Liquidity crisis

As water becomes ever more scant the world needs to conserve it, use it more efficiently and establish clear rights over who owns the stuff

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"NOTHING is more useful than water," observed Adam Smith, but "scarcely anything can be had in exchange for it." The father of free-market economics noted this paradox in 18th-century Scotland, as rain-sodden and damp then as it is today. Where water is in ample supply his words still hold true. But around the world billions of people already struggle during dry seasons. Drought and deluge are a costly threat in many countries. If water is not managed better, today's crisis will become a catastrophe. By the middle of the century more than half of the planet will live in areas of "water stress", where supplies cannot sustainably meet demand. Lush pastures will turn to barren desert and millions will be forced to flee in search of fresh water.

Where water is available, when and in what condition matters hugely. About 97% of the water on earth is salty; the rest is replenished through seasonal rainfall or is stored in underground wells known as aquifers. Humans, who once settled where water was plentiful, are now inclined to shift around to places that are less well endowed, pulled by other economic forces.

Climate change is making some parts of the planet much drier and others far wetter. As people get richer, they use more water. They also "consume" more of it, which means using it in such a way that it is not quickly returned to the source from which it was extracted. (For example, if it is lost through evaporation or turned into a tomato.) The big drivers of this are the world's increased desire for grain, meat, manufactured goods

and electricity. Crops, cows, power stations and factories all need lots of water.

To make matters worse, few places price water properly. Usually, it is artificially cheap, because politicians are scared to charge much for something essential that falls from the sky. This means that consumers have little incentive to conserve it and investors have little incentive to build pipes and other infrastructure to bring it to where it is needed most. In South Africa, for example, households get some water free. In Sri Lanka they pay initially a nominal 4 cents for a cubic metre. By contrast, in Adelaide in Australia, which takes water conservation seriously, an initial batch costs $1.75 per cubic metre. Globally, spending on water infrastructure faces a huge funding shortfall. A hole of $26trn will open up between 2010 and 2030, estimates the World Economic Forum, a think-tank.

In many countries people can pump as much water as they like from underground aquifers, because rules are either lax or not enforced. Water use by farmers has increased sharply in recent decades (see chart). This has allowed farmers to grow huge amounts of food in places that would otherwise be too dry to support much farming. But it is unsustainable: around a fifth of the world's aquifers are over-exploited. This jeopardises future use by causing contamination. It also damages the layers of sand and clay that make up aquifers, thereby reducing their capacity to be replenished.

People do not drink much water—only a few litres a day. But putting food on their tables requires floods of the stuff. Growing 1kg of wheat takes 1,250 litres of water; fattening a cow to produce the same weight of beef involves 12 times more. Overall, agriculture accounts for more than 70% of global freshwater withdrawals.

And as the global population rises from 7.4bn to close to 10bn by the

middle of the century, it is estimated that agricultural production will have to rise by 60% to fill the world's bellies. This will put water supplies under huge strain.

Food for thought

Extravagance must be tamed. Farmers produce far more food than finds its way into stomachs. Some estimates suggest that as much as a third of all food never actually makes it to a plate, wasting as much water as flows down Russia's Volga river in a year. Richer households are responsible for throwing out the largest share of unwanted victuals. Poorer ones may never even see the produce that rots on slow, bumpy journeys to market.

Water is vital not only for food and domestic well-being. It is "fundamental to economic growth", points out Usha Rao-Monari, head of Global Water Development Partners, an investment outfit backed by Blackstone, a private-equity giant. Scarcity stalls industrial development by squeezing energy supplies. Electricity generation depends upon plentiful quantities; nuclear power requires water both for cooling turbines and the reactor core itself, for example. Coal-fired plants cannot function without it.

Power generation is a thirsty business. Overall about 41% of America's withdrawals go towards cooling power stations. In countries such as Brazil, where hydroelectric power provides more than two-thirds of the country's needs, scarcity is also a worry, particularly when dam designs rely on rivers fed by rainfall (see article). Spikes in energy prices often follow dry periods. Zambia endured sporadic blackouts that began a year ago and lasted until April, when drought crippled power generation from the Kariba dam.

