Water: Cycle of Life

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> "We sing to the water because it is alive, it hears, it has feeling. It is a living thing. We are drops from the same river, part of the same water cycle."
>
> *Arhuaca* (Colombia), female tribe-member

Morning comes quickly for the women of Kutch, a village on the edge of the desert in the state of Gujarat, India. At 4.30 a.m., daily chores begin, often including walking four hours to collect water. They are, according to the World Health Organization (WHO), among the almost 900 million (one-eighth of the world's population) people without access to safe drinking water. The Organization for Economic Cooperation and Development (OECD) estimates that 2.5 billion people (almost half of the world's population) don't have access to proper sanitation. By 2025, the WHO estimates that approximately two-thirds of the world's population will live in "water stressed" areas.

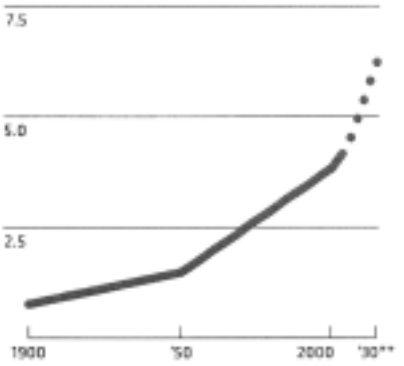
While those reading this report are not likely to experience a lack of clean water, it is likely that all of our lives will be impacted by water, in one way or another. Besides our daily water use, water is critical in food production and energy.

Ninety-seven per cent of the earth's water is saltwater in oceans. Of the 3% of the earth's 35 million cubic kilometres (km^3) of freshwater reserves, most is inaccessible to humans, buried in glaciers, permanent snow cover, or in very deep groundwater. Humans use water from rainwater, surface and groundwater stocks, soil moisture, as well as other sources. In aggregate, less than 1% of the earth's water is "available" for our use. While much of the water is renewable, a great deal of the available water is used in ways that diminish its quality so that it becomes essentially worthless. Due to the inefficient usage, contamination and overuse of renewable and non-renewable sources of water, as well as the disparate distribution of the earth's water sources, many areas are essentially "running out" of water. Over the last century, the global population has doubled, while water use has grown four times. By 2050, the world's population is expected to grow 50%, from six billion to nine billion people.

Total global freshwater use is estimated at approximately 4,000 cubic kilometres per year, supplemented by 6,400 cubic kilometres of rainwater per year. Of this freshwater supply, approximately 70% is used for agriculture, with the balance used by industry (including 20% for energy), and domestic usage. Population growth, as well as rapid economic growth, particularly in developing nations, has created a dislocation between water resources and water requirements (see Chart 1).

Water withdrawals have tripled over the past 50 years as a result of population growth and increased development of irrigation for food demand. As developing populations grow wealthier, they consume more protein, which further stresses water. The United States Department of Agriculture (USDA) estimates that it takes seven pounds of grain to produce one pound of beef. Many commonly used products require significant amounts of water during

Chart 1
Global Demand (in millions of cubic metres), 1900–2030



Sources: Pacific Institute; *The World's Water, 2008–09*

Chart 2
Litres of Water Necessary to Form Various Products

Beverages	**Per litre**
Glass of water	~ 1
Bottled water	3-4
Glass of beer	300
Glass of wine	960
Milk	1,000
Cup of coffee	1,120
Roasted coffee	21,000
Assorted produced goods	**Per kilo**
Finished cotton textile	11,000
Hamburger	16,000
Microchip	16,000
Leather shoes	16,600
Assorted crops	**Per kilo**
Soybeans	1,100–2,000
Rice	1,900–5,000
Assorted animals	**Per kilo**
Beef	15,000–70,000

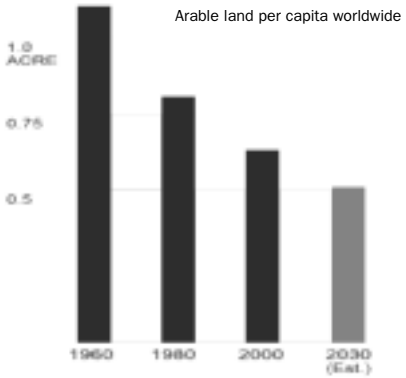
Sources: The World's Water, 2008–09; www.waterfootprint.org

the production process, which most people don't realise. Such dramatic increases have created conflicts between urban and rural demand for water, as well as regional disputes (see Chart 2).

