SECTION 4

Water

Photo credit: Flickr: Arne Hoel / World Bank

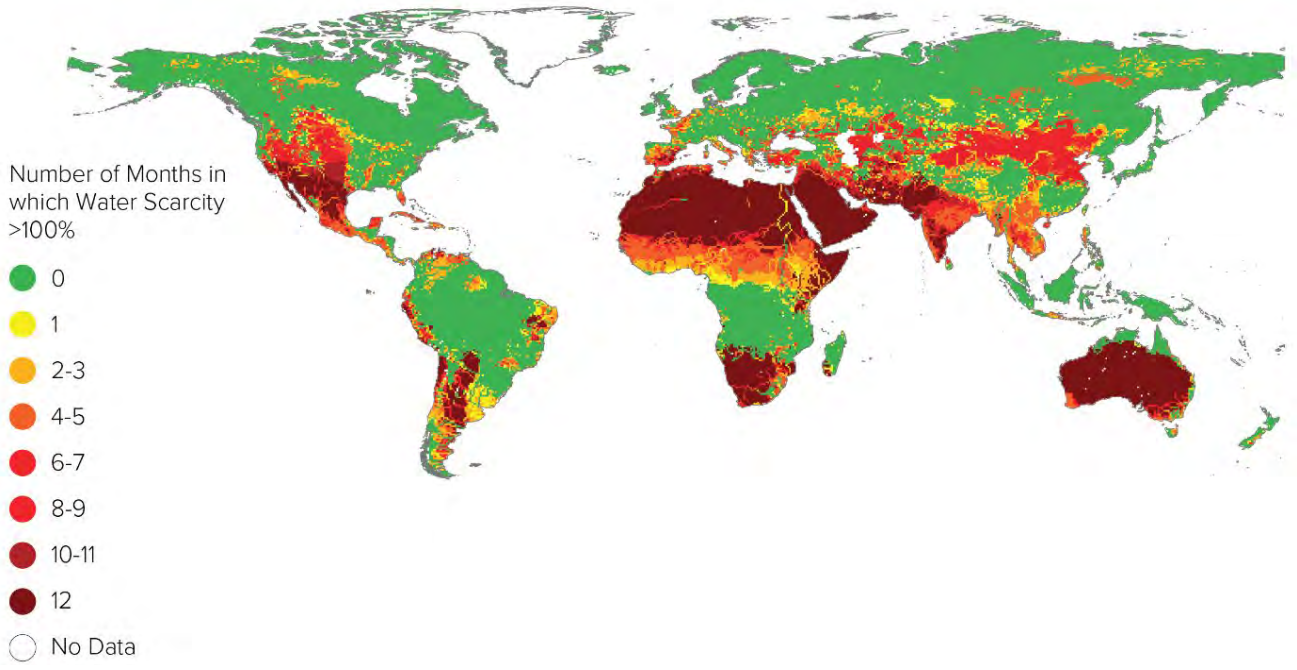
Flowing through every part of our economy, water is a fundamental necessity for lives and livelihoods. Access to safe, sufficient water and sanitation and sound management of freshwater ecosystems are essential to economic prosperity, health and development outcomes, and to environmental sustainability.[864] Yet the world is not managing water well or making the most of it, due above all to failures of policies, governance, leadership and markets. The existing challenges include inadequate access, poorly managed risks and increasing competition for water resources. Climate change will amplify all of these challenges (Box 40).

Already, 4.5 billion people, about two-thirds of the world's population, rely on sanitation that puts their own or their neighbours' health at risk from waterborne diseases, and 2.1 billion people live without readily available, safe water supplies at home.[865] Where piped water is absent, women and girls spend hours every week, or even every day, collecting water at the cost of their education and earnings. Fewer than a quarter of women and girls in Niger are literate,[866] and on average every one of them loses 13 days a year travelling to and from a water source.[867] What's more, the effects of poor management of water risks can play out over an entire lifetime. For instance, a girl in rural Africa born during a severe drought is more likely to grow up physically shorter, receive less education, become less wealthy and, indeed, pass on aftereffects to her own children, who are also more likely to suffer from malnutrition.[868]

Today, more than half the world's population, roughly 4.3 billion people, live in areas where demand for water resources outstrips sustainable supplies for at least part of the year (Figure 26).[869] Societies can move and store water, for example in reservoirs, to manage the impacts of this kind of water deficit on their economies and people. Freshwater ecosystems however, do not have this option, and require water of specific quantity (and quality), at specific times, to thrive and build resilience to local and global change.[870]

Figure 26

The Number of Months per Year in Which More Water Is Withdrawn Than Is Sustainably Available (Annual Average 1996—2005).



Source: Mekonnen, M., and Hoekstra, A., 2016.[871]

Irrigated agriculture already uses around 70% of available freshwater,[872] and the world will need to produce 55-70% more food to feed its people by 2050.[873] With demand in other sectors set to rise by 55% globally over the same period—mainly for electricity generation, manufacturing, and domestic use—competition is set to increase.[874] It is vital to improve the productivity of water use, getting more value from each drop, but it is also vital to protect poor and marginalised users who are most likely to lose out from increasing competition. Better governance is needed to balance supply and demand, securing sustainable, productive, and equitable shares of water for all in a changing climate. We also need investment to improve access to water where and when it is needed, and to protect people from hazards that are already increasing in frequency and intensity (Box 40).

