Smarter Cities of the Future

White Paper: Water & Sanitation

BOFFIN & FUNDI

Contents

Introduction

Water is an essential part of everyday life - from being our essential drinking liquid to removing our waste. Just as water circulates in the global hydrologic cycle, water in our cities also flows in an urban water cycle that is one of the modern world's fundamental systems.
However, reduced rainfall, increased population, pollution and the rapid urbanization and development of impoverished societies are depleting the amount of water available to humankind. These factors are plunging the world into a water crisis that is projected to become more severe in the coming decade.

In 2015, the Organization for Economic Cooperation and Development, determined that significant water shortages were already being experienced in many parts of the world, costing the global economy half a trillion dollars a year, not including the cost of environmental damage. At this rate, it is also projected that water shortages will lead to increased political instability, displacement of populations and potentially, also, political unrest.

According to the Global Water Partnership (GWP), an organization founded by the World Bank and the United Nations Development Programme, **"The increasing pressures of climate change, population growth, urbanization, and evolving energy needs are together putting unprecedented pressure on our finite freshwater resources."** Since none of the causes listed by the GWP are going away, solutions can only come from changing the way we find and use water, as well as our collective attitude towards it.

Although the water crisis overlaps with the widely discussed problem of climate change, it is different in several ways. It is more acute and more concrete since the issue lies with a single resource without which humanity cannot live. **While the causes of the water crisis are less controversial, emotive and politically sensitive, the catastrophic effects of water shortages are also more easily measured and are already playing out graphically in various parts of the world.** Fortunately effective solutions to the water crisis have already been found and are successfully being implemented in certain of the driest places on earth.

This white paper will look at the context of the water crisis globally, as well as from an African and South African perspective. We will examine the water management issues facing cities and communities in both developed and developing nations, including: **water procurement, quality and delivery, treatment of waste water and delivery of sanitation services.**

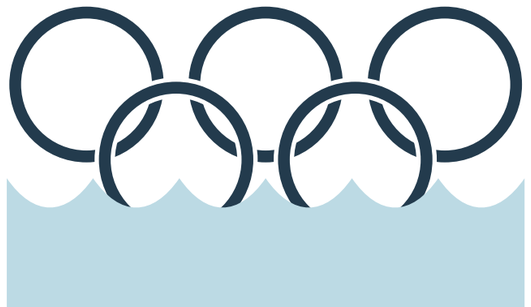
We will learn from the spectacular success of Israel's innovative approach to water, having solved many of the problems of water supply and consumption through a host of initiatives including: **spearheading efforts to deal with water leakage, improved farming efficiency, water recycling, desalination, pricing policy, and education.**

We will also learn from the failures of water management in other parts of the world where water shortages are resulting in a huge surge in reliance on groundwater for farming. In addition, the absence of proper regulation has led to plundering of aquifers, pollution of water sources and general degradation of the environment that threatens livelihoods as well as general health and well being. These management issues are often compounded by the large-scale cultivation of highly profitable, but thirsty crops such as almonds that need more than 4 litres of water to produce just 1 almond.

In fact, everything we eat and drink as well as every item of clothing we wear and virtually everything we use in our daily lives requires water to produce. A steak takes a 16,000 litres of water to produce, much of that being used to grow the grain that feeds the cow and one hamburger requires as much as 2,400 litres of water. This water footprint of the things we consume, together with the water we use for drinking, washing and bathing quickly adds up. In some developed countries such as the US, Italy and Japan, each individual uses nearly 500 liters of water per day or an Olympic-size swimming pool each year.

We will look at the twin roles of education and community involvement in tackling the issues head-on in order to change attitudes - and change they must if we are to stay ahead of the ever-increasing demand for water. We will also look at new technologies and how these innovations as well as the use of Big Data can help us to better manage our scarce resources.

In developed countries, each individual uses nearly **500 liters** of water per day or an **Olympic-size swimming pool** each year.



In conclusion, we will present various solutions, the implementation of which will be necessary for South African cities to become leading cities of the future. Such cities will be able to provide water security in order to sustain economic development, meet the demand for service delivery from all sectors of the community, deliver social upliftment and bring dignity to poor communities through the introduction of sustainable sanitation.
In the face of the rapidly-developing water crisis, the public sector, the private sector as well as every private individual will be challenged to reassess their relationship with as well as their attitude to water as a 'free' resource. Water in all its forms, will have to be treated as a precious commodity, given its scarcity and importance.

In particular, the design of the urban water cycle needs careful thought. **This cycle incorporates water supply, wastewater disposal, stormwater and groundwater management, urban design and environmental protection.** This new way of thinking about the urban water cycle represents a fundamental shift in the way water, related environmental resources and water infrastructure are considered in the planning and design of cities and towns in the future.

Global Context

With 70 percent of global freshwater resources to be found in the Arctic and Antarctic regions as well as in the form of ice and permanent snow cover in mountainous areas, it may be true that water is everywhere around us, but the vast majority of it is not readily available.

While rainfall is the main source of fresh water for plants and animals and is essential for life on earth, **reduced rainfall and shifting weather patterns have increased our reliance on accessible freshwater contained in rivers, lakes and underground aquifers.** However, as the global population increases and the effects of climate change deepen, these sources of freshwater are **under pressure from the world's seven billion people** whose thirst for water in all its guises, appears to be nearly insatiable.

The International Fund for Agricultural Development (IFAD), estimates that by **2025 there will be 1.8 billion people living in countries or regions with intense water scarcity** - without access to the 20-50 litres of safe freshwater a day for drinking, cooking and cleaning. In addition, two-thirds of the world's population could, by 2025, be living under stress conditions caused by water scarcity.

IFAD studies also show that developed nations are the highest and most wasteful water consumers and that this trend is set to continue with predictions that **water use in developed countries will increase by 18% over the next 10 years.** As the water footprint of individuals in the developed world continues to grow, and as the demand for water in developing countries ramps up by as much as 50% - **driven by population growth, economic development, urbanisation and changing diets** - the demand for water will soon exceed supply unless this valuable resource is properly managed.

In developing countries, these issues are exacerbated by rapid economic growth and urbanisation which has lured many people away from the rural areas and into the cities in search of employment and a better life. As a result, cities across the developing world are faced with the challenge of providing adequate housing, water and sanitation for their burgeoning population, many of whom live in unplanned informal settlements with little or no infrastructure.

The United Nations estimates that there are **2.5 billion** people (including **1 billion children**) who live without basic sanitation and that a child dies every 20 seconds as a result of poor sanitation.

Globally, diarrhoea is the leading cause of illness and death, and 88% of diarrhoeal deaths are due to a lack of access to sanitation facilities, together with **unsafe drinking water** and **inadequate availability** of water for hygiene.

