of collection lead to costly resource misallocation (land used for water-intensive crops and housing construction in dry areas). Sizable water subsidies (and energy subsidies that help users extract ground water) exacerbate fiscal imbalances and/or crowd out more efficient uses of scarce resources. Some countries face large water infrastructure investment needs that have significant

macroeconomic impacts and cannot be met from their own resources or by commercial borrowing (for example, Djibouti).

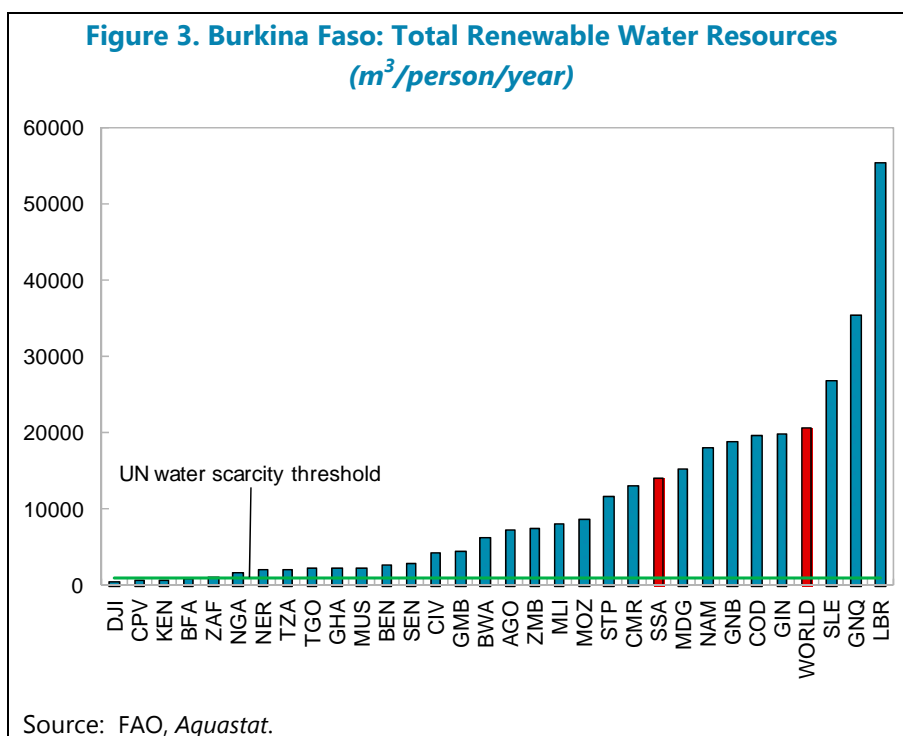
11. The region also features some relative success stories. These include Algeria, which has achieved continuous water supply in Algiers after a decade of massively investing in the water sector, and Tunisia, which has been implementing active water management policies since the 1970s and as result has achieved the highest access rates to water supply and sanitation services in the MENA region. That said, both countries still face important issues such as costly water subsidies.

CASE STUDIES

C. BURKINA FASO⁷

12. Burkina Faso has one of the lowest per capita supplies of water in SSA and in the world (Figure 3). A land-locked West African country, Burkina Faso's climate is tropical, with Sahelian (desert) dominance. Burkina Faso is well below the United Nations water scarcity threshold, largely resting on a crystalline surface that does not support productive aquifers. The country relies exclusively on surface water, and up to 49 percent of its renewable annual freshwater resources are consumed by

evaporation and, to a lesser extent, water sharing agreements. Thus, water collection, treatment, and distribution are critical. Water variability is also a major challenge. Rainfall from year to year varies as much as 50 percent, causing ongoing droughts that affect food security. Seasonal rainfall fills reservoirs and rivers, but they systematically run dry in the dry season. The timing of rain is a determining factor: if too much time elapses between rainfalls, crops fail, even in abundant rain years.



⁷ Contributors: Laure Redifer and Samba Mbaye.

13. However, Burkina Faso’s low level of water use has kept supply constraints from being binding. Annual water withdrawals per capita are half the SSA average and about one-eighth the world average. Low use compared to SSA is related to depth of access, as an adaptation to scarcity, and low access to improved sanitation (Table 1). Agriculture accounts for the lion’s share of usage. Water scarcity and variability have brought about innovation through increasingly efficient home-grown means for meeting agricultural demands for water. For example, in sugarcane fields, large cisterns collect water and distribute it via highly water-efficient drip irrigation methods. The introduction of genetically modified cotton allowed more drought- and pest-resistant plants that required one-third the fertilizer applications and doubled yields.

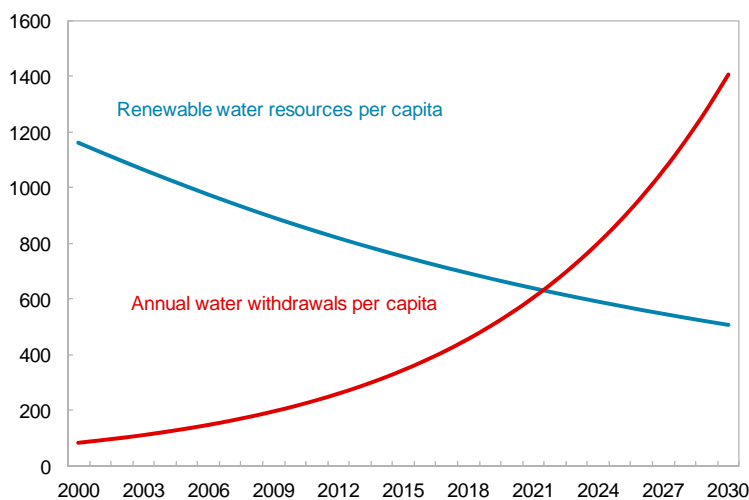
Table 1. Burkina Faso: Selected Indicators

	Annual water withdrawals per person (m ³)	Percent of pop. With access to improved water	Percent of pop. with access to improved sanitation	Dam capacity per capita (m ³)
Burkina Faso	62	82	19	321
SSA average	152	73	35	1146
World Average	473	89	72	1785

Sources: WHO/UNICEF, *Joint Monitoring Program* and FAO, *Aquastat*.

14. Despite major strides on drinking water in urban areas, a significant rural-urban gap remains, and progress on improved sanitation has lagged considerably. Over the last two decades, access to drinking water has doubled, with nearly universal access in urban areas and access in rural areas only catching up to earlier urban levels. While the Millennium Development Goals (MDG) target for drinking water has already been met, with the 5th highest progress in the world, the target for improved sanitation will not be met (WHO and UNICEF, 2014). Access to improved sanitation is constrained by an acute deficit of infrastructure.

Figure 4. Burkina Faso: Actual and Projected per Capita Supply and Use, 2000–30 (m³)



Sources: FAO, *Aquastat*; World Bank, *World Development Indicators*; and IMF staff calculations.

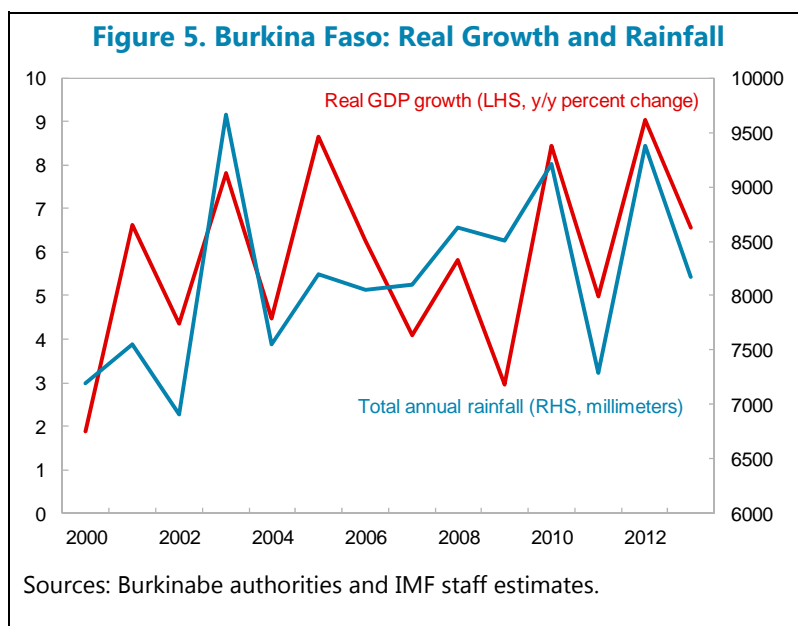
15. Going forward, water demand is likely to outpace the country’s low supply, reflecting mainly population growth, urbanization, and climate change. As a function of population

growth alone, per capita water use could outstrip supply in roughly 10 years. In addition, water pollution (including fertilizers and cyanides in informal mining), encroaching desertification, and land degradation will put pressure on supplies (Figure 4).

16. Burkina Faso’s water challenges impose significant constraints on growth and social outcomes, with significant fiscal costs (Figure 5).

The main channel of impact on growth is the agricultural sector, which employs a large majority of the population (70 percent of the labor force), provides a significant contribution to growth (25 percent), and is highly dependent on annual rainfall. Growth is indirectly impacted by the health consequences of low access to drinking water and

improved sanitation and the costs associated with water fetching, especially for women. The World Bank’s Water and Sanitation Program recently estimated that the cost of insufficient access to improved sanitation in Burkina Faso was as much as 2 percent of 2010 GDP, but addressing the sanitation deficit will require substantial infrastructure investment. Beyond infrastructure costs, fiscal costs include contingency food stocks, subsidized prices, and distribution mechanisms to ensure food security in light of ongoing droughts and floods. The 2011–12 drought, for example, created fiscal costs of around 2–5 percent of GDP.

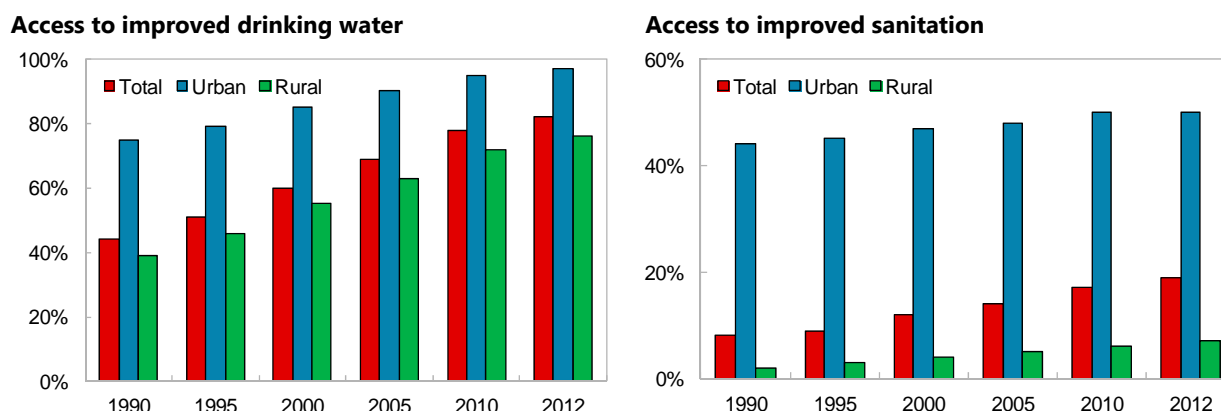


17. In the face of its considerable water challenges, Burkina Faso has developed a widely praised approach to water management. Two aspects of its strategy are particularly notable: (i) water access in urban areas; and (ii) investments in agricultural productivity and water storage and irrigation. These investments have coincided with a sustained increase in growth and a concurrent drop in its variability. Five-year average real growth doubled between 1990 and 2012, with a decline in the standard deviation from 3.8 to 2.5 percentage points over the same period, despite numerous shocks.