Box 40
How Climate Change Affects the Water Cycle

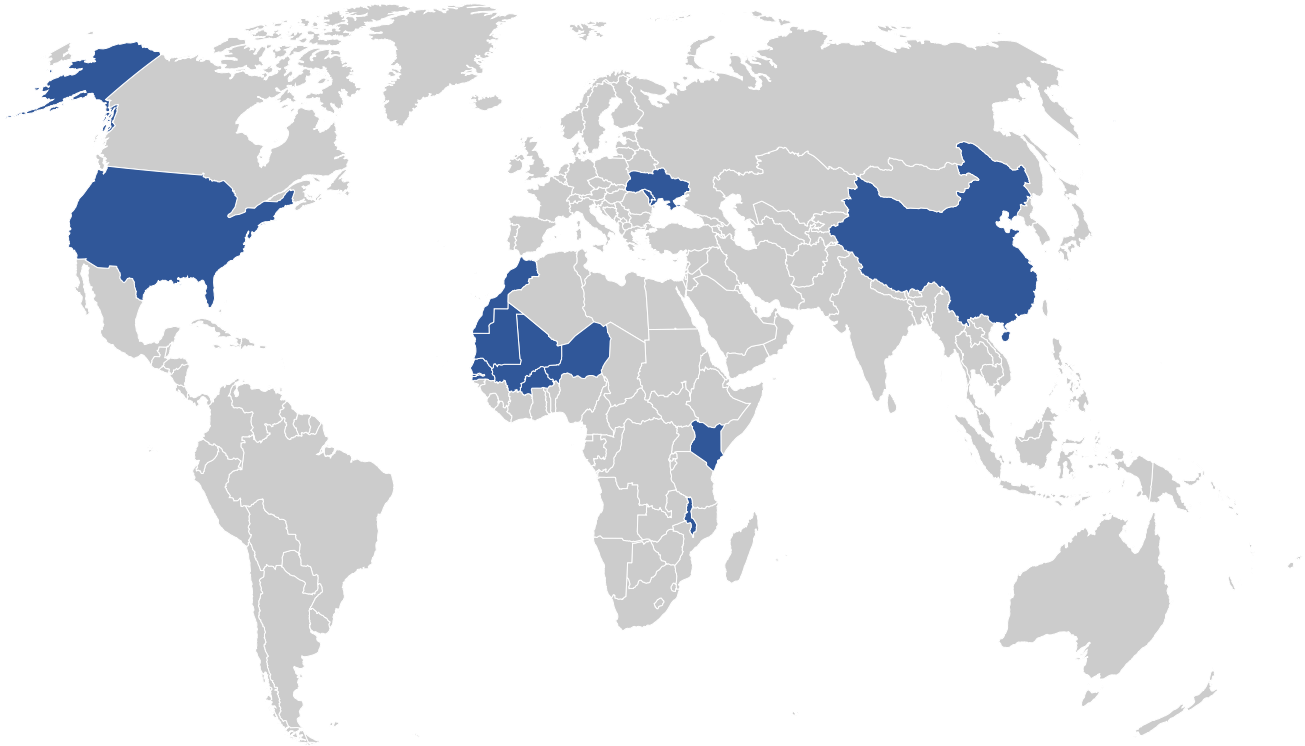
Water is the front-line for climate change and the sector most often mentioned for adaptation actions in developing countries' NDCs.[875] Climate-change impacts affect the water cycle primarily on four fronts, amplifying existing challenges. First, climate change affects availability: less water for some and more for others. Recent estimates suggest that climate change will expose more people to water scarcity,[876] which, combined with other factors, could lead to greater demand for already-depleted groundwater.[877] Second, climate change affects unpredictability, including increased levels of rainfall variability, as well as glacier loss and rain rather than snow at altitude, that reshape the flows of rivers and stores of groundwater.[878] Third, quality is affected. For example, rising sea levels and storm surges drive saltwater into unconfined coastal aquifers and deltas.[879]

Finally, extremes: Water-related natural disasters are increasing in frequency and intensity, with mounting evidence from China[880] to California[881] attributing these crises to a changing climate. Climate change tripled the likelihood of the drought that pushed Cape Town to the brink of 'Day Zero'.[882] Moreover, the economic costs of these disasters are also projected to rise. California's drought cost US$2.2 billion and over 17,000 jobs in the agricultural sector in 2014 alone.[883] Germany, France, Italy, and Poland can all expect average annual flood damage costs to rise to more than €1 billion each by 2020. The proliferation of infrastructure in flood-risk areas could nearly double these costs for Poland and Germany to around €2 billion each.[884]

There is sufficient freshwater on the planet to secure clean and accessible water for all, according the UN.[885] Locally, physical water volume is already a serious concern in some areas, whether in terms of scarcity or floods, and climate change could worsen this. But the biggest existing water and sanitation challenges have more to do with economics and politics than physical availability. Market failures and weak policies occur not only within the water system, but also in the other systems discussed in this Report. Energy sector planning ignores water risks. Subsidised fertiliser, energy, and crops drive unsustainable levels of water usage and pollution in agriculture. Politicians and service providers ignore the vulnerability of sprawling city slums to waterborne disease and floods. The political economy challenges are also exacerbated by the transnational nature of water, given that 151 countries and roughly 2.8 billion people share transboundary river basins. Managing water resources will require strong international collaboration, for example through adaptation planning initiatives such as in the Dniester Basin (see Box 41).[886]

Market and policy failures are already undermining our ability to balance supply and demand, and to improve access and resilience.[887] There is a heavy economic and social cost of doing nothing, but climate change provides new impetus and ways to turn those costs into benefits. This chapter identifies two key opportunities: first, to improve water governance through policies and collective action that balance supply and demand, as well as the benefits and risks from water; second, to make smarter investments in resilient, low-carbon infrastructure to improve access. In both of these areas, this chapter highlights promising examples of water management around the world.

Figure 27
Locations of Transformative Examples in Water Highlighted in This Report.



Note: The map reflects the regional example on the African Risk Capacity (ARC) insurance pool (see Box 43). It shows the ARC signatory countries that have participated in the insurance pool.

Box 41
Climate Adaptation Planning as an Entry Point to Cooperation in the Transboundary Dniester Basin

The Dniester River is one of the largest basins in Ukraine and the largest in Moldova, covering more than 10 million people over an area of more than 72,000 km2 and supporting a wide range of industries including mining, extractives, chemicals, food and forestry, and hydropower production.

In 2015, high-level government representatives from the two countries signed a Strategic Framework for Adaptation to Climate Change that identified joint cooperative actions at the basin level, including improving the monitoring and forecasting of flows and information-sharing, updating rules for the system of reservoirs in the basin, and providing public and local authorities with timely information on flood risk. [888] Critically, careful facilitation ensured that the framework was developed without political dispute. For example, at national workshops, a basin-wide map without national borders was used by stakeholders to discuss the location of vulnerable areas within the basin and potential climate adaptation measures. [889] The strategic framework was developed by expert representatives from both countries but was supported by the United Nations Economic Commission for Europe (UNECE) Water Convention secretariat and the Organization for Security and Co-operation in Europe with financial support from the Austrian Development Cooperation and the European Union's Instrument for Stability.

