



drivers of change water

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Thanks to

Mark Fletcher, Justin Abbott, Jennifer Laight,
David Hetherington, Tevon Strand-Brown, Felicitas zu Dohna,
Arup's Water Skills Network, all Arup workshop participants,
and all contributing photographers.



water

social

population growth

how much water will 9bn people need?

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Historically, the rate of global water consumption has doubled every 20yrs — which is double the rate of population growth. If population and consumption trajectories continue, 1.8bn people will be living in water scarce regions by 2025. —Population Institute (July 2010)

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population growth

The global population reached 7bn in 2011 and is projected to reach 9bn by 2050. Growth is driven by increasing life expectancy and a rise in the number of women surviving to reproductive age, particularly in developing Africa and Asia. Sub-Saharan Africa — which accounted for 10% of the world's population in 2000 — will host 17% of the world's population by 2050. By 2050, the population of every country in East-, Southeast-, South- and Central Asia (excl. Japan and Kazakhstan) will grow substantially, with numbers nearly doubling in Pakistan, Nepal, Bangladesh, Afghanistan, Cambodia, and Laos.

As populations expand, demand for water will increase dramatically. This will be driven primarily by a growing demand for food — which is expected to increase by 70% by 2050 — and associated agricultural water use, expected to increase by at least 19% by 2050. A growth in overall consumption will lead to more water use in the manufacturing and production sectors. Consumer spending in India, for example, is expected to expand from US\$991bn in 2010 to US\$3.6tr by 2020.

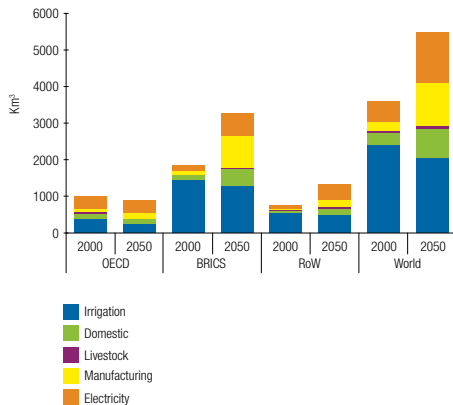


Fig 1: Global water demand: Baseline scenario 2000 and 2050
[OECD, 2012]

urbanisation

is your city too thirsty?



Brazil is 'blessed' with 1/8 of the world's freshwater, but its natural disaster monitoring service estimates that Sao Paulo's main reservoir could run dry within the next year. The water utility has already lowered pressure in the system to reduce flow. — New York Times Online (16 February 2015)

urbanisation

The percentage of the global population living in urban areas is expected to reach 66% by 2050. A review of the world's developing regions reveals that Africa and Asia are the two regions suffering most from lack of urban water supply and sanitation. Major concerns include over-exploitation and pollution of water sources. According to The Times of India, 22 out of 32 major Indian cities deal with daily water shortages. This is driven by a steady increase in demand, inefficiencies in transfer and use, and persistent water pollution. Inadequate infrastructure — such as lack of wastewater treatment and drainage facilities — can lead to pollution of ground- and surface water supplies.

In addition to a shortage of reliable water supplies, the street surfaces of many cities continue to be highly impermeable to water. As a consequence, stormwater management has become a high priority to prevent floods and sewer overflows. Investment in green infrastructure — such as bioswales which use vegetation at street level and subterranean storage to soak up storm water — is leading to more sustainable forms of urban water management.

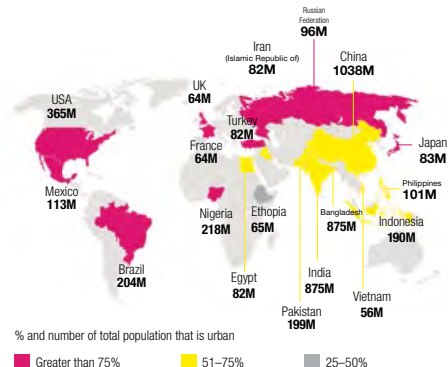


Fig 1: Urban population 2050
[UNICEF, 2012]

Urban Agglomeration	Country	Population
Tokyo	Japan	36,933,000
Delhi	India	21,935,000
Mexico City	Mexico	20,142,000
Shanghai	China	19,554,000

Fig 1.1: Largest cities under water stress
[Global Environmental Change, 2014]

water access

how far should you walk to get water?



82% of those who lack access to improved water live in rural areas, while just 18% live in urban areas. —World Health Organization and UNICEF Joint Monitoring Programme (2014)

water access

The World Health Organization defines reasonable water access as the availability of at least 20 litres of water per person per day from a source within 1km of the user's dwelling. From 1990 to 2012, an additional 2.3bn people received access to an improved drinking water source, such as piped water or protected wells. This represents a global coverage of 89% of the world's population with access to clean drinking water in 2012. Despite this improvement, 748M people globally still have no access to clean, safe water. These people continue to rely on unimproved drinking water sources, and almost a quarter (173M people) still rely on direct use of surface water.

Furthermore, despite lower per-capita water consumption in the developing world (31 litres/person/day in African countries vs 307 litres/person/day in developed countries), achieving universal access will be difficult. The population in developing regions is expected to increase and middle-class consumption will rise, while at the same time usable supply may diminish due to over-extraction, pollution, and climate change. This could reverse previous global gains towards improved freshwater access for all.

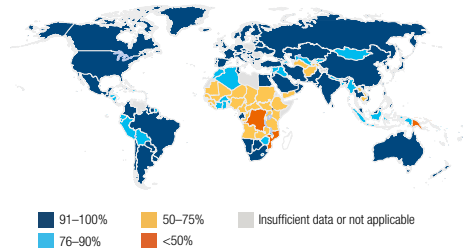


Fig 1: Proportion of the population using improved drinking water sources in 2012
[WHO and UNICEF, 2012]

water

social

sanitation and hygiene

did you wash your hands?



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Of the approximately 7bn people in the world today, almost 6bn have access to a mobile phone, while only 4.5bn have access to working toilets.
—TIME Magazine Online (25 March 2013)

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sanitation and hygiene

Water is critical to staying clean and healthy. Yet, according to international charity WaterAid, about 2.5bn of the world's population lack adequate sanitation facilities, and 1.1bn still practice open defecation. More than 3.4M people die annually from water, sanitation and hygiene-related causes (99% of which occur in the developing world).