18. Burkina Faso’s public water utility (ONEA) has been responsible for a remarkable improvement in the population’s access to drinking water (Figure 6). The company is charged with water management in urban areas. In the early 2000s, three-year performance-based service contracts between ONEA and the government were introduced, bringing in experienced private management from abroad, combined with large infrastructure investments by donors. Elements of the public-private partnership that were essential to its success include: arm’s length management contracts; performance benchmarking with independent monitoring; new infrastructure investments

based on strict financial sustainability; performance-based compensation for the private manager; and cost recovery tariffs. As for the latter, a progressive tariff grid was introduced for drinking water, based on the volume of use, with the higher tiers subsidizing the lowest tier, as well as part of sanitation activities. The company has recovery bill rates of 97 percent and low debt ratios and realizes annual profits.

Figure 6. Burkina Faso: Access to Water and Sanitation
(Percent of population)



Source: WHO/UNICEF, *Joint Monitoring Program*.

19. A second notable aspect of Burkina Faso's water management strategy has been its aggressive investment strategy to improve resilience to water scarcity and variability. In the context of its development strategy, since the mid-2000s the country has invested extensively in water collection and storage and productivity-enhancing initiatives in agriculture, including reservoirs, irrigation, crop rotation, genetically modified cotton, and diverse crops. Agricultural productivity has increased notably and cash crops are no longer lost to droughts. One unique innovation is the Bagré "growth pole." Thirty years ago, the river basin was plagued by river blindness. The government bought the land, relocated residents, and flooded the valley to create a huge man-made reservoir. In the past 10 years, the government has invested in industries and supportive services to attract private investors and create jobs around the water source. The reservoir now supports fishing, irrigation for diverse crops, livestock and dairy, eco-tourism, and a hydro-electric power plant.

20. Despite having one of the most challenging water situations in SSA, Burkina Faso has been one of the continent's best performers in providing access to water for its population and reducing its vulnerability to water variability. Some lessons include:

- Restricted access/high costs for water can bring about home-grown solutions to improve efficiency and reduce per capita use.
- Public water utilities can achieve cost recovery for drinking water access. ONEA's focus on independent management, cost recovery, financially sustainable investment, quality of service, and social objectives serve as a model.

- Resilience to variability of water supply can be improved through aggressive government investment strategies, including in introducing diversified crops, land rotation, and use of new technologies (GMO cotton seeds). The decline in the volatility of growth in Burkina Faso suggests that the government’s aggressive investment strategy has yielded benefits fairly quickly.
- Avoiding water stress will require more aggressive policies in the future, particularly for countries with high population growth. Even after significant investment, Burkina Faso still faces major water challenges, including a large infrastructure gap, low access to sanitation, and still high vulnerability to water shocks. Going forward, the country will face more pressure on its already-scarce resources, as a result of high population growth, contamination, urbanization, climate change, and structural transformation.

D. DEMOCRATIC REPUBLIC OF THE CONGO⁸

21. The Democratic Republic of the Congo (DRC) has more than half of the water resources of sub-Saharan Africa (SSA). The country’s territory is covered by a large system of rivers and lakes, providing 19,967 cubic meters of freshwater per person per year for an estimated population of 77 million, well above the SSA average (14,048.97 cubic meters). In addition, the DRC’s large rivers offer a vast potential for electric power generation because of the strength and low variability of the water flow. Rainfall is reliable and abundant across most of the country, averaging 1,545 millimeters (mm) per year, more than twice the continental average of 680mm per year.

22. Despite water abundance, current water usage is far below SSA averages, implying significant untapped economic potential. The population’s consumption of drinking water is far below the regional average, and only a fraction (6,800 hectares in 2000) of the potential 4 to 7 million hectares of agricultural land are irrigated. Currently, 356 million cubic meters of water are withdrawn every year, less than 1 percent of the available renewable water resources. That is around 7 cubic meters per person per year against an SSA average of 152 cubic meters, reflecting the poor state of water infrastructure in DRC. Only 46 percent of the population has access to improved drinking water against an SSA average of 73 percent (Table 2).

Table 2. Democratic Republic of the Congo: Selected Indicators

	Annual water withdrawals per person (m ³)	Percent of pop. With access to improved water (2012)	Percent of pop. with access to improved sanitation (2012)
DRC	7	46	31
SSA average	152	73	35
World Average	473	89	72

Sources: WHO/UNICEF, *Joint Monitoring Program*; and FAO, *Aquastat*.

⁸ Contributors: Roldopho Maino and Klaus Peter Hellwig.

23. The unavailability of safe drinking water and poor sanitary conditions pose a major threat to public health. The difficult sanitary conditions are a root cause of poor health outcomes in DRC. The mortality of children under the age of five in DRC (11.9 percent) remains higher than in SSA (9.2 percent), with a high prevalence of diarrhea and recurring outbreaks of cholera and other diseases linked to unsafe water. Moreover, malnutrition associated with a lack of safe water continues to affect large parts of the population.

24. The DRC stands as a prime example for the urban/rural gap in access to water that characterizes the water sector throughout SSA. There is considerable heterogeneity in access to improved water with 79 percent of the urban population having access against 29 percent in rural areas. The level of access to improved sanitation facilities is comparable, though low at 29 percent in urban areas and 33 percent in rural areas.

25. Poor management of the water resources has contributed to the weak water outcomes. Since 1990, the national public water utility for urban areas (REGIDESO) has experienced a steep decline in its operational performance. As a consequence, the country's urban water supply coverage rate fell from 88 percent in 1990 to under 79 percent in 2012. Most of REGIDESO systems serving secondary towns are presently out of service due to the combined effect of a lack of electricity and the absence of new investment and maintenance. Moreover, operating costs are significantly higher in DRC than in other SSA countries, weighing heavily on the water administration authorities' finances. Staff expenses amount to 35 percent of REGIDESO's turnover, against 20 percent in Burkina Faso. In addition to its inadequate size, the composition of REGIDESO's staff is skewed toward executives and clerical workers instead of field agents. REGIDESO's dire financial situation is compounded by the lowest bill collection rate in SSA as well as an inadequate tariff structure. The current water tariff structure results in a billing price that is, on average, 80 percent of production cost.

26. Many years of civil war have also been a contributing factor. The armed conflict that has ravaged the DRC since 1997 has led to the destruction and pillaging of crucial water infrastructure. Likewise, critical maintenance work has been neglected over these years, resulting in a sharp drop in access to improved water and sanitation in urban areas from their pre-conflict levels of 88 percent and 32 percent in 1990. Similarly, the use of irrigation in agriculture was more widespread before the civil war with 13,500 hectares of land under irrigation in 1995.

27. Lack of reforms and a poor regulatory environment hamper progress. While improving the water infrastructure would require large investments, the slow pace of institutional reforms remains the main impediment for immediate progress. The water sector is governed by a multitude of conflicting laws and regulations with policies falling into the domains of several ministries and agencies at the national, provincial, and local levels. While a coordinating body has been put in place, a clear distribution of responsibilities is still missing. A proposed law to address these deficiencies and reform the water sector has yet to be passed. As a consequence of the low implementation capacity, only 50 percent of the resources originated from donors and devoted to water projects can be absorbed. Achieving the MDG targets (providing access to safe water to 71 percent of the population by 2015) remains out of reach. To meet its own less ambitious goal of

providing safe water access to 50 percent of the population, the government estimates a required investment of US\$171 million per year. In 2007–08, public expenditure on water and sanitation was around US\$65 million, or less than US\$1 per person.

28. The main takeaways of the DRC water situation are the following:

- Strengthening the institutional environment is crucial for adequate management and expansion of the water infrastructure. The water situation in DRC mirrors the weaknesses of other sectors (mining, oil extraction), where delays in the passage of crucial legislation and limited capacities of state institutions such as ministries and administrative bodies are impeding a full exploitation of an otherwise abundantly available and diversified natural resource.
- The current cross-subsidized system among user categories is not working properly given the very low collection rate.
- Investment in the water and sanitation infrastructure is a potential channel for enhancing the inclusiveness of growth in DRC. Currently, there are large regional differences in the allocation of investment, with a large share of public expenditure directed toward Kinshasa. A more equitable distribution of funds could reduce the urban/rural gap in access to water and sanitation and let the most disadvantaged benefit from DRC's recent growth of mining export revenues.
- Despite the abundance of water resources, international coordination is important for medium-term sustainability. The DRC's surface waters draw from a wider basin covering 10 countries, and major developments in upstream countries would directly affect the quality and quantity of water available in DRC.

E. PAKISTAN⁹

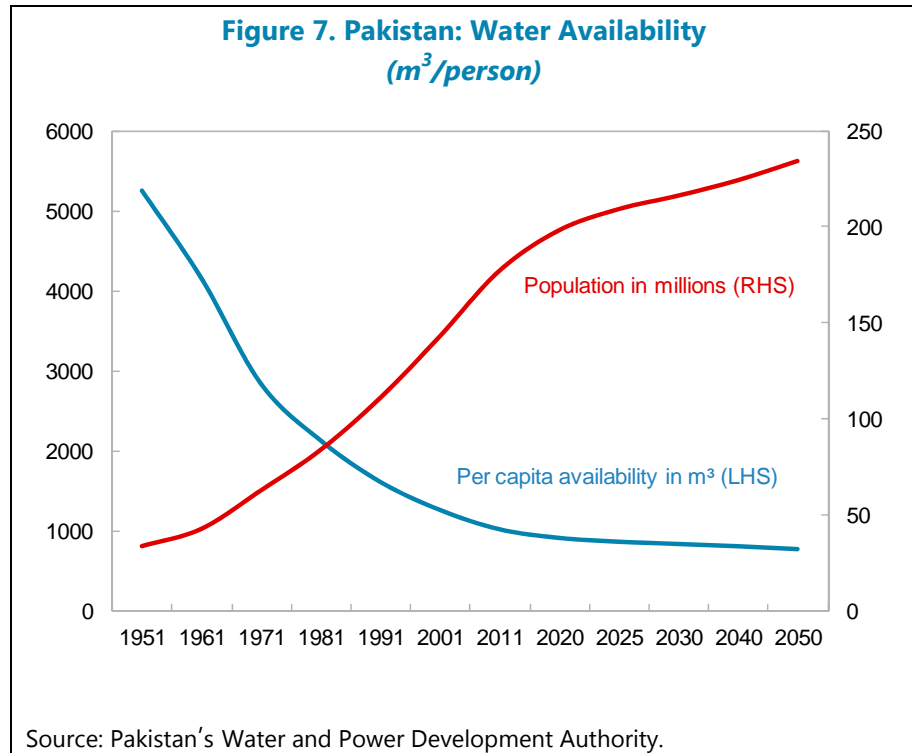
29. Despite having the world's largest glaciers, Pakistan is facing the prospect of water scarcity. Pakistan is among the world's 36 most water-stressed countries, with its agricultural, domestic, and industry sectors scoring high on the World Resource Institute's water stress index. Per capita annual water availability has dropped, fundamentally due to population growth, from 5,600 cubic meters at independence to the current level of 1,017 cubic meters, and is projected to decline further under the current infrastructure and institutional conditions (Figure 7). Demand for water is on the rise, projected to reach 274 million acre-feet (MAF) by 2025, while supply is expected to remain stagnant at 191 MAF, resulting in a demand-supply gap of approximately 83 MAF. Concerns over this widening gap between water supply and demand are compounded by certain characteristics of Pakistan's geography, climate, and hydrological cycle:

- Pakistan depends on a single source, the Indus system and its tributaries, for most of its water supply needs. Fed mostly by snow and glacier melt in the greater Himalayas, water availability in the Indus system is highly seasonal, with 85 percent of annual river flows occurring during the June-

⁹ Contributors: Mansoor Dailami, Tasneem Alam, and Hiba Zaidi.

September period, which coincides with the concentration of rainfall in the monsoon. Rainfall varies from 1,500 mm per year in northern Punjab to 150 mm per year in upper Sindh province.

- Pakistan is exposed to extreme weather conditions, including severe episodes of floods and droughts that wreak significant damage on the country’s agricultural, livestock, and water infrastructure. Much of these costs have been attributed to lack of adequate storage capacity and control structures. Total dam storage in Pakistan represents only 30 days of average demand, compared to 1,000 days for Egypt and 220 days for India.