Some measures—ecosystem restoration, monitoring stations, and awareness-raising activities—have already been implemented. Outcomes have included increased adaptive capacity in the basin as well as the improvement of transboundary water cooperation more broadly, particularly through the entry into force of the transboundary Dniester treaty in 2017.[890]

Lessons from here are being shared and replicated elsewhere in the framework of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention).[891] There are opportunities to learn from them in river basins from the Danube to the Mekong, where several transboundary climate adaptation strategies are agreed to or in development.[892]

Box 42
Finance for Water

By 2030, investment in water and sanitation infrastructure will need to be around US$0.9—1.5 trillion per year, roughly 20% of the total infrastructure investment requirement.[893] About 70% of this total infrastructure investment will be in the global South with a large share in rapidly growing urban areas.[894]

In developed countries, large investments will be required for renovation and upgrade, while in developing countries many people lack even minimal sanitation and water supply services. For example, in sub-Saharan Africa, 72% of the people lack even a 'basic' standard of sanitation, and 42% lack a basic water supply.[895] (See also Figure 13 in Section 2.B). Roughly US$114 billion per year, mainly in developing and emerging economies, could secure access to safely managed drinking water and sanitation for all. While the financing required for infrastructure to meet SDG 6 water supply and sanitation targets is modest compared to total water and sanitation investment needs, it is still more than three times historic investment trends.[896]

Making sure water and sanitation infrastructure is sustainable need not cost more than non-sustainable infrastructure. In fact, it may even be cheaper, but it requires shifting the way we invest and prioritise finance, including prioritising public finance for the most vulnerable. To that end, all public and private water and sanitation investments should take into account climate risks, which in turn requires the embedding of climate risk-screening and design into public procurement policies.[897]

Maximising returns on investment requires recognising the potential for natural or green infrastructure to complement or replace built infrastructure. For example, watershed protection can reduce the need for investment in water purification and storm water management (see Box 45). [898] Downstream users can pay upstream users for land and water conservation activities that improve water availability and quality and reduce flood risk (see Box 32 on Finance for Food and Land Use).[899]

To mobilise private finance and investment at scale, it will be vital to put an appropriate value on water and sanitation services, without pricing out poor consumers, to generate reliable revenue streams. Greater concern over water risks with climate change provides even greater impetus to do this. For example, in water-scarce South Africa, the secure revenue offered by mining companies purchasing treated wastewater helped secure a US$37 million commercial loan for upgrading Rustenburg's wastewater and water infrastructure.[900] In Jordan, where large volumes of treated wastewater are already reused for irrigation, freeing up freshwater for higher value uses in cities. Here, a public private partnership (PPP), was used to finance, upgrade, and operate the As-Samra Wastewater Treatment Plant.[901] Disaster risk financing offers another set of tools to improve people's ability to cope with unavoidable water risks and shocks, but action will need beyond to extend beyond the water sector to expand financial and social inclusion (including for women and girls), to promote social protection, the use of insurance, and the availability of contingent finance.[902] (See Box 43). These examples show how use of scarce public funds can leverage private-sector engagement to raise capital and help close the water and sanitation infrastructure financing gap.[903]

Use of green bonds is gaining some traction as a way to finance water and sanitation infrastructure investment. Notable are the water sector criteria established in the new Climate Bonds Initiative (CBI) standard, which are being extended to cover upstream natural or green infrastructure.[904] The recent issuance of green bonds by San Francisco and Cape Town, both of which were certified by CBI and received a positive market response,[905] shows the potential for scaling up green bond debt financing in this sector.[906]

Finally, financial disclosure of climate-related and other water risks is another key way to shift investment. Institutional investors and their asset managers should explicitly integrate sustainability considerations into their decision-making processes and report on how they are doing this, per the recommendations of the TCFD. While an increasing number of companies are voluntarily disclosing water risk information, with more than 2,000 companies reporting annually to CDP,[907] the lack of standardisation in disclosure slows change. To truly shift financial markets, regulators need to move towards mandatory and standardised approaches to enhanced disclosure.

4.A. Fair Flows: Balancing Benefits and Risks from Water between Different Users

Climate change has the potential to amplify extremes and further disrupt the delicate balance between water demand and supply. Better governance, policy, and planning is urgently needed to allocate water resources and the risks and benefits arising from water more equitably, efficiently, and sustainably.[908] This section points the way, highlighting successful examples of governments balancing demand and supply with clear plans and the right information; of companies taking action to understand and reduce their water risks and working with others to address shared water challenges through collective action; and of international collaboration to manage water-related disaster risks through packages of policies that balance ex-ante risk reduction with investments that can enable faster post-disaster recovery.

Evidence of the Benefits

Robust policies for sustainable and equitable water allocation safeguard the availability of water for people and for a huge range of valuable goods and services. While poor water allocation policy can hamper economic growth, the World Bank estimates that sound policies could increase GDP in some regions by as much as 6% by 2050, despite climate change and population growth.[909] Governments bear overall responsibility for water allocation policy, especially at the national and river basin scales. However, at smaller scales, such as the watersheds that make up a larger river basin, a wide range of stakeholders can also contribute to wiser water management and share the benefits.

Businesses can reduce costs by using less water in their own operations. Beverage company Diageo estimated that it saved US$3.2 million in 2014 in this way.[910] But businesses can also secure broader benefits by working with others beyond the factory fence. An increasing number of companies see sufficient business value to invest in water stewardship, a stakeholder-inclusive approach to secure benefits from water use through on-site and watershed-based actions.[911]

Payment for watershed protection services is an increasingly prominent instrument to incentivise collective responses to balance and mitigate shared water risks, both in water stewardship initiatives and more widely (for example, as part of smart agricultural subsidies, see also Section 3.C). These allow downstream users to pay upstream users for land and water conservation activities that improve water availability and quality or reduce flood risk.[912] In Nairobi, business and industry partners contribute to a scheme helping farmers upstream on the Tana River to reduce deforestation, which in turn prevents sediment from running into waterways and clogging dams and other water supply systems. The initiative, managed by The Nature Conservancy, has reduced water delivery interruptions caused by sediment spikes by 30% since 2013.[913]

At a range of scales from countries to individuals, improved water policy and planning also carries economic and resilience benefits where it mitigates water-related disasters. At the level of a single national economy, historical analysis suggests that mitigating half the effects of major droughts between 1980 and 2012 could have added 7% to per capita GDP in Brazil and as much as 20% for Malawi.[914] At the individual level, during large and protracted reductions in rainfall in the period 1990—2013, formal sector workers across Latin America lost around 7% of labour income, while those outside the formal sector lost as much as 11%.[915] To avoid costs and unlock additional benefits of resilience to disasters, countries need a wide range of complementary policies and an assessment of water governance conditions in place to establish priorities for the future.[916] Water-related disasters account for 70% of all deaths related to natural disasters,[917] and efforts to improve water governance and management are an important but often a neglected strategy to reduce exposure and vulnerability to climate variability and change. However, to improve people's ability to cope with unavoidable shocks, action is needed far beyond the water sector: to expand financial and social inclusion (including for women and girls), to promote social protection, the use of insurance, and the availability of contingent finance.[918] Approved in 2017, the ADB's US$15 million Pacific Disaster Resilience Program for Samoa, Tonga, and Tuvalu supports policy actions for disaster risk management (DRM) and provides the three countries with a source of contingent financing for timely disaster relief, early recovery, and reconstruction activities.[919] Box 43 on African Risk Capacity Insurance Company Limited (ARC Ltd.), a sovereign insurance pool, highlights one possible part of this resilience package, operating at an international scale, as well as the need to integrate it with other parts, such as national social protection systems.