As poor countries develop, global demand for electricity from industry is expected to increase by 400% over the first half of the 21st century. The majority of water-intensive industries, such as coal mining, textiles and chemicals, are found in countries that are particularly prone to water

shortages: China, Australia, America and India. Industry can increase strains on supplies too, by polluting water, making it unfit for human use. Over a third of China's waterways have been spoiled by industrial effluent and other nasties.

Climate change will only make the situation more fraught. Hydrologists expect that a warming climate will see the cycle of evaporation, condensation and precipitation speed up. Wet regions will grow wetter and dry ones drier as rainfall patterns change and the rate increases at which soil and some plants lose moisture.

Deluges and droughts will intensify, adding to the pressure on water resources. Late or light rainy seasons will alter the speed at which reservoirs and aquifers refill. A warmer atmosphere holds more moisture (the water content of air rises by about 7% for every 1ºC of warming) increasing the likelihood of sudden heavy downpours that can cause flash flooding across parched ground. This will also add to sediment in rivers and reservoirs, affecting storage capacity and water quality.

Less snow in a warmer world creates another problem. Places such as California depend upon mountain meltwater flowing down in time for summer. Climate change will make the availability of water more variable in Southern Africa, the Middle East and America. The World Resources Institute, a think-tank, ranked 167 countries, and found that 33 face extremely high water stress by 2040 (see map).

Uncertainty surrounds what this will mean for crop yields but a study by academics at Columbia University is not encouraging. Higher concentrations of carbon dioxide in the atmosphere may make plants use water more efficiently in some parts of the world (they will lose less moisture during photosynthesis). Average yields of wheat-growing areas fed by rainfall—mostly located in North America and Europe—might rise almost 10% by 2080 and water consumption decline by the same

proportion. But average yields of irrigated wheat—common in countries such as China and India—could drop by 4% and maize harvests would fall everywhere.

High and dry

Altered weather patterns will mean that crops may wither where they once thrived. By 2050, even if temperature increases can be limited to 2°C, crop yields could slump by a fifth in Africa. Altered rainfall patterns could make conditions too dry and hot to grow beans in Uganda and Tanzania, for example, according to a study published this year in *Nature Climate Change*. But forecasting precisely how regions will fare from deluges or drying is difficult as past weather records are a less useful guide as the climate changes.

There is no single solution for the world's water crisis. But cutting back on use, improving the efficiency of that use and sharing out water more effectively would all help. There are many schemes around the world to meet each objective but so far these tend to be implemented piecemeal rather than in a co-ordinated effort to preserve the world's supplies.

Farming, because it uses water so heavily, is an important target. Changing agricultural practices is vital and farmers, at least in the rich world, are becoming more shrewd in their use of water. Precision planting, hybrid seeds that require less watering and other technologies are all helping to conserve precious supplies. Drip irrigation, which targets water directly to the roots of plants rather than spreading it indiscriminately, can cut use by 30-70%.

Water for farming can be gathered through means other than raiding aquifers. Schemes for harvesting rainwater, by collecting it in tanks rather than letting it run away, are commonplace. Recycling wastewater has huge potential. Fruit trees in Israel are showered with it. Overall the country recycles 86% of its sewage, a vastly higher share than any other; Spain is

next at just 20%. Israel does not think it can rely on its neighbours to supply it with water. Singapore, reluctant to depend on Malaysia, recycles sewage into drinking water. But politicians elsewhere are too squeamish to let people drink recycled waste.

Water stress afflicts one in four cities worldwide. Policymakers could do a lot of basic things better to cope with it. Plugging leaky pipes would be a start: they cause some big cities in the Middle East and Asia lose up to 60% of their water. Rich cities still have a long way to go too: London wastes 30% of its water through leaks, equivalent to a bathful a day for every household, by one estimate. In Chicago wooden pipes still carry water. Fixing pipes could soon become easier and cheaper. Robotic systems are being tested which can detect and repair leaks by sensing pressure changes around them and plugging holes while pipes are still in use.

Poor countries, where millions live in slums without proper sanitation, need more pipes in the first place, not to mention reservoirs and purification works. Where new infrastructure is required, better methods of modelling scarcity could help. They would let new installations be sited where they will guarantee supplies, even if climate change has an effect on patterns of rainfall. Space Time Analytics, a Brazilian company, is working on a global water-risk management system that will have the ability to predict likely shortages with much more precision.