30. Pakistan needs to develop an integrated approach to water resource management that prioritizes conservation and sustainable water use through improved cost recovery, upgrading infrastructure, and bringing agriculture under the tax regime. Pakistan has a long history of water resource development, in close engagement with the international donor community. The key challenges facing the country have been well articulated, with a fair degree of consensus emerging on the main policy and institutional reform imperatives. These include:

- **Reform water tariffs and cost recovery.** Tariff reform is critical to ensure sustainable water use in both the agricultural and urban sectors. Canal water is heavily underpriced and cost recovery is poor, resulting in high inefficiency in the use of water and a financially unsustainable irrigation system. The prevalent irrigation water charges (*abiana*) only recover 24 percent of the annual operating and maintenance costs, and collection is only 60 percent of total receivables, imposing a drain on the government budget. The pricing structure for major crops is uniformly based and, thus, does not reflect differential water consumption, even though, for instance, rice consumes 60 percent more water than cotton does. This has impeded adoption of more efficient technology and high-value crops. Furthermore, excessive irrigation water use has resulted in poor water quality (36 percent of groundwater is highly saline). Similar problems of inadequate tariff and low cost recovery have afflicted urban drinking water. Tariffs for water utilities for consumption in households are quite low and have not been revised for several years. Tariff collection varies from 20–80 percent across cities. Access to piped water supply in rural and small towns remains inadequate.

- **Increase investment in water infrastructure.** Pakistan’s water infrastructure was historically built to cater to the needs of agriculture, but as urbanization accelerates and industry grows, there will be significant investment needs to build the necessary infrastructure to supply safe drinking water and sanitation. Currently more than 35 percent of the population lacks access to safe drinking water. Harnessing Pakistan’s huge hydro potential through construction of new dams and hydropower projects, as highlighted in National Power Policy 2013, also deserves serious attention. With hydro potential of 50,000 megawatts of electricity generation, Pakistan could overcome its energy shortage several times over, notwithstanding the seasonality involved in hydropower generation. Of this potential, only 13 percent has been developed so far at a relatively low cost of 2 cents/kilowatt hour. The country’s two existing mega hydropower dams—Mangla and Tarbela, commissioned in 1967 and 1976 respectively—are losing their storage capacity because of rapid silting. In both urban and hydro sectors, reliance on private investment and capital needs to be an integral part of the solution.

31. There are both equity and efficiency rationales for bringing agriculture within the tax net. Because of the country’s arid and semi-arid climate, agriculture in Pakistan is predominantly irrigated (90 percent) and consumes about 95 percent of annual available surface water. Though the bulk of farmland is irrigated through the canal system, farmers utilize water from other sources, including groundwater exploitation, and this has increased significantly in recent decades: subsidized water and electricity tariffs have induced adoption and expansion of electric pumps to tap groundwater at an alarming rate. Approximately 60 percent of farm-gate-delivered water in Punjab comes from tube wells. Yet agriculture is largely untaxed (contributing less than 0.1 percent of total tax revenues), even though it accounts for 21 percent of GDP and employs 43 percent of the population.

32. Given water’s multifaceted development role and its global dimension, there is room for closer engagement of the IMF through awareness raising and leveraging the ongoing lending arrangement. The IMF’s support for water reform in Pakistan should focus on agriculture taxation in the context of the upcoming National Finance Commission’s (NFC’s) award; phasing out electricity subsidies; and policy design for water pricing as part of the broader energy sector reform.

33. What are the lessons? Water can serve as an engine of economic growth and regional trade expansion in Pakistan. The country has the necessary natural endowment and is blessed with the world’s most extensive irrigation system. Harnessing such potential needs virtually a paradigm shift in reframing water policy and management in a national context that emphasizes demand-side measures that would promote conservation and control of excessive groundwater exploitation. Pakistan has a long history of experience with supply-side measures, including construction of mega hydro power projects and dams. Moving forward, the thrust of policy reform needs to be on improving water-use efficiency in agriculture, which continues to dominate water consumption while escaping taxation at the federal level and lightly taxed at the provincial level. This would require greater engagement of stakeholders at the local level in water management and capacity building of water management institutions. Furthermore, encouraging the provinces to reform their agriculture taxation systems in the context of the forthcoming NFC award could be a major step in overcoming

the entrenched political interests of powerful landowners and bringing agriculture into the tax net. The nexus between water and electricity is the other area calling for reform of water and electricity subsidies. Reforming NFC revenue-sharing mechanisms and phasing out electricity subsidies are two major reform areas supported by the current IMF Extended Fund Facility for Pakistan.

F. SINGAPORE¹⁰

34. Singapore is a densely populated city-state with no natural fresh water resources, apart from rainfall. It is located on an island (and some 60 small islets) with a total area of some 714 square kilometers (roughly the area of five boroughs of New York City). With a population of almost 5½ million, the country is third in the world in terms of population density. Ever since achieving independence, the authorities have been looking into ways to secure its water supply. The “*Four Taps*” strategy, which looks into alternative sources of water, was put in place in the late 1990s and aims at achieving self-sufficiency by 2062. The Singaporean approach is not limited to diversification of the supply sources. It also relies on demand management tools, research and development (R&D), and broad public support.

35. The *Four Taps*, the four sources of water, are:

- *Imports (up to 1,100 thousand cubic meters a day)* have been the main source of water since 1932, when a pipeline from the Malaysian state of Johor was inaugurated. Under the current agreements, expiring in 2061, the country is entitled to receive up to 60 percent of its current needs.
- *Local catchment water (900–1,400 thousand cubic meters a day)* is collected from about two-thirds of the country’s territory through a system of 17 reservoirs (started in 1868) and a comprehensive network of drains, canals, rivers, and storm-water collection ponds. The catchment territory is classified as partly protected with certain restrictions on land use in place, with land and water management processes closely integrated. Reservoir water is treated through chemical coagulation, rapid gravity filtration, and disinfection.
- *Reclaimed water (up to 520 thousand cubic meters a day)* refers to used water turned into potable using advanced membrane technologies. The NEWater project originated in 1974 but had to be shelved until 1998 given unreliability of the process and high costs. Today four plants meet up to 30 percent of the nation’s water needs, and the capacity is to be expanded to 55 percent by 2060. Although quality of treated water exceeds the WHO standards for drinking water, it is mostly used by industries for non-potable uses.
- *Desalinated seawater (up to 230 thousand cubic meters a day)* is produced by two plants that were launched in 2005 and 2013, are among Asia’s largest seawater reverse-osmosis plants, and allow meeting up to 25 percent of the current water needs. The plan is for this source to continue supplying a quarter of the country’s water needs in the 2060s.

¹⁰ Contributor: Robert Tchaidze.

36. Singapore employs a pricing policy that aims at discouraging excessive use of water and recovering costs to the fullest extent possible. Unlike in many other countries, both domestic and non-domestic users face the same base tariff, with no cross-subsidization of households by industrial and commercial users. Moreover, beyond a certain level of consumption, households face an additional surcharge that brings the total tariff to the rate higher than that for commercial and industrial users. There is no subsidized “basic” consumption; instead the government provides targeted help for low-income families. Consumers are also charged a flat water-borne fee (to offset costs of treating used water and maintaining public sewage system; for non-domestic users this fee doubles); a flat sanitary appliance fee (charged per sanitary fitting); and a progressive water conservation tax (supposed to reflect the marginal cost of the “next,” alternative water sources, including the R&D costs).

37. Rigorous management practices, continued investment in new technologies, and involvement of the broad society are other building blocks in the Singaporean approach. Singapore has a single agency—the Public Utilities Board (PUB)—that is responsible for all aspects of the water cycle, such as collection, production, distribution, and reclamation. The PUB is autonomous and enjoys support both from politicians and the general population. It undertakes significant investments in its own assets as well as assets that are in the government’s ownership, but under its management (such as sanitation and drainage infrastructure). Since 2005 it has regularly issued bonds to finance some of these investments.

38. Opening the *third and fourth taps* would have been impossible, had it not been for decades of investment into research and development of new, revolutionary technologies. The PUB cooperates with local and international researchers by making its research facilities available as test-beds and by sharing the costs and risks associated with these tests. This allows it to attract both private and public sector innovators and to remain ahead of the curve in implementation of new technologies. In addition, the National Research Foundation promotes R&D in the water sector through an inter-agency outfit, Environment and Water Programme Office, led by the PUB. Finally, an Institute of Water Policy has been established at the National University in 2008.

39. Given the emphasis put on water-related R&D by the government, Singapore has emerged as an international hub for water-related research. Today, the country is home to over 70 local and international water companies and more than 20 research and development centers. It also hosts an annual event, the Singapore International Water Week, where key global industry players share and co-create innovative water solutions.

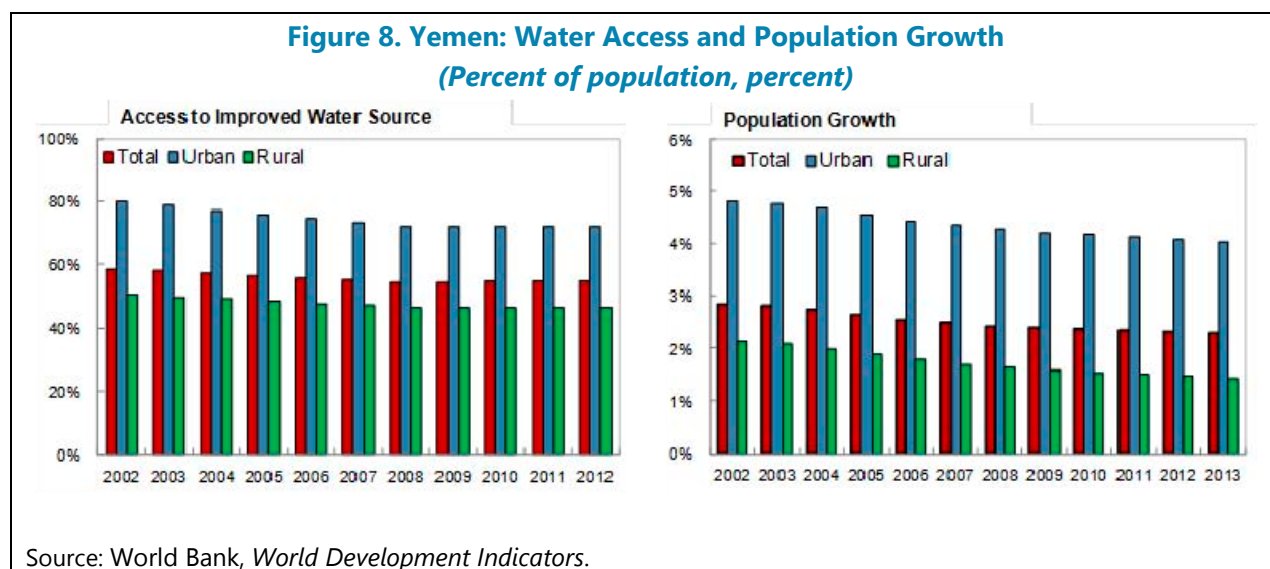
40. The PUB encourages every segment of the society to engage in efforts to make use of water resources more efficient. This is done through various public programs that aim at the so-called *3P* of population and public and private sectors and call for cleanup, beautification, and conservation of water resources. The PUB also gathers feedback on its work and suggestions for alternatives from the water industry and the broad community.

41. What are the lessons? High-level political support for long-range policy objectives and strong institutions, including an autonomous technocratic institution such as the PUB, seem to be among the key factors that enabled Singapore to put in place such a comprehensive strategy. The rapid improvement in living standards and industrialization of the economy, with a significantly reduced role of the agricultural sector, may have helped secure broad support for the government’s water management policies.