Box 43
Africa's Sovereign Disaster Risk Insurance

Agriculture is the main source of income for 90% of Africa's rural population, and over 95% of farmed land in the continent is rain-fed, making many African farmers vulnerable to drought.[920] Drought risk can be managed in part with better policies and investments in adaptation in the water and agriculture sectors. However, when severe drought strikes, poor rural communities need rapid and dependable support to stave off hunger and avoid having to sell off their assets.

In response, African governments through the African Union have established a specialised agency, African Risk Capacity (ARC). One of ARC's innovations is a sovereign risk pooling facility, African Risk Capacity Insurance Company Ltd (ARC Ltd). ARC Ltd. is designed to provide predictable and rapid financial assistance to meet part of member governments' response costs as extreme weather hits. The drought insurance is parametric, meaning it is paid according to a country specific pre-determined index and can therefore can arrive in countries' treasury accounts well before either international humanitarian appeal funds or conventional insurance, which involves an assessment of actual loss.

After an extensive 12- to 18-month capacity building exercise, which involves learning the proprietary early warning system of ARC and the completion and subsequent approval by peer member states of a contingency plan, the sovereign is entitled to purchase the insurance. The insurance drought model employs an index based on satellite rainfall estimates, which are used to model the impact of rainfall on crop yields and pastures at different times of the season and overlaid with in-country vulnerability data to ensure it serves the most vulnerable in society. Development partners have supported this with funding for capitalisation of ARC Ltd., as well as grant funding for technical support and capacity-building in ARC member states.

Because risks are pooled across countries in very different climatic zones, the fund is unlikely to have to make payouts to all countries at once.[921] In three years of operation, ARC Ltd. made two payouts to four countries: US$26.3 million to Mauritania, Senegal, and Niger in 2015, against a combined premium of US$8 million; and US$8.1 million to Malawi against a US$4.7 million premium. Together the payouts supported an estimated 2 million drought-affected people.922 There are challenges. For instance, Malawi's payout in 2017 was not triggered until the software model translating rainfall data into a response cost was recalibrated, slowing disbursement of funds.[923] Investing in risk insurance also clearly carries opportunity costs, potentially shifting scarce funds from other priority objectives.

As occasional extreme weather events become more frequent,[924] a grim new normal especially in Southern Africa, the longer-term implications for ARC Ltd. will need to be carefully considered. In the meantime, this innovative model is also being used in the Caribbean and Pacific region and supported by the InsuResilience Global Partnership. The InsuResilience Global Partnership seeks to facilitate faster and more reliable post-disaster responses. In further developing these regional risk pools, it aims to better prepare for climate and disaster risk by using financial solutions, reducing humanitarian impacts, and assisting the poor and vulnerable in order to strengthen adaptive capacity and local resilience.[925] The partnership has raised US$715 million in less than three years.[926]

Empirical evidence is still limited on how effective insurance is in supporting poor people in the face of disasters, however. Investment in climate and disaster-risk financing, including through insurance at the sovereign level or below, is one piece in a much larger adaptation puzzle. To be effective for the poorest people, risk financing requires strong social safety nets in-country[927] and should be complemented by ex-ante risk reduction.[928]

Challenges

Water allocation and management regimes in many countries are not fit for purpose under current climate conditions, let alone under a changing climate.[929] Policy reform efforts are often blocked or captured by powerful interest groups. India's groundwater levels, for example, are already over-exploited, and 54% of the country faces high or extremely high water stress.[930] Here and elsewhere, groundwater will be increasingly important, as climate change increases variability in precipitation, soil moisture, and surface water availability[931] (see Box 40). Subsidies for electricity, however, continue to drive unsustainable groundwater withdrawals. Solar powered groundwater pumps open up new opportunities for irrigation around the world, including in India where they, too, are being heavily subsidised.[932] To keep withdrawals to sustainable levels, policy-makers need to work around vested interests or develop compensatory measures. For example, quantitative regulation of water use in the manner developed in China's Turpan Prefecture has reduced groundwater overdraft, while still boosting farmer income by around 4% with higher value crops.[933] (see Box 44).

Water's physical characteristics also pose challenges. Establishing real water savings at the scale of a river basin is much harder than saving water at the level of a single field, factory, or home. There may be real energy savings from saving water—moving and treating water globally used nearly as much as Australia's total energy demand in 2014[934]—but unlike energy, water that is seemingly wasted through inefficiencies will often be used productively by someone else within a basin.[935] Policy and planning to manage demand and ensure that risks are properly allocated must therefore be based on solid water accounting at the level of the river basin.[936] Ultimately, the key strategic objective must be to establish and enforce sustainable limits on total withdrawals for the entire river basin—including ensuring enough water, seasonally, to ensure resilient freshwater ecosystems. Only then can the overall productivity of water use be improved, through a range of policies and technologies, including permitting and pricing, precision irrigation, making industrial processes more water-efficient, and wastewater reuse. Circular economy approaches that consider the productivity of water across multiple users can offer greater value overall. Jordan, for example, successfully used treated wastewater for nearly a quarter of its irrigated agriculture in 2014.[937] In Belgium, Heidelberg Cement has ensured that 95% of water pumped out of its limestone quarry in Antoing is used for drinking water supplies, helping groundwater levels to stabilise and increase.[938]

Much better data are needed to support water accounting, with the number of hydro-meteorological monitoring stations declining since the 1980s.[939] Business and civil society can contribute to plugging the water data gap. For example, WRI's Aqueduct is seeking to expand its public data platform with a global geodatabase of public water management indicators crowdsourced from companies.[940] New technologies, such as remote sensing to measure evapotranspiration (Box 44), can increase transparency on how much water is actually being used by agriculture at least at larger scales. Strides are also being made in measuring the benefits and risks associated with water—from water utilities in the United Kingdom that are mainstreaming natural capital accounting into their infrastructure planning decisions[941] to metrics that reveal the much greater impact of disasters on poor people, by focusing on well-being in addition to infrastructure and production.[942]

Box 44
Getting More Value from Less Water in Turpan, China

Agriculture accounts for around 70% of employment in China's Turpan Prefecture, and the expansion of irrigated land has increased pressure on groundwater reserves. Traditionally managed and distributed through a network of tunnels and access shafts, called the Karez, in many areas these traditional approaches have been overwhelmed by the intensification of farming and other industries. Despite initial government efforts to use modern irrigation technologies with the aim of expanding production while saving water, groundwater levels continued to decline by 1.5 to 2 metres each year because water savings from more efficient technologies were used to expand the area under production (by a third from 2000 to 2008), ultimately driving increases in overall water consumption at a basin-scale.

