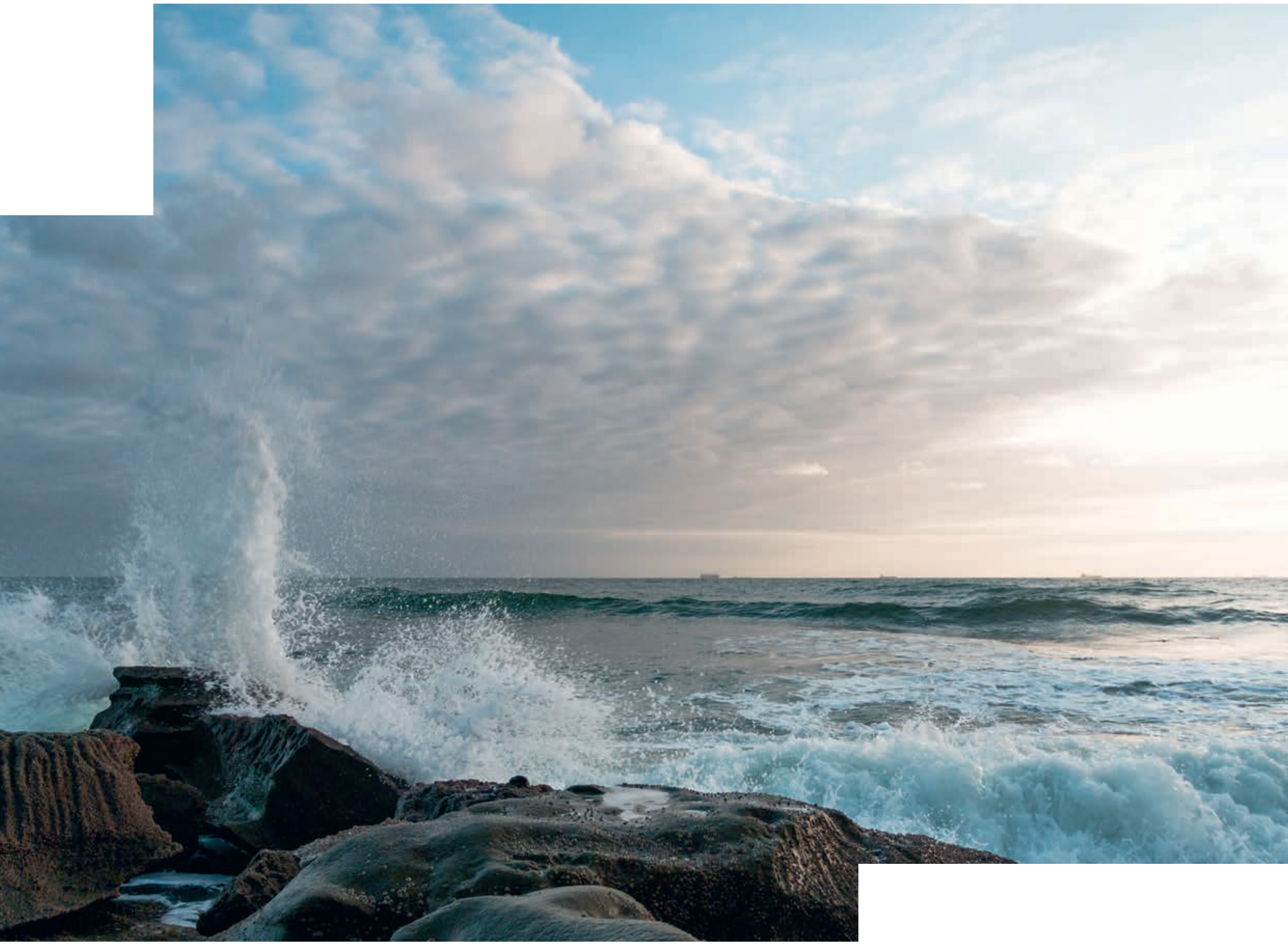
Davos edition 2020

# Research Institute

## Water scarcity: Addressing the key challenges



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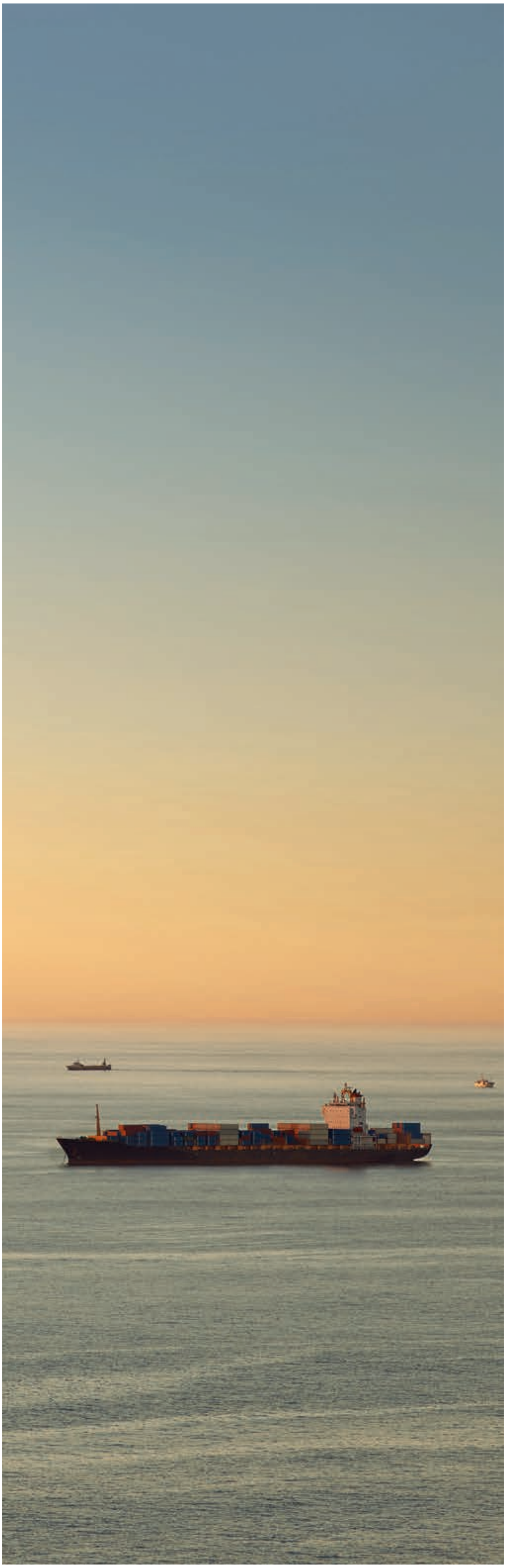
# Editorial

Water scarcity, and the societal risks it poses, is one of the primary challenges faced by the world today. Over two billion people still live in countries experiencing high water stress, while four billion people experience severe water scarcity for at least one month a year. Poor water quality exacerbates the issue, with 80% of waste water globally being returned to the environment untreated, while 4.5 billion people still lack access to safely managed sanitation services. As with any scarce resource, security of supply and related disputes around it threaten to become a rising source of geopolitical tension.

Sources of the problem show no immediate sign of dissipating. With the world's population set to increase to over ten billion by 2050 from around seven billion today, water demand can potentially increase by more than 70% driven by urbanization and changing consumption patterns in the emerging world. Also, water stress and climate change are inextricably linked with the related disruption in rainfall patterns. The severe bushfires in Australia are a stark reminder, although only one of a series of extreme weather events. Addressing the consequences of the problem is central to six of the United Nations Sustainability Goals (SDGs). The social and economic benefits are clear, but meeting the aims of the SDGs comes at a cost. The OECD estimates the investment needed to address water scarcity globally at USD 13.6 trillion between 2016 and 2030. Beside governments, private sector capital has to play a more substantial role in developing the necessary infrastructure and new technologies. Accordingly, we consider regulatory and financial frameworks needed to achieve this goal.

We hope that our findings will prove valuable and wish you an interesting read.

**Urs Rohner**
Chairman of the Board of Directors
Credit Suisse Group AG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**For more information, contact:**

Richard Kersley
Head of Global Thematic Research, Global Markets
Credit Suisse International
richard.kersley@credit-suisse.com

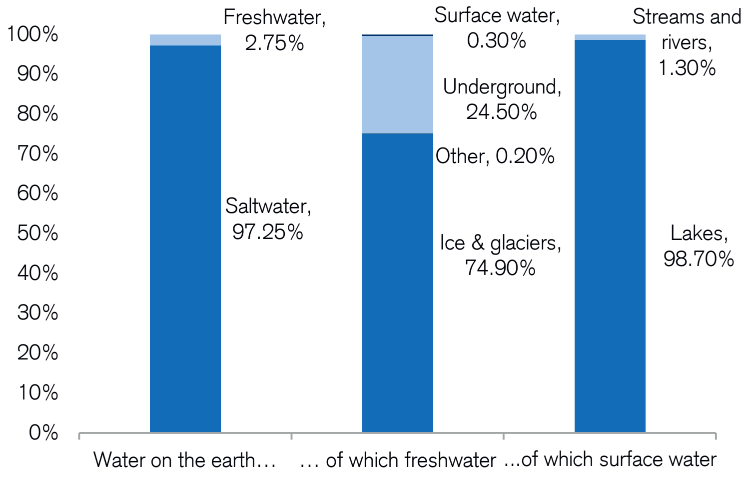
**Credit Suisse Research Institute**
research.institute@credit-suisse.com
**credit-suisse.com/researchinstitute**

# 1. Water scarcity: Framing the problem

**Eugène Klerk, Richard Kersley, Oliver Isaac**

The great irony surrounding the problem of water scarcity is that water as a resource is widely available, but only a small percentage is readily available for human consumption. With freshwater accounting for less than 1/100th of 1% of the planet's total water, we note that addressing water scarcity requires improving the efficiency with which we use, and reuse, the total amount of water available, including that supplied by the natural water cycle through precipitation, not least because desalination is too expensive at this point. Water is paradoxically abundant and scarce at the same time.

**Figure 1: Excluding inaccessible and saline water leaves only a fraction that is readily available for human consumption**



Source: Michael J Pidwirny, Credit Suisse research

## The problem today

According to the United Nations, water use has more than tripled since the 1950s, growing by more than twice the rate of population growth over the last century. Specific targets related to water, sanitation and hygiene have been included as part of the UN Sustainable Development Goals (SDGs, see Chapter 6 on page 71), and while some progress has been achieved on these, much remains to be done. For example, over two billion people still live in countries experiencing high water stress, while four billion people experience severe water scarcity for at least one month a year. Furthermore, only one in three countries with less than 99% of basic water coverage is on track to achieve the required "nearly universal" coverage stipulated by SDG6 by 2030, and only four out of ten people around the world use safely managed sanitation services (40% of people globally do not have basic handwashing facilities at home).

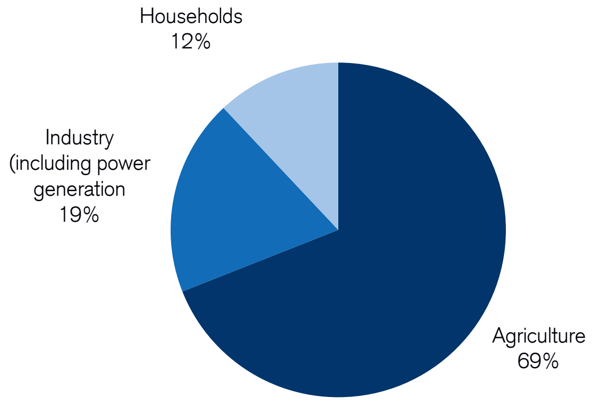
## The problem tomorrow

Forecasts from the Organisation for Economic Co-operation and Development (OECD) indicate that water demand will continue to grow at a similar rate as the past 30 years, resulting in an estimated 35.1% increase by 2050. Although agriculture currently represents 69% of global water use, the majority of incremental water demand is expected to come from industry, which includes energy generation, currently at 19% of total water use. Domestic use makes up the balance at 12%.

Industry-related water use is likely to be almost 120% higher in 2050. Sectors that are most water-intensive include metals and mining, utilities, energy, consumer staples and automobiles. Household-related water consumption is likely to rise 65% between now and 2050 as the penetration of water-consuming appliances and basic water infrastructure increases.

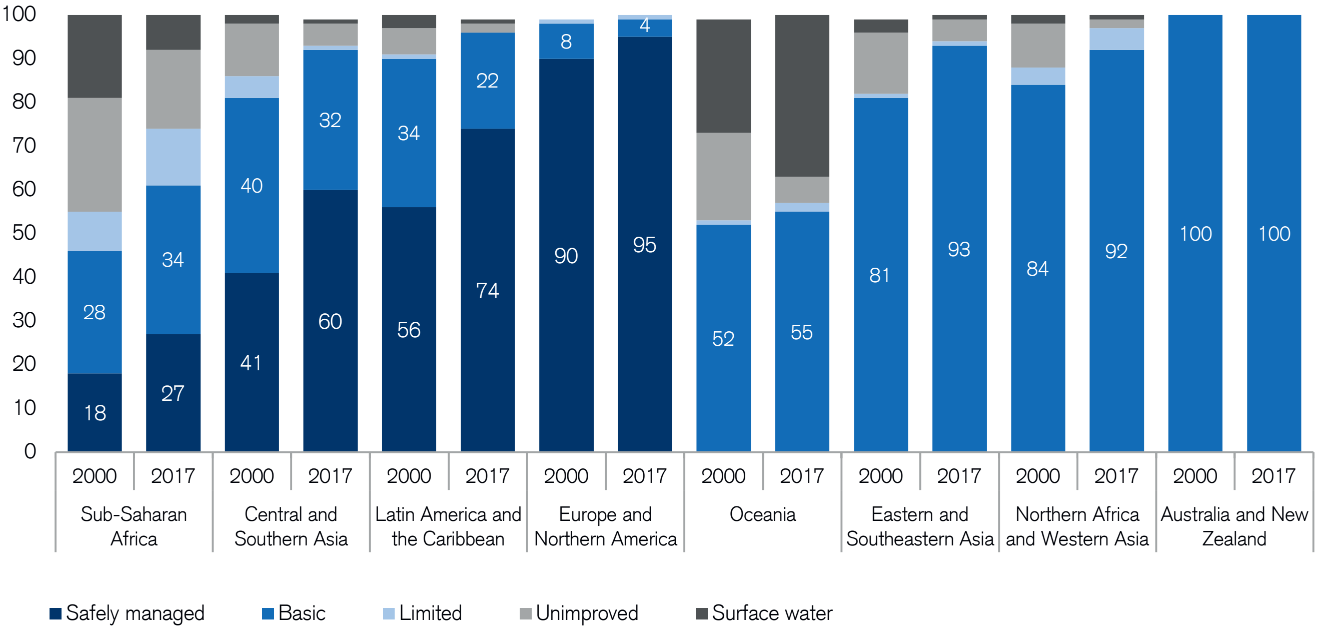
The likely increase in water demand is set to put the water supply-demand imbalance under even more pressure. In order to alleviate some of this pressure, we believe that consumer behavior will likely need to adapt. The reason for this is that a wide range of consumer products that could see incremental demand from consumers in developing countries as their disposable incomes rise are high in water intensity. For example, producing one ton of beef requires more than 15,000 liters of water, one pair of jeans requires over 7,000 liters of water, while leather boots can require more than 15,000 liters per pair. A growing emerging middle class adopting a "developed consumer approach" would put significant incremental stress on already challenged freshwater availability. This in turn should drive local governments to support policies that adopt a circular economic model.

**Figure 2: Water use by sector – agriculture constitutes 69% of water consumption**



Source: UN, Credit Suisse research

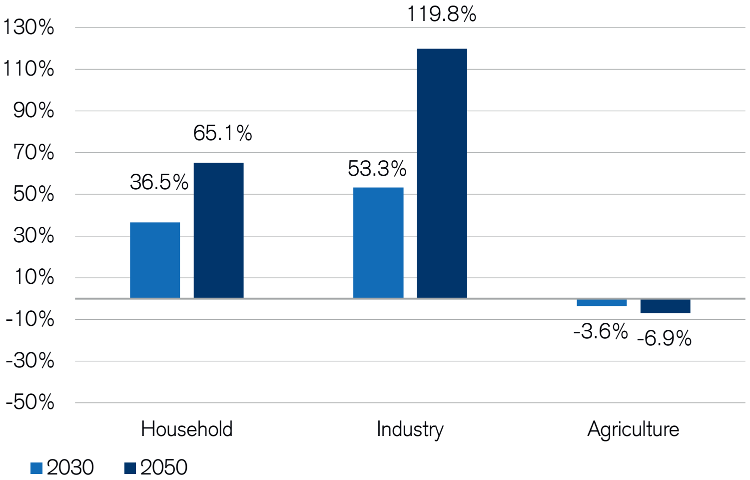
**Figure 3: Access to water has improved globally, but significant regional differences remain (progress on household drinking water, sanitation and hygiene 2000–2017)**



Source: UNICEF, WHO, Credit Suisse research

Further stress on water is added by climate change through increasing drought, flooding and soil degradation. Overall, the United Nations predicts that, by 2050, up to 5.7 billion people around the globe will live in areas that are water-scarce, with the overall majority in developing countries. Furthermore, the number of people at risk from flooding will have increased to 1.6 billion from 1.2 billion today. Four out of every five people impacted by sea-level rise will likely live in East and Southeast Asia.

**Figure 4: Projected growth in types of freshwater use – households and industry to drive incremental withdrawals**



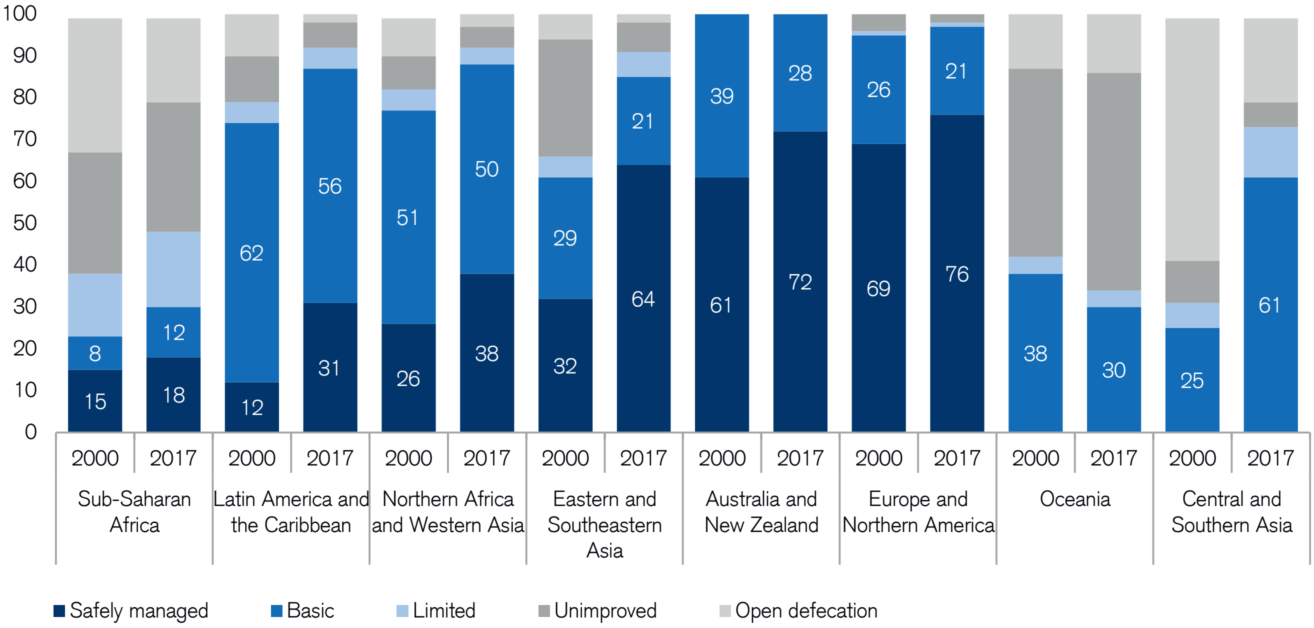
Source: OECD, Credit Suisse estimates

The potential cost of water stress should not be underestimated, in our view. The World Bank has estimated that water scarcity exacerbated by climate change could cost some regions more than 6% of gross domestic product (GDP) by 2050. Additional risks include water-related conflicts and increased migration. In 2017, some 22–24 million people were forced to move due to weather events such as drought and flooding. The World Bank believes that the number of climate-related migrants in Latin America, sub-Saharan Africa and Southeast Asia will reach 143 million by 2050, unless water scarcity and climate change are addressed.

## Water quality, sanitation and hygiene

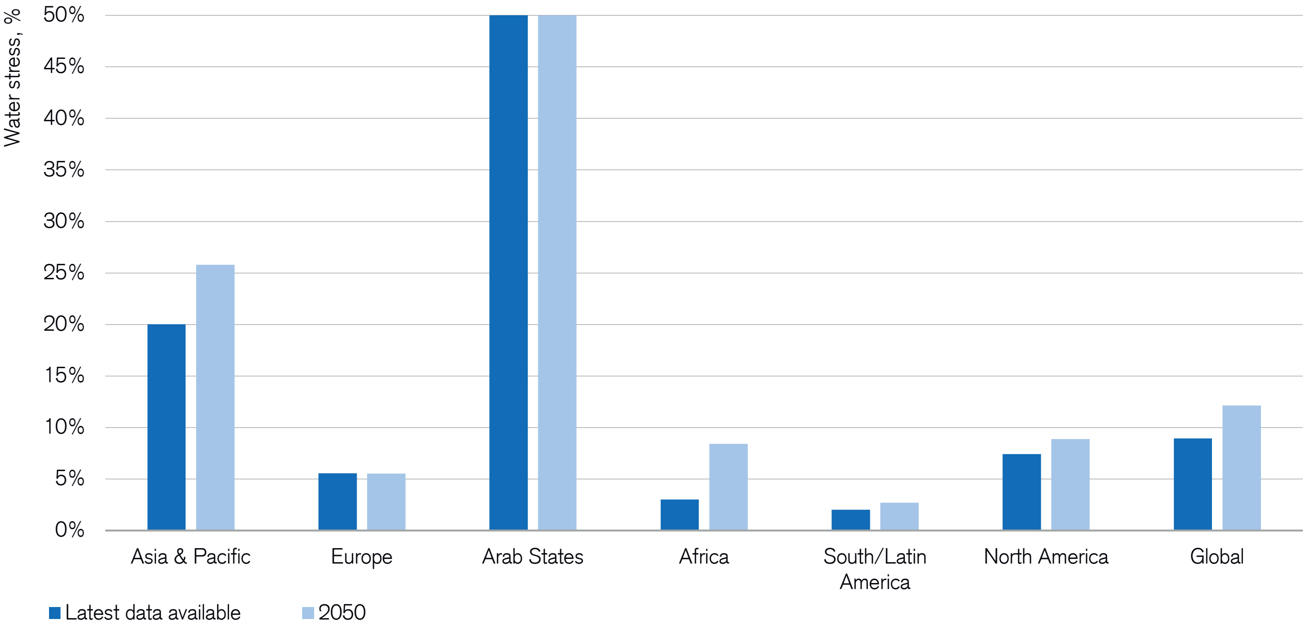
As much as access to water remains a challenge, the quality of water is also a problem. According to the World Water Assessment Programme (WWAP) in 2017, worldwide, over 80% of all wastewater returns to the environment without being treated, which leads to water-related diseases such as cholera and schistosomiasis. Access to safely managed sanitation services also remains poor, with 4.5 billion people globally lacking access to these facilities according to a report from the World Health Organization (WHO) and the United Nations International Children's Emergency Fund (UNICEF). In fact, only 45% of the world's population use proper sanitation services, most of whom live in developed countries.

**Figure 5: Access to sanitation services has improved, but regional differences remain significant (progress on household drinking water, sanitation and hygiene 2000–2017)**



Source: UNICEF, WHO, Credit Suisse research

Figure 6: Regional water stress – Asia and Africa will likely see the greatest increases in stress



Source: FAO, Aquastat, CIA World Factbook, UN, Credit Suisse estimates

## Geography is key

Although water scarcity already affects every continent, its impact is felt to varying degrees based on geography. Regions and countries currently experiencing the greatest water stress include the Middle East and India, although climate change makes the effects of water scarcity unpredictable and difficult to forecast. As part of this report, we will forecast the countries where water stress is mostly likely to be problematic in 2050, considering factors such as population growth and current withdrawal rates.

## Investment requirements and solutions

The lack of proper water infrastructure across developing countries requires substantial investment. This is not all, however, as existing infrastructure in developed countries is often old and in need of replacement or upgrading too. For example, the OECD estimates that water leakage across key cities in developed countries can be as high as 37% of total water supply. Estimates for the required amount of investment in global water and sanitation infrastructure vary widely. Reviewing a range of estimates, the OECD believes that USD 13.6 trillion is needed between 2016 and 2030. The World Bank believes that just achieving SDG targets 6.1 and 6.2 alone will require USD 114 billion per year.