G. YEMEN¹¹

42. Yemen is one of the world’s most water-deficient countries. The extremely low level of water has led to increasing local conflict over water rights since the year 2000. Groundwater and rainfall are the sole sources of freshwater. Water availability per capita is around 2 percent of the world average, and has been trending downward in recent years, from 113 cubic meters in 2002 to 86 m³ in 2013. Over the same period, access to “improved water sources” declined from 60 percent to 55 percent of the population in aggregate. Both urban and rural population access to safe water also declined, with the latter now standing at 46 percent (Figure 8).

43. Demand for water is rising, while renewable supply has remained stable and groundwater is being depleted. Several factors contributed to the surge in demand for water in recent years, including rapid population growth, urbanization, and economic growth. Annual freshwater use has increased from 3.4 billion m³ in 2002 to 3.9 billion m³ in 2010. Meanwhile, annual renewable supply remains relatively constant at 2.5 billion m³ during the same period, and the inefficient and unregulated use of groundwater is depleting Yemen’s deep aquifers.



¹¹ Contributors: Mohd Zaher and Fouad Al-Kohlany.

44. Disparity in access to safe water follows the poverty map. The majority of urban consumers have access to a public water network, even though around 40 percent rely on trucked water; this figure is considerably higher for rural residents because fewer people are connected to public water networks. According to the World Bank, the cost of trucked water is up to 10 times that of network water.¹² The cost and effort involved in obtaining safe water are also considerably less for the well-to-do, compared to the poor. The high cost of water is forcing many rural women and girls to walk for hours fetching water.

45. The bulk of water resources is consumed by the agricultural sector, supported by generous diesel fuel subsidies. The share of the agricultural sector in water consumption remained relatively stable over the last decade, around 91 percent. Irrigating qat, a local cash crop and a mild stimulant, consumes around 40 percent of water used in agriculture. Similar to qat, a significant portion of agricultural exports, such as bananas, is also water intensive. The expansion of these crops has benefited from subsidies, which kept the price of diesel fuel, used in pumping groundwater for irrigation, extremely low until mid-2014.

46. The authorities have reduced fuel subsidies and raised the price of diesel by 50 percent since July 2014. While this move was largely motivated by the need to reorient public spending in favor of growth-oriented capital and development spending, it is expected to reduce the rapid depletion of groundwater resources and the distorted production costs that favor water-intensive crops such as qat. At the same time, to improve the poverty orientation of the budget, the authorities have increased the Social Welfare Fund monthly transfers to households by 50 percent.

47. Notwithstanding data limitations, a number of indicators point to significant socio-economic costs associated with water shortage in Yemen. The contamination of water sources and the decline in water availability to households have contributed to the spread of diseases in rural areas. Water and fuel shortages—particularly acute before the reduction in fuel subsidies—and more recently the increased production costs resulting from higher fuel prices have also placed farmers and agricultural workers at risk of unemployment, further exacerbating Yemen's economic situation.

48. Going forward, the water situation in Yemen is expected to deteriorate further. Assuming the continuation of the current consumption and production patterns, weak governance will impose a toll on the water sector. The fact that groundwater—which is by nature the most difficult to regulate—plays a key role in Yemen makes the governance of the sector particularly challenging. Recent estimates show that non-renewable water resources are expected to be exhausted within one to two decades in the most densely populated highlands, putting major Yemeni cities in a dire water situation. Sana'a, the capital city, is 2,000 meters above sea level in the water-scarce mountain ranges, where the groundwater table is dropping by more than six meters a

¹² World Bank 2012.

year. The location and altitude of the capital city are also making the cost of trucking or pumping water from coastal areas very expensive.

49. The government's response to the water crisis has been lagging. With help from the World Bank and GIZ, the government of Yemen introduced a water sector strategy in 2005, with the chief objective to gradually reduce the rate of groundwater depletion. The strategy has had no impact beyond enhancing awareness of water challenges in Yemen. Minimal impact on water usage and practices has been observed.

50. Political instability over the past four years hampered investments in the water sector and raised costs. The difficult security situation, lack of government presence in certain areas, and the inability to enforce the rule of law have all weakened the government's endeavors to rationalize water usage. The impact of the 2011 crisis on the water sector was severe. There has been widespread damage to installations and equipment and declining rates of water billing and collection.

51. Desalinization has been proposed as a long-term answer. However, this is an energy-intensive solution and will require large long-term investment. Without donors' support, this solution seems infeasible, especially as the country's fiscal balances can barely support its basic infrastructure needs. Furthermore, restoration of security in Yemen remains a priority to resume many of the foreign-financed water projects suspended following the 2011 crisis.

52. In summary, Yemen's water future appears challenging, and a broad reform agenda is needed to rationalize water consumption and improve efficiency. Unless addressed properly, the water sector difficulties could further delay the country's development, lead to internal migration and tribal conflict, and increase the cost of water in the major urban centers. Any viable solution should incorporate better management of water resources, public and private investments, foreign aid, closing the urban-rural water gap, and boosting water supply. As the largest water consumer, the agricultural sector in Yemen deserves special attention. Efforts should be scaled up and directed toward enhancing the efficiency of production and irrigation. The high urbanization rate in Yemen also requires the achievement of more inclusive growth to moderate the unbalanced growth of urban areas. Strengthening regulation and enforcement mechanisms is a priority to stop the widespread and unregulated extraction of underground water. Reforms should also encompass creating an enabling business and regulatory environment to encourage more active private sector participation in financing water projects and infrastructure.

53. The water sector will benefit from the full implementation of structural reforms embedded in the Extended Credit Facility program (ECF). Improving the overall efficiency of the economy through macro-critical structural reforms, particularly in terms of completing the phase-out of highly distortive energy subsidies, directing public resources to growth-enhancing investment and poverty-reducing transfers, and improving public sector management, will also benefit the water sector. These will be in the form of efficiency gains and water savings as farmers adapt their farming practices in response to changes in cost of inputs. Supporting the private sector's activity

and investments will also benefit from enhanced financial intermediation, better access to finance by small and medium-size enterprises, and an improved business environment.

54. The way forward: there is an urgent need for Yemen to improve its water resource management. A broad reform agenda, along with well-coordinated donor support, is needed to boost water supply, rationalize consumption, and improve efficiency. Most important, Yemen needs to implement price-based reforms and to change the legal and social understanding of water rights to reflect the true cost of water resources and minimize inefficient use.

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June, 2015

ISSUES IN MANAGING WATER CHALLENGES AND POLICY INSTRUMENTS: REGIONAL PERSPECTIVES AND CASE STUDIES

Prepared by an IMF Staff Team

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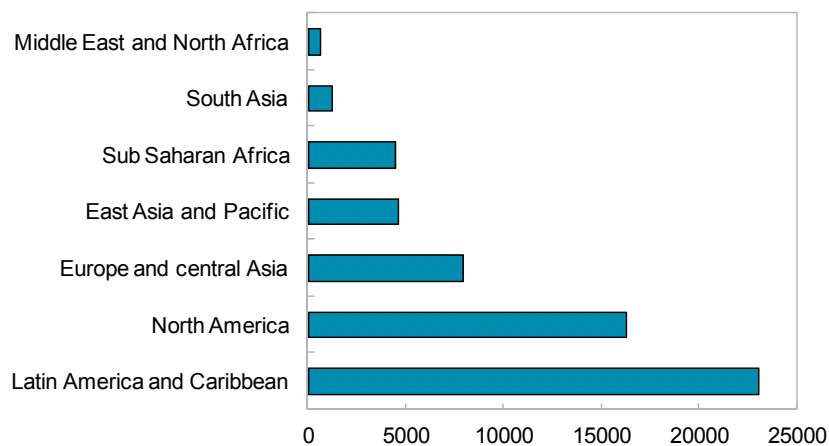
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REGIONAL PERSPECTIVES

A. Key Water Issues in Sub-Saharan Africa¹

1. Sub-Saharan African (SSA) countries are characterized by highly variable water resources, with relatively low per capita supply on average. Countries in the western Sahel, eastern horn, and southern tip have scarce access to watersheds and highly variable rainfall (e.g., Burkina Faso, Kenya, Niger, Zimbabwe), with relatively abundant resources in the middle of the continent (Angola, Cameroon, Democratic Republic of the Congo (DRC), Republic of Congo). On average, SSA countries have relatively limited water resources compared to other regions of the world (Figure 1).

Figure 1. Annual Renewable Freshwater Resources per Capita (m^3 /person/year)



Source: FAO, *Aquastat*.²

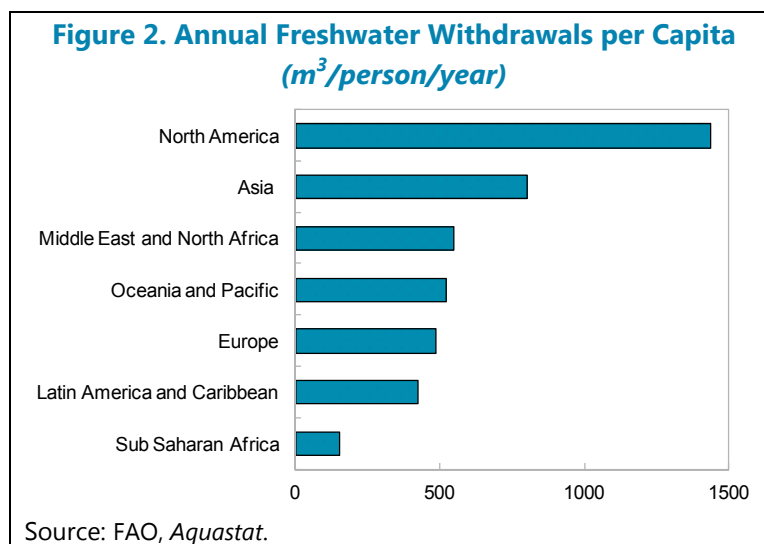
2. Despite low per capita supply of resources, “water stress” (as defined elsewhere in this exercise) is tempered by low annual withdrawals, reflecting both low access rates and low depth of access to water. On average, SSA countries withdraw the lowest annual volume per capita of all regions (Figure 2) and display the lowest rate of access to drinking water (64.5 percent), except for Oceania (55.2 percent).³ Chief among the reasons for this low access is a deficit of infrastructure (including energy), reflecting insufficient, outdated, or poorly maintained water storage, distribution, and treatment facilities. The annual infrastructure investment gap in Africa’s water sector is estimated to be \$22 billion (Foster and Briceño-Garmendia 2010). The infrastructure deficit is magnified by poor management, including through poor maintenance, waste, below-cost-recovery tariffs, and low collection rates. Ironically, such problems seem more pronounced in some countries with relative water abundance. Particularly acute examples are DRC and Angola, gifted with some of the most ample supplies of water resources in the world, yet with some of the lowest rates of access

¹ Contributors: Laure Redifer and Samba Mbaye.

² Aquastat is a global water information system, developed by the Land and Water Division of the Food and Agriculture Organization (FAO) of the United Nations, <http://www.fao.org/nr/water/aquastat/main/index.stm>. The main mandate of the program is to collect, analyze, and disseminate information on water resources, water uses, and agricultural water management, with an emphasis on countries in Africa, Asia, Latin America, and the Caribbean.

³ The concept of “access” masks large discrepancies across regions in the amount of access per person.

to drinking water in SSA (46 and 54 percent, respectively). On the other hand, other SSA countries have been successful in expanding access through large-scale investment and sound management strategies. These countries have often been able to achieve full recovery of costs for drinking water, partly through the application of a progressive tariff grid (Burkina Faso, Lesotho, Mozambique, and Seychelles).



3. There is a pronounced lag in the rate of access of rural vs. urban areas. On average in SSA countries, there is a 28 percentage point gap between urban and rural rates of access to drinking water.⁴ In several countries, the responsibility for operating rural water systems has been decentralized and transferred to local communities, as opposed to urban areas, where the responsibility generally falls to a publicly owned water utility. Increasing access to drinking water in rural areas and the efficiency of their operations is one of the main challenges in most African countries and the object of numerous ongoing initiatives by development partners. To improve rural access and irrigation, the authorities have often invested in smaller-scale mechanisms, such as wells, small reservoirs, and rainwater collection schemes.