In 2008, the government tried a new approach, in collaboration with the World Bank. A thorough assessment of the water balance at basin level helped build the case for the politically challenging decision to reduce the area under irrigation and impose strict water consumption caps. The prefecture's water managers turned to satellite remote-sensing to assess evapotranspiration, allowing them to monitor water use and productivity and reform the allocation system on the basis of actual consumption. The programme focused on getting more value from less land and water through a shift from commodity crops like cotton and maize to higher value melons and grapes. As a consequence, farmer incomes increased at around 4% above inflation, and groundwater decline reduced by almost 170 million m3. [943]

Accelerators

- **Governments should put in place robust water allocation policies and plans that establish the full value of water, protect the poor as well as ecosystems, and factor in population growth and a changing climate.** Incentives like water pricing and permits and technologies to enhance water productivity can contribute to balancing supply and demand. Yet as the Turpan experience shows, strong public regulation is essential, using accurate water accounting to establish agreed and enforceable limits on overall and individual usage. Taking account of climate change and other drivers like population growth, water accounting must also underpin planning, and water can be better embedded in national development and climate plans, including both mitigation and adaptation components of NDCs. Government can also establish cross-subsidies for poor users in water pricing regimes and make dedicated allowance for environmental needs within allocation policies. Women can play a key role in improving water management outcomes: Countries can follow the example of Uganda, which has a dedicated five-year gender strategy for water and sanitation.[944] The World Bank estimates that improved policies for water allocation could increase GDP in 2050 by 6% in some regions.[945]
- **Businesses should identify water risks, develop water-smart business models, and monitor progress in their operations and supply chains against context-relevant targets.** Companies around the world are waking up to water risks and opportunities. Those companies disclosing on water issues to CDP reported US$23 billion in investment commitments in 2017 to tackle water risks in their operations and beyond.[946] Radical transparency requires all businesses to work to understand and disclose water risks to their stakeholders, including investors and customers, and mitigate these through actions in their own premises, factories, and farms. Companies can also do more to improve water management in their supply chains[947] and engage with government and other stakeholders, transparently, to improve water policy at river basin scale.[948] Targets to drive ambition and innovation should be set contextually, according to the capacity of surrounding river basins to provide water and absorb pollution.[949]
- **Water users, including businesses, utilities, public agencies, and households, should collaborate via watershed protection schemes.** Improving water management requires finding innovative ways to incentivise collective action, for example, by better allocating benefits and costs. In 2015, 197 watershed protection payment schemes around the world—covering an area greater than Mexico's total arable land—channelled US$657 million from upstream users to downstream users for land and water conservation activities in order to secure improved water availability and quality and reduce flood risk for downstream users. A much larger sum, US$23.7 billion, was spent by governments in the form of incentives for landowners to undertake watershed protection.[950] These kinds of payments could also support a just transition for vulnerable communities away from conventional agricultural subsidies that encourage unsustainable use of water, energy, and land.
- **Governments and regional organisations should promote tailored policy packages to reduce exposure, minimise losses from natural disasters, and increase resilience, at least cost.** A wide range of policies and investments from improving water management to slum-upgrading, land zoning, and titling and investments in early warning, can reduce exposure and vulnerability of people and infrastructure before disaster strikes (see also Section 2 on Cities). Additional policies to improve financial inclusion and establish social safety nets, contingency funds, and insurance (such as ARC, Box 43) can increase resilience by accelerating recovery and smoothing the impacts of shocks. Implemented globally, a comprehensive package of policies for disaster risk reduction and improved resilience could avoid losses of around US$100 billion per year, once the outsize impacts of disasters on poor people are properly accounted for.[951]

4.B. Priming the Pump: Targeting Investment to Resilient Infrastructure for People and Economies

The world will need to invest around US$90 trillion by 2030 to close the global infrastructure gap.[952] Around 20% of this is the infrastructure needed for water resources management and water and sanitation services, for which investment needs by 2030 are estimated at US$0.9—1.5 trillion per year.[953] While infrastructure renovation and upgrade are needed in developed countries, roughly two-thirds of the global infrastructure investment that is required will be in the global South.[954] Here, especially, investments can help to bridge the adaptation gap and reduce poverty.[955] For example, a small share of total global water infrastructure spending—an estimated US$0.1 trillion per year, mainly in developing and emerging economies—could secure access to safely managed drinking water and sanitation for all (SDG targets 6.1 and 6.2). These volumes of finance, while relatively modest, are still more than three times historic investment trends.[956] Currently, billions lack these essential services, exposing them to diseases like diarrhoea (still a leading cause of death globally);[957] imposing huge burdens on well-being, dignity, and productivity; and undermining their ability to cope with climate change. Similar deficits are found in infrastructure for water storage, irrigation, and flood defence, which are needed to manage rainfall variability and climate extremes.[958]

Infrastructure in other sectors also needs to contribute to water security and withstand water-related climate risks such as floods, droughts, and rainfall variability.[959] Not only are 40% of India's power plants located in highly water-stressed areas, but the country's largest power utilities lost more than US$1.4 billion in potential revenue due to water shortage-related disruptions between 2013 and 2016.[960] The transition to a low-carbon economy is not immune to water risk. Hydropower dams being built on Africa's Zambezi and Nile rivers, for example, are clustered in areas with high rainfall variability, increasing the risk of a single dry period interrupting electricity generation and critical energy services.[961] Under one clean energy scenario, water withdrawals could be reduced by 12% by 2040, but in other scenarios with more biofuels, concentrating solar, carbon capture and storage, and nuclear in the mix, the amount consumed (not available to other users downstream) could still increase by 2%. Impacts are dependent on the exact mix of technologies and how they are distributed in relation to available water.[962]

Excitingly, innovations are opening up new possibilities for water system design and management, for example, in ICT, circular economy approaches, and nature-based solutions. China's Spong City project, for example, aims for 70% of rainwater to be absorbed and reused across 80% of its urban areas by 2030, through a mix of green and grey infrastructure.[963] Initial results include reduced urban waterlogging and improvement of water-related ecosystems, as well as improved public satisfaction.[964] While interest rates may be low, financing challenges must also be overcome, not only to find the money but to make spending more climate-smart.[965] That means embedding climate resilience as well as mitigation into infrastructure investments. This can be done by ensuring that international grant finance goes towards increasing access to basic infrastructure, including drinking water and sanitation services in the poorest countries, and incentivising resilience and reduced emissions. In emerging and developed economies, domestic and concessional international finance, including through MDBs, can crowd in private investment in infrastructure. Much more can be done to direct this private investment to infrastructure that offers resilience as well as mitigation co-benefits. And private finance can also incentivise improved and mainstreamed assessment, disclosure, and action on water-related and other climate risks across infrastructure projects and portfolios.