We believe that investments in water infrastructure will increase going forward. Our view is not only driven by the need to address infrastructure deficiencies and achieve the targets associated with the relevant SDGs, but also because investing makes sense economically given the multiplier effect of these investments on other sectors and the wider economy.

## Defining water scarcity

Throughout this report we adopt the UN's definition of water scarcity, spanning from scarcity in availability due to a lack of physical storage as well as scarcity in access due to the failure of institutions to ensure regular supply or to provide adequate infrastructure. Numerically, there is no universal classification; the Falkenmark indicator considers the renewable water resources per capita. If the renewable resources per person per year are below 1,700 $m^3$ then the country is experiencing water stress, below 1,000 $m^3$ and the country is experiencing water scarcity and below 500 $m^3$ and the country is experiencing absolute water scarcity. Clearly however, this fails to capture any variation in water demand. As such, in this report we focus on the criticality ratio, where a country's water stress is based on the percentage of permanent renewable resources withdrawn each year. The different classifications are given below:

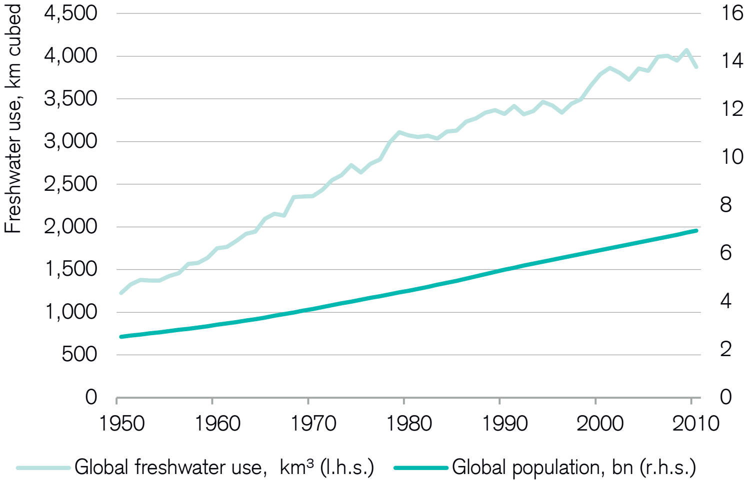
<10% = low stress
10-20% = low-to-medium stress
21-40% = medium-to-high stress
41-80% = high stress
81-100% = extremely high stress
>100% = scarcity as water demand exceeds internal water resources.

# 2. Water demand: A secular challenge

**Eugène Klerk, Oliver Isaac**

The challenges related to addressing the rapidly increasing water stress globally are twofold. First, we find that demand for freshwater is showing structural growth. In addition, however, we also see growing challenges related to water supply.

**Figure 1: Global freshwater use has consistently outstripped global population**



Source: UN, Global International Geosphere-Biosphere Programme, Credit Suisse research

### Freshwater use growing in all regions

Since the 1950s, total annual water consumption globally more than tripled from 1.22 trillion $m^3$ to 3.9 trillion $m^3$ in 2011. When broken down by region, we find that water consumption has risen not just across developed markets, but across emerging markets too. The so-called BRIC countries (Brazil, Russia, India, China), for example, account for 43.7% of current global freshwater use, up from a low of 39% in 1956.

Despite the stronger growth seen across emerging markets, we note that water use on a per capita basis across the least-developed countries (e.g. Africa) remains well below that of the developed markets. Water use across North America, in particular, stands out at around 1,200 $m^3$ per capita, which is more than double the global average and roughly 12 times the level seen in Africa.

## End-markets: Agriculture, industry and households

The growth in water consumption across emerging countries, as highlighted above, might lead some people to conclude that increased personal consumption is the cause. While there is some truth to this, water consumption increases take place across different parts of the supply chain for goods and services. As mentioned, when water consumption is broken into its key components, we find that agriculture (which includes the entire supply chain related to food and beverage products) accounts for the lion's share of global freshwater consumption at 69%. Industrial-related water consumption, which covers water consumption related to electricity generation as well as manufacturing-related processes, accounts for 19%. Domestic consumption, also known as household water use, constitutes the balance at 12%.

Although the global average for agriculture as a proportion of total freshwater use stands at 69%, we note that this figure can reach well over 90% in a number of emerging economies. Given that emerging economies are generally more geared toward agriculture, this in part explains why agriculture-related water consumption is often more dominant in emerging as opposed to developed economies.

As emerging economies develop and broaden their range of economic activities, one could be mistaken for believing that this reduces water intensity as the relevance of agriculture declines. However, we are not convinced that this is the case. First, we note that a shift to a more industrial or service economy does not necessarily mean that the absolute size of the agricultural activities will decline. More important, however, is the fact that the water intensity of industrial activities should also not be underestimated, not least because this includes energy-related water use.

Figure 2: Average per capita freshwater withdrawals by region (m³)

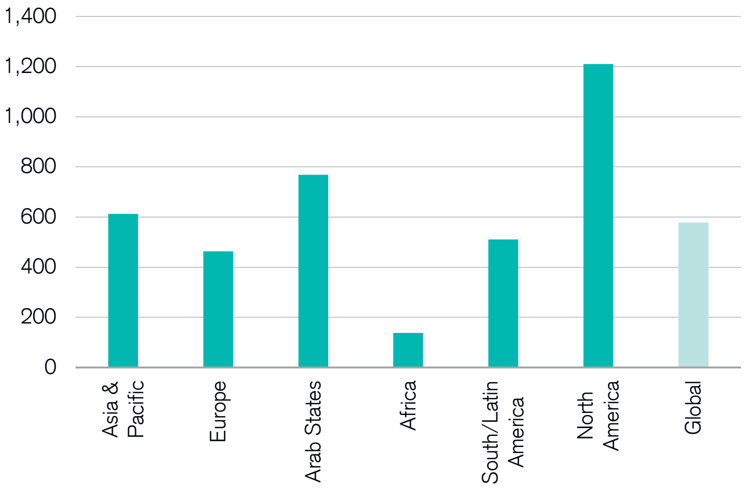


Figure 3: Regional freshwater use (trillion m³); OECD countries have seen flat freshwater use since the 1980s

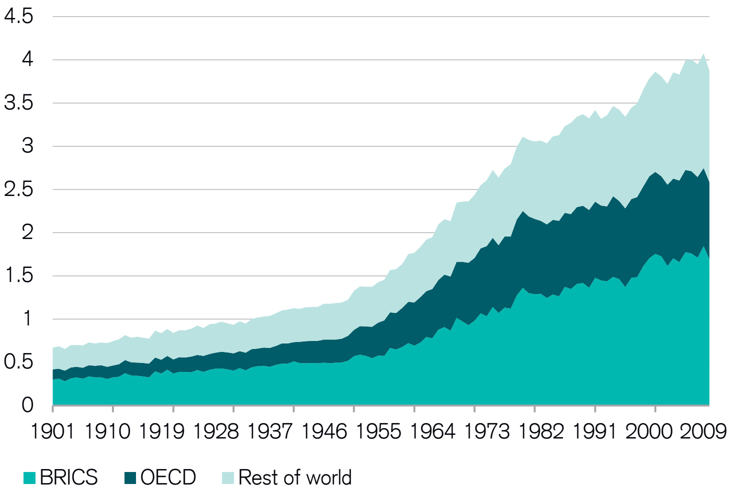
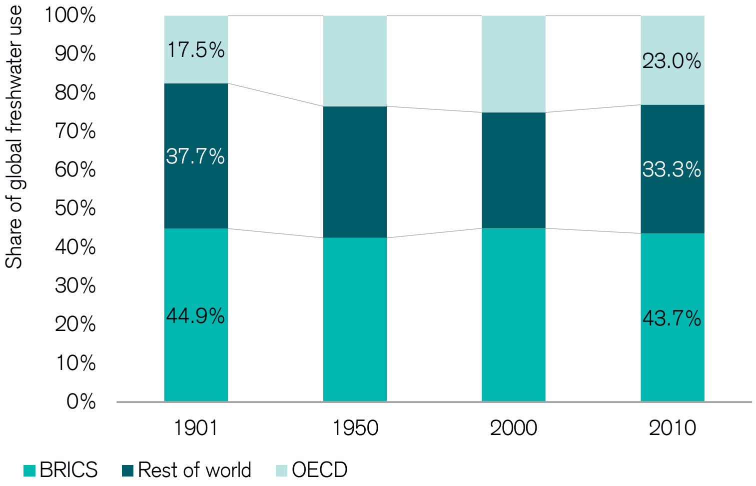
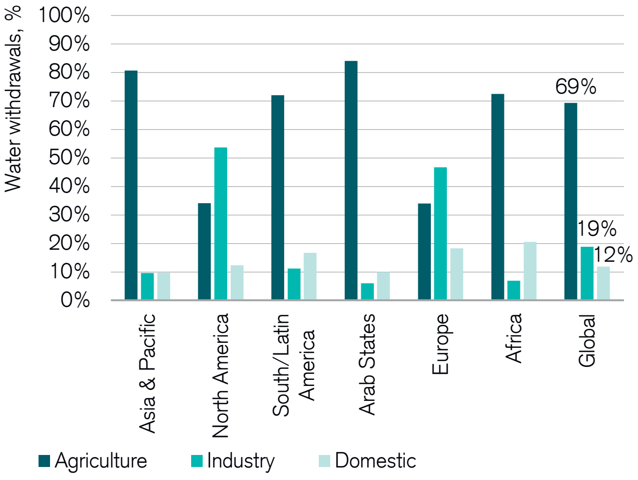


Figure 4: Regional mix of freshwater use



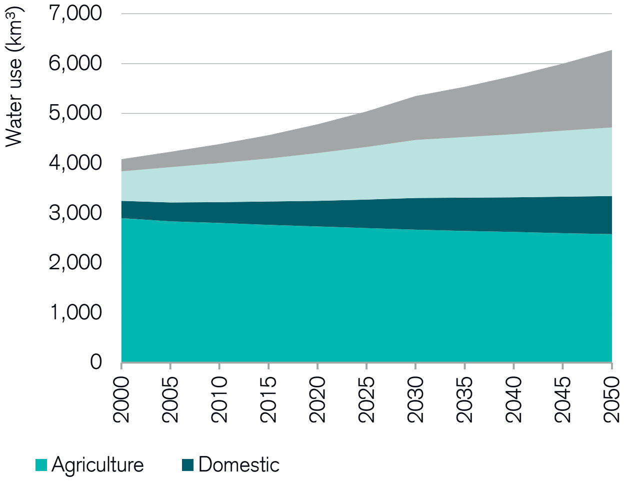
Source Figures 2–4: Global International Geosphere-Biosphere Programme, Credit Suisse research

### Figure 5: Europe and North America are the only regions where industry as a share of water use exceeds agriculture



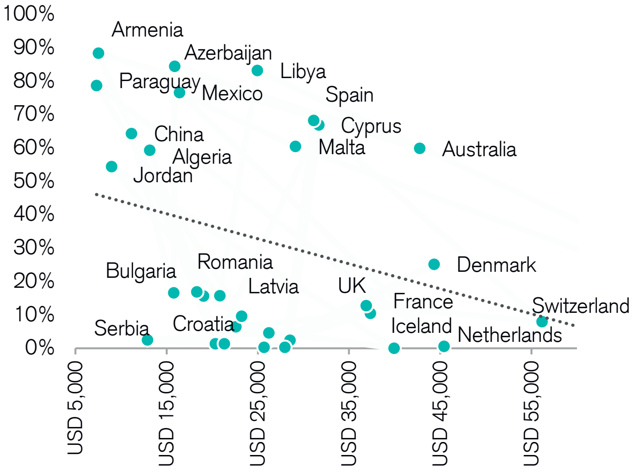
Source: Aquastat, OECD, Credit Suisse Research

### Figure 6: Global water consumption – future growth expected to be concentrated in manufacturing and electricity

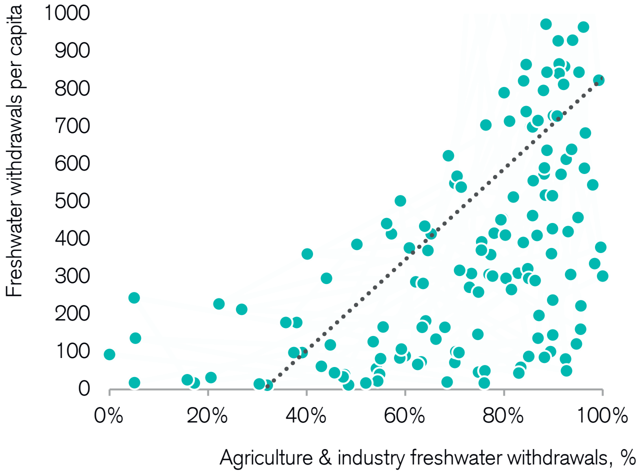


Source: World Bank

### Figure 7: As GDP per capita rises, agriculture as a proportion of freshwater withdrawals falls…

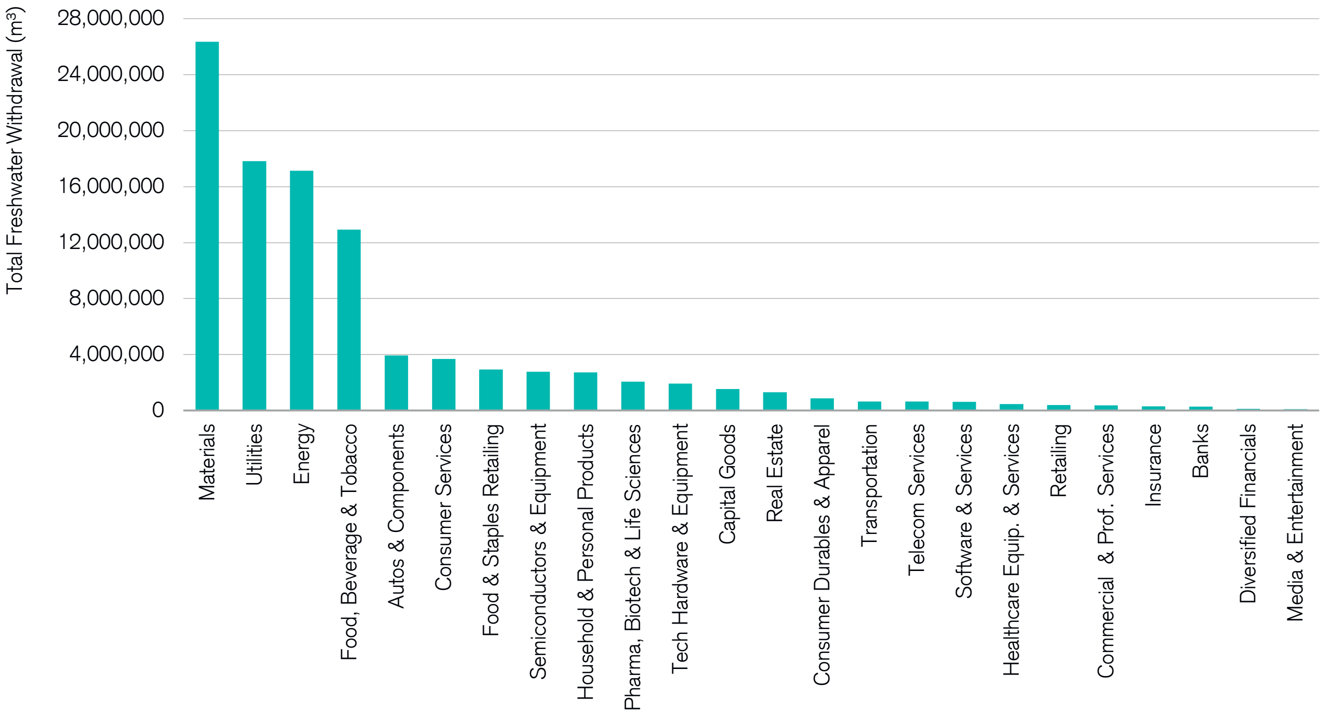


### Figure 8: …but reductions in water use are offset by industry, which is also high in water intensity



Source Figures 7 and 8: World Bank, Credit Suisse estimates

### Figure 9: Total freshwater withdrawal by sector (m³)



Source: Refinitiv, Credit Suisse estimates

## Water demand by sector

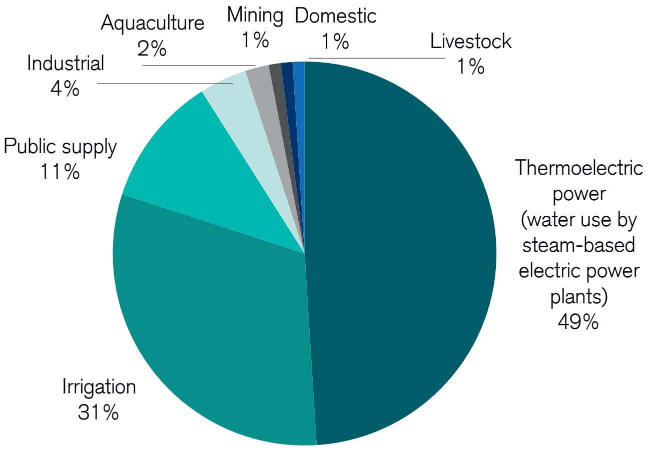
To provide more context around what the impact of a changing economy can be on water intensity, we screened some 20,000 companies across all sectors with regard to their water use. Data availability is an issue, as only 1,269 of the almost 20,000 companies have water withdrawal data for 2018 according to data from market research company Refinitiv.

Although an imperfect exercise given the problem of data deficiency, we calculated total freshwater withdrawal by sector. This shows that an economy with an above-average representation of materials (including metals and mining), energy, utilities, consumer staples and automotive companies is likely to face above-average water challenges too.

## Electricity generation drives water use

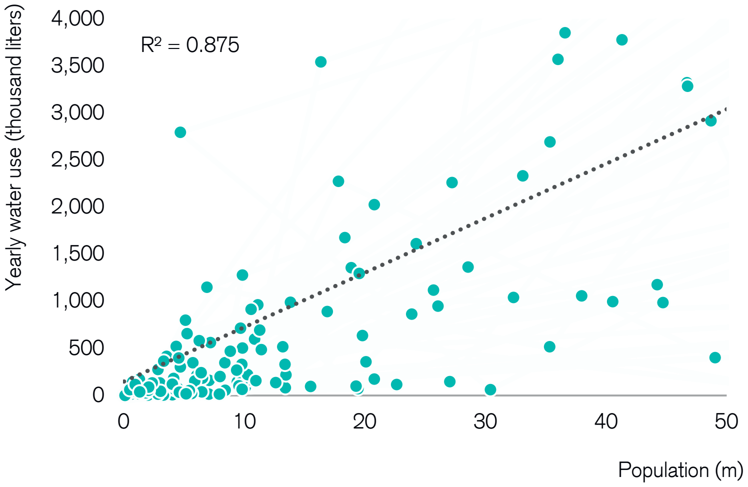
The relevance of the energy sector with regard to water consumption is high. In 2014, for example, 10% of total water withdrawals were related to the energy sector according to the International Energy Agency. Electricity generation makes up the majority of this amount at 251 billion cubic meters (bcm), of which

### Figure 10: US water use split: electricity generating power plants represent almost half of all US water use



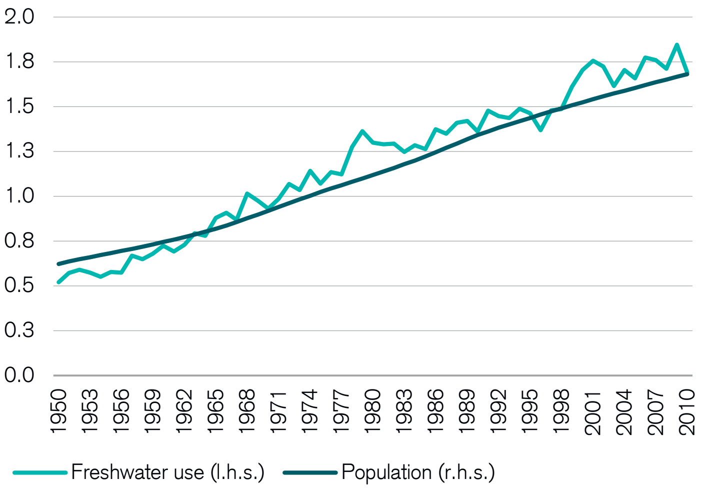
Source: NRDC, Credit Suisse estimates

**Figure 11: Population versus annual water use has an R-squared of 0.875**



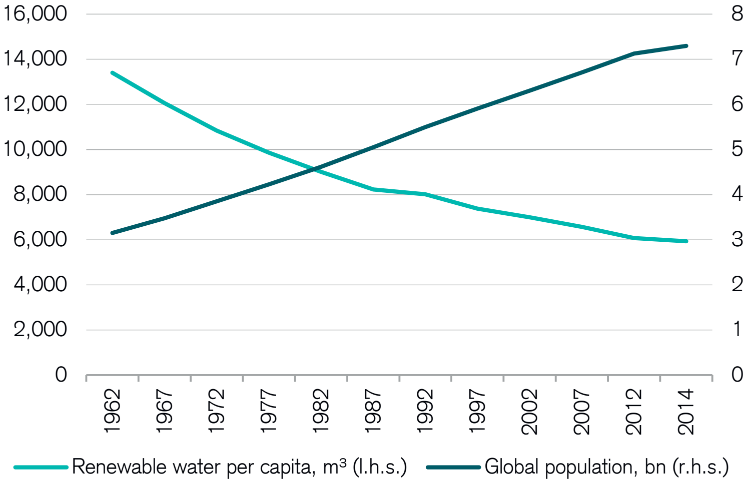
Source: UN, UNESCO, FAO, Credit Suisse research

**Figure 12: BRIC freshwater use has largely been a function of population increases for the past 70 years**



Source: Global International Geosphere-Biosphere Programme, UN, Credit Suisse research

**Figure 13: Inelastic water supply means water resources per capita are inversely related to population**



Source: UN, Credit Suisse research

fossil-fuel derived electricity accounts for 230 bcm, nuclear 112 bcm and renewables nine bcm. The key reason why electricity generation requires substantial water use is because most power plants use water to cool the steam that spins the electricity generating turbines.

In the USA, for example, cooling power plants represent the largest share of freshwater withdrawals at 49%. Of all cooling methods, once-through cooling is the most harmful. The process involves withdrawing water from nearby bodies, diverting it through a condenser where it absorbs heat from steam and then discharging it back to the original source at higher temperatures, causing disruptions to ecosystems and having severe environmental effects. Indeed, 75,000–190,000 liters of water are withdrawn per MWh generated using this process.

## Drivers of water consumption

With total water consumption set to see structural growth for decades to come, the key question is what the driving forces behind this growth are. We see three factors driving water demand: (1) population growth, (2) urbanization and (3) the impact of the rise of the emerging middle class.

### Population growth

The link between water demand and population is obvious as, ceteris paribus, a higher population will always consume a higher quantity of water. Since the 1960s, the global population has grown from around three billion people to more than seven  billion today. Given that freshwater supply is relatively stable, this naturally means that so-called “renewable water per capita” has declined substantially. In fact, calculations from the UN suggest that renewable freshwater per capita has declined by more than 50% since 1962.

Forecasts by institutions such as the UN and the World Bank suggest that the global population is set to reach ten billion by 2050. When taking their forecasts by country, we can calculate the potential increase in total water consumption, assuming that current per capita levels stay flat. This suggests that global water usage will reach 5.3 trillion m³ by 2050, up from 3.7 trillion m³ currently. This estimate is probably too low, in our view, as it does not incorporate per capita changes in water consumption that are likely to occur as income levels rise, allowing consumers to buy more discretionary, often water-intensive, products.

## Urbanization

While population growth is a natural driver of water consumption, we note that urbanization, especially when driven by economic development, is another key factor. The growing shift of demographics to urban environments can assist in explaining why the growth in freshwater withdrawals has outstripped population growth. Urbanization-related factors that are relevant for the theme of water scarcity include the following:

**1. Urbanization helps improve access to water:** The long-term trend toward a more urban world is likely to improve the quality of water infrastructure in our view. Access to water in the urban areas of both developed and emerging countries is higher than in rural environments, where accessibility is limited and often time-consuming.

As indicated below, data from UNICEF suggests that approximately 85% of urban individuals have access to safely managed drinking water, whereas this rate is just over 50% in rural areas. Indeed, of the 844 million people globally that do not have access to basic water supplies at all, 79% live in rural areas. At the same time, 2.1 billion people do not have access to safely managed drinking water supply system services. This means that 14.9% of the urban population, and 45.2% of the rural population, need improved services.