It is estimated that nearly 10% of the global disease burden could be reduced through improved water supply, sanitation, hygiene, and water resource management. Good hygiene behaviour can combat the ill effects of diseases that are caused by poor personal hygiene and skin or eye contact with contaminated water. SuperAmma, a successful handwashing campaign in rural India, used emotional motivators (instead of health messaging) to improve hand-washing behaviours. Six months after the campaign, washing hands with soap in programme-targeted areas had increased by 31% compared with areas without the programme. Organisations such as UNICEF often combine improved sanitation facilities with hygiene education at schools.

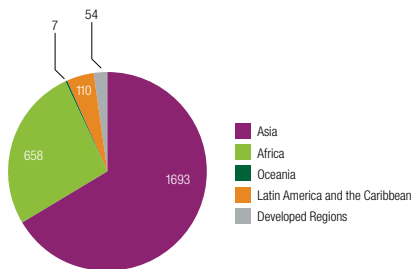
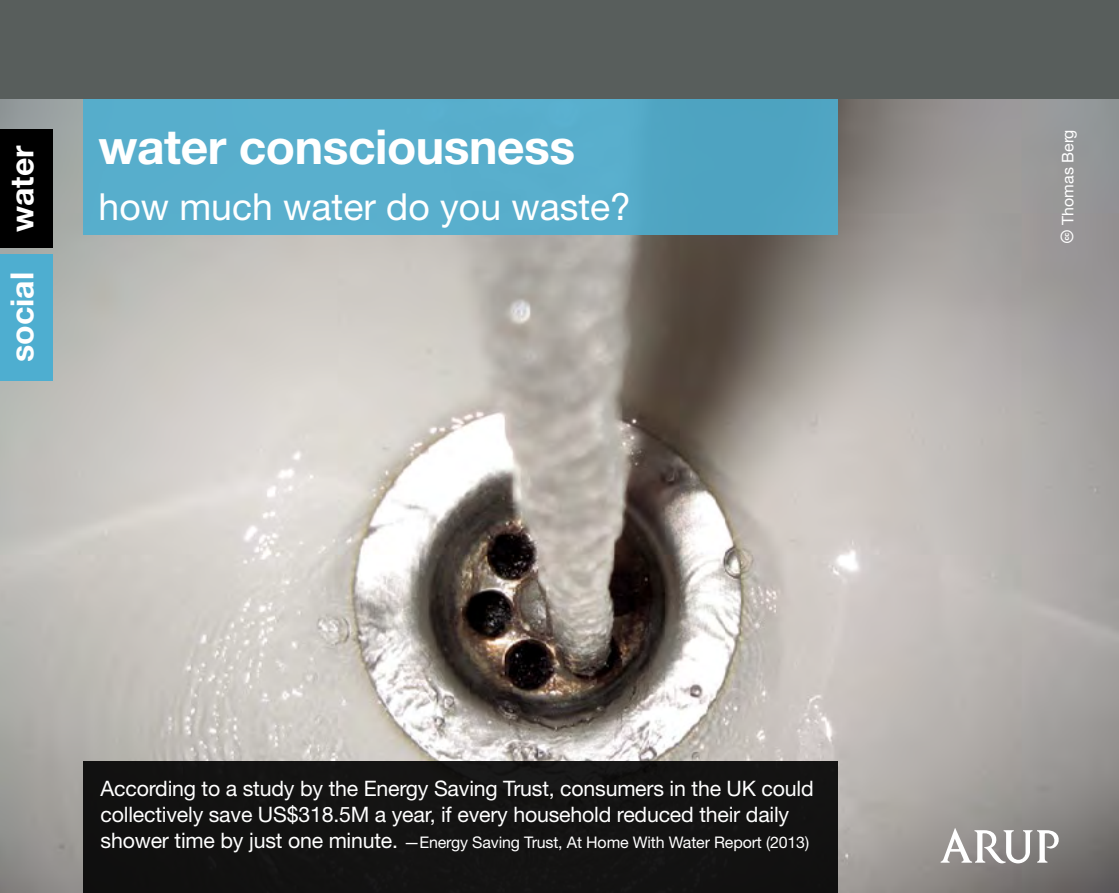


Fig 1: Number of people (in millions) without access to an improved sanitation facility in 2012
[WHO and UNICEF, 2012]

water consciousness

how much water do you waste?



According to a study by the Energy Saving Trust, consumers in the UK could collectively save US\$318.5M a year, if every household reduced their daily shower time by just one minute. —Energy Saving Trust, At Home With Water Report (2013)

water consciousness

In 2012 Americans consumed 1053bn m³ of water whereas China and India consumed 1207bn m³ and 1182bn m³ respectively. Fuelled by population growth and a rise in middle- and upper-class consumption, developing countries will also see increasing pressure on their static (or even shrinking) water supplies.

Growing water scarcity increases the need for more efficient water consumption. This starts with consciousness at the individual and community level. World Water Day spread the word about water conservation to more than 700M people in 2014 alone. Water use efficiency can be achieved through better education, behaviour change and technical efficiency. For example, the average American family could save 60,000 litres a year by installing low-flow toilets, or save 1.3M litres a year by not eating beef. Some corporations are helping to elevate consciousness regarding water use as well; Unilever, for example, has pledged to halve the water associated with using their products by 2020.

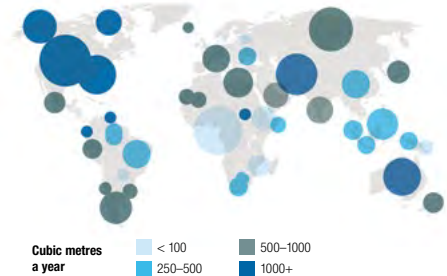


Fig 1: Annual water withdrawals per person by country
[Seametrics, 2012]

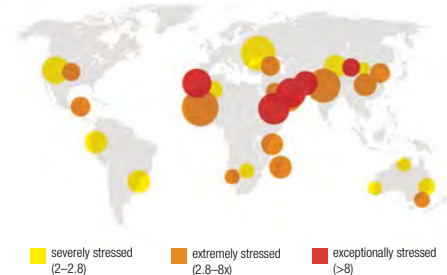


Fig 1.2: Impact of water withdrawal by 2020
[Seametrics, 2012]

water

technological

novel water sources

are there untapped sources of freshwater?

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According to an article by Peter Brabeck-Letmathe, former CEO of Nestlé, growth in global desalination between 2010-2030 could cover as much as 5% of the estimated gap between freshwater withdrawals and sustainable supply. —Nestlé, Water Challenge Blog (19 February 2014)

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novel water sources

Desalination enables the conversion of salt water to fresh water. Between 2001 and 2011, industrial desalination capacity expanded by 276%. As of 2013, there were 17,277 commissioned desalination plants in the world with a total capacity of 80.9M m³/day. Countries leading the way in capacity are Saudi Arabia, UAE, Spain, Kuwait and Algeria. In Israel, nearly 25% of the water supply comes from desalination. The practice is highly energy intensive, but as salt water is seen as a limitless resource — and with many urban centres facing water shortfalls located on coastlines — the technology continues to gain traction.

