world energy
We.
MARCH 2020

WATER STORIES

Number 46

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by John H. Lienhard V

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Taking Stock/The President of the World Water Council

Water Emergency

If we fail to manage the availability of water, we condemn entire populations to exclusion from development and equitable enjoyment of fundamental human rights

LOÏC FAUCHON

He has been president of the World Water Council since 2018, after having previously served two mandates from 2005 to 2012. From 1991 to 2019, he was successively General Director, Chief Executive Officer and President of the Water Supply Company of Marseille (SEM). He was awarded the French Legion of Honor in 2003.

On the left, Aïda Muluneh (Ethiopia, 1974), “The Schackles of Limitations” (2018).

The world is thirsty. Energy and water are becoming increasingly scarce or erratic resources. People are facing growing threats to their health, as well as vital food supplies. Billions of people all over the world are suffering from the accumulated effects of many crises. As demographic growth and urbanization reach unprecedented levels, as news spread ever faster, and people's hopes for a better quality of life are raised, this suffering is becoming more intense and more brutal. And at the same time, there is a new consciousness about the necessary environmental approach. Peace and dignity, and a fairer world, in the long term, depend on two elements: access to development opportunities and the need to protect the natural world. To develop and protect nature, we need to act with mutual respect and find a sustainable balance between the use of our increasingly coveted natural resources and the need to protect them.

Water is one of these resources. And it has become a rare commodity, in terms of both quantity and quality. Due to our careless domestic, industrial and agricultural uses of water, resources in our rivers, boreholes, water tables, dams and reservoirs are under pressure and are rapidly being depleted. As the demand for water increases, supply is stagnating.

At the global and local scales, our lives depend on the availability of water. If we fail to manage its availability, we condemn entire populations to being excluded from development and equitable enjoyment of fundamental human rights. Collectively →

WATER LIFE

In producing this series, the photographer has in particular addressed the difficulty of accessing drinking water and its effects not only on a society but also on women who live in rural areas. City dwellers often take for granted the privilege of being able to access water, while those who live beyond the urban network face challenges that not only affect their health but also their ability to contribute to the development of their community. Each shot is therefore a reflection on how to deal with the consequences of access to water, since it concerns women's emancipation, health, hygiene and education. "Working in various regions of Ethiopia," explains the photographer, "I often come across lines of women walking along the road and laboriously carrying water. I realized that women spend enormous amounts of time going to fetch water for their family, with serious repercussions on women's emancipation in our society. I chose to take some of these shots in Dallol, in the Ethiopian region of the Afar, to emphasize the message I am transmitting and also to produce an anthology that uses art to spread a message using a different approach."

A contemporary Ethiopian photographer and artist, Aïda Muluneh has published photographs in numerous international magazines and exhibited in major museums around the world. She founded the Addis Foto Fest, the only international photography festival in East Africa. As one of the leading experts on photography from Africa, Muluneh has been on the juries of several international photography competitions.

Above, Aïda Muluneh (Ethiopia, 1974), "Steps" (2018); below, "The Woman's Work" (2018).

Above Aïda Muluneh (Ethiopia, 1974), "The Meter" (2018).

and individually, this is our responsibility, or rather, these are our responsibilities.

We must ensure water security for us all

To secure water use, we first need to secure the availability and protection of the resource itself. We have to find the right approach between "Water Now and Water in the Future." That means a balance between the demand for water and the restrictions that come with water stress.

Securing resources means finding the additional water resources needed to meet demand and respect that balance. To achieve all of this, we can rely on human ingenuity and the ability to constantly innovate and come up with new solutions. This begins with technical solutions. In the future, we will need to drill for water more deeply, transport it over longer distances, store it for longer and purify it more efficiently. We will develop new, cheaper and more advanced solutions, such as the greater use of desalination and wastewater reuse. Energy and digital innovation will be key for water security. The great cycle of water supply and wastewater treatment is involved. For example, digital technologies include sensors, remote controls, weather forecasts, data processing, augmented reality and process optimization. And all kinds of mobile applications. Let us use the best of wireless networks, data processing, the internet of things, cloud and the blockchain for water but also for sanitation, waste, air and →

© AÏDA MULUNEH. USED WITH PERMISSION

Above, Aïda Muluneh (Ethiopia, 1974), "Burden of the Day" (2018).

energy. The digital revolution will bring citizens closer to the decisions and will reinforce the feeling of a more local and more participative democracy.
But we need to be careful and never forget to put the people "in the loop." Technological innovation will give us a fantastic source of freshwater for agricultural and industrial use. Technological advances will enable us to speed up the roll out of new, smarter, more efficient, more environmentally-friendly, more sustainable and fairer solutions. But apart from human technology, there is also the need, indeed the obligation, to take political action. Water is not one Sustainable Development Goal among 17 others. Global water security has now become an integral part of every country's national security and foreign policy.

The three pillars of water management

We can think of water management →

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Water crisis numbers

785
MILLION PEOPLE – 1 in 9 – lack access to safe water

2
BILLION PEOPLE – 1 in 3 – lack access to a toilet

200
Women and girls spend **200 MILLION HOURS** every day collecting water

1
MILLION PEOPLE die each year from water, sanitation and hygiene-related diseases

260
BILLION DOLLARS is lost globally each year due to lack of basic water and sanitation

Source: water.org

Above, Aïda Muluneh (Ethiopia, 1974), "Beside the door" (2018); on the left, "Star Shine, Moon Glow" (2018).

as a house supported by three pillars: governance, finance and knowledge. These three pillars need to be well built to ensure that every drop of water is useful. To improve efficiency, we now need to go beyond the concept of integrated water resource management, which is a vertical approach, to the short water cycle. It needs to be combined with a horizontal approach, based on the fundamental links between water, energy, food, health and education, by applying the "Five Fingers Alliance" concept. This is a new approach, one which finally enables, at a national and local level, development policies to be implemented without segmentation or isolation, and without opposing each of the five "Fingers" against the others, seeing them as interrelated rather than conflicting. Thus expanding a city or building a school must answer each of these five basic factors simultaneously, rather than focus on one to the detriment of the others. The right to water, so easily proclaimed yet so difficult to enforce, will be the common thread running through collective action and policy on water security.

Water and energy: rights and interdependence

The right to water and the right to energy need a common approach, as the days of easy water and easy electricity are gone. Today, nobody questions the fact that water along with energy are essential to human, economic and social development. Water and energy are indispensable to fulfill humanity's basic needs: health, food and education. There is also a strong interdependence between water and energy: water is key for clean energy production and energy is essential for water supply. When the cost of energy is too high, the cost of water is unaffordable. To implement access to water for all, we must take into account energy and water management. The World Water Council advocates five recommendations promoting a common approach for water and energy:

1 | Access to energy and water should be given the same importance and implemented together at international, national and local levels

2 | The financing of water and energy, together as a whole, should be considered as one main priority for sustainable and equitable development for humans and nature

3 | Urban and rural planning should include water and energy together as a whole, in the same scope

4 | Electricity and water resources should both be approached as renewable energies. Water recycling and re-use should be a legal obligation

5 | Combined governance of water and energy should be promoted at all levels in order to give consistence and priority to affordable and sustainable supplies.

We are on the road to the 9th World Water Forum, which will be held in March 2021 in Dakar, co-organized by the World Water Council and the State of Senegal. Let's seize this opportunity to work together. I invite the large energy community to join the water community to bring joint solutions and give answers and responses to the world, as populations need our joint commitment to improve the planet. It is an emergency.

Aïda Muluneh (Ethiopia, 1974), "Access" (2018). The photo entitled *Access* is an artistic representation of the concept of access to water. As the photographer explains, "The world is continually bombarded with images of Africa's social situation, so my special interest in this project was to address these issues without the clichés presented in the traditional media and in way to raise awareness through art."

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Scenario/The challenges posed by the fractures in international politics

Water in a G-Zero World

Living in an era characterized by the unravelling of the old American-led world order complicates both geopolitics and access to water more than ever, largely because geopolitics will cause water stress, which in turn will set the geopolitical agenda

THE G-ZERO WORLD

The term "G-Zero world," first coined by political scientists Ian Bremmer and David F. Gordon, refers to an emerging vacuum of power in international politics created by the decline of Western influence. It aims to explain a world in which there is no single country or group of countries that has ability and will, economically and politically, to drive a truly global agenda.

IAN BREMMER

President of the Eurasia Group and GZERO Media, and author of *Us vs. Them: The Failure of Globalism*, a *New York Times* bestseller published in Italy with the title of *We against Them* (Bocconi University Publisher, 2018).

Ours is a G-Zero world, one defined by the unravelling of the old American-led world order. The lack of a clear geopolitical pecking order has affected the way countries approach trade (see: US vs. China, TPP), technology (see: 5G leadership, the battle for AI supremacy), and security (see: Syria, NATO tensions). The result is a world that is less stable, less secure and less predictable as the geopolitical risks steadily mount.

Those risks will only be compounded by the looming era of water stress. Global demand for water will be 55 percent higher in 2050 compared to 2000, while climate change is going to result in too much or too little water across every part of the world. Put another way—a fundamental building block of human infrastructure is going to be increasingly threatened, and at a time when there is no international structure in place to effectively deal with that reality and all the complications that will inevitably arise.

Living in a G-Zero world makes both our geopolitics and our access to water trickier than ever. And a big reason for that is that geopolitics will drive water stress, and water stress will drive our geopolitics. Here's how.

How geopolitics drives water stress

First, two big examples where geopolitics is already driving water stress, and will continue to do so for years to come:

Per capita, Asia is the world's driest continent, and the geopolitical instincts of its major powers are only exacerbating the continent's water challenges. The geostrategic rivalry between India and China is the backdrop to both countries' decisions to build dams, divert or otherwise manipulate rivers, and even to ionize clouds in the Himalayan plateau to increase rainfall. These actions are having a major impact on the availability and quality of water for hundreds of millions of people; better coordination between the sub-continental countries and China would lead to much better water outcomes for all involved. But the prospects of that are lower in a G-Zero world, where countries feel like they are increasingly forced to fend for themselves. That breeds competition, not cooperation—and water will be one of the resources over which competition will be fiercest, in Asia and beyond.

Africa is where the impacts of water stress will be most acutely felt. This is nothing new for the continent—start with the Nile. A 1929 treaty (and a subsequent one in 1959) gave Egypt and Sudan rights to nearly all of the river's waters (Egypt depends on the river for 90 percent of its water →

© ANTON ALEKSENKO/ALAMY/IPA

© GETTY IMAGES

THE DISPUTED WATERS OF THE NILE

A treaty signed in 1929 granted rights to Egypt and Sudan to almost all the river's waters. Ethiopia, which was excluded from the agreement, proceeded with the construction of a large dam on the Blue Nile, one of the main tributaries of the Nile, which rises and flows for a long stretch within its territory. This initiative sparked protests from the Egyptians.

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THE RIVALRY BETWEEN INDIA AND CHINA

The geostrategic rivalry between India and China is the backdrop to decisions taken by the two countries to build dams, divert the flow of rivers and even ionize the clouds on the Tibetan highlands to increase rainfall. Greater coordination between the parties involved would have far better consequences for the water supply in both countries.

© GETTY IMAGES

THE CLASH OVER THE ARCTIC

The gradual melting of polar ice due to climate change raises questions about who has the right to control the new routes that are opening up and to benefit from the undiscovered deposits of natural resources that lie below the surface. The five states with Arctic coastlines have clashed over these issues several times.

THE MIDDLE EAST

The Middle East peace plan proposed by the Trump administration does not consider the water stress affecting Israel, the Palestinian territories, Syria and Jordan. Today's political conflicts have made it impossible to devise a plan in which territorial divisions are based on the types of cross-border water relations necessary to allow sustainable use of water.

needs). Ethiopia was not party to the deal even though its Blue Nile contributes much to the flow, and the country has moved ahead with the construction of a major dam to generate the electricity it needs to achieve its domestic and regional ambitions. Talks between the three countries have so far failed to produce an agreement. That's not surprising given the dependence of all three on access to the Nile, and the difficulty of compromising on such a critically important resource. That points to the need of other political actors, like the U.S. and/or the African Union, to step in and help broker a viable agreement acceptable to all.

How water stress drives geopolitics

The other side of the coin is how water stress both causes and amplifies geopolitical conflicts. The political and humanitarian crisis in Syria, the northwards migration of people from South and Central America and the flow of refugees from North Africa into Europe have all been linked with varying degrees to increasing levels of water stress. It's not hard to see why and how populations affected by water stress tend to move, and that such movement tends to cause conflict with significant geopolitical implications. But there are two less obvious—but equally important—links between water stress and geopolitics that tend to get overlooked.

The first stems from too much water, not a lack of it. As climate change at the poles turns increasing amounts of ice into water, competing geopolitical interests come to the fore. The sea lanes that open up, including in the Northeast and Northwest, present new questions about who has the right to control these seaways and to benefit from the undiscovered natural resource deposits that lie beneath them. There's a history of conflict between the five Arctic Coastal states—Canada, Denmark, Norway, Russia, and the United States. Factor in China's growing interest in securing energy commodities that are now increasingly open to extraction and transport, and the change in the hydrosphere becomes an intensifier of geopolitical rivalry.

The second less-obvious way water stress drives geopolitics is by limiting the possibility of geopolitical reconciliations. Take the Trump Administration's Middle East peace plan for instance; the acute water shortage faced by Israel, the Palestinian territories, Syria and Jordan make it much harder to achieve the outcomes laid out in the plan, as it relies on the new territories achieving and maintaining a form of self-sufficiency as a means of reducing conflict. Yet, acute water shortages, caused by drought conditions in the Eastern Mediterranean for 15 of the last 20 years, means each of the key states is likely to face increasing domestic water stress. That reality is not accounted for in the peace plan. Indeed, a peace plan that would have been built from the "water up"— i.e., if renewed rights and territory allocations were based on the types of cross-border water relationships required to enable sustainable water use—would look very different than the one ultimately presented. That's wasn't feasible given the political realities of today, which is a big problem when water stress constrains the political realities of the future.

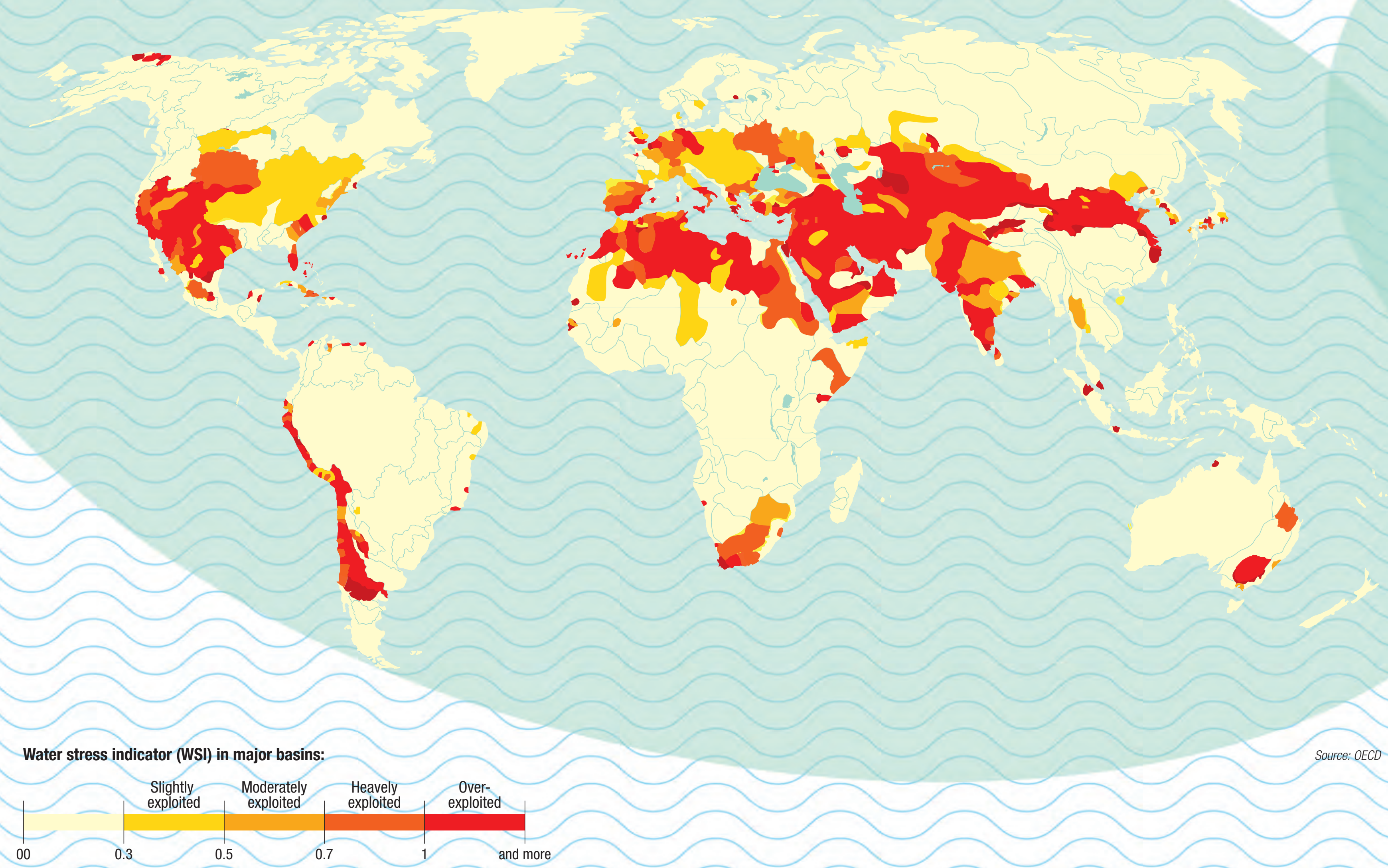
Water politics is nothing new; what's new is the fractured international politics of the moment. We will be living in this G-Zero world for the foreseeable future, which means water will be more important and more contentious than ever. How countries prepare for this reality will go a long way in determining which governments are most successful at navigating the choppy geopolitical waters ahead.

Analysis/Managing water trade-offs

All that Glitters is not (Blue) Gold

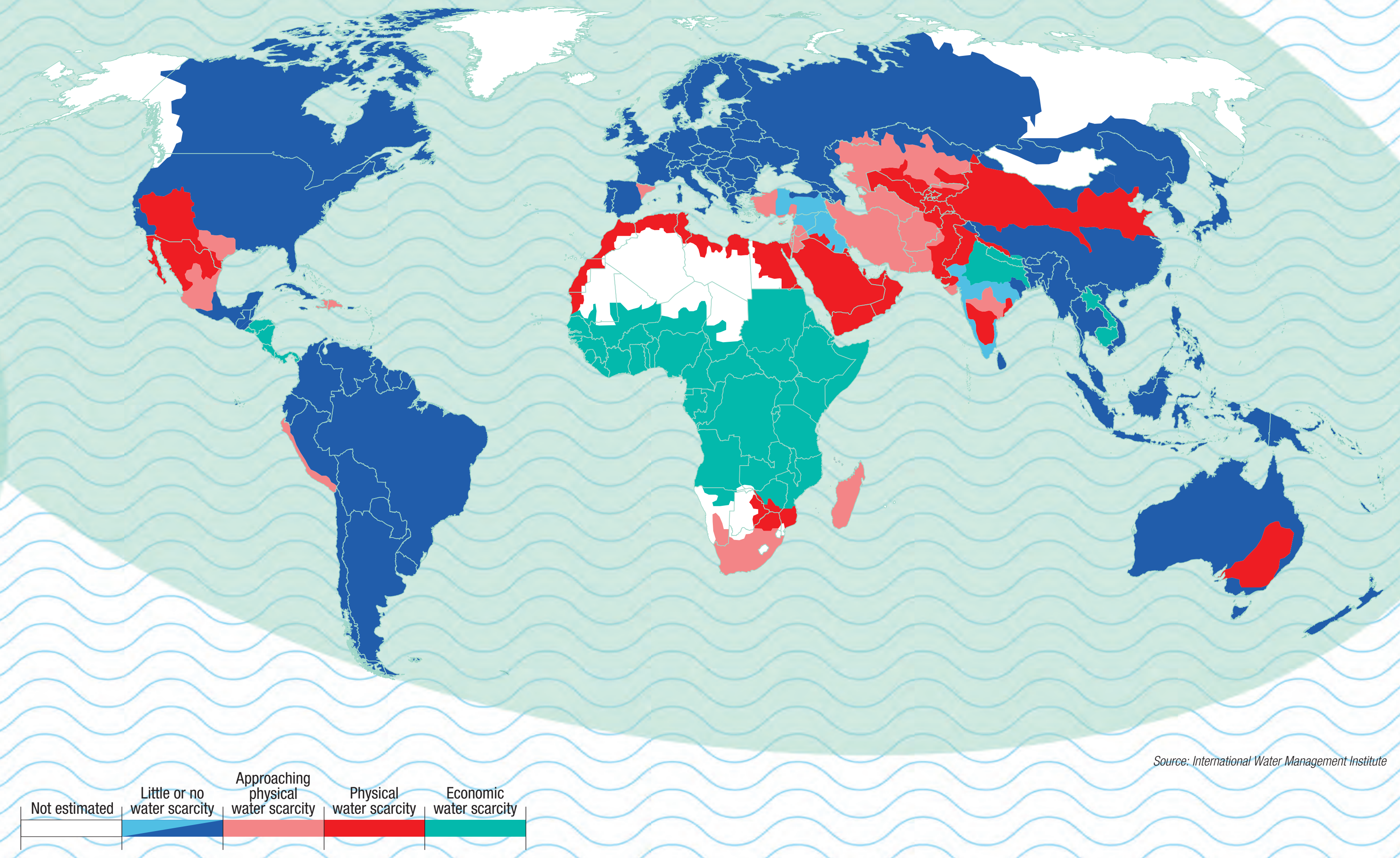
The water crisis is not about a lack of water but about creating a system of rules that determines who manages and governs it and how the economic cost is paid to make it widely available

FIGURE 1 — **WATER STRESS INDICATORS ON A GLOBAL SCALE**



Source: OECD

FIGURE 2 — **PHYSICAL AND ECONOMIC SCARCITY**



Source: International Water Management Institute

ANTONIO MASSARUTTO

Teaches public economics at the University of Udine. Director of IEFE (the Center for Research on Energy and Environmental Economics and Policy at Bocconi University, Milan), working on environmental policies and the organization of local public services, especially in the water and environmental fields.

According to the OECD, if current trends do not change, 4 billion human beings will experience issues of "water stress" by 2030: North Africa, the Middle East, Central Asia and the U.S. Pacific seaboard are the main candidates.

The water stress index represents a combination of the allocation of natural resources (precipitation per capita) and intensity of use (usage per capita). This does not mean per se that we're going to die of thirst, but rather suggests a growing conflict between its usages. Economists use the term "trade-off": do either one thing or another. The alternatives are mutually exclusive, and something has to be sacrificed.

In the media debate, however, the terms of the issue are often misunderstood. In the dominant narrative, water scarcity is framed as a problem of physical scarcity. Water is becoming increasingly scarce, because we are squandering it by running out of "reserves," and because humanity is growing, the world population having now exceeded 7 billion. Conflicts are therefore bound to arise over "blue gold," the oil of the 21st century. The multinationals, long since aware of this, are trying to grab usage rights, to later be sold off at a profitably high price. Citizens have revolted against this attempt, proclaiming a "right to water," acknowledged by a movement ranging from the UN to Pope Francis and now even codified in national constitutions. The same tendency equally forcefully vaunts citizens' ownership of water (a trope of the "common good"), resulting in a corollary of requiring government management, alien to the logic of profit.