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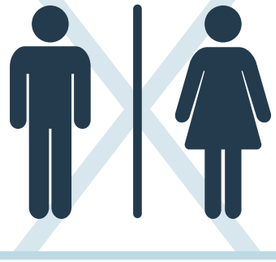

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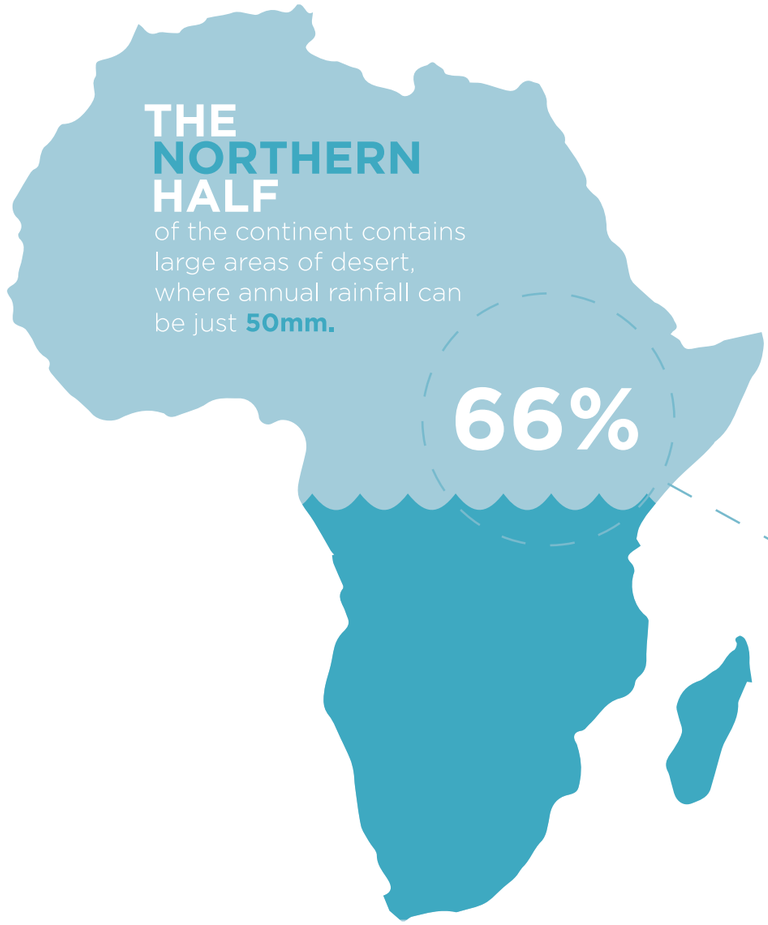
Africa

Against this backdrop, Africa faces more than its fair share of challenges. As the world's second largest continent, Africa has a wide variety of climates and rainfall varies dramatically across the continent. The northern half of the continent contains large areas of desert, where annual rainfall can be just 50mm. But in central areas, tropical rainforests can receive over 4 000mm each year (Scotland has an average of around 1 500mm). However, with 66% of Africa being arid or semi-arid, more than 300 of the 800 million people in sub-Saharan Africa live in a water-scarce environment.

Across Africa weather patterns are also changing with droughts becoming more common. In the semi-arid Sahel region (which stretches across countries such as Senegal, Mauritania, Mali, Niger, Chad and Sudan) droughts have become so common that scientists think a rise in water temperatures in the nearby Gulf of Guinea has shifted the flow of rain clouds southwards. **As the climate warms, the Sahara desert is also believed to be advancing south at a rate of 600 metres each year.** Deforested areas where trees have been cleared for farming or to supply fire wood, are more at risk of becoming deserts since bare earth is blown away and replaced by sand.

Since most agriculture in Africa relies on rainfall, crop growth is severely limited by water availability. The variability of rainfall during the growing season also frequently causes crop failure resulting in food shortages in many subsistence communities. At the same time, the development of African economies is driving demand for energy from all sources including hydroelectric power. **Competing water demands have led to a so-called nexus between water, agriculture and energy which is set to play out over the next few years** on the back of a demographic boom coupled with rapid expansion in all sectors of these economies.

Urbanisation and rapid economic growth are also bringing about a dramatic increase in the individual wealth of some of the continent's poorest people and with it a change in diets from a predominantly starch-based diet to one high in meat and dairy. **Since it takes five times more water to produce 1kg of beef than it does to produce 1kg of rice or corn, this dietary shift of large numbers of people is already having a significant impact on overall water consumption.**



Southern Africa

Occurring every two to seven years, El Niños are caused by warming of the Pacific Ocean. Although scientists believe El Niños have been around for millennia, the droughts and floods they trigger may be becoming more intense as a result of climate change and these effects are already being felt in Eastern and Southern Africa.

UNICEF estimates that as many as 11 million children are at risk from hunger, disease and lack of water in parts of Southern Africa, threatening to undo gains in nutrition, health and education. This situation has been exacerbated by a series of climatic shocks in 2014 and 2015 that ruined harvests, leaving the survival of many children and their families dependent on food aid in several countries in the region.

South Africa, with an average annual rainfall of only 492mm by comparison with a world average of 985mm, is by definition a water-stressed nation. In fact, with low rainfall and a large population, South Africa is, in relative terms, more waterscarce than neighbouring Namibia, despite the fact that Namibia has approximately half of South Africa's average annual rainfall. It is therefore not surprising that the **World Wildlife Fund (WWF) estimates in a March 2017 report that water demand will exceed supply in South Africa by 17% in 2030**.

South Africa's water security depends on sustained supply from our water resources, including rivers, lakes and groundwater all of which are replenished by rainfall. By volume, our water resource base is dominated by surface water from our river systems. However, **60% of the river basins in South Africa include flow to or from another country** and South Africa has international obligations under the National Water Act, to ensure that we sustainably manage a portion of the flow across our borders.

In addition, according to the World Wildlife Fund, **only 8% of South Africa's land area produces the runoff (water that drains from the surface of an area of land into the river systems) that generates 50% of the water in our river systems.** This makes us particularly vulnerable to changed weather and rainfall patterns.

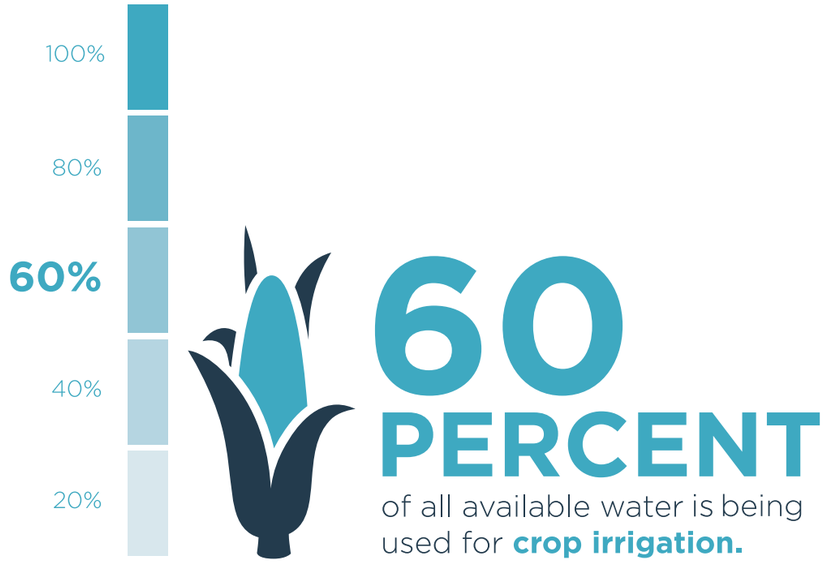
There are six major sectors that use water in South Africa. These are agricultural irrigation, urban use, rural use, mining and bulk industrial, power generation, and forestation. According to studies by the Department of Water and Sanitation, the vast majority of water is used in the agricultural sector with over 60% of all available water being used for crop irrigation.

