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Future of Water

The Global Challenge

Unlike most of the resources we consume such as oil, rice and steel, there is no alternative for water - it is the only natural resource with no substitute. Today over 6 billion people share the same volume of water that 1.6 billion did a hundred years ago. Although two thirds of the earth's surface is water, only 3% per cent of this is fresh water and, if you deduct the majority share that is locked up in the polar ice-caps and other glaciers, we only actually have access to around 0.5%.

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Water consumption varies enormously across countries and regions and is similar to patterns in energy consumption. No surprise then that water and energy share some of the same drivers and challenges. For example, water follows a similar trajectory as energy in that its use increases relative to GDP growth. Today, average annual water withdrawals for urban and agricultural use in the US are running at around 1.7m litres per person: In China the numbers are less that a third of this. As the populations and GDP of the emerging economies continue to grow, overall demand for freshwater will exceed supply by more than 50% by 2025 and so the number of people living in water stressed regions will increase. Without decisive action the imbalance between availability and demand will continue to escalate.

In a 'business-as-usual' scenario where average households' income increases, in many countries, so does their direct domestic water consumption. In others experiencing water shortages, demand management has controlled this growth. Equally important is the indirect consequence of a changing lifestyle: As diets in developing countries change from rice to meat so the demand for water rises as it takes more water to produce meat than it does to grow rice. Another indirect impact relates to 'virtual water flows'. These are a result of exporting goods (both agricultural as well as consumer products) that have been produced with the use of water from a local source. As global trade increases, this will result in further reduction in water availability especially in countries like China, where water consumption is already on the rise and sources of water are on the decline. This challenge is compounded when you recognise that population growth is primarily occurring in regions where water usage per capita is still relatively low and so has the potential to increase dramatically. This trend of increased water consumption is adding major strains in key areas of the planet over the next decade. While today much of India, China, the Middle East, Australia, Africa, the US and southern Europe are already water stressed, by 2020 significant areas of Northern Europe and South America will be added to the list.

One major concern for the UN is how the increasing scarcity of water will play out at national levels. Although the likes of Singapore and Australia have well-developed National Water Strategies, other countries are recognising the higher chances of conflict as different economies seek to secure resources. Some believe that in the future we will again fight wars over water not oil, and if you look carefully at what is going on in Israel, Egypt and areas of the Indochinese borders, the reality of this is all to evident.

Options and Possibilities

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Options for countries with weak economies and poor access to resources are limited and so require different strategies going forward. Access to water here is a primary health need: Sanitation is considered a key global issue and is a millennium goal in itself, but one in danger of not being achieved if new solutions for sustainable water supply are not available. This is not just a problem in places like Africa but in Eastern Europe as well.

Living in Australia, I see that a country at the forefront of managing and responding to water scarcity is facing a number of major urban water systems challenges: A projected 40 percent population growth over the next quarter century will increase demand for water well beyond the capacity of existing supplies. This as well as the increase wastewater flows and storm-water runoff will present a significant number of urban water problems that will need scientific solutions. The current urban infrastructure valued in excess of $94 billion was mainly constructed during the 1960s and faces significant deterioration. Management of the annual revenue of $9 billion and capital investment of $4.5 billion provides significant opportunities for major financial savings from small increments in efficiency. These issues are not unique to Australia and either already are, or soon will be, relevant in other regions across the world.

Although most of the challenges we face will be common across various regions, they will vary at a country level, as will the solutions to address them. We therefore need to understand the total water cycle system that will account for alternative water and land management options, including addressing changes to flow, nutrient and sediment regimes; energy use; greenhouse gas emissions; and the impacts on rivers, aquifers and estuaries.

Recent droughts, such as the one in Australia, highlight the vulnerability of existing urban water supply systems. Alternative investment in desalination and other potable and non-potable water supplies and their linkages into regional water grids may potentially cause issues with respect to water quality and public health if not properly managed. In a few countries such as the UAE and Singapore where desalination is economically or politically viable, we are starting to see alternative technical solutions for freshwater supply, but the mass global application of new breakthroughs is more than 20 years away.

Global drivers to reduce the carbon footprint will increase the cost of energy, compounding the economic and emissions risks associated with the adoption of energy-intensive manufactured water supplies and wastewater treatment. This driver will also present opportunities for recovery of water, energy and nutrients from urban water systems.

In addition we must recognize the impact of extreme events on the complete water cycle, including water availability, use, resilience, infrastructure performance, etc. Potential changes in climate variability will further compound these issues by causing increased uncertainty in supply and engineering issues associated with bushfires, flooding and infrastructure failure. Whether or not you believe the different projections of how temperature rises will impact in different parts of the world, the high probability of more variable weather conditions and hence water availability will certainly add more complexity.