To understand why water supplies become insecure, you first need to know two things that affect the volume of water stored in lakes and reservoirs, says Juan Carlos Castilla-Rubio, the firm’s boss. The first is the changes in the volume stored over the years. The second is the variability during any given year. This is because, in many places, water storage represents the buffer between triumph and disaster during unexpected dry spells. And knowing how it may be likely to vary in the face of climate change could justify appropriate infrastructure investment ahead of time.

Go with the flow

Better modelling tools may also convince governments everywhere of the urgency of dealing with water scarcity. There is plenty of capital available for water infrastructure, reckons Ian Simm of Impax Asset Management, an investment firm. The problem lies in securing consistent political support for it, especially at the local level. Hard-nosed private investors have turned away from water, reluctant to risk vast sums for uncertain returns stretched across future decades. "If I build a billion-dollar desalination plant, will I get paid? That is the sector's biggest issue," explains Ms Rao-Monari.

Desperately dry countries have shown that impressive infrastructure can be built with money and consistent political support. Desalination plants convert seawater to drinking water, but at a cost that can induce tears. Unsurprisingly, most of the biggest are in the Middle East. The Sorek plant in Israel, the country's largest, supplies more than 1.5m people—equivalent to about 20% of municipal demand. But the process is still more expensive than almost all other ways of supplying fresh water because of the enormous quantities of electricity required.

Desalinated water is far too expensive for irrigation, points out Mike Young, a water-policy expert at the University of Adelaide. Better for countries to eke out the little they have more efficiently, he argues. Existing management systems often hinder such sharing. In poor countries they are often rudimentary. In rich countries entitlement and allocation schemes largely came into being during times of abundance. They are often slow, bureaucratic and far too scattered. America, for example, has more than 50,000 water utilities. Everywhere, water is devilishly difficult to manage. As it flows, it is used and reused, making it hard to track and measure.

Rights regimes that are well designed and implemented are among the

most effective tools for distributing water fairly and sustainably. Under one such system, Australian states began reforming water management in 1994. Few others have followed, though attempts at reform in Chile and Yemen have met with varying degrees of success.

An "unbundled" system, in which component parts are managed separately, could replace irrigation systems where those who arrived first enjoy more senior rights. In California this has created a division between those who came to the state before and after 1914, for example. And as any water saved by irrigators passes down to more junior rights holders, there is little incentive there to adopt technologies which boost water efficiency.

To create tradable water rights, Australia first drew up a baseline for water use, taking into consideration past commercial, social and environmental needs. Next, old water rights were replaced with shares that granted holders (usually landowners) a proportion of any annual allocations. Clever formulae take account of the seniority of pre-existing rights. Different classes of shares determine who gets what and when to balance the competing claims of upstream farmers and downstream urbanites. After that a regulatory board makes sure that all users get as much as they are entitled to.

A drop worth fighting over?

Allocations made to shareholders are tradable, but those receiving them can also store them for the future. This prevents any sudden wasting of water at the end of each year and encourages thrift during a drought. Issuing shares in perpetuity ensures that a holder can have more water only if someone else is prepared to have less. A centralised register holds everything together. Two markets for trading have been created: one in which shares are exchanged, and another for allocations of water in a given year. The idea is not a new one. In places such as Oman, *aflaj* systems involve villages trading in shares and in minutes of water flow.

Pooling resources

Such regime change originally met strong resistance from farmers and other big users in Australia. But trading allocations reaped enormous rewards for shareholders. During the first decade of reform the annual internal rate of return from owning a water right was over 15%; those who held water shares saw the value of their rights double every five or so years. But following this example elsewhere will be tough. Even rich countries will struggle to unbundle rights that have accumulated over decades.

Reforming water management is urgent nonetheless. More than two centuries ago Adam Smith was only moderately gloomy about the precious liquid. Filmmakers today take a more dystopian view. In the latest "Mad Max" film, for example, armed gangs race around desert landscapes, fighting and dying for water. Such scenarios are still fiction, fortunately. But the prospect of water wars is far from fanciful. Some think that global drying is one of the causes of bloodshed in such places as Somalia, Sudan and Syria.

With clever pricing, clearer ownership and a bit of co-operation, water scarcity can be alleviated. If humanity fails to act, it will get just deserts.