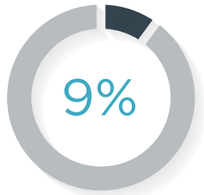
As much as 30% of water in South Africa is made available for urban and rural use (including domestic use), while the rest is split among industrial, power generation and forestation uses. Both population growth and economic development in South African will clearly bring new tensions to issues of water use.

Furthermore, at a municipal level, research indicates that of the 278 municipalities in the country, 23 (9%) are in a state of crisis with regards to their water management and systems and a further 38% are deemed high risk, with the potential to deteriorate into a state of crisis.

The Blue Drop Certification, a benchmark for international water standards, has been used to monitor the quality of water in South African municipalities.

In her 2015 budget speech to Parliament, Minister for Water and Sanitation, Nomvula Mokonyane called for a Water and Sanitation Revolution to reclaim and better manage South Africa's water in order to tackle the challenges of inequality, poverty and unemployment.





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Out of the **932** water systems audited in 2012, only **98 (10%)** were given the Blue Drop Certification, posing questions about our water quality.

Challenges in Developed Markets

Water crises are generally viewed as a problem of only the poorest nations. However, a combination of climate change, drought and loss of wetlands that store water, along with poorly thought-out water infrastructure and poor resource management, is resulting in a water crisis that is truly global.

In a report entitled, Rich Countries, Poor Water, the World Wildlife Fund (WWF) provided an overview of water issues in the developed world, showing that economic riches do not translate into plentiful water.

Australia

The world's driest continent, **Australia is facing an environmental crisis as underground salt deposits are being drawn to the surface as a consequence of the large-scale clearing of native vegetation to make way for farming of crops and pastures.** This so-called dry land salinity occurs when salt-tolerant and deep-rooted native vegetation is replaced with crops that have shorter root systems and need less water. With each rainfall in these cleared areas, unused water "leaks" down to the water table, raising the water table, and bringing the salt up with it.

> **2.5 million** hectares of land is already affected and salinity is now also impacting on Australian river systems as these become contaminated by salt runoff.

As land clearing continues at a rate of around 300,000 hectares a year, the issue of dry land salinity is expanding rapidly and affects every Australian state. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) data indicates that **2.5 million hectares of land is already affected and salinity is now also impacting on Australian river systems as these become contaminated by salt runoff.**

Projections are that the Murray River in South Australia will, **over the next 20 to 30 years, have salinity levels that will be outside of the World Health Organisation's recommended level for drinking water,** putting Adelaide's drinking water at risk.

> In 1974, water used for household purposes was **63 % lower** than it is today and water use per person per day was **30% lower**. In 2017, the average Japanese person uses in excess of **322** litres of water per day.

Spain

Due to its geographical location and climate, **Spain can only access 8% of its water resources without the help of storage and diversion facilities.** Its 1200 dams and other storage facilities have provided access to 40% of water resources but reduced rainfall and rising temperatures are contributing to a bleak water outlook with an estimated **20% reduction in fresh water supplies.** As consumer demand for water continues to grow, particularly from the tourism sector, and as agricultural areas requiring irrigation are increased, **Spain is facing serious water problems including aquifer depletion, drying of wetlands, farmland salinization and pollution.**

Japan

Despite its high rainfall, **Japan is struggling with contamination of water supplies which is a serious issue in many areas.** Six years after the earthquake and tsunami which triggered the meltdown at the Fukushima nuclear power plant, the problem of dealing with contaminated water leaks - **which now exceeds 760 000 tonnes** – has emerged as a major challenge to the decommissioning of the Fukushima plant and a major threat to the environment and safe water supplies.

While Japan grapples with the water issues around Fukushima, per capita water use has also shown a dramatic increase. **In 1974, water used for household purposes was 63 % lower than it is today and water use per person per day was 30% lower.** In 2017, the average Japanese person uses in excess of 322 litres of water per day. Furthermore, since Japan relies on imports for 60% of its food (on a caloric basis) and over 80% of its timber, these trends present a major problem not only for Japan but for the world and its finite water resources.

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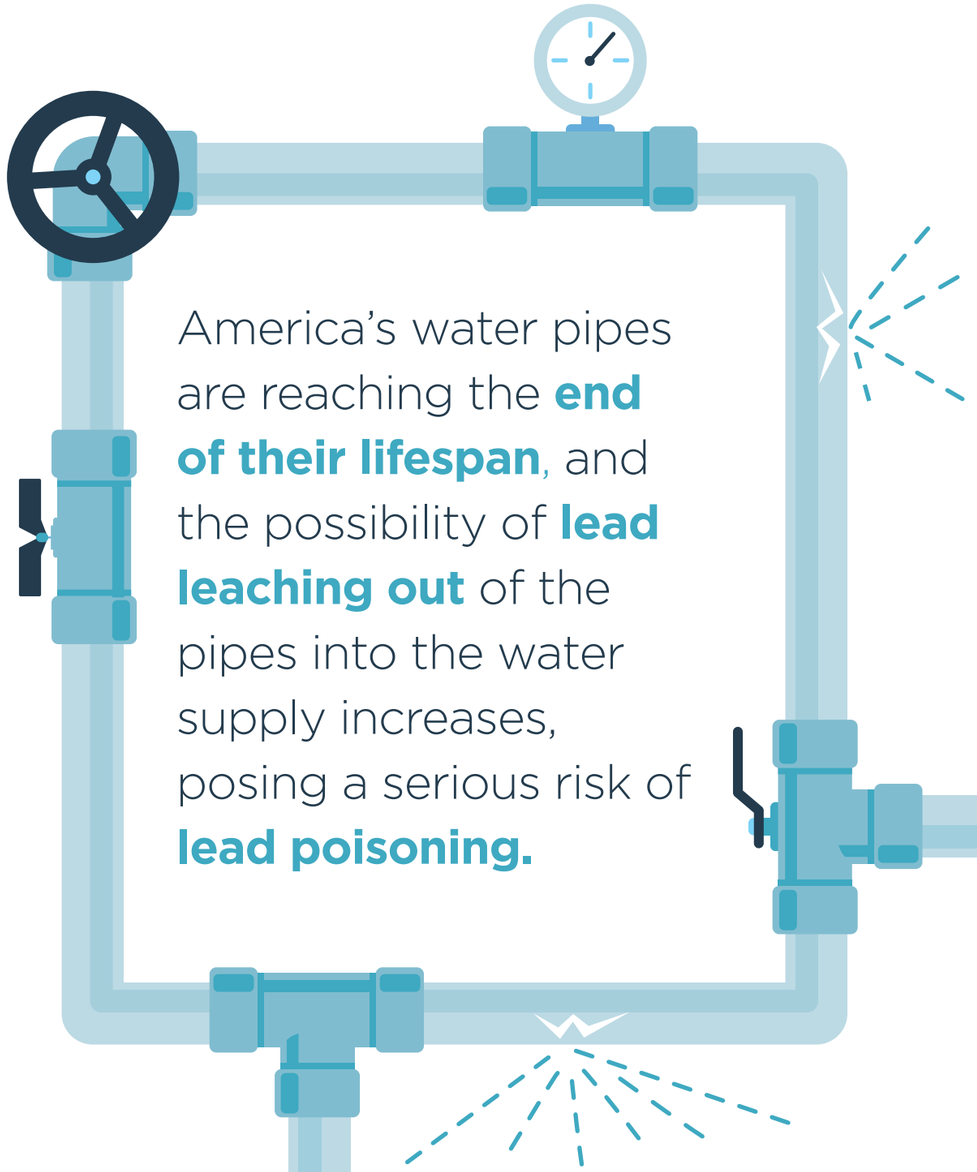
United States

In the United States, large areas are already using substantially more water than can be naturally replenished - a situation that will only be exacerbated as global warming brings lower rainfall, increased evaporation and changed snowmelt patterns.