4. In general, access to improved sanitation in SSA lags far behind drinking water access. As of 2012, average access to improved sanitation was 35 percent, with a 20 percentage point gap between urban and rural access rates.⁵ There are numerous factors responsible for this: cultural, difficulties in charging for access, lack of maintenance, and hoarding.

5. Water challenges in SSA put significant constraints on growth, but these are difficult to quantify. Water in most SSA countries is concentrated on agricultural and household use, followed by energy generation and industrial uses. Because agriculture is a key component of growth, employment, and subsistence in most SSA countries, water supply and variability are key

⁴ WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation, <http://www.wssinfo.org/data-estimates/>.

⁵ WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation.

determinants of growth, agricultural productivity, and food security. Variations in GDP growth are highly correlated with rainfall, with growth affected strongly by drought and flood events. A World Bank study (for period 1981–2004) suggested that GDP growth in Mozambique is reduced by about 1.1 percentage points annually due to the impact of shocks typically occurring every five years (World Bank 2007a). The vulnerability of agriculture to consistent water supplies also leads to risk-minimizing strategies that favor low-return, low-risk crops over those with high returns and high risk. Finally, in many countries, low or difficult-to-access water supplies negatively impact women’s participation in income-generating activities and education, as women and girls are usually in charge of fetching water. The costs of gaps in improved sanitation are numerous, including disease, water contamination, violence, lost time, etc. Sharing access of water across country borders does not seem to be a large source of stress in SSA, with a few exceptions.

6. Water stress will become more acute going forward, due to high population growth, urbanization, structural transformation, climate change, and contamination. Currently, most SSA countries are not classified as “water stressed,” since per capita withdrawals remain lower than per capita supplies. However, with an average population growth rate of around 2.5 percent, per capita supplies will quickly diminish. Many countries report that increased urbanization and the development of more water-intensive activities have put stress on existing infrastructure. Several countries report that the quality of water resources is deteriorating due to contaminants, ranging from fertilizers to mining activities. Almost all SSA countries have extensive infrastructure development strategies for the water sector, many with support from development partners.

B. Key Water Issues in Middle-Eastern and Central Asian Countries⁶

7. Middle-Eastern and Central Asian countries face important water challenges. Many countries are faced with high water stress, given limited renewable water resources. Much of the Middle-Eastern and North African (MENA) region already faces difficulty meeting current water demand, and per capita water availability in the MENA region is projected to fall by half by 2050 (World Bank, 2007b). Some economies, particularly countries in Caucasus and Central Asia (CCA), as well as Afghanistan, are highly water intensive while facing significant water stress. Countries in both the MENA and CCA regions share significant water resources across international borders, adding an additional layer of complexity to their water management challenges.

8. While past water policy has led to some successes, important challenges remain. Countries have a long history in implementing water policy, including, over the last few decades, large public investment programs. As a consequence, the MENA region’s proportion of surface freshwater resources stored in reservoirs is by far the highest in the world. Overall access to improved water and sanitation is relatively widespread. However, it has been uneven, with rural populations in oil-importing countries at particular disadvantage. In addition, individual well drilling has led the MENA region to use more of its renewable and non-renewable water resources than

⁶ Contributor: Harald Finger with inputs from the country teams.

other regions, with regulators having insufficient capacity to control the extraction. There remains ample scope for improving resource management, in light of continued allocation of water to low-value uses, significant service outages, vulnerability to droughts and floods, overextraction of groundwater, and water-related environmental problems.

9. In addition to natural water scarcity in often arid climates, three sets of issues are important in Middle-Eastern and Central Asian countries:

- **Subsidies or lack of metering.** The prevalence of water subsidies and/or the failure to properly meter and bill for water use—both for domestic use and in agriculture—encourages overconsumption and can imply sizable costs for the public sector (often outside of budgets). For example, costs are estimated at around 2 percent of GDP in the Gulf Cooperation Council (GCC) countries, in part reflecting the high costs of desalinating water, which are not passed on to consumers; and 1 percent of GDP in Algeria and Jordan. Issues of subsidies or lack of metering are prevalent in Algeria, Armenia, Djibouti, Egypt, the GCC countries, Iraq, Jordan, Kyrgyz Republic, Lebanon, Mauritania, Pakistan, Sudan, Tunisia, and Turkmenistan. Tajikistan faces water-related financial sector issues linked to ailing utilities' defaulted bank loans. In Yemen, subsidized diesel encourages overconsumption because it makes pumping of groundwater relatively cheap.
- **Infrastructure issues and water management.** Aging infrastructure or general lack of adequate infrastructure lead to low water quality and large network losses in many countries, reinforcing water shortages. Examples include Afghanistan, Armenia, Azerbaijan, Iraq, Kyrgyz Republic, Pakistan, Sudan, Turkmenistan, West Bank/Gaza, and Yemen. In a number of cases, water supply is rationed (e.g., Jordan, Lebanon), leading the private sector to step in with more reliable but also more expensive ways to supply water (such as with water trucks). The estimated cost of infrastructure needs to address these issues can be sizable (for example, in Djibouti, Kyrgyz Republic, and Lebanon).
- **Potential for cross-border coordination issues.** Actual or potential cross-border issues can come into play where water sources are shared among countries. These are often linked to existing or planned dams for flood control, electricity generation, and irrigation. Examples of cross-border sharing of significant water resources include Egypt/Sudan/Ethiopia, Jordan/Israel/West Bank, Iraq/Turkey/Syria, Afghanistan/Iran/Uzbekistan/Turkmenistan/Pakistan, India/Pakistan, Uzbekistan/Tajikistan/Kyrgyz Republic.

10. Water challenges in Middle-Eastern and Central Asian countries can have important macroeconomic implications. Reliance on, and high variability of rainfall can have a sizable impact on economic growth, as agricultural output directly depends on it (for example, Morocco). More broadly, water scarcity constrains productivity of agriculture and, to some extent, industries, thereby depressing economic growth potential. In some countries, underpricing of water and/or lack of collection lead to costly resource misallocation (land used for water-intensive crops and housing construction in dry areas). Sizable water subsidies (and energy subsidies that help users extract ground water) exacerbate fiscal imbalances and/or crowd out more efficient uses of scarce resources. Some countries face large water infrastructure investment needs that have significant

macroeconomic impacts and cannot be met from their own resources or by commercial borrowing (for example, Djibouti).

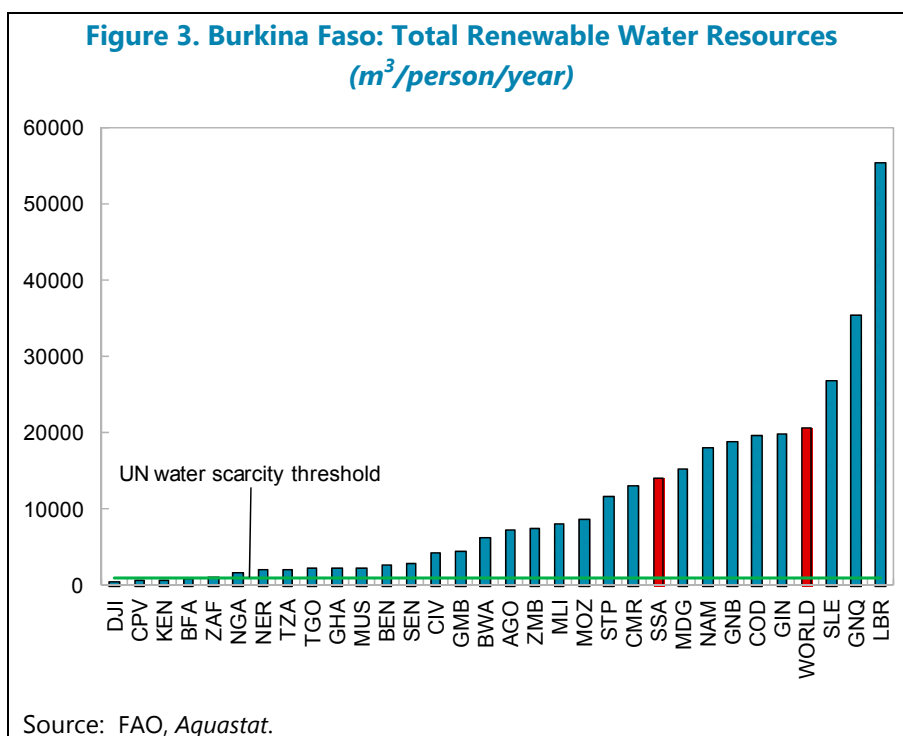
11. The region also features some relative success stories. These include Algeria, which has achieved continuous water supply in Algiers after a decade of massively investing in the water sector, and Tunisia, which has been implementing active water management policies since the 1970s and as result has achieved the highest access rates to water supply and sanitation services in the MENA region. That said, both countries still face important issues such as costly water subsidies.

CASE STUDIES

C. BURKINA FASO⁷

12. Burkina Faso has one of the lowest per capita supplies of water in SSA and in the world (Figure 3). A land-locked West African country, Burkina Faso's climate is tropical, with Sahelian (desert) dominance. Burkina Faso is well below the United Nations water scarcity threshold, largely resting on a crystalline surface that does not support productive aquifers. The country relies exclusively on surface water, and up to 49 percent of its renewable annual freshwater resources are consumed by

evaporation and, to a lesser extent, water sharing agreements. Thus, water collection, treatment, and distribution are critical. Water variability is also a major challenge. Rainfall from year to year varies as much as 50 percent, causing ongoing droughts that affect food security. Seasonal rainfall fills reservoirs and rivers, but they systematically run dry in the dry season. The timing of rain is a determining factor: if too much time elapses between rainfalls, crops fail, even in abundant rain years.



⁷ Contributors: Laure Redifer and Samba Mbaye.

13. However, Burkina Faso’s low level of water use has kept supply constraints from being binding. Annual water withdrawals per capita are half the SSA average and about one-eighth the world average. Low use compared to SSA is related to depth of access, as an adaptation to scarcity, and low access to improved sanitation (Table 1). Agriculture accounts for the lion’s share of usage. Water scarcity and variability have brought about innovation through increasingly efficient home-grown means for meeting agricultural demands for water. For example, in sugarcane fields, large cisterns collect water and distribute it via highly water-efficient drip irrigation methods. The introduction of genetically modified cotton allowed more drought- and pest-resistant plants that required one-third the fertilizer applications and doubled yields.

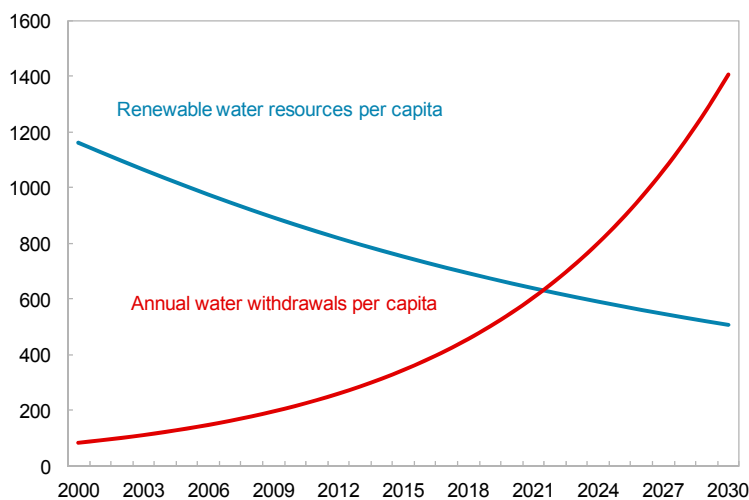
Table 1. Burkina Faso: Selected Indicators

	Annual water withdrawals per person (m ³)	Percent of pop. With access to improved water	Percent of pop. with access to improved sanitation	Dam capacity per capita (m ³)
Burkina Faso	62	82	19	321
SSA average	152	73	35	1146
World Average	473	89	72	1785

Sources: WHO/UNICEF, *Joint Monitoring Program* and FAO, *Aquastat*.