Such a reformulation has become so ingrained in the back of our minds that it has become a kind of conditioned reflex, an inalienable truth, even a mantra. All we need to understand the fundamental mistake being made is a little data analysis. Of course there is some truth in this, but the causal concatenation, the way concepts and data are juxtaposed, ends up somewhat blurry and ultimately misleading.

Physical and economic scarcity

To begin with, who ever said that water is scarce in a physical sense? The availability of fresh water is accounted for in billions of cubic meters, usage in millions of cubic meters. The difference is a factor of 1000. This is confirmed not only on a global scale, but also on a continental and sub-continental level. Yes, there are regions of the world where water is actually scarce in a physical sense (the deserts of the U.S., North Africa, some parts of Central Asia and northern China, southeastern Australia), although that scarcity could be thought of as due to the concentration of population in resource-poor areas.

Again, it should be considered that, at a certain finite cost—a high but not very high one—water can be made available in desired quantities, anywhere. The cost of seawater desalination in plants of sufficient size is around USD 0.50/m³; this technology is already being widely used, from California and Spain to Greece and Israel.

Another fact that should be noted is that water resources are not a finite stock, as is the case with fossil fuels. Water is a flow, constantly renewed with the cycle of evaporation and precipitation. Total precipitation has become less significant than outflows, the profile of which is reliant on the capacity of "natural reservoirs" (snow, ice, lakes and underground aquifers) and, to a much lesser extent, artificial ones (regulated lakes, dams, aquifer recharge).

In another light, this feature ensures that the usages of water do not necessarily involve consumption or grabbing from other possible uses. In other words, the highly intensive usage of water where it is available in abundance is not necessarily a waste (the water taken would otherwise have ended up at sea, certainly not increasing availability to those in need).

So, where's the problem?

Firstly, what matters is not the absolute availability of water resources, but rather accessibility and usability at a reasonable cost. The fact that we can have all the water we want at a given cost does not protect us from conflict. That cost may be higher than the theoretical option of paying per use, especially for irrigation. Secondly, that cost may still be out of reach for potential users, because they are too poor to afford it. It's "economic scarcity," rather than physical, where there is an issue for a significant portion of humanity. That is, where purchasing power is insufficient, drilling a well to access an underground aquifer can also be prohibitive. Especially in terms of agriculture, the issue of scarcity is mainly the concern of those whose livelihoods depend on self-sufficiency on agricultural products, and not so much of those where agriculture is fully incorporated into a market mechanism.

To add a little levity, water isn't scarce, it's heavy. For human use, it must be available in the times and places it's needed, at the right quality. This is possible, but it requires wastefulness of technology and economic means. It's not water scarcity, it's a lack of money, warns Bernard Barraqué, one of the European gurus in the sector.

So, we need an organization, a management system, a system of rules that determines who manages and governs it, by whom and how it is accessed, by whom and how the economic cost is paid to make it widely available.

On closer inspection, "water wars" are almost never conflicts over the appropriation of one disputed resource or another; they involve much more subtle conflicts. They are an issue of governance, inasmuch as they relate to the need to cope with stressful situations (there is less water than is needed) with an evolution of the system of services and rules.

Disorderly growth of megacities and lack of infrastructure

The visible growth of megacities, especially in the poorer countries of the world, is the most obvious symptom of "water stress": not because of a lack of water, because there is no way to support such a tumultuous development with the service networks that could accommodate them. In the never-ending suburbs, people do not have water because there is a lack of adequate infrastructure, due both to supply and the equally important factor of sanitation and hygiene.

"There is enough water for everyone…. Water insufficiency is often due to mismanagement, corruption, lack of appropriate institutions, inertia and a shortage of investment in both human capacity and physical infrastructure," the United Nations noted in 2006.

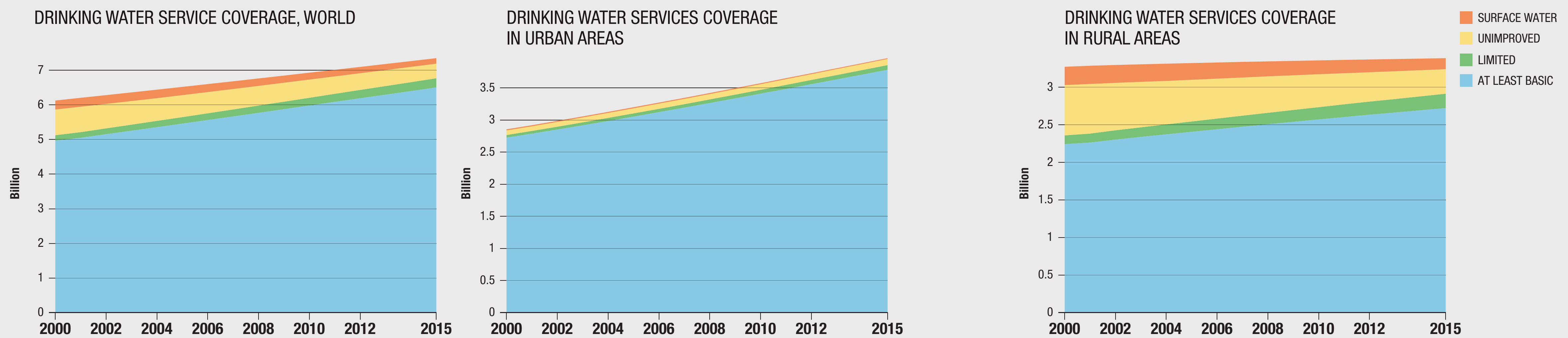
Secondly, stating that water is a resource that is cyclically renewed does not mean that human use cannot interfere negatively with this cycle, as is the case, for example, when an aquifer is permanently damaged by too much tapping.

As well as its heaviness, water is also vulnerable. If we want to use it for all →

SUSTAINABLE DEVELOPMENT GOALS
WATER AND SANITATION, **GOAL 6.1**

FIGURE 3 — **ACHIEVE ACCESS TO SAFE AND AFFORDABLE DRINKING WATER**

Population using a given drinking water sources (total, in urban areas and in rural areas). At least basic drinking water represents an improved source within 30 minutes' round trip to collect water; "limited" constitutes an improved water source more than a 30 minute round-trip away; "unimproved" is one that by the nature of its construction does not adequately protect the source from outside contamination; and "surface" is that from surface water sources.



our needs (in both the civil and the production sectors), we cannot forget the ecological functions nor act in such a way as to alter the renewability profile.
Thirdly, the case of water clearly reveals one of the most critical and disturbing features of what we usually know as the Anthropocene, a phase of the Earth's evolution, characterized by the near-ubiquitous extent of anthropogenic impact on the ecosystem. The "water-food-energy nexus" reveals to us the increasing interdependence that exists between these three issues, all crucial to our development. It is not possible to address one without affecting the others, and we therefore need an integrated vision that considers all the interrelations between them.
The use of water resources, even if abundant, needs to be made hugely more efficient. The linear model of the past, that of the Roman aqueducts, traveling further and further to find more resources to feed the metropolis, is no longer practicable. It is necessary to invest intensively in a completely new system, drawing its inspiration from "circular" recycling, i.e., doing more with less, supplying the uses of one with the (treated) waste of another, increasingly replacing "natural capital" with the "artificial capital" of technology.
Translated into practicalities, this awareness means that not only is the investment of immense resources needed to achieve water infrastructure, but that even more money must be spent to ensure that the water we return to the environment does not affect the essential functions of the water ecosystem. Taking Italy as an example, we see that the real water emergency is not drought or anyone dying of thirst, but rather the inadequacy of the country's sewage and treatment systems, the incompleteness of which has already resulted in E.U. sanctions. But more generally, Italy is suffering from an aging infrastructure overall, a lot of which needs modernization. Only recently have we seen a relatively clear and uniform framework of information on service levels and needs for maintenance and improvement, a worrying situation that requires investment of tens of billions of euros.
As demonstrated by a recent REF study, however, such an investment plan could be a major boost to overall demand, and could also therefore promote Italy's economic recovery. These resources can be mobilized through tariffs—still lower than in most European countries. However, this will require a complete overhaul of tariff structures to avoid impacting the weaker social groups.

Goal 6, safe access for all

Things are not that different around the world, although due proportionality is vital.
The Millennium Development Goals for drinking water (to cut by half the number of people with no access to a guaranteed and controlled water supply) were achieved on time. It's proving a tougher challenge to meet the Sustainable Development Goals for 2030 (ensuring safe and economically sustainable access to drinking water), despite the fact that the numbers have risen by around 1 billion over 15 years. The rise in global population, especially in poorer countries, is moving the goalposts further and further apart (Figure 3). The graphs clearly show that the main problem is in rural areas.
Further still lie the goals on purification (Figure 4). Despite some progress in absolute terms, distance from this goal is widening even more. Again, the issue is mainly concentrated in rural areas. Access to personal hygiene in much of the world is guaranteed to less than half of the total population.
The main issue here, however, is the ability to mobilize the necessary economic resources. Although even a significant increase in tariffs would not be an insurmountable problem in terms of social impact, in most poor countries these margins are much more limited. This does not mean that they are non-existent, as demonstrated by multiple studies conducted by the United Nations, the World Bank, the OECD and the Asian Development Bank.
The consequence of this reasoning is that when we talk about sustainability, in terms of water, we need to look at four different factors at least (Figure 5).
The first dimension is the environment: water use should interfere as little as possible with its ecosystem functions, ensuring its integrity. The second is ethics. Water is a fundamental asset—access to it is considered a fundamental human right, so its cost cannot exclude those who are unable to pay. Third, the financial aspect. The costs of building infrastructure and managing services must be covered, so the system can mobilize adequate human, technical and financial resources. The fourth is economics. Water resources must be allocated efficiently (i.e., favoring the uses that create the most value), but economic resources must also be allocated efficiently (i.e., investment to upgrade infrastructure should only be made if the value of the water made available exceeds the cost).
All four are equally significant, even if they do result in a paradox. If it is true that the economy consists of the application of the scientific method to trade-offs, that is, to mutually exclusive choices, the essentially economic nature of water scarcity and its associated conflict is revealed.

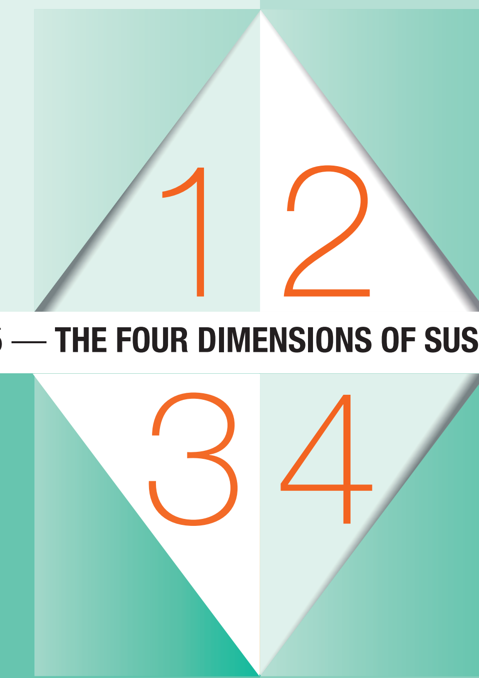
FIGURE 5 — **THE FOUR DIMENSIONS OF SUSTAINABILITY**

ECOLOGICAL SUSTAINABILITY

- Prevent depletion of critical natural capital
- Guarantee ecological functions of water natural capital
- Avoid unnecessary artificialization of natural water cycles
- Avoid unnecessary interference with natural processes
- Achieve circular economy targets

SOCIAL SUSTAINABILITY

- Guarantee access to "merit uses" in a fair and equitable way
- Identify basic ecological functions to guarantee as human right
- Water price should be affordable to any individual
- Share water resources and costs in a democratically accepted way
- Prices should be clear and transparent
- Encourage public participation and stakeholders' involvement



FINANCIAL SUSTAINABILITY

- Guarantee financial viability of water management
- Compensate inputs at their market price
- Be attractive for high quality inputs
- Avoid excessive sunk costs
- Generate cash flows that are coherent with investment needs and debt service requirements
- Guarantee cost recovery and financial equilibrium

ECONOMIC SUSTAINABILITY

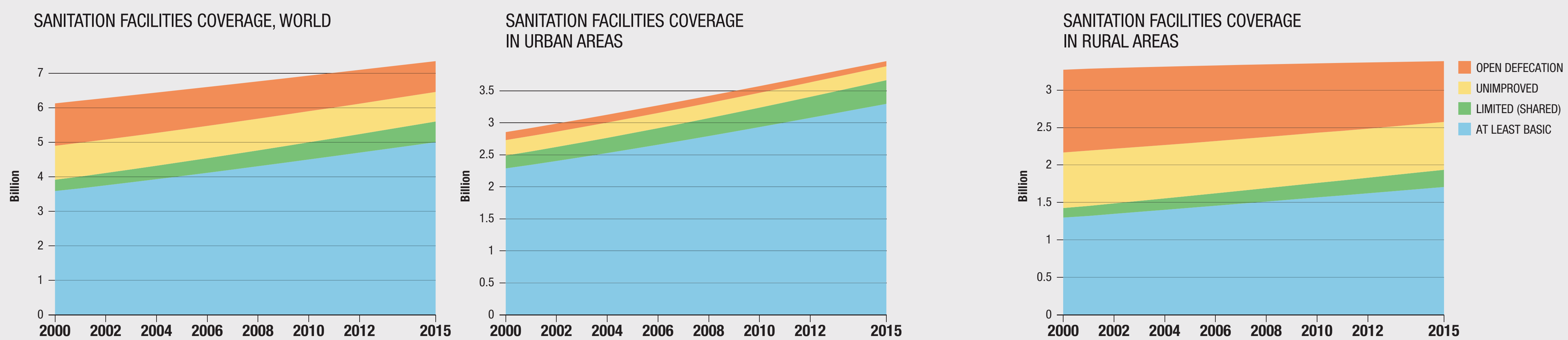
- Allocate available scarce resources to most valuable uses
- Encourage cost-saving innovation
- Reduce cost of service provision to the lowest possible
- Augment water supply and infrastructure only if socially valuable
- Avoid remuneration of inputs > opportunity cost (profit, rents, etc.)
- Discourage excessive use of inputs (over-staffing, gold-plating etc.)
- Avoid waste of social welfare opportunities

Source: Massarutto A., "Servant of too many masters. Residential water pricing and the channel of sustainability", Utilities Policy, 63, 2020

SUSTAINABLE DEVELOPMENT GOALS
WATER AND SANITATION, **GOAL 6.2**

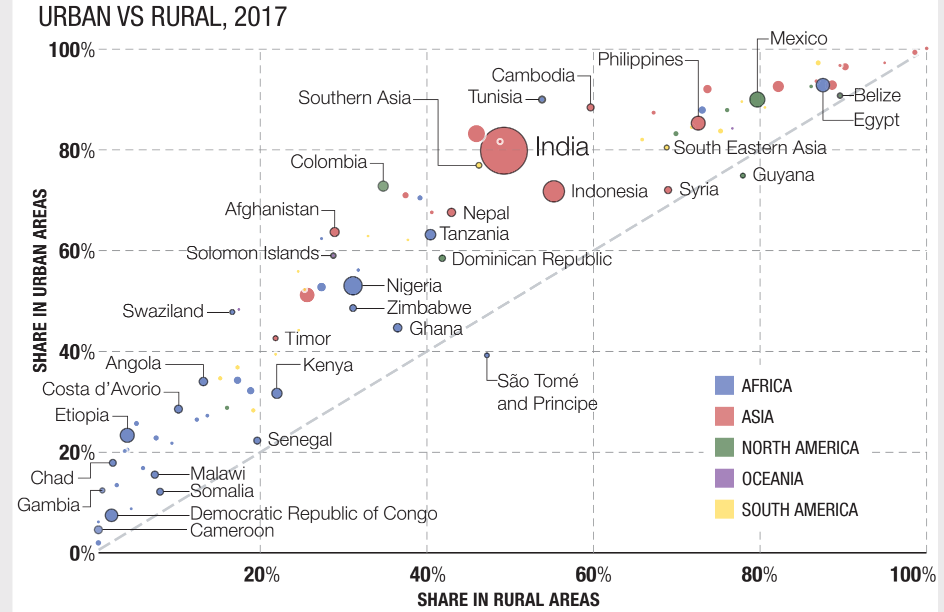
FIGURE 4 — **ACHIEVE ACCESS TO SANITATION AND HYGIENE**

Number of people with access to different sanitation facilities (total, in urban areas, in rural areas). "At least basic" are improved sanitation facilities not shared with other households; "limited" are improved facilities shared with other households; "unimproved" are facilities without a flush/pour flush (to piped sewer system, septic tank, pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, or composting toilet.



Source: UN, Sustainable Development Goal 6 – Synthesis Report on Water and Sanitation

PROPORTION OF POPULATION WITH BASIC HANDWASHING FACILITIES, URBAN VS RURAL, 2017



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Focus/The water footprint of agriculture and how it reflects on our economies

The Virtual Water Concept

GLOBAL WATER FOOTPRINT OF AGRICULTURE PRODUCTION, INDUSTRIAL PRODUCTION AND HOUSEHOLD CONSUMPTION

Source: *Mekonnen and Hoekstra, 2010a **Mekonnen and Hoekstra, 2010b

THE GRAPH SHOWS THE GLOBAL WATER FOOTPRINT OF AGRICULTURAL PRODUCTION, INDUSTRIAL PRODUCTION AND DOMESTIC CONSUMPTION, CALCULATED IN THE YEARS 1996-2005.

	AGRICULTURAL PRODUCTION			INDUSTRIAL PRODUCTION	DOMESTIC WATER SUPPLY	TOTAL
	CROP PRODUCTION	PASTURE	WATER SUPPLY IN ANIMAL RAISING			
GREEN	5,771*	913**	-	-	-	**6,684**
BLUE	899*	-	46**	38	42	**1,025**
GREY	733*	-	-	363	282	**1,378**
TOTAL	**7,404**	**913**	**46**	**400**	**324**	**9,087**
WATER FOOTPRINT FOR EXPORT (Gm³/yr)		1,597		165	0	**1,762**
WATER FOOTPRINT FOR EXPORT COMPARED TO TOTAL (%)		19%		41%	0	**19%**

Grey water is the water needed to dilute pollution in the return flows of water to the environment after agricultural, industrial and household use. Blue water is the freshwater that can be pumped, valued and consumed in all economic sectors. Green water is the water in soil profiles that supports natural vegetation and crops.

GLOBAL AVERAGE VIRTUAL WATER CONTENT OF SOME SELECTED COTTON CONSUMER PRODUCTS

THE DETAIL OF THE AVERAGE OVERALL VIRTUAL WATER CONTENT OF SOME COTTON CONSUMER PRODUCTS.

	1 PAIR OF JEANS	1 SINGLE BED SHEETS	1 T-SHIRT	1 DIAPER	1 BUD OF COTTON	
STANDARD WEIGHT	**1,000 g**	**900 g**	**250 g**	**75 g**	**0.3 g**	GRAMS
BLUE WATER	4,900	4,400	1,230	370	1.6	LITERS
GREEN WATER	4,450	4,000	1,110	330	1.5	
DILUTION WATER	1,500	1,350	380	110	0.5	
VIRTUAL WATER CONTENT	**10,850**	**9,750**	**2,720**	**810**	**3.6**	

Tony Allan, winner of the prestigious Stockholm Water Prize, who devised the concept, explains how much water is used to produce food and non-food consumer goods, including energy. It is a vital but economically invisible resource

TONY ALLAN

A scientist and professor, Allan is recognized as a world authority on water-related issues. In 2008, he received the prestigious Stockholm Water Prize for his pioneering contributions to understanding and communicating water problems. In 1993, he introduced the concept of "virtual water."

The concept of virtual water is important because it enables us to understand why we enjoy the illusion of water and food security despite strong evidence that the water resources available to sustain our national economies are inadequate.

What is virtual water? Virtual water is the water embodied in the production of food and fiber and non-food commodities, including energy. For example, it requires about 1300 tons (cubic meters) of water to produce a ton of wheat and 16000 tons (cubic meters) of water to produce a ton of beef. Thus, someone who eats a lot of beef can consume as much as five cubic meters of embodied water daily, whereas a vegetarian will consume only about 2.5 cubic meters. Production of a cotton T-shirt weighing about 250 grams requires about 2.7 cubic meters of water.

Hoekstra and Mekonnen estimated that the global annual average water footprint of humanity was about 9,087 billion m³/year. This is a tiny proportion of global blue and green water and approximates the blue water flow of the Amazon, the world's largest river. But it is the volume of water our rainfed farmers and irrigators have been able to use in the farmland they have converted from natural vegetation. Agricultural production accounts for about 92 percent of global water consumption, industry accounts for about 4.4 percent and household water consumption about 3.6 percent. They also estimated that the total volume of international virtual water "flows" related to trade in agricultural and industrial products was 2,320 billion m³/year.

The concept of virtual water—the water embodied in food and non-food commodities—helps explain why our unsustainable political economies of food-water resources exist. More importantly the concept explains why the existence of the dysfunctional food system can be so effectively backgrounded politically.

Types of water and competition for water

This is a food-water story rather than a non-food-water story because much more water is consumed in producing food than in any other economic or social activity. The world population is currently over 7.5 billion and predicted to rise to over 11.5 billion by the end of the century. Levels of competition for water are in most places unsustainable, and the current dysfunctional food and water consumption systems are retained at the expense of the health of the planet's natural water.

Society and its legislators are poorly informed on the emotional issue of water security, although there is general awareness that access to essential volumes of water is fundamental to the existence of a secure food system and a stable society. There are occasional food-water crises, but they come and thus far go away. It has proved politically feasible to background the fact that our water systems are economically and environmentally unsustainable, but the increasingly intense climate change debate has exposed the need to improve the health of Nature's water ecosystems. Unfortunately, the policy agenda is congested, and water allocation and management tend to be crowded out by other critical issues.

There are the two major types of natural water. First, blue water exists in flows and storages of freshwater that exist at the land surface and in groundwater systems. Blue water can be easily pumped and engineered and can, with difficulty, be valued. The demands for blue water are diverse, as it can be consumed in all economic activities including the generation of energy. It is normally over-used because blue water cannot look after itself and is vulnerable to over-consumption. Unregulated farmers, energy generators and industrial and household consumers can pump last year's water if it is in a reservoir. They can, unfortunately, also consume the water that might be in a reservoir next year.

Second, green water, known as effective rainfall by some water scientist, exists as flows and storage in the soil profiles of farmland and natural landscapes. It cannot be pumped or moved, except as virtual water embedded in food supply chains. Farmers access green water on behalf of society. They can do this because they work with the biggest pumps in the world: vegetation and crops have the capacity to pump green water upwards. This water can in turn be moved as virtual water to food consumers. Engineers and shippers can only dream of pipelines and transportation systems that could move the equivalent volumes of real water. The world's food supply chains move →

FIGURE 1 — **LONG TERM TREND IN INTERNATIONAL FOOD COMMODITY PRICES**

REAL PRICE
LONG TERM TREND
OUTLOOK 2017
HIGH SUPPLY – LOW DEMAND
LOW SUPPLY – HIGH DEMAND

The long term trend in international food commodity prices reveals periodic food price spikes during two 20th century world wars and the oil commodity price volatility of the 1970s, which affected all commodity prices. The 10 year projections are consistent with the long term trend of real/constant prices, but things could change!