In addition, water delivery systems throughout the United States use lead pipes which are potentially hazardous to health. Lead, like most metals, will break down over time, especially when it is continuously exposed to water. **America has close to 2 million kilometres of lead piping that is used for water delivery and these pipes only have a lifespan of about 75 years. Since many of America's water pipes are reaching the end of their lifespan, the possibility of lead leaching out of the pipes into the water supply increases, posing a serious risk of lead poisoning.** In the wake of the 2016 water contamination issue in Flint, Michigan, where lead-contaminated water from city pipes caused serious lead poisoning in residents, **researchers have identified a further 3,000 locations in the United States where the lead contamination in drinking water is more than double the amount found in Flint's drinking water.**

This aging infrastructure which is also prone to leaks, is a recipe for disaster, that **experts warn will cost close to $1 Trillion to fix, putting even greater pressure on water affordability.** A 2017 report from Michigan State University notes that water prices across the United States have risen by about 41% since 2010, and if this trend continues, **35% of American households will not be able to afford water services within the next five years.**



Challenges in Developing Markets

While the effects of the global water crisis can be felt in almost every part of the world, in developing countries the issues around water and waste water are inextricably linked with poverty, inequality and lack of human dignity.

In July 2010 the United Nations General Assembly explicitly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights. **The Assembly recognized the right of every human being to have access to sufficient water for personal and domestic uses (between 50 and 100 litres of water per person per day), which must be safe, acceptable and affordable (water costs should not exceed 3% of household income). Water also needs to be physically accessible (the water source has to be within 1 000 metres of the home and collection time should not exceed 30 minutes).**

UNICEF estimates that women and girls in undeveloped countries around the world spend up to 200 million hours every day collecting water for their families. When water is not piped to the home, the burden of collecting and transporting it falls disproportionately on women and children, especially girls. A UNICEF study of 24 sub-Saharan countries showed that when the collection time is more than 30 minutes, an estimated 3.36 million children and 13.54 million adult females were responsible for water collection.

For women in particular, the related costs of collecting water are high and have far reaching implications. The time spent collecting water shortens the time they have available to spend with their families, to care for their children and to perform other household tasks. It also impacts on their ability to work outside the home or to spend time on education or self improvement. For children, water collection can take time away from their education and sometimes it even prevents them from attending school.

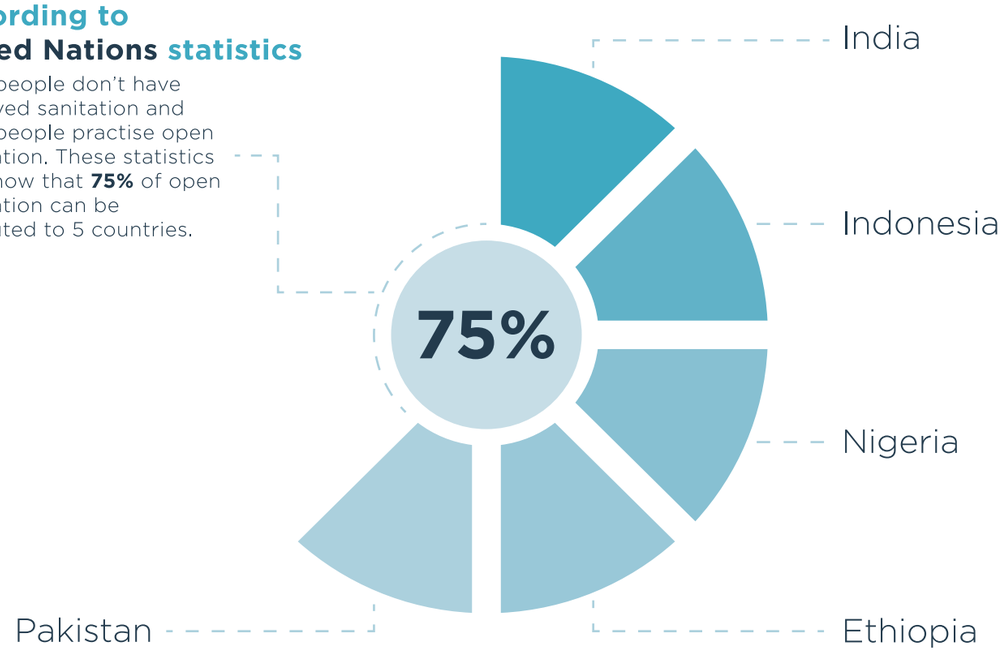
Collection of water can also seriously affect the health of the whole family and particularly of children. When water is not readily available at home, even if it is collected from a safe source, the fact that it has to be transported and stored increases the risk that it will become contaminated by the time it is consumed. **This increases the risk of diarrhoea which is the leading cause of death among children in developing nations.**

Childhood diarrhoea is closely associated with insufficient water supply, inadequate sanitation, water contaminated with communicable diseases, and poor hygiene practices. According to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, nearly **2 billion people world-wide are estimated to drink water that is contaminated by faeces** and a vastly greater number of people drink water that is delivered through a system that does not provide water that is of a consistently adequate quality.

WOMAN AND GIRLS
in undeveloped countries around the world spend up to **200 million hours** every day **collecting water** for their families.

According to United Nations statistics

1 in 3 people don't have improved sanitation and **1 in 7** people practise open defecation. These statistics also show that **75%** of open defecation can be attributed to 5 countries.



India

India is the second most populous country in the world, with more than 1 billion citizens, 77 million of whom do not have access to safe drinking water. Roughly half of India's population, a staggering **569 million people, practise open defecation** and the World Bank estimates that 21% of communicable diseases in India are linked to unsafe water and the lack of hygiene practices. **In addition, more than 500 children under the age of five die each day from diarrhoea in India alone.**

India is also the largest user of groundwater in the world using over a quarter of the global total each year. **More than 60% of irrigated agriculture and 85% of drinking water supplies are dependent on groundwater.** Increasingly, urban residents are relying on groundwater due to unreliable and inadequate municipal water supplies, making groundwater a critical resource for the Indian population. According to the World Bank, this is leading to over exploitation of an increasing number of aquifers and if current trends continue, **in 20 years about 60% of all India's aquifers will be in a critical condition.** This will have serious implications for the sustainability of agriculture, long-term food security, livelihoods and economic growth. It is estimated that over a quarter of the country's harvest will be at risk.

