Water security

Taking a fresh look at water in a time of scarcity

The world is running out of fresh water. Simultaneously, an increasingly volatile climate is raising the complexity of managing the water we do have. This creates a fundamental resource challenge on a global scale, which will require the adoption of a new paradigm relating to how water is managed. If human ingenuity and sober, long-term thinking prevails, water security could be preserved despite the challenges of climate change and increasing demand. If not, water scarcity could become more pervasive, and increasingly the source of conflict. The onus is on planners and water managers everywhere, to craft a water secure future, writes Dawid Bosman.

Throughout human history, man has had a very close relationship with water; it could be no other way, as water brought life, and in scarcity or excess, it took life away. Before the ancient Egyptians and Mesopotamians built the first primitive gravity dams around 4 000 years ago, early humans were vulnerable to the variances of water availability. The Romans brought better materials and cement to the art of dam-building some 2 000 years ago (although their primary contribution was mainly in aqueducts and sanitation systems). It was only in the 17th century that the Spanish brought significant advances in dam-building technology, with the advent of the first arch dams. This technology found its way to the New World colonies, and paved the way for water infrastructure over the next three centuries.

Population growth and a rise in living standards have been made possible by the management of water resources; dams offer protection against floods, and serve as reservoirs, to offer a sustained supply. Should perennial shortages occur, water can be transferred from one basin to the next. These developments have made the availability of water more predictable and manageable, allowing us to mitigate the effect of droughts and floods, and for humanity to grow and prosper.

During the last fifty-odd years man has developed the technology to remove the pathogens from wastewater, and the salt from seawater, to produce potable water. Today, humanity relies on water in countless ways to sustain a global population of nearly 7.5 billion people, in an unprecedented state of collective global prosperity. Our reliance on water is visible everywhere; beyond direct consumption and personal use, it is an essential ingredient in virtually every value chain of everything we use, from consumer electronics to clothes to energy. Water has become ***the*** essential common denominator.

Looking to the future, it seems inevitable that our relationship with water will be changing fundamentally. Two trends, mainly, will cause a shift in the tectonic plates: Human demand is outstripping the readily available supply, and the climate is changing, which is affecting water availability. (This is one indicator that we are living in the Anthropocene, the geological age that commenced when human activity began to impact global climate and ecosystems back in the 1760s.)

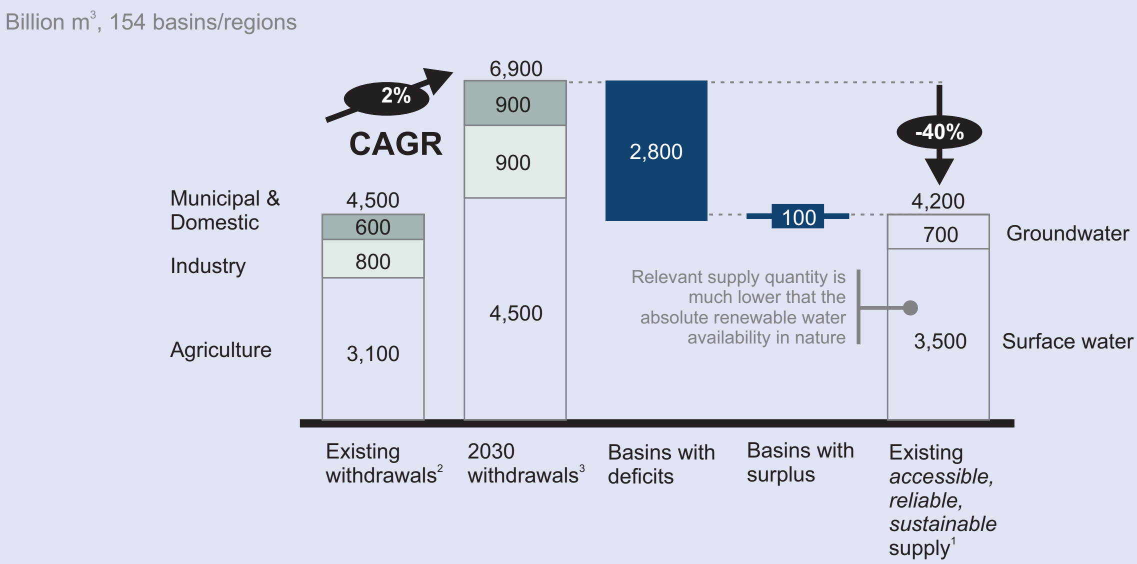
Dealing first with the matter of global water supply. Until now, humanity has been living off that 0.5% sliver of the Earth's water pie-chart; water that is both fresh and readily accessible, drawn from rivers, lakes and dams. This ease of access probably created the common perception that water should be cheap and plentiful; after all, it falls from the sky, and can be accumulated in great quantities, enough for all. This dispensation is not sustainable in the long term.