Evidence of the Benefits

The return on investment from conventional water and sanitation infrastructure and services is high. At the global level, every dollar invested in sanitation returns on average US$5.5 in benefits, and every dollar invested in drinking water supply returns US$2 (Figure 28).[966] Adequate water supply, sanitation, and hygiene for all could avert the deaths of 361,000 children under the age of five every year.[967] In urban slums particularly, closely packed living conditions, inadequate infrastructure, and poverty combine to increase disease risk.[968] Investments in water storage and conveyance infrastructure also carry significant benefits. In 2010, securing water for existing irrigators could have generated global welfare gains of US$94 billion.[969]

Well-constructed and managed water supply networks, sanitation systems, storage, flood defences, and early warning systems are also a foundation of resilience to climate change and water-related extremes.

Nonetheless, water and sanitation infrastructure, and indeed all infrastructure, needs to be made more resilient through better choice of technology, siting, and, above all, improved policies, governance, and management. There will be costs to this. Adaptation costs for water supply and riverine flood protection, for instance, have been estimated at US$27—34 billion per year from 2010 to 2050.[970] A related challenge is that it is not always easy to quantify the benefits especially if they accrue over time.

There are clear advantages to acting now. First, including a more comprehensive assessment of risk and design in adaptability from the outset may not be more expensive than conventional approaches and could even be cheaper. Here, there is an increasingly recognised role for nature-based solutions to help build resilience to climate change and disasters, as an alternative to fixed concrete infrastructure. Nature-based solutions are frequently emphasised in National Adaptation Programmes of Action,[971] and there are many opportunities to use them in water management. In the United States, the DC Water utility has, for example, invested in natural or green infrastructure to manage stormwater and prevent pollution of rivers, allowing it to adaptively increase capacity in ways that large concrete infrastructure often prohibits, as well as spread costs more smoothly for its ratepayers over time. The utility also raised US$350 million in 2014 for its wider Clean Rivers project through a municipal century bond with a 100-year tenure—the first of its kind in the United States. Attracting over US$1 billion in market interest, there are signs that smart investors are increasingly looking for this kind of long-term, green opportunity.[972] DC Water has issued a further US$200 million in green bonds[973] and in 2016 pioneered an innovative US$25 million environmental impact bond, again the first of its kind in the United States (see Box 45).[974]

Box 45
Greening Washington DC's Water Infrastructure

Combined sewer overflows (CSOs), where drains mixing sewage and rainwater overflow into rivers during storms, are a major problem for DC Water, in the historic heart of the US capital city. Nitrogen and other pollutants flow into the Potomac river when CSOs occur, ultimately starving aquatic life of oxygen in the Chesapeake Bay, the largest estuary in the US.[975] In response, DC Water initially planned a US$2.6 billion Clean Rivers Project involving three large holding tunnels for sewage and stormwater, and the utility funded it through a green 'century bond'. The bond, worth US$350 million and attracting more than US$1 billion in market interest, was the first bond from a municipal water and wastewater utility with a 100-year tenure and the first green bond in the United States to receive an independent review.[976]

Subsequent to the bond issuance, DC Water negotiated with federal authorities to substitute one of the tunnels with green infrastructure. Green infrastructure, including grassed swales, permeable pavements, and increased tree cover, can absorb stormwater and reduce the amount running into drains in the first place. Although mandated by a federal decree, the whole project depends ultimately on revenue from customers. A levy is placed on customer bills, based on the impervious area of properties.[977] This links the fee closely to the proximate cause of CSOs and and includes an offset mechanism in which customers can get a small discount for specified stormwater management actions on their own property. Some regard the charge as unfair, as it penalises customers such as cemeteries and churches with minor wastewater treatment needs but large impervious areas. Nonetheless, the project is set to meet the objectives of a 96% reduction in system-wide CSO volume and prevent 500 tonnes of nitrogen from flowing into the Chesapeake, while offering additional benefits. These include increased property values through improved aesthetics and more opportunities for local job creation.[978] Made up of many small interventions, green infrastructure initiatives of this kind are also more adaptable in the face of climatic and other future changes, compared to a large single tunnel project.

DC Water has subsequently issued a further US$200 million in green bonds,[979] and in late 2016 it issued the first US Environmental Impact Bond, at US$25 million, privately placed with Goldman Sachs and the Calvert Foundation. A portion of risk associated with green infrastructure construction is transferred to investors, for whom a higher return is triggered if reduction in storm water runoff per acre exceeds an estimated 41.3%, while investors owe a risk-share payment to DC Water if runoff reduction is below an estimated 18.6% (generating funds for further remedial work to reduce sewer overflows, if required).[980]

Second, any increase in up-front costs—a potential 'resilience premium'—must be set against the cost of adaptation in the case of action. Without up-front action, of which infrastructure is a key part, the climate-change adaptation costs in developing countries alone are expected to soar to as much as US$300 billion per year by 2030 (6–13 times current levels of international public finance for adaptation) and US$500 billion by 2050.[981] Already, inadequate drinking water supply and sanitation entails an estimated US$260 billion per year in economic losses globally, more than twice the investment required for safely managed services for all. These economic losses represent 4.3% of GDP in sub-Saharan Africa and 2.9% in South Asia.[982]