Kenya

With a population of 47 million, Kenyans are, according to the United Nations, one of the most struggling populations in the world. **37% of Kenyans still rely on unimproved water sources, such as ponds, shallow wells and rivers for their drinking water and 70 % of Kenyans use unimproved sanitation solutions.** These challenges are especially evident in the rural areas and the urban slums and only **9 out of 55 public water service providers in Kenya provide continuous water supply.** Intermittent water supply often leaves individuals to find their own solutions to meet even their most basic needs.

Since Kenya is an arid country with only a small percentage of land suitable for agriculture, Kenyans have flocked to the cities where there is very little or no formal provision of water and sanitation services. **Overcrowding exacerbates the health issues which include exposure to cholera and parasitic worms.** The rate of exposure is very high since water is contaminated at the basins and pumps where water is collected and also by the containers used for water collection, most of which are second-hand objects previously used for oil, fertilizer or wastes.

Brazil

Brazil is the world's second-largest food exporter with agriculture and related agro-industries accounting for 8.4% of GDP. Irrigation of land has increased exponentially over the past decade and water consumption in this sector is expected to continue to rise.

While Brazil has nearly a fifth of the world's water reserves, it also has a water shortage since the sectors that contribute most to the Brazilian economy, are also the biggest water consumers – agriculture and hydropower plants. High water consumption and environmental degradation by industry further contribute to the Brazil's water problems. According to a World Bank report, researchers found industrial effluents, including heavy metals, in water bodies in several metropolitan areas and industrial wastewater is discharged into waterways without prior treatment. In Sao Paulo and Recife, for example, this has made surrounding rivers unsafe sources of potable water, forcing these cities to procure water from distant basins or from wells.

Although improvements have been made in recent years, **among the poorest 40% of Brazil's population, the percentage of households with toilets connected to the sanitation network is still low compared with the wealthier segment of the population.** The lack of wastewater treatment means that pollutants are discharged directly into rivers and other bodies of water or processed in unregulated septic tanks, with serious consequences for water quality as well as for the well-being of the population.

China

While China has almost 20% of the world's population, it has less than 7% of the world's fresh water, leaving it with much less annual fresh water available per capita than most other countries. In addition to a growing population, pollution further limits the amount of water available for use since one-third of China's lakes and rivers are unfit for human use.

Industrial pollution is the most frequently discussed source of pollution, however, according to the World Economic Forum, **land use and degradation accounts for about half of the pollution found in China's water.** Fertilizers, pesticides, and livestock waste are carried into lakes, rivers, wetlands and coastal waters. Aquifers are also impacted as rainfall and snowmelt carry pollutants underground. Aside from rivers and lakes, **China's water pollution has an impact on the coastal areas where wastewater discharge along the eastern seaboard has resulted in dead zones in the sea.**

As this truly global water crisis takes hold and the effects become undeniably evident, the reality of what this crisis will mean for an increasingly water-scarce world, is becoming an area of intense focus for international policy makers and regulators.

In 2011, the UN Security Council recognized climate change for its security implications, with water being the medium through which climate change will have the most effect. In his remarks to the Security Council meeting, Secretary-General Ban Ki-moon said: "Around the world, hundreds of millions of people are in danger of going short of food and water, undermining the most essential foundations of local, national, and global stability. Competition between communities and countries for scarce resources – especially water – is increasing, exacerbating old security dilemmas and creating new ones."

But it is not all bad news. According to a 2013 UN Water Analytical Brief entitled "Water Security and the Global Water Agenda", **while competition for water resources may result in regional and international tensions, acknowledging water insecurity could also act as a preventative measure for regional conflicts.** The report said that increased co-operation to achieve essential water security could contribute to achieving increased regional peace and security in the long term.

The middle-east is a case in point. **Having successfully used innovation and technology to overcome water scarcity, Israel has created a situation where it is no-longer reliant on rainfall and has a water surplus.** With its own water security needs taken care of, Israel is now in a position to make water and water related technology available to its Arab neighbours with the possibility of improving Arab-Israeli relations. Already Israeli water scientists are planning a Water Knows No Boundaries conference for 2018, which will bring together water scientists from Egypt, Turkey, Jordan, Israel, the West Bank and Gaza for a meeting of minds.

> Around the world, **hundreds of millions** of people are in danger of going **short of food and water**, undermining the most essential foundations of local, national, and global stability. **Competition** between communities and countries for scarce resources – **especially water** – is increasing, exacerbating old security dilemmas and creating new ones.
>
> - BAN KI-MOON

Opportunites

Technology and Innovation

In 1948, the semi-arid slither of land that became known as Israel, had a population of 650,000 residents, with a gross domestic product (GDP) of US $300 per capita and consumed 300 cubic meters (mĐ) of water per person for all uses. **By 2005 Israel's population had reached seven million, its GDP had increased to $18,000 per capita, yet water consumption for all sectors remained at approximately 300 m³ of fresh water per capita despite the giant leap in income and population.**

Israel continues to experience economic growth and prosperity despite its limited water supply. This is because, in a process lasting decades, Israel has largely separated its water consumption from Mother Nature.

By overcoming extreme water scarcity, Israel has shown not only what is possible, but has proved decisively that we can make our water go a lot further and that we can do a lot more with a lot less water. **By employing innovation and technology in the areas of agriculture, waste water recycling, desalination and loss reduction, Israel has made itself immune to the intense droughts that have plagued the middle- east and has become a global leader in the sphere of water management.**

Agri-technology

With agriculture being the single biggest user of water around the world, this is a good place to start looking for savings. **More than 60% of South Africa's available fresh water is used for crop irrigation.** Our farmers employ various methods of irrigation including flood irrigation, mobile irrigation systems and micro-irrigation techniques such as micro sprayers and sprinklers, all of which have contributed to the knowledge base of applying irrigation methods correctly. However, more emphasis needs to be placed on increased efficiency and reduced water loss to non-beneficial spray evaporation and wind-drift, in-field conveyance, filter and other minor losses and how these can reduce the overall consumption of fresh water by agricultural users.

The extensive use of drip irrigation was pioneered by the Israeli company Netafim, which has developed technology to deliver exactly the right amount of water directly to the roots of each plant in order to maximise growth and crop yield while minimising water loss. As one of the most significant developments in agrotechnology today, drip irrigation has revolutionised agricultural production in Israel and resulted in massive growth and profitability in this sector.

In addition, the planting of genetically-modified drought-tolerant seeds as well as growing crops that can thrive using brackish water, has allowed Israel to ensure that agricultural water is used in the most efficient way possible. **And with more than 80% of the water used for crop irrigation coming from treated effluent to begin with, the use of fresh water for irrigation is kept to an absolute minimum.**

In Israel, government policy also favours the export of agricultural produce that requires less water and imports of products that require more water. By centralising control and putting in place a National Water Carrier (NWC), an integrated water demand management strategy was created, enabling the authorities to maintain a national pumping policy and to balance the water needs and demands of all water use sectors.

Desalination

In 2005 Israel launched its first industrial sized reverse-osmosis (RO) desalination plant on the Mediterranean coast. Since then several more RO desalination plants have been added to the water infrastructure and in 2013 the Sorek desalination plant became operational.
Located about 15km south of Tel Aviv, the Sorek plant has a seawater treatment capacity of 624 000m/day, making it the world's biggest seawater desalination plant.