As humanity grows more populous and affluent, and the climate becomes less predictable, we start competing, rather unfairly, with other elements of the natural ecosystem who also depend on that tiny sliver of available fresh water; and when the well runs dry, human needs have always taken priority. And yet, the sea, that vast reservoir which contains 97% of the planet's water, and has 40% of human population living within 100 km of its shores, has barely been tapped into; less than 1% of current global water consumption is sourced from the sea. More about that later.

So, how much fresh water is there, and how much do we need? Perhaps the most comprehensive, recent analysis of global water security came from the 2030 Water Resources Group (2030 WRG), through their 2009 study 'Charting our Water Future'. Their assessment of the freshwater supply-demand balance, with a forward-looking view towards 2030, covering 154 basins around the globe, is captured in Figures 1 and 2 below. It describes a global resource challenge of massive importance, and significantly, it does not factor in the effect of climate change, and it assesses only the 0.5% of global water stock that is fresh.

Referring to Figure 2 : The 2010 withdrawals from global households, industry and agriculture amounted to 4 500 billion cubic metres (bcm or $1x10^9$ m^3), compared with the 90% reliable supply of 4 200 bcm, with environmental requirements already netted off. The 300 bcm deficit indicates that globally, human water needs are already encroaching on environmental needs.

Demand is then forecast through to 2030, upon the assumption of an average 2% compound annual growth rate (CAGR), based on population and economic growth projections, and the further assumption that there will be no progress in water use efficiency in this time. The latter assumption makes the projected "gap" of 2 800 bcm (per annum, by 2030) somewhat hypothetical; certainly, gains ***will*** surely be made in water efficiency, and additional water infrastructure ***will*** be built to increase the system yield across the 154 basins, so the actual deficit by 2030 should be less than 2,800 bcm. But what is not so obvious, and will require vast inputs of planning, investment and human ingenuity to rectify, is how much of the gap could be closed, and what needs to be done to achieve this.



1 Existing supply which can be provided at 90% reliability, based on historical hydrology and infrastructure investments scheduled through 2010; net of environmental requirements
2 Based on 2010 agricultural production analyses from IFPRI
3 Based on GDP, population projections and agricultural production from IFPRI; considers no water productivity gains between 2005-2030

SOURCE: water 2030 Global Water Supply and Demand model; agricultural production based on IFPRI IMPACT-WATER base case

Figure 1: The gap between supply and demand, by 2030.