In areas of Chile and Peru with limited rainfall and water infrastructure, fog-harvesting technology is being developed and adopted. A team at the Massachusetts Institute of Technology (MIT) developed a mesh fog net in 2013 which can capture 12l/m². In cities, the creation of blue roofs and the building of integrated water capture systems are resulting in the use of under-utilised physical assets for water creation. Hundreds of schools across Israel, for example, collect enough rainwater during the rainy season to meet 1/3 of their water demands for the entire year.

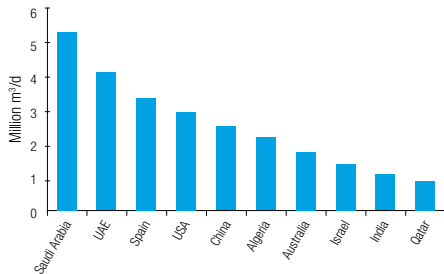


Fig 1: Top ten countries by total installed desalination capacity since 2003
[DesalData, 2012]

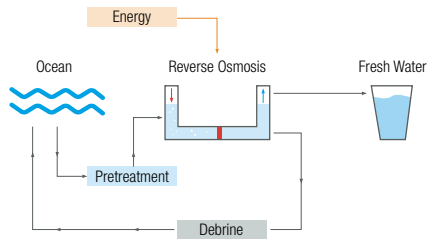


Fig 2: Reverse osmosis method of desalination
[New Sky 24, 2015]

smart infrastructure

how smart is your water network?

© PSNH

water

technological

Recent research estimates that the smart water meter business was worth US\$575m at the end of 2013, and will increase in value to US\$1.1bn in 2019. — IHS Global Analytics (10 October 2014)

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smart infrastructure

In 2013, the average American city lost 30% of its water through leaks or unbilled usage. In New Delhi, India, losses are estimated to be closer to 53%, and for many developing nations around 38%. New smart systems aim to improve the efficiency and function of water infrastructure through increased automation, distributed sensor networks and geo-spatial information systems (GIS). These help to observe, understand and manage water systems in real-time, improving system efficiency. In Singapore, 130 network sensors take readings every millisecond and feed the data back to a central server. Leakage and flow is monitored and controlled remotely, giving unparalleled insight into the system and radically reducing leakage. Sensors measure pH, temperature, electrical conductivity and other properties useful to ensure water quality and safety.

Though criticised for its high up-front cost, smart infrastructure helps operators optimise capital allocation, improving system-wide assessment, maintenance and replacement practices. Smart technologies can also help the end-user monitor and reduce water usage by providing data-driven feedback loops and smart metering. The East Bay Municipal Utility in California, US, for example, reduced residential water usage by 5% after the installation of smart meters.

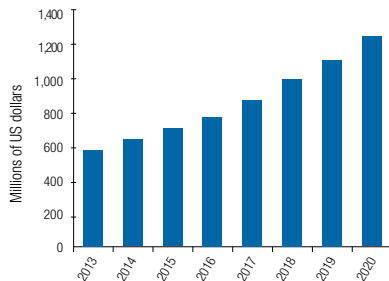


Fig 1: Global revenue forecast for smart water meters
[IHS Technology, 2014]

water

technological

waterless design

can our systems function without water?



Between 2013 and 2014, Toyota North America reduced its freshwater usage by 16.6M gallons (63M litres) at the South Paint Shop of its TMMC facility. —Toyota Environment Report (2014)

waterless design

From cars to computers, soap to soft drinks, most products require water at some stage in their manufacture and distribution. One pair of jeans, for instance, requires about 12,000 litres of water for growing, dyeing and washing the required cotton, even before the product reaches the consumer. The manufacture of one ton of steel can require up to 340,000 litres. Assembling the average smartphone requires 1,000 litres; as of 2013 there were more than 1.4bn smartphones produced globally. On the whole, industry accounts for roughly 20% of the total freshwater withdrawals across the globe.

Increasingly, though, companies are looking to minimise water use in their design and production processes to limit their dependency and exposure to water-based financial risks. In 2013, Kia Motors' total water consumption at the Hwasung, Sohari and Gwangju plants decreased by 305M litres from the previous year (down 30% since 2003). Similarly, Cascade Tissue Group, based in Canada, employs a range of state-of-the-art water reuse technologies, enabling the company to use one-fifth of the industry average. This approach saves 2.6bn gallons annually, reducing the company's operating costs by US\$20M.

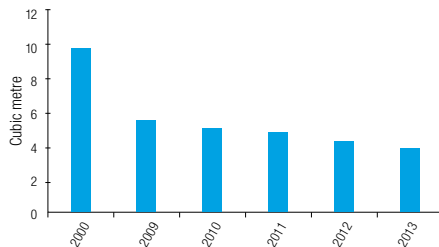
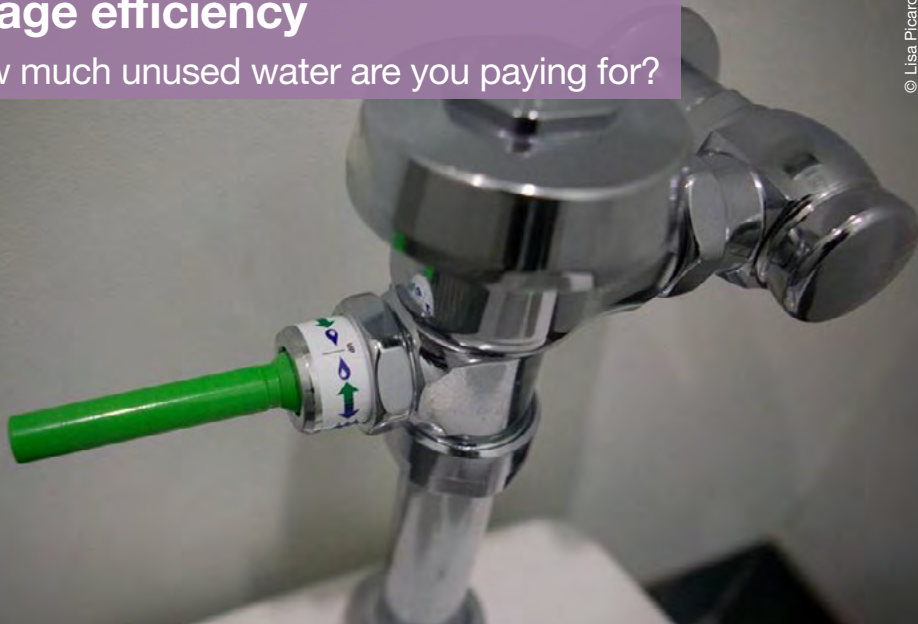


Fig 1: Ford's global water use per vehicle produced
[Ford, 2014]

usage efficiency

how much unused water are you paying for?