With the advent of new water strategies, water quality and treatment will be more critical to maintain our lifestyle. New risks are emerging (e.g. endocrine disrupting chemicals, N-nitrosodimethylamine (NDMA)) that need solutions to be developed to ensure the purity of our potable water supplies. With an ageing asset base in many countries, the integration of new supplies from alternative sources and demand management strategies requires us to manage changing flows and demand profiles in water and wastewater networks. Blended water sources will influence water quality in water distribution networks, and higher contaminant concentrations in sewer systems and treatment plants will require the development of new management strategies. The effects of these changes on exiting assets are largely unknown at present.

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Proposed way forward

For the majority of us, the options focused on managing our existing water supply are the only ones really on the table for the next decade. Breakthroughs in desalination and point of use purification are still some way off. Developments in membrane technology that will realize significant changes are pushing in many different directions, for example companies such as "Aquaporin" are seeking to leverage learning from white biotech principles: Membranes mimicking specific natural processes could be one breakthrough that makes desalination viable across more geographies than is the case today. In addition, developments in membrane distillation could significantly reduce the energy costs associated with desalination. However, these developments are many years away. Therefore, considering the challenges ahead, three key elements need to be viewed together if we are to address them successfully: Sensible policies; (technology) solutions; and lifestyle/behavior changes.

Emerging thinking about the evolution of large cities demands the revisiting of the fundamental role of water system design in sustainable city development. We need to embrace the concept of the 'water sensitive city'. In this context, the development of suitable decision-making methods, as well as planning and management processes, should be based on sustainability concepts. This drive for improved water management has led companies such as GE and Siemens as well as newcomers like IBM to focus on innovating new businesses around water. Similar to 'clean energy' startups in the past decade, water is now also attracting the attention of investors and entrepreneurs from other areas to fund and found new companies. It is expected that the penetration of the "business world" in to water management will add a different perspective to how water services are provided compared with the traditional local government view.

Maximizing recycling of water from local wastewater and storm-water sources in the context of a water sensitive city will require the development of efficient and reliable treatment options for environmental protection and public health. In addition we need options for energy and nutrient recovery during water and wastewater treatment, thus transferring waste streams from a disposal problem to a source of wealth. Examples of this can be found in the renewed interest in harvesting algae for the production of bio-fuels and in the development of microbial fuel cells: Clean water meets clean energy.

Furthermore, containing leakage rates to acceptable levels requires continual 'active' leakage detection that is expensive, labour intensive and slow to deliver: The ability to automate leakage detection could provide a

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step change in water loss control. Australia already uses close to world's best practice in minimizing leakage from distribution networks and utilities in the UK, France and the US are now focused on similar aims. The gains to be achieved are clear - the UK looses about 3.3bn litres of clean water every day.

In a scenario of ageing infrastructure and growing cities, we need to develop new strategies for water, wastewater and storm-water systems. These must accommodate the inevitable population growth and increase resilience to climate change. At the same time, they should provide sufficient flexibility to adopt a mix of centralized and decentralized components where most appropriate to meet both environmental and stakeholders' needs.

It is also essential that we develop real-time management, operational and control systems which will greatly manage risk and increase public confidence in the increasingly complex water networks. This will require the understanding of system condition and performance, detection of impending system deterioration and failure via networked sensors, and accurate prediction and detection of significant 'events'.

Lastly, planning is needed for the integration of new water sources and treatment processes into existing water supply and wastewater networks. In the context of an ageing asset base, we also require the development of optimal management techniques for new water supply grids.

Impacts and Implications

The water debate has accelerated over the past 18 months and is now considered by several governments as the single greatest challenge we face. Since the issue is so intertwined with many other topics (energy, food, health), in fact with pretty much anything we do, whether in policy, technology implementation or change in life-style, it will have an impact on not only our lives, but the lives of generations to come. We must therefore "get it right".

In urban environments water scarcity might force us to reconsider certain lifestyles and at the same time open up opportunities for innovation in areas such as water capture, treatment, conservation and efficiency. Changes in behavior will require measuring our water consumption before we can manage it and solutions such as smart metering will find their way into our homes. The questions are at what level and how granular will we require this to happen and who will manage the change?

Agriculture accounts for most of our water consumption and, with developments in biotechnology, by 2020 new crops will be introduced that are more efficient in their water use as will new ways to grow them. Concepts including vertical farming might find their way into, or close to, urban environments if there is a real benefit both in terms of water recycling and lower energy consumption.

Finally, businesses will soon learn more about embedded energy and have a more mature understanding of how to measure this in their products. Water will likely follow the same path - but this might be introduced faster as a result of the prior experience with CO2. Success depends on common ways to measure water footprints supported by clear and simple messages to the public. Governments will undoubtedly play a role in this, and may follow Australia's and other countries' lead in developing national water strategies as well as developing capabilities to secure a sustainable water supply that meets demand.

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