The problem is best captured in rural Africa, where average daily water use ranges from 20 to 40 liters per person, while, in certain rural areas of Ethiopia, this falls to just 6.68 liters per person per day. Another way of considering this problem is by reviewing how people access water in rural developing countries. Analysis from the WHO and UNICEF Joint Monitoring Program for Water, Sanitation and Hygiene suggests that 25% of global households do not have water sources located on their premises and more than 200 million households need to travel more than 30 minutes to collect water. In Sierra Leone, for example, more than one in four households travel more than 30 minutes to collect water, and three of out five households rely on females for collection.

While urban environments can provide the antidote to the water accessibility problem, this can also result in negative side effects. In the USA, for example, residents in San Diego use 700 liters per person each day, while residents in Reno use 1,166 liters per person each day. Urban areas might improve access to water, but as these statistics seem to indicate, improved access might also induce consumers to take an overly liberal approach to water use.

Figure 14: Rural populations have been on the decline since 2007

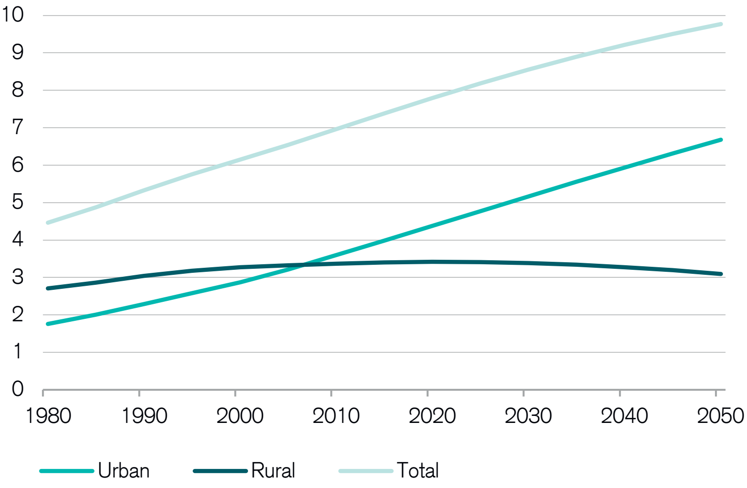
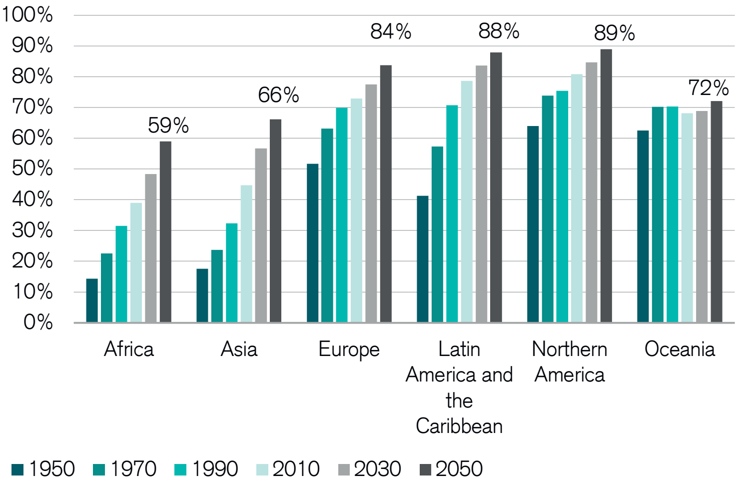
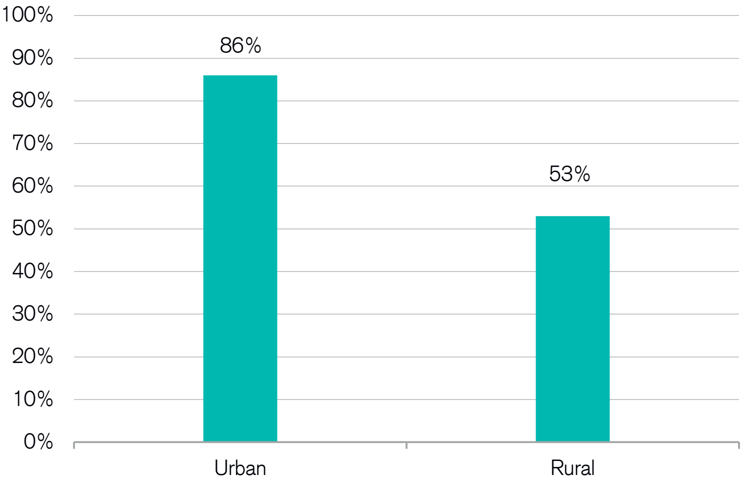


Figure 15: Percentage of regional population living in urban environments



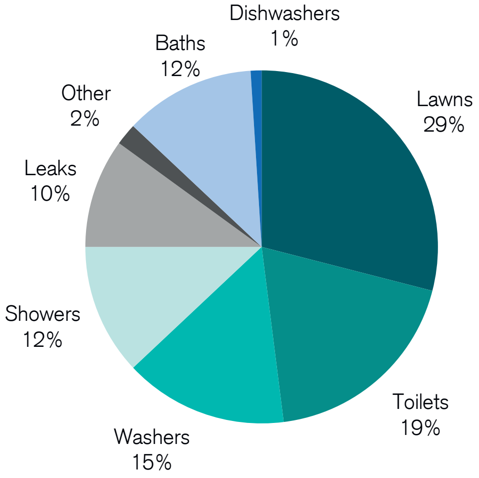
Source Figures 14 and 15: UN, Credit Suisse estimates

Figure 16: Multiple studies indicate accessibility to water is markedly higher in urban environments



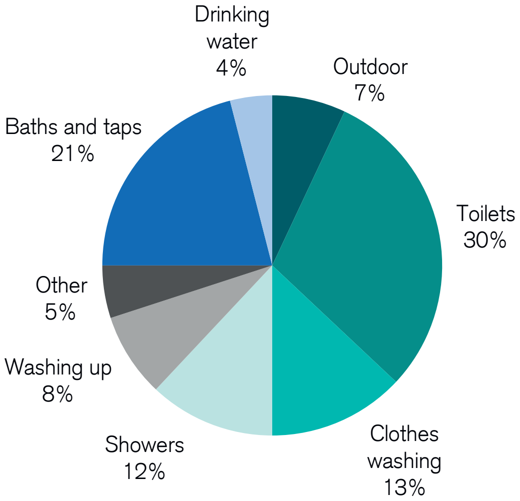
Source: UNICEF, Statista, Credit Suisse research

**Figure 17: US household water use**



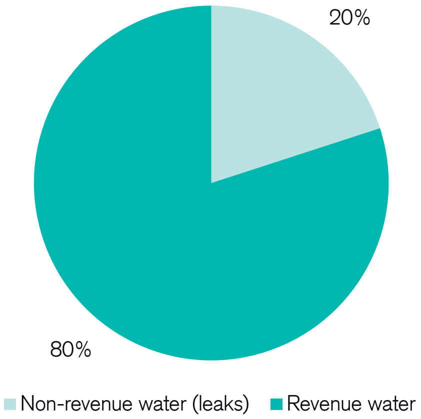
Source: Benjamin D Inskeep & Shahzeen Z Attari, Credit Suisse estimates

**Figure 18: UK household water use**



Source: Waterwise, Credit Suisse research

**Figure 19: UK water use – one fifth of all UK water is lost in the UK due to inadequate infrastructure**



Source: EurEau, Credit Suisse estimates

**2. Household water consumption dominates in urban areas:** Of all water delivered to urban areas each year, most is used in and around our homes, with residential water use accounting for 64% of total urban use. Urban areas in most countries, not least in developing ones, tend to have above-average GDP per capita. This, combined with typically better water access to households, suggests greater penetration of water-consuming appliances such as washing machines, dishwashers, sanitary systems and other devices (e.g. coffee machines and water cookers). Indeed, data from developed countries such as the USA and the UK suggest that household water consumption is mainly driven by greater toilet use, clothes washing, showers and baths.

As spending power increases across urban areas in the developing world, we expect water usage to do so as well. To underline this point, we note that the average resident of Indonesia has a GDP/capita of USD 3,900 (PPP-based) and uses just 28.9 $m^3$ of water each year. On the other hand, the average resident of Canada with GDP/capita of USD 40,200 (PPP-based) uses 276 $m^3$ each year.

**3. Rapid urbanization could create indirect water challenges:** Urbanization not only increases water demand, but if urbanization takes place too rapidly, we find that alternative water-related challenges emerge. Water loss is one of the key issues that needs to be addressed across urban areas, especially those in developed markets. While access to water may be higher in cities,  water losses also tend to be high, suggesting a lack of maintenance investment. In England and Wales, for example, about 20% of water is lost, resulting in more than 500 million liters of water being lost in 2018 alone. To underscore the lack of maintenance investment, we note that over 60% of London's 32,000 km of water infrastructure is now more than 60 years old.

Water loss is not just a developed market issue. In some cities across emerging markets (e.g. Mexico City), water leakage can represent more than 40% of total water supply. In order to meet the expected growth in water demand, we see increased investment in maintenance and replacement of existing infrastructure as key, not least across urban areas in emerging as well as developed countries.

### The rise of the emerging market middle-class

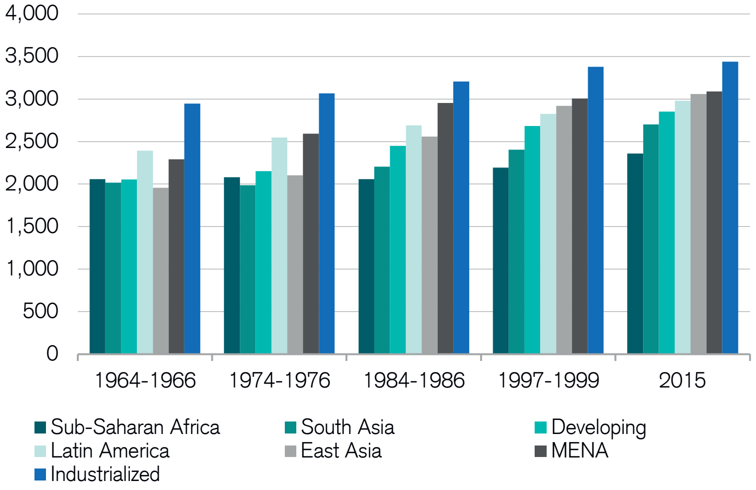
A third key driver likely to result in continued strong growth of water consumption globally relates to changing consumer spending patterns across emerging markets. The rise of the emerging market middle-class could lead to significant water challenges if these consumers adopt consumption patterns seen in other countries with higher GDP-per-capita levels. Some of the reasons are as follows:

**1. Increased consumption of water-intensive, higher-calorie food:** Rising wealth in emerging economies is most likely to lead to higher per-capita food and calorie intake as higher incomes allow greater expenditure on food. This trend is already being felt and will only continue going forward – since 1964, the largest rises in average daily consumption have been in East Asia, where daily calorie intake has increased by 49%, from 1,967 to 2,921 calories, according to the WHO. Developing economies have risen by 29%, from 2,054 to 2,850 calories over the same period. The UN Food and Agriculture Organization (FAO) expects global food demand to rise by 60%–100% by 2050. As a result, water withdrawals are likely to follow suit, with greater impact on more agriculturally dominated countries.

As real incomes continue to rise, food consumption could shift from grain-based diets (where water intensity is low) to protein-based diets (where water intensity is high). Meat is of particular importance in this regard, as livestock requires significant water consumption. In the chart below, we show that variations of meat products represent some of the most water-intensive food, with beef standing out as needing over 15,000 liters of water per kilo of meat produced. In contrast, cereals require just 1,644 liters per kilo of food.

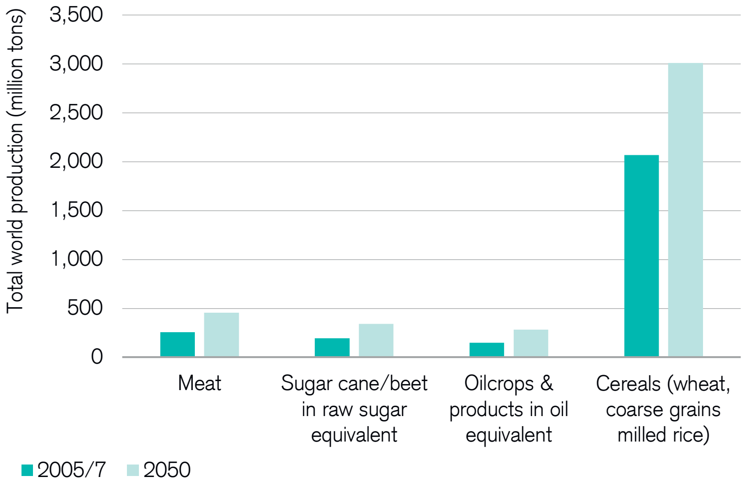
Even when factoring in protein requirements where meat is a rich source, cereals require just 21 liters per gram of protein versus beef at 112. While we do not immediately believe that a “meat-free” diet is a realistic scenario for most consumers, the relative water intensity of meat and the expected increase in meat consumption by a growing middle class across emerging markets suggest that this should be a major topic for governments to analyze.

**Figure 20: Average daily calorie consumption is rising in all regions, but most strongly in developing markets**



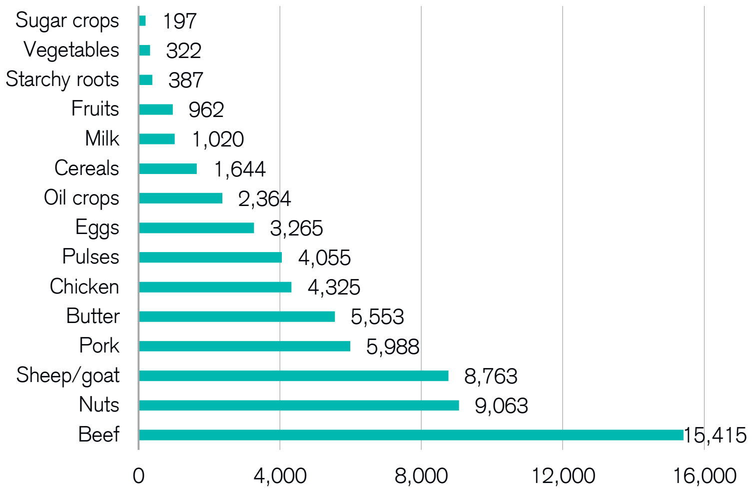
Source: WHO, Credit Suisse estimates

**Figure 21: Food production is forecast to outpace population, indicating per capita calories consumption will rise**



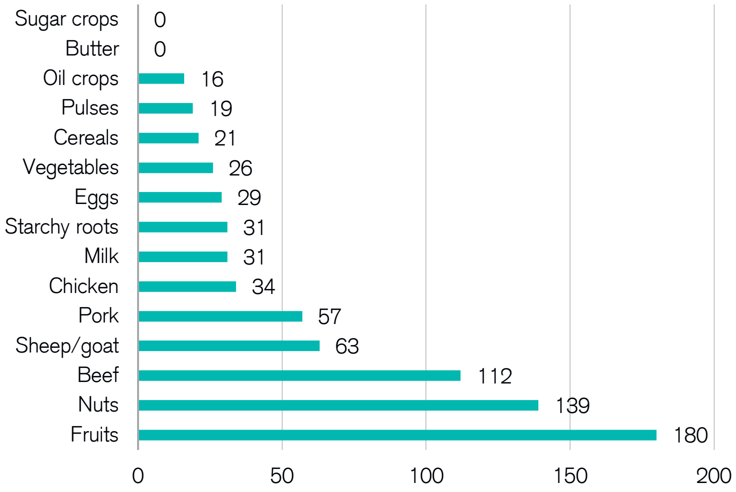
Source: FAO, Credit Suisse estimates

**Figure 22: Water requirement per kilo of food product (liters)**



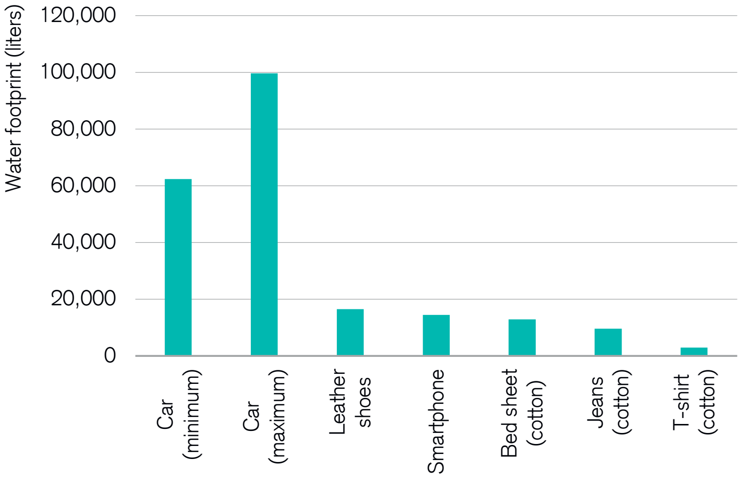
Source: Mekonnen, M.M. and Hoekstra, A.Y. (2012), Credit Suisse

Figure 23: Water requirement per gram of protein (liters)



Source: Mekonnen, M.M. and Hoekstra, A.Y. (2012), Credit Suisse

Figure 24: Water footprint of common, non-food consumer products



Source: Berger et al, Credit Suisse research

**2. Increased consumption of water-intensive non-food products:** Rising disposable incomes across developing countries also likely mean greater spending on other, non-food water-intensive products. For example, the water intensity of apparel products is high, with an average pair of jeans requiring more than 7,000 liters of water, whereas leather boots can require more than 15,000 liters to produce. Consumer electronic products such as smartphones also require significant amounts of water and the water footprint of a car can be as high as 100,000 liters.

Given how much water is needed to produce non-food products, we see a significant need for the world's governments, not least in emerging markets, to increase their focus on issues such as the "circular economy" (i.e. systems aimed at eliminating waste and the continual use of resources) and raising consumer awareness as to the impact of their spending on water stress.

## Potential water demand scenarios

Based on the drivers highlighted above, forecasting future water consumption is clearly not straightforward. All variables are changing, but not all in the same direction. In order to provide an indication of future water demand, we have calculated a stress scenario by assuming that per capita consumption of water in emerging markets increases to current developed-market levels by 2050. This scenario would represent total freshwater use of seven trillion $m^3$ by 2050 or 76% above current levels. Such a scenario would also represent substantial challenges on a global level given that global total freshwater supply is around 43 trillion $m^3$. More importantly, such a growth scenario is likely to present even greater challenges at the regional level, considering that freshwater supply is not equally distributed.

To understand where these regional issues are most likely to emerge, we have reviewed a range of different scenarios and countries. First, in Table 2, we show the forecast for the 20 most populous countries by 2050 using UN data and run a scenario assuming current water consumption per capita remains fixed along with water supply. As such, we are able to evaluate the likely water stress that these countries will face in 2050 without investments in new water infrastructure or efficiency gains. The table shows that only four of the 20 most populous countries in 2050 will have low water stress. It appears that India will be particularly stressed for water by 2050 as its potential annual freshwater consumption per capita could represent 70% of its available domestic renewable water resources in 2050.

## Table 1: Both scenarios forecast water stress at low-to-medium; however, we see the distribution of water as more pertinent

| Scenario | Freshwater withdrawal per capita (m$^3$) | Renewable internal freshwater resources per capita (m$^3$) | Population (bn) | Global freshwater withdrawals (trn m$^3$)" | Total renewable internal freshwater resources (m$^3$) | Increase in freshwater withdrawals (%) | Freshwater withdrawal/ renewable resources (%) | WRI water stress classification |
|---|---|---|---|---|---|---|---|---|
| **2014** | Current situation | | | | | | | |
| | 546 | 5921 | 7.30 | 3.99 | 43.19 | — | 9.2% | Low |
| **2050: no change** | We assume average per capita freshwater withdrawals remain flat and apply the UN's 2050 population forecast | | | | | | | |
| | 546 | 5921 | 9.74 | 5.32 | 43.19 | 33.4% | 12.3% | Low-to-medium |
| **2050: stressed** | We assume global average per capita withdrawals reach the current OECD average and apply the UN's 2050 population forecast | | | | | | | |
| | 721 | 5921 | 9.74 | 7.02 | 43.19 | 76.2% | 16.3% | Low-to-medium |

Source: FAO, Aquastat, CIA World Factbook, UN, OECD Stat, Credit Suisse estimates

## Table 2: The 20 most populous countries by 2050

| Country | Population (m) | Renewable water resources (million m$^3$) | Renewable water resources per capita (m$^3$) | Falkenmark water stress classification | Total freshwater withdrawal (million m$^3$) | Freshwater withdrawal per cap. (m$^3$) | Freshwater withdrawal/ renewable resources (%) | WRI water stress classification |
|---|---|---|---|---|---|---|---|---|
| India | 1,639.2 | 1,512,926 | 923 | Scarce | 1,063,825 | 649 | 70.3% | High |
| China | 1,402.4 | 2,923,675 | 2,085 | – | 587,318 | 419 | 20.1% | Med. to high |
| Nigeria | 401.3 | 238,516 | 594 | Scarce | 40,934 | 102 | 17.2% | Low to med. |
| USA | 379.4 | 2,837,950 | 7,480 | – | 457,603 | 1,206 | 16.1% | Low to med. |
| Pakistan | 338.0 | 58,881 | 174 | Absolute scarcity | 369,786 | 1,094 | 628.0% | Scarce |
| Indonesia | 330.9 | 2,100,512 | 6,348 | – | 154,863 | 468 | 7.4% | Low |
| Brazil | 229.0 | 5,912,902 | 25,823 | – | 70,754 | 309 | 1.2% | Low |
| Ethiopia | 205.4 | 132,122 | 643 | Scarce | 14,959 | 73 | 11.3% | Low to med. |
| Bangladesh | 192.6 | 102,976 | 535 | Scarce | 45,060 | 234 | 43.8% | High |
| Egypt | 160.0 | 1,872 | 12 | Absolute scarcity | 159,796 | 999 | 8531.9% | Scarce |
| Mexico | 155.2 | 411,294 | 2,651 | – | 112,174 | 723 | 27.3% | Med. to high |
| Philippines | 144.5 | 495,740 | 3,431 | – | 120,214 | 832 | 24.2% | Med. to high |
| Russia | 135.8 | 4,251,230 | 31,299 | – | 61,800 | 455 | 1.5% | Low |
| Tanzania | 129.4 | 82,206 | 635 | Scarce | 17,984 | 139 | 21.9% | Med. to high |
| Japan | 105.8 | 431,656 | 4,080 | – | 74,803 | 707 | 17.3% | Low to med. |
| Iran | 103.1 | 130,329 | 1,264 | Stress | 141,450 | 1,372 | 108.5% | Scarce |
| Turkey | 97.1 | 229,678 | 2,364 | – | 54,203 | 558 | 23.6% | Med. to high |
| Kenya | 91.6 | 21,612 | 236 | Absolute scarcity | 7,967 | 87 | 36.9% | Med. to high |
| Uganda | 89.4 | 41,982 | 469 | Absolute scarcity | 1,073 | 12 | 2.6% | Low |
| Germany | 80.1 | 105,714 | 1,320 | Stress | 31,400 | 392 | 29.7% | Med. to high |

Source: FAO, Aquastat, CIA World Factbook, UN, Credit Suisse estimates

# 3. Water supply: A static problem

**Eugène Klerk, Oliver Isaac**

Having considered the secular trends in water use and consumption, we reconcile our findings with where water resources can be found across the globe. We find that water supply, which we measure using renewable internal freshwater resources, excluding external resources, is typically very static.

## The global supply-demand gap

### The 2030 40% supply-demand gap

One of the most widely cited figures that comes up in the water-scarcity discussion is the 2030 supply-demand gap from the UN-endorsed "Charting Our Water Future" report in 2009. The report notes that incremental water use will largely come from industry in the future, which could see its share of total water use rise from 16% currently to around 22% by 2030.