Israel now gets 55% of its drinking water from desalination and at a very reasonable cost.
According to a recent article in Scientific American, desalination used to be an expensive energy hog, but the kind of advanced technologies being employed at Sorek, allow water to be produced by desalination at a third of what it cost in the 1990s. **Sorek can produce a thousand litres of drinking water for 58 US cents. Israeli households pay about US$30 a month for their water, which is similar to the cost of water in most US cities.**

Desalination is a game changer for the bulk provision of water to a thirsty planet and enables virtually any government with a coastline to solve its water scarcity problem simply and decisively.

Waste Water

Identified by the International Water Association as one of the greatest untapped opportunities for water-scarce developing countries, the treatment and re-use of effluent or waste water presents many possibilities to reduce the fresh water requirement of various water-use sectors, particularly agriculture and industry.

In Israel, the re-use of sewage effluents forms an integrated part of the country's demand management strategy, which ensures the best use of water in all its guises and that water is fit for its intended use. Stringent regulations are in place to ensure the quality of water from sewage treatment plants in order to maximize the re-use potential of waste water as well as to minimize health and environmental risks. **This allows for treated waste water to be exchanged for freshwater allocations, mainly for irrigation purposes. Selling treated waste water to farmers also enables Israeli municipalities to generate income, helping to offset the cost of essential water treatment facilities.**

Locally, improving sanitation and the effectiveness of water treatment facilities also has the potential to deliver significant benefits. Not only will it improve the quality of life and afford dignity to millions of people in poor communities, but UN statistics show that every dollar spent on water and sanitation delivers a five-fold return, mainly through diminished health costs and increased productivity. **The introduction of sustainable sanitation projects is being pioneered in developing countries such as India and Kenya where the concept of container based sanitation (CBS) is being trialled as an alternative to piped sanitation for poor communities.**
Uniquely suited to the challenges of dense urban populations, it offers the privacy, security and convenience of having a safely-managed toilet in your own home at a price that's affordable.

There is also considerable potential for recycled water to be put to a variety of industrial uses including for cooling towers, boiler feeds and process water. **By employing water reclamation technology, companies can reduce their reliance on municipal fresh water supplies which has not only water saving and environmental benefits but can lead to significant cost savings as well.**

Loss Reduction

A 2015 article in the UK Guardian newspaper estimates that 46 billion litres of drinking water is lost globally every day. Water loss is often referred to as non-revenue water (NRW) – water that is produced in a network but never reaches the consumer. This might be due to aging networks which have leaks or haven't been properly managed, metering inaccuracies, theft or unmetered authorised consumption such as from a fire hydrant.

According to a 2017 GreenCape market intelligence report, **37% of South Africa's water supply is lost through leaks and the United Nations estimates that losses of up to 50% of water in urban distribution systems is not uncommon.** Unsurprisingly technology to prevent, detect and repair leaks is now a multi-million dollar global industry.

This includes technology that uses advanced electronic controllers to optimize water pressure in a water network, significantly reducing leaks and preventing new bursts while still allowing water providers to maintain the required service levels. Another system uses existing satellite images to pin-point water leaks and other providers offer multi-layer monitoring using micro sensors to detect leaks across an entire water network.

Foremost among the implementers of this chiefly home-grown technology is Hagihon, the public company that runs Jerusalem's state-of-the-art water system. Every day, sensors in the pipelines, powered by little hydroelectric pinwheels, record the sounds of rushing water in 10-second increments. They transmit them, via the cellular network, to a central computer that analyzes the sounds and crunches the data, using differences in sound to detect leaks. In other parts of Jerusalem's water network, GPS-guided robots crawl through sewers looking for leaks. By employing specific cutting-edge technology, Hagihon has the ability to track down small leaks in their infrastructure and get them fixed well before they ever become big ones, significantly reducing water loss.

Opportunites

Data & Dashboards

Around the world, the water industry is facing challenges on an unprecedented scale. Water supplies are increasingly more volatile, water infrastructure is increasingly failing, and conservation - both mandatory and voluntary - is driving revenue down. In fact, **reports indicate that up to 30% of water utilities are seeing their year-on-year revenues fall for a variety of reasons.** In addition, in our increasingly Internet of Things (IoT) - driven world, customers are demanding more information, simpler engagement and greater transparency from their service providers. For utilities whose business models haven't changed much over the decades, and whose revenues are on the decline, this shift is bringing with it significant challenges.

The answer, according to online water publication Water World, lies in leveraging integrated data systems to build a smart grid for water. This smart grid would bring data, analytics and insight together so that utilities and municipalities can better understand how, where and when water is used while at the same time optimising their business operations. **A smart grid for water would also tackle issues in three key areas: metering, billing efficiency and customer centricity.**

Metering

A typical water utility collects customers' meter data on a monthly basis. This relatively infrequent collection of data makes it difficult for utilities to efficiently monitor their meter population and quickly identify faulty units or address anomalies. With no reliable real-time performance metrics available, meters may begin malfunctioning or leaks may go undetected resulting in both water and revenue being lost.

However, with the advent of two-way smart water meters that form part of an advanced metering infrastructure (AMI) network, this picture is rapidly changing.
Led by the US and Europe, expectations are that the market for smart meters will be worth $1.1 billion in 2019 and that by 2020, smart devices will make up 29 percent of instruments recording total revenue for water meters in the US, compared to 18 percent last year.
In addition, removing the human element from meter reading produces greater data accuracy than the traditional basic one-way meters.

Given their two-way nature, smart meters can also be used to gather other data which can be fed into smart water network applications. **Analytics using big data from multiple sources can protect municipal revenue by identifying faulty meters in real time, identifying meters that are missing from a utility's billing system and predicting imminent meter failure.** This continuous two-way meter monitoring enables utilities to wring every last drop out of their supply, infrastructure and revenue.

In South Africa, while the official estimate of water loss in the network is 37%, a recent report commissioned by the Water Research Council **warns that this figure could be closer to 50% due to a massive volume of unpaid bills as well as a complete lack of meters in informal settlements and many RDP houses.** As a result, many municipalities do not know how much water they are using. Hence, metering, billing and cost recovery continue to present major challenges to local municipalities.

Billing

The majority of utilities around the world still log meter data manually. Combined with other inefficiencies in billing, collections, remittance management and customer service, the typical water utility spends more than 10 times that of other industries (like telecommunications) to manage the bill-payment process. For cash-strapped water utilities and municipalities, minimizing the costs associated with billing and collections is an imperative while maximizing the ability for customers to self-serve can also result in immediate benefits.

Cloud-based software-as-a-service (SaaS) platforms offer the opportunity to meet these needs at reduced cost and reduced risk. Without hardware installation and often without cumbersome IT integrations, **SaaS systems offer a relatively low cost back office and data management system that modernizes and standardizes processes while improving the user experience.** In addition to streamlining operations, moving to a cloud-based platform also enables utilities to offer their customers significantly enhanced services and notifications.

Efficiency and Customer Centricity

As our planet experiences increasing water scarcity, future water utilities and their customers will need to work together in order to protect and proactively manage this scarce resource and to make better decisions.