According to the University of Technology in Sydney, Australia, 2008 was the eighth year in a row that the six billion inhabitants of the planet consumed more food than was produced by farmers. The Food and Agriculture Organization (FAO) of the United Nations (UN) estimated that there was only sufficient food in storage, globally, to feed the planet for 55 days, less than half the supply in the 1990s and the lowest level in 37 years. According to the UN, in 1960 there were 1.1 acres of arable farmland per capita throughout the world. By 2000, that number had dropped to 0.6 acres (see Chart 3).

Chart 3 **Precious Acres**

Growing population and widespread development are shrinking the amount of farmland per person.



Source: Food and Agriculture Organization of the United Nations

Drought, or water scarcity, is a problem on every continent. Demand for water has particularly stressed the southwestern United States, where population growth and food production is incompatible with water resources. California is a prime example of this phenomenon. The state, which produces more than half the nation's fruits, vegetables, and nuts, faces severe water shortages. Reuters recently reported that some federal sources of irrigation water will be dry this year and the top state water project will not fulfil more than 15% of requested water. Recently, the cities of Sacramento, San Diego, and Los Angeles introduced water rationing programs limiting water for lawn watering and car washing. California, like many other western states, receives its water from the Colorado River, which faces increasing demand and depletion. Farmers of thousands of acres of agricultural land in California's important Central Valley were forced to leave land fallow, as authorities cut off water deliveries to the valley due to low reservoir levels. This February, California governor Arnold Schwarzenegger declared a state of emergency (the first since 1991) requesting residents of the nation's most populous state to reduce water use by 20%.

Las Vegas, an oasis constructed in the middle of the Mojave Desert, also has severe water problems. For years, Las Vegas was one of the fastest growing cities (and Nevada one of the fastest growing states) in the US. An example of a growing population pitted against limited resources, Las Vegas receives an average of only four inches (10 cm) of rain per year, 10% of that received by the city of Chicago. Amid the worst ten-year drought in recorded history along the Colorado River, Las Vegas has looming water problems. The city depends on Lake Mead, a 110 mile-long reservoir that feeds off the Colorado River, for its water. Lake Mead's level has dropped 1% per year since 1999. By 2012, the surface of the lake could fall below the existing pipe that delivers 40% of the city's water. That would also cause the federal government to cut the supply of water to the seven states that depend on the Colorado River for water. The Hoover Dam, constructed in 1935, which regulates the river and forms Lake Mead, would also be unable to supply electricity to 750,000 residents of Los Angeles.

The arid southwest isn't the only area impacted. The Ogallala Aquifer, which supplies water to the Great Plains and the Midwest (breadbaskets of the US), is at record lows in some areas. The aquifer, the largest in the US, is depleting at the rate of 12 billion cubic metres per year. Pumping from the aquifer began 60 years ago and since then, water levels have dropped 100 feet (30.48 metres) in some places. The withdrawal rate is far in excess of the rate of replenishment. Other areas of the US are water stressed, as well, as seen by water restrictions being imposed by authorities in Texas, Florida, North Carolina, and Georgia.

Globally, the situation is just as dire. Australia is in the midst of a severe drought. Last year, the one million ton rice crop in the Murray–Darling Basin failed, driving up prices which, among other crop price increases, resulted in food riots in 34 countries. Australia, which was the world's sixth-largest exporter of wheat the last two years, managed to harvest a little more than 50% of the million tons of grain it normally produces.