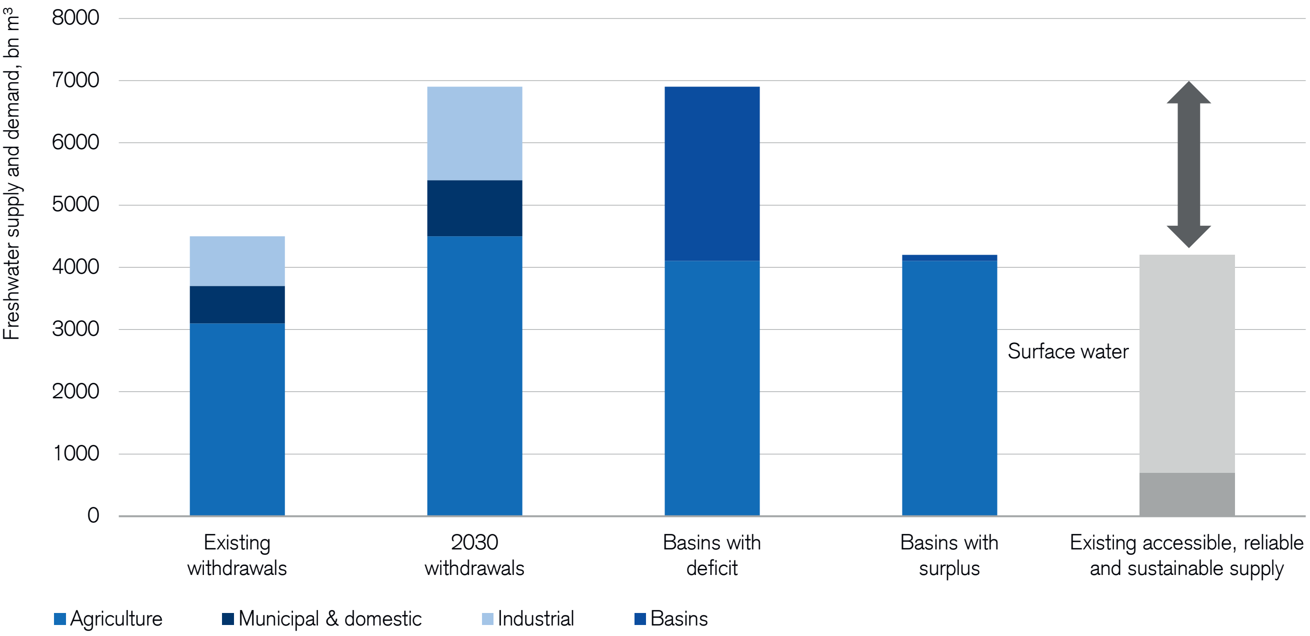
This scenario assumes stable economic growth and an absence of efficiency gains. Historically, annual efficiency gains in agricultural water use between 1990 and 2004 averaged 1%, with industry following a similar trend. Applying a similar rate of efficiency gains until 2030 helps close 20% of the 40% supply-demand gap, while adjusting for supply growth from technology and cost developments closes another 20%. Despite these potential improvements, there would still be a gap of 24% between supply and demand, suggesting significant water stress on a global scale.

### The need for a global response

Climate change has received a global, coordinated response through, for instance, the 2015 Paris Agreement, which marked a universal acceptance and recognition of the greenhouse gas (GHG) crisis and was signed by 196 countries. On the other hand, the challenges related to growing water scarcity have yet to provoke a comparable response.

Part of the reason why the issue of water scarcity has not received the necessary attention by the global community to date might, in our view, be because water scarcity is perceived as a more local issue than climate change. Although water scarcity and stress differ by country, we believe that a global approach is needed. The fact that water is a specific part of the 17 Sustainable Development Goals as highlighted by the United Nations in 2015 underscores the need for a coordinated global approach to address water stress on a local level, in our view.

### Figure 1: The forecast 2030 supply-demand gap



Source: McKinsey, Credit Suisse estimates

## Supply stress differs by country

### The most water-stressed countries today

Given the regional nature of the water-scarcity problem, it is not surprising to find a number of countries facing high levels of stress just north of the equator, as renewable resources are low in these areas given climate and geography. Notably, North Africa and the Middle Eastern countries, along with some Asian countries such as India, are all facing high stress levels.

### The most water-stressed countries in 2050

To assess how water scarcity will evolve in the future, we apply a scenario where per capita withdrawals remain constant and apply the UN's 2050 population forecast for each country, holding renewable resources constant over time. In essence, we assume no investment in water infrastructure is made, as well as an absence of efficiency gains, but also assume no growth in per capita demand from urbanization and economic development. We view this as a conservative consumption given that, globally, per capita withdrawals have fallen from just over 700 m³ in the 1980s to under 600 m³ today.

### The least water-stressed countries in 2050

Having listed the 20 countries where we believe water stress could be most significant by 2050, we note that, symmetrically, there are countries with surplus water accounts, which we again measure using the criticality ratio where freshwater withdrawals are divided by renewable internal freshwater resources.

Although, simplistically, a lower criticality ratio is usually positive, this is not necessarily always the case as poor accessibility to water may be the reason for a country's relatively low water withdrawals. For example, the Central Africa Republic appears to be the least-stressed country based on the criticality ratio of 0.1%. However, freshwater withdrawals per capita stand at just 17 m³, clearly suggesting that the low criticality ratio is not because of an abundance of water supply, but more likely because people have poor or no access to available freshwater.

Notably, no countries appear stressed in terms of water according to the Falkenmark metric, which expresses the level of water scarcity in a certain region as the amount of renewable freshwater that is available for each person each year. This suggest that sufficient water supply exists in absolute terms and thereby clearly supports the notion that it is the lack of access that needs to be addressed, which in turn calls for greater investment.

## Table 1: The 20 most water-stressed countries in 2050

| Country | Population (m) | Renewable water resources (million m³) | Renewable water resources per capita (m³) | Falkenmark water stress classification | Total freshwater withdrawal (million m³) | Freshwater withdrawal per capita (m³) | Freshwater withdrawal / renewable resources (%) | WRI water stress classification |
|---|---|---|---|---|---|---|---|---|
| Egypt | 160.0 | 1,872 | 12 | Absolute scarcity | 159,797 | 999 | 8531.9% | Scarce |
| United Arab Emirates | 10.4 | 196 | 19 | Absolute scarcity | 16,232 | 1,557 | 8271.9% | Scarce |
| Turkmenistan | 7.9 | 1,433 | 180 | Absolute scarcity | 44,866 | 5,644 | 3129.9% | Scarce |
| Saudi Arabia | 44.6 | 2,684 | 60 | Absolute scarcity | 39,037 | 876 | 1454.4% | Scarce |
| Mauritania | 9.0 | 421 | 47 | Absolute scarcity | 3,944 | 437 | 936.7% | Scarce |
| Pakistan | 338.0 | 58,882 | 174 | Absolute scarcity | 369,786 | 1,094 | 628.0% | Scarce |
| Iraq | 70.9 | 38,454 | 542 | Scarce | 206,507 | 2,911 | 537.0% | Scarce |
| Uzbekistan | 42.9 | 17,087 | 398 | Absolute scarcity | 89,578 | 2,086 | 524.2% | Scarce |
| Israel | 12.7 | 751 | 59 | Absolute scarcity | 3,435 | 270 | 457.3% | Scarce |
| Yemen | 48.1 | 2,232 | 46 | Absolute scarcity | 8,270 | 172 | 370.5% | Scarce |
| Jordan | 12.9 | 744 | 58 | Absolute scarcity | 2,108 | 163 | 283.5% | Scarce |
| Oman | 6.9 | 1,431 | 207 | Absolute scarcity | 3,250 | 470 | 227.1% | Scarce |
| Azerbaijan | 11.1 | 8,542 | 772 | Scarce | 16,266 | 1,470 | 190.4% | Scarce |
| Niger | 65.6 | 3,907 | 60 | Absolute scarcity | 5,313 | 81 | 136.0% | Scarce |
| Barbados | 0.3 | 81 | 294 | Absolute scarcity | 97 | 351 | 119.4% | Scarce |
| Iran | 103.1 | 130,330 | 1,264 | Stress | 141,451 | 1,372 | 108.5% | Scarce |
| Malta | 0.4 | 51 | 120 | Absolute scarcity | 52 | 123 | 102.7% | Scarce |
| Netherlands | 17.2 | 11,125 | 648 | Scarce | 10,934 | 637 | 98.3% | Extremely high |
| Tunisia | 13.8 | 4,378 | 317 | Absolute scarcity | 4,056 | 294 | 92.6% | Extremely high |
| Algeria | 60.9 | 11,656 | 191 | Absolute scarcity | 10,723 | 176 | 92.0% | Extremely high |

Source: FAO, Aquastat, CIA World Factbook, UN, Credit Suisse estimates

## Supply stress differs even within countries

So far, we have considered the water-scarcity problem in a country-based context, viewing water stress as a function of a country's supply and demand. Although this captures much of the problem, it masks significant inequalities that can exist within countries. Specifically, we see several issues that can drive intra-country water stress.

**Regional water imbalances within countries**
One aspect of intra-country water challenges relates to the fact that supply-demand distribution can be severely out of sync. For example, China is home to 20% of the world's population but possesses just 7% of the freshwater supply. In terms of supply, China's overall renewable resources per capita is 2085 m³, or over 300 m³ more than required to be classified as "stressed" based on the Falkenmark indicator. However, the distribution of this water is very uneven, with 77% of all water resources located in the south. Indeed, eight provinces in the north of the country suffer from acute water scarcity, with a further four suffering from scarcity. Critically, these provinces represent 38% of China's agriculture, 50% of its power generation and 41% of its population.

## Table 2: The 20 least water-stressed countries in 2050

| Country | Population (m) | Renewable water resources (million m³) | Renewable water resources per capita (m³) | Falkenmark water stress classification | Total freshwater withdrawal (million m³) | Freshwater withdrawal per capita (m³) | Freshwater withdrawal / renewable resources (%) | WRI water stress classification |
|---|---|---|---|---|---|---|---|---|
| Central African Rep. | 8.4 | 145,719 | 17,345 | – | 143 | 17 | 0.1% | Low |
| Iceland | 0.4 | 174,407 | 463,006 | – | 216 | 573 | 0.1% | Low |
| Liberia | 9.3 | 210,138 | 22,499 | – | 420 | 45 | 0.2% | Low |
| Gabon | 3.8 | 176,181 | 46,253 | – | 381 | 100 | 0.2% | Low |
| Sierra Leone | 12.9 | 182,219 | 14,077 | – | 466 | 36 | 0.3% | Low |
| Fiji | 1.1 | 28,757 | 26,844 | – | 96 | 90 | 0.3% | Low |
| Paraguay | 9.1 | 125,055 | 13,740 | – | 801 | 88 | 0.6% | Low |
| Guinea | 26.0 | 225,313 | 8,675 | – | 1,506 | 58 | 0.7% | Low |
| Colombia | 56.0 | 2,185,997 | 39,065 | – | 16,004 | 286 | 0.7% | Low |
| Guyana | 0.8 | 241,503 | 292,746 | – | 1,807 | 2,191 | 0.7% | Low |
| Lesotho | 2.7 | 5,872 | 2,203 | – | 51 | 19 | 0.9% | Low |
| Cameroon | 50.6 | 300,979 | 5,951 | – | 2,883 | 57 | 1.0% | Low |
| Suriname | 0.7 | 103,560 | 152,241 | – | 1,038 | 1,526 | 1.0% | Low |
| Norway | 6.6 | 393,349 | 59,595 | – | 4,211 | 638 | 1.1% | Low |
| Panama | 5.9 | 144,449 | 24,680 | – | 1,697 | 290 | 1.2% | Low |
| Brazil | 229.0 | 5,912,902 | 25,823 | – | 70,755 | 309 | 1.2% | Low |
| Nicaragua | 8.5 | 160,311 | 18,791 | – | 2,047 | 240 | 1.3% | Low |
| Brunei Darussalam | 0.5 | 8,705 | 17,679 | – | 114 | 232 | 1.3% | Low |
| Russia | 135.8 | 4,251,231 | 31,299 | – | 61,800 | 455 | 1.5% | Low |
| Bolivia | 15.8 | 323,806 | 20,443 | – | 4,720 | 298 | 1.5% | Low |

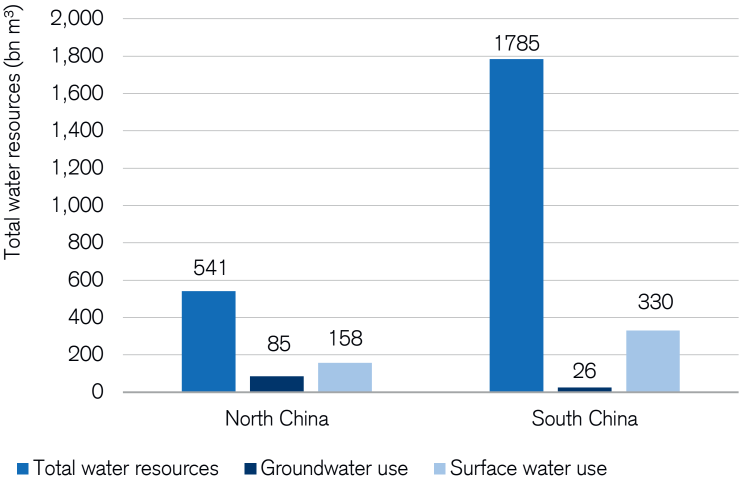
Source: FAO, Aquastat, CIA World Factbook, UN, Credit Suisse estimates

China is fully aware of the problem, with the Financial Times reporting that its 13th Five Year Plan aims to halve per capita water consumption while doubling China's 2010 GDP. Its USD 62 billion South-North Water Transfer Project also aims to divert 44 billion m³ from the Yangtze River in South China to the Yellow River Basin in the arid north, but is only set for completion in 2050.

### Groundwater depletion in agriculturally intense regions

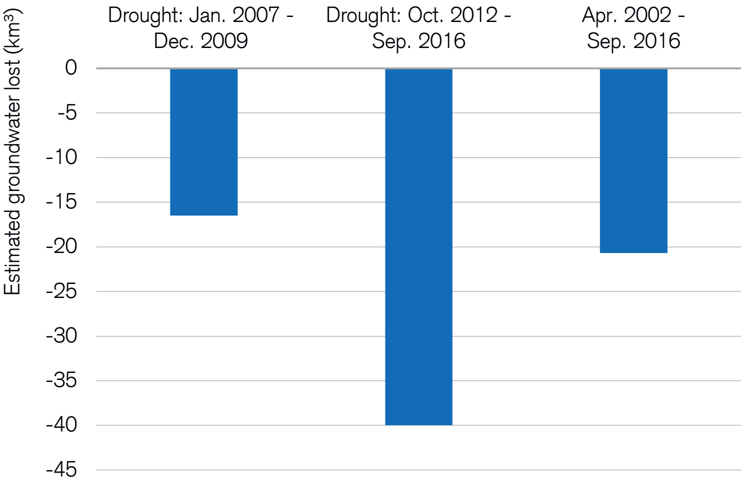
Groundwater depletion as a result of heavy irrigation is another factor that can impact areas within countries. If aquifers (layers of rock and sand containing or transmitting groundwater) located close to areas with high irrigation intensity are not replenished at a rate close to that at which they are used, water supply becomes permanently impaired. These localized water stress challenges also have global implications. According to a 2016 study by the Colorado School of Mines, it is estimated that the nearly 50% of food production in warm, dry

### Figure 2: 77% of China's water resources lie in its Southern provinces



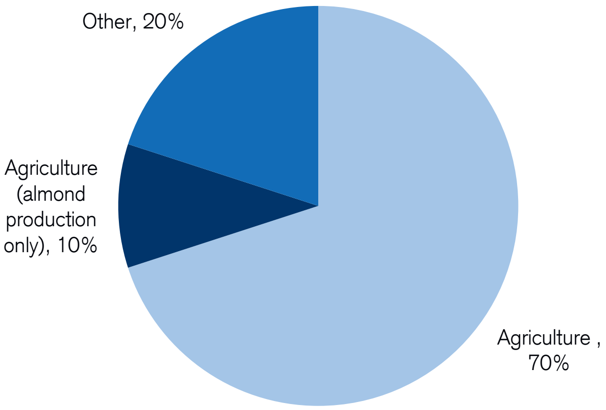
Source: China Water Risk, Credit Suisse estimates

### Figure 3: Groundwater supply in the Central Valley; California has been in structural decline since 2002



Source: USGS

### Figure 4: California's water use – agriculture represents 80% of water use, with almond production making up 10%



Source: Slate, Credit Suisse research

parts of the planet that rely on excessive aquifer extraction could be at risk by 2050. Not only does this extraction threaten food supply, but it could also leave some 1.8 billion people without access to this crucial supply of freshwater.

### California's agricultural water crisis

California is a notable example of the problems generated by excessive groundwater extraction for agricultural purposes. Annually, the state has around 200 million acre-feet of water supply, with half absorbed by plants and nature and the rest used by humans. Agriculture and farming use 80% of this water supply, and cities consume most of what's left.

The Central Valley encapsulates the problem, spanning 11% of the state's land area and its watershed covering just over a third of California. Most salient is that the Valley grows over 250 crops, which constitute around 25% of the country's food supply. As such, water demand is vast, particularly given the growth in water-intense foods such as almonds, which are prominent in the region. Combined with the volatility in rainfall and surface water, where water supply can fluctuate by 40 million acre-feet per year, farmers have been aggressively leveraging their groundwater supplies. With little regulation surrounding groundwater withdrawals until recently, the Central Valley has seen groundwater storage fall by almost 60 million acre-feet since 1960.

## Groundwater depletion in urban environments

Groundwater depletion is not only an issue in agriculturally intense areas, but also in some urban environments. Large aquifers underneath cities are being depleted as the shift from rural to urban environments is concentrating demand. Diminished aquifers not only raise the risk of so-called "Day Zero" events for cities, but also trigger more geological risks.

### Increasing risks of "Day Zero"

Although in part driven by drought, problems surrounding the concentration of water use from urban environments are clear from the increased risk of "Day Zero" for cities across the globe. Coined during Cape Town's 2018 crisis, "Day Zero" is the day when the taps are turned off as water supply reaches a critical level.

**Cape Town, 2018**: In 2018, Cape Town came within 90 days of Day Zero, defined by city officials as the point water supply in its reservoir reached just 13.5% of full capacity. Had the event occurred, water was to have been rationed to 25 liters per day, with 200 sites earmarked for distribution.

**Sao Paulo, 2015:** Home to some 22 million people and one of the ten most populous cities in the world, Sao Paulo came within 22 days of Day Zero in 2015. Although 12%–14% of the world's freshwater lies in Brazil, with the country appearing in the 20 least-water-stressed countries in our 2050 analysis, Sao Paulo's difficulties capture the problems of concentrated urban demand. Most of Brazil's freshwater lies in the Amazon River and northern rain forests, beyond reach of Sao Paulo. Prior to the 2014–17 Brazilian drought, daily water use per person per day in Sao Paulo stood at 155 liters. This amount fell to 118 liters in March 2015. Although both cases were triggered by harsh droughts, these represent the real regional risks of diminishing water supply surrounding urban environments.

### The side-effects of diminished aquifers: Beijing is "sinking"

One side-effect of falling groundwater levels near cities is the gradual lowering of ground levels. Beijing is experiencing precisely this, as some neighborhoods are subsiding at a rate of four inches per year as the aquifer below the city is pumped. Indeed, the North China Plain (the aquifer below the city) has been so heavily extracted to cater to the city's population of over 20 million that Beijing is now the fifth most-stressed city in the world. In 2014, Beijing's supply per inhabitant stood at just 145 $m^3$, which is classified as "absolute water scarcity" according to the Falkenmark index.

### Jakarta

With more than ten million people, Jakarta faces very significant risk from both flooding and groundwater depletion. Recent events that underscore these risks include floods in 2007, which caused more than 300,000 people to be evacuated while 80 citizens died. A Dutch engineering firm (Witteveen and Bos) estimated that the city would need seven-meter high walls to protect itself from rising sea levels. Models from the Bandung Institute of Technology suggest that 95% of the city will be submerged by 2050. This is not only driven by rising sea levels, but also by the fact that the city is sinking quickly. Over the past ten years the city has sunken by 2.5 meters.

GettyImages, Narongsak Kumma / EyeEm

# 4. Climate change and water stress

**Phineas Glover, April Lowis**

Water stress and climate change are intrinsically linked – not least because disruption to rainfall patterns is a direct, incontrovertible result of climate change. The implications are two-fold. One is an immediate disruption: increased droughts, floods and temperatures. The other is a more permanent, systemic effect where increases in water vapor in the atmosphere increase heavy downpours and, ultimately, soil erosion.

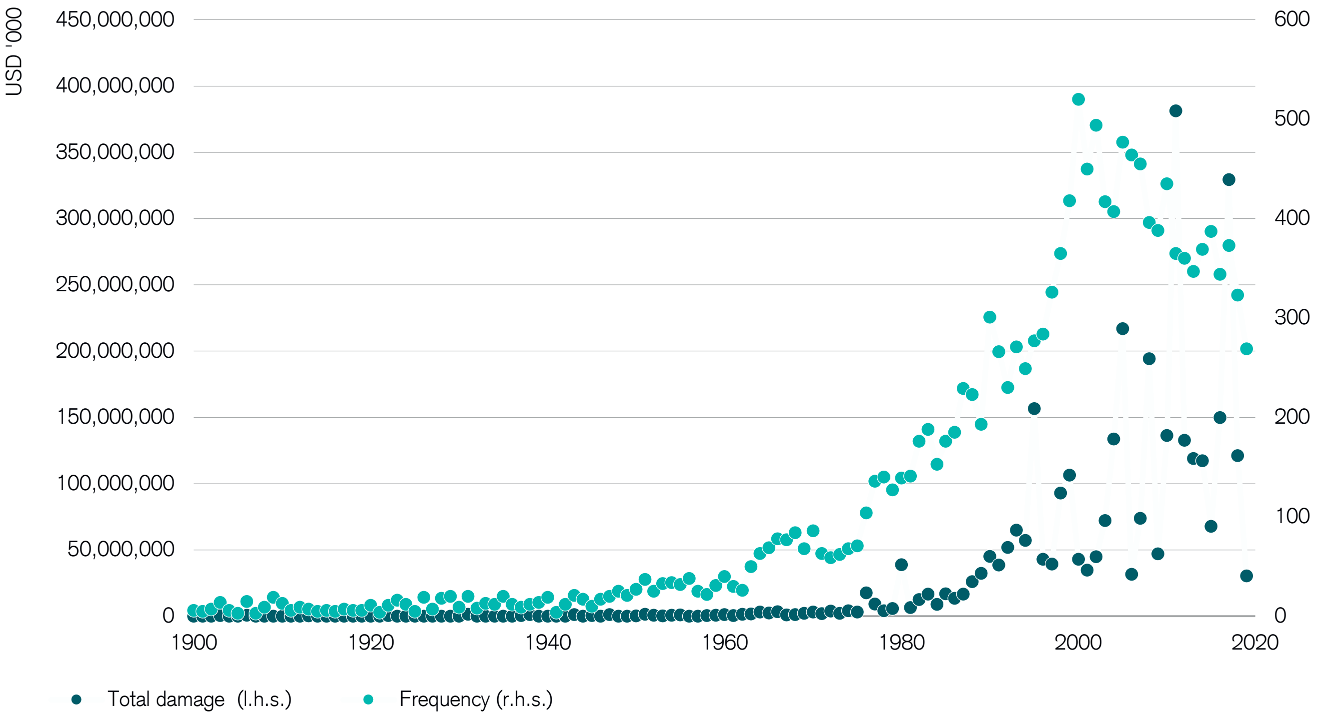
Heavy downpours have a debilitating effect on the productivity of the soil: water run-off increases, thereby decreasing water infiltration and the storage capacity of the soil, which in turn exacerbates future droughts. Soil that contains about three times more nutrients than what is left in the remaining soil is eroded, topsoil that contains 1.3–5 times more organic matter is eroded, and lower soil depth stunts plant growth. The surest sign of these issues manifesting is an increase in droughts.

Therefore, water is the most acute and current phenomena affected by climate change. Higher temperatures and more extreme, less predictable weather conditions are projected to affect availability and distribution of rainfall, surface water (snowmelt, river flows and lakes), and even the sustainability of large and ancient groundwater aquifers. According to scientists from the Intergovernmental Panel on Climate Change (IPCC), anthropogenic influences have affected the global water cycle since 1960, and such effects are the increased likelihood of more intense droughts and precipitation events.

Climate change affects water in several, inter-connected, ways:

- The hydrological cycle is strengthened: higher temperatures mean that there is increased evaporation (from the land and sea) and transpiration (from plants) into the atmosphere. As air gets warmer it holds more water vapor, resulting in more frequent and intense rainstorms. Intense rainstorms increase the risk of flooding, but much of the water runs off into rivers and streams, doing little to dampen soil.
- Altering when, where, and how much precipitation falls and resulting in a bifurcation in rainfall coverage and intensity: a reduction in the subtropics and an increase in subpolar latitudes and some equatorial regions. These material changes in spatial and temporal patterns and variability of precipitation ultimately affect surface water flows and storage levels.
- Altering key ocean temperature oscillations: increases in sea surface temperatures are altering long-standing oscillations in warmer and colder phases, weakening the cold phases and resulting in large divergences in rainfall on land, e.g. the Indian Ocean Dipole more frequently in positive oscillation correlates with more frequent and severe droughts in Southeast Asia and Southern Australia.