FIGURE 2 — **VIRTUAL WATER BALANCE BY COUNTRY AND TRADE-CONNECTED FLOWS**

Net virtual water import (Gm³/year)
-95 – -75
-75 – -35
-35 – -15
-15 – -5
-5 – 0
0 – 5
5 – 10
10 – 50
50 – 100
100 – 305
Gm³/year = billion m³/year

Source: Mekonnen, M. M., & Hoekstra, A. Y., 2011a, The green, blue and grey water footprint of crops and derived crop products. "Hydrology and Earth System Sciences", 15(5), 1577–1600.

The map shows the virtual water balance by country and the direction of virtual gross water "flows" connected with the trade in agricultural and industrial products in 1996-2005. Only the biggest gross flows (>15 billion cubic meters a year) are shown; the thicker the arrow, the greater the "flow" of virtual water.

water invisibly at negligible cost as the virtual water in food supply chains. Green water consumption is limited to sustaining natural vegetation and producing local crops. The competition for green water is between irrigators and nature. Green water is extremely difficult to value as it is associated with low value outputs. Unfortunately, the costs of mobilizing or protecting green water are not taken into account in our food systems. However, green water can to some extent look after itself as farmers can only use the green water actually available for the current season. The important thing to know is that a ton (cubic meter) of green water can produce as much food as a ton of blue water. Ignoring this fact will lead to bad water policy.

There are also two main types of water consumption. Food-water consumption and non-food-water consumption. Food-water can be blue or green. Non-food-water is always blue. The difference between water use and water consumption is also very important, as high rates of blue water re-use can be achieved in non-food systems. In highly developed economies, in California and Israel for example, levels of re-use as high as 80 percent have been achieved in non-food-water uses.

The main purpose of this introduction has been to foreground the idea that the water resources consumed by society are not just the 30 percent which are blue water resources. Green water resources produce most of society's food and fiber needs and green water accounts for 80 percent of the virtual water embodied in the 20 percent of food that is traded internationally.

Virtual water and international trade

It is the idea of international 'trade' in virtual water that has the biggest explanatory power. Figure 2 conveys the global reach and scale of virtual water 'trade.' It also shows the extreme asymmetry of this 'trade' in terms of the small number of major virtual water 'exporters'—Canada, USA, Brazil, Argentina, Australia and India and the very large number—over 160—of virtual water 'importers.' Russia and Ukraine have joined the group of major virtual water 'exporters' since 2000 after the fall of communism and the integration of their grain exports into the 150 year old global food trading system dominated by U.S. and French food commodity traders. These four ABCD corporates are the commodity traders ADM, Bunge, Cargill and Dreyfus, and they have been joined by Glencore (Switzerland) and COFCO (China).

Figure 3 shows trends in the past half century in the export and import of food and its virtual water content. On the left of the diagram there are seven economies well endowed with green and blue water resources as well as with farmland that enables them to be net virtual water 'exporters.' Australia is in this category because it has a small population. The net virtual water importers—there are in excess of 160 of them—are shown on the right of the diagram.

The idea that water can be embodied in goods and services is very powerful when it is deployed in the analysis of international trade and food security. An economy that imports food and manufactured commodities is apparently weak. But for the past 150 years, food importers have been beneficiaries of an economically and environmentally irrational system. Importers have not had to endure the daunting economic and political stress of mobilizing water resources from within their own water scarce economies.

Food and virtual water were available at low or no cost on the world market. Nor do they have to seriously damage their own biodiverse environments in producing food. It is estimated that food and fiber production accounts for 92 percent of society's water consumption and for 66 percent of society's negative impacts on the world's biodiverse environment. Since farmers provide food production services and ecosystem stewardship services, farming is the economic activity that most negatively impacts our water resources and other natural ecosystems. We should, but don't yet, value the stewardship services provided by farmers. It should be noted that many farmers across the world have grasped the importance of what is called regenerative agriculture. It involves the adoption of no till practices, cover cropping and rotational cropping. The establishment of the system has usually been farmer-led. Farmers have often shown that they are more responsible than scientists and governments.

The most important characteristic of virtual water 'trade' is that it is effective in meeting society's vital needs and at the same time is economically invisible and politically silent. It enables the water scarce to enjoy an affordable version of food and water security. Politicians dream of such stress-free solutions to what otherwise would be terminal disorder.

LOTS OF FOOD, LOTS OF WATER
Food and fiber production is estimated to account for 92 percent of society's water consumption. As farmers provide food production and ecosystem management services, agriculture is the economic activity that most negatively affects our water resources and other natural ecosystems.

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How virtual water was identified

The progressive increase in the demand for food commodities and for industrial goods and services in the second half of the 20th century progressively forced more and more economies into the category of net food importers. These countries did not have the water resources for them to be food and water self-sufficient. By the 1960s, there were many influential voices, especially in the water scarce Middle East and North Africa (MENA), predicting water wars. I followed this debate closely from the mid-1960s, and by the mid-1980s the population of the region had almost doubled, as had food demand. For two decades, water wars discourse had raged but no one was explaining the absence of armed conflict. National leaders did not need to explain the contradiction, and apparently they were handling difficult water resource issues effectively. There were no international water wars and street violence over occasional volatile food prices was rare.

As a water scientist, however, I needed to explain the absence of water wars. I was searching for economic processes that enabled economies such as Egypt to transition from water self-sufficiency into water deficit without apparent economic or political stress.

In the late 1980s, when investigating→

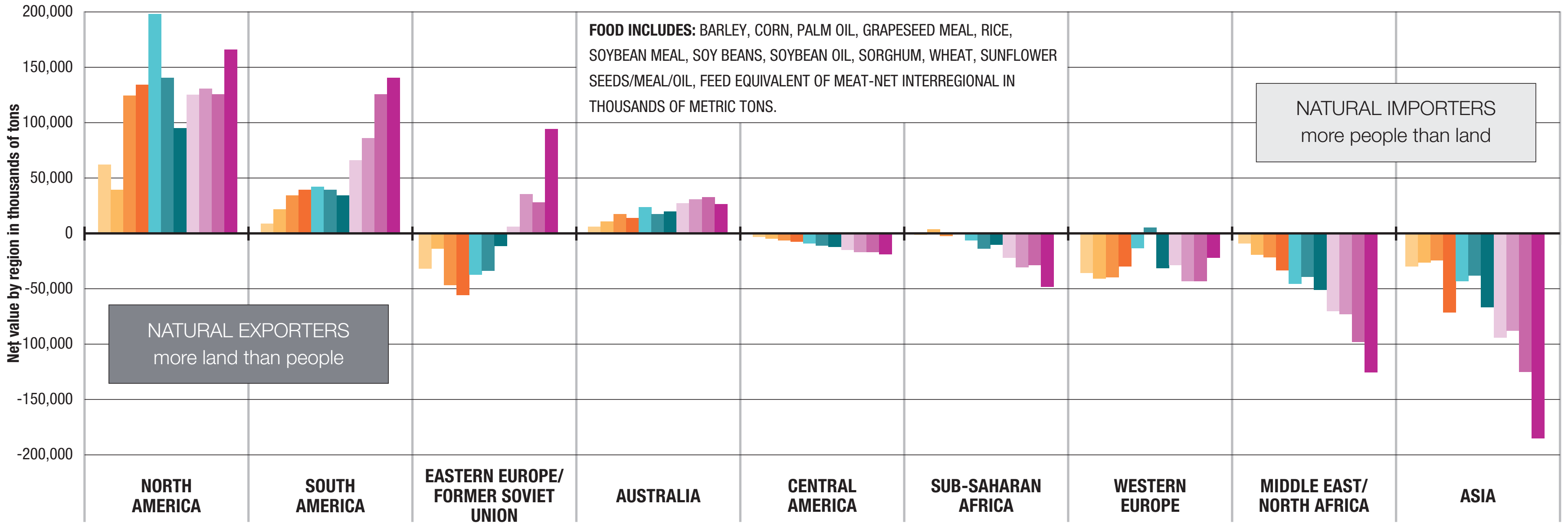


FIGURE 3 — **GLOBAL INTERNATIONAL TRADE IN MAJOR FOOD COMMODITIES**

Source: Cargill, 2017, Fed By Trade - Food Must Move to Feed a Hungry World.

Global international trade in major food commodities, 1965-2010, showing the seven economies that 'export' virtual water resources to the 160 or so economies on the right categorized in five regions that are dependent on food and virtual water 'imports.'

Egypt's food commodity trade, I noticed that in 1972 its wheat and flour imports started to rise from a very low level to a high level. Here was the answer to the absence of water wars. If you had to import food because you had run out of water, it was not a problem. Food importers were in a very privileged position. Food exporting economies charge neither for water consumed in food production nor for the costs of damaging their water ecosystems and their natural biodiversity. The biggest attraction, however, of importing food staples such as wheat has been that the food commodity prices enjoyed by importers of staple grains did not even reflect the full costs of farm production. Prices were subsidized by the exporters, and they remain subsidized. Importing underpriced food is a no-brainer for those managing low income and water scarce economies.

Figure 1 highlights the exceptional 1970s. There were two oil price spikes and associated food commodity price spikes in 1974 and 1979 and frightening rates of inflation. International food prices soared briefly and the former Soviet Union withdrew from the MENA region. It was an extraordinary decade of global oil and food politics. (Woertz 2013) which cannot be analyzed fully here. Suffice it to say the decade showed that politicians everywhere were very keen to align to ensure that the regime of under priced food returned as soon as possible. The global food system was and remains a dysfunctional political economy that does not operate according to the assumptions of economists. The economically invisible and politically silent 'trade' in virtual water operated throughout to make it possible to keep in place the social contract between politicians and people that food prices would fall rather than rise.

In the late 1980s, I called the water embodied in international food commodity trade embedded water. I decided to adopt the term virtual water in about 1992 when it was used during a weekly seminar in the University of London. I and many water scientists did not like the term, but it was evident that it had immediate popular appeal. Many water scientists still do not like the term but it is now widely used by water resource professionals in water science and policy.

Why is virtual water vital but economically invisible

Secure access to water and affordable food are very emotional issues and they can easily incite destabiliizng politics. Politicians have long made social contracts with their underpaid people to provide under priced food and free virtual water. This necessary but awkward contract needs to be handled carefully. When economies run out of water, they have to resort to 'importing' virtual water embodied in food. Governments in both high-income and low-income economies need to ensure that low cost food is available for those on low incomes. The United States provides food welfare for about 40 million people, or 14 percent of its own population, and it also provides high levels of food welfare for scores of the world's economies. Most important it determines levels of international food prices. It has become normal for most economies in the world to enjoy the benefits of underpriced food and free virtual water. But these food prices do not capture the costs of the food system and the result is a system that damages both the environments of food exporters and the long term food security of future global populations. This remarkable political economy can only exist if it is economically invisible and politically silent, but it is self-harming for the United States and other food exporters.

U.S. economic and environmental policies

The so-called dust bowl of the 1930s was a tragic rain-fed and green water mismanaging experiment that seriously harmed U.S. farmland. The U.S. lost vast volumes of soil as a consequence of deep ploughing soils vulnerable to wind erosion. Conservation measures were introduced and belatedly, 80 years later, soil and soil health are being valued as environmental capital. However, by the 1980s, farmers in the same plains of the Midwest were imposing an even worse version of irreversible degradation. This time it is the natural capital of blue water in the vast Ogallala aquifers that has suffered, and U.S. groundwater systems have paid the price. The United States has operated self-harming land and water managing policies for over a century. Despite the clear need to steward as well as consume precious groundwater, U.S. agricultural policy has been misallocating water to unsustainable farming systems. These systems include cereal production to keep in place an unsustainable first-generation bio-energy project, an environmentally unsustainable feedlot beef project and the production of rice and cotton in sub-optimum conditions. The U.S. is able to continue to operate its self-harming policies because it does not internalize their real costs. These policies are currently being strongly endorsed by President Trump and his secretary of agriculture. U.S. farmers are currently being urged to export more food without charging the full cost of production or accounting for the negative impacts on U.S. ecosystems.

In the arcane prioritization that takes place in the political economy of international food supply chains, there are a number of politically feasible outcomes. One of them is that U.S. farm livelihoods will continue to receive the support of public funds and the U.S., and the world's, underpaid will have access to underpriced food. This system enables the U.S. to continue to exert a measure of control over global food security. It operates a global food welfare system which tends to lower international food commodity prices. It is a system to which the world has become accustomed and one that stabilizes a critical element of the global political economy—namely food production and consumption.

We are left to question whether the U.S. can afford to keep this system in place. Or should it instead start to reverse the policies that are degrading its environmental capital in 'exports' of food and virtual water. Adopting this approach is not yet politically feasible, but it could guarantee the global water and food security of the human population in the second half of the twenty-first century.

Sustainable development/Policies to prevent risks and implement synergies

A Fundamental Nexus

An approach that takes into account the close connection between water and energy would lead to significant steps forward on some of the main challenges of our times: tackling climate change, ensuring energy security and providing energy, drinking water and sanitation to the billions of people who lack these today

MOLLY A. WALTON

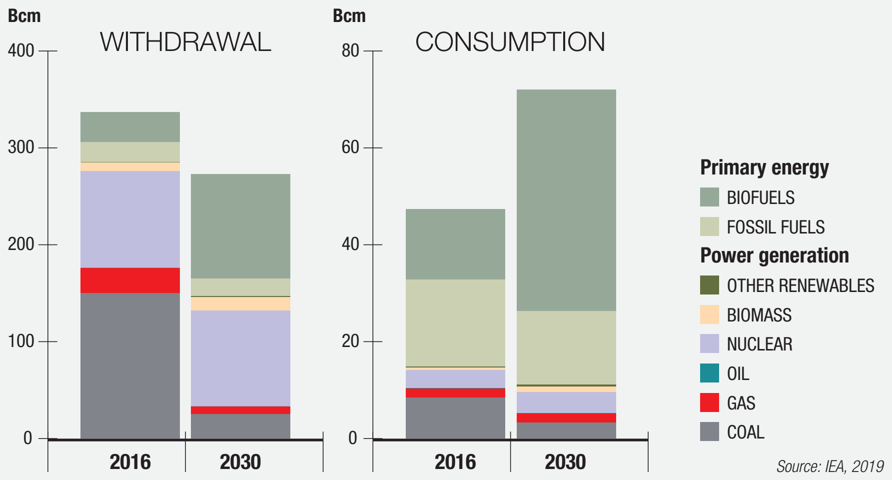
She is an energy analyst with the World Energy Outlook (WEO) at the International Energy Agency (IEA). In this capacity, she leads the IEA's analysis and engagement on the water-energy nexus and co-led the WEO-2017 special report on energy access.

Energy and water have always been closely intertwined; water is needed for all phases of energy production and energy is critical to water supply, wastewater treatment and desalination. How this nexus is managed is critical for the energy community as it has implications for the transition to a low carbon pathway, energy security and the attainment of the Sustainable Development Goals (SDGs).

Analysis by the International Energy Agency (IEA) found that the energy sector withdraws around 340 billion cubic meters (bcm) of water—defined as the volume of water removed from a source—and consumes roughly 50 bcm—the volume that is withdrawn but not returned to the source. This amounts to 10 percent of total global water withdrawals and 3 percent of consumption. While the energy sector's share is relatively low, global water demand could increase by 30 percent by 2050 (UN Water, 2019).

On the other side of the energy-water equation, the IEA found that the →

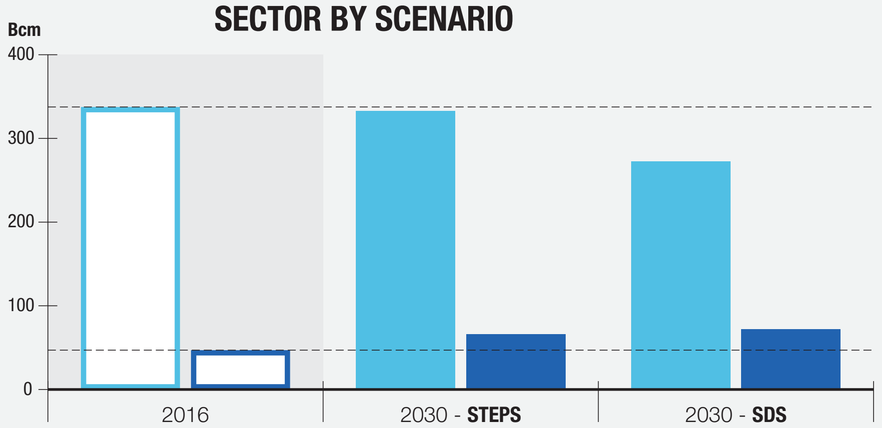
FIGURE 1 — **GLOBAL WATER USE IN THE ENERGY SECTOR IN THE SUSTAINABLE DEVELOPMENT SCENARIO**



Notes: Other renewables include wind, solar PV, CSP and geothermal. Hydropower is excluded.

The technology and policy choices in the Sustainable Development Scenario lower the energy sector's water withdrawals by 20 percent but increase consumption by 50 percent.

FIGURE 2 — **GLOBAL WATER USE BY THE ENERGY SECTOR BY SCENARIO**

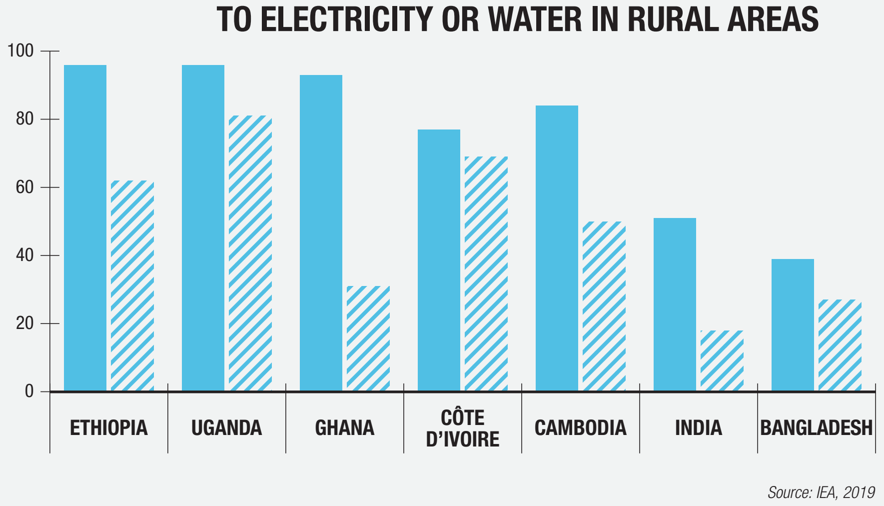


Notes: STEPS= Stated Policies Scenario, formerly called the New Policies Scenario; SDS = Sustainable Development Scenario.

WITHDRAWAL CONSUMPTION *Source: IEA, 2019*

The energy sector's water consumption rises in both scenarios relative to today. Withdrawals in the Sustainable Development Scenario are much lower in 2030 than they are in a scenario based on current trends and policies.

FIGURE 3 — **SHARE OF POPULATION WITHOUT ACCESS TO ELECTRICITY OR WATER IN RURAL AREAS**



WITHOUT ACCESS TO SAFELY MANAGED DRINKING WATER WITHOUT ACCESS TO ELECTRICITY

Almost two-thirds of those without access to clean drinking water in rural areas also lack access to electricity, opening opportunities to coordinate solutions.

water sector uses almost as much energy as Australia. Most of this is in the form of electricity, 850 terawatt-hours (TWh)—primarily for water supply and wastewater treatment—and represents around 4 percent of global electricity consumption. In addition, some 50 million tons of oil equivalent of thermal energy is used for desalination and diesel pumps for irrigation.

With both energy and water demand on the rise, it is increasingly important to understand the water-energy nexus in order to avoid unintended consequences, anticipate stress points and implement policies, technologies and practices that soundly address associated risks and maximize synergies.

How much water does a low-carbon pathway need?

While the energy transition can provide significant environmental benefits, the fuels or technologies used to achieve this transition can, if not properly managed, exacerbate or introduce water stress depending on the location, availability of water and competing users. Similarly, a lack of water could limit the options available to pursue a low-carbon pathway. While some low-carbon technologies such as wind and solar PV require very little water, others, such as biofuels, concentrated solar power (CSP), carbon capture, utilization and storage or nuclear power are relatively water-intensive. This underscores the importance of factoring water use into all energy policy decisions.

IEA analysis, which assessed the future water needs of various potential energy scenarios, found that an integrated approach focused on tackling climate change, delivering energy for all and reducing the impacts of air pollution (our Sustainable Development Scenario) results in lower water withdrawals in 2030 relative to today (Figure 1). This is due to the increased deployment of solar PV and wind, a shift away from coal-fired power generation and a greater focus on energy efficiency. As a result, withdrawals in the Sustainable Development Scenario are much lower in 2030 than they are in a scenario based on current trends and policies (our Stated Policies Scenario).

Comparatively, the energy sector's water consumption rises in both scenarios relative to today (Figure 2). The rise in consumption in the Sustainable Development Scenario is underpinned by a shift to more wet-tower cooling in the power sector, a rise in nuclear and greater reliance on biofuels in transport. Moreover, consumption accounts for a higher share of the energy sector's water withdrawals in this scenario (26 percent). Though water withdrawals are the

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first limit for energy production when water availability is constrained, water consumption reduces the overall amount of water available to satisfy all users.

Many of the climate impacts will be felt through water, which has implications for energy security

Water scarcity is already having an impact on energy production and reliability, and further constraints may call into question the physical, economic and environmental viability of future projects. On the other side, diminished freshwater resources can lead to a greater reliance on energy-intensive sources of water supply such as desalination. Each of these have potential implications for energy security.

Many countries already face some degree of water stress, and there is increased uncertainty about future water availability and the impact that climate change will have on water resources. Climate change is expected to alter the frequency, intensity, seasonality and amount of rainfall as well as the temperature of the resource, with an impact on both energy and water infrastructure.

Several countries that are large energy consumers, such as India, China and the United States, may find that their plans to increase power generation in some parts of the country will be dependent on water availability. Droughts and water shortages have already affected India's thermal power plants: India lost 14 terawatt-hours (TWh) of thermal power generation in 2016 due to water shortages (Luo et al., 2018). Rising temperatures may also mean some power plants are no longer able to comply with the temperature regulations for water discharge. Thus, plans for power generation that rely on more water-intensive technologies will need to take into account current and future water availability in the choice of sites and cooling technologies, and, where possible, use alternative water sources.

Hydropower, which plays an important role in many countries' decarbonization plans, is especially vulnerable to climate impacts. Hydropower accounts for 22 percent of electricity generation in Africa, compared to 16 percent globally. Climate change has already affected the capacity of Zambia's largest hydropower plant, leading to power blackouts.

Rising water demand coupled with increasing uncertainty over water sup- →

DESALINATION IN THE MIDDLE EAST

Desalination currently provides just 3 percent of the Middle East's water supply, but accounts for 5 percent of its total energy consumption. According to the IEA's Stated Policies Scenario, by 2040 desalination will provide about a quarter of the region's water supply and will make up almost 15 percent of total final energy consumption. In the photo, the Al Shuwaik desalination plant in Kuwait.