14. Despite major strides on drinking water in urban areas, a significant rural-urban gap remains, and progress on improved sanitation has lagged considerably. Over the last two decades, access to drinking water has doubled, with nearly universal access in urban areas and access in rural areas only catching up to earlier urban levels. While the Millennium Development Goals (MDG) target for drinking water has already been met, with the 5th highest progress in the world, the target for improved sanitation will not be met (WHO and UNICEF, 2014). Access to improved sanitation is constrained by an acute deficit of infrastructure.

Figure 4. Burkina Faso: Actual and Projected per Capita Supply and Use, 2000–30 (m³)



Sources: FAO, *Aquastat*; World Bank, *World Development Indicators*; and IMF staff calculations.

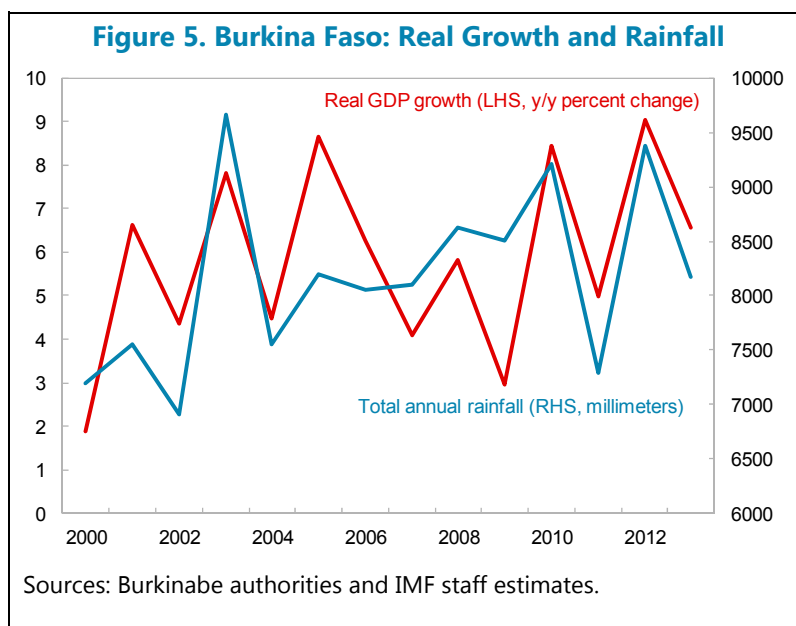
15. Going forward, water demand is likely to outpace the country’s low supply, reflecting mainly population growth, urbanization, and climate change. As a function of population

growth alone, per capita water use could outstrip supply in roughly 10 years. In addition, water pollution (including fertilizers and cyanides in informal mining), encroaching desertification, and land degradation will put pressure on supplies (Figure 4).

16. Burkina Faso's water challenges impose significant constraints on growth and social outcomes, with significant fiscal costs (Figure 5).

The main channel of impact on growth is the agricultural sector, which employs a large majority of the population (70 percent of the labor force), provides a significant contribution to growth (25 percent), and is highly dependent on annual rainfall. Growth is indirectly impacted by the health consequences of low access to drinking water and

improved sanitation and the costs associated with water fetching, especially for women. The World Bank's Water and Sanitation Program recently estimated that the cost of insufficient access to improved sanitation in Burkina Faso was as much as 2 percent of 2010 GDP, but addressing the sanitation deficit will require substantial infrastructure investment. Beyond infrastructure costs, fiscal costs include contingency food stocks, subsidized prices, and distribution mechanisms to ensure food security in light of ongoing droughts and floods. The 2011–12 drought, for example, created fiscal costs of around 2–5 percent of GDP.

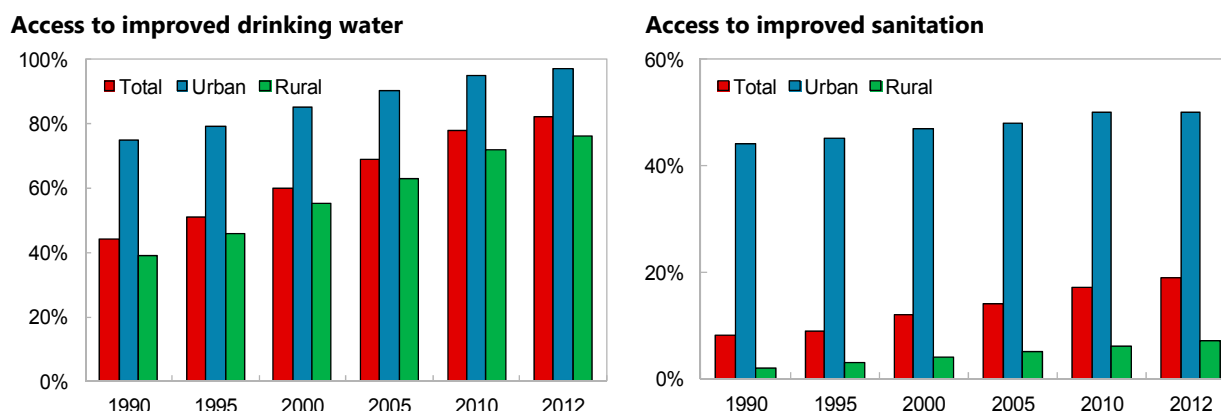


17. In the face of its considerable water challenges, Burkina Faso has developed a widely praised approach to water management. Two aspects of its strategy are particularly notable: (i) water access in urban areas; and (ii) investments in agricultural productivity and water storage and irrigation. These investments have coincided with a sustained increase in growth and a concurrent drop in its variability. Five-year average real growth doubled between 1990 and 2012, with a decline in the standard deviation from 3.8 to 2.5 percentage points over the same period, despite numerous shocks.

18. Burkina Faso's public water utility (ONEA) has been responsible for a remarkable improvement in the population's access to drinking water (Figure 6). The company is charged with water management in urban areas. In the early 2000s, three-year performance-based service contracts between ONEA and the government were introduced, bringing in experienced private management from abroad, combined with large infrastructure investments by donors. Elements of the public-private partnership that were essential to its success include: arm's length management contracts; performance benchmarking with independent monitoring; new infrastructure investments

based on strict financial sustainability; performance-based compensation for the private manager; and cost recovery tariffs. As for the latter, a progressive tariff grid was introduced for drinking water, based on the volume of use, with the higher tiers subsidizing the lowest tier, as well as part of sanitation activities. The company has recovery bill rates of 97 percent and low debt ratios and realizes annual profits.

Figure 6. Burkina Faso: Access to Water and Sanitation
(Percent of population)



Source: WHO/UNICEF, *Joint Monitoring Program*.

19. A second notable aspect of Burkina Faso's water management strategy has been its aggressive investment strategy to improve resilience to water scarcity and variability. In the context of its development strategy, since the mid-2000s the country has invested extensively in water collection and storage and productivity-enhancing initiatives in agriculture, including reservoirs, irrigation, crop rotation, genetically modified cotton, and diverse crops. Agricultural productivity has increased notably and cash crops are no longer lost to droughts. One unique innovation is the Bagré "growth pole." Thirty years ago, the river basin was plagued by river blindness. The government bought the land, relocated residents, and flooded the valley to create a huge man-made reservoir. In the past 10 years, the government has invested in industries and supportive services to attract private investors and create jobs around the water source. The reservoir now supports fishing, irrigation for diverse crops, livestock and dairy, eco-tourism, and a hydro-electric power plant.

20. Despite having one of the most challenging water situations in SSA, Burkina Faso has been one of the continent's best performers in providing access to water for its population and reducing its vulnerability to water variability. Some lessons include:

- Restricted access/high costs for water can bring about home-grown solutions to improve efficiency and reduce per capita use.
- Public water utilities can achieve cost recovery for drinking water access. ONEA's focus on independent management, cost recovery, financially sustainable investment, quality of service, and social objectives serve as a model.

- Resilience to variability of water supply can be improved through aggressive government investment strategies, including in introducing diversified crops, land rotation, and use of new technologies (GMO cotton seeds). The decline in the volatility of growth in Burkina Faso suggests that the government’s aggressive investment strategy has yielded benefits fairly quickly.
- Avoiding water stress will require more aggressive policies in the future, particularly for countries with high population growth. Even after significant investment, Burkina Faso still faces major water challenges, including a large infrastructure gap, low access to sanitation, and still high vulnerability to water shocks. Going forward, the country will face more pressure on its already-scarce resources, as a result of high population growth, contamination, urbanization, climate change, and structural transformation.

D. DEMOCRATIC REPUBLIC OF THE CONGO⁸

21. The Democratic Republic of the Congo (DRC) has more than half of the water resources of sub-Saharan Africa (SSA). The country’s territory is covered by a large system of rivers and lakes, providing 19,967 cubic meters of freshwater per person per year for an estimated population of 77 million, well above the SSA average (14,048.97 cubic meters). In addition, the DRC’s large rivers offer a vast potential for electric power generation because of the strength and low variability of the water flow. Rainfall is reliable and abundant across most of the country, averaging 1,545 millimeters (mm) per year, more than twice the continental average of 680mm per year.

22. Despite water abundance, current water usage is far below SSA averages, implying significant untapped economic potential. The population’s consumption of drinking water is far below the regional average, and only a fraction (6,800 hectares in 2000) of the potential 4 to 7 million hectares of agricultural land are irrigated. Currently, 356 million cubic meters of water are withdrawn every year, less than 1 percent of the available renewable water resources. That is around 7 cubic meters per person per year against an SSA average of 152 cubic meters, reflecting the poor state of water infrastructure in DRC. Only 46 percent of the population has access to improved drinking water against an SSA average of 73 percent (Table 2).

Table 2. Democratic Republic of the Congo: Selected Indicators

	Annual water withdrawals per person (m ³)	Percent of pop. With access to improved water (2012)	Percent of pop. with access to improved sanitation (2012)
DRC	7	46	31
SSA average	152	73	35
World Average	473	89	72

Sources: WHO/UNICEF, *Joint Monitoring Program*; and FAO, *Aquastat*.

⁸ Contributors: Roldopho Maino and Klaus Peter Hellwig.

23. The unavailability of safe drinking water and poor sanitary conditions pose a major threat to public health. The difficult sanitary conditions are a root cause of poor health outcomes in DRC. The mortality of children under the age of five in DRC (11.9 percent) remains higher than in SSA (9.2 percent), with a high prevalence of diarrhea and recurring outbreaks of cholera and other diseases linked to unsafe water. Moreover, malnutrition associated with a lack of safe water continues to affect large parts of the population.

24. The DRC stands as a prime example for the urban/rural gap in access to water that characterizes the water sector throughout SSA. There is considerable heterogeneity in access to improved water with 79 percent of the urban population having access against 29 percent in rural areas. The level of access to improved sanitation facilities is comparable, though low at 29 percent in urban areas and 33 percent in rural areas.

25. Poor management of the water resources has contributed to the weak water outcomes. Since 1990, the national public water utility for urban areas (REGIDESO) has experienced a steep decline in its operational performance. As a consequence, the country's urban water supply coverage rate fell from 88 percent in 1990 to under 79 percent in 2012. Most of REGIDESO systems serving secondary towns are presently out of service due to the combined effect of a lack of electricity and the absence of new investment and maintenance. Moreover, operating costs are significantly higher in DRC than in other SSA countries, weighing heavily on the water administration authorities' finances. Staff expenses amount to 35 percent of REGIDESO's turnover, against 20 percent in Burkina Faso. In addition to its inadequate size, the composition of REGIDESO's staff is skewed toward executives and clerical workers instead of field agents. REGIDESO's dire financial situation is compounded by the lowest bill collection rate in SSA as well as an inadequate tariff structure. The current water tariff structure results in a billing price that is, on average, 80 percent of production cost.

26. Many years of civil war have also been a contributing factor. The armed conflict that has ravaged the DRC since 1997 has led to the destruction and pillaging of crucial water infrastructure. Likewise, critical maintenance work has been neglected over these years, resulting in a sharp drop in access to improved water and sanitation in urban areas from their pre-conflict levels of 88 percent and 32 percent in 1990. Similarly, the use of irrigation in agriculture was more widespread before the civil war with 13,500 hectares of land under irrigation in 1995.