A standard western toilet has historically used up to 30 litres of water per flush, whereas a high-efficiency toilet can use as little as 4 litres, or 86% less water, per flush. —Southern Nevada Water Authority (2015)

usage efficiency

In Hyderabad, India, up to 40% of the water in the city is wasted every day. In many countries, 17% is seen as the “admissible rate of water loss” and system inefficiency. According to a 2014 UN Water report, if efficiency does not improve, worldwide water demand will outstrip supply by 40% by 2030. Increasing water usage efficiency is critical to effectively managing water supplies.

Weather-based irrigation controllers (WBICs) can automatically adjust water volume and timing in response to changing weather conditions. Residential users can save an estimated 60,000 litres of water per year using this technology. At agricultural scale, researchers at the University of Georgia have developed a GPS-based system which enables farmers to accurately target irrigation through geo-spatial data and sensor networks, thus reducing water consumption by as much as 15%. At the urban scale, IBM and Veolia have announced a strategic partnership to use software and analytics for the integration, analysis and optimisation of all data related to water use in municipalities.

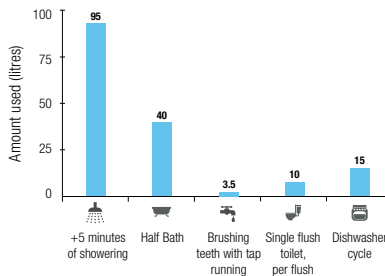


Fig 1: Average water used for daily activities
[Anglian Water, 2014]

water

technological

water reuse and recycling

do you drink recycled water?



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After a successful 3-year trial, the government of Perth, Australia, is scaling up a water recycling program to supply 7bn litres of water per year. In the coming decades, it will be able to supply 20% of Perth's drinking water.

—Government of Western Australia (1 August 2013).

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water reuse and recycling

New filtration, recycling and treatment technologies will continue to increase the amount of wastewater available for both industrial processes and human consumption. Global markets for wastewater recycling and reuse technologies grew from US\$6.7bn in 2009 to US\$9.5bn in 2012 and are forecast to reach US\$23.4bn by 2017. Greywater recycling — collecting used water from sinks, showers and baths, and cleaning it for use in toilets, washing machines, and landscaping — has the potential to reduce freshwater usage by 50% at a building level.

NEWater is a high-grade, drinkable water produced by passing waste-water through membrane purification and UV disinfection. In 2014, Singapore met 30% of its total water needs through NEWater, with a target of expanding this to 55% by 2060. In January 2015, Bill Gates publicly drank a glass of water filtered at a local sewage facility. The sewage sludge had been converted to drinking water by the OmniProcessor, a technology that the Gates Foundation hopes will provide clean, safe water in the developing world. Reuse and recycling fall below avoidance and reduction in the hierarchy of water management strategies, but can help make the most of a limited supply.

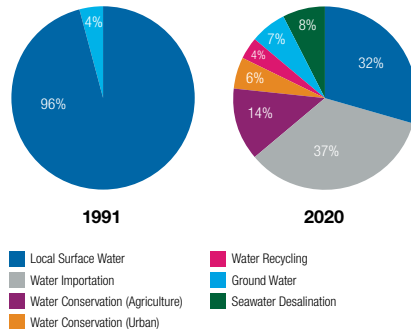


Fig 1: Trends in water supply sources, San Diego, CA
[San Diego County Water Authority, 2011]

ecosystem services

how much is your local ecosystem worth?

water

economic

A study on The Economics of Ecosystems and Biodiversity (TEEB) in Southeast Asia predicted that under business-as-usual circumstances, mangrove losses would account for roughly US\$2.2bn in foregone annual benefits by 2050. —UNEP et al (12 October 2013).

ecosystem services

Ecosystem Services are the human and economic benefits provided by natural ecosystems. The term was popularised by the Millennium Ecosystem Assessment in the UK, and typically covers four categories: Provisioning (eg producing potable water and food); regulating (eg controlling climatic conditions); supporting (eg crop pollination); and cultural (eg spiritual and recreational benefits).

Aquatic ecosystems provide immense value, from transportation, to recreation, to resilience, to stormwater management and water filtration. According to the UK's 2011 National Ecosystem Assessment, the benefits of inland wetlands for water quality were worth up to £1.5bn per year to the UK. In 2013 the New York City Department of Environmental Protection started a US\$2bn investment programme into green infrastructure — green spaces, bioswales, and more — using nature to help manage stormwater runoff. According to a 2014 Oxfam report, every dollar invested in wetland restoration returns US\$15 in net economic and social benefits, such as buffering storm surges, safeguarding coastal homes, creating nursery habitats for fish, and supporting recreation.

US\$4.3–20.2tn/yr

Global loss of ecosystem services due to land use change

US\$125tn/yr

The estimate for the total value of global ecosystem services in 2011

Fig 1: The value of ecosystem services

[Global Environmental Change, 2014]

energy supply

how much water is needed to run your power plant?

economic
water

India generates 19% of its energy from hydroelectric power plants. Due to a season of low rainfall in 2012, hydroelectric production fell 19% from the previous year. A resulting blackout that left nearly 670M people without power in the height of summer. —World Resources Institute (6 August 2012).

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energy supply

The UN has predicted that by 2030, adequately supporting the growing global population will require at least 40% more water and 50% more energy. Water is a critical input in the production and transmission of energy. In 2010, roughly 15% of the world's total water withdrawals were directed to energy generation, particularly for hydroelectric, nuclear, and thermal energy sources. A large nuclear power plant using once-through cooling technology can withdraw up to 4.5bn litres of water per day. According to a 2013 GlobalData report, installed hydropower capacity is expected to grow 32% from 1,064GW in 2012 to 1,407GW in 2020. Hydroelectricity, however, can have a significant impact on marine ecosystems, changing water temperatures, limiting downstream river flow, and disrupting wildlife migration.

In addition to power stations, increased use and production of biofuels has led to an incremental increase in demand for water, as many biofuel processes require highly water intensive agricultural feedstock. According to UN Water's 2012 World Water Development Report, a small increase in biofuel demand could elevate agricultural water demand by as much as 20% worldwide.