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THE THREAT OF CLIMATE CHANGE
Many countries are already suffering a certain degree of water stress and there is growing uncertainty about the future availability of water and the effects that climate change will have on our water resources by changing the frequency, intensity, seasonality and quantity of rainfall. In the photo, terraced rice fields in Bandung, Indonesia.

ply could lead more countries to turn to desalination to help narrow the gap between freshwater withdrawals and sustainable supply. This would come with an energy cost. Take the Middle East as an example: desalination accounts for just 3 percent of the Middle East's water supply today but 5 percent of its total energy consumption. By 2040 in the Stated Policies Scenario, it is expected that desalination will account for roughly a quarter of the region's water supply and almost 15 percent of total final energy consumption. Using water more efficiently and tackling water losses from pipe leaks, bursts and theft can help mitigate the increase in energy demand and increase water availability. If all countries were able to reduce water losses to a level seen in the best-performing countries, the equivalent of the entire annual electricity needs of Poland could be saved today.

Energy has a role to play in attaining SDG 6

More than 2.1 billion people lack access to safe drinking water. More than half the global population lacks access to proper sanitation services. More than a third is affected by water scarcity. And roughly 80 percent of wastewater is discharged untreated, thus adding to already problematic levels of water pollution. Energy is an essential part of the solution to these challenges, and IEA analysis shows that achieving universal access to clean water and sanitation would add less than one percent to global energy demand in its Sustainable Development Scenario by 2030.
Several synergies emerge when the SDGs are viewed through an integrated lens, especially between SDG 6 (water and sanitation for all) and SDG 7 (energy for all). In rural areas, almost two-thirds of those who lack access to electricity also lack access to clean drinking water (Figure 3). As a result, considering water supply needs when planning electricity provision can open different pathways for both and lower the cost of electricity for households. The production of biogas from waste can facilitate cleaner cooking in households that currently rely on wood and charcoal for cooking. When wastewater management in urban areas requires new infrastructure, integrating energy efficiency from the start can have a significant impact on the energy and GHG emissions footprint of the wastewater sector. Moreover, harnessing the energy embedded in wastewater can allow wastewater utilities to become energy producers. That said, providing access is just the start, as it is critical to ensure that it is reliable, affordable and scalable in order to meet the rising demand that results from population growth and increasing standards of living. Where water services can provide an "anchor load" for power generation, approaching water and electricity in an integrated way may shift the emphasis towards more mini-grid or grid-connected solutions instead of off-grid solutions. Moreover, beyond just the household level, the provision of energy and water for productive uses, such as agriculture, can foster economic opportunities and create a stronger business case for entities to invest in related infrastructure.
SDG 6 is also about ensuring that water is used more efficiently. While the energy sector's share of total global water use is relatively low, it could be reduced further. Changes in the fuel and technology mix, improving power plant efficiency, deploying advanced cooling systems, and making better use of non-freshwater and water recycling can not only help the energy sector improve its water use efficiency and contribute to SDG 6 but also improve its resilience against climate change.

Conclusion

Water does not have to be a limiting factor for the energy sector and a rise in water demand does not have to be accompanied by a similar increase in energy demand. However, tackling climate change, shoring up energy security and ensuring progress on the SDGs will require that energy and water be considered in tandem.
The good news is that many of the policies and technologies needed to reduce water and energy demand and ease potential choke points already exist. These include integrating energy and water policymaking, taking current and future water availability into consideration in the choice of power plant sites and cooling technologies, co-locating energy and water infrastructure, utilising the energy embedded in wastewater, using alternative sources of water for energy and improving the efficiency of both sectors.
A coordinated approach to development between the water and energy communities could also unlock significant progress on some of the most deep-rooted issues of our day: providing electricity, clean cooking, clean drinking water and sanitation to the billions of people who lack these today. This will require innovative business models, cross-sectoral planning and a well-designed regulatory framework that allows for the integration of decentralized solutions into the grid should it arrive. Additionally, coordination and financing will be vital to ensure that the necessary infrastructure, technical and financial knowledge, capacity and access to markets are in place.

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AN INTEGRATED APPROACH
An integrated approach focused on combating climate change, ensuring energy access for all and reducing the effects of air pollution would lead to a decrease in water withdrawals by 2030 compared to today. Among the decisive factors are the greater use of solar photovoltaic and wind power. In the photo, a wind farm in the Wadden Sea, in Denmark, Germany and the Netherlands.

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*"Putting first things first:
Thousands have lived without love, not one without water."*
W.H. Auden

Geopolitics/The causes of a crisis and its potential solutions

Instability Factors

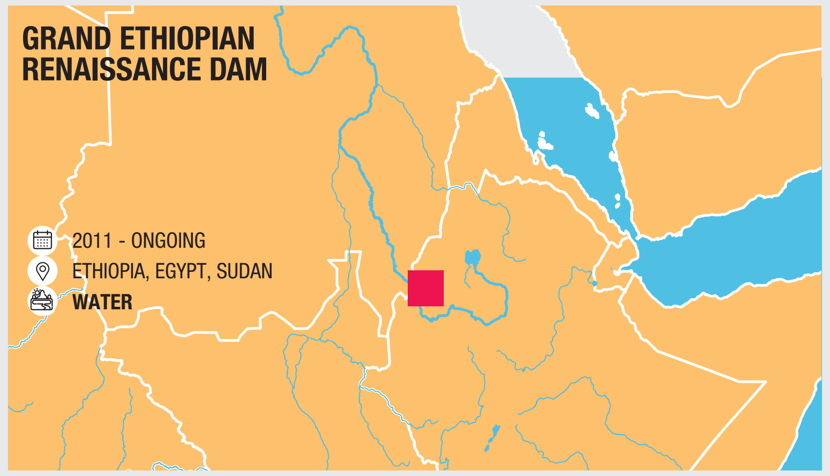
The huge global imbalances in water availability, aggravated by climate change and population growth, increase the chances of growing social instability and clashes between states. Technological innovation is a partial solution

MOISÉS NAÍM

He is a distinguished Fellow at the Carnegie Endowment for International Peace, in Washington, D.C. and a founding member of *WE*'s editorial board. His most recent book is *The End of Power*.

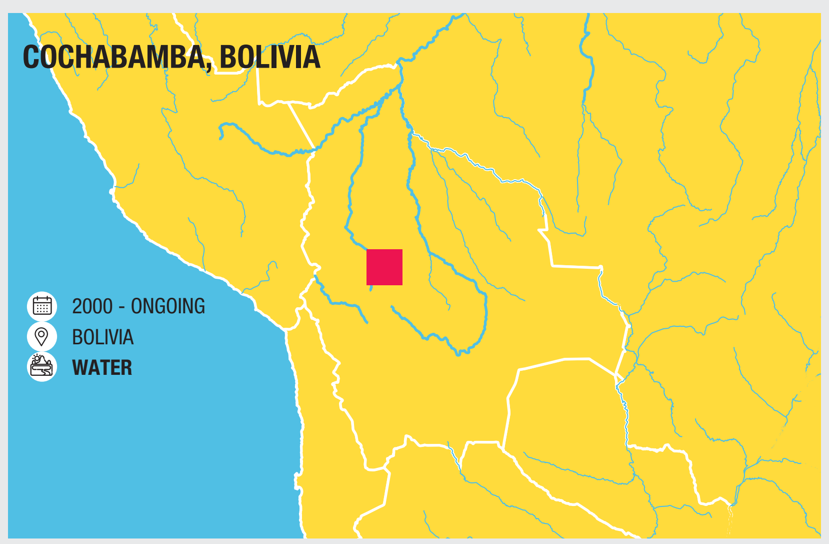
Last January, the foreign ministers of Egypt, Ethiopia and Sudan met in Washington, D.C. for urgent discussions about a water project, the Renaissance Dam. While the dam would clearly benefit Ethiopia, it would also add to the growing water stresses that affect millions of Egyptians. The risks of a major violent confrontation over this issue seemed imminent until the negotiators reached an eleventh-hour agreement. While tensions have temporarily abated, the situation is unstable, as current trends point to continuous and increasingly acute water crises in the region. These crises will inevitably result in deeper tensions and more frequent confrontations. Farmers along the 4000-mile course of the Nile River already experience recurrent and significant water shortages, which in turn create a highly conflictive environment in the region. The conflicts over water in the Nile Basin are not an isolated case. In fact, they have become a common occurrence in many parts of the world propelling water scarcity and the conflicts it feeds to the top of international concerns. For example, the 2019 World Economic Forum Global Risks report identifies water conflicts as one of the three main global risks. The report warns water crises could lead to profound social instability and even to violent interstate confrontations.
Conflicts over water are nothing new. In the last 3000 years, no fewer than 900 major confrontations over access to water broke out. Today, the probabilities of an all-out, water-led conflict are growing due to the dramatic →

The main epicentres of the water conflict



The dispute over Nile water has escalated due to Ethiopia's decision in 2011 to construct a new dam, the Grand Ethiopian Renaissance Dam, in the absence of any agreement with downstream Egypt. Negotiation have, in 2015, resulted in a framework agreement, but the question is still open.

The Nile basin features significant conflict over access to and rights over the water resources among its eleven riparian countries. In 2015, negotiations between Egypt, Sudan and Ethiopia over a major dam under construction in Ethiopia led to a framework agreement that may, in time, prepare the ground for a broader agreement.



In 2000, privatisation of the drinking water in Cochabamba incurred violent protests and escalated into the so-called Water War of Cochabamba. Eventually, the city's water was renationalised. However, dwindling water supplies induced by global climate change and over-consumption continue to heavily strain Bolivia.

START - END DATE COUNTRIES INVOLVED RESOURCES

imbalances in water availability. Studies by the Massachusetts Institute of Technology and United Nations estimate that by 2025, two thirds of the world's population will suffer significant water shortages and by 2050, one-half will suffer extreme scarcity. More than a third of major cities, such as Sao Paulo, Tokyo, Mexico City, New Delhi and Los Angeles are already experiencing extreme water stress. In 2008, the city of Cape Town barely escaped the so-called Day Zero, the day when all its dams would dry up. A 2019 study published by *Earth's Future* indicates that U.S. states like New Mexico, California, Arizona, Colorado and Nebraska will have to act urgently if they want to prevent severe water-shortage problems. Wang Schucheng, China's former minister of water resources has stated: "*To fight for every drop of water or die: that is the challenge facing China*." When access to water becomes a matter of life and death for a country with a fifth of the world's population, the probabilities of violent water-wars become significant.

The drivers of the global surge in water demand

Climate change, population growth and technological change are three important drivers of the global surge in the demand for water. More people consume more water and some new, and rapidly spreading, technologies also boost water consumption. Perhaps the best example of these water-intensive technologies is hydraulic fracturing, commonly known as fracking. The explosive growth of fracking for shale oil and shale gas production in the U.S., China and other countries has generated massive new demand for water and also sparked intense competition for freshwater resources with agricultural and urban use. The water used in fracking is mixed with chemicals of several degrees of toxicity and cannot be easily recycled for human consumption.

Meanwhile, rapid climate change is exacerbating existing water stresses and challenging the ways water is produced and allocated. For example, there is mounting evidence that as global average temperature increases, the cloud cover migrates away from the tropical regions to the poles, causing drastic changes in the tropical ecosystems and increasing drought in these regions, while increasing precipitation in the northern latitudes. A report by the World Resources Institute, WRI, forecasts that, by 2030, mid-latitude regions of the planet will experience extreme water shortages.

The unequal distribution of and access to water

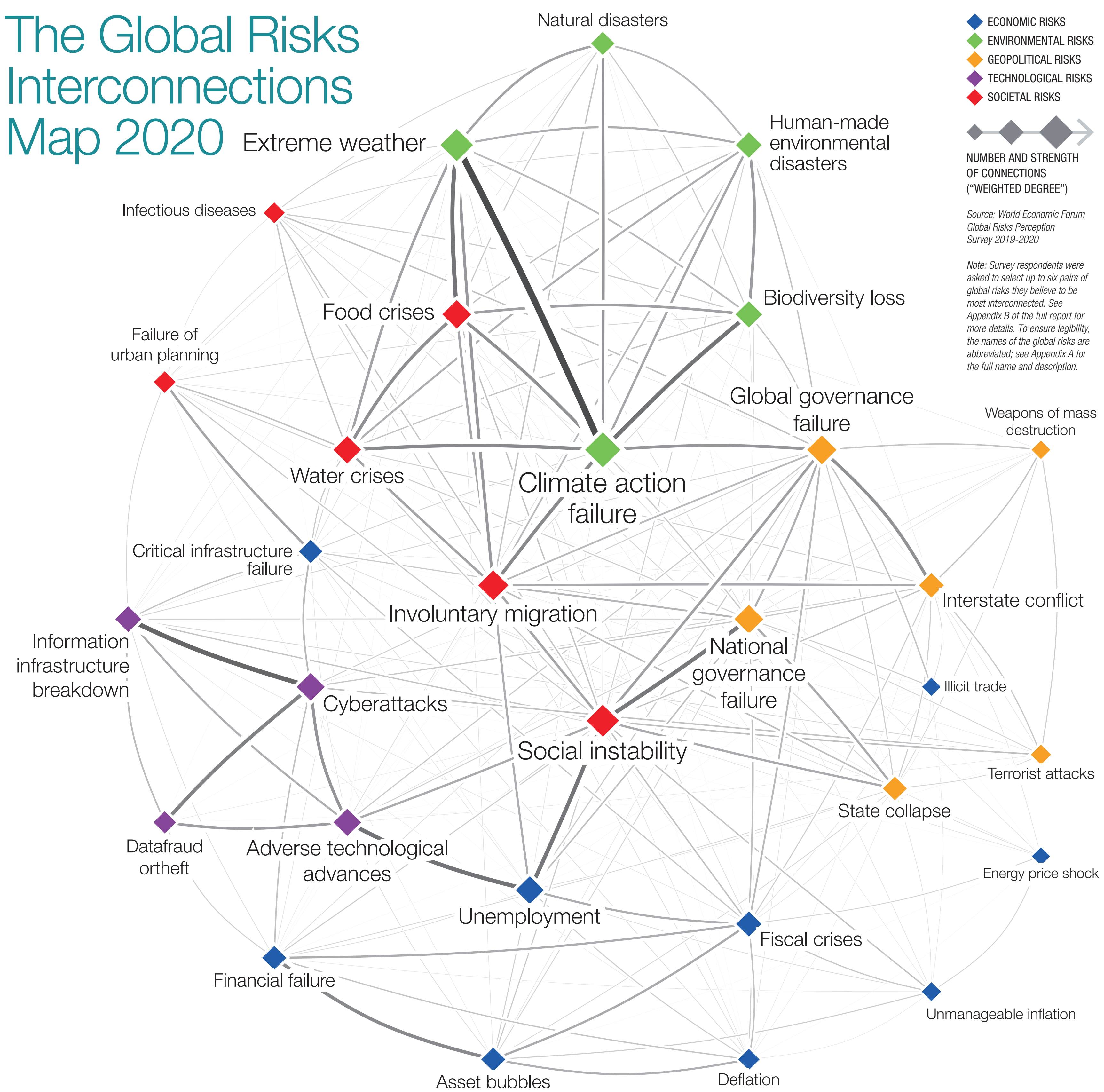
Another important factor is the distribution of water resources in the planet and its difficulty of access. Almost 70 percent of the fresh water on Earth is found in icecaps and glaciers, non-available to humans, while 30 percent of more accessible water exists in in subsurface aquifers. Extracting water at a rate that exceeds the speed at which it is replenished naturally creates substantial availability restrictions in many areas of the world. In Yemen, an extreme example, extraction has been estimated to exceed recharge by some 400 percent. Similar situations exist in China, Mexico, India and Pakistan, among other countries. In general, depletion of ground water is becoming especially acute in urban areas due to population growth and industrial usage.

Another factor that adds to water problems is the poor management of water infrastructure and watershed protection. A 2019 report by the U.S. National Association of Corrosion Engineers of the United States warns that water distribution lines and treatment facilities in that country are in urgent need of upgrading due to the heightened risk of corrosion-related failure. Every year, the report claims, more than two trillion gallons of water are wasted due to this situation. A recent letter to President Trump from the Mayor of Newark notes that "the decaying infrastructure of our water systems has created a crisis in Newark, the State of New Jersey and across America." Besides Newark, informs the mayor, "more than 20 other New Jersey cities and towns have elevated levels of lead in their tap water, and so do thousands of municipalities in our nation." A 2016 OECD report on water security indicates that global financing needs for improved water infrastructure would increase from $6.7 trillion by 2030 to $22.6 trillion by 2050, not including expenditures in irrigation or in the energy sector. A Global Forest Watch report on the world's 216 watersheds estimates that they have lost an average of 6 percent of their cover. In the past 14 years, fires, erosion, urbanization and agricultural encroachment have eroded the canopies that provide the needed cover. Naturally, this leads to the loss of both the quality and the quantity of water availability.

The inadequate pricing of water services, a politically explosive issue

Another complex driver of acute imbalances in water accessibility is the inadequate pricing of water services as well as the methods and practices through which people access water and their costs. Historically, the price of water to consumers has been based on delivery costs. The reality is that, in most parts of the world, even this marginal cost is never recovered. The notion that water is a basic human right and therefore must be

The Global Risks Interconnections Map 2020



free permeates water-policy debates everywhere—but especially in poor and middle-income countries.

Only in wealthier countries is charging recovery fees an accepted and common practice. About two-thirds of OECD member countries already meter (and charge) over 90 percent of their single-family houses. This is far from the norm in Eastern Europe, Central Asia, Latin America or large countries like China, India and Indonesia. These are all places that face longstanding and significant financial deficits in the water sector, leading to chronic and massive underinvestment, deteriorating water infrastructure and increased health and environmental hazards. In the poorer regions of the world, some 650 million people lack access to safe water due to the political obstacles that make it impossible for governments to get consumers to pay for operating costs. In this sense, water is politically explosive. Efforts to adopt these systems have often led to social conflict, such as the so-called Cochabamba Water War, which took place in Bolivia in 2000, a violent protest that took place as a reaction to an increase in water tariffs to finance a new dam.

As a result of the lack of modern water distribution systems, the poor are forced to pay much more for their water than in those countries where such systems exist. In Nairobi, the urban poor pay 10 times more for water than do people in New York City. In New Guinea payment for the required daily water can be as high as half of a worker's daily income, while in the U.K. that cost rarely exceeds one or two percent of daily earnings.

Technological innovation as a partial solution

Humanity is facing grave problems regarding the availability and usage of water. While technologies like fracking, for example, deepen some of our water problems, we can reasonably expect that technological innovation will help us fix some of them. It is not overly optimistic to expect that in the not too distant future, new technologies will make desalinization cheaper, more environmentally friendly and easily accessible to water-stressed cities and regions. It is also possible to envisage the ascent to power of political leaders who are able to persuade their followers that it is in their self-interest to pay for the water they consume. The other two main drivers of water crises—population growth and climate change—are harder to contain and, unless vigorously addressed, will seriously threaten the survival of important portions of animal and vegetal life in our planet.

Balances/The relationship between climate change, water resources and political tensions

The Wrong Prophecy. . . for now

The prediction made in 1995 by World Bank official Ismail Serageldin that wars in the 21st century would be fought over water has not come true. But we'll need inclusive and competent institutions to ensure that it never does

SCOTT MOORE

He is a political scientist whose work focuses on water politics and policy, especially in China and South Asia. Moore is currently a Senior Fellow at the Penn Water Center as well as Director of China Programs in the Office of the Provost at the University of Pennsylvania. Until 2018, he was a Young Professional and Water Resources Management Specialist with the World Bank Water Global Practice.

Though we don't often think of it this way, climate change is really about water. Indeed, for humans, the most marked impacts of climate change have to do with shifts in the distribution and availability of water. For some areas, like coastal and many mid- and high-latitude regions, climate change will bring too much water in the form of rising seas and more intense flood events. For other parts of the world, droughts will become longer and more severe. And across much of the globe, water availability will become more erratic, making it more difficult to ensure that cities and farms have enough water to make it through periods of shortage.

These changes have many implications, but one of the most concerning is the prospect of increased conflict over water. Former World Bank official Ismail Serageldin's 1995 prediction that "the wars of the next century will be fought over water" is one of the most well-known warnings of this prospect. But two decades into the twenty-first century, it's clear that the relationship between climate change, water and conflict is far from simple. For one thing, water has not, so far, been a significant cause of violent conflict—in fact, cooperation is far more common. And while most people assume that it's water scarcity that drives conflict, in fact issues like pollution are equally important causes. Yet as the world continues to warm and its water resources become stretched ever further, it's important to understand the relationship between water and conflict—and how to prevent it.

The peculiar features of water

The first thing to understand about this relationship is that water is special. More specifically, it has at least four distinctive characteristics as a resource, as described by American political scientist Frederick Frey. First, it's essential to all forms of life. Second, it's often scarce across both space and time. Third, it's very unevenly distributed—areas like North America's Great Lakes possess vast reservoirs of easily accessible freshwater, while huge expanses of the Middle East and North Africa have essentially no perennial water sources. Fourth, finally, and most significantly, most water bodies are shared between multiple countries. Very few rivers, lakes, or groundwater aquifers are contained entirely within one nation's borders, meaning that decisions like who gets how much water, or where to build a dam, are inherently international issues. These four characteristics, Frey believed, make water a natural focal point for international conflict. Subsequent research, though, makes it clear that there's nothing automatic about conflict over water, even when water itself is very scarce.

In fact, several authoritative studies suggest that violent conflict, especially outright warfare between states, over water is very unusual, at least in recent history. The most comprehensive measure of international water conflict, known as the International Water Event Database, records fewer than 30 instances of inter-state violence over water from 1948 to 2008, and no cases of actual interstate warfare. Other studies struggle to identify any clear-cut examples of water-related conflict between states in the modern era. Historians have largely debunked claims that, for example, the 1967 Six Day War was precipitated by diversion of the Jordan River. As in most alleged cases of water conflict, the Six Day War had much deeper roots, not least the two previous Arab-Israeli armed confrontations. From an academic point of view, it makes good sense that cooperation over water is more common than conflict. While it's tempting to see the use of water as a zero-sum game in which its use by one party, such as a country upstream, means less for someone else, such as a downstream country, in the real world such cases are rare. Even big dams like Ethiopia's Grand Renaissance Dam, which downstream Egypt fears will disrupt flow on the Nile, present just as many opportunities for cooperation as for conflict. The purpose of such high dams is typically to generate hydropower, which can be easily transmitted between countries.

Of course, water does frequently cause tensions between countries, and the Nile is a good example. Construction of the Grand Renaissance Dam has been fiercely opposed in Cairo, and the Egyptian government has made numerous threatening statements in response to the Ethiopian government's decision to complete the dam. Yet, tellingly, despite this history of threats and Egypt's formidable military capabilities, it has yet to resort to arms. At the same time, while both Indian and Pakistani leaders have engaged in frequent verbal sparring over the shared Indus River, the Indus Water Treaty they both signed in the 1960s has proven to be a model of cooperation—virtually the only shared institution that has survived three full-scale wars between the South Asian →

THE ROLE OF INTERNATIONAL ORGANIZATIONS

In order to prevent water conflict, national governments and multi-lateral bodies like the World Bank need to invest in building inclusive and capable water management institutions at the regional, national and sub-national level.