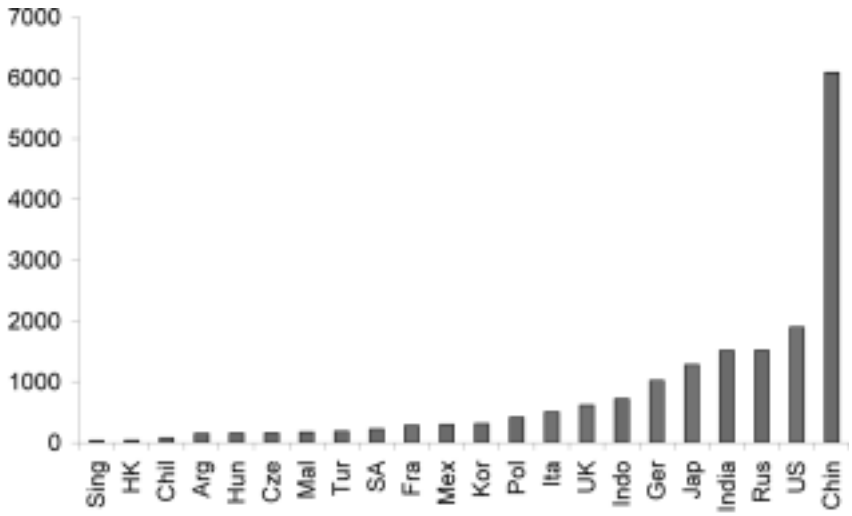
Argentina, the world's third-largest exporter of corn, recently experienced its worst drought in 38 years. Estimates are that the nation's corn harvest will be reduced by 25%, and wheat production will be down by 50%. Chile experienced a spring drought that increased the risk of blackouts in its most populous regions and at copper mines. The Mexico City Water System cut water service for a third time this year. According to Global Water News Watch, water from the Lerma System, which also supplies the Mexican Federal District, has dropped from 4,000 litres per second to 1,000 litres per second. Further, dry weather this year will lead to a decrease in Colombian coffee production by an estimated 13%.

Africa has also been harshly impacted by drought and water shortage. This year alone, drought has stressed Ethiopia, Somalia, Kenya, Eritrea, Djibouti, and Uganda, among other nations. In central Africa, Lake Chad, once the third-largest source of freshwater in Africa, is disappearing, threatening millions of people in Chad, Cameroon, Niger, and Nigeria. Due to long-term drought and excessive withdrawals, the lake is a mere 5% of its previous size.

The Middle East consumes more water than it receives from renewable sources. Kuwait consumes 22 times its annual rainfall, according to a report by UBS. Saudi Arabia, which will exhaust its aquifers within the next ten years, announced that it will become 100% reliant on food imports by 2016. Also, in July of this year, Israel restricted water use for each household, with penalties for exceeding the limitations, in an effort to reduce water consumption. The Middle Eastern governments of Qatar, Abu Dhabi, and Saudi Arabia have begun acquiring or leasing large tracts of farmland in Asia and Africa (including in war-torn Sudan).

Of course, the poster child for water stress is China, one of the earth's most arid regions, with 20% of the world's population and only 7% of the world's water supply. Following an economic growth rate averaging 20% per year for the last 20 years, China's water resources are over-allocated, inefficiently used, and terribly polluted, according to *The World's Water 2008–2009* (TWW) (see Chart 4).

Chart 4 **Emissions of Organic Water Pollution ('000 kilos per day), 2003**



Sources: World Bank; Independent Strategy

Much of China's water is beyond reclamation, with many dead rivers and lakes polluted by industrial and human waste. The TWW report notes that of the 20 most polluted cities in the world, 16 are in China. Three hundred million of the nation's people lack access to safe drinking water. The Chinese State Environmental Protection Agency, the WHO, and the OECD report that 40% of Chinese surface water is fit only for industrial or agricultural use, even after treatment. Approximately 20,000 chemical factories, half along the Yangzte River, discharge untreated or partially treated contaminants into Chinese rivers. Only 69% of China's largest cities meet national potable water standards. Drought and floods also devastate China. According to China's State Flood Control and Drought Relief agency, annual losses from drought since the 1990s have been the equivalent of 1.1% of GDP, while annual losses from floods averaged nearly 2% of GDP. (US losses from floods, for the comparable period, were 0.25% of GDP.)

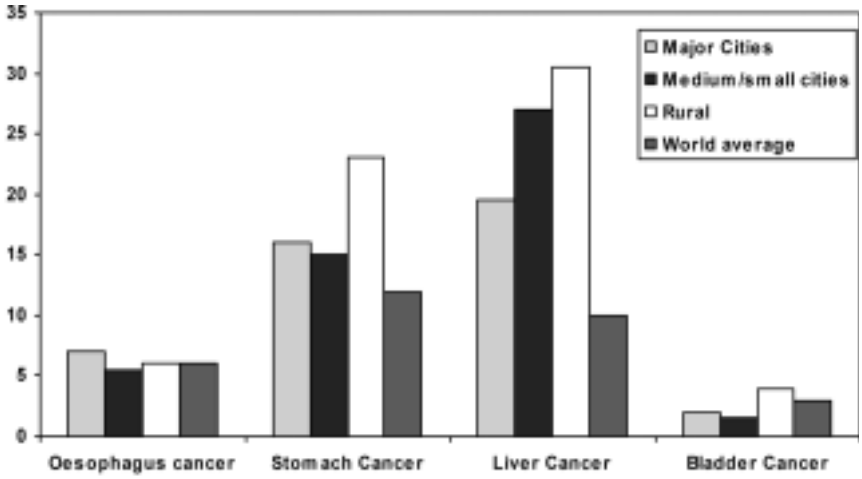
Within China, the uneven distribution of water resources and the transfer of water between regions have led to regional conflicts. Violence over allocations of water from the Zhang River has been escalating for over 30 years between villages in Shexian and Linzhou counties, according to TWW. Both Beijing and Hebei provincial officials have diverted water from the Juma River, leading to conflicts between the two governments. Perhaps the most significant conflict is the one between the Chinese government and Tibetan protesters. The Tibetan Plateau has plentiful water and serves as the headwaters of many of Asia's most important rivers, including the Yellow, Yangtze, and Mekong. While routinely thought of as a religious dispute, some observers think the conflict may also result from disagreements over the management of Tibet's freshwater. Industrial activities and deforestation have already impacted Tibet's freshwater reserves, according to the Chinese Academy of Science.