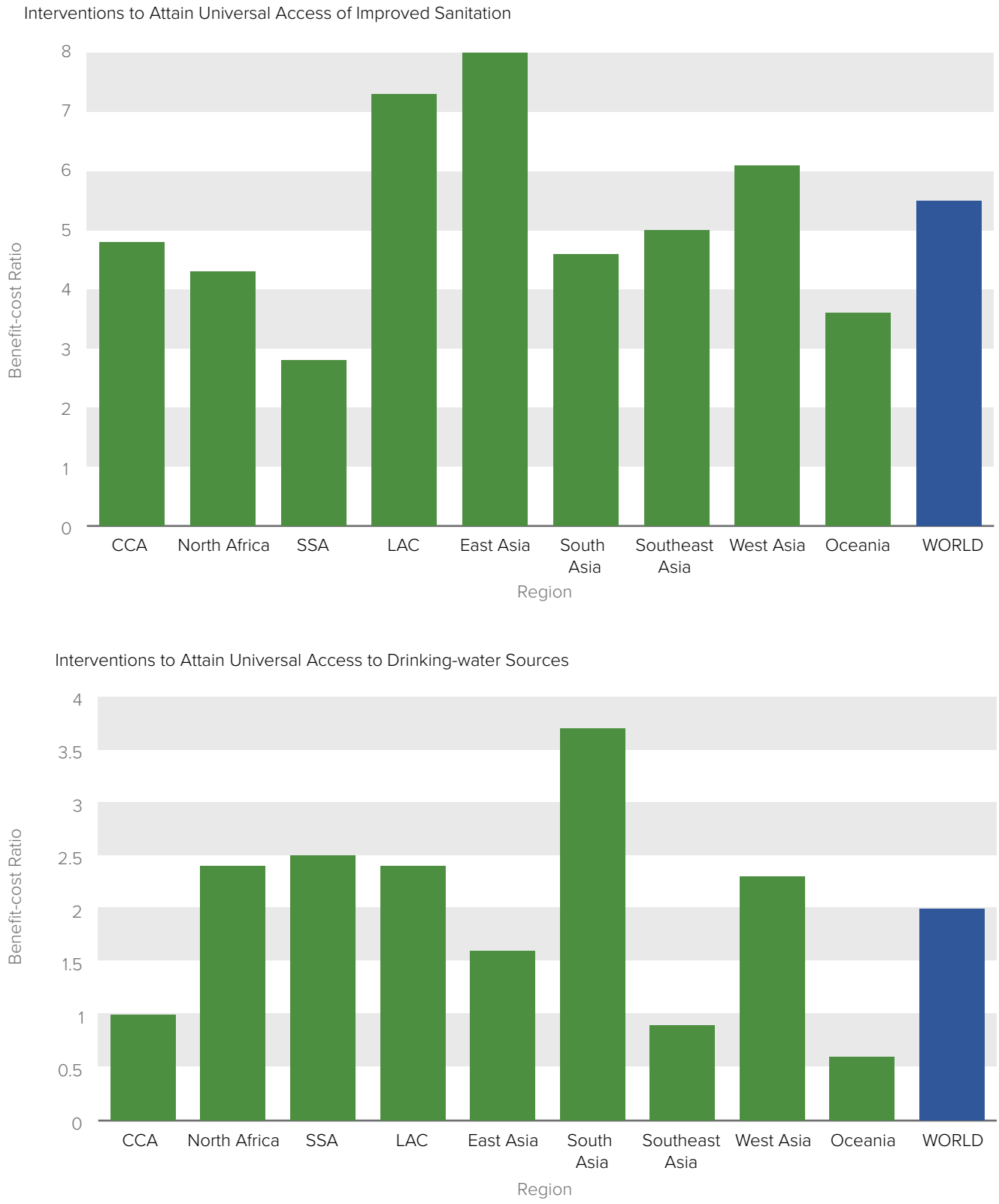
Third, there are significant benefits to optimising current and future infrastructure investments, which could see a modest extra investment in planning generate large financial and non-financial returns. The Nature Conservancy, for example, estimates that a system-scale approach to planning and managing hydropower could keep 100,000 km of river free-flowing, providing biodiversity and ecosystem service benefits without sacrificing energy development. This would cost an estimated US$3 billion per year globally, over business as usual.[983] Yet in basins where hydropower has a significant role, even a 5% improvement in other water services like irrigation, drinking water supply, and flood protection could generate an additional US$38 billion per year in additional benefits.[984]

Fourth, there is uncaptured value in the form of climate-related opportunities to reduce costs by improving efficiency and recovering value in the water and sanitation space. In water supply, a programme of leakage identification and control in Lisbon by the utility Empresa Portuguesa das Águas Livres generated approximately US$84 million (€64 million) in accumulated savings from 2005 to 2015, increasing drought resilience while also reducing emissions for treatment and pumping.[985] In wastewater, a pilot waste-to-energy project in Xiangyang, China, is set to reduce emissions 95–98% compared to traditional sewage sludge treatment. The sale of biogas and digestate obtained from sewage sludge generates more than US$1.5 million for the Chinese plant annually.[986] Circular economy approaches that can recover energy, agricultural products, water, and other vital resources from human waste are being expanded worldwide, including in many developing countries.[987] In India, which has a huge sanitation shortfall, it has been estimated that adopting technologies that can recover biogas compared to conventional pit latrines could avert a 7% increase in national emissions.[988] Meanwhile in Ghana, the company Safi Sana is pioneering a design-build-operate model for waste-to-energy factories, which receive faecal and organic waste from slums and sell biogas, fertiliser, and recycled water as end-products.[989]

Photo credit: Flickr: Arne Hoel / World Bank

Figure 28

Benefit-cost Ratios of Interventions to Attain Universal Access to Improved Sanitation (Top) and Drinking-water Sources (Bottom), by Region (2010).



Source: The World Health Organization, 2012.[990]

Challenges

The key challenge is not the infrastructure price tag itself but making the money that is available (most of which is public) deliver stronger services that secure revenue streams, while delivering to all segments of society, including poor people. No matter the source of finance, people need to receive reliable, quality services if they are to pay the fees or taxes that will ultimately repay infrastructure costs. Again, underlying policy and market failures must be overcome, requiring strong institutions and regulation.

Water supply and sanitation have proved stubborn in this regard, particularly in developing countries. High capital costs for infrastructure stretch public budgets, while limited demand for sanitation, low economies of scale in rural areas, and weak policy and regulation make private investors wary. In urban piped water systems, monopolies are hard to avoid and require strong regulation to ensure poor consumers are not exploited by high connection fees and tariff hikes, whether they are publicly or privately operated. Politicians may neglect whole sections of society—from remote rural communities to urban slum settlements—in favour of large, visible infrastructure and services for more powerful constituents like wealthy users and businesses.[991] The challenges are significant but not insurmountable. With political commitment and patience, Senegal has reformed its water sector, regulating its private operator and public asset holder through performance contracts.[992] Eighty-seven percent of its urban citizens have access to piped water, against a regional average in sub-Saharan Africa of 57%.[993] Donors can provide public financial management support to poorer countries to improve generally low utilisation rates of budgets for water and sanitation.[994] They can also help more utilities secure finance from domestic capital markets by providing viability gap funding and facilities to aggregate projects, as is being done in Kenya.[995] More developed cities, like Casablanca in Morocco, can explore alternative finance sources like levies and taxes on land value (seeBox 46). Public-private partnerships could develop supplementary revenue streams—the Toilet Board Coalition estimates that sanitation could be a US$62 billion market in India, once circular economy and health data collection possibilities are exploited.[996]