The French Water Agencies

France has created special bodies, known as Water Agencies, to manage water throughout the country. Each Agency includes a council that reserves 25% of seats for civil society representatives. The Seine-Normandy Basin Committee, one of the country's most active, has four permanent committees that reflect the scope of its functions and ability to coordinate across sectors, including Plans and Programs, Aquatic Environment, Coastal and Maritime Affairs, and Land-Use Planning and Flood Management. The coastal committee (Commission de littoral et de la mer, or COLIMER) is especially notable as an example of collaborative, participatory management that extends beyond the basin itself and engages coastal stakeholders, including fishermen and tourism authorities. Just as notable is the fact that the Seine-Normandy Basin Committee decision-making is supported by a robust technical support infrastructure, including 21 expert members of a Scientific Council. These members include agricultural engineers, hydrologists, and sociologists, and are charged with delivering recommendations to the Basin Committee as a whole.

powers. The most common form of water conflict, meanwhile, are sub-national disputes over things like water-sharing from shared rivers. And while these conflicts can be costly—2016 protests in southern India in response to a court decision over water allocation caused some USD 3.75 million in damages—they only rarely involve violence or loss of life.

Beyond water shortage, the causes of wars

So why do water wars occur? Existing research suggests that for conflict over water to occur, several specific circumstances have to apply. Notably, it's not enough for there simply to be too little water to go around. In addition, some groups or users of a shared water resource have to be systematically excluded from using it or their usage controlled or impeded by other groups. It's this sense of inequity and deprivation that stokes conflict. This type of situation is most common when social and political institutions aren't working—for example, in failed states where there's no functioning government. It's no coincidence that many of the clearest examples of water conflict come from places like Yemen that are plagued by a combination of poverty and instability.

When circumstances like these apply, several forms of water-related conflict can take place—and again, not all of them have to do with water scarcity. I divide forms of water conflict into three types, which I call infrastructural, allocative and qualitative. Basically, the first type has to do with dams and other forms of water infrastructure. Construction of these structures typically displaces, inconveniences and otherwise harms people living nearby—if they're not properly compensated, it can lead to conflict. Another form of infrastructural conflict happens when dams disrupt the flow of a shared waterway downstream, which might increase flood risk, harm fisheries, or degrade scenic areas. Allocative conflict, on the other hand, arises when people disagree over who gets how much water. These decisions are always contentious, and unless they're made in a transparent, inclusive, and equitable way, conflict is a common response. Qualitative conflict, finally, occurs because of water pollution or water quality degradation. A frequent example of qualitative conflict is when a factory or city upstream on a shared waterway fails to control pollution, contaminating the water source for people living downstream.

Technology and political reforms to ward off conflicts

How then can we prevent water conflict in the future? Part of the answer is technology, coupled with policy reforms. Advanced water treatment and desalination technology can play an important role in addressing the root causes of qualitative water conflict, while also alleviating water stress for coastal cities. Costs are falling quickly: recent estimates from the International Water Association predict significant decreases in capital costs coupled with considerable improvements in treatment and desalination efficiency. When combined with policies like water pricing to encourage conservation and water use efficiency, technologies like desalination can also help prevent some forms of allocative water conflict, which frequently pits urban and rural water users against each other. Alternative sources of supply for urban areas might reduce pressure on agricultural water users.

Technology is only part of the answer, however. When conflict over water does occur, the academic literature is clear that effective institutions are essential for resolving it. These institutions must exist at several levels, from local bodies that help manage small streams and rivers, to international commissions that help govern large rivers like the Nile. These institutions can take a number of forms, from informal groups of community members who meet regularly to take decisions about how a common water source should be used, to formal commissions or councils that reserve a certain number of seats for different constituencies. Whatever form water management institutions take, the important thing is that they a) bring together different water user groups, whether they be pastoralists or city-dwellers, and b) have the resources and credibility to make decisions that can be accepted by all water users. This last point is crucial to resolving water conflicts and means that institutions must be trusted by the parties to a potential water conflict.

This second consideration also implies that water management institutions must have substantial capacity. This capacity falls into several categories. First, it must have the technical capacity to understand the specific water resource issues at play, which often means having access to reliable sources of data on water use and availability. Second, an effective water management institution must have administrative capacity, including formal rules and processes for resolving conflicts and making decisions, that allow it to function effectively. Third, these institutions should ideally have financial capacity to implement decisions, especially those that lie at the heart of preventing or resolving water conflicts. France's Water Agencies are a good example of an institutional model that successfully incorporates technical, administrative and financial capacity (see Box on page 38). Of course, for many countries, especially fragile regions like Yemen, institutions like the French water agencies will be difficult to replicate. That is why, to prevent water conflict into the future, national governments and multi-lateral bodies like the World Bank need to invest in building inclusive and capable water management institutions at the regional, national and sub-national level. So far, Ismail Serageldin's prediction that the wars of this century will be fought over water hasn't come true, even as climate change accelerates. But it will be up to us to ensure it never does.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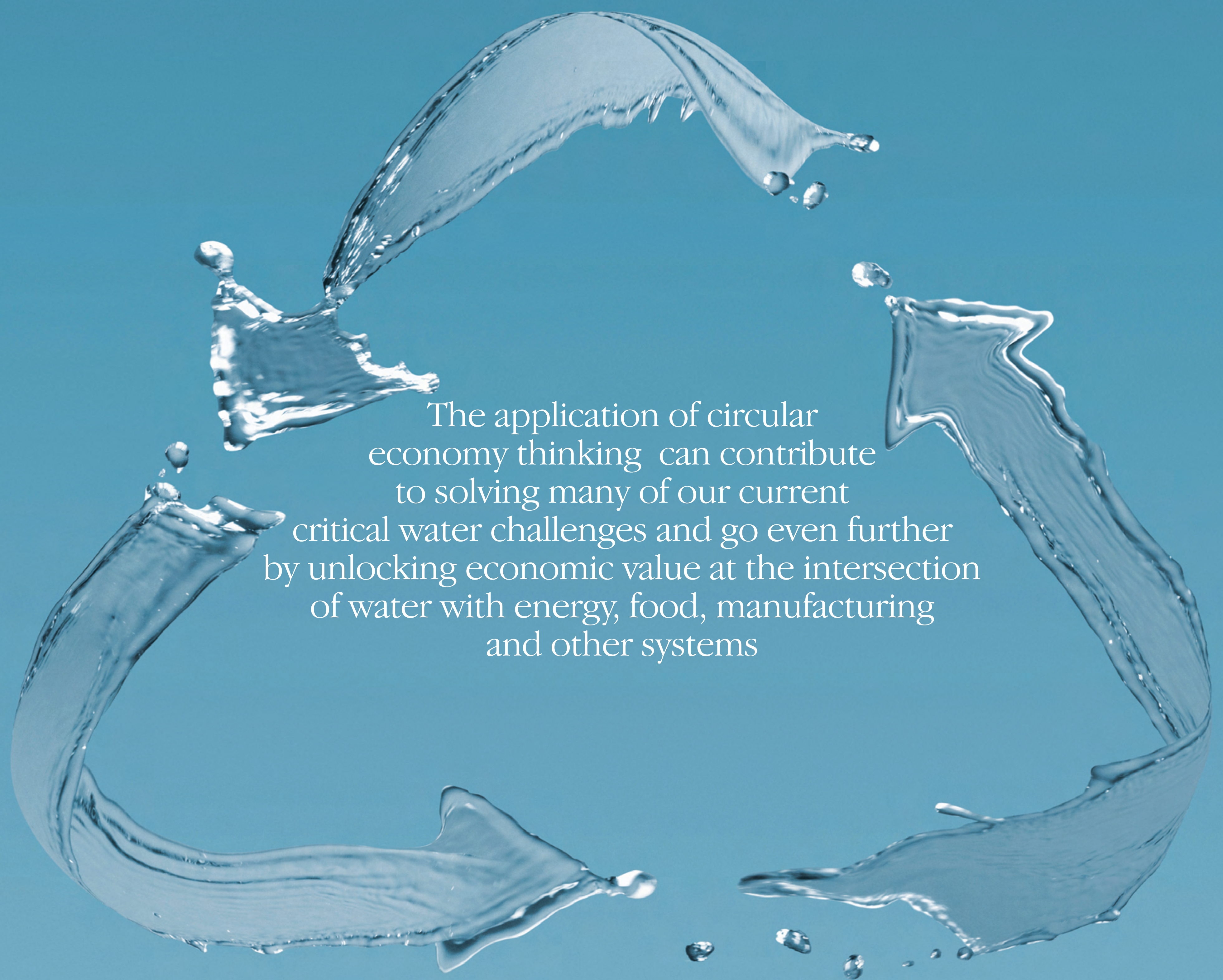
TECHNOLOGY HELPS
Advanced water treatment and desalination technology can play an important role in addressing the root causes of qualitative water conflict. In the photo, a plant of water treatment.

Circular economy/Big opportunities from more effective water management

The Ultimate Circular Resource



The application of circular economy thinking can contribute to solving many of our current critical water challenges and go even further by unlocking economic value at the intersection of water with energy, food, manufacturing and other systems

NICK JEFFRIES

He is a senior expert at the Ellen Macarthur Foundation. His main work addresses the many challenges of the global food system by applying system-thinking and circular economy principles. Before working at the Foundation, he spent more than 10 years working on water projects around the world.

The El Torno treatment plant in Cadiz, southern Spain, receives wastewater flows from surrounding businesses and homes. Like thousands of similar treatment facilities across the world, El Torno purifies the water so it can be safely discharged into the nearby river. However, an aerial view of the El Torno site indicates that this plant is different from others.
Extending from the northwest corner of the facility is a pair of straight emerald green channels, each about 100 meters long. In these 'raceways,' algae are cultivated that produce oxygen to fuel the biological treatment of the wastewater, almost eliminating the need for an energy supply for the facility. To avoid suffocating the water flow, dead algae are constantly harvested and pumped to an anaerobic digester, where they are converted to biogas. The gas is then scrubbed of impurities, leaving pure biomethane, which is pressurized and used to fuel a fleet of cars. Results from the full-scale pilot facility indicate that just one hectare of algae can treat the effluent of 5,000 people and produce enough biofuel to power 20 cars driving 30,000 km a year. This is four times the productivity of conventional biofuels grown in the same area.
The El Torno facility illustrates that what many construe as waste is potentially valuable feedstock; and that by considering the wider system, it is possible to transform a costly carbon emitting process into both an economic opportunity as well as a means of addressing a number of global challenges. The implications are significant. Water and wastewater treatment consume about three to four percent of U.S. energy demand, and in India, inadequate wastewater treatment, due to unreliable or expensive power, costs the Indian economy more than USD 50 billion a year. Imagine the impact if all future wastewater treatment facilities in Africa were designed as power plants.

"Waste is an error of design"
Gonzalo Muñoz, founder, TricCiclos

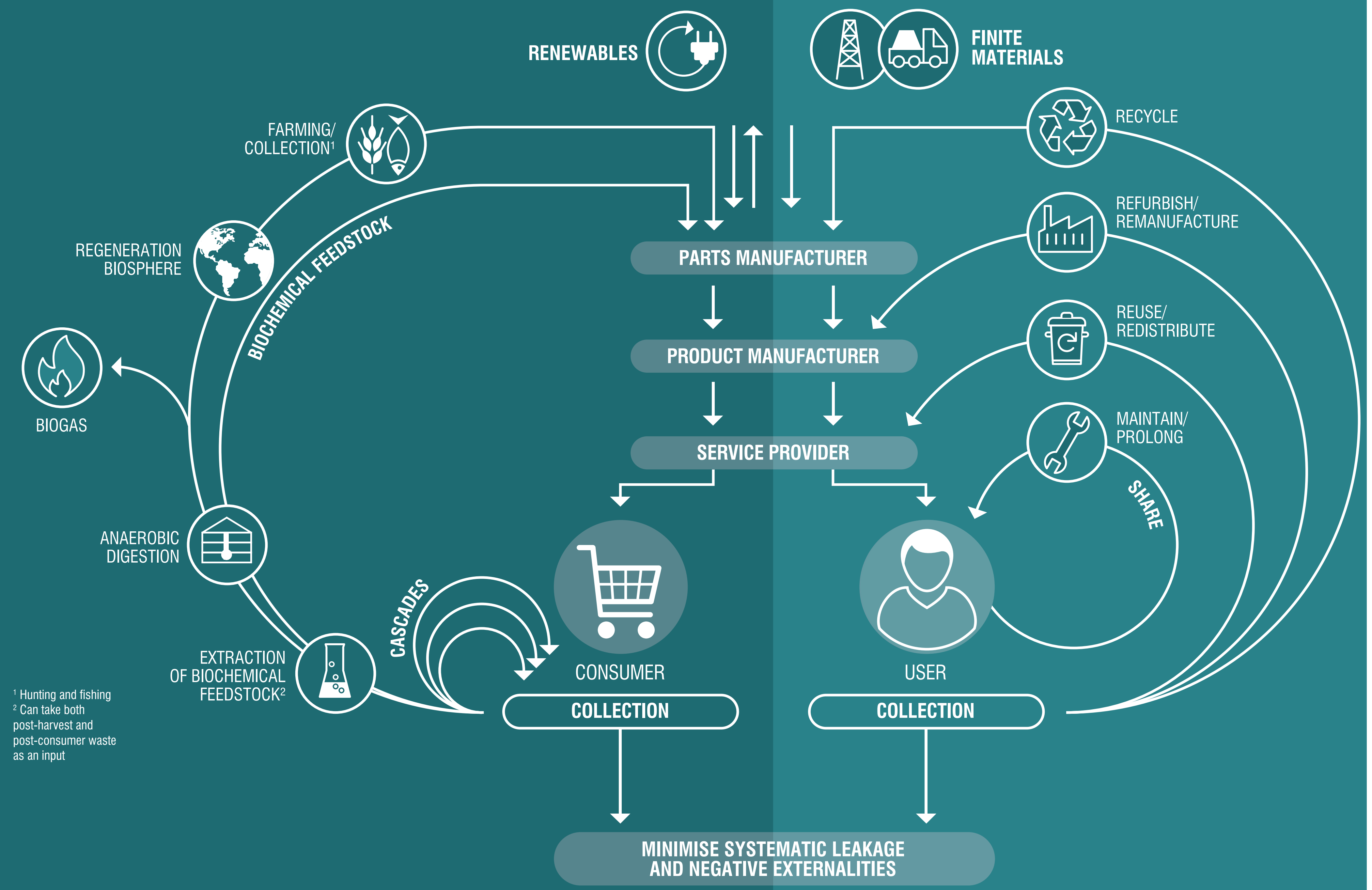
Such thinking is a hallmark of the circular economy, a system change approach inspired by nature that aims to decouple economic growth from the consumption of finite resources. Embodying a number of 'schools of thought' including Cradle-to-Cradle, the Performance Economy, Industrial Ecology, Natural Capitalism and Biomimicry—the circular economy concept is underpinned by three guiding principles and can be visualized in the systems diagram below. The diagram shows the numerous strategies in different parts of the economy that allow designers, manufacturers, service providers, and other economic actors to capture value by applying circular economy thinking. The Ellen MacArthur Foundation (EMF) has been building the evidence base for the society-wide benefits of a transition to the circular economy since 2010.
For example, a white goods manufacturer could design a washing machine that is modular, durable and Internet of Things (IoT) enabled. This allows the machine to be offered as a service, where users 'pay-per-wash' rather than buying the machine upfront. In this model, the product's use-period is extended and its constituent materials and components can be easily disassembled, facilitating easy upgrades or reuse in future machines. Applying this circular approach means the amount of virgin materials mined is reduced, machines operate more efficiently, businesses capture more economic value from their products and users access higher quality equipment in a more flexible way.
Aggregate benefits to the broader economy and the rationale behind the transition to a circular economy start to look very attractive. In the report Growth Within (EMF 2015), the annual economic opportunity across three sectors (built environment, mobility, and food) of the European economy was estimated to reach €1.8 trillion by 2050. Another study (EMF 2018) on five sectors of the Chinese economy (built environment, mobility, nutrition, textiles, and electronics) estimated a potential USD 10 trillion cost saving for businesses and households.
Such economic benefits have been shown to be firmly in line with the low-carbon approaches needed to comply with the Paris Agreement. The report *Completing the Picture* (EMF 2019) found that the adoption of circular economy principles in five key material sectors (steel, cement, aluminium, plastic, and food) can achieve a greenhouse gas (GHG) emission reduction in those sectors of almost 50 percent by 2050. The overriding message from this report was clear: there is no zero-carbon future without a circular economy.

"When we try to pick out anything by itself, we find it hitched to everything else in the universe"
John Muir

Water is the quintessential circular resource, purifying and renewing itself endlessly as it flows through the planet's hydrological cycle. However, in the last century, intensive industrial activities and urbanisation have disrupted this natural cycle, of- →

Circular economy: how it works

The circular economy concept is underpinned by three guiding principles and can be visualized in the systems diagram to the right. The diagram shows the numerous strategies in different parts of the economy that allow designers, manufacturers, service providers, and other economic actors to capture value by applying circular economy thinking.



ten exceeding nature's capacity to purify and circulate on her own. The fashion sector illustrates the level of intensive water use: to make just one pair of jeans requires around 7,500 litres of water, and between 2000-2015 the volume of clothes produced each year doubled from 50 billion to 100 billion units. Extrapolating this growth across the economy, and factoring in expanding population and urbanization, it is easy to understand why the UN estimates that water demand will exceed accessible supply by 40 percent by 2030.

To make things more complex, the evolving climate emergency leads to more unpredictable rainfall and greater frequency of extreme and unusual weather events, manifested as floods in South East Asia, droughts in California and Australia and wildfires in Greenland. The recent UN Water Policy Brief on Climate Change and Water is unambiguous on such effects: "The global climate change crisis is inextricably linked to water." In the context of these increases in both demand and unpredictability, it is worth asking how circular economy principles can be applied to reduce risks and improve the effective management of water resources.

> **"Wastewater is the largest untapped waste category, as big as all solid waste categories combined. It is a natural starting point for the circular revolution."**
> Martin Stuchtey, Rethinking the Water Cycle

There are many reasons why water is so useful. It transports solids, dissolves minerals, chemicals and nutrients, and stores thermal energy. This 'carrier characteristic' allows for countless industrial, agricultural and transport processes and means that water which would once have been considered waste can be used as feedstock for other systems. By using wastewater productively, we put into action the first and second principles of the circular economy.

The basic requirement for safe and reliable sanitation has not changed. However, wastewater treatment plants (WWTPs) are re-imagined not just as protectors of public health but also as generators of energy and sources of soil fertility. Such thinking is not an imaginary ideal but has become a reality in many cities around the world. The Ebjy-Molle plant in Aarhus (Denmark), the Strass plant in Innsbruck (Austria) and the Gresham City plant in Colorado (U.S.) have all operated as energy positive for a number of years.

Making the most of the water we have also means eliminating unnecessary waste. One of the most significant forms of waste is referred to by experts as 'non-revenue losses,' or to most other people as 'leaky pipes.' Massive amounts of high quality water, purified and pumped with expensive energy and chemicals, is lost from the world's underground pipework every day. In Mexico City, a mega-city of over 20 million people with huge challenges around water availability and quality, enough water leaks into the ground every day to supply Rome. In the UK, almost 3 out of every 10 litres of water produced leak from pipes. The reasons for leakages vary, the most common being poor maintenance of difficult to access, ageing infrastructure.

Early detection and repair of cracks, before they become too costly and disruptive to fix, is a powerful tool, but fraught with technical difficulties. The first challenge is pinpointing the precise site of the leak. The start-up Watchtower Robotics has looked to nature for inspiration to solve this. Combining the efficient propulsive mechanism of a moon jellyfish, the agility of an octopus, and the pressure sensing ability of a blind cave fish, Watchtower founder Dr You Wu has created a pipe-swimming robot that can detect tiny leaks and create a 3D map of pipe networks at a tenth of the cost and five times faster than traditional methods. Biomimicry designs such as this, which demonstrate the great store of ideas that exist in the natural world, are part of the DNA of the circular economy.

Having pinpointed the leak, the next challenge is to make a repair in an economic and non-disruptive way. A company called Curapipe offers a solution to this in the form of their Trenchless Automated Leakage Repair (TALR) system. Suitable for a wide range of pipe materials and diameters, TALR uses 'pipeline pigs,' devices used for maintenance tasks in pipes, to convey a proprietary curing substance that is injected into pipe cracks. Israel, where Curapipe is based, not only has the lowest rate of leakage losses on the planet but also annually exports USD 2.2 billion of water technology. The convergence of technology like Watchtower and Curapipe, enabled by emerging digital IoT platforms, illustrates perfectly the great opportunities in managing resources more effectively.

> **"The goods of today are the resources of tomorrow, but at yesterday's prices."**
> Walter Stahel, The Performance Economy

Our current use of water is typical of ineffective resource management. We extract from nature often at great cost, treat it, pump to where it is needed, use it briefly, and then throw it away, often after more costly treatment and pumping. This 'take-make-waste' linear approach leads to a significant loss of value. The second principle of the circular economy recognizes that a great amount energy, chemicals, and other resources can be saved by 'closing the loop' and keeping water at its highest possible value.

Not all water is equal. Depending on the use, different water quality standards are acceptable. For example, a typical IBM microchip facility requires nine custom varieties of water, to flush toilets, supply water fountains, run air-con units, mix chemicals, as well as ultra-pure water to clean semiconductors. Recycling water generates many additional benefits besides lowering freshwater consumption. Between 2000 and 2009, when IBM engineers started using IoT technology to manage water more effectively in their Burlington factory, USD 740,000 per year was saved on water use, which gave rise to almost USD 3 million savings on chemicals and energy.

On a smaller scale, products and systems can be developed that enable reuse and recycling of water. Aquafresco, a company in Boston, has a patent-pending filtration system that allows 95 percent of laundry water to be recycled, as well as 90 percent of detergent to be collected for reuse. Dutch company Hydraloop has developed an easy to install system that collects shower and washing water, economically converting it to a quality suitable for washing, toilets, garden use, and swimming pools. Hydraloop can save a typical household 30,000 litres of water per year.

Cities have a unique opportunity to make the most of such innovations. Las Vegas, Singapore, Windhoek, and Berlin all recycle their water in different ways, allowing the cities to improve water security and greatly reduce costs. The Solaire apartment block in New York recycles 165,000 litres per day, allowing for secondary use in toilets, air-con systems and roof-top irrigation. The reuse system reduces water demand by 50 percent and discharge volumes to local sewers by 60 percent as well as reducing building energy consumption.

In addition to making the most of the water we use every day, changing the way products are made has significant water conserving potential. Take for example the pair of jeans that requires 7,500 litres for its production. In the Netherlands, a company called MUD offers jeans on a subscription model as well as using over 40 percent recycled content in the production process. Together, this saves 5,500 liters of water for every pair.

Circular strategies to conserve water can be applied in all sectors. Renault's Choisy-le-Roi plant collects old gear boxes, turbo injectors and other engine parts, cleaning and remanufacturing them to a good-as-new condition. By doing so the plant uses 88 percent less water than manufacturing from scratch as well as using 80 percent less energy, 90 percent fewer chemicals and producing 70 percent less waste. The Choisy plant turns over EUR 100 million in revenue, and customers save 30-50 percent on a good-as-new part.