Other regional conflicts, some in already unstable regions, could be triggered by water stress as well. Shrinkage of the Himalayan Mountain glaciers could trigger conflicts between China, India, and Pakistan. According to a report by the Asia Society, 77% of Pakistan's water emanates from beyond its borders. India and Pakistan have a water treaty, in effect since Pakistan gained independence, but the two nations have been arguing about violations of the treaty. Israel, Jordan, Lebanon, and Syria have all diverted water upstream from the Jordan River.

Contaminated water is a significant issue. Where freshwater is scarce, brackish water and waste water are also utilised to meet water demand. According to the *World Water Development Report* (WWDR), in 2006, 54% of the world's population had piped water connections to their dwelling, plot, or yard, while 33% used other improved drinking water sources. The balance, 13% (884 million people), were forced to use unimproved water sources. In a recently published study by the WHO, it was estimated that China suffers 750,000 deaths per year, in excess of normal mortality rates, due to pollution (see Chart 5).

Some potentially long-term harmful effects of water contamination have recently been noted. The Associated Press reports that many pharmaceutical products,

Chart 5 **Mortality Rates for Diseases Associated with Water Pollution (per 100,000) in China in 2003 and World Averages in 2000**



Sources: MoH, 2004; WHO, 2006

including antibiotics, anti-convulsants, chemotherapy products, mood stabilisers, and sex hormones, as well as veterinary medications, have been detected in the drinking water supplies of the US, Europe, Asia, Australia, and Canada. The presence of so many medications, which are partially absorbed by the body, but mostly pass through as waste, raises concerns about the long-term consequences of even small detectable amounts. With advances in pharmaceutical products, global water systems are not designed to detect or eradicate these contaminants. A huge market exists for those creating techniques to protect the integrity of water. There are also indications that adding chlorine, one of the most common methods of treating drinking water, elevates the toxicity of some of these pharmaceuticals.

Malnutrition is another consequence of water stress and contaminated water. According to the WWDR, malnutrition accounts for approximately one-third of disease in developing nations. Another consequence of lack of water and malnutrition is "stunting" (low height for age), also more prevalent in developing nations.

While we have only touched upon some of the problems associated with water, we will offer a few solutions to the gloomy picture. Obviously, significant public and private resources will have to be dedicated to relieving some of the water stress, particularly given the stressed financial status of many cities, villages, states, and nations.

Interestingly, bottled water isn't a real solution to water problems. While travellers from developed nations don't leave home without it, bottled water is at least 2,000 times more energy-intensive than tap water. Much of the energy is involved in the production of plastic bottles, as well as the energy required to transport the bottles over long distances. Generally, the bottles end up in landfills, presenting other environmental issues. With more than one unit of water used to produce one unit of bottled water, one solution to water stress is to reduce the amount of water consumed in bottled water production. Nestlé SA, maker of Perrier and San Pellegrino water, has announced that it has reduced the amount of liquid it requires to produce one litre of bottled water to 1.76 litres, 26% less than in 1999. Safina, a Ghanian bottled water producer, has managed to produce its products with only a 30% loss of liquids. Such thinking, unheard of years ago, is critical to conserving a shrinking resource.

Ironically, few people have any sense of the "cost" of water. Although it is a necessity, water is generally not competitively priced between regions and is certainly not priced according to its "value", as it is often subsidised by governments (see Chart 6).