Box 46
Capturing the Value of Land to Finance Urban Services in Casablanca, Morocco

Morocco has made greater progress on urban water and sanitation than many of its regional neighbours, but half a million people in the greater Casablanca area still lack access to adequate services.[997] By 2030, the population of the city is set to grow from around 3.5 million to 5 million. The city has developed an innovative financing mechanism to internalise the value of service provision for property developers. Developers' contributions finance the costs of land acquisition, network extension, and social connections via a dedicated fund. Contributions range from 1.3% of the selling cost of luxury apartments, to 0.7% for social housing and may be waived altogether when a development occurs in slum areas, while they are increased for developments that are not part of the city's master plan. In 2014, the fund financed 54% of the investment programme for water supply and sanitation services and flood risk mitigation, versus 7% in 2004. The remaining costs, mainly operations and maintenance and asset renewal, are funded by user fees. The mechanism is one example of land-value capture—charging developers fees to connect developments or using taxes to capture increased real estate value arising from infrastructure provision (see also Box 24 in Section 3). It is easier to internalise the additional value of infrastructure where there is a new development on undeveloped, unserved land. This might imply that the mechanism would incentivise sprawl, but it is possible in principle to tailor the different contribution rates paid by property developers to avoid this, such as by reducing contributions on infill developments.[998] (See also Box 16 on Morocco's solar deployment).

Ultimately, however, it is likely that public finance, whether from international transfers or domestic sources, together with strong sector leadership from national governments, will continue to be key to close the water supply and sanitation access gap. Governments and their development partners will therefore need to strive to improve the effectiveness of direct public spending on infrastructure—improving policy coherence as well as prospects for climate resilience, for example, by mainstreaming climate-risk screening and low-emissions technology preferences into public procurement.

The story is different where revenue streams are more secure, as is increasingly the case for several infrastructure sectors, including for water and sanitation in some emerging as well as developed economies. Here private finance will be possible. Across all infrastructure sectors this could contribute an additional US$1—1.5 trillion per year if barriers are tackled—as much as half the current shortfall in total investment requirements.[999] The barriers, however, are significant, and include undeveloped and unclear investment pathways and project pipelines from governments;[1000] insufficient project scale; political economy challenges like corruption; and financial regulations that discourage long-term, cross-border investments.[1001] Public policy, as well as smarter financing from MDBs, is therefore essential to improve the attractiveness of infrastructure investments for private partnerships and investors. The public sector also needs to carefully consider what risks it takes on, for example, by stepping in when large infrastructure projects fail, as well as protecting vulnerable groups through effective regulation.

Climate-related risks from water and other factors introduce additional uncertainties, which must be priced and allocated to the best placed party. Depending on the overall risk-return profile, governments may choose to absorb climate-change risks (for example, through partial guarantees) or not. PPP frameworks in the United Kingdom, Belgium, and Australia, for example, pass risks of certain weather events like floods and storms to contractors, separating them out from force majeure events.[1002] Financial regulations also have a key role to play, for example in encouraging greater disclosure on water-related climate risks. Central banks, financial regulators, and finance ministers have the most powerful levers at their disposal in this regard. They have a key role to make mandatory the recommendations of the TCFD, which call for disclosure on climate-related governance, strategy, risk management, and metrics and targets in public annual company filings.[1003] For developing countries, however, better disclosure of physical climate impact risks will often highlight greater existing climate vulnerability, increasing the cost of capital they face when borrowing to finance resilient infrastructure. This makes public international and domestic finance to improve resilience, and innovative risk financing initiatives such as insurance (see also Box 43) even more essential.[1004]

Accelerators

- **Together with their development partners, governments of countries with inadequate drinking water, sanitation, and bulk water systems should invest scarce public finance in resilient infrastructure for the most vulnerable.** Since 2000, China has brought drinking water to the homes of nearly half a billion people and provided safely managed sanitation for a similar number.[1005] Both existing and new water and sanitation infrastructure must be made more resilient. By using climate resilience and low-carbon criteria in public procurement[1006] and promoting risk-management tools such as climate-resilient water safety plans,[1007] governments can safeguard the significant benefits from water and sanitation for their citizens and economies in the face of extreme events.
- **Governments worldwide should encourage private capital to flow to infrastructure that is resilient to water-related and other disaster risks that are driven by climate change.** Better regulation, credible long-term strategies, project preparation and pipeline development, and selective guarantees are needed to attract private investment in water and sanitation infrastructure, especially given additional climate risks on top of existing political risks to revenue streams.[1008] The public sector must also be ready to appropriately allocate these risks through PPP frameworks and regulation to secure value for money for taxpayers and to protect poor users. In some cases, climate-change risks could provide

additional impetus for innovative private finance. In water-scarce South Africa, the secure revenue offered by mining companies willing to purchase treated wastewater secured a US$37 million loan for upgrading Rustenburg's wastewater and water infrastructure.[1009] Since May 2016, the San Francisco Public Utilities Commission has issued more than US$1 billion in green bonds,[1010] and the City of Cape Town has issued a US$76 million green bond, both mainly for water.[1011] Both were certified under the water sector criteria of the CBI standard, which includes mitigation and adaptation elements, and are being extended to cover upstream natural or green infrastructure.[1012] The San Francisco and Cape Town bonds received strong ratings from credit agencies and a positive response from the market,[1013] showing the potential for scaling up green bonds for infrastructure.[1014]

- **Government, private institutional investors, and international financial institutions should set out standards requiring that projects and portfolios are transparently assessed for exposure to water-related and other disaster risks driven by climate change and that these risks are disclosed and managed.** There has been significant progress with voluntary disclosure, for example the water risk disclosures secured by CDP from over 2,100 companies annually.[1015] However, agreement on disclosure standards for assessing the resilience of infrastructure investments would also steer much needed capital to the right endpoints.[1016] Investors can insist on such disclosure by investment managers in mainstream annual filings, and financial regulators can make it mandatory or provide incentives for disclosure, building on the TCFD recommendations.[1017] MDBs and DFIs should also be using state of the art climate-risk screening tools to identify and manage climate-risk across their infrastructure portfolios. With improved disclosure, poor countries will need international public finance and policy support to ensure they do not pay a premium for their existing vulnerability, when financing infrastructure on the international debt capital markets.[1018]

Photo credit: Heather Arney / WaterPartners International