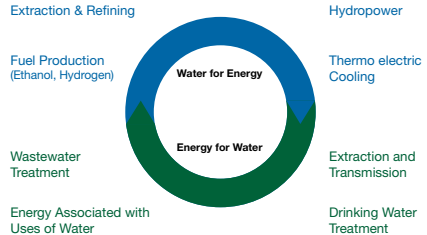


Fig 1: The water / energy cycle
[WUIM, 2012]

16

Gallons of water used to power a single 60-watt light bulb for 12 hours

25

Gallons of water needed to power a mobile device for an entire year

2030

The year energy use is projected to increase by 30% and demand for water by 40%

Fig 2: Water for energy
[GE, 2014]

ageing infrastructure

how old are the water pipes in your city?

water

economic

If the 10tn litres of treated water that leaks from US infrastructure each year ended up in New York City, a 298-foot deep flood would engulf Manhattan.
—Center for Neighborhood Technology, The Case for Fixing Leaks Report (2013)

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ageing infrastructure

A lot of developed countries require upgrades or replacement of failing critical assets such as treatment plants or distribution pipelines. This includes improving water asset management practices to make the most of existing and new investments. On a macro scale, the OECD estimates that by 2025, water infrastructure will be the largest recipient of infrastructure investment globally, with water spending in OECD and BRIC countries topping US\$1tn.

In the US, researchers estimate that 27bn litres of treated water are lost each day due to ageing and leaky pipes, broken water mains and faulty meters. That amounts to 540,000 individual breaks each year. The US Environmental Protection Agency estimates the minimum repair investment at US\$335bn for fresh water and US\$298bn for wastewater in the coming decades. Similarly, England and Wales invested US\$136bn between 1992 and 2012 to try to keep their water infrastructure up to standards, but according to the Institution of Civil Engineers, they will need to invest even more in the coming decade to reduce leakage and improve system efficiency to serve the needs of their population.

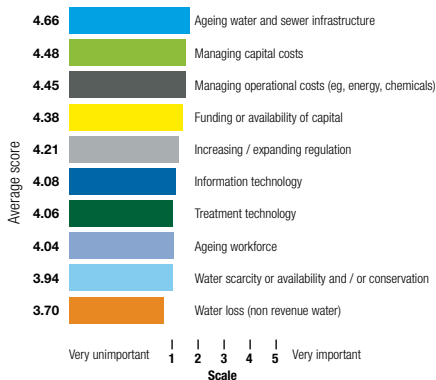


Fig 1: Top utilities industry issues for North America
[Black & Veatch, 2014]

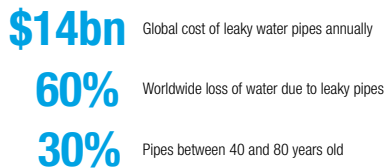


Fig 2: Ageing infrastructure
[The World Bank and Environmental Protection Agency, 2012]

virtual water

how much water is in a smartphone?

water

economic

It takes approximately 1,000 litres of water to produce one smartphone — including everything from mining metals to polishing the glass screens to making microchips. —Stephen Leahy, *Your Water Footprint: The Shocking Facts About How Much Water We Use to Make Everyday Products* (2014)

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virtual water

Virtual Water (also called Embedded or Embodied Water) characterises the 'unseen' water required to produce food and non-food services and products. About 65% of the water that most people consume is actually embedded in their food. For example, it takes nearly 10,000 litres of water to produce just 0.5kg of beef, or around 2,000 litres for 0.5kg of chicken. Most goods require water at some point in their production. A pair of blue jeans, for instance, requires up to 13,000 litres of water to produce. One computer chip requires roughly 45 litres of water to produce. And one pound of plastic can require up to 100 litres.

Water Footprinting is one approach to evaluating and communicating the total virtual water content of any product and service, enabling consumers and producers to better understand the quantity and geography of the water embedded in their products. The water footprint of Chinese consumption, for example, is about 1070m³ per year per capita, while in the US it is 2840m³ per year per capita.

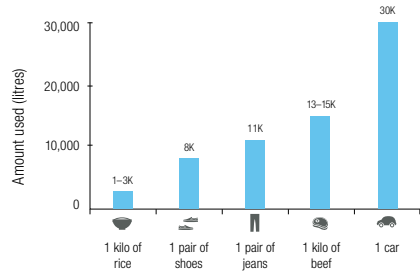


Fig 1: Water footprint
[World Water Forum, 2012]

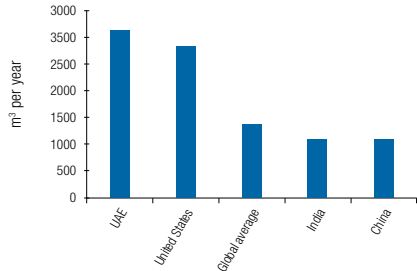


Fig 2: Water footprint of consumers by country
[Waterfootprint.org, 2014]

climate adaptation

is your city prepared for the impacts of climate change?

water

economic

In 2013, the Rockefeller Foundation pledged US\$100M to enable at least 100 cities around the world to hire resilience officers to improve response to climate change and other shocks. — Philanthropy News Digest, *Thirteen New Commitments Announced at 2013 Clinton Global Initiative Meeting* (2013)

climate adaptation

The UN estimates that between 2000-2013, direct losses from disasters globally were roughly US\$2.5tn. Climate change increases the frequency and intensity of extreme weather events. Responding to and preparing for extreme weather patterns incurs both economic and societal costs. The charity Oxfam recently reported that between 2009 and 2014, approximately \$490bn was spent on climate-related disasters on a global scale. A 2014 UNEP report on the state of climate change adaptation found that the global cost of adaptation is likely to be US\$250-500bn by 2050, two to three times higher than original estimates by the Intergovernmental Panel on Climate Change (IPCC).

Given that extreme weather events are likely to increase in both frequency and severity, many governments and municipalities are developing strategies to prepare for the future, both in terms of mitigation and adaptation. In the wake of Hurricane Sandy, the Mayor of New York City outlined a US\$20bn plan to protect the city from rising sea levels and powerful storm surges. Adaptation measures included building an extensive network of flood walls, levees and bulkheads along the cities shoreline. The City of Chicago is investing in permeable pavement and enlarging the size of its street tree wells to significantly increase stormwater absorption.