Perhaps the most significant improvement that would lessen the stress on the global water supply is more efficient usage and recycling. As we continue to overburden a finite freshwater system, any means to reduce demand or increase supply is paramount. For example, many residents of the US and other nations use water that is partially treated, as well as recycled sewage. The practice is growing. Although the concept may not be appetising, it is quite effective. After treatment, recycled sewage allows the 2.4 million residents of Santa Ana, California to enjoy water with a measure of purity (TDS — total dissolvable solids) of 30 parts per million, less than many brand-name bottled waters. Santa Ana's system also allows it to provide water to meet the needs of 500,000 more people, without taxing its own supply.

More efficiency in transporting water is a critical solution to water stress. Water is very expensive to transport (estimates for water pipe production and installation are from $1 million per mile in rural areas to $10 million per mile in urban areas in the US), so preventing leakage and water loss (which can be up to 40% of transported water) is critical. Leaking pipes in the US lose an estimated seven billion gallons of drinking water per day, according to the American Society of Civil Engineers. The group states that water systems in the US face an annual shortfall of $11 billion to replace crumbling water facilities. Over the next five years, 70% of the one million-mile US water system will have surpassed its useful life. Some water pipes in the US predate the 1860s. Over the next 20 years, over $1 trillion will be required to upgrade the US water infrastructure.

Water is also transported by

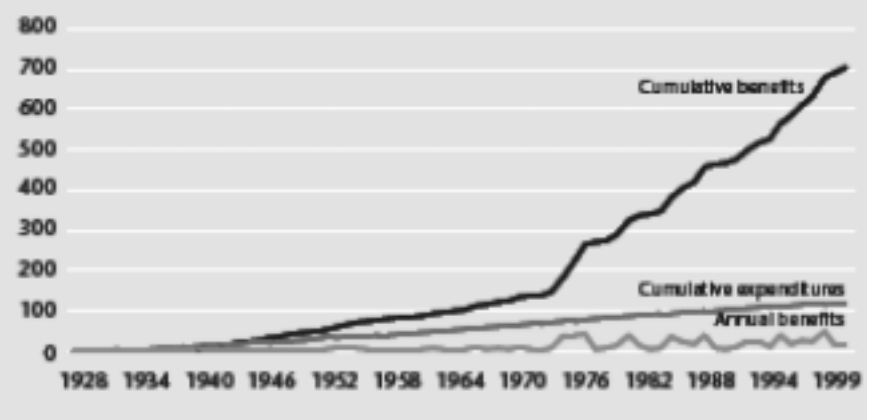
Chart 6

Product	Average price ($/gallon)
Tap water	$0.0025
Gasoline	$2.20
Coca-Cola	$2.64
Organic milk	$4.25
Tide liquid detergent	$8.39
Imported beer	$12.00
Evian bottled water	$21.19
Pepto-Bismol	$58.52
American whisky	$150.00
Revlon nail enamel	$983.04
Chanel #5 perfume	$45,056.00

Source: The Environmental Benchmarker and Strategist

Chart 7 **Investment in Water Infrastructure (1999 US$ billions, adjusted using Construction Cost Index), 1928–1999**

US government investments in water infrastructure during 1930–96 yielded $6 in damages averted for each $1 invested.



Source: Based on Delli Priscoli and Wolff, 2009

canals. Lining irrigation canals, along with smaller opening gates and narrower channels, has reduced agricultural water loss by 50% in parts of Australia's Murray–Darling Basin. Hardwood from Cameroon is processed and shipped to the Netherlands to line the canal systems there, also to prevent leakage. China has constructed a new system of canals and pumps to transfer water from the southern region of the country to the north. However, transporting water by pipe is not only expensive, but energy intensive. The *New York Times* estimates that 20% of California's energy use is for the transporting of water from the north to the south. Nevertheless, investments in water infrastructure have been effective (see Chart 7).

Often simple ideas, such as catchment (retaining and storing water) and conservation, are significant. Using existing deltas (low-lying level areas of terrain), or excavating the deltas to create reservoirs, is quite effective at catching groundwater or mountain runoff, which would otherwise be lost at sea or to evaporation. This is particularly effective in central California. According to the International Union for Conservation of Nature, based in Switzerland, cities like Caracas, Venezuela, are protecting local water basins, as a method of reducing new investments in pipes and pumps. Jakarta, Indonesia is among many cities preserving forests, as trees shield streams and rivers from evaporation and erosion, providing cheap water for the city and avoiding $1.5 billion per year to transport water from distant reservoirs.