Getting more from less is a classic and enduring feature of a circular economy.

> **"The global economy is dependent on resources and services that nature provides. However, it does not conform to its own accounting principles. It liquidates its capital and calls it income."**
> Paul Hawken, Amory Lovins, L. Hunter Lovins, Natural Capitalism

The third principle of the circular economy recognizes the critical importance of well-functioning natural systems by advocating that economic activities are net-positive for nature. The decline of the Polynesian culture of Easter Island, the Mayans of Central America and numerous other once-thriving civilizations, primarily because of environmental degradation, are powerful reminders that prosperous and healthy societies rely on well-functioning ecosystems. Natural systems provide us with oxygen and clean water, regulate our climate and much more besides. WWF's Living Planet Index estimates these 'ecosystem services' provide humans more than USD 120 trillion of benefits each year. Our current extractive and polluting economic model drastically lessens the ability of ecosystems to provide these services.

No sector of the economy illustrates →

the potential of the third principle more than agriculture and, as farming consumes 70 percent of the planet's freshwater, no part of the circular economy offers more to the conservation of water resources than regenerative agriculture.

Regenerative agriculture describes a broad set of food production methods with two complementary outcomes: the production of high-quality food and the improvement of the natural environment. It recognizes that farms are part of larger ecosystems, from which farming activities must not just take, but also give. Farming in this way shifts from practices that are heavily reliant on chemical inputs and monoculture towards a more holistic way of thinking that cherishes diversity, encourages virtuous cycles of renewal and focuses on the health of the system as a whole. The specifics vary, or as soil expert David Montgomery puts it: "what works for temperate grasslands may not work so well in tropical forests." However, there are common regenerative practices that can be applied across all soil farming. These include the use of cover crops, wider crop diversity, minimum soil disturbance and, most importantly, the building up of soil organic matter. Together these practices can trigger a cascade of benefits. Every 1 percent increase in organic matter in the top 20 cm of topsoil, for example, can sequester 90 tons of carbon and store an additional 144,000 litres of water per 1 hectare of farmland. This shows that regenerative agriculture is both a powerful tool to reduce GHG emissions, make farmland carbon-positive and adapt to climate change, all while meeting demand for food. But what does it look like on individual farms?

On a 50,000 acre farm in Sao Paulo province, Brazil, Leontino Balbo, Jr. has gradually converted his sugar cane plantation to 'ecosystem revitalising agriculture' that focuses primarily on soil health. Balbo's regenerative journey has not been easy, with numerous failures and the need to manufacture his own bespoke 'green harvesting' equipment. The machines simultaneously cut cane, as well as shredding and returning leaves and other plant residue to the soil, and operate on low pressure tires to avoid over-compaction of soil. Twenty years on, the farm has increased biodiversity to half that of a national park, increased productivity by 20 percent and all but eliminated mechanical irrigation.

In North Dakota, farmer Gabe Brown has integrated livestock grazing with many different species of saleable crops. Pigs and chickens help to cycle nutrients so that the ranch can thrive without any synthetic inputs, while organic content in the topsoil has increased from 1 to 14 percent. The additional carbon both feeds microbes and improves soil structure so his fields now store over three times more water than before, providing insurance against years of drought or lower rainfall. The 5000-acre farm, which was heavily degraded 20 years ago, is now profitable without the need for government subsidies.

There are many other regenerative agriculture practices—such as agroforestry, conservation agriculture, agro-ecology, silvopasture and 3D ocean farming—all illustrate that agriculture does not have to be a zero-sum game. It is possible to produce plentiful food, conserve water, make profit, protect farmers and local communities from harm, and benefit the environment—all at the same time.

System thinking is key

The most essential tool in the circular economy armoury is the ability to think in systems. All of the pioneering individuals and organizations whose ideas were synthesized into the Foundation's circular economy model prompt us to move away from simple binary metrics such as throughput of materials or energy as measures of economic health,and instead consider the optimisation of the system as a whole. Two examples illustrate the power of system-thinking when applied to water.

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LINEAR VERSUS CIRCULAR
The current way that we use water is typical of ineffective resource management. We extract it from nature, treat it, pump it to where it is needed, use it briefly, and then throw it away, often after more costly treatment and pumping. This 'take-make-waste' linear approach leads to a significant loss of value. The second principle of the circular economy recognizes that a great amount of energy, chemicals, and other resources can be saved by 'closing the loop' and keeping water at its highest possible value. In the photo, an aerial view of a water treatment plant.

The Catskill catchment basement program has saved the city of New York billions of dollars in plant and maintenance costs. In 1989, changes to federal government regulation mandating the filtering of surface water supplies meant that city authorities needed to build a USD 6 billion treatment plant with projected annual running costs of USD 250 million. A study was carried out on the wider water catchment to consider possible alternatives, concluding that watershed protection projects costing only USD 1.5 billion would result in the same level of water filtration. The projects entailed the ecological improvement of thousands of acres of upstate land that not only avoided billions in capital and maintenance costs but also boosted the rural economy, created local employment, increased investment in rural businesses and expanded eco-tourism.

In Kenya, a similar win-win situation has been instigated by the Nature Conservancy in the form of the Upper Tana water fund. The Tana river provides 90 percent of Nairobi's water supply as well as much of the city's power from hydroelectric schemes along its length. In recent years, an expansion of agricultural activity in the steep-sloping upper catchment has increased soil erosion and the volume of silt run-off into the river, leading to frequent expensive de-silting operations in reservoirs, water treatment plants, bottling plants and other downstream facilities. The water fund is paid into by the city utilities and businesses impacted by the increase in silt loading. These funds are then disbursed to support and educate over 30,000 farmers in regenerative agriculture methods, reducing soil loss, improving soil fertility and increasing revenues. The downstream users' investment in the fund is more than covered by the reduction in maintenance costs. The Upper Tana water fund shows how system-thinking, combined with an innovative redirecting of funds, can create a situation where all stakeholders benefit.

The projects described in this article demonstrate that circular economy thinking can help solve many of our current critical water challenges and go even further by unlocking economic value at the intersection of water with energy, food, manufacturing or other systems. However, to scale up the benefits, it is not enough to simply copy and paste promising technologies from one place to another, the system conditions also need to be right. In other words, to realize the opportunities of a circular economy for water, we must also improve policies, governance, institutions, pricing structures and most importantly our respect for water. By doing so, our relationship with this quintessential circular resource will allow us to thrive rather than survive in an unpredictable future.

Environment/A new approach to managing environmental risks

Biodiversity at Risk

We need to move from the fire-fighting, issue-by-issue approach to climate change to one focusing on the root of the problem, which includes recognition of the importance of biodiversity at the base of the system

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THE ECOSYSTEM HERITAGE

Biodiversity and water are inextricably linked. Most people recognize that water is an essential part of almost all the services we derive from nature, but few realize how much biodiversity is connected to these same services.

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n this issue, the importance of water as one of the greatest environmental risks facing business and society is made clear. So why an article on biodiversity? What relevance do pandas and parrots have for the challenges we face of droughts and floods and access to the most important substance for life on our planet? In this article we hope to show how biodiversity and water are inextricably linked. Most people recognize that water is an essential part of almost every service we derive from nature but not as many realize the way biodiversity is intertwined into these very same services. We describe how biodiversity impacts the water services we depend on for the water we drink, the food we grow, the energy we demand and how biodiversity mitigates the impact of water-related natural disasters. However, while understanding the role of water in the provision of environmental services is relatively clear, understanding the dynamics of biodiversity and the specific role it plays in the same services is less understood. As a result, we continue to undervalue and underestimate biodiversity and thus fail to address its decline. This is particularly true for biodiversity associated with freshwater systems, which represent some of the most threatened life systems on the planet. Moving forward, we need a new approach to the way we manage environmental risks. We need to move from a fire-fighting, issue-by-issue approach of climate change today, water tomorrow and maybe biodiversity next year to focusing on the root of the problem, which includes recognition of the importance of diversity at the base of the system.

Nature as an economic 'stock'

The water cycle is a physical process, driven by the energy of the sun. Seawater evaporates, clouds condense, rain falls and rivers and groundwater flow back to the sea—what have the birds and the bees got to do with this and what has that got to do with us? The answer is everything. One useful way of picturing the relationship for those with a more business-orientated mind frame is to borrow from the economic concepts of capital stocks and benefit flows (Figure 1).

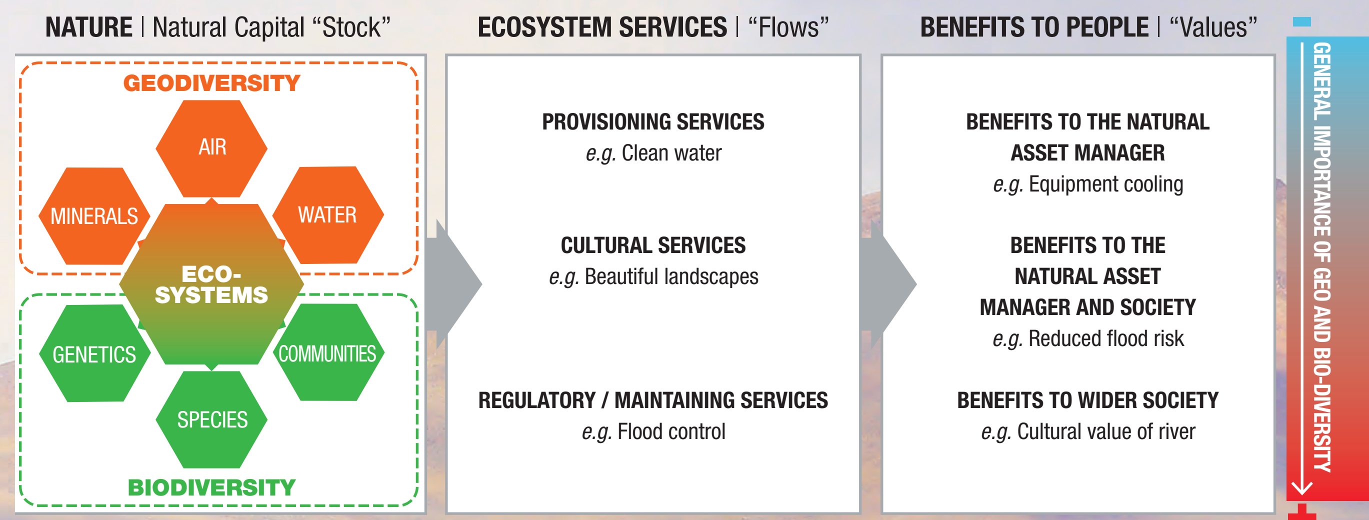
Think of nature as an economic stock—a natural asset or 'natural capital.' This stock is made up of non-living components (collectively known as 'geodiversity') and living components (collectively known as 'biodiversity'). These living and non-living elements combine to form 'ecosystems'—a biological community of interacting organisms and their physical environment such as a coniferous forest on acidic soils or sea grass meadow in the coastal shallows. Like any other form of capital, under the right conditions this natural capital can yield a flow of benefits that have value to people. These flows are known as 'ecosystem services' and they include the foods and fibers we like to consume, the health and well-being services we like to enjoy and the ecological services that underpin these. Each of these services has some level of value to different parts of society. Some may be important to the owner of the natural asset (for example a farmer is dependent on the services producing their crop). Some may be more important to wider society (for example a peat bog may provide important climate regulation services that are essential for society as a whole but have less value to the asset owner) and some may benefit all (for example the flood protection service of a forest may benefit the asset owner and the surrounding communities). Most people recognize water is an essential component of the natural capital stock and involved in most of the services we derive from nature. For some of these services it is the water itself that forms the service, such as the flows of freshwater that are used to drink or cool machinery or the removal of pollutants from the land by rivers. For other services, water plays an underpinning role—from the growth of the food and fibers we consume to the weathering of the rocks to form the landscapes we like to enjoy. Fewer people recognize biodiversity is of equal importance to the generation of services. In a similar way to water it is sometimes a direct component of biodiversity that provides the service—fungal genes for antibiotics, the range of plants and animals we eat, or the range of pest-controlling predators we rely on to control disease. But like water, biodiversity has an underpinning role for almost every service we derive from nature. That is not to say every service depends on biodiversity—the minerals we mine and the petrochemicals we extract arguably have little interaction with biodiversity, at least on the time scales relevant to us today, but services that are generated without some level of interaction with living things are the exception to the norm.

Forests and wetlands and flood plains as natural infrastructure

It should come as no surprise, therefore, that the key services we associate with water also involve biodiversity. The water cycle may be a geo- →

Nature is capital

The water cycle is a physical process, powered by the energy of the sun. What does this process have to do with us? The answer is: everything. People with a more entrepreneurial mentality can fruitfully represent this link by borrowing the economic concepts of social capital and utility flows.



Nature is comprised of living and non-living elements that combine to form ecosystems. Biodiversity and geodiversity describes the level of variation within the living and non-living components respectively.

The interactions between and within the living and non-living elements of nature generate a flow of services beneficial to people. In general, the more diversity in the stock, the greater the range of services.

Ecosystem services generate value for different parts of society. While it is possible to quantify many of these values, determining the specific services and stocks involved in generating them is very difficult.

physical cycle driven by the sun, but it rarely occurs without the influence of living organisms at some point.
For example, one of the key ecosystem services is the provision of fresh water for drinking and sanitation. Every person on the planet depends on these services. The 'natural infrastructure' of forests, wetlands and flood plains and the biodiversity that forms them plays a major role in the cycle of water that provides these services. Forests play a role in determining where water falls in the first place. The loss of forest cover in the Amazon is now occurring at a level that is visibly changing regional rainfall patterns. Natural infrastructure also plays a key role in regulating the flow of water after it has fallen, with diversely vegetated land slowing and smoothing water flow and avoiding the management challenges caused by peaks and troughs in flows that occur in urban areas where water flows directly over impermeable concrete infrastructure. Thirtythree of the world's 105 largest cities derive their drinking water from catchments within forest protected areas such as national parks and reserves. Biodiversity then plays a further role when wastewater is ejected from the system. Over 80 percent of global wastewater is released untreated into the environment and it is the natural processes associated with living organisms associated with riverine systems that play a vital role in breaking pollutants down and avoiding us poisoning ourselves. For these reasons, and others, the water utility sector is now considered to be one of the top ten sectors with both direct and supply chain dependence on biodiversity.
A sector with even greater reliance on biodiversity is agriculture, where living organisms play a huge role in regulating the water required to grow the crops and livestock we rely on and to process the pollutants that flow from agricultural systems. Agriculture accounts for 70 percent of global water withdrawal and any changes in the supply and flow of this water can have huge implications. In the Amazonian example, if current trends in forest loss continue, prolonged periods of drought are forecast, with resulting annual agricultural losses of over USD 400 million projected.
The energy sector is another industry highly reliant on water and biodiversity, with 90 percent of global power generation a water-intensive process. These dependencies are clearest for hydroelectric power, which generates about 16 percent of global energy. Vegetation and soil biodiversity play a crucial role in managing the water sediment load of the reservoirs used by these power stations, a function that can be carried out using technology but at greatly increased cost. The benefits of catchment biodiversity to hydroelectric power companies are one of the few areas where the value of biodiversity is being recognized and acted on, with various examples of 'payment for ecosystem service' contracts between companies and local communities to manage forests for the benefits they provide to the water services the company relies on. By 2035, water withdrawals for energy production are projected to increase by 20 percent and consumption by 85 percent. Ensuring biodiversity is considered in managing the impacts of this demand will be essential.
Finally, biodiversity plays a key role in the mitigation of damage from natural disasters. Annual economic losses from weather-related disasters are estimated at between USD 250 billion and USD 300 billion and 90 percent of these are water related. Biodiversity can play a key role in mitigating the damage from such events, with mangroves, wetlands and other coastal ecosystems playing an important role in shielding communities and absorbing much of the impact of natural disasters. For example, following Hurricane Sandy in 2012, wetlands were estimated to have saved more than USD 625 million in avoided flood damage. In a recent report by WWF on the economic contribution of nature to the global economy, the UK was highlighted as being particularly vulnerable to risk due to the extent of its coastline in the face of rising sea levels, but it was also identified as one of the countries where nature-based investment could therefore have some of the biggest economic impact. It has been estimated that protecting coastal wetlands could save the insurance industry USD 52 billion a year through reduced losses from storm and flood damage.

Ecological Jenga

How water interacts with other parts of natural capital to generate services is fairly well understood. The same cannot be said of biodiversity. There are several reasons for this. To begin with, measuring biodiversity is a nigh impossible task—unlike water or carbon it is difficult to capture biodiversity in a single value. The best we can do is measure proxies like the diversity of a single taxa, or the presence of endangered species. Secondly, we often don't know which services we need to understand. A couple of decades ago the carbon sequestering services of peat bogs were of little interest, but today they are perceived as immensely important. Thirdly, we simply don't understand enough about the infinitely complex pathways involved to generate the services we value. Science may have teased out the roles of a handful of key genes or species in the production of some services, but we can never hope to understand every interaction between every pest, predator and pathogen involved in every service we value. Ecosystems are like an ecological Jenga, the game where bricks are stacked and then removed one by one with the aim of not collapsing the tower. Every biodiversity brick in the ecosystem tower plays some role in the overall structure of the system but knowing the relative contribution of every brick is almost impossible. Some can be removed without major impact, but the more we remove, the weaker the system becomes. Finally, many of us are now so disconnected from biodiversity, sitting in our urban centers at the end of complex supply chains, that these relationships are simply out of sight and out of mind. That is not to say science has got nowhere understanding how biodiversity relates to ecosystem services, and there are some generalizations that can be made. The first of these is that, in general, more biodiversity and geodiversity mean a greater range of services are being generated. Related to this, more diversity generally means a greater resilience of a system to change, or adaptability to change if it occurs, because higher diversity gives more options for response. However, more biodiversity does not necessarily lead to a greater volume of a single service. In agriculture, for example, greater volumes of a target crop are generated by low diversity monoculture production, focusing on the volume of one service at the expense of the range and resilience of services from the system as a whole. As a result, the services that are most dependent on biodiversity tend to be the less visible maintaining and regulatory services and the values associated with these services tend to be the values that benefit society as a whole rather than the individuals that control the assets (Figure 1).
Because water is measurable, its role in services is fairly well understood and the benefits generally accrue to the people managing the assets, we are better at recognizing the economic importance of managing our water supplies which in turn incentivizes better management. The same is not true for biodiversity, which remains largely economically invisible and thus absent from most decision-making processes. Yet calls to protect biodiversity without a firm economic argument simply fail to carry sufficient political weight. Despite being every bit as important as water in generating the services we rely on to live and to thrive, biodiversity remains perceived as a low priority 'nice to have.' The result is a biodiversity crisis— biodiversity is being lost at levels unprecedented throughout human history, with over a million species threated with extinction. Biodiversity associated with water seems particularly vulnerable. We are losing wetland habitats three time faster than we are losing forests. Since 1970, declines have affected 81 percent of inland wetland species populations and 36 percent of coastal and marine species.

The approach of companies to environmental problems

Understanding and management of companies' relationship with the environment has evolved rapidly in recent decades. As part of a general reform of the way environmental, social and governance (ESG) issues are perceived, many businesses are now moving from seeing a strong environmental policy as a peripheral 'nice to have' within a corporate social responsibility program to an integral component of the business model that adds real value by managing dependencies and mitigating impacts and associated risks. However, as companies grapple with the scale of the challenge, a typical response has been to deal with issues as and when they arise—triggered by public pressure, competitor movement or incoming regulation. Climate change is rightfully the headline environmental concern facing the world today. Water is fast being recognized as the next environmental risk on the horizon.
Some would argue biodiversity is next, as illustrated by its unenviable rise in the WEF's annual summary of global risks. But these issues are not separate threats—they are intricately connected and symptoms of the same common driver. Some companies actually assign responsibility for each of these issues to different divisions, at best operating independently and, at worst, competing for resources. Solving the problem requires an all-inclusive approach to all aspects of natural capital at once. It requires thinking on different geographical and temporal scales and, often, it requires cross-sectoral cooperation.
There are examples of such approaches being put into action. Many companies are now involved in the development of multi-stakeholder, pre-competitive standards that integrate environmental and social issues beyond legal compliance and there is increasing interest in landscape or jurisdictional approaches that attempt to manage environmental issues at an ecosystem scale across sectors. Interest in the value of 'natural infrastructure' is also on the rise.
For example, Eni Congo has been working together on maintaining healthy, intact habitats as part of the management of infrastructure corridors. Deluges of rain in the tropics produce flash floods that can cause rapid erosion of exposed ground and undermine the engineering stability of substrates for important pipelines and service roads. Vegetation can prevent this erosion and avoid expensive maintenance costs or safety issues such as bent and burst pipelines or vehicles damaged by rough roads and potholes. Eni are now integrating ecosystem-based water management across their systems to ensure the sustainability of water available to them and the communities they operate with and within.

Forestry/Effective management guarantees the supply of water ecosystem services

A Natural Solution

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In addition to capturing roughly two billion tons of carbon dioxide a year, forests supply water. 75 percent of accessible fresh water comes from the forested river basins that supply 90 percent of urban centers across the world

The views expressed in this publication are those of the authors and do not necessarily reflect the views or policies of the Food and Agriculture Organization of the United Nations.

SARA CASALLAS RAMIREZ AND ELAINE SPRINGGAY

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Based on growth projections and current or announced policies, emissions from the energy industry will continue to increase in the coming decades. In fact, with contributions averaging 475g CO_2 per kilowatt hour (kWh), global electricity grid emissions would need to decrease to 50 g/kWh to meet the target of limiting global warming to 1.5 C set by the Paris Agreement. This does not bode well for achieving the Sustainable Development Goals (SDGs), in particular SDG 7, the goal concerned with affordable and clean energy for all. According to the UN SDGs Platform, 840 million people lack access to electricity and 3 billion people still use highly inefficient and polluting cooking systems. The energy sector thus finds itself in a difficult situation, as it must change drastically if it is to provide energy for all while at the same time it reduces emissions.

More than just biomass: the importance of forests for hydroelectricity

Forests are key to rectifying this situation. Traditionally viewed as sources of biomass such as timber and wood fuel, forests are increasingly being recognized for their importance to the energy sector, in particular for hydropower. They provide key provisioning services such as freshwater and regulation services such as water purification, erosion prevention and controlled water flow that can reduce costs and increase the lifespan of existing plants. Carbon sequestration and storage potential also make them allies for achieving targets set by the Paris Agreement. Proper management of forests for wood fuel production and their services for the hydropower industry can benefit communities, biodiversity and climate change and contribute to achieving SDGs 6 clean water and sanitation, 13 climate action and 15 improved life on land.

The challenge is to incentivize the energy sector, governments and local communities to improve their practices. Market schemes that support sustainable forest and water management such as Payment for Ecosystem Services (PES) are one way this could be achieved. However, this needs to be a collective effort among all sectors of society.

The ecosystem services provided by forests range from the provision of freshwater and biodiversity habitats to carbon sequestration and erosion control. These ecosystem services are vital to human existence and are affected by changes in land use, climate, human populations and demand. Today, forest ecosystems, which have been drawing increasing global attention due to their loss from land conversion and forest fires, are some of the largest ecosystem services providers. Forests sequester around two billion tons of carbon dioxide per year and also provide water, with an estimated 75 percent of global accessible freshwater coming from forested watersheds that deliver water to over 90 percent of the world's urban centers.