Modern water utilities are faced with masses of data from various sources including: supervisory control and data acquisition (SCADA) systems, flow statistics, online monitoring, dissolved oxygen (DO) measurements and air flows, as well as data from laboratory information management systems (LIMS) and computerized maintenance management systems (CMMS). All of this data is beneficial and much of it has been around for years but the data is often gathered in a highly fragmented way and one computer system may not talk to another.
The internet has driven the ability to funnel disparate data into a single, meaningful pool and to use analytics to look for patterns that make this information understandable and useful. Big Data analytics are therefore key to optimising operations and increasing efficiency on the supply side of the water equation.

On the other side of the water equation, providing consumers with access to water usage data has never been more important. With the tools of a smart grid for water, customers can be given access to an intuitive online platform that allows them to connect their daily activities with consumption metrics. **By providing customers with highly granular, near real-time data, along with push notifications based on usage and costs, customers can be empowered making them better informed participants in the conservation conversation.**

Improved communication and interactivity will also go some way towards bridging the trust gap between municipalities and their customers while promoting sustainable use of our most precious natural resource.

Opportunites

Education & Collaboration

For any community, effectively addressing the issues around water management requires an approach that looks not only at increasing supply and reducing demand, but in managing the deficit. While innovation and new technologies can be successfully employed to increase supply, unless all water users understand the issues and the role they play in conserving our finite resources, the provision of water becomes little more than a race between supply and demand most likely at the expense of the environment.

In a March 2017 article published in Business Day, University of Cape Town (UCT) environmental and geographical science lecturer, Kevin Winter, explained that in light of Cape Town's water crisis, **supplying more water and containing demand would not be enough and that by 2019 Cape Town is likely to run out of water.** That is, unless the citizens of the mother city are able to take the next step and adapt to water scarcity as a new norm and to become active participants to ensure that water is used sustainably.

The City of Cape Town has dealt with dwindling water supplies by implementing a water-demand management programme that includes increasing block tariffs, fixing leaks, reducing pressure and educating consumers. The programme has achieved impressive results and despite a rising population, urbanisation and increasing demand, **the growth in water demand has been restricted to just 2% a year. But all of this is not enough.**

Winter argues that dealing with any water deficit begins with an integrated water management approach that recognises and internalises the belief that:
water is valuable; that there is no such thing as "waste water" or water to waste; and that a diversity of water sources is acceptable. This is where the challenge of education of citizens and collaboration between local government, private enterprise and ordinary citizens, lies.

Water Has Value

In general, expectations are that when we turn on a tap, good quality water will flow from it and that since water is required for life, it should be free or virtually so. This mindset however, is part of the problem since something that is free, or has only a nominal cost attached, is treated as having little or no value whereas something for which one has had to pay, inherently has more value and is treated with greater respect. This is a simple fact of human nature. The reality is that water doesn't come from a tap and it isn't free. A lot of money goes into getting water to our taps - from finding water sources, storing, pumping and treating it, ensuring its quality as well as maintaining the pipes and other infrastructure that delivers the water to us – this all costs money and it is high time that consumers are made aware of these costs.

In the early 2000s, the Israeli Water Commission led an on-going and aggressive water conservation campaign over a number of years that delivered excellent results and consumer usage decreased by 8%. Then in 2008, the government passed a new law requiring the whole water system to be revenue-neutral. This meant that the entire cost would be covered by consumers. Suddenly consumers were paying more for water and everyone knew exactly what water was costing. **Israelis, faced with higher water bills quickly found ways to reduce their usage by 16% in the following year - double the water savings that had been achieved in more than five years through education alone.** As it turns out, while education had delivered results, it was pricing that was most effective in changing habits and delivering real water savings.

Israel is the only country in the world with anything resembling real pricing for water use. **It has a two tier system of prices that firstly allows for cost recovery and secondly reflects the "scarcity" cost of water, however it also sets a 'human right' price for some water but charges more for use in excess of 98 liters per person per day.** Although slow on the uptake, many other countries are reviewing their water pricing policies and Singapore has this year introduced new water pricing that will significantly increase the cost of water in order to register the strategic and scarcity value of water with its citizens.

No such thing as ‘Waste Water’

By definition, waste water, is any water that has been adversely affected in quality by anthropogenic influence. Waste water can originate from a combination of domestic, industrial, commercial or agricultural activities, surface runoff or storm water, and from sewer inflow or infiltration. But, in a water scarce world, water in any form is precious and worthy of preservation. With this mindset, many ways can be found and many technologies exist to reclaim, recycle, and re-use water that has previously been used for another purpose. Educating and partnering with consumers, particularly those in the domestic and industrial sectors can help to change behaviours that will not only reserve fresh water for drinking, food preparation and bathing, but will also significantly reduce pollution levels by helping people to understand the water cycle and make them more aware of the impact of their actions on the environment.

As technology improves, scientists are able to detect more pollutants, and at smaller concentrations, in our freshwater bodies. As a result, we now know that our planet’s lakes, rivers, streams and groundwater are often a chemical cocktail containing traces of contaminants ranging from birth control pills and sunscreen to pesticides, petroleum and other toxic waste. **National Geographic estimates that more than half of the world’s rivers are suffering from serious pollution issues and our lakes are in even worse condition** making now the very best time to drive home the message that whatever goes down the drain, is flushed down the toilet or is pumped by industry into a tailing dam ends up in our freshwater systems and ultimately the ocean. In addition to improving treatment of previously used water, limiting the amount of domestic effluent that goes back into the environment is a sound ecological and water management practice. Promoting the use of ‘grey water’ from baths, showers and washing machines to flush toilets and water gardens as well as the installation of water efficient toilets and aerated taps and showerheads are easily implementable water conservation initiatives. **Some cities are even promoting “green” infrastructure, such as green roofs and rain gardens, as a way to naturally filter out pollutants and to stop polluted water from reaching fresh water supplies while at the same time greening and cooling densely populated urban areas.**

While there is no shortage of technology, ideas and initiatives, driving home and sustaining behavioural change is a very real challenge. **Experience all around the world shows that initiatives in various areas of conservation are most successful if the use of new technology or changed behaviour is incentivised.** This, together with legislation that allows for hefty penalties or fines for those that continue to treat our natural resources with contempt, is our best hope of achieving a sustainable future for water.

Acceptable Sources of Water

One of the keys to overcoming water scarcity, is adaptation, much like the way certain desert animals and plants have evolved to survive with very little water. Successful adaptation is achieved when consumers accept that sustainable water use is imperative and that water comes from various sources, including re-use and recycling, that make it fit for particular purposes.

Although Namibia has been reclaiming sewage water for use as drinking water for 50 years, the so-called ‘yuk’ factor has made the use of recycled water an unpalatable option for drinking water in many parts of the world. As the water crisis deepens, we will all ultimately be required to adapt and to accept all sources of water as acceptable. In the meanwhile, there are many ways to put reclaimed water to good use, such as for irrigation of farmland. Even here there may be resistance from certain agricultural or consumer groups making it necessary to work collaboratively with all stakeholders to allay fears, to build trust and to bring about changes in attitude and behaviour.