As irrigation use continues to grow, more efficient techniques are necessary. Netafim, an Israeli company that started as an experiment in 1965, has grown into a large enterprise controlling over one-third of the global drip irrigation market. Drip irrigation is a system of low-volume irrigation that is less water intensive. Recently, the company launched a low-pressure irrigation system that is suitable for areas where water pressure or electrical generation isn't conducive to high-pressure systems.

The concept of "virtual water", or replacing uses of water from areas of water scarcity to areas where water is more plentiful, or "externalising" water usage, is growing. Approximately 80% of virtual water is related to trade in agricultural products and the remainder to industrial products. The global volume of virtual water flows in commodities each year accounts for approximately 40% of all water consumption, according to WWDR. As an example, Mexico imports wheat, maize, and sorghum from the US, which requires 7.1 billion cubic metres of water per year in the US to produce. If Mexico was to produce the imported crops domestically, it would require 15.6 billion cubic metres per year. Global water savings through international trade of agricultural products has been estimated by the WWDR at approximately 350 billion cubic metres of water per year (6% of water used globally for agricultural production). In the first four months of 2009, China, which had to abandon its policy of food self-reliance, imported a record 13.9 million tons of soybeans. A number of countries, including Japan, Mexico, most of Europe, the Middle East, and North Africa, are net importers of virtual water.

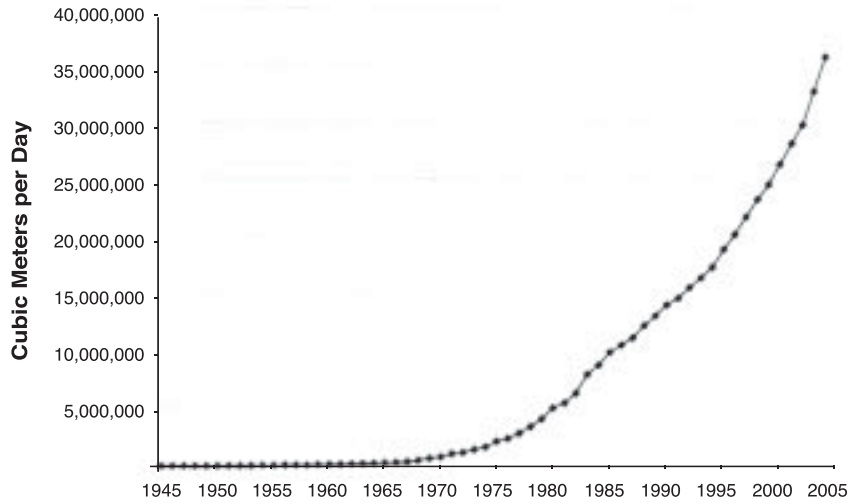
A final example of solutions to freshwater stress is desalination. Although an expensive option (estimated cost $1,700–$2,200 per acre foot) versus treated water (approximately $600 per acre foot, in the same region) and energy intensive, as well as creating an environmental footprint (desalination chemicals can be harmful to marine life), its use is

increasing as a measure of last resort (see Chart 8). China will be forced to use desalination as a source of coastal water supply. Due to the high cost of transporting water, desalination isn't the answer for water-stressed inland areas.

Many countries allow the purchase of water rights either with or without the land under which the water flows. Distressed real estate developers, and banks offloading bad loans, often are compelled to sell assets with embedded water rights. Also, allocation of water can be sold or adjusted. For example, agricultural land can be removed from production, and its accompanying water allocation can be sold to a buyer willing to pay dearly. We have found this activity to be a very interesting investment. Often, there is additional optionality, such as using the fallow land to generate wind or solar power.

Water, which we often take for granted, is a finite resource and we are using it up or contaminating it. It isn't only future generations who will bear the consequences — even now, wealthy and developing nations have been forced to confront the consequences of misuse of one of our most precious resources. As with all problems, the solutions aren't necessarily easy. However, with recycling, better infrastructure, more efficient allocation, and other remedies, as a world of water users, we can better address the issue. So, the next time you take a leisurely shower, leave the water running while you brush your teeth, or eat a steak, think about the women of Kutch, or the farmers in the Murray–Darling Basin, or the children of stunted growth in Africa. After all, we are all drops from the same river.

Chart 8 **Cumulative Installed Desalination Capacity, 1945–2004**



Source: The World's Water, 2006–07