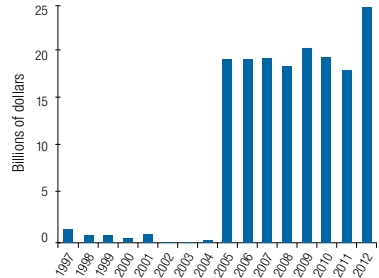


Fig 1: National flood insurance programme debt post Hurricane Katrina

[White House Federal Budget and Congressional Research Service, 2013]

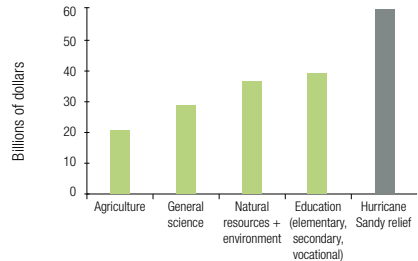


Fig 2: 48-hour hurricane relief vs 2012 Federal budgets

[White House Federal Budget and Congressional Research Service, 2013]

flood risk

what if a 100-year storm happened yearly?

© Global Water Partnership

water

environmental

2013 saw the highest recorded number of billion-dollar weather disasters in history. Out of the 261 weather-related disasters that year, 41 caused at least \$1bn in damage, with flooding causing a large portion of the losses.

—Brian Kahn, *Record Number of Billion-Dollar Disasters Globally in 2013*, Climate Central (2014)

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flood risk

According to a 2015 report by the World Resources Institute, the number of people affected by river flooding alone could triple between 2015-2030, affecting nearly 50M and costing the world economy roughly US\$500bn. The World Bank and OECD predict that global flood losses could rise from US\$6bn in 2005 to US\$1tn in 2050 in light of urbanisation, population growth, sea level rise and sinking land. The ten cities most vulnerable to flood events (as a percentage of GDP) are Guangzhou, China; New Orleans, US; Guayaquil, Ecuador; Ho Chi Minh City, Vietnam; Abidjan, Ivory Coast; Zhanjing; China; Mumbai, India; Khulna, Bangladesh; Palembang, Indonesia; and Shenzhen, China.

In most of Europe, flooding is the most common extreme weather event. In the coming years, winter floods are expected to increase, affecting an additional 1.6M people each year in the EU alone. Southeast Asia, however, is widely considered to be the most flood-prone region globally in terms of magnitude, frequency and severity.

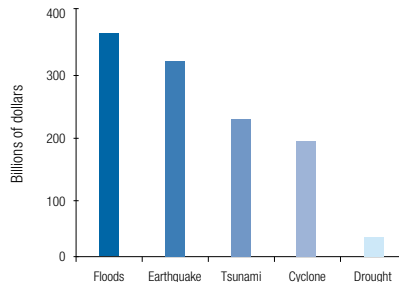


Fig 1: Cost of natural disasters

[Centre for Research on the Epidemiology of Disasters, 2013]

Most Vulnerable Cities to Natural Disasters

1 Guangzhou	6 Zhanjing
2 New Orleans	7 Mumbai
3 Guayaquil, Ecuador	8 Khulna, Bangladesh
4 Ho Chi Minh City	9 Palembang, Indonesia
5 Abidjan	10 Shenzhen

Fig 2: Most vulnerable cities based on GDP

[The World Bank, 2013]

persistent drought

what happens if the rains stop coming?

© Global Water Partnership

water

environmental

A protracted drought in Australia has had significant impacts on the country's economy. There are forecast falls of 8.2% in wheat production, 17% in canola production, and 11.4% in cotton production. —Sydney Morning Herald (4 March 2014).

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persistent drought

Precipitation in the form of rain is the main source of freshwater for humans and natural ecosystems. However, geographic and temporal rainfall patterns are shifting in unpredictable ways, in many cases leading to protracted droughts and shortages of freshwater. In India, there have been “statistically significant decreases in peak-season precipitation over the core monsoon region” causing significant shortages to regional water supplies, and affecting agricultural and economic production.

The US has recently experienced its most severe drought conditions in decades; at the peak of 2012, 81% of the US was under abnormally dry conditions, causing an estimated US\$30bn in damages. California experienced the worst regional drought in 1,200 years from 2012-2014, with devastating ecological and economic consequences for the region, specifically in the agricultural sector. As of July 2014, the drought was expected to cost the state US\$2.2bn for the year and result in the loss of 17,000 jobs.

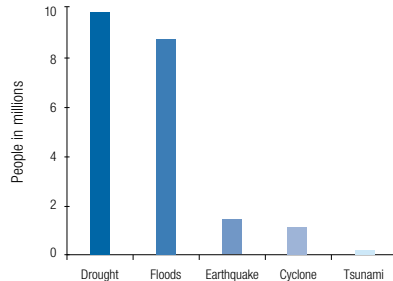


Fig 1: Fatalities from natural disasters in Asia, 1900-2013

[Centre for Research on the Epidemiology of Disasters, 2013]

groundwater depletion

when will your aquifer run dry?

environmental
water

As of July 2013, 18 major countries (containing approximately half the world's population) were over-pumping their aquifers, far beyond the replenishment rate. Among these are the three largest global grain producers - China, India and the US. —The Guardian (6 July 2013)

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groundwater depletion

Groundwater is water found below the earth's surface, typically in cracks and gaps in rock, sand and soil. According to the US National Groundwater Association, this water is the most extracted raw material in the world, with estimated withdrawal rates of about 982 km³/year. According to a 2012 UN Report, it is estimated that almost half the global population uses groundwater as the main source of their drinking water. Agriculture is by far the largest user of groundwater, accounting for 60% of the global usage.

Depletion of groundwater reserves can lead to long-term food and water insecurity and geo-structural instability. As of 2011, Bangladesh was extracting groundwater at a rate of 53bn cubic metres a year, despite a recharge rate of only 50bn cubic metres annually. This could prove problematic for sustaining major cities like Dhaka, where 97% of water demands are met by groundwater. In many coastal communities groundwater extraction is causing the ground and water to sink. In Japan, parts of Tokyo are reported to have sunk by up to two metres before groundwater abstraction in the city was banned.

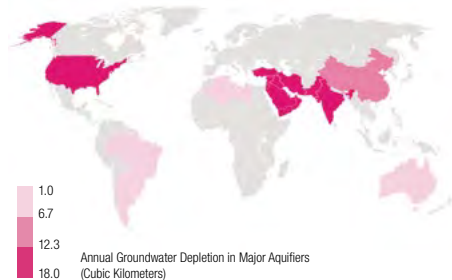


Fig 1: Groundwater depletion
[NASA GRACE and Quartz, 2014]

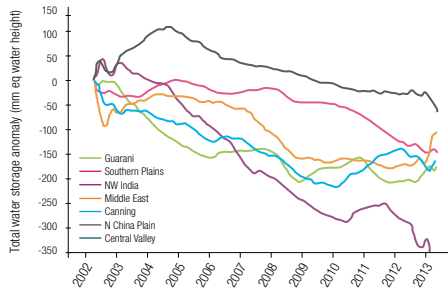


Fig 1: Declining storage in major global aquifers
[NASA GRACE and Quartz, 2014]

food production

should we all become vegetarians?