**Figure 1: The frequency and severity of natural disasters and weather extremes has increased significantly**



Source: The International Disaster Database, Credit Suisse Research

- Increasing pollution run-off and risking water quality: An additional complicating factor is that increased occurrences of heavy downpours may result in higher run-off of pollutants, thereby worsening the quality of nearby water sources, both surface and sea water (US EPA Climate Impacts on Water Resources, 2017). One result is the promotion of algal blooms that can clog coasts and waterways with clouds of algae and, ultimately, block sunlight and diminishing oxygen levels within the water. This further exacerbates the existing trend of dissolved oxygen being depleted faster as water temperatures increase.
- Resulting in "water tower" drawdown: Sometimes called "water towers" as critical headwaters to major rivers systems, mountain meltwater and runoff provide more than 50% of the world's freshwater (Viviroli et al, 2003, Mountain Research and Development). However, as global temperatures increase, glaciers are melting at an unprecedented rate. Moreover, as freshwater from melted glaciers runs into the ocean and sea levels rise, saltwater can more easily contaminate underground freshwater-bearing rocks (aquifers).

Water availability changes could range from –5% to +5% due to climate-change effects, but changes can be much more pronounced at the country level (source: Burek et al. 2016). With 18 of the 19 warmest years on record having occurred in the 21st century, and 2019 being the 43rd consecutive year (since 1977) of global temperatures exceeding the 20th-century average, we expect a continuation of climate change impacting the water cycle (NOAA, European Union, World Bank). In a "business-as-usual" scenario (RPC 8.5), global temperatures could increase by 4°C (7.2°F) by 2100, with some regions experiencing temperatures up to 12°C (21.6°F) hotter than their 2005 baselines, according to the intergovernmental Panel on Climate Change (IPCC).

## Emerging markets disproportionately affected

Emerging markets and low-income OECD countries are more exposed to extreme weather events. Furthermore, mitigation measures are significantly less comprehensive relative to developed nations, and so shocks to GDP are likely to be amplified:

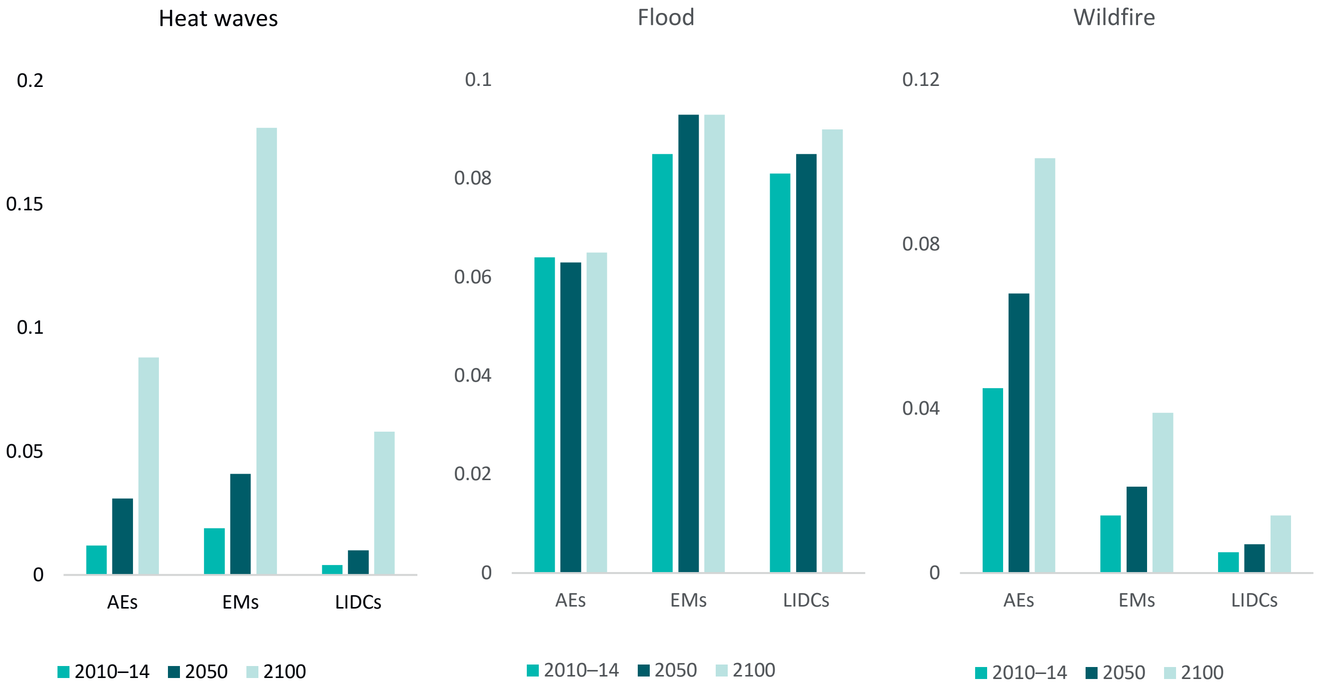
- Emerging markets are acutely exposed to shifts in precipitation: In a 4°C world, precipitation is projected to decline between in 20% and 50%, in Central America, the Caribbean, the Western Balkans, the Middle East and North Africa, significantly increasing the risk of disruption in exposed countries. At the other end of the spectrum, precipitation intensity increases by around 30% and flooding risks rise substantially in large areas of Central and Eastern Siberia and northwestern South America (World Bank, 2014).

- Rising temperatures have highly uneven macroeconomic effects: The adverse consequences of increasing temperatures are borne disproportionately by countries with hot climates, such as most low-income developing countries. A small rise in temperature lowers per capita output in countries with high average temperatures in both the short and medium term through a wide array of channels.
- The negative effects for low-income countries could be far-reaching: Under the conservative assumption that temperature increases affect the level rather than the growth path of output, International Monetary Fund (IMF) model simulations suggest that the output of a representative low-income country could be 9% lower than otherwise, with considerable downside risks.

### Extreme weather events in 2019

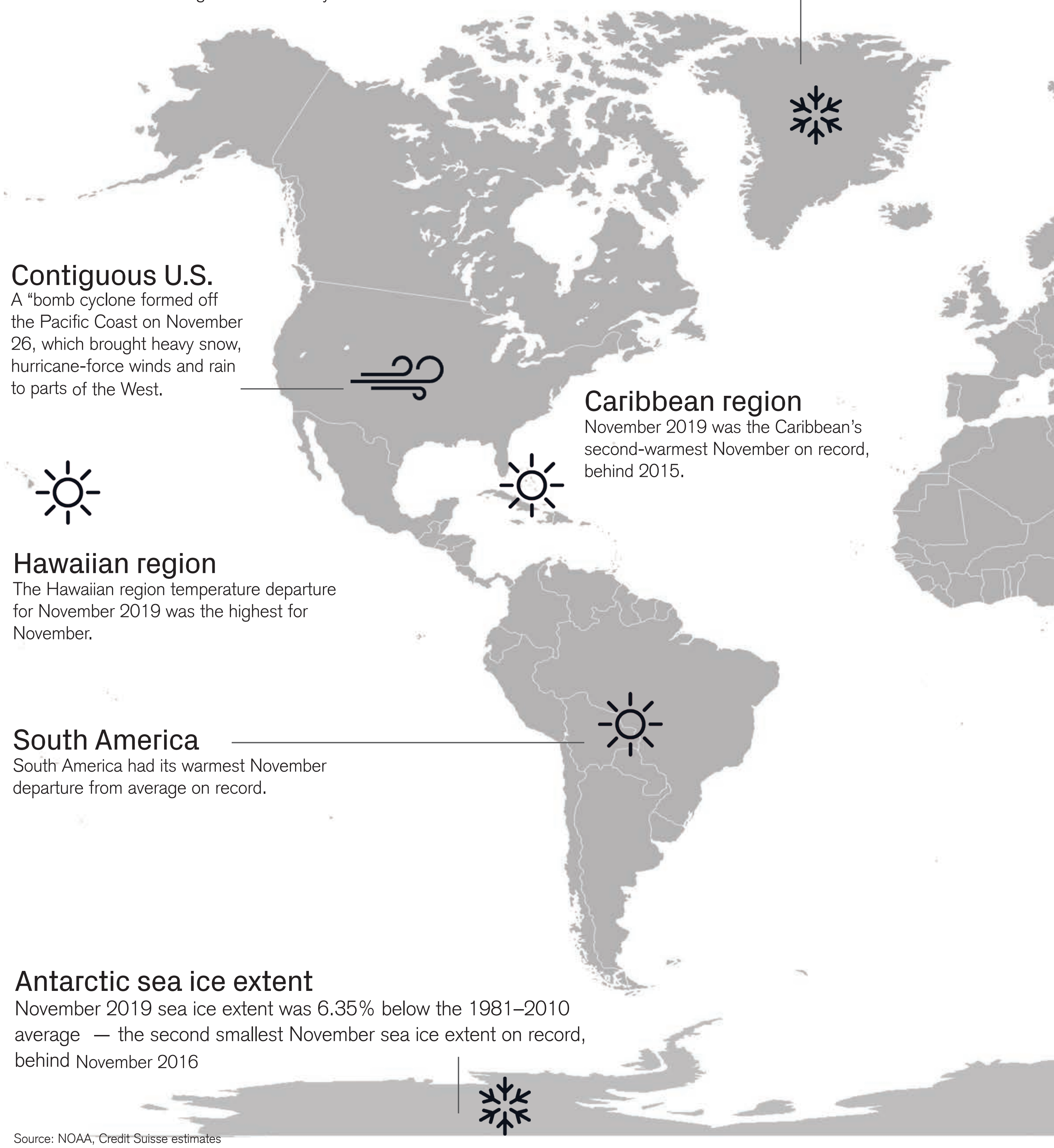
- **Flooding:** Ten separate flood events in Asia in 2019 led to a total death toll of 891 people: 326 were from India and 181 from Indonesia. One of the most significant flood events in Asia occurred in mid-July from monsoonal downpours, resulting in widespread flooding and landslides across South Asia, and the deaths of 89 people across Bangladesh, China, India, and Nepal. In April 2019, South Africa experienced significant flooding in the coastal city of Durban caused by torrential rain. The floods resulted in approximately 85 deaths from collapsed buildings, mudslides and sinkholes. In December 2019, heavy rains precipitated a series of flash floods, mudslides and landslides in northwestern Burundi, killing 27 people and leaving ten missing.
- **Drought:** Spring 2019 was officially Australia's driest on record and comes on top of previous dry seasons, with the year-to-December rainfall the second lowest on record. Water storages in some areas of eastern Australia reached 0%, causing debate between political parties, residents, industry and environmental advocates. One of the strongest positive Indian Ocean Dipoles (IOD) on record influenced the severity

**Figure 2: Analysis by the IMF of historical and projected monthly probability of natural disaster occurrences shows a pronounced risk exposure in emerging markets versus advanced economies**



Source: IMF, Credit Suisse research

# Selected significant climate anomalies and events in November 2019



## Arctic sea ice extent

November 2019 sea ice extent was 12.8% below the 1981 average the second smallest November sea ice extent since satellite records began in 1979. Only November 2016 was smaller.

## Contiguous U.S.

A “bomb cyclone formed off the Pacific Coast on November 26, which brought heavy snow, hurricane-force winds and rain to parts of the West.

## Caribbean region

November 2019 was the Caribbean’s second-warmest November on record, behind 2015.

## Hawaiian region

The Hawaiian region temperature departure for November 2019 was the highest for November.

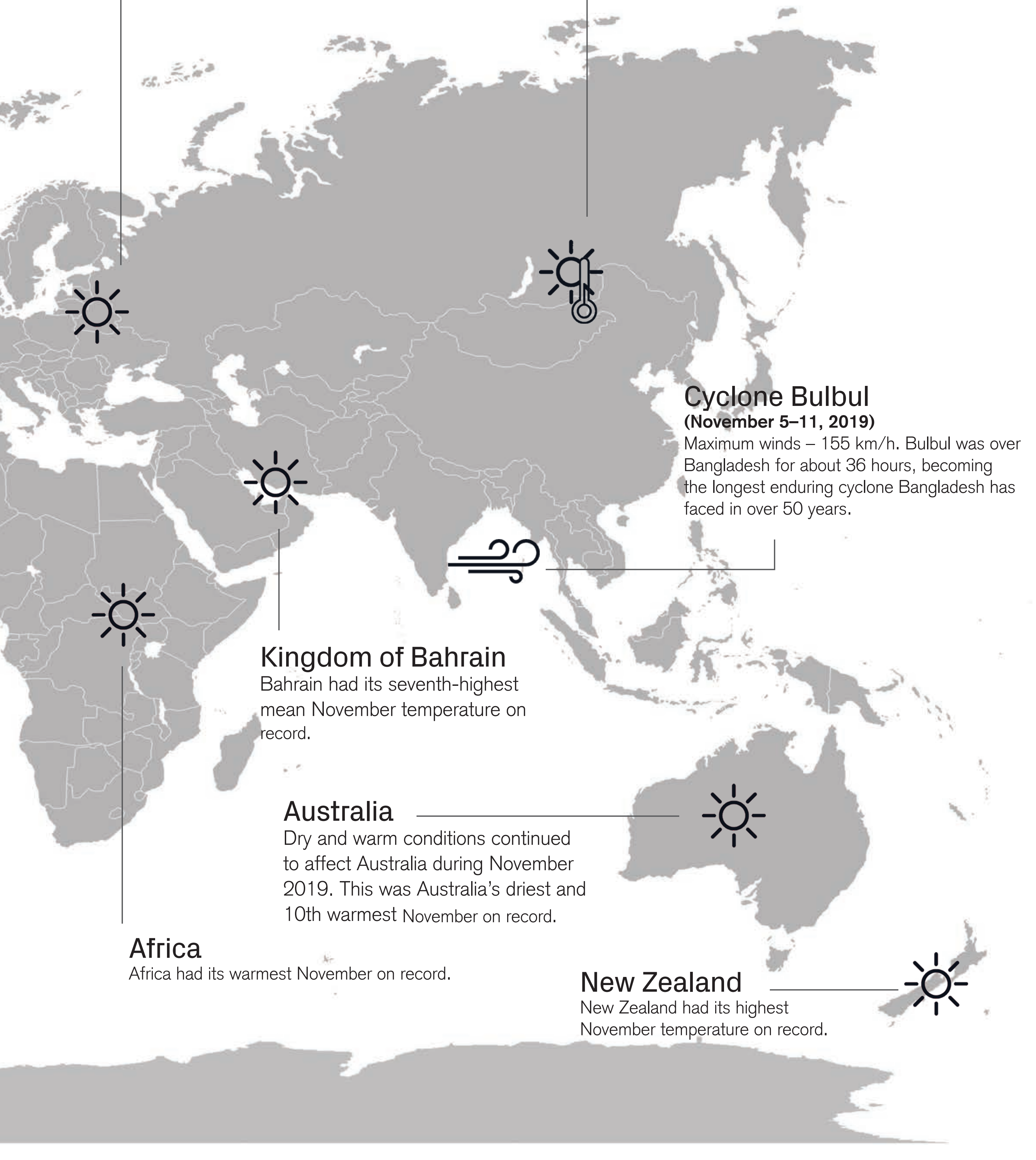
## South America

South America had its warmest November departure from average on record.

## Antarctic sea ice extent

November 2019 sea ice extent was 6.35% below the 1981–2010 average — the second smallest November sea ice extent on record, behind November 2016

Source: NOAA, Credit Suisse estimates



### Europe

Europe had its seventh warmest November on record

### Asia

While much of western and central Asia had near to cooler-than-average temperatures, much of the south and north-eastern had warmer-than-average conditions. Overall, Asia's November 2019 temperature departure from average tied with 1938 and 1924 as the 26th warmest November on record.

### Cyclone Bulbul

**(November 5–11, 2019)**

Maximum winds – 155 km/h. Bulbul was over Bangladesh for about 36 hours, becoming the longest enduring cyclone Bangladesh has faced in over 50 years.

### Kingdom of Bahrain

Bahrain had its seventh-highest mean November temperature on record.

### Australia

Dry and warm conditions continued to affect Australia during November 2019. This was Australia's driest and 10th warmest November on record.

### Africa

Africa had its warmest November on record.

### New Zealand

New Zealand had its highest November temperature on record.

of the drought. The climate driver brings wet conditions to eastern Africa, but dry conditions to Australia, with warm waters in the western Indian Ocean and cool waters near Australia. It has also caused record-low rainfalls in places like Singapore. The year 2019 saw large parts of India experience the worst drought in decades, with one government report finding that 600 million Indians (nearly half the population) face acute water shortages. Chennai, a city of eight million, reached Day Zero in June 2019, with officials declaring there was no more water available for consumption.

- **Heat:** July 2019 was the hottest month on record globally since temperature records began. Europe was a primary driver of record-breaking temperatures, with heatwaves in both June and July 2019. The June heatwave broke records in multiple cities including Conqueyrac, France, which broke its previous record by 2°C. One month later, a similar and more severe heatwave occurred that broke temperature records in cities across several European countries. All-time national heat records were broken by 3.1°C in the Netherlands, by 3°C in Belgium, by 2.9°C in Luxembourg, by 2.1°C in Germany and by 0.2°C in the United Kingdom. On 27 December 2019, Australia experienced its hottest day on record with the national average temperature reaching a high of 40.9°C.
- **Cyclones/hurricanes/typhoons:** Hurricane Dorian was the most intense tropical cyclone on record to affect the Bahamas, and is regarded as the worst natural disaster in the country's history, with estimated damages reaching USD 3.4 billion. Damage in the Bahamas was catastrophic due to the prolonged and intense storm conditions, including heavy rainfall, high winds and storm surges, with thousands of homes destroyed and at least 73 deaths recorded (282 people are still missing). Typhoon Wutip in the Philippines was the most powerful February typhoon on record, surpassing Typhoon Higos in 2015. Wutip was a Category 5 super typhoon and caused at least USD 3.3 million in damages in Guam and Micronesia. Cyclone Idai was one of the worst tropical cyclones on record to affect Africa and the Southern Hemisphere and killed more than 1,300 people, with many more missing.
- **Fires:** The 2019 Amazon rainforest wildfires season saw a year-on-year surge, burning approximately 906,000 hectares. The wildfires were caused by deforestation for agriculture and led to international concern about the fate of the Amazon rainforest, the world's largest terrestrial carbon dioxide sink. Beginning in late August 2019, the Australian east coast experienced a number of major bushfires across multiple states.

  By 21 December 2019, the fires had burnt over 3,000,000 hectares, destroyed over 700 houses and killed at least nine people.

### Both floods & droughts drive water scarcity

It is important to note that actual water availability is impacted by projected increases in both flooding and drought going forward. Climate models project an increase in the amount of water evaporating and precipitating over the Earth – a strengthening of the global hydrologic cycle. This brings a bifurcation in rainfall coverage and intensity: a reduction in the subtropics and an increase in subpolar latitudes and some equatorial regions. The National Oceanic and Atmospheric Administration (NOAA) describes this as the "wet getting wetter and the dry getting drier,"

**Figure 3: Vulnerability to temperature increases and adaptation prospects**

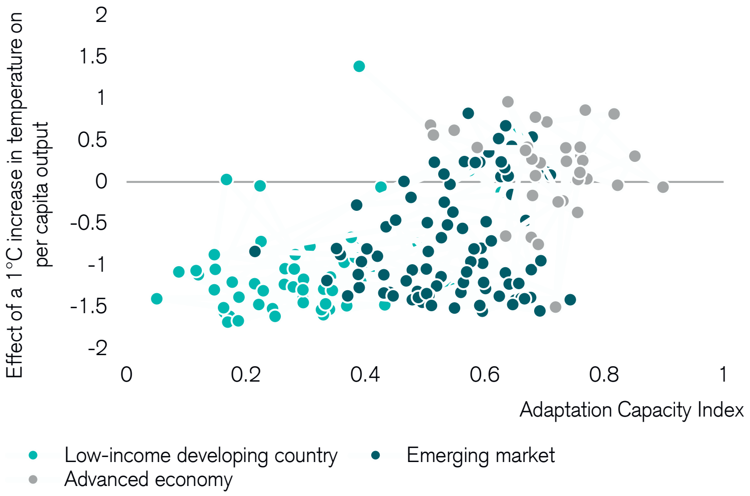
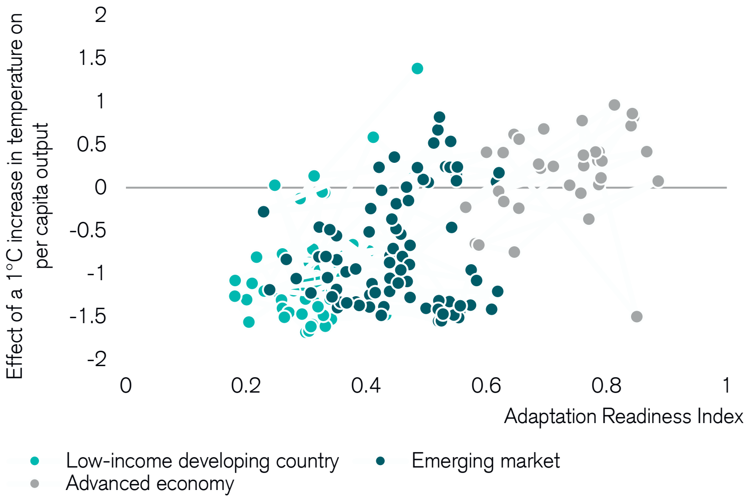


**Figure 4: : Vulnerability to temperature increases and readiness prospects**



Source Figures 3 and 4: IMF, Notre Dame Global Adaptation Index, Credit Suisse research since subtropical land regions are mostly semi-arid today, while most subpolar regions currently have an excess of precipitation.

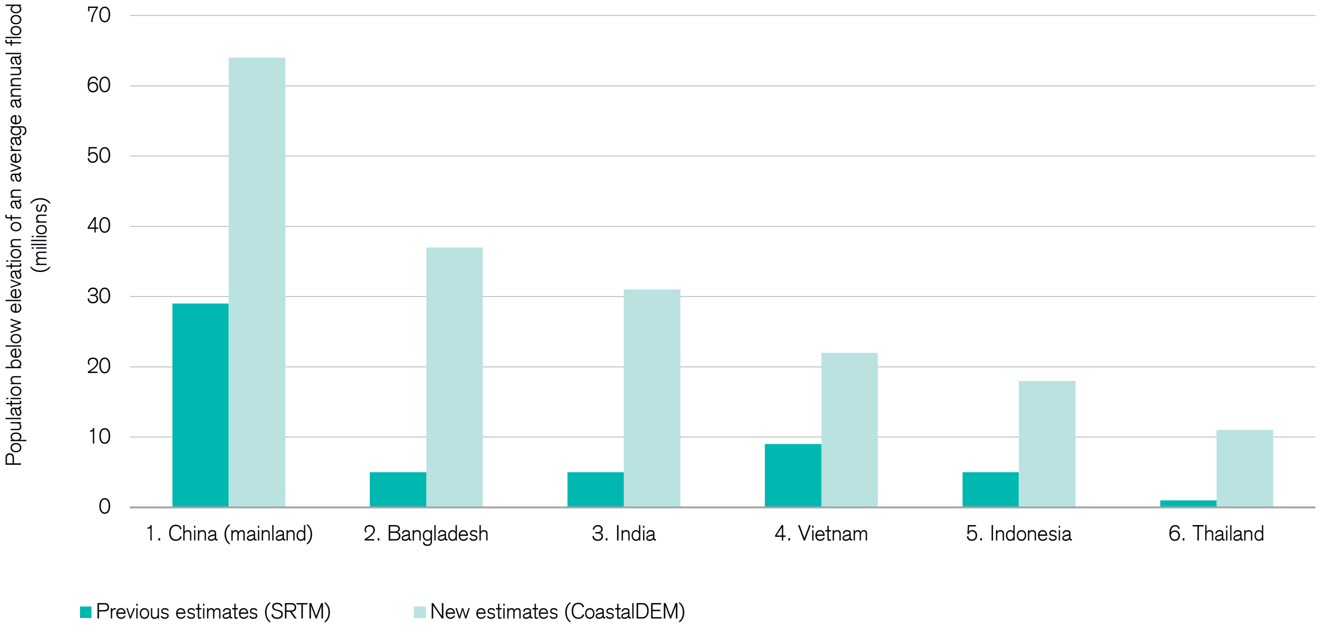
The drying is projected to be strongest near the poleward margins of the subtropics (for example, South Africa, southern Australia, the Mediterranean, and the southwestern USA). This large-scale pattern of change is a robust feature present in nearly all of the simulations conducted by the world's climate modeling groups for the IPCC, including those conducted at NOAA, and is evident in observed 20th century precipitation trends.