In the energy sector, woodfuel and hydropower are the sub-sectors most relevant to forests. As of 2017, 18.5 percent of the total final energy consumption globally was estimated to be renewable energy, with 7.5 percent coming from traditional biomass such as woodfuel, 3.6 percent from hydropower and the rest from other renewable sources. According to the 2019 World Energy Outlook report, the use of renewable energy not including traditional biomass use is set to increase mainly due to increased use of bioenergy, which includes pellets, biogas, biomethane and biofuels and is an important sector for biomass from forestry industries.

While this projection is promising, however, the same report highlights that actions to reduce emissions also need to increase. The energy sector, in general, should prioritize better management of existing systems, better planning of new infrastructure, improved efficiency and increased use of renewable energy sources. These solutions translate into major interventions, changes in consumer behavior and investments. This means that, in order to succeed, all sectors of society must be involved. Moreover, change must also be catalyzed through incentives that reward best practices in the energy sector. These could come from governments, financing institutions and international organizations.

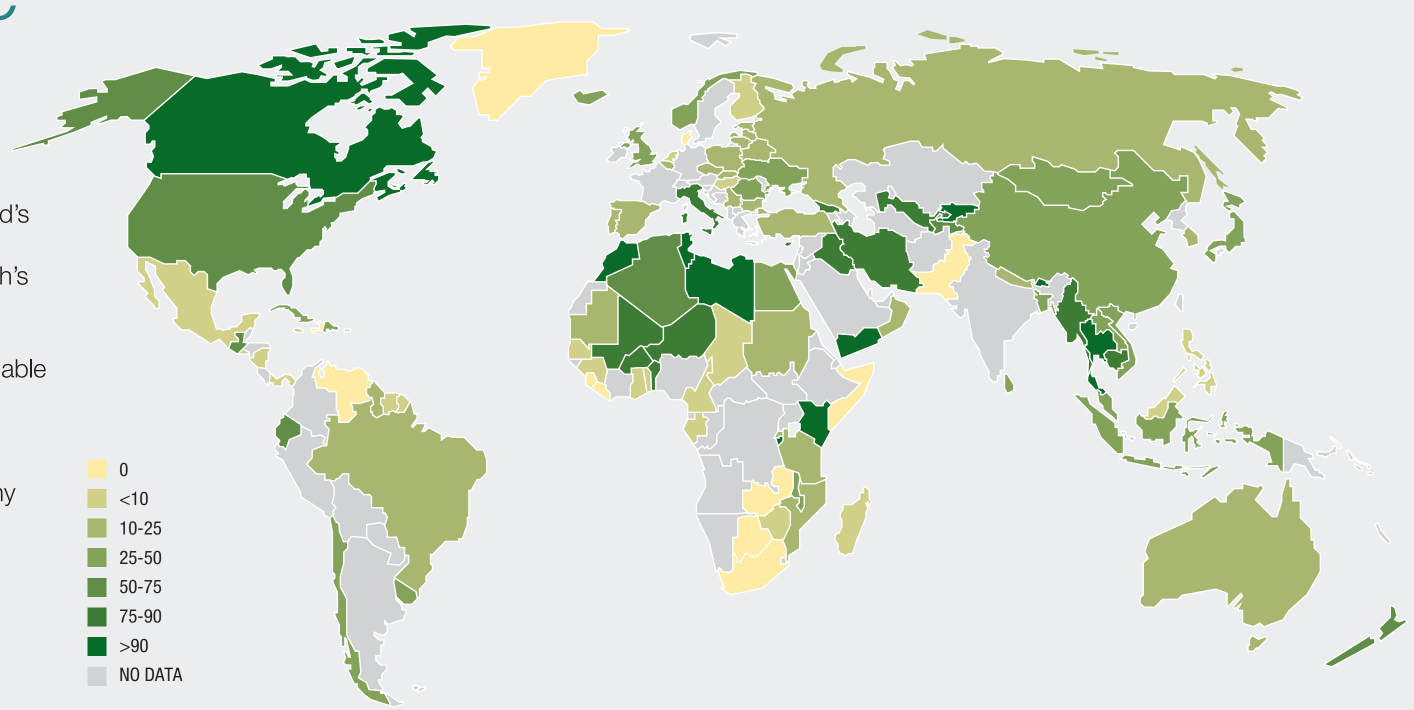
Under this scenario, how can forests help? Forests are increasingly recognized as cost-effective green infrastructure from which many benefits can be derived, particularly in a changing environment. By investing in protecting the ecosystem services provided by forests, the energy sector is enabling carbon sequestration and quality water supply, thereby →

The ecosystem services provided by forests range from the provision of freshwater and biodiversity habitats to carbon sequestration and erosion control. These ecosystem services are vital to human existence and are affected by changes in land use, climate, human populations and demand.

An inseparable bond

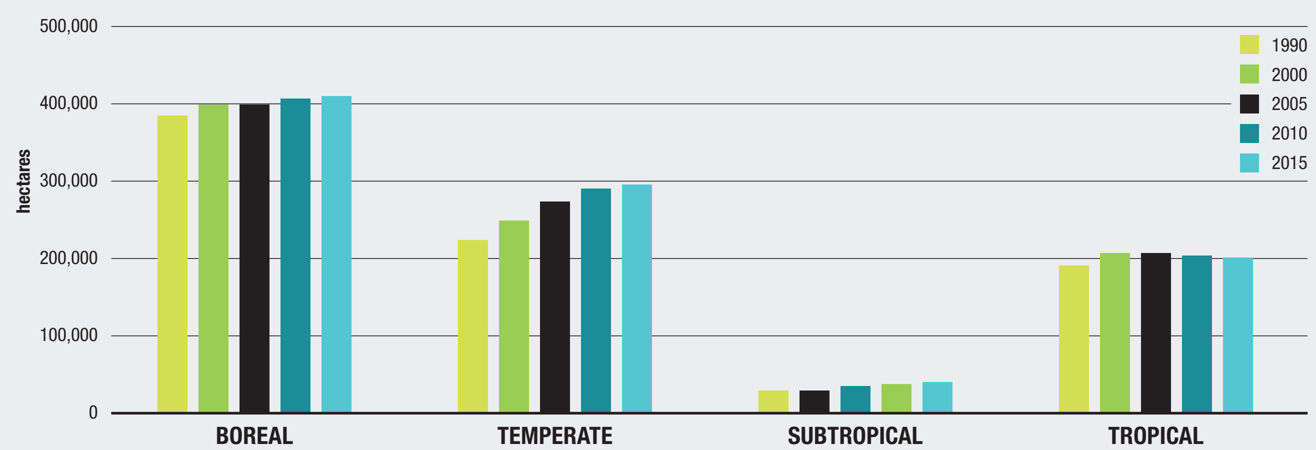
Forested watersheds provide an estimated 75 percent of the world's accessible freshwater resources, on which more than half the Earth's people depend for domestic, agricultural, industrial and environmental purposes. Sustainable forest management is essential, therefore, for good water management, and it can provide "nature-based solutions" for many water-related challenges.

PERCENTAGE AREA OF FORESTS FOR SOIL AND WATER CONSERVATION BY COUNTRY...



Source: FAO, 2018

...AND BY FOREST TYPE



Despite growing recognition of the influence and importance of forests for water, only 25 percent of forests globally are managed with soil and water conservation as one of the primary objectives.

ensuring the energy, water and food security of communities. Properly managed forest ecosystems could provide habitats for species, better water quality and quantity for fish species and increased water for irrigation and human consumption.

Sustainable forest management in the energy sector

Ideally, existing natural forests are managed and conserved properly for ecosystem services delivery. This is because reforested, afforested or restored watersheds can function differently from "pristine" ecosystems, and there can be trade-offs between managing for different ecosystem services. Natural forests are diverse, often with mixed species and different age classes, which means they are more resilient and consistent in their provision of ecosystem services. Planted forests—especially those with the fast-growing exotic species preferred for carbon sequestration—use high quantities of water. Therefore, management regimes involving species selection, density and thinning/harvesting should be taken into consideration to optimize ecosystem service benefits and reduce trade-offs.

A good example of how active management of forests can optimize ecosystem services and reduce trade-offs is Sweden's use of bioenergy. Three-eighths of Swedish energy comes from bioenergy mostly provided by biomass from forests managed and harvested for the lumber, pulp and paper industries. To achieve this, Sweden has been implementing active forest management that involves replanting harvested areas, conserving about one quarter of the forest during harvesting and sustainably using harvested wood. This type of management makes forests more resilient to fires and infestations and has resulted in increased land productivity, forest biomass and carbon storage capacity. The government and the public were key in financing and supporting the bioenergy sector, increasing its potential for growth and resulting in an opportunity for the energy sector. Globally, the lessons from Sweden could be applied in other countries with boreal forests in order to increase the use of wood as a renewable and clean source of energy.

In the case of hydropower, maintaining the delivery of ecosystem services from forests is perhaps a more urgent matter. Hydropower is widely used, and some countries in central and eastern Africa and South America depend on hydropower for almost 100 percent of their electricity. Considering that hydropower relies on water flows for electricity generation and that forests and trees can influence rainfall, contribute to reducing soil erosion and sediment runoff and regulate water flow, it is safe to say that hydropower generation is highly dependent on the link between forests and water. Sustainable forest management to maintain the forest-water-energy link is incredibly important to mitigate climate change impacts, which will increase hydrological risks. For example, changing rain patterns may lead to increased floods and droughts and affect the reliability of the system to provide electricity. This was the case in Malawi in 2017 where the levels of the Shire River, critically decreased due to drought, affected electricity generation and resulted in power outages for weeks. Deforestation in the river catchment area has been recognized as a major driver in the reduction of water quantity and quality.

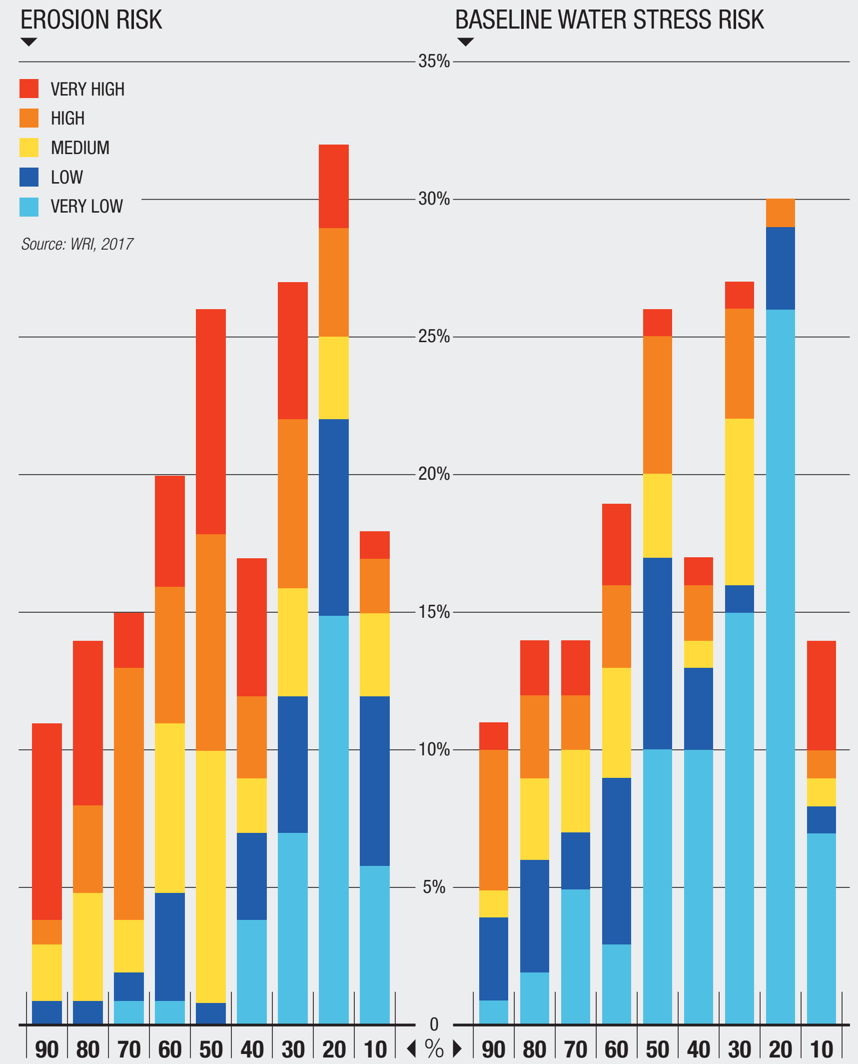
Sustainable forest management in watersheds could also lead to major costs savings for hydropower. Reduced sedimentation in source water prevents sediment buildup in reservoirs, leading to decreased maintenance costs such as dredging and repairing. In India, a study showed that key soil and water conservation measures in forested watersheds have the potential to reduce up to 44 percent of sediment transported from upstream areas into reservoirs. It was also estimated that high sediment inflows account for up to 5 percent of capital costs towards operations and maintenance.

A study in the Ecuadorian Amazon showed that the Coca-Codo Sinclair dam, which supplied 30 percent of the total national energy consumption in 2017, depends on the protected native forest areas within the watershed. Without the 209,818 hectares (ha) of protected areas, maintenance and operations costs of the dam would increase by up to USD 2.14 million per year. Furthermore, implementing conservation, restoration and silvopastoral systems in the watershed through the National Incentives Plan (a PES scheme) could result in net profits for hydropower reaching USD 16.7 million while land degradation could result in losses of up to USD 6.3 million. This evidence shows that there is a case for investing in sustainable forest management.

ITAIPU Binacional is a hydroelectric power company shared by both Brazil and Paraguay. It is located in the Paraná River and has a management method focused on watersheds. According to ITAIPU's 2018 Sustainability Report, their investments in social and environmental projects to ensure the quantity and quality of water in the reservoir have resulted in the increased lifespan of the reservoir to more than 180 years.

These efforts include working with communities in areas such as forest restoration projects in adjacent watersheds that feed the reservoir, the creation of biological corridors and the conservation of agricultural soils. The results in this report also show that the protection of 101,000 ha of forests for water contributes to providing biodiversity habitats and maintaining remnants of the Atlantic Forest in Paraguay, Brazil and Argentina. Both sides of the reservoir have been recognized as UNESCO biosphere reserves, and the company has been to UNFCCC COP24 and COP25 to share its experiences, best practices and lessons learned.

RISK BY PERCENTAGE TREE COVER LOSS



The forest loss and degradation associated with land conversion and poor land management practices may also increase the risk to and damage from water-related hazards, such as floods, landslides and storm surges. Of the hydrosheds that had lost at least half their tree cover by 2015, 88 percent had a medium to very high risk of erosion and 48 percent had a medium to very high risk of baseline water stress.

Moving forward

As we move forward, it is imperative that energy projects be designed with future social and environmental conditions in mind. ITAIPU Binacional is an example of the energy sector doing so. These are long-term investments that, if designed for sustainable development, could contribute to ensuring food, energy and water security for people. Recent studies show that basin-scale planning for hydropower can minimize the impacts of dams, especially in mega diverse river basins such as the Amazon, Congo and Mekong basins, which are experiencing a boom in hydropower construction. Incentivizing sustainable forest management in these planning processes is crucial, as is the need for market schemes that evolve with the sector and include climate change considerations.

Currently, new schemes are being developed with the basin scale concept in mind. The Cloud Forest Blue Energy Mechanism, which is being developed by Conservation International and The Nature Conservancy, is an example. In Latin America, 50 percent of cloud forests have been lost due to land degradation from mining, cattle and agriculture. These tropical and sub-tropical forests are particularly useful for water ecosystem services. Their mechanism for capturing water from fog and their low evapotranspiration result in additional water reaching the watershed. They generate up to 50 percent of the available surface water that flows into reservoirs in Latin America, regulating inflow and flow regularity of hydropower plants.

PES schemes that target cloud forests and hydropower have been implemented with mixed results in countries such as Costa Rica and Mexico. The Cloud Forest Blue Energy Mechanism, as explained by the Global Innovation Lab for Climate Finance, uses a "pay-for-success" approach where a hydropower plant pays for measured reduced sedimentation, increased water flow and improved water regulation provided by cloud forests within the plant's catchment area. The aim is to reverse the trend in deforestation while contributing to climate change mitigation and adaptation. The innovation comes from the "pay-for-success" approach, which is new in developing countries, new in performance metrics used and its comprehensive implementation structure.

For these schemes to work, monitoring of forest-water interactions at basin and local scales needs to become common practice in the hydropower industry. International organizations currently involved in forest and water monitoring, government agencies, academia and environmental civil society organizations will have an important role to play in this regard.

Championing progress

Governments are stepping up and recognizing the importance of forest and water management for sustainable development. Evidence of this is the 25 percent of forests globally that are managed with soil and water objectives as a priority and the 49 percent of 168 (Intended) Nationally Determined Contributions ((I)NDCs) to the Paris Agreement that refer to forest and water management, integrated (water) resource management and the water ecosystem services provided by forests. The energy sector and international organizations are also stepping up. At the UNFCCC COP24 in December 2018, the Sustainable Water and Energy Solutions partnership was launched. Led by ITAIPU Binacional and the United Nations Department of Economic and Social Affairs, it aims to share best practices and enhance capacity and cooperation across sectors to address SDGs 6 and 7 and their interlinkages with other SDGs.

The energy sector has an important task ahead. Best practices that target landscape management approaches that include sustainable forest management for the provision of water related services should be widely adopted in current and future projects. Participating in market mechanisms such as PES schemes that focus on these landscape management approaches will also be important for individual plants and could have significant returns on investment. Furthermore, engagement from the energy sector with governments, financial institutions, international organizations and other productive sectors such as the forestry sector and the general public will be of paramount importance to champion best practices to close the energy and emissions gap. In summary, the energy sector is at a crossroads where it could continue with its business as usual practices or it could grow in a direction that can create economic opportunities for the sector while contributing to sustainable development for all.

Projects/The World Bank's pilot experiment in Tanzania

Closing Gaps and Financing Taps

In many countries in the sub-Saharan region, the financing capacity of individuals and governments is small compared to the amount of resources needed to guarantee that rural populations have access to water. The new model currently being tested combines mixed financing and emerging technologies

KRISTOFFER WELSIEN

He is a World Bank water and sanitation specialist. He has spent the last eight years in East Africa and specifically focused on strengthening the sustainability of rural water supply and mainstreaming solar powered water pumping.

Filling one bucket is easy. Filling buckets of water for an entire rural village is doable. But ensuring clean water for an entire sub-Saharan country can prove difficult. There are two fundamental reasons why half of the rural population in many sub-Saharan countries lack access to safe water. First, rural water systems break down frequently. Second, rural water systems are expensive. These seemingly simple reasons mask a remarkably complex reality. That's because a body of evidence points to a multitude of challenges affecting the sustainability of rural water supply. This includes funding, where the combined financing capacity of donors and governments is far exceeded by the resources required to close the existing funding gap. In the meantime, thousands of rural villages lack safe water. This begs the question: what should a deep-well rural water system look like in the future? How will it avoid breaking down? And perhaps most importantly, how should it be financed? A new model in Tanzania is experimenting with a bold solution combining blended financing with emerging technologies. →

Addressing the sustainability of rural water supply

Achieving sustainability involves perfecting a range of complex issues. The advancement of technology, the Internet of Things and its increasing affordability and applicability allow for a range of improvements potentially favorable to sustaining rural water schemes. Remote monitoring of pumping systems is now widely available and allows operators to remotely monitor and troubleshoot pump performance and groundwater levels. Solar pumping significantly reduces the cost of water extraction and could potentially return financially struggling village water utilities back to profitability. Over the last seven years, the technology and price of solar pumping have evolved dramatically and opportunities have therefore increased. Water pumping via solar energy, once a niche market, is now being mainstreamed. Driven by low PV prices, improved technology is now able to pump higher volumes of water and reach even deeper sources of groundwater.

Solar photovoltaic water pumping (SWP) uses energy from solar photovoltaic (PV) panels to power electric water pumps. The entire process, from sunlight to stored energy, is elegant and simple. A solar pumping system includes the solar panel itself, the pump and a power conditioner. SWP systems are now flexible and can work in tandem with a back-up generator and the electrical grid.

The evolution of solar pumping

- SWP system capacity and ability have expanded. Early solar pumps (1980-2007) had limited performance and were restricted to pumping installations with a shallow water source and low water demand. Today, pumps can reach deeper wells (500 meters (m) compared to the previous 200 m) and push larger volumes of water (1,500 m³ /day, compared to the previous 500 m³ /day at low head). Efficiencies have also increased considerably as new pump and motor designs have increased water outputs over the entire pump range
- Prices of PV panels have dropped exponentially. High demand for PV modules for grid-tied applications has resulted in massive economies of scale in production as well as competition among vendors. The commodity price of silicon, the key material, has also dropped substantially
- The number of SWP manufacturers and suppliers has increased. Old monopolies have been broken, and although the technology leaders continue to innovate, competition is fierce on price, performance and quality
- SWP is being mainstreamed and awareness is growing. Good news travels fast, and markets are increasingly demanding SWP in place of conventional pumping solutions. Further opportunities are arising as intensive awareness campaigns support and elaborate on the details of system performance and savings. Retrofits to diesel pump systems represent a market for further potential savings.

Financial benefits

There are several technically viable options for new pumping systems, generally distinguished by their energy source—diesel pump, wind or solar. Cost-benefit analysis (CBA) is often used to assess the economic merits of alternative investment options. Pumping systems typically have a 20-year lifespan, and over that period they incur various costs, some at the outset, and others at different times throughout the system lifetime. Consideration of all costs incurred during the system lifetime is often referred to as a life-cycle cost analysis (LCCA). LCCA is particularly important for renewable energy projects because of high initial investment costs. More conventional options based on fossil fuels may appear cheaper due to lower initial costs; however, operating costs can be considerable over the project life.

An example from Tanzania illustrates the economic benefits of solar pumping. Exactly 418 existing operational diesel pump water schemes (i.e., water pumps running on diesel generators) were studied in rural areas. Data were collected on these schemes to compare the LCC of a typical system with the LCC of solar pumping.

The initial average cost of a diesel fueled genset pumping system is around USD 13,000. During its 20 years of operation, the system incurs substantial annual costs for diesel fuel (the average yearly expenditure in fuel is over USD 5,000, or 40 percent of initial costs), as well as periodic replacement costs. Solar pumping systems by comparison, have higher initial costs (around USD 30,000) and there would be significant expenditure in year 10 to replace the pump, but these costs are more than compensated for by the vast reduction in energy costs. If a diesel-powered pumping scheme were converted to solar, the calculation shows that the life-cycle cost would be about USD 59,000, 36 percent down from USD 93,000 for the diesel pumping with a return on investment in 2-3 years compared to a diesel-fueled pump. Particularly compared with diesel pumping, solar is not only more energy efficient, but the financial benefits far outweigh the costs.

Considerations for designing a solar pumping system include various parameters that include water demand (volume), water storage, water depth (head), location of PV panels and solar irradiance among others. Fortunately, modern software provides a free and user-friendly tool that enables engineers to easily design and size solar pumping system. To increase awareness, the World Bank has produce a simple handbook as part of a larger package on solar pumping produced by the World Bank Water Global Practice, which includes a comprehensive knowledge base, video tutorials, case studies, and more.