27. Lack of reforms and a poor regulatory environment hamper progress. While improving the water infrastructure would require large investments, the slow pace of institutional reforms remains the main impediment for immediate progress. The water sector is governed by a multitude of conflicting laws and regulations with policies falling into the domains of several ministries and agencies at the national, provincial, and local levels. While a coordinating body has been put in place, a clear distribution of responsibilities is still missing. A proposed law to address these deficiencies and reform the water sector has yet to be passed. As a consequence of the low implementation capacity, only 50 percent of the resources originated from donors and devoted to water projects can be absorbed. Achieving the MDG targets (providing access to safe water to 71 percent of the population by 2015) remains out of reach. To meet its own less ambitious goal of

providing safe water access to 50 percent of the population, the government estimates a required investment of US\$171 million per year. In 2007–08, public expenditure on water and sanitation was around US\$65 million, or less than US\$1 per person.

28. The main takeaways of the DRC water situation are the following:

- Strengthening the institutional environment is crucial for adequate management and expansion of the water infrastructure. The water situation in DRC mirrors the weaknesses of other sectors (mining, oil extraction), where delays in the passage of crucial legislation and limited capacities of state institutions such as ministries and administrative bodies are impeding a full exploitation of an otherwise abundantly available and diversified natural resource.
- The current cross-subsidized system among user categories is not working properly given the very low collection rate.
- Investment in the water and sanitation infrastructure is a potential channel for enhancing the inclusiveness of growth in DRC. Currently, there are large regional differences in the allocation of investment, with a large share of public expenditure directed toward Kinshasa. A more equitable distribution of funds could reduce the urban/rural gap in access to water and sanitation and let the most disadvantaged benefit from DRC's recent growth of mining export revenues.
- Despite the abundance of water resources, international coordination is important for medium-term sustainability. The DRC's surface waters draw from a wider basin covering 10 countries, and major developments in upstream countries would directly affect the quality and quantity of water available in DRC.

E. PAKISTAN⁹

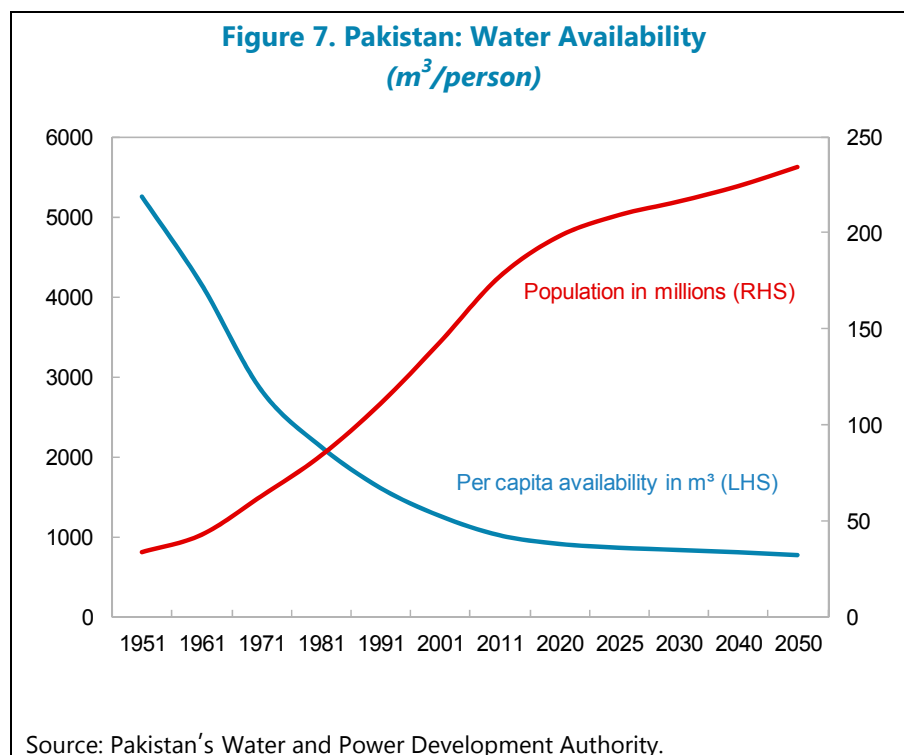
29. Despite having the world's largest glaciers, Pakistan is facing the prospect of water scarcity. Pakistan is among the world's 36 most water-stressed countries, with its agricultural, domestic, and industry sectors scoring high on the World Resource Institute's water stress index. Per capita annual water availability has dropped, fundamentally due to population growth, from 5,600 cubic meters at independence to the current level of 1,017 cubic meters, and is projected to decline further under the current infrastructure and institutional conditions (Figure 7). Demand for water is on the rise, projected to reach 274 million acre-feet (MAF) by 2025, while supply is expected to remain stagnant at 191 MAF, resulting in a demand-supply gap of approximately 83 MAF. Concerns over this widening gap between water supply and demand are compounded by certain characteristics of Pakistan's geography, climate, and hydrological cycle:

- Pakistan depends on a single source, the Indus system and its tributaries, for most of its water supply needs. Fed mostly by snow and glacier melt in the greater Himalayas, water availability in the Indus system is highly seasonal, with 85 percent of annual river flows occurring during the June-

⁹ Contributors: Mansoor Dailami, Tasneem Alam, and Hiba Zaidi.

September period, which coincides with the concentration of rainfall in the monsoon. Rainfall varies from 1,500 mm per year in northern Punjab to 150 mm per year in upper Sindh province.

- Pakistan is exposed to extreme weather conditions, including severe episodes of floods and droughts that wreak significant damage on the country's agricultural, livestock, and water infrastructure. Much of these costs have been attributed to lack of adequate storage capacity and control structures. Total dam storage in Pakistan represents only 30 days of average demand, compared to 1,000 days for Egypt and 220 days for India.



30. Pakistan needs to develop an integrated approach to water resource management that prioritizes conservation and sustainable water use through improved cost recovery, upgrading infrastructure, and bringing agriculture under the tax regime. Pakistan has a long history of water resource development, in close engagement with the international donor community. The key challenges facing the country have been well articulated, with a fair degree of consensus emerging on the main policy and institutional reform imperatives. These include:

- **Reform water tariffs and cost recovery.** Tariff reform is critical to ensure sustainable water use in both the agricultural and urban sectors. Canal water is heavily underpriced and cost recovery is poor, resulting in high inefficiency in the use of water and a financially unsustainable irrigation system. The prevalent irrigation water charges (*abiana*) only recover 24 percent of the annual operating and maintenance costs, and collection is only 60 percent of total receivables, imposing a drain on the government budget. The pricing structure for major crops is uniformly based and, thus, does not reflect differential water consumption, even though, for instance, rice consumes 60 percent more water than cotton does. This has impeded adoption of more efficient technology and high-value crops. Furthermore, excessive irrigation water use has resulted in poor water quality (36 percent of groundwater is highly saline). Similar problems of inadequate tariff and low cost recovery have afflicted urban drinking water. Tariffs for water utilities for consumption in households are quite low and have not been revised for several years. Tariff collection varies from 20–80 percent across cities. Access to piped water supply in rural and small towns remains inadequate.

- **Increase investment in water infrastructure.** Pakistan’s water infrastructure was historically built to cater to the needs of agriculture, but as urbanization accelerates and industry grows, there will be significant investment needs to build the necessary infrastructure to supply safe drinking water and sanitation. Currently more than 35 percent of the population lacks access to safe drinking water. Harnessing Pakistan’s huge hydro potential through construction of new dams and hydropower projects, as highlighted in National Power Policy 2013, also deserves serious attention. With hydro potential of 50,000 megawatts of electricity generation, Pakistan could overcome its energy shortage several times over, notwithstanding the seasonality involved in hydropower generation. Of this potential, only 13 percent has been developed so far at a relatively low cost of 2 cents/kilowatt hour. The country’s two existing mega hydropower dams—Mangla and Tarbela, commissioned in 1967 and 1976 respectively—are losing their storage capacity because of rapid silting. In both urban and hydro sectors, reliance on private investment and capital needs to be an integral part of the solution.

31. There are both equity and efficiency rationales for bringing agriculture within the tax net. Because of the country’s arid and semi-arid climate, agriculture in Pakistan is predominantly irrigated (90 percent) and consumes about 95 percent of annual available surface water. Though the bulk of farmland is irrigated through the canal system, farmers utilize water from other sources, including groundwater exploitation, and this has increased significantly in recent decades: subsidized water and electricity tariffs have induced adoption and expansion of electric pumps to tap groundwater at an alarming rate. Approximately 60 percent of farm-gate-delivered water in Punjab comes from tube wells. Yet agriculture is largely untaxed (contributing less than 0.1 percent of total tax revenues), even though it accounts for 21 percent of GDP and employs 43 percent of the population.

32. Given water’s multifaceted development role and its global dimension, there is room for closer engagement of the IMF through awareness raising and leveraging the ongoing lending arrangement. The IMF’s support for water reform in Pakistan should focus on agriculture taxation in the context of the upcoming National Finance Commission’s (NFC’s) award; phasing out electricity subsidies; and policy design for water pricing as part of the broader energy sector reform.

33. What are the lessons? Water can serve as an engine of economic growth and regional trade expansion in Pakistan. The country has the necessary natural endowment and is blessed with the world’s most extensive irrigation system. Harnessing such potential needs virtually a paradigm shift in reframing water policy and management in a national context that emphasizes demand-side measures that would promote conservation and control of excessive groundwater exploitation. Pakistan has a long history of experience with supply-side measures, including construction of mega hydro power projects and dams. Moving forward, the thrust of policy reform needs to be on improving water-use efficiency in agriculture, which continues to dominate water consumption while escaping taxation at the federal level and lightly taxed at the provincial level. This would require greater engagement of stakeholders at the local level in water management and capacity building of water management institutions. Furthermore, encouraging the provinces to reform their agriculture taxation systems in the context of the forthcoming NFC award could be a major step in overcoming

the entrenched political interests of powerful landowners and bringing agriculture into the tax net. The nexus between water and electricity is the other area calling for reform of water and electricity subsidies. Reforming NFC revenue-sharing mechanisms and phasing out electricity subsidies are two major reform areas supported by the current IMF Extended Fund Facility for Pakistan.

F. SINGAPORE¹⁰

34. Singapore is a densely populated city-state with no natural fresh water resources, apart from rainfall. It is located on an island (and some 60 small islets) with a total area of some 714 square kilometers (roughly the area of five boroughs of New York City). With a population of almost 5½ million, the country is third in the world in terms of population density. Ever since achieving independence, the authorities have been looking into ways to secure its water supply. The “*Four Taps*” strategy, which looks into alternative sources of water, was put in place in the late 1990s and aims at achieving self-sufficiency by 2062. The Singaporean approach is not limited to diversification of the supply sources. It also relies on demand management tools, research and development (R&D), and broad public support.

35. The *Four Taps*, the four sources of water, are:

- *Imports (up to 1,100 thousand cubic meters a day)* have been the main source of water since 1932, when a pipeline from the Malaysian state of Johor was inaugurated. Under the current agreements, expiring in 2061, the country is entitled to receive up to 60 percent of its current needs.
- *Local catchment water (900–1,400 thousand cubic meters a day)* is collected from about two-thirds of the country’s territory through a system of 17 reservoirs (started in 1868) and a comprehensive network of drains, canals, rivers, and storm-water collection ponds. The catchment territory is classified as partly protected with certain restrictions on land use in place, with land and water management processes closely integrated. Reservoir water is treated through chemical coagulation, rapid gravity filtration, and disinfection.
- *Reclaimed water (up to 520 thousand cubic meters a day)* refers to used water turned into potable using advanced membrane technologies. The NEWater project originated in 1974 but had to be shelved until 1998 given unreliability of the process and high costs. Today four plants meet up to 30 percent of the nation’s water needs, and the capacity is to be expanded to 55 percent by 2060. Although quality of treated water exceeds the WHO standards for drinking water, it is mostly used by industries for non-potable uses.
- *Desalinated seawater (up to 230 thousand cubic meters a day)* is produced by two plants that were launched in 2005 and 2013, are among Asia’s largest seawater reverse-osmosis plants, and allow meeting up to 25 percent of the current water needs. The plan is for this source to continue supplying a quarter of the country’s water needs in the 2060s.