© AgriLife Today

water
environmental

Vegetables require 50,000 litres of water per ton to produce, and fruits need 175,000 litres per ton. Pork, on the other hand, consumes 550,000 litres of water per ton of meat produced and beef, about 660,000 litres per ton. —New York Times Online (7 March 2014)

ARUP

food production

The world population is predicted to grow to 8.3bn by 2030. By that time, food demand is predicted to increase by 60%. Roughly 70% of global freshwater is used by the agricultural sector, making it the largest consumer of freshwater by a significant margin. Primary uses are for irrigation and in the production of animal feed, fertilizer and pesticides. For example, as of 2013, nearly 1/3 of the world's water went to livestock production.

Concurrently, economic growth and globalisation are fueling a shift to diets containing more meat and dairy, both of which require more water to produce than traditional grain and vegetable diets. Producing half a kilo of beef, for example, requires nearly 10,000 litres of water, whereas producing one pound of wheat requires only 800 litres. To complicate matters, industrial agriculture required to produce enough food has, in many cases, led to irrigation salinisation, a condition resulting from excessive watering wherein a rising water table brings increased salt to the surface. If salt concentrations in soils reach 0.5-1.0%, the land becomes toxic to plant life.

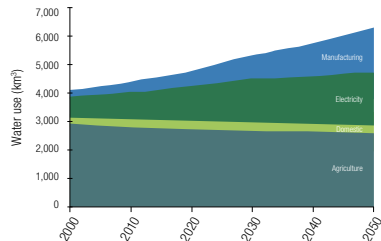


Fig 1: World water use by sector
[OECD Environmental Outlook Baseline, 2007]

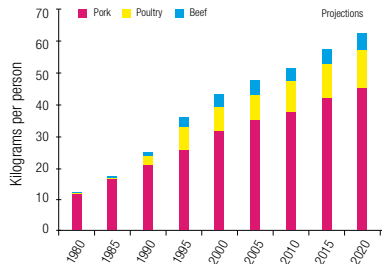


Fig 1: Meat consumption in China
[USDA, 2014]

ecosystem pollution

are you poisoning your own well?

© Gustavo Verissimo

water

environmental

According to research by the United Nations Environment Program (UNEP), every year, lakes, rivers, and deltas take in pollution that is equivalent to the weight of the entire human population — nearly 7bn people.

—UNEP, Clearing The Waters Report (2010)

ARUP

ecosystem pollution

A 2012 report by the Chinese Ministry of Environmental Protection found that 40% of China's rivers were "seriously polluted" and 20% were too toxic for human contact. Chemical spills, industrial waste discharge, acidified rain, sewage overflows and fracking fluids are all examples of man-made pollutants affecting aquatic and marine ecosystems.

According to a 2010 UNEP report, industry releases about 300–400M tons of heavy metals, solvents, toxic sludge, and other wastes into the world's waters each year. Beyond industry, in some developing countries roughly 80% of sewage is discharged directly into communal waterways without treatment. Degraded water costs countries in North Africa and the Middle East between 0.5 and 2.5% of GDP per year. According to the World Resources Institute, as of 2011 more than 25% of the world's reefs were considered to be "threatened" by water-based pollution, with nearly 10% considered to be "highly threatened." The resultant losses in biodiversity could be extremely damaging to the food chain and other ecological systems upon which humans, and other species, rely.

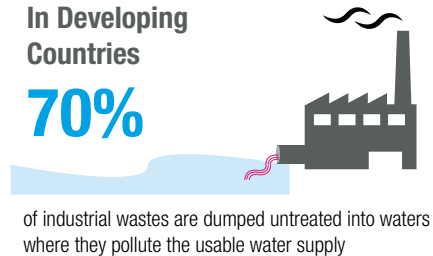


Fig 1: Water pollution

[World Water Assessment Programme, 2012]

water stress

should we fight over water?

© Siegfried Modblay/IRIN

water

political

According to UN Water, in 2014, roughly 1.2bn people — or approximately 1/5 of the world's population — were living in areas of physical water scarcity. —United Nations Water (24 December 2014)

ARUP

water stress

According to the European Environment Agency, “water stress occurs when the demand for water exceeds the available amount during a certain period.” At a national level, this is often measured using Falkenmark’s Water Stress Index (WSI), which divides the volume of available water for each country by its population. A country is considered to be “water stressed” if the average amount of water available per inhabitant is less than $1,700\text{m}^3$, “water scarce” if that amount is less than $1,000\text{m}^3$ and “absolutely scarce” below 500m^3 . Bank of America Global Research predicts that 50% of the world’s population will be living in “water stressed” conditions by 2030.

Water stress and competing interests for limited resources often lead to political turmoil at regional, national or even international levels. Ethiopia’s Renaissance Dam project, for example, has angered Egyptian authorities, who claim it will limit their water supply, with some asserting a 25% reduction in farmland. Additionally, land grabs in water-secure nations seem to be on the rise, as at-risk countries aim to secure their food supply.

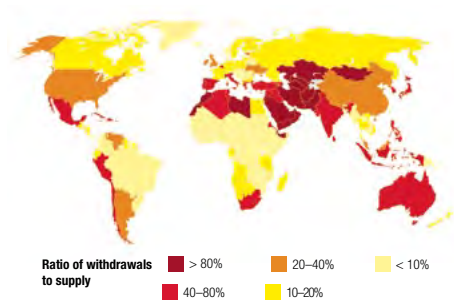


Fig 1: Water stress by country
[World Research Institute, 2013]

ownership models

who owns your water supply?

© Global Water Partnership

water

political

In 2013, 102 new private water contracts were signed in the BRIC nations alone, serving 53.9M people (roughly 88% of the global total of people served by new contracts). —Global Water Intelligence (2015)

ARUP

ownership models

As of 2013, nearly 15% of the global population received water and/or wastewater services from private providers. International financial institutions such as the World Bank and the IMF have encouraged privatisation, particularly in the developing world. Between 1990 and 2013 the World Bank invested US\$74.5bn in privatising water infrastructure. Around 28% of this investment, however, went to projects that were cancelled or under distress. Although privatisation does work to finance, develop and operate infrastructure, many see it as turning a low-return public utility into a profit-making venture, thus putting the needs of shareholders above the public good.