### Increased flooding puts 800 million to 1.2 billion people at risk by 2050

Over the course of the 21st century, global sea levels are projected to rise between about two and seven feet under varying climate-warming scenarios, and a sizeable number of coastal cities have yet to adequately prepare for rising sea levels:

- As the World Economic Forum's Global Risk Report 2019 shows, around 90% of all coastal areas will be affected to varying degrees, with some cities experiencing sea-level rises as high as 30% above the global mean.
- Another factor of increasing importance is that coastal cities are sinking at the same time as sea waters are rising. This is due to the sheer weight of growing cities, combined with higher rates of groundwater extraction (Jakarta has sunk 2.5 meters in less than a decade).
- According to the UN, floods have represented nearly half of all weather-related disasters since 1995, affecting a total of 2.3 billion people (source: UN 2018) and, based on EM-DAT 2019 data, increasing in frequency by15 times since 1950.
- Even if we collectively manage to keep global temperatures from rising by 2°C, at least 570 cities and some 800 million people will be exposed to rising seas and storm surges by 2050 (WEF, 2019).
- Flooding in urban areas alone costs the global economy USD 1 trillion a year (source: The Global Opportunity Network ), but sea level rises and flooding are likely to have a more permanent impact on essential public infrastructure services (e.g. Hurricane Sandy in New York affected an estimated 90,000 buildings and caused over USD 19 billion in damages).
- While all coastal cities will be affected by sea-level rises, some will be affected much worse than others. Asian cities will be particularly badly hit:
  - Asia: About four out of every five people impacted by sea-level rise by 2050 will live in East or Southeast Asia.
  - US cities, especially those on the East and Gulf coasts, are similarly vulnerable. More than 90 US coastal cities are

**Figure 5: Current population below the elevation of an average annual flood in 2050, top six countries using RCP4.5 and new elevation data**



Source: IMF, Credit Suisse research

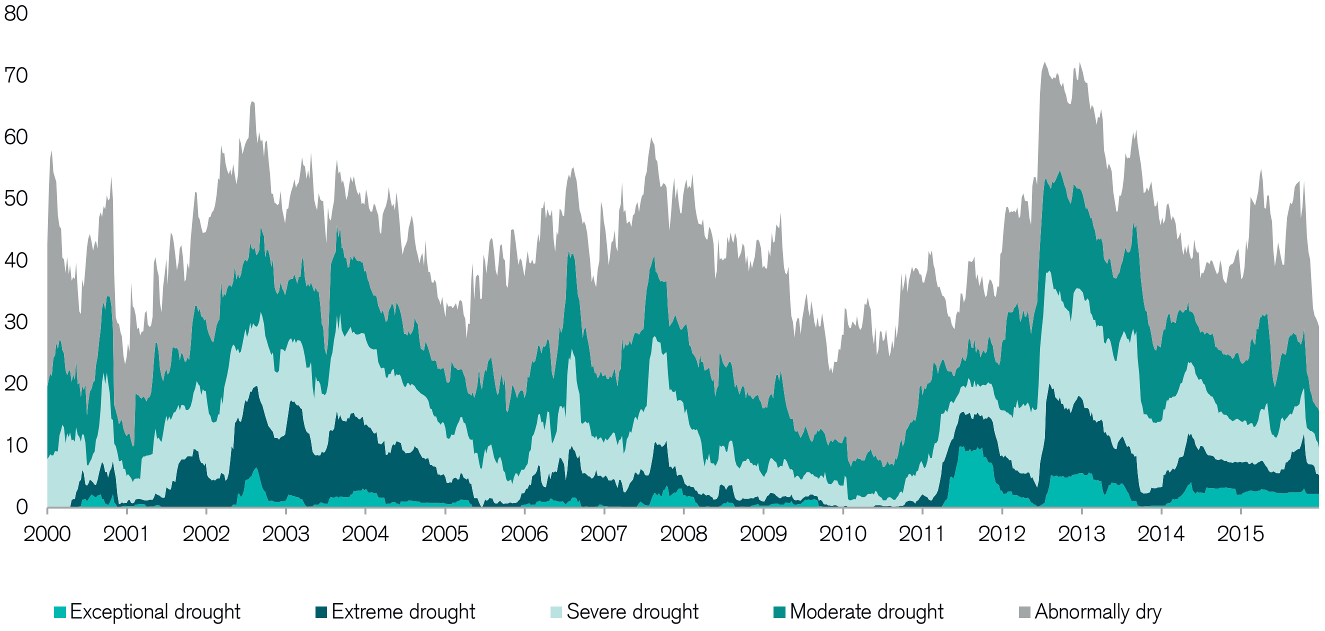
  already experiencing chronic flooding – a number that is expected to double by 2030.
  - Meanwhile, about three-quarters of all European cities will be affected by rising sea levels, especially in the Netherlands, Spain and Italy.
  - So-called "delta cities" are already bearing the brunt of rising seas. More than 340 million people live in deltas like Dhaka, Guangzhou, Ho Chi Minh City, Hong Kong, Manila, Melbourne, Miami, New Orleans, New York, Rotterdam, Tokyo and Venice.
- As climate change is driving changes to longstanding weather systems, flood risk is increasing most in traditionally water-scarce areas (e.g. Chile, China, India), where local coping strategies can be non-existent (source: UN 2018).

### New modelling projects a much more severe outcome from rising sea levels

The most recent global scientific study, incorporating new coastline elevation data, triples estimates of global vulnerability to sea-level rise and coastal flooding (Kulp and Strauss, 2019 ). The report, commissioned by Climate Central, finds that under a high emissions scenario, up to 630 million people will live on land below projected annual flood levels by 2100, and up to 340 million are at risk using a mid-century cut-off point. This compares to 250 million that are at risk right now. In fact, the report estimates that one billion people now occupy land less than ten meters above current high-tide lines, with 230 million people living less than one meter above current high-tide lines. Countries and regions flagged as particularly vulnerable, absent of additional coast defenses such as seawalls or levees, include:

- **China:** By 2050, land now home to 93 million people could be lower than the height of the local average annual coastal floods. Shanghai, which is the country's most populous city, is projected to be particularly vulnerable to ocean flooding in the absence of coastal defenses. The analysis also points to the following low-lying areas of China as vulnerable: Jiangsu Province, Tianjin, the main port for the capital city of Beijing, Pearl River Delta, an urban agglomeration comprising several major mainland cities and the special administrative regions of Hong Kong and Macau.
- **India:** By 2050, the projected sea level rise could push average annual floods above land currently home to some 36 million people. West Bengal and coastal Odisha are projected to be particularly vulnerable, as is the eastern city of Kolkata.

**Figure 6: Percentage area of land in the USA covered by drought**



Source: US EPA, Credit Suisse research

- **Bangladesh:** Coastal land is currently home to 42 million people and could be affected by saltwater flooding at least once per year by 2050. By that time, average annual coastal floods are projected to rise higher than a wide swath of Bangladesh, including parts of the cities of Dhaka and Chittagong.
- **Vietnam:** Coastal land is currently home to 31 million people and annual ocean floods are projected to particularly affect the densely populated Mekong Delta and the northern coast around Vietnam's capital, Hanoi, including the port city of Haiphong.

**Figure 7: The number of droughts globally is up by five times since 1950…**

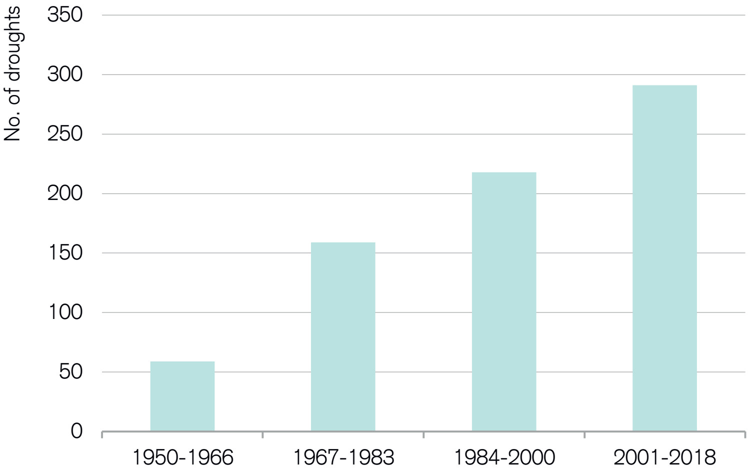
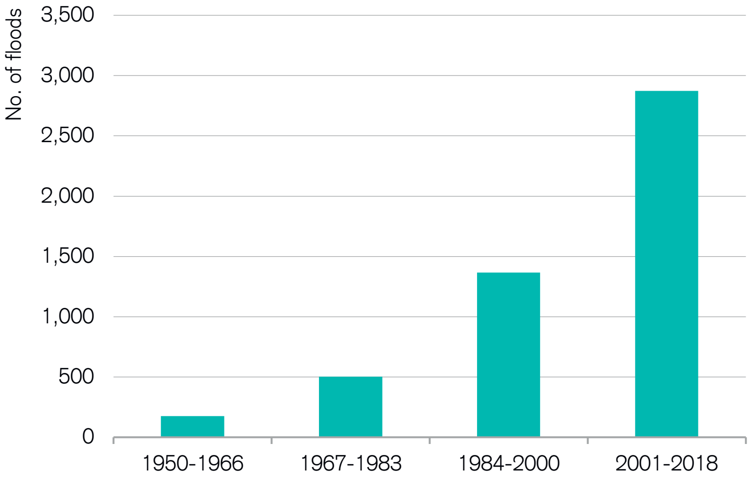


**Figure 8: …and the number of heavy downpours resulting in floods is up 15 times**



Source Figures 7 and 8: EM-DAT database

### Drought is the single greatest threat of climate change

Compared to the sporadic impacts of flooding, drought is a chronic, long-term issue, and arguably the most pernicious result of climate change (source: UN 2018). The population currently affected by severe drought is estimated at two billion by the UN, making it one of the most significant categories of "natural disasters" based on socioeconomic impact relative to GDP per capita (source: UN 2018). The subsequent UN World Water Development Report estimates that this could increase to five billion people by 2050 (in severe drought for at least one month per year). As of 2019, a total of 17 countries are now experiencing "extremely high" levels of baseline water stress, according to recent data from the World Resources Institute (WRI). As part of its analysis, the WRI also shows that this equates to around 0.7 billion people being displaced by drought.

Water and climatic changes pose complex, inter-connected challenges. Population growth, urbanization, temperature extremes, droughts, and floods are intersecting in ways that can be difficult to decipher and address. The recent bushfire crisis in Australia is a tragic reminder of the inter-connected nature of these challenges and the emerging climate we face today. By mid-January, almost 16 million hectares of land had been burnt in Australia, according to the BBC. In the days to follow, Australia's extreme weather continued with substantial hail storms and flooding in many of the fire-impacted areas.

Scientists have long warned that a hotter, drier climate will contribute to fires becoming more frequent, spreading faster, and ultimately more intense (IPCC, CSIRO and BOM). In Australia, the leading federal government agency responsible for scientific research, CSIRO, projected in 2005 that the combined frequencies of days with very high and extreme Forest Fire Danger Index ratings would likely increase 4%–25% by 2020 and 15%–70% by 2050. Unfortunately, the exact conditions they warned would increase fire risk have prevailed over the last two decades.

Eight of Australia's ten warmest years on record have occurred since 2005, and winter rain, which helps reduce the intensity of summer fires, has declined significantly. Australia's Bureau of Meteorology has now confirmed that 2019 was both the warmest (1.52 °C above the 1961–1990 average) and driest year on record. It is this combination that has been the driving force behind the worst drought in Australia's history, and a telling reminder of many of the cascading water scarcity impacts across industry, agriculture and rural communities that we cover as part of this report.

# 5. Water scarcity and geopolitical stress

**Phineas Glover, April Lowis**

As water becomes scarcer and demand continues to grow, how water resources are shared between countries will become more contentious, in our view. While limited numbers of conflicts have resulted from water issues in the past, due to the supply and demand imbalances we have set out, we expect tension between and within countries over water security issues to grow.

Water, ultimately, transcends international boundaries. The world's 286 transboundary river basins span 151 countries, include more than 2.8 billion people (around 42 % of the world's population), cover 42 % of the total land area of the Earth, and produce 54 % of the global river discharge per year  (UNEP-DHI and UNEP, 2016). Of these essential transboundary basins, 39 countries have over 90% of their territory within one or more basins and 21 lie entirely within one or more of these watersheds (UNEP-DHI and UNEP, 2016).

As competition for these resources increases, we expect to see an increase in upstream/downstream disputes over excess consumption and the construction of permanent dams and hydroelectric plants.

## Water conflicts are already occurring, but are projected to increase significantly due to the absence of multilateral governance arrangements and dispute resolution

Based on the Transboundary Freshwater Dispute Database, various countries were involved in nearly 2,000 water-related incidents between 1990 and 2008, including conflict and negotiations. Water issues have resulted in social unrest, violent acts and water-related terrorism. Contributing factors have involved dam construction, water tariff changes, and increasing industrial use of water in water-stressed areas. Almost 2,000 incidents related to conflict in transboundary basins took place between 1990 and 2008. Overall, there were approximately twice as many cooperative events as conflictual events during this period. However, when external events overwhelm institutional coping mechanisms, conflict becomes dangerous (Wolf et al. 2003). This is reflected in the hotspots in regions where resilient conflict resolution mechanisms are absent.

Water disputes also affect developed nations: Increasing water scarcity is sparking disputes between states in the USA as climate change worsens droughts. Prominent examples would include the Colorado basin, which supplies seven US states and Mexico, and is projected to face increasing drought and increasing demand from a growing population. The Menominee River in Michigan and Wisconsin featured in National Geographic's top 10 most endangered rivers due to the threat of open pit sulphide mining. In Australia, the Murray-Darling Basin covers four states and represents 60% of Australia's surface water. It supplies 40% of Australia's farms, but is facing severe drought and over-extraction, with current storage levels at 32% (MDBA).

## Table 1: Examples of current transboundary water disputes as a result of reduced availability of water

| Start date | Countries involved | Details |
|---|---|---|
| 1980 – ongoing | Kyrgyzstan and Uzbekistan | The proposed Kambar-Ata-1 Dam situated on the Naryn River in central Kyrgyzstan has been a source of tension between upstream Kyrgyzstan and downstream Uzbekistan. Kyrgyzstan believes the dam is crucial for economic development, securing domestic requirements and providing an energy surplus for export, but Uzbekistan contends that flowing water is needed for agriculture (its primary export). These disputes have been intensified by global climate change and remain unresolved. |
| 1995 – ongoing | Laos, Cambodia, Vietnam, Thailand, China | The Mekong basin has seen an enormous expansion of dam-building for hydropower generation, especially in China and Laos. This has led to diplomatic tensions as countries downstream of the dams fear it may result in greater flooding and/or seasonal lack of water, along with the destruction of ecosystems and fisheries. As of 2014, seven hydropower projects have already been constructed and the Chinese government reportedly has plans for 21 more dams. The effectiveness of the Mekong River Commission (MRC) in resolving these tensions has so far been limited due to its lack of enforcement powers and China's reluctance to join as a full member. |
| 2011 – ongoing | Ethiopia, Egypt, Sudan | The dispute over water rights in the Eastern Nile Basin has escalated in recent years due to Ethiopia's decision in 2011 to construct a major new dam, the Grand Ethiopian Renaissance Dam (GERD), in the absence of any agreement with downstream Egypt. Ethiopia argues that developing this resource is crucial to its economic development and to overcoming poverty and famine, and that it will increase Sudan's potential for irrigated agriculture. However, higher water use upstream may make downstream projects uneconomical. The new Egyptian government has embraced trilateral negotiations (including Sudan) that, as of March 2015, have resulted in a framework agreement. |
| 1957 – ongoing | India, Bangladesh | The construction of the Farakka Barrage in India along the Ganges has created water stress in Bangladesh by exacerbating the dry season and increasing the likelihood of flooding. The two countries have engaged in various levels of negotiations, but are yet to agree on a solution to meet the needs of both states, particularly in the context of changing climate conditions. The purpose of the barrage was to divert water from the Ganges in order to reduce silt build-up in Calcutta Port. Diversion of water from the Ganges had severe consequences on water availability downstream in Bangladesh. In 1977, an agreement was negotiated, but not signed until 1996. The treaty regulates water distribution from Farakka Barrage over a 30-year period. However, it fails to account for climate change impacts and their effects on the distribution of water. |
| 1984 – ongoing | Pakistan | For over three decades, plans to construct the Kalabagh dam on the Indus River in western Punjab have been the source of recurring disputes. Proponents present it as a way to mitigate the pressures of shrinking water resources and meet increasing national energy demands. However, efforts to build the dam have been repeatedly dismissed over concerns of its effects on downstream water access, ecology and livelihoods. Opposition is led by downstream provinces, especially by politicians and groups from Sindh. The current political conflict is primarily over changes in the regional distribution of water and has centered on ambiguities in the 1991 Water Apportionment Accord (WAA), which allocates water between provinces. |
| 1991 – ongoing | Tajikistan, Uzbekistan | The construction of the Rogun Dam situated on the Vakhsh River has been a major source of contention between Tajikistan, located upstream, and Uzbekistan, located downstream. This geopolitical conflict is part of wider international strains between Central Asian states due to the overuse and mismanagement of scarce water resources in the region, a factor intensified by global climate change. The conflict remains unresolved. |

| | | |
|---|---|---|
| 2001 – ongoing | Iran, Afghanistan | Afghanistan's efforts to use water from the Helmand River and the Harirud to support post-conflict reconstruction and development is being perceived by Iran as a threat to water security. With a largely ineffective water treaty in place, cooperative initiatives have not yet achieved a breakthrough. Afghanistan's reluctance to engage in water negotiations, coupled with Iran's alleged "paradoxical" activities of support versus disruption, have further complicated resolution. |
| 1960 – ongoing | Iraq, Turkey, Syria | The Euphrates-Tigris Basin is shared between Turkey, Syria and Iraq, with Iran comprising parts of the Tigris basin. Since the 1960s, unilateral irrigation plans altering the flows of the rivers, coupled with political tensions between the countries, have strained relations in the basin. Disputes have prevented the three governments from effectively co-managing the basin's rivers. Although cooperation efforts were renewed in the 2000s, these have yet to result in a formal agreement on managing the basin waters. |
| 1990 – ongoing | Armenia, Turkey | Turkey and Armenia succeeded in putting aside their tensions to continue cooperation over the Arpacay River on water-sharing issues. However, this cooperation needs to be extended to water quality and protection. Environmentalists have found that the water from the reservoir is polluted with heavy metals and toxic materials. |
| 1947 – ongoing | Pakistan, India | Climate change and transforming water-usage patterns in the Indus River Basin have placed increasing stress on the foundations of the Indus Water Treaty. This scenario is causing diplomatic tensions between India and Pakistan. In Pakistan, 90% of the country's food and 65% of its employment depend on agriculture sustained by the Indus Basin and its tributaries. |

Source: ECC Platform Factbook, Credit Suisse research

### The common drivers of water conflict

- Water access can feature in, and exacerbate, regional conflicts: As transboundary legal customs and practices remain incomplete or, simply, unenforced, some countries and states increasingly use water as leverage in negotiating treaties and consolidating regional power through an upstream position.
- Conflict 50% more likely as a result of drought: A University of Geneva study (Journal of Environmental Economics and Management, 2017) found that the sudden depletion of water resources through droughts increased the risk of outbreaks of rioting by 10%–50%. The study reviewed 1,800 riots in sub-Saharan Africa over 20 years.
- Corruption undermines the institutions set up to resolve disputes and share water equitably: Mismanagement of water supplies, involving the design of large infrastructure projects and access to groundwater, are particularly susceptible to corruption. Transparency International reports that in some developing countries, connecting to water supplies can cost 30%–45% more due to corruption.
- Climate change will continue to impact the hydrological cycle, altering rain patterns and water distribution. This is expected to create unexpected catalysts for conflict as countries are forced to assess their resources and exposure to extreme weather events.
- Hunger: Countries classified as drought-sensitive in sub-Saharan Africa have seen the prevalence of undernourishment increase from 17.4% to 21.8% over the last six years, while undernourishment in the same period actually dropped from an average of 24.6% to 23.8% in the other countries of the region. The number of undernourished people in drought-sensitive countries has increased by 45.6% since 2012.
- There will be an increasing trade-off between industrial and human consumption: Increasing consumption by industries in water-scarce areas and subsequent pollution of water resources has led to protests, lawsuits and regulatory action. The combination of population growth, urbanization and increasing industrialization of emerging markets means that competing industrial needs for water resources may precipitate additional conflict.

- Four regional hotspots for water conflict identified: Results from a "business-as-usual" projection analysis by the Transboundary Water Assessment Programme show that many of the risks to transboundary river basins will increase in the next 15–30 years with a changing climate, socioeconomic development, and increasing populations. Based on the combined projected impacts for five indicators, including Environmental Water Stress, Human Water Stress, Nutrient Pollution, Exacerbating Factors to Hydropolitical Tension, and Change in Population Density – a number of regions face the highest risk of instability/conflict as a result of water. These include Central Asia, the Ganges-Brahmaputra-Meghna basin in Northern India, China, Nepal, Bangladesh and Bhutan, the Orange and Limpopo basins in South Africa, Botswana, Mozambique and Zimbabwe, and also the Middle East.

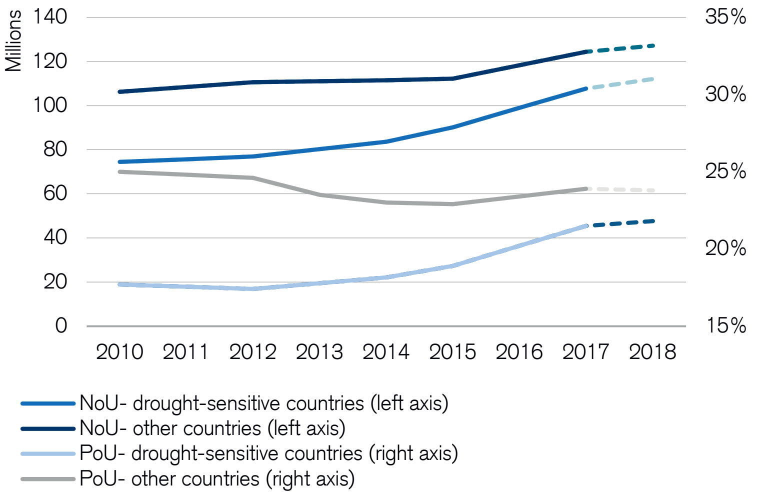
## Drought, conflict, migration

Climate change is causing a pronounced increase in the frequency and severity of natural disasters, such as floods and droughts, and these high-impact events are driving episodes of mass migration. Substantial migration flows, potentially spilling across country borders, could arise if climate change leads to a significant rise in sea levels. Hundreds of millions of people in low-lying areas could become vulnerable to flooding, forcing them to abandon their homes and relocate (Usery, Choi, and Finn 2007, 2009).

This migration can act as a source of tension or exacerbate issues relating to resource sufficiency in already water-scarce locations:

- In 2015, 8.3 million people were internally displaced by floods and 6.3 million by storms (double the number displaced by conflict and violence). This number spiked significantly in 2016, with 24.2 million people being fully displaced (source: World Bank).
- The poor are disproportionally affected by water conflicts and migration, with 95% of displacement from disasters occurring in low- and middle-income.
- In the USA alone, more than four million people living in coastal areas could be affected if oceans rise. Under the IPCC's unmitigated climate change scenario, sea levels will rise 80 centimeters by 2100. If the rise in sea levels is twice as much, the affected population would exceed 13 million (Hauer, Evans, and Mishra 2016).