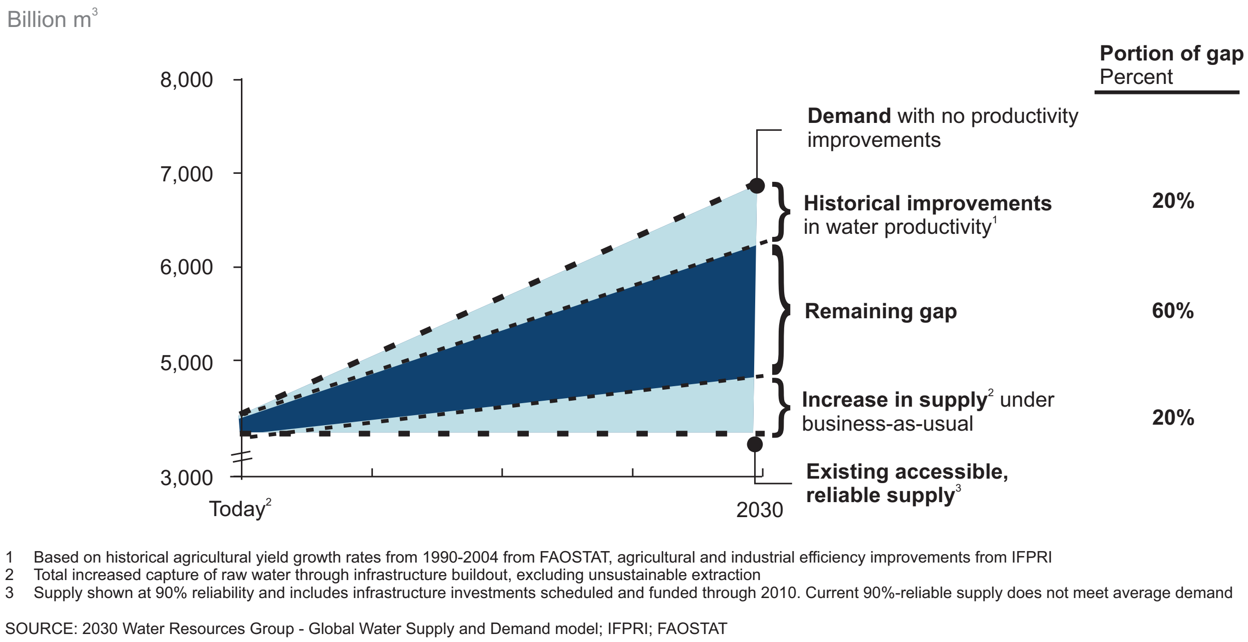


Figure 2: Closing the gap will require a whole new approach.

Referring to figure 2, if water efficiency (i.e. economic output for a given amount of water consumed) improves only at the historical rate, and if water supply grows due to similar levels of investment and similar projects as before, then only 40% of the gap will be closed. The remaining gap of 60%, quantified as 1,680 bcm per annum by 2030, will need to be addressed by measures and actions beyond the ordinary, according to the 2030 WRG study.

This headline-level finding is the sum of projected water balances across 154 basins, worldwide. With very few exceptions, planners in each basin or region will need to find an optimal balance of solutions that either increase water productivity, reduce water demand or increase water supply, specific to their local conditions.

Collectively, this will be a massive effort, and require an unprecedented focus on the water sectors of most countries, attracting human and financial resources. Water will, in its scarcity, need to be managed like the strategic resource it has always been.

Whereas the 2030 WRG study provides a clear view on water scarcity through to 2030, it did not deal specifically with the water challenges created by an increasingly volatile climate. The body of evidence is growing, indicating that in years to come, we will face an increasing severity and probability of both floods and droughts, in different parts of the world. The imperative will be on policy-makers and planners to not only apply the water supply and water efficiency solutions called for by the 2030 WRG study, but also pursue urban infrastructure design that is more resilient to climate extremes.

The importance of such resilience is clearly demonstrated by a few instances in recent years, when the water infrastructure of cities where unable to withstand extreme weather conditions:

In January 2011, the potable water supply of Brisbane, Australia was inundated by flood waters, following a record-breaking flood that claimed 38 lives and reduced the national GDP by about A$40 billion. Fortunately, and with a good measure of irony, a large-scale seawater desalination plant had been completed in nearby Gold Coast just months earlier, in response to a record-breaking 13-year drought. Being a closed system, the desalination plant was not affected by the flood, and over a period of nearly four months, provided much-needed potable water, between 40 and 90 million litres per day, into the regional water grid, thus averting a potential humanitarian and health crisis.

When a two-year drought ended late in 2015, the metropolitan area of Sao Paolo, Brazil, with 20 million inhabitants, was on the verge of running out of water - an ironic situation for the largest, wealthiest city in a country endowed with one eighth of the world's fresh water. But the confluence of the worst drought in a century, poor planning, population growth and extensive environmental degradation allowed by weak regulation, resulted in a situation so dire that water utility managers contemplated a warning to civilians to "flee from the city", when the crisis peaked. Whereas the water reserves have now been restored, households and businesses have lost confidence in the water utility and city management's ability to avoid a recurrence. The city still loses 31% of its water during reticulation, and an apparent obsession amongst planners with surface water resources leads to the more resilient and sustainable groundwater resources not being developed.

In April 2016, and again in February this year, the Chilean capital of Santiago suffered extensive water supply interruptions, leaving 4.5 million people in distress for several days. Again, the causes were a mix of poor planning, and weather extremes. An extremely hot summer brought extensive, barely controllable wildfires, promptly followed by excessive rainfall, also at altitudes where it usually snows. The result was extensive soil erosion and mudslides, which overwhelmed the water treatment facilities. Industry was interrupted, and households had to rely on water being trucked in from other centres. With Chilean water supply completely privatised, accusations are being levelled that under-investment in infrastructure had contributed to the vulnerability. A reservoir is under construction, which should improve the ability to withstand future, similar events, but is only due for completion in 2018. In the interim, the ability of the local authorities to deal with crises and environmental management, is being questioned.