¹⁰ Contributor: Robert Tchaidze.

36. Singapore employs a pricing policy that aims at discouraging excessive use of water and recovering costs to the fullest extent possible. Unlike in many other countries, both domestic and non-domestic users face the same base tariff, with no cross-subsidization of households by industrial and commercial users. Moreover, beyond a certain level of consumption, households face an additional surcharge that brings the total tariff to the rate higher than that for commercial and industrial users. There is no subsidized “basic” consumption; instead the government provides targeted help for low-income families. Consumers are also charged a flat water-borne fee (to offset costs of treating used water and maintaining public sewage system; for non-domestic users this fee doubles); a flat sanitary appliance fee (charged per sanitary fitting); and a progressive water conservation tax (supposed to reflect the marginal cost of the “next,” alternative water sources, including the R&D costs).

37. Rigorous management practices, continued investment in new technologies, and involvement of the broad society are other building blocks in the Singaporean approach. Singapore has a single agency—the Public Utilities Board (PUB)—that is responsible for all aspects of the water cycle, such as collection, production, distribution, and reclamation. The PUB is autonomous and enjoys support both from politicians and the general population. It undertakes significant investments in its own assets as well as assets that are in the government’s ownership, but under its management (such as sanitation and drainage infrastructure). Since 2005 it has regularly issued bonds to finance some of these investments.

38. Opening the *third and fourth taps* would have been impossible, had it not been for decades of investment into research and development of new, revolutionary technologies. The PUB cooperates with local and international researchers by making its research facilities available as test-beds and by sharing the costs and risks associated with these tests. This allows it to attract both private and public sector innovators and to remain ahead of the curve in implementation of new technologies. In addition, the National Research Foundation promotes R&D in the water sector through an inter-agency outfit, Environment and Water Programme Office, led by the PUB. Finally, an Institute of Water Policy has been established at the National University in 2008.

39. Given the emphasis put on water-related R&D by the government, Singapore has emerged as an international hub for water-related research. Today, the country is home to over 70 local and international water companies and more than 20 research and development centers. It also hosts an annual event, the Singapore International Water Week, where key global industry players share and co-create innovative water solutions.

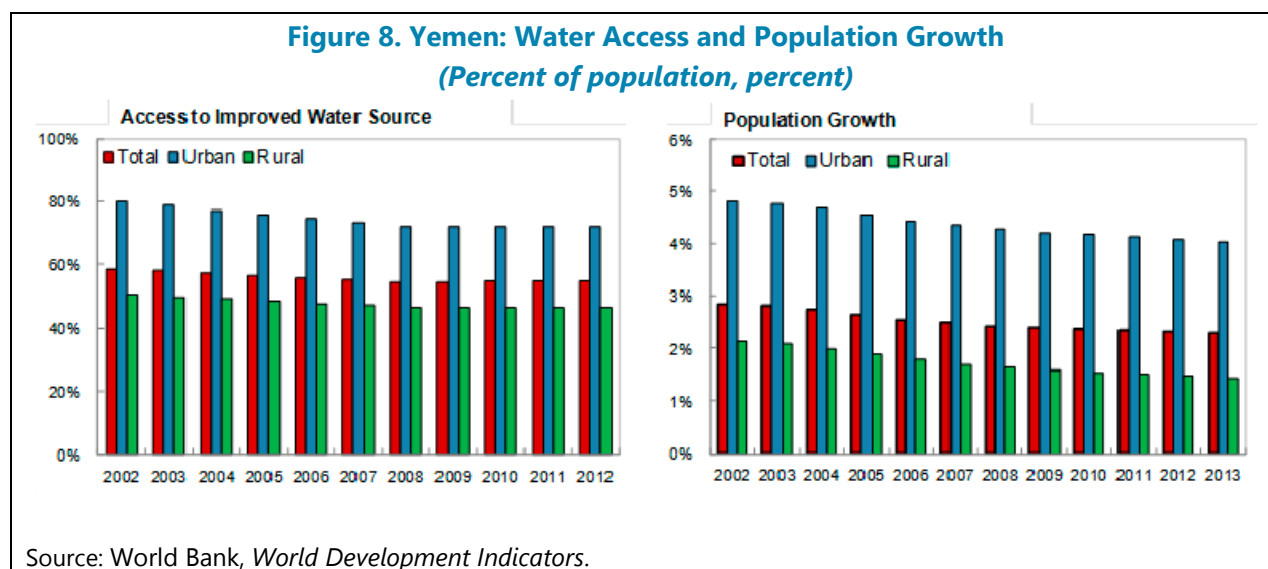
40. The PUB encourages every segment of the society to engage in efforts to make use of water resources more efficient. This is done through various public programs that aim at the so-called *3P* of population and public and private sectors and call for cleanup, beautification, and conservation of water resources. The PUB also gathers feedback on its work and suggestions for alternatives from the water industry and the broad community.

41. What are the lessons? High-level political support for long-range policy objectives and strong institutions, including an autonomous technocratic institution such as the PUB, seem to be among the key factors that enabled Singapore to put in place such a comprehensive strategy. The rapid improvement in living standards and industrialization of the economy, with a significantly reduced role of the agricultural sector, may have helped secure broad support for the government’s water management policies.

G. YEMEN¹¹

42. Yemen is one of the world’s most water-deficient countries. The extremely low level of water has led to increasing local conflict over water rights since the year 2000. Groundwater and rainfall are the sole sources of freshwater. Water availability per capita is around 2 percent of the world average, and has been trending downward in recent years, from 113 cubic meters in 2002 to 86 m³ in 2013. Over the same period, access to “improved water sources” declined from 60 percent to 55 percent of the population in aggregate. Both urban and rural population access to safe water also declined, with the latter now standing at 46 percent (Figure 8).

43. Demand for water is rising, while renewable supply has remained stable and groundwater is being depleted. Several factors contributed to the surge in demand for water in recent years, including rapid population growth, urbanization, and economic growth. Annual freshwater use has increased from 3.4 billion m³ in 2002 to 3.9 billion m³ in 2010. Meanwhile, annual renewable supply remains relatively constant at 2.5 billion m³ during the same period, and the inefficient and unregulated use of groundwater is depleting Yemen’s deep aquifers.



¹¹ Contributors: Mohd Zaher and Fouad Al-Kohlany.

44. Disparity in access to safe water follows the poverty map. The majority of urban consumers have access to a public water network, even though around 40 percent rely on trucked water; this figure is considerably higher for rural residents because fewer people are connected to public water networks. According to the World Bank, the cost of trucked water is up to 10 times that of network water.¹² The cost and effort involved in obtaining safe water are also considerably less for the well-to-do, compared to the poor. The high cost of water is forcing many rural women and girls to walk for hours fetching water.

45. The bulk of water resources is consumed by the agricultural sector, supported by generous diesel fuel subsidies. The share of the agricultural sector in water consumption remained relatively stable over the last decade, around 91 percent. Irrigating qat, a local cash crop and a mild stimulant, consumes around 40 percent of water used in agriculture. Similar to qat, a significant portion of agricultural exports, such as bananas, is also water intensive. The expansion of these crops has benefited from subsidies, which kept the price of diesel fuel, used in pumping groundwater for irrigation, extremely low until mid-2014.

46. The authorities have reduced fuel subsidies and raised the price of diesel by 50 percent since July 2014. While this move was largely motivated by the need to reorient public spending in favor of growth-oriented capital and development spending, it is expected to reduce the rapid depletion of groundwater resources and the distorted production costs that favor water-intensive crops such as qat. At the same time, to improve the poverty orientation of the budget, the authorities have increased the Social Welfare Fund monthly transfers to households by 50 percent.

47. Notwithstanding data limitations, a number of indicators point to significant socio-economic costs associated with water shortage in Yemen. The contamination of water sources and the decline in water availability to households have contributed to the spread of diseases in rural areas. Water and fuel shortages—particularly acute before the reduction in fuel subsidies—and more recently the increased production costs resulting from higher fuel prices have also placed farmers and agricultural workers at risk of unemployment, further exacerbating Yemen's economic situation.

48. Going forward, the water situation in Yemen is expected to deteriorate further. Assuming the continuation of the current consumption and production patterns, weak governance will impose a toll on the water sector. The fact that groundwater—which is by nature the most difficult to regulate—plays a key role in Yemen makes the governance of the sector particularly challenging. Recent estimates show that non-renewable water resources are expected to be exhausted within one to two decades in the most densely populated highlands, putting major Yemeni cities in a dire water situation. Sana'a, the capital city, is 2,000 meters above sea level in the water-scarce mountain ranges, where the groundwater table is dropping by more than six meters a

¹² World Bank 2012.

year. The location and altitude of the capital city are also making the cost of trucking or pumping water from coastal areas very expensive.

49. The government's response to the water crisis has been lagging. With help from the World Bank and GIZ, the government of Yemen introduced a water sector strategy in 2005, with the chief objective to gradually reduce the rate of groundwater depletion. The strategy has had no impact beyond enhancing awareness of water challenges in Yemen. Minimal impact on water usage and practices has been observed.

50. Political instability over the past four years hampered investments in the water sector and raised costs. The difficult security situation, lack of government presence in certain areas, and the inability to enforce the rule of law have all weakened the government's endeavors to rationalize water usage. The impact of the 2011 crisis on the water sector was severe. There has been widespread damage to installations and equipment and declining rates of water billing and collection.

51. Desalinization has been proposed as a long-term answer. However, this is an energy-intensive solution and will require large long-term investment. Without donors' support, this solution seems infeasible, especially as the country's fiscal balances can barely support its basic infrastructure needs. Furthermore, restoration of security in Yemen remains a priority to resume many of the foreign-financed water projects suspended following the 2011 crisis.

52. In summary, Yemen's water future appears challenging, and a broad reform agenda is needed to rationalize water consumption and improve efficiency. Unless addressed properly, the water sector difficulties could further delay the country's development, lead to internal migration and tribal conflict, and increase the cost of water in the major urban centers. Any viable solution should incorporate better management of water resources, public and private investments, foreign aid, closing the urban-rural water gap, and boosting water supply. As the largest water consumer, the agricultural sector in Yemen deserves special attention. Efforts should be scaled up and directed toward enhancing the efficiency of production and irrigation. The high urbanization rate in Yemen also requires the achievement of more inclusive growth to moderate the unbalanced growth of urban areas. Strengthening regulation and enforcement mechanisms is a priority to stop the widespread and unregulated extraction of underground water. Reforms should also encompass creating an enabling business and regulatory environment to encourage more active private sector participation in financing water projects and infrastructure.

53. The water sector will benefit from the full implementation of structural reforms embedded in the Extended Credit Facility program (ECF). Improving the overall efficiency of the economy through macro-critical structural reforms, particularly in terms of completing the phase-out of highly distortive energy subsidies, directing public resources to growth-enhancing investment and poverty-reducing transfers, and improving public sector management, will also benefit the water sector. These will be in the form of efficiency gains and water savings as farmers adapt their farming practices in response to changes in cost of inputs. Supporting the private sector's activity

and investments will also benefit from enhanced financial intermediation, better access to finance by small and medium-size enterprises, and an improved business environment.

54. The way forward: there is an urgent need for Yemen to improve its water resource management. A broad reform agenda, along with well-coordinated donor support, is needed to boost water supply, rationalize consumption, and improve efficiency. Most important, Yemen needs to implement price-based reforms and to change the legal and social understanding of water rights to reflect the true cost of water resources and minimize inefficient use.

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