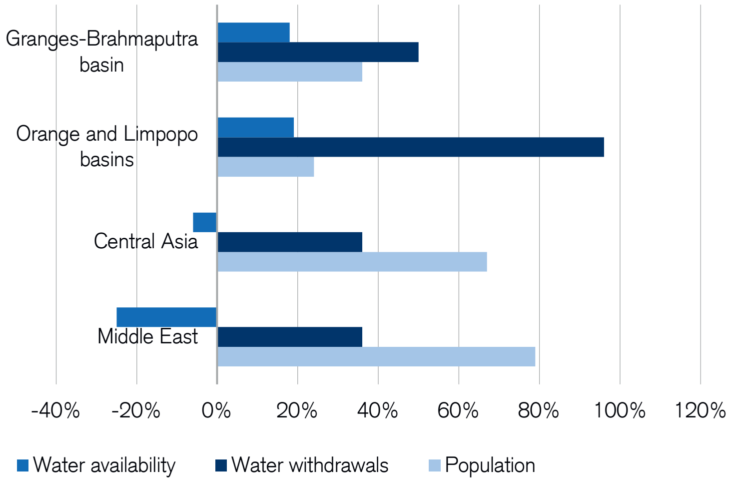
**Figure 1: Droughts are one of the factors behind the recent sharp increase in undernourishment in sub-Saharan Africa**



Source: FAO, Credit Suisse estimates; NB: PoU: prevalence of undernourishment, NoU: number of undernourished

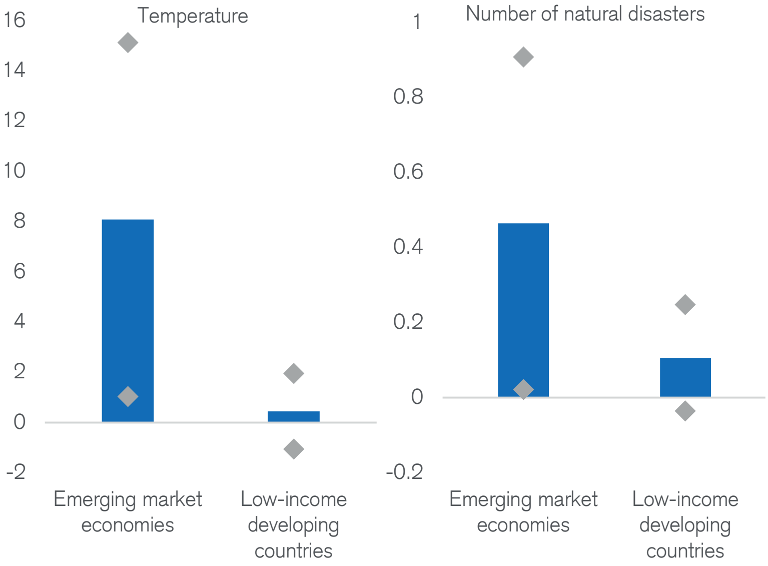
**Figure 2: Regions with the highest projected risk of geopolitical instability due to a structural imbalance between water supply and demand**

% change 2010–2050



Source: Transboundary Water Assessment Programme, Credit Suisse estimates

**Figure 3: Effect of temperature and natural disasters on migration**
(percentage points of origin country's total population)



Source: IMF, Credit Suisse Research; NB: marker range represents the 90% confidence intervals

In the table below, using the UNEP and GEF Transboundary Waters Assessment Programme data, which assesses basins, basin country units and lakes against 15 key risk metrics, we show regions with the highest risk exposure to a composite of seven key water scarcity risks (for regions with >10 million population).

The World Resource Institute recently published a new Water, Peace and Security tool, which harnesses machine learning to estimate the risk of conflict over water. The model identifies patterns between violent conflict and more than 80 environmental, economic and social variables going back 20 years, and then compares those patterns with current conditions to pinpoint potential hotspots. The tool currently shows that about 2,000 administrative districts across the Global South are at risk of violent conflict between October 2019 and September 2020. In parts of Iraq, Iran, Pakistan, India, Nigeria, Mali and elsewhere, such conflicts could be partly correlated to water-resource problems.

**Table 1: Basin country unit water risk using a composite of key water scarcity indicators for populations >10 m**

| Country | River basin | Pop.(m) | 1. Environmental water stress | 2. Human water stress | 3. Agricultural water stress | 5. Wastewater pollution | 6. Econ. dependence on water | 7. Exposure to floods and droughts | Water composite | Projected risk against baseline – 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Pakistan | Indus | 138 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 |
| Uzbekistan | Aral Sea | 27 | 5 | 5 | 5 | 5 | 5 | 3 | 4.6 | 3.8 |
| China | Tarim | 10 | 5 | 5 | 5 | 5 | 3 | 5 | 4.6 | 4 |
| Iraq | Tigris-Euphrates/ Shatt al Arab | 29 | 4 | 5 | 5 | 5 | 5 | 3 | 4.5 | 4.3 |
| Sudan | Nile | 26 | 3 | 5 | 5 | 5 | 5 | 4 | 4.5 | 4.3 |
| India | Ganges-Brahmaputra-Meghna | 53 | 4 | 4 | 3 | 5 | 5 | 5 | 4.3 | 3.5 |
| Egypt | Nile | 37 | 4 | 5 | 5 | 3 | 5 | 4 | 4.3 | 3.8 |
| South Africa | Limpopo | 12 | 5 | 5 | 3 | 4 | 3 | 5 | 4.1 | 3.5 |
| Bangladesh | Ganges-Brahmaputra-Meghna | 141 | 2 | 4 | 3 | 5 | 5 | 5 | 4 | 3 |
| India | Indus | 24 | 4 | 5 | 4 | 5 | 1 | 3 | 3.6 | 3.8 |
| Iran (Islamic Republic of) | Tigris-Euphrates/ Shatt al Arab | 13 | 4 | 4 | 4 | 5 | 3 | 2 | 3.6 | 3.3 |
| Niger | Niger | 13 | 3 | 4 | 2 | 5 | 5 | 3 | 3.6 | 4.3 |
| Syrian Arab Republic | Tigris-Euphrates/ Shatt al Arab | 12 | 4 | 5 | 5 | 1 | 4 | 3 | 3.6 | 4 |
| South Africa | Orange | 11 | 3 | 4 | 3 | 4 | 3 | 5 | 3.6 | 3.3 |
| Cambodia | Mekong | 14 | 2 | 2 | 2 | 5 | 5 | 5 | 3.5 | 2.5 |
| Afghanistan | Indus | 11 | 4 | 3 | 3 | 5 | 4 | 2 | 3.5 | 3.8 |
| Thailand | Mekong | 25 | 2 | 3 | 2 | 5 | 4 | 4 | 3.3 | 2.8 |
| Nepal | Ganges-Brahmaputra-Meghna | 29 | 2 | 1 | 2 | 5 | 5 | 4 | 3.2 | 2.5 |
| Nigeria | Lake Chad | 25 | 2 | 3 | 2 | 5 | 3 | 4 | 3.2 | 3.8 |
| Ethiopia | Awash | 16 | 2 | 3 | 2 | 5 | 5 | 2 | 3.2 | 4 |

Source: UNEP & UNEP-DHI (2015). Transboundary River Basins: Status and Future Trends. UNEP, Nairobi, Credit Suisse Research. NB: 1= very low risk, 5= very high risk

# 6. Water and the Sustainable Development Goals

**Eugène Klerk, Oliver Isaac**

In 2015, the United Nations adopted 17 "Sustainable Development Goals" (SDGs) aimed at addressing a range of issues including environmental, social and equality-related concerns. These SDGs have been adopted by more than 190 countries to date and include more than 160 targets, with water scarcity as one of the key areas of focus. Addressing water scarcity holds both direct and indirect benefits to citizens globally. The SDGs that are most relevant in relation to water scarcity are highlighted below.

### SDGs relevant to water scarcity

**SDG 6** calls for the availability and sustainable management of water and sanitation for all. We also find, however, that there are five other SDGs affected by resolving the problem of water scarcity.

**SDG 2** (zero hunger) and SDG 3 (good health and well-being): Given that 69% of annual water withdrawals globally are for agricultural purposes, water is a vital input for food creation, so countries facing deficits will struggle to achieve SDG 2. Linked to SDGs 2 and 6, and with more than 60% of the human body made up of water, guaranteeing its supply is critical for human health and thus achieving SDG 3's goal of health and well-being for all.

**SDG 5** (gender equality): Water accessibility is currently a significant obstacle to achieving SDG 5. Of households where water is accessed off-premises, females are presently responsible for its collection in eight out of ten households and this is typically a time-consuming procedure. In 25 sub-Saharan countries, for instance, women spend a total of at least 16 million hours a day collecting drinking water, compared to men at six million. Most notably, the effects of doing so are sizeable: one study in Tanzania found that halving the time it takes to collect water to 15 minutes leads to a 12% increase in female school attendance. Clearly, resolving water accessibility is crucial to helping achieve SDG 5.

**SDG 10** (reduced inequality): It is often argued that, while there is enough water on the planet for the global population to sustainably consume, the issue is rooted in the inequalities between countries. Geographic environments, population dynamics and other exogenous factors mean that there are countries with surpluses and, inversely, countries with deficits. Currently, just 62% of the population in least developed countries have access to basic drinking water compared to 89% for the global population, while basic sanitary service penetration is just 32% for least developed countries versus the global average of 68%. Achieving SDG 6 requires closing these inequalities.

**SDG 12** (responsible consumption and reduction): Lastly, given that water is a finite resource, resolving this issue is reliant on both production and consumption patterns evolving to become more responsible in the quantity of water consumed, as well as the treatment of wastewater post-production.

**Figure 1: Resolving the problem of water scarcity will likely assist in achieving 6 SDGs**

<table>
<tr><th colspan="6">Relevant SDG impacted</th></tr>
<tr><td>2 ZERO HUNGER</td><td>3 GOOD HEALTH & WELL-BEING</td><td>5 GENDER EQUALITY</td><td>6 CLEAN WATER & SANITATION</td><td>10 REDUCED INEQUALITIES</td><td>12 RESPONSIBLE CONSUMPTION & PRODUCTION</td></tr>
<tr><th colspan="6">Developments that might benefit the Sustainable Development Goals</th></tr>
<tr><td>Agriculture and therefore food production) represents 69% of freshwater use, so resolving scarcity assists in securing global food supply.</td><td>Water is a fundamental requirement for human consumption, so improving accessibility directly improves overall health.</td><td>Achieving SDG 6 will require a focus on improving female access to sanitation and water (6.2) which, if achieved, will help to combat some of the current gender imbalances.</td><td>Resolving universal access to clean water directly contributes to SDG 6 and is a key requirement in ensuring minimum hygiene and sanitation standards are met.</td><td>Achieving universal access to water ensures countries which currently have limited access are on equal footing to those that currently do not have this problem.</td><td>Given that water is a finite resource, for it to become unconstrained, use and consumption must become more efficient and responsible.</td></tr>
</table>

Source: UN, Credit Suisse research

Additional data points to note include:

- 6.1 (achieve access to safe and affordable drinking water): Globally, the proportion of the population using safely managed drinking water services stood at 71% in 2017, up from 61% in 2000. However, this means 785 million people still lack access to basic drinking water services. Based on this rate, 77.8% of people will be using drinking water services by 2030. Achieving 6.1 also requires improving the quality of water services for 2.1 billion people who lack accessible water on premises.
- 6.2 (achieve access to sanitation and hygiene and end open defecation): Access to basic sanitation services increased from 45% in 2000 to 59% in 2017, however 2.3 billion people still lack basic services. Over 892 million people still practice open defecation, although this stood at 1.2 billion in 2000.
- 6.3 (improve water quality, wastewater treatment and safe reuse): Data in this area is limited, although based on 79, largely high and high-middle-income countries, 59% of wastewater is properly treated.
- 6.4 (increase water-use efficiency and ensure freshwater supplies): Although median water stress is only 13.9%, 31 countries experience water stress between 25% and 70%, and 22 countries are above 70%, thus being classified as seriously stressed.
- 6.5 (implement integrated water resources management): The global average implementation of integrated water resources management was 48% (medium-low), but only 25% of countries in the three lower Human Development Index (HDI) groups reached this level.
- 6.6 (protect and restore water-related ecosystems): The UN pointed to insufficient data to make any comments on progress for this target.
- 6.a (expand international cooperation and capacity-building): Total water-sector official development assistance (ODA) disbursements increased from USD 7.4 billion in 2011 to USD 9 billion in 2016.
- 6.b (support stakeholder participation): Currently, more than 75% of counties have reported having clearly defined policies and procedures for service users and communities to participate in planning programs for drinking water supply. In addition, 83% of reporting countries have policies and procedures for water-resource planning and management in place.

Overall, although progress has been made on a number of indicators, it appears unlikely that SDG 6 will be achieved by 2030 based on current trends, thus advocating the need for the water scarcity solutions we outline later in this report.

**Table 1: SDG 6 targets, indicators and latest progress (as of 2017)**

| Target | Target description | Indicator | Indicator description | Progress |
|---|---|---|---|---|
| **6.1** | By 2030, achieve universal and equitable access to safe and affordable drinking water for all. | **6.1.1** | Proportion of population using safely managed drinking water services. | **70.6%** |
| **6.2** | By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. | **6.2.1a** | Proportion of population using safely managed sanitation services. | **45.0%** |
| | | **6.2.1b** | Proportion of population using a hand-washing facility with soap and water. | **60.1%** |
| **6.3** | By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally. | **6.3.1** | Proportion of wastewater safely treated. | **59.0%** |
| | | **6.3.2** | Proportion of bodies of water with good ambient water quality. | **61.5%** |
| **6.4** | By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity. | **6.4.1** | Change in water-use efficiency over time (GDP per cubic meter of freshwater withdrawal, USD per $m^3$). | **USD15/ $m^3$** |
| | | **6.4.2** | Level of water stress: freshwater withdrawal as a proportion of available freshwater resources. | **13.9%** |
| **6.5** | By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate. | **6.5.1** | Degree of integrated water resources management implementation (proportion of medium-very high level of implementation). | **48.0%** |
| | | **6.5.2** | Proportion of transboundary basin area with an operational arrangement for water cooperation. | **59.2%** |
| **6.6** | By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. | **6.6.1** | Change in the extent of water-related ecosystems over time (share of water bodies with good quality water calculated as average across rivers, groundwater and open water bodies). | **75.0%** |
| **6.a** | By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies. | **6.a.1** | Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan (USD bn). | **USD 9 bn** |
| **6.b** | Support and strengthen the participation of local communities in improving water and sanitation management. | **6.b.1** | Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management. | **82.9%** |

Source: Our World in Data, the UN, Credit Suisse research (all data originated with indicator custodian)

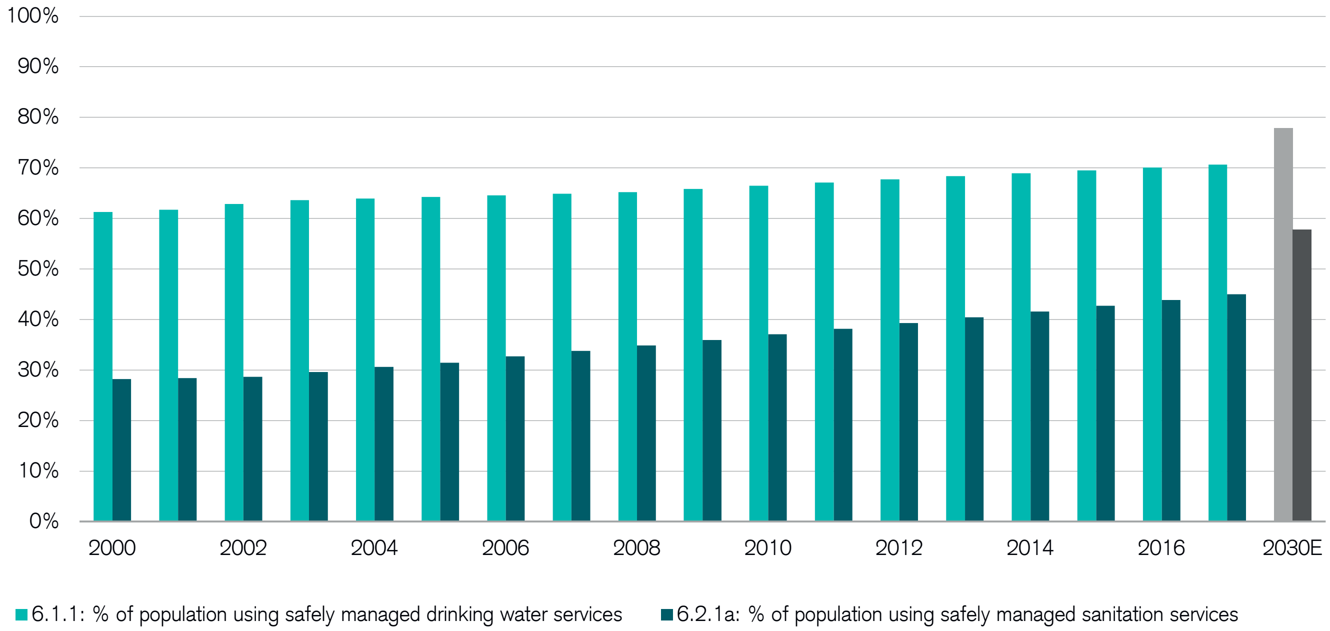
Note: where 2017 data is not available, we have used the closest year. In cases where global data is not provided, we have taken the median of the country data or the figure cited in the 2018 UN Synthesis Report

## Investment requirements for SDG 6

In 2018, Global Water Intelligence estimated that USD 449 billion of annual investment was needed between now and 2030 to ensure the UN's water and sanitation SDG was achieved. These investments largely need to be targeted on water infrastructure, as well as being financed by the private sector.

Separate analysis by the World Bank suggests that, in addition to money, strong institutions, accountability and mechanisms that turn investment into effective services are also required to achieve SDG 6. Monetarily, achieving SDG targets 6.1 and 6.2 alone would require USD 114 billion, indicating the need for improvements in water infrastructure to accelerate current progress on these metrics. In the following section, we consider the investment requirements for resolving the water scarcity problem more broadly.

**Figure 2: Both drinking water and sanitation accessibility has improved, but there is still work to be done for 2030**



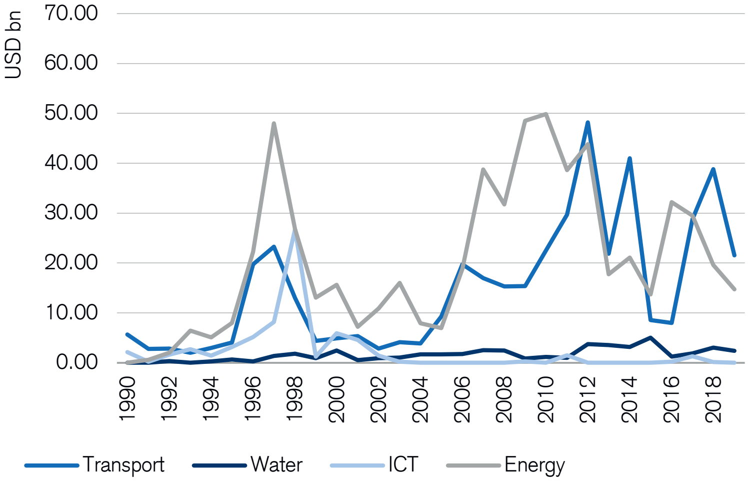
Source: Our World in Data, Credit Suisse estimates (based on historic rates)

# 7. Investment requirements and challenges

**Eugène Klerk, Phineas Glover, John Walsh**

Water faces a mismatch between the daunting infrastructure investment requirements and the capital costs entailed, with the current ability to price water being significantly constrained and regulated. Estimates of the required investment in global water and sanitation infrastructure by 2030 vary considerably from USD 7.5 trillion (McKinsey 2016) to USD 23.1 trillion (New Climate Economy Report, 2014). An OECD technical note reviewing varying forecasts, estimates a USD 13.6 trillion cumulative investment requirement (2015 USD, 2016–2030).

**Figure 1: Private sector investment in emerging markets in water, ICT, energy and transport – water a clear laggard**



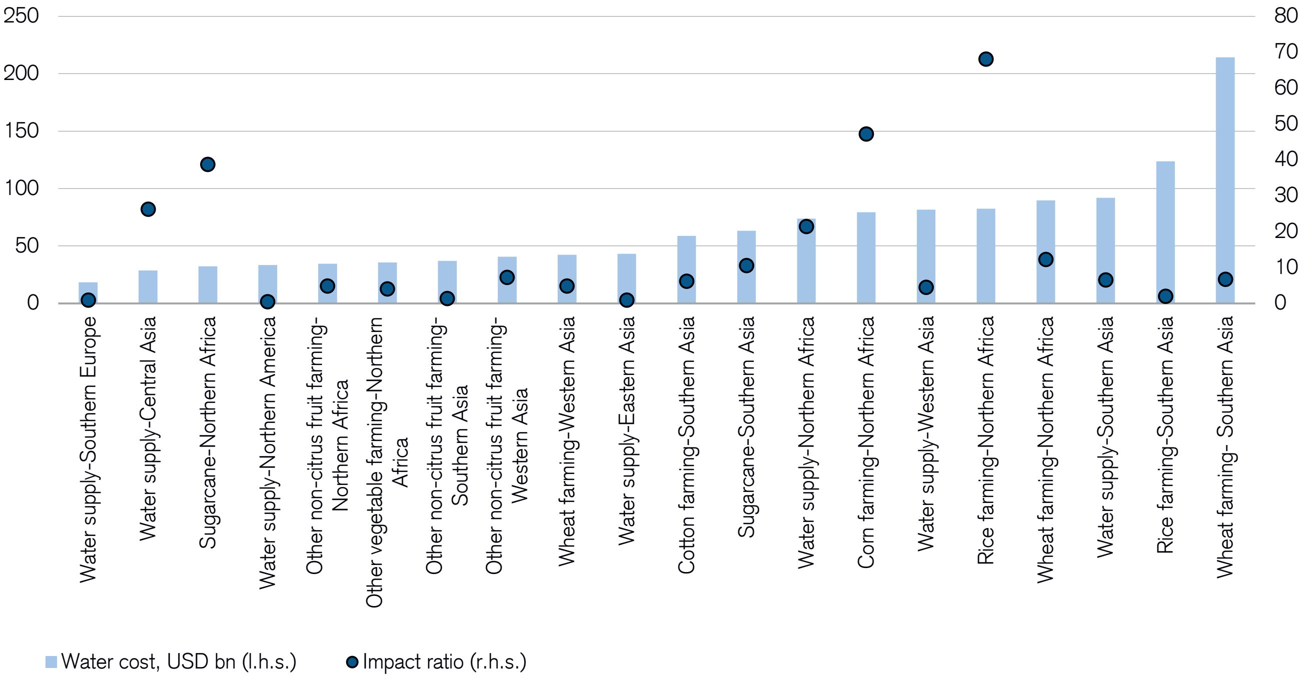
Source: World Bank, Credit Suisse estimates

## The need for higher water prices

Data from the World Bank indicates that water investments from the private sector in emerging market infrastructure has averaged just USD 1.6 billion over the past 30 years. By way of contrast, transport investments have averaged USD 14.9 billion, while energy investments have averaged 20.5 billion. Evidently water infrastructure in emerging markets has been heavily underinvested and solely reliant on public finance to drive improvements. To change this trend, clearly the private sector needs incentives to invest.

To fund these projects, there needs to be a shift in the current orthodoxy of pricing. The average price for water and wastewater is USD 2.06 per m3, which falls well short of its true capital cost (source: Global Water Intelligence (GWI)). GWI estimates that water tariffs need to increase by 5.9% every year to achieve the UN SDGs by 2030. These vast but essential sums necessitate a growing role for private sector investment. This will include collaborative public-private partnerships (PPPs), as well as innovative financing arrangements that match capital markets with specific projects through green and blue bonds.

**Figure 2: Rankings of the top 20 regions with the greatest water consumption when measured in estimated monetary terms**



Source: Trucost 2013, Credit Suisse research

But this funding gap is underpinned by a fundamental imperative. If no efficiency gains are assumed, global water requirements could grow from 4,500 billion m3 today to 6,900 billion m3 in 2030 (2030 Water Resource Group). This is a full 40% above current accessible, reliable supply. This scarcity gap is overwhelmingly concentrated in Asia, where one-third of the population concentrated in developing countries is estimated to live in basins with a deficit larger than 50%.

## Pricing: Mismatch between price and capital cost

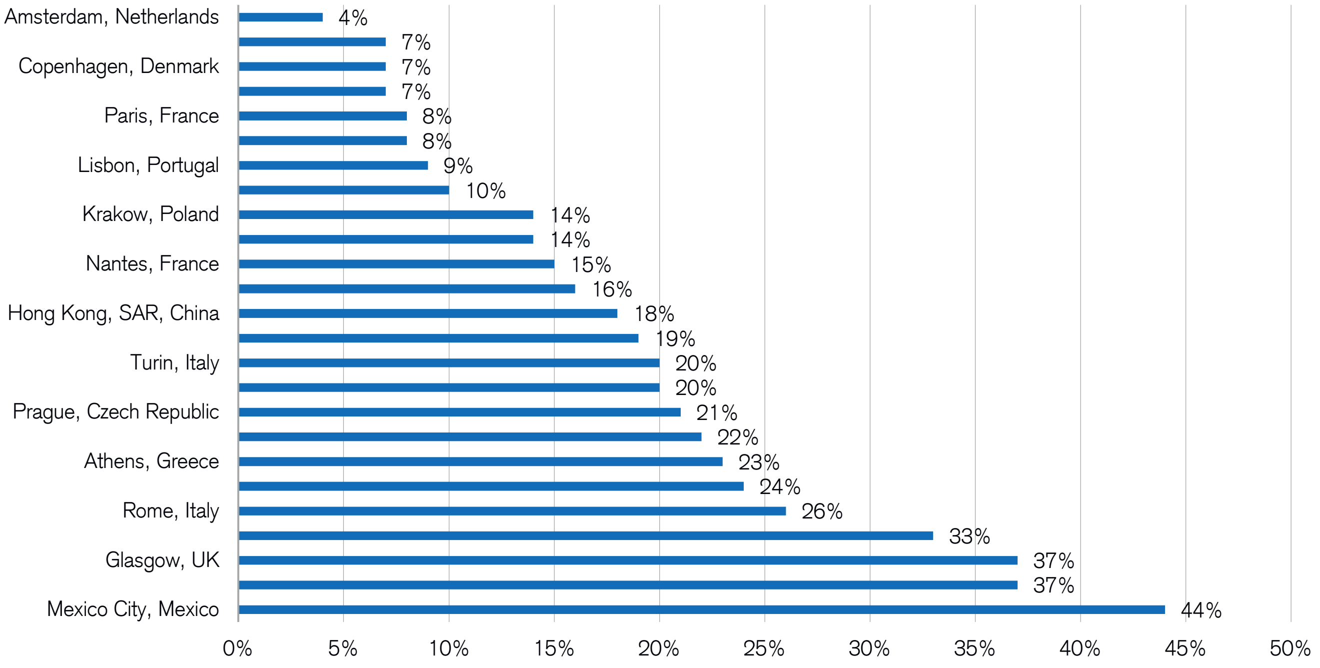
While water is an essential part of life, consumers pay heavily regulated and subsidized prices, distorting the long-term economics of project finance. Ultimately, the current low pricing in many regions means that the return hurdles on many long-term capital investments are not met. The obvious response to this would be to raise pricing. However, this is challenging on a number of levels, and confronted with trade-offs between the social and environmental dimensions. Therefore, the current orthodoxy has been for water pricing to be subject to a range of limitations due to government regulation and resistance from other stakeholders.