In the midst of perhaps the worst drought in a century, the reserve in Cape Town's five major dams have dropped to 31%, as at 10 March, with conservation and demand management the only actionable defence against running out in another 115 days, unless ample rains arrive in the interim. Even though plans are underway for water reuse, groundwater development, a diversion scheme and large-scale seawater desalination, these solutions require longer lead-times, and could not avert the potential crisis. The impact, on inhabitants, investor confidence and politically, should a major metropolitan city (population 3.7 million) run out of water, will be unprecedented in South Africa. Similar incidents in recent years, such as Beaufort West (population 34 000) and Kroonstad (population 197 000), were on a much smaller scale, and may not be useful templates for the contingency planning befalling the local authorities.

The World Health Organisation (WHO) describes what can happen to a water supply system during weather extremes: "When the weather is abnormal or the climate is under pressure, water and wastewater services systems stand to lose much of their environment and health benefits, for two main reasons:

- They lose their ability to deliver the services required because of direct infrastructure damage (from floods, windstorms and tide surges) or from lack of water (e.g. when a cold spell turns water to ice);
- They become a significant source of chemical and biological contamination of ecosystems, water bodies and soil by means of their discharges and polluted overload."

The probability of extreme heat or rainfall occurring, which could exceed a city's resilience and compromise its water supply, is closely related to global warming, found a recent study by Dr Erich Markus Fischer of the Swiss Federal Institute of Technology. According to Fischer, future warming will result in a more volatile, dangerous environment, even if global average temperature increase can be contained within the 2º C limit to which governments have committed themselves.

This is echoed by the WHO, which has observed a 65% increase in annual, disastrous, weather-related events occurring in Europe from 1998 to 2007. The quantum of losses as a result of these events followed an even greater rate of increase. In essence, the likelihood of extreme weather events is generally increasing, as illustrated by Figure 3 below.

Most world leaders seem to understand the causal links underlying water security, coming from population growth and climate change. In recent years, a very high priority has been given to water security in the annual Global Risk Report of the World Economic Forum (WEF). The former Secretary General of the United Nations, Ban Ki-moon, articulated his sombre concern at the meeting of the WEF in 2008: "A shortage of water resources could spell increased conflicts in the future. Population growth will make the problem worse. So will climate change. As the global economy grows, so will its thirst. Many more conflicts lie just over the horizon."

Taking stock: The world is busy running out of readily accessible fresh water. This will compel us to find new sources of water, and improve the efficiency by which we consume water. Also, climate change is bringing an increase in the severity and frequency of both droughts and floods.

In response to this, we need to improve the resilience of our cities, i.e. the ability to withstand and recover from such extremes, as a result of sound, integrated urban planning. Cities of the future would need to be climate-independent, resilient to floods, droughts and heat waves. Coastal cities would also need to contend with storm-surges and rising sea-levels.

We already see such "best practices" being adopted by the more advanced and forward-thinking waters sectors. The manner in which Perth, Western Australia have drought-proofed itself through a diversification of water resources, including two large-scale seawater desalination plants, is exemplary. The dedication with which Singapore captures run-off for recycling, and the efficiency with which most of the southern and coastal regions of Israel desalinates seawater and recycles wastewater on a fit-for-use basis, are further examples.

Despite large-scale seawater desalination being a key component of urban resilience, there is still much of a debate, in other parts of the world, as to how the practice should be applied: Should desalination be seen as a response to periodic supply shortages (e.g. a drought or highly seasonal demand) only, or should it be seen as a structural, permanent adjustment to the water supply inventory, yielding a continuous supply? The debate may not yet be settled, but the need for urban resilience is adding substantial weight to the latter argument.

As it is, large-scale reuse and seawater desalination are rapidly growing into mainstream practices. Whereas surface water resources will probably continue to dominate for the foreseeable future, the multiple needs of (a) Adding a component of highly-assured water supply, (b) Preserving the ecological flow, (c) Improving the quality of water being indirectly reused, and (d) Preventing return flows from being released to the sea, are all emerging as key issues shaping the conversation.

Looking ahead, our infrastructure and urban design choices will need to reflect these challenges. The solutions may not be simple, and may require a systemic approach to deal with all the moving parts. But, with good fortune, thorough planning, hard work and innovation, perhaps we can avoid the dystopian future that Ban Ki Moon predicted nearly ten years ago.