Israel may have overcome its water scarcity issues and what it has accomplished is nothing short of miraculous, but it doesn’t have a one-stop-shop magic solution to every water related issue. What it does have is holistic water management policies driven by necessity, designed over decades and internalised by its population. What Israel has given the world is a blueprint for what can be achieved by tackling the issue head on and taking a multi pronged approach. **In Israel this included centralising control of all water resources, launching an intensive water conservation campaign, improving water use efficiency and incentivising technological development and innovation.**

Through its various initiatives, the Israeli government has made water conservation a national priority to the extent that it has become an intrinsic part of Israeli culture. Taught in primary schools and reinforced at every possible touch point, water conservation in Israel is everyone’s problem and everyone knows how they contribute to ensuring the future viability of their arid homeland.

But, it is human nature to become fatigued and complacent, so the Jewish National Fund (JNF) launched a rainwater harvesting initiative in schools across the country. Through this initiative launched in 2013, students in schools across Israel began collecting the rainwater that falls onto their school buildings, harvesting and reclaiming it in tanks right in the schoolyard and learning the ins and outs of water conservation in a completely hands-on way.

The objective of this education is not only to teach children about the global water crisis and about water conservation in their own country, but to turn them into ‘water warriors’ who can go home to their parents knowing how to use a water meter and able to point out ways that their parents may be wasting water. **The idea is to make conservation solutions so simple that children see it as a solution that they can own and influence in their homes, schools and communities. Israel’s future water security will not be in the hands of government, nor in the hands of municipalities, but in the hands of its children who have grown up understanding the true value of water.**

The Future and Beyond

In the face of dwindling water resources and increased demand, our children and almost certainly our grandchildren will inherit a water scarce planet. As communities around the world are forced to come to terms with scarcity as the new normal, the way humans use water in the future will look very different from today's practices. **The current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100, according to a United Nations Department of Economic and Social Affairs (UN DESA) report.** According to this report, most of the projected increase in the world's population can be attributed to a short list of high-fertility countries, mainly in Africa, or countries with already large populations. Over the period from 2015-2050, half of the world's population growth is expected to be concentrated in nine countries: **India, Nigeria, Pakistan, Democratic Republic of the Congo, Ethiopia, United Republic of Tanzania, United States of America (USA), Indonesia and Uganda, listed according to the size of their contribution to the total growth.**

To meet the water demands that around 10 billion people will place on the earth's resources, water and food security in particular will require regional inter-governmental co-operation and an acknowledgement that the planet's water resources belong to everyone. Governments around the world will be accountable not only to their own constituents but to the global community for their environmental and water use practices in the knowledge that what happens in one part of the world in terms of green house gas emissions, environmental pollution or water usage, will inevitably have repercussions that affect all the earth's inhabitants.

Developing countries in already water-scarce regions will be forced to prioritise the delivery of water and sanitation services to all sectors of their populations. With five of the nine largest contributors to population growth coming from Africa, finding comprehensive solutions to these issues in an African context will be imperative for the health and well-being of both citizens and the environment at large. In order to improve the living standards of millions of the planet's poorest people as well as to protect fresh water supplies from increased faecal contamination, the provision of safe, cost effective and sustainable sanitation will enjoy priority. **This is particularly the case in Africa where several of the African countries that are expected to contribute most to population growth over the next few decades, are also those where open defecation is a widespread practice given the lack of available sanitation services.** Container Based Sanitation or other similar models will be implemented through licensed utilities and will cover the entire sanitation service chain by incorporating a social marketing concept, technical concepts for infrastructure, emptying and transportation as well as business and financing models, making this a true collaboration between the public and private sectors to service community needs.

Putting a more appropriate price on water in acknowledgement of the strategic and scarcity value of this essential commodity will also play a key role in achieving global sustainable water use. Finding pricing models that fit, will allow governments to take local conditions into consideration while addressing both supply and demand issues as well as balancing the competing demands of various water use sectors. **Using pricing to curb demand for fresh water as well as to make recycled water more attractive to bulk users will allow governments to generate revenue from various water use sectors in order to fund the development of new infrastructure and technology to augment water supply.**

Water is also likely to be used and re-used several times over. Fresh water resources in the form of rivers, lakes, streams, wetlands and ground water will be treated as national treasures and will be guarded from pollution of all kinds. These sources, in conjunction with the extensive use of desalination of sea water, are likely to be the major provider of fresh water that will be reserved exclusively for drinking, food preparation and bathing. Water for other uses including for agriculture and industry, will be drawn from treated, previously used water.

In addition to using recycled water, agricultural users will implement more effective irrigation practices and will plant crops that are most appropriate to the local environment. This will avoid over use of water to grow thirsty crops in water scarce areas, as well as reducing the likelihood of creating dry land salinity and contamination of water sources from saline run-off. In urban environments, greater use will also be made of grey water, harvested rainwater as well green roofs and rain gardens, all of which will use water of appropriate quality to cool and green our environment, to cultivate urban food gardens and to sustain life.

While smart cities around the world are already embracing the need to move away from traditional methods of providing power, lighting and other utilities in favour of more environmentally friendly options, there is a limit to how much of the latest technology can be retro-fitted into existing urban environments. However, as new man-made cities are created in various parts of the world, there will be an opportunity to harness this technology. Its uses will enable the design and construction of buildings that use environmentally sound materials for better insulation, make better use of natural heating and cooling and are compatible with a host of smart technologies. **In this way, our reliance on rainfall for water, on burning of fossil fuels for energy and on petroleum for powering our modes of transport, will be dramatically reduced, resulting in a future that is cleaner and greener and more able to sustain its billions of inhabitants.**

Conclusion

If every political decision-maker and major consumer on earth internalized the fact that usable water is a limited, quantifiable resource rather than just a gift from the heavens, the revolution would take hold.

As this white paper illustrates, water is largest mass flux into and out of our cities; more than food, freight, people, or anything else. **Water management, therefore, is a global challenge that requires understanding and input from both the private and public sector. Lack of water infrastructures or obsolete infrastructures, solid waste management and climate adaptation are key areas that need to be addressed.**

Cities of the future will need to use a myriad of new technologies to monitor and maintain their water and waste water infrastructure, to ensure the quality of water in their distribution network and to find and repair water leaks to limit water loss. Smart metering, improved billing and municipal collection will allow water usage to be tracked and charged, for anomalies to be brought to light and for excessive use to be dealt with by way of fines or other punitive measures. Improved municipal metering and billing practices will increase municipal revenue as well as providing transparency, allowing consumers to be more aware of their water usage as well as their role in water conservation. By leveraging the Internet of Things, municipalities will transform their water systems into open communications systems enabling them to improve the service they offer their customers and increase the connectivity of all city services.

Through a combined and collective effort towards the implementation of innovative approaches and smart technology, as well as sustained behavioural changes, we believe that the water and sanitation needs of every sector can be achieved.

As a leading consulting firm in the field of engineering, revenue optimization and IT, **Boffin and Fundi is committed to making progress within communities throughout South Africa specifically with regards to addressing the challenges surrounding water and sanitation.**

When understood and implemented correctly, **Boffin and Fundi believe that this paper outlines recommendations and trends that can help set in motion the necessary instruments for developing and driving positive change and improving overall quality of life for all.**

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&FUNDI

SMART | INNOVATIVE | SOLUTIONS

Tebogo Nkosi
tebogo@bofn.co.za

1016 Jan Shoba Street, Brooklyn, Pretoria
Tel: (011) 318 4800 | Fax: (011) 318 0012
boffinfundi.co.za