The relationship between public water utilities and their citizens is fundamentally different to that between private water utilities and their customers. The relationship between a customer and a private utility is much more transactional — customers expect a certain standard of service and there is little connection to the private company. Citizens, on the other hand, feel a sense of ownership, as they may pay for the service indirectly through taxation or rates, and are more likely to act for the common good. How people engage with their water suppliers can have a significant impact on behaviour.

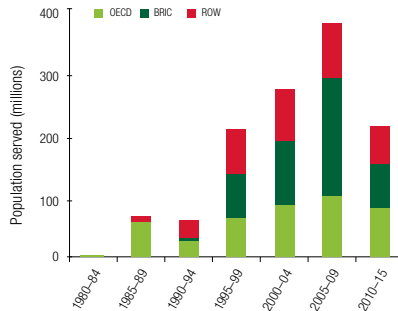


Fig 1: Water/wastewater PPP contracts signed by region
(Global Water Intelligence, 2015)

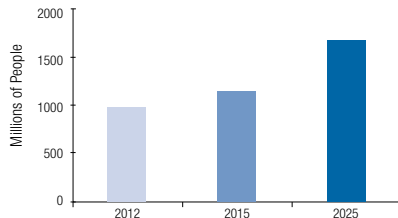


Fig 2: People served by private water or sewage services
(Pinsent Masons LLP, 2012)



watershed cooperation

should you share with your neighbour?

© Klaus Leidorf

water

political

According to Resolution A/RES/65/154, in December 2010, the UN General Assembly decided to proclaim 2013 International Year of Water Cooperation. —UN General Assembly (2011)

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watershed cooperation

Globally, there are 276 river basins and at least 200 aquifers that cut across international borders. 148 out of 195 nations have territory in international basins. 18 of these basins worldwide are shared by more than 5 different nations. Sharing these limited resources may result in potentially conflicting upstream and downstream uses, yet despite the possible conflicts arising from these shared resources, studies suggest that cooperation is highly likely in shared basins. Between 1820 and 2007, 450 agreements on international waters were signed. Many of these treaties remain weak due to lack of water allocations, poor water quality provision, lack of monitoring and enforcement or conflict resolution mechanisms, and failure to include all parties with a water interest.

Integrated Water Resources Management (IWRM) is an approach that supports the co-ordinated development and management of water, land and related resources. The aim is to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. In 2012, UN Water reported that 80% of the 130 countries surveyed had made reforms to enable integrated water resources management.

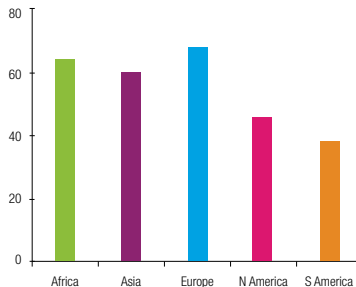


Fig 1: Transboundary river basins by continent
[Unwater.org, United Nations, 2013]



Fig 2: Watershed cooperation
[United Nations, 2013]



system vulnerability

how secure is your supply?

© U.S. Naval Forces Central Command / U.S. Fifth Fleet

water

political

Our water is only as secure as our energy system: The State of California uses 19% of its total energy budget to transport water great distances to meet the household water needs of its people.

—LA Times Online (15 December 2014)

ARUP

system vulnerability

According to a 2010 study in the journal Nature, 80% of the world's population lives in areas where the water supply is not secure. In general, leakage in the water system is one of the most prevalent vulnerabilities. In the US specifically, according to the 2013 Infrastructure Report Card, there are approximately 240,000 water main breaks every year.

The contamination of drinking water or distribution chain sabotage are often regarded as likely terrorist acts, yet the quantity of toxic chemical needed to contaminate a municipal water supply is hard to define. In the developed world, most biological pathogens would fail to survive in water as a contaminant due to standard water treatment practices. While the vulnerability of the water supply increases post-treatment, the population size affected diminishes as well. In response, vulnerability assessment can help water utilities evaluate their susceptibility to potential threats and identify corrective actions that could reduce the risk of serious consequences. New safety measures such as remote monitoring technologies and critical system redundancies are being developed, and protocols are being adopted in an effort to fortify water supplies.

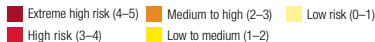
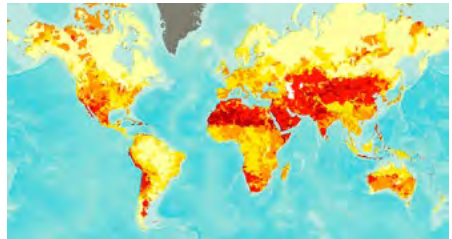


Fig 1: Overall water risk
[World Research Institute, 2013]

water rights

is water a human right?

water

political

The human right to safe drinking water and sanitation is derived from the right to an adequate standard of living and inextricably related to the right to the highest attainable standard of physical and mental health. As well as the right to life and human dignity. —UN Human Rights Council (2010)

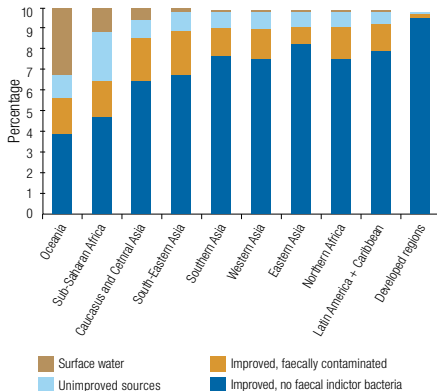
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water rights

The concept of water rights is evident in the ancient text *The Institutes of Justinian*, which states: “By the law of nature these things are common to mankind: the air, running water, the sea and consequently the shore of the sea.” Countries such as India have long viewed water as being outside the realm of individual property rights. The beginnings of European water law go back to the time of the Romans. The Riparian Doctrine established that the owner of property adjacent to a body of water automatically acquires the right to use the water as long as the quality and quantity of the downstream water supply are not affected.

In late 2010, a report by WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation announced that 89% of the world’s population used improved drinking water sources. With close to 10% of the global population living without safe drinking water and nearly 30% without sanitation, there is work still to be done, and it remains to be seen how local authorities, national governments, and the international community will rise to the challenge.



Note: Estimates based on a systematic analysis of 345 studies containing information on drinking water quality.

Fig 1: Proportion of population by access to drinking water sources
[United Nations, 2012]

social

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