Water externalities yet to be factored in: This price/value mismatch is most evident if the true environmental cost is incorporated. Research by Trucost (for the TEEB for Business Coalition) estimates the unpaid environmental cost of water consumption by global primary production and processing business sectors at USD 1.9 trillion, or around 2.5% of global GDP. Wheat and rice farming in Southern Asia were found to have the greatest water risk due to high irrigation rates in this water-scarce region.

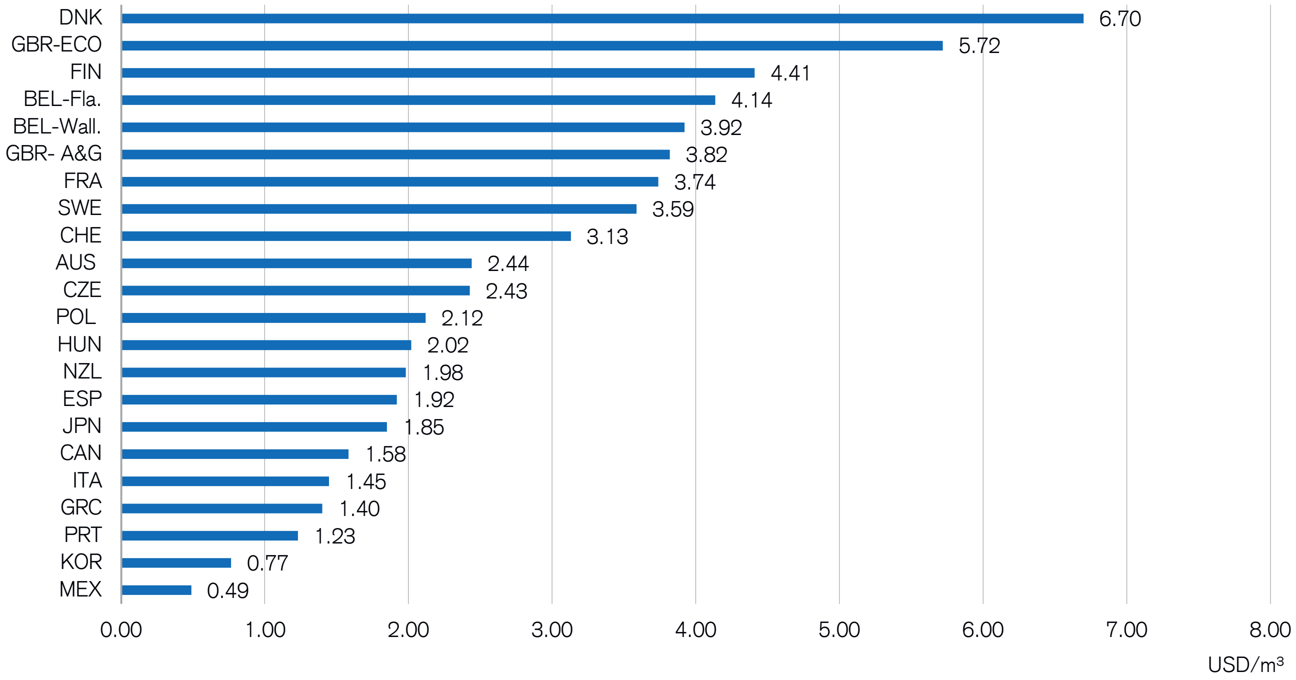
The global average cost of water and wastewater tariffs in Global Water Intelligence's 2017 survey across 452 cities worldwide was USD 2.06/m3. There was considerable variance, with South Asia remaining the cheapest region for water at just USD 0.14/m3, while Denmark was the most expensive at USD 8.52/m3.

One way to assess the need for increased water prices is to review the state of existing water infrastructure in various areas and compare that to the water prices applied. **Figure 3** provides an overview of so-called leakage rates for a range of cities globally. These vary from just 4% of water lost through leakage in Amsterdam to as high as 44% in the case of Mexico. **Figure 4**, on the other hand, provides an overview of water prices for key countries.

## Figure 3: Water leakage rates for key cities



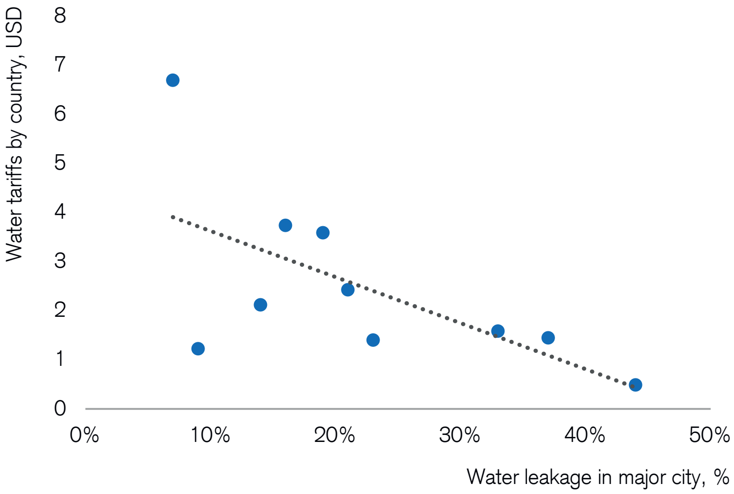
## Figure 4: Water prices for key countries (USD/l)



Source Figures 3 and 4: OECD, Credit Suisse research

**Figure 5** shows that when we compare leakage rates to water prices, a clear negative correlation exists. In other words, higher water prices not only make the economics of investing in new water infrastructure more attractive to external capital providers, but they also appear to result in improved investments in existing infrastructure.

**Figure 5: Water leakage tends to be lower when tariffs are higher**



Source: OECD, Credit Suisse estimates

### Water tariffs beginning to increase in response to the investment requirement

Water tariffs rose 3.91% between July 2016 and July 2017, more than two times the global inflation rates (source: GWI 2017). Notable examples of large increases in water tariffs included in the 2018 and 2019 GWI Water Tariff Survey are:

- Across North America, combined rates rose by 3.80% on average, with several cities increasing tariffs to generate funding for planned water infrastructure updates.
- Residents of Rio de Janeiro saw tariffs grow by 12.35%, which will provide funding for the clean-up of Guanabara Bay.
- South Tarawa's rates have increased by 394%, making it 2019's highest tariff increase. The new tariff will be contributing toward new infrastructure developments, including a new desalination plant.
- Singapore increased water prices by 30% in 2018 – the first hike in 17 years.
- Cape Town increased water tariffs by 26.9% in July 2018, having increased tariffs by 28.4% in 2017.
- New York City water tariffs rose 40% in the three years up to 2016.
- Beijing water prices, although still significantly below the world average, grew 35% between 2013 and 2016.
- Delhi has raised water tariffs for high-volume users by 20% this year.
- Los Angeles increased its water tariffs by 18% in 2017.
- In the USA, urban rates have overtaken Europe or the first time, with the USA experiencing a CAGR of 5.3%. According to GWI, these tariff rises will need to double to cover the costs of aging infrastructure.
- Ecolabs estimates that water costs will rise by 78% in India, 133% in China and 192% in the USA by 2030 relative to 2014 figures.

GWA cites three main drivers of tariff increases in 2019:

- To fund projects that will combat the effects of climate change, such as building infrastructure that can withstand irregular weather patterns.
- Water scarcity concerns have led to multiple regions restructuring tariffs to encourage water conservation and fund alternative sources of freshwater, such as desalination.
- In order to sustain the growing urban population, several cities across the globe have raised combined tariffs to raise funds for upgrading existing aging infrastructure or for building new networks, particularly in North America and Western Europe.

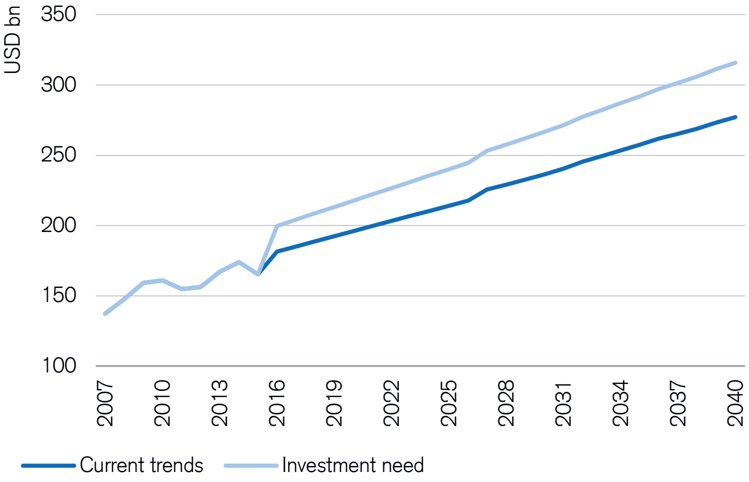
### Financing water

Water infrastructure is extremely capital-intensive and costly, with estimates ranging from USD 7.5 trillion to USD 23.1 trillion needed for additional global water and sanitation infrastructure by 2030. Many of these projections exclude aging infrastructure. In the USA, maintaining aged infrastructure as well as increasing capacity in line with demand is estimated to result in a USD 1 trillion spending gap between 2010 and 2035 (source: American Water Works Association (AWWA).

Furthermore, the industry suffers from a lack of awareness of the essential services it provides. With the main technical infrastructure underground and water coming directly to homes in developed countries, citizens in general lack an awareness of the complexity and immense value of the systems in place and the benefits received.

Nonetheless, as water scarcity is increasingly both a developed and developing market problem, we anticipate that water infrastructure will be a growing investment theme for the private sector. The UN estimates that every USD 1 invested in water and sewage infrastructure provides long-term private GDP of USD 6.35  and the return for other industries is USD 2.40 (World Health Organisation).

**Figure 6: Global Infrastructure Hub Outlook data indicates a USD 38 billion annual global water investment gap to meet capacity demand consistent with best-performing countries**



Source: GI Hub Outlook, Credit Suisse research

**Figure 7: Market share of the water industry by sub-sector**

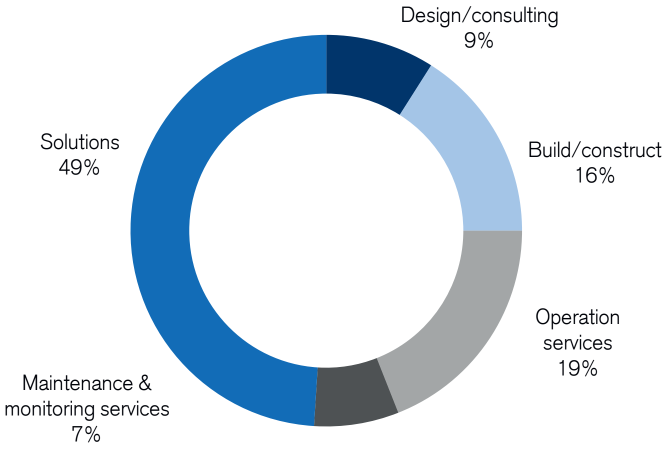
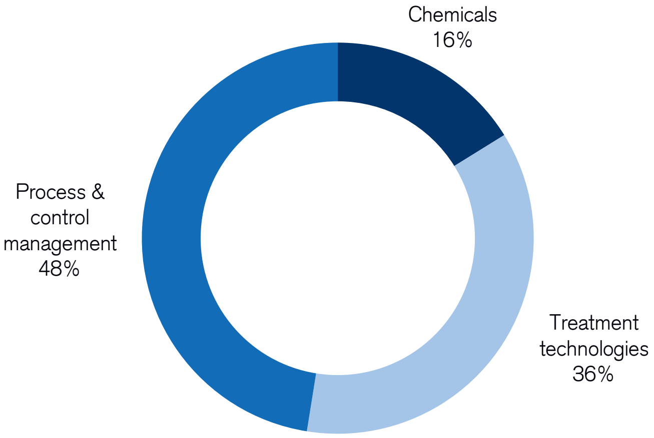


**Figure 8: Global market share of sub-industries in solutions and services in the water industry, 2016**



Source Figures 7 and 8: Frost & Sullivan, Credit Suisse research

### The water industry market

In 2016, the water and wastewater market was valued at USD 624.97 billion, with 51% consisting of utilities and the remaining 49% solutions and service. The municipal water market makes up 76.5% of the market, with the remainder attributed to industrial water (source: Frost & Sullivan).

### Public-private partnership financing

The capital-intensive nature of the water industry has meant a reluctance to spend large quantities to gain limited returns from low tariffs. This has resulted in an increased uptake of risk-sharing funding mechanisms through various public-private partnerships. While PPPs have struggled under models where the subsequent revenue streams are unclear, this can be clearly defined in the water industry through regulated tariffs set specifically to meet acceptable return hurdles. These are being used for water treatment, water supply, desalination, wastewater and stormwater system-upgrade projects.

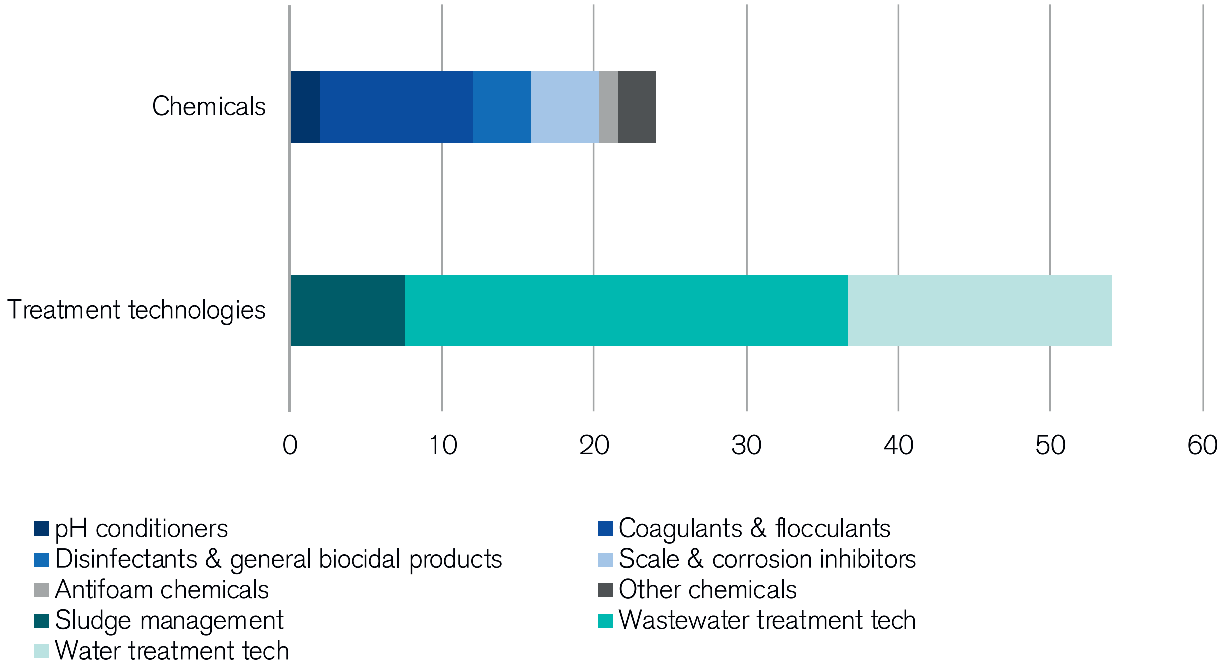
### The water supply chain

Having reviewed the challenges in relation to water scarcity and the necessary investment requirements, we finally provide an overview of some of the key areas across the water supply chain. The water supply chain covers a variety of different sectors ranging from pump filtration and membrane manufacturers to engineering and construction firms as well as metering companies and technology firms. Communication and broadband companies are also becoming involved as water infrastructure becomes connected. Some of the key water-related services offered include water management and water treatment.

## Water management services

We define water management as the planning, development and optimization of water resources. Currently, this is largely accomplished through a series of command-and-control regulations. For example, in the USA, the Clean Water Act sets pollution limits and imposes penalties if that limit is exceeded. While this structure remains relevant, certain countries (e.g. Australia) and regions (e.g. western USA) are shifting to market- or incentive-based governance. Under this framework, programs such as water trading (e.g. Australia's Murray-Darling Basin), payment for ecosystem services (PESs), or water-quality trading become prevalent. While we will not go so far as to endorse a specific regulatory framework, we think a combination of measurable, open and transparent policies will be required to tackle this global issue. Furthermore, any solution will need to focus on the demand side of the equation as the supply side is finite.

**Figure 9: Global market share of chemicals and treatment technologies in 2016**



Source: Frost & Sullivan, Credit Suisse research

Water management covers a wide range of applications, but we believe the most important themes are (1) “non-revenue” water, (2) storm water management, and (3) water supply-system management (infrastructure and optimization).

### Non-revenue water

Non-revenue water is water that has been treated by a utility (i.e. cost incurred), but with no associated revenue (i.e. customer consumption) owing to infrastructure issue and leakage. In developing markets, non-revenue water can represent 15%–60% or more of net water produced. In its 2018 annual report, water technology provider Xylem estimated the size of the total addressable market to be approximately USD 550 billion.

### Stormwater run-off

Climate change is resulting in more extreme weather events, which in turn drive increased stormwater overflow. These events can cause significant negative environmental impacts, especially when they result in combined sewer overflows (CSOs). Combined sewer systems collect rainwater runoff, domestic sewage and industrial waste water in the same pipe. When excess rainfall or snowmelt result in excess capacity, these waste streams are discharged into the environment.

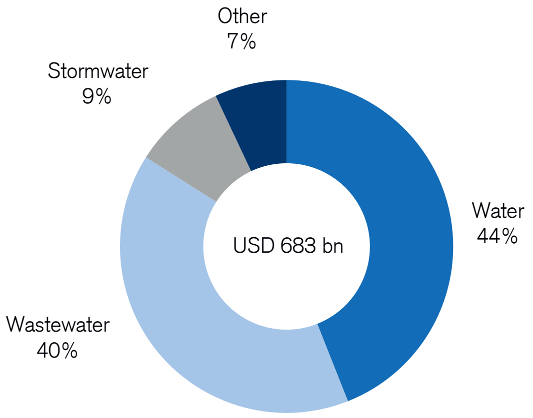
### Metering

Rather than automatically replacing all pipes as they reach a particular age, companies are starting to use technology to monitor their water supplies and detect leaks, thus reducing costs and improving efficiencies. The water utility monitoring system market is projected to grow at a 5.11% CAGR up to 2022 (source: ReportsnReports).

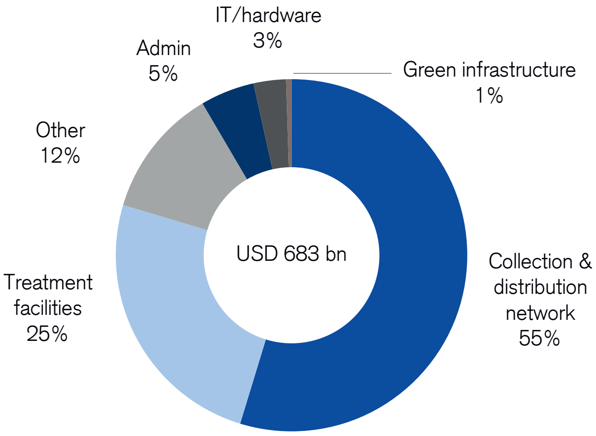
Using advanced asset management solutions such as data collection, analytics and visualization of network conditions and operations could save utilities globally USD 41.9 billion in capex by 2027 (source: Bluefield Research, 2018).

Metering makes it possible for utilities to correctly bill their customers and understand how water is moving through the system. This is in an interesting part of the market as we have seen faster adoption of digital technology. For example, meters used to be recorded by hand, then by passing car, and currently by dedicated networks in certain geographies. Said another way, this represents the transition from AMR (automated meter reading) to AMI (automated meter infrastructure).

### Figure 10: Overall breakdown of forecast capex spending by the water industry in the USA, 2018–2027

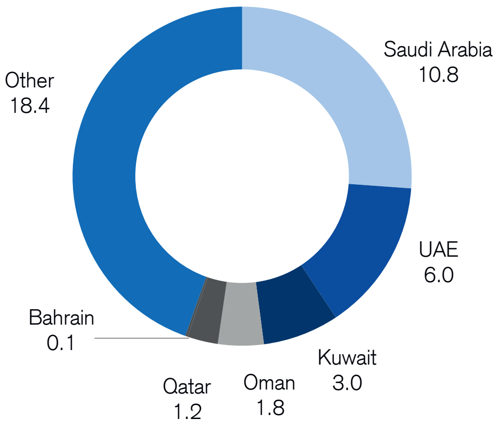


### Figure 11: Overall breakdown of forecast capex spending, 2018–2027



Source Figures 10 and 11: Bluefield Research, Credit Suisse research

### Figure 12: Capital investment in desalination in the Gulf countries (2020–2024, USD bn)



Source: GWI DesalData, Credit Suisse research

### Table 1: Emerging contaminants from AWWA survey

| Rank | Area | % Ranked extremely concerned |
|---|---|---|
| 1 | Nonpoint source pollution | 17.1% |
| 2 | "Per- and polyfluoroalkyl substances (PFAS)" | 15.8% |
| 3 | Cyanotoxins | 14.6% |
| 4 | Chemical spills | 16.0% |
| 5 | Point source pollution | 13.5% |
| 6 | Combined sewer overflows | 14.9% |
| 7 | Disinfection byproducts | 12.3% |
| 8 | Nutrient removals | 13.0% |
| 9 | Lead and copper | 14.0% |
| 10 | Pathogens | 14.4% |
| 11 | Radionuclides | 10.9% |
| 12 | Arsenic | 10.7% |

Note: 1,663 survey participants were asked about their levels of concern regarding the water industry's ability to comply with current regulations. Source: AWWA State of Water Industry Report

## Water treatment services

We define water treatment as the process of calibrating water for a specific end-use such as human consumption or industrial/process applications and its return to the environment. The reason why this is an important investment area in our view is not only because 30% of the world's population could be living in areas without adequate water supply by 2025 (Xylem 2018), but because increased water treatment solutions and services relate to further industrialization and increased consumer consumption, whereby new and emerging contaminants such as pharmaceuticals, pesticides, herbicides, microplastics, and per- and poly-fluoroalkyl substances (PFAS and PFOA) need to be monitored.

## Desalination

While currently a costly solution, demand for desalination plants appears somewhat inevitable given the growing difficulty in meeting water demand in urban areas versus the inherent limitations in supply (due to the range of trends set out in this report). Therefore, cost reductions and technological efficiencies will continue to be a focus of the market (source: Grand View Research – 2017 Market Research Report). Capital expenditures in the desalination market appears set to reach USD 41.3 billion by 2024 (Global Water Intelligence DesalData), but are dominated by a relatively small number of markets. The six Gulf Cooperation Council (GCC) countries on their own account for more than half of expenditure expected in the next five or so years.

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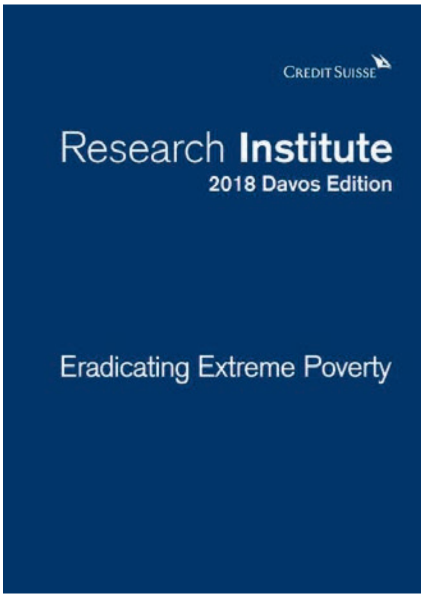

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