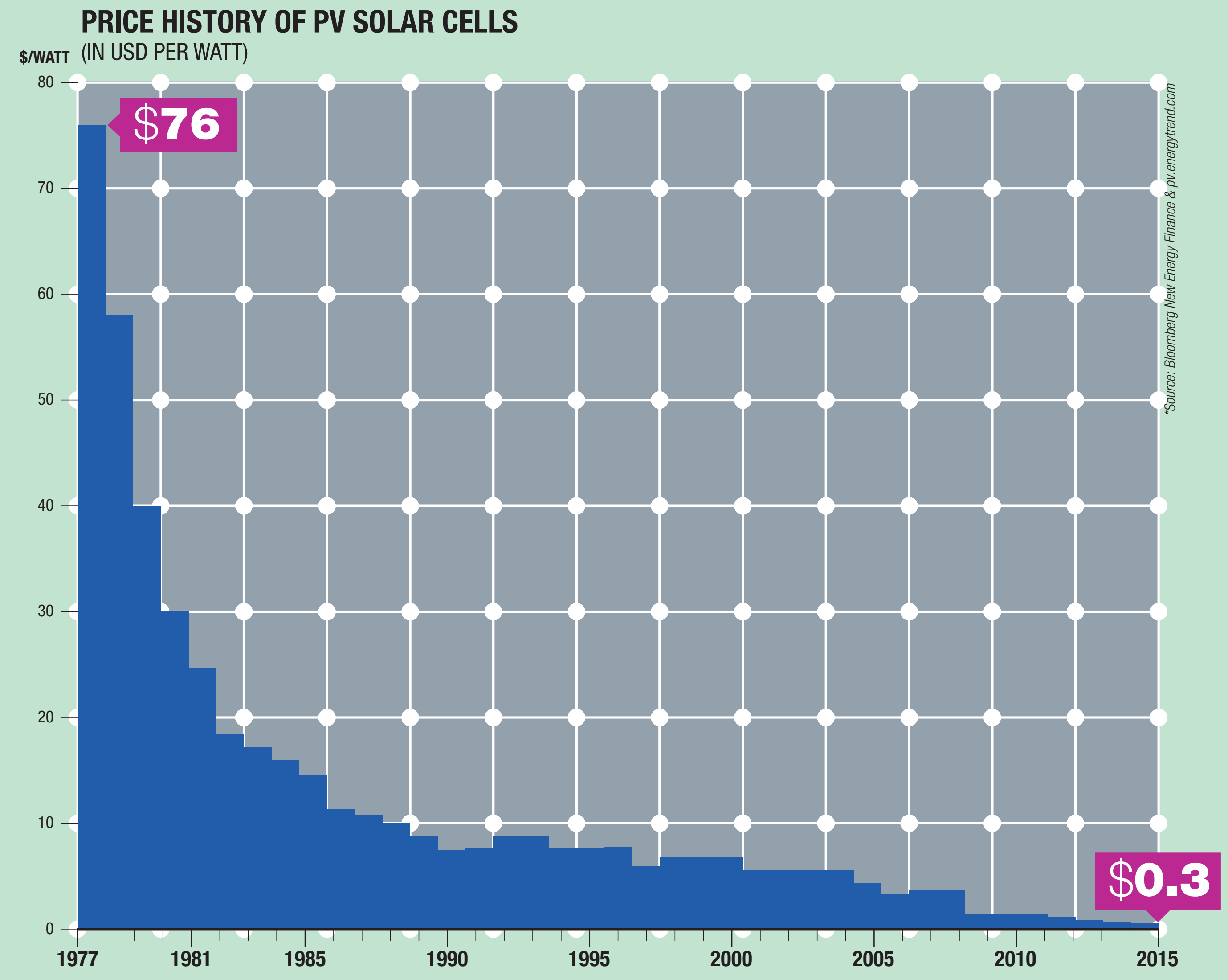
Applying the technology in Tanzania

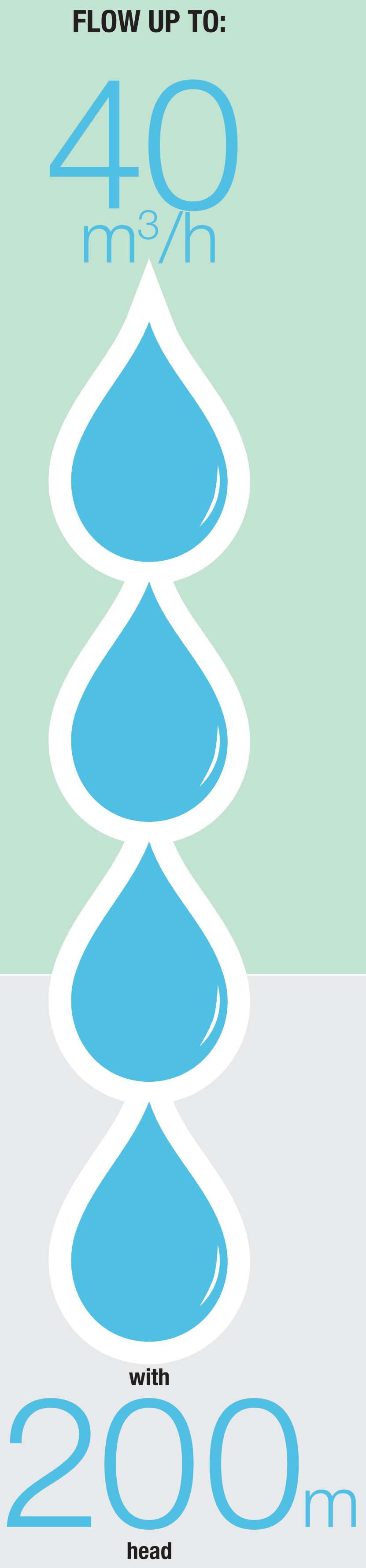
Rural communities may not always have the full capacity to service and maintain modern pumping systems, and the private sector has traditionally only been involved during the construction phase. However, what if contractors were obliged to commit to a four-year service agreement, including extended warranties through the so-called "build and operate" contracts enforced by a performance bond? Such long-term contracts are often expensive due to the remoteness of rural villages. Nevertheless, economies of scale in the provision of service and maintenance could be achieved by clustering 50 neighboring villages and awarding the works and service provision to just one contractor. This approach would further benefit from standardization of equipment, remote sensing of all 50 sites and the long-term sustainability enhanced by an option for the participating villages to extend the service contract beyond the initial four-year service period.

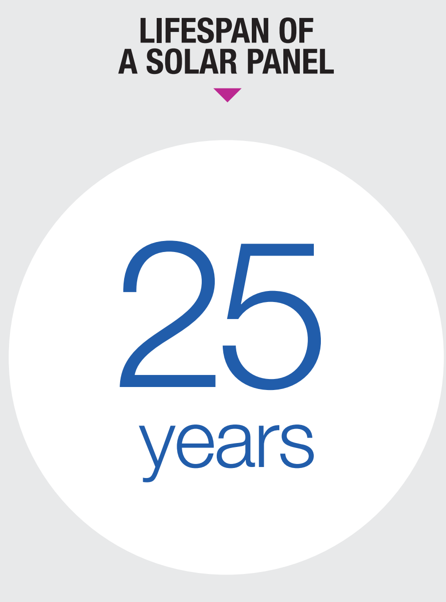
While the above mentioned model may contribute to the sustainability of rural water schemes, the financing gap in the sector is perhaps the largest obstacle to achieving Sustainable Development Goal 6: ensure availability and sustainable management of water and sanitation for all. Closing this financing gap has historically been a tall order for government and donors, especially considering that about one-in-five newly constructed water schemes breakdown within the first few years. Taking Tanzania as an example, let's presume that there are 6,000 rural villages without access to safe water. And for argument's sake, let's assume that a new rural water scheme for 3,000 people costs USD 100,000, leaving an investment gap of USD 600 million for new rural water schemes (discounting the rehabilitation needs of existing water schemes and the need to expand existing schemes to meet the demand of the growing population). In summary, there is a dire need for rethinking the traditional financing model for the rural water sector.

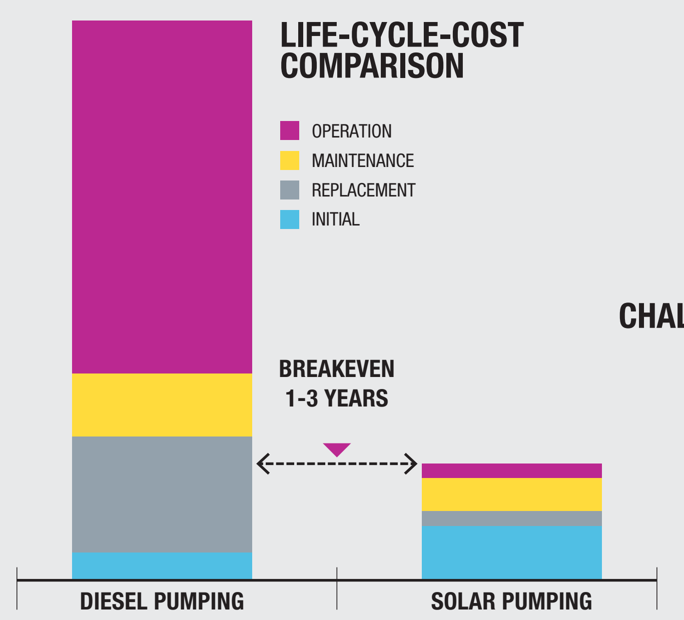
Solar photovoltaic water pumping

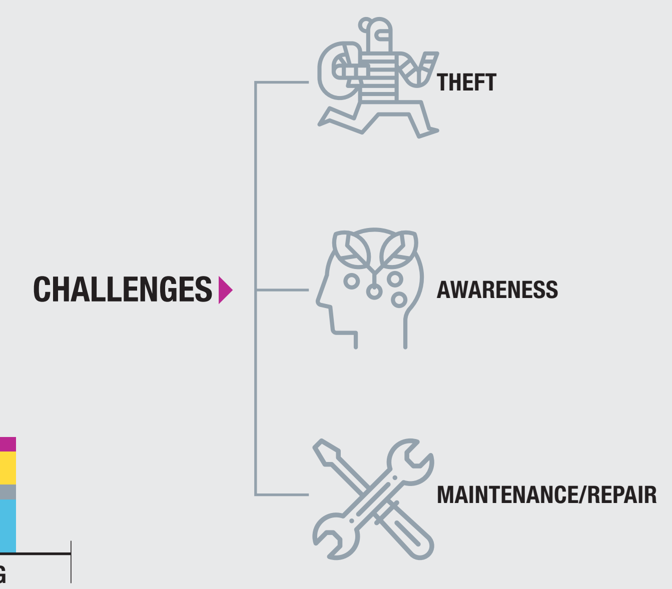
Solar photovoltaic water pumping (SWP) uses energy from solar photovoltaic panels to power electric water pumps. SWP, once a niche market, is now being mainstreamed. Driven by low PV prices, improved technology is now able to pump higher volumes of water and reach even deeper sources of groundwater. More conventional pumping systems based on fossil fuels may appear cheaper due to lower initial costs; however, operating costs can be considerable over the project life.











A New Model: Accelerating Solar Water Pumping via Innovative Financing

This project in Tanzania combines the above-mentioned technologies and approaches and targets existing rural water schemes powered only by diesel generators and where water customers are used to pay for water. The pilot seeks to demonstrate that rural communities can repay 40 percent of the capital investment and maintenance service contracts without increasing the price of water. The 40 percent will be financed through a four-year loan from the TIB Development Bank. The other 60 percent will be subsidized through a grant funded by SIDA and the Dutch Government through the World Bank's Global Partnership on Results-based Approaches (GPRBA). The pilot also received assistance from Global Water Security and Sanitation Partnership. The benefits from this initiative are two-fold. Firstly, it harnesses the power of private sector financing in community development through blended subsidy-loan combinations. Secondly, transitioning from diesel pumps to solar pumps leads to demonstrable environmental and economic advantages in the form of lower CO_2 emissions and high life-cycle cost savings.

Collecting monthly revenues from rural remote villages poses obvious challenges. Mobile-money-enabled pre-paid water dispenser technology has been around for about a decade. The price was previously prohibitive for mainstreaming, but recent pilots in East-Africa have demonstrated that it is dropping rapidly. By digitizing revenue collection to a ring-fenced bank account, this technology has anecdotally increased revenue collection by 50-400 percent in remote rural villages in Tanzania.

Over the next two years, the project will find out whether this new model will create the envisioned synergies. A successful pilot could be transformational in that the loans could be extended from four years to possibly 15-20 years, potentially enabling the communities to cover a larger portion of the capital investment of their water scheme while keeping the price of water constant, thereby helping bridge the financing gap. We are entering a period where sound financial engineering is just as important as civil engineering and closing the financing gap will open new opportunities for reaching the SDGs.

A rendering of a recreational space that also serves as a stormwater-filtering wetland for the city of Los Angeles, California by a multi-disciplinary MIT research team from the Department of Civil and Environmental Engineering as well as the Department of Architecture. This team developed a design framework for modular and scalable urban wetlands that can be adapted to a variety of urban settings for more efficient stormwater treatment while providing ecosystem services and recreational spaces.

Technology/MIT's efforts towards a water-secure future

Water Security for All

Water and sanitation infrastructure built in the twentieth century, which has significantly reduced mortality, is one of the greatest engineering achievements of the time. Today, even greater innovation is needed to guarantee access to clean water for current and future populations

JOHN H. LIENHARD V

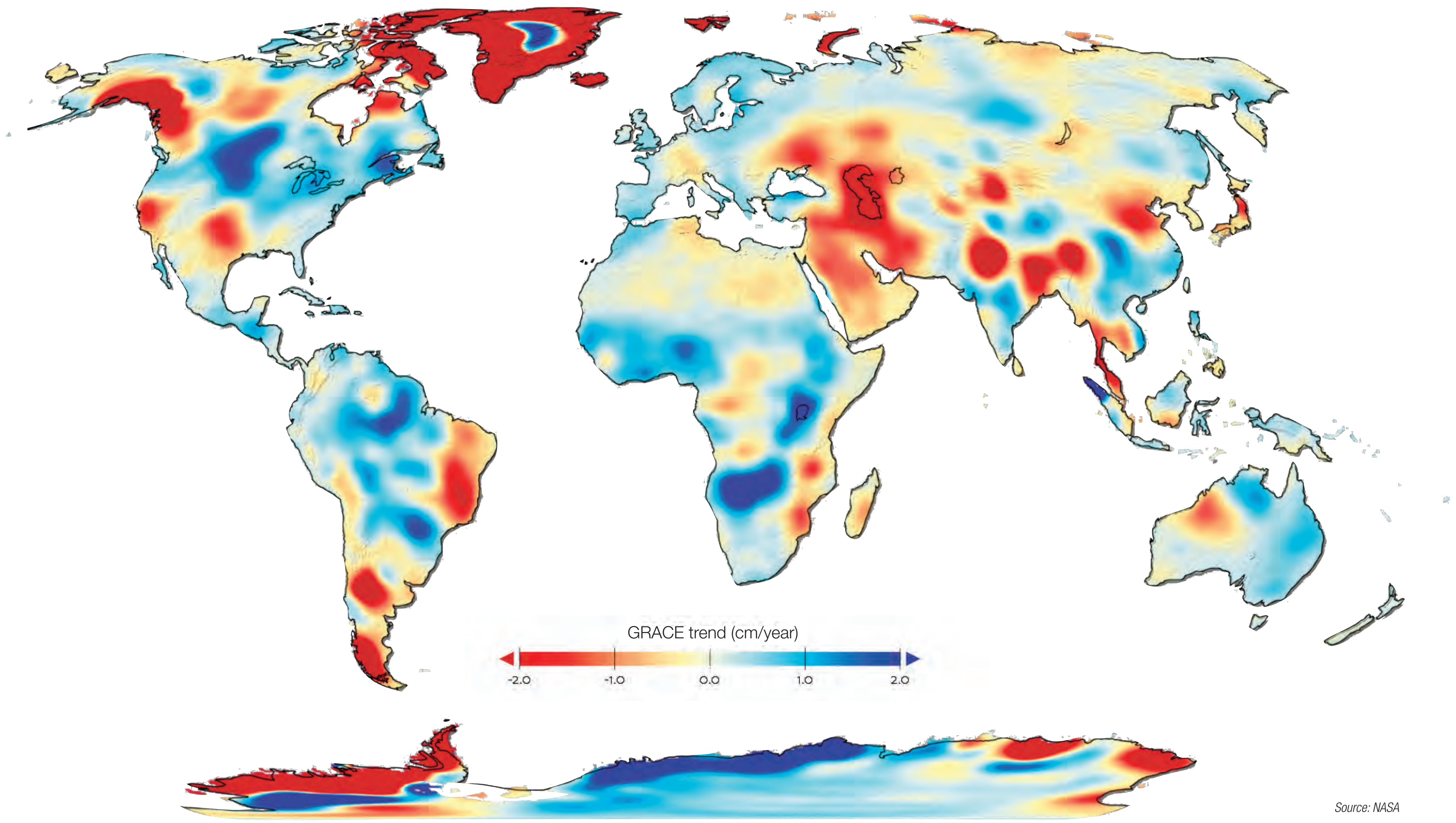
He is the Abdul Latif Jameel Professor of Water and Mechanical Engineering at MIT. During three decades on the MIT faculty, Lienhard's research and educational efforts have focused on heat and fluid flow, water purification and desalination, and thermodynamics.

In 1943, the psychologist Abraham Maslow proposed a universal hierarchy of human needs. He framed this need as a pyramid comprised of five horizontal layers. The layers range upward, from safety, through love and belonging, then to esteem, finally to self-actualization at the top. But at the very base of his pyramid, serving as its foundation, Maslow placed our physiological needs, including air, water and food. Without that foundation, higher levels of human achievement are impossible.

Humans have created many technologies to support these basic needs. Examples range from millennia-old water jugs, wells and aqueducts to the industrial water treatment and desalination facilities that now feed municipalities across the globe. Indeed, the water and sanitation infrastructure built in the 20th century—which greatly decreased mortality and raised our quality of life—is one of the greatest engineering achievements of the era.

Today, we need even greater technical innovation to ensure that current and future populations have reliable access to clean water. Our rapidly expanding cities demand more fresh water than local watersheds can provide. Our industries and dwellings still release wastes into our rivers and streams. The intensifying climate crisis is altering historical precipitation patterns worldwide, straining the existing infrastructure, food production and ecosystems upon which we depend. Arid regions are particularly stressed, although water scarcity is now a global phenomenon.

At the Massachusetts Institute of Technology, where I am based, researchers from diverse fields are driving toward solutions. They are creating new technologies, better poli- →



Source: NASA

Based on satellite data collected over a period of 14 years by a NASA Earth observation mission called Gravity Recovery and Climate Experiment (GRACE), the map shows how the availability of fresh water in the world is changing. High latitude regions, tropical areas and low latitudes are becoming more humid, while at the same time middle latitudes (the arid and semi-arid belt in the middle) are becoming drier.

cies and novel business models, many specific to a local cultural context. MIT's Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) is fueling much of that work through seed grants, commercialization support, and industrial partnerships. In this article, I highlight a few of these efforts to ensure a water-secure future for everyone.

Water for agriculture

Agriculture uses much more water than cities and towns—roughly seven to eight times more. This high demand, coupled with poor stewardship of dwindling resources and the consequences of climate change, makes our food systems vulnerable.

For example, agricultural irrigation most often uses surface water. In areas such as Southern Australia, however, long-term drought and wildfires have shrunk surface water supplies and lowered water quality. Farmers there have experienced a 300 percent increase in water costs, cutting sharply into profit margins. Irrigation has also overdrawn groundwater resources. In parts of India and in the irrigated High Plains of the U.S., over-pumping and excessive use of pesticides and fertilizers have led to sinking water tables and drinking water contamination. In Egypt, a rising population strains the Nile River—the agricultural lifeline of the country—and the Grand Ethiopian Renaissance Dam, a hydropower project, threatens to reduce Nile water flow while it fills. Managing supplies like these more effectively is essential to long-term food and water security.

Low cost and water-efficient irrigation technology can protect farmers of all incomes across the globe. At MIT, professor Amos Winter in mechanical engineering is developing low-pressure, solar-powered drip-irrigation systems that can reduce a farm's water consumption by as much as 60 percent. His work is aimed at farmers in India and other developing parts of the world where irrigation may rely on inefficient diesel pumps or traditional flood irrigation.

What about food crops that are better adapted to climate stress? Advanced biological science enables faster and more effective crop breeding than is possible by the traditional, slow path of hybridization. MIT's David Des Marais, a professor of civil and environmental engineering, and Caroline Uhler, a professor of computer science, are working on a J-WAFS-backed project to find the genetic foundations of plant tolerance to the stresses of heat and drought. With machine learning, they aim to find the gene networks that impart drought resistance to certain grasses similar to wheat and rice. Their research will guide accelerated hybridization of food crops, through precise gene editing. These new strains should produce more grain from less water and ensure that crops survive our increasingly variable climate.

Apart from supply-side solutions, better demand management is essential. For example, one-third of the grain grown in the world simply feeds livestock. And some foods, particularly beef, require much more water to produce. For those who are not vegetarians, even a small movement toward a more plant-based diet can help reduce burden on water and on agricultural lands.

Water for people

What of the 10 percent of fresh water used across the globe for drinking, washing, and domestic purposes? Water for human consumption and household use faces an array of challenges: the vast trend of urbanization, rising population and evolving standards of living. Urban areas usually draw their water from a surrounding watershed—rivers or lakes and the lands that feed them. But other resources must be tapped when populations exceed what can reliably be drawn nearby.

Desalination

Over the last half-century, desalination plants have had a growing role in offsetting fresh water scarcity. Yet, this technology has ancient origins.

J-WAFS-funded research under the direction of T. Alan Hatton, Ralph Landau Professor of Chemical Engineering at MIT, has resulted in the development of a new method for removing even extremely low levels of unwanted compounds from water. The new method relies on an electrochemical process that can selectively remove organic contaminants such as pesticides, chemical waste products, and pharmaceuticals.

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In antiquity, seawater was directly boiled, and the steam was condensed to make fresh water. That vaporization consumed a great deal of fuel. Today's most efficient desalination plants don't use heating at all. Instead, they pressurize seawater behind thin polymer membranes. The pressure drives fresh water through the membranes, in a process called reverse osmosis (RO).

Through technology improvement, desalination's energy use has fallen dramatically. But this kind of improvement has limits. Desalination can never be "zero energy" because water must be pumped and pretreated and because thermodynamics sets a minimum energy to separate water from salt water. Even so, cost and carbon footprint continue dropping as processes improve. Most importantly, RO plants are electrically powered and fit easily into a low-carbon electrical grid (perhaps based on solar or wind power, as noted in a 2016 J-WAFS study). Planners throughout the Middle East are looking to large-scale, renewably-powered RO as the primary choice for many new desalination plants.

A community-scale example is Brazil's Água Doce program, launched in 2004. This government effort promotes sustainable use of brackish groundwater in rural communities. Água Doce has deployed more than 600 small desalination plants across semi-arid eastern Brazil. Today, hundreds of thousands of people receive potable water through the program. The program's goals include community empowerment, environmental sustainability and building technical capacity. Likewise, MIT research has created several small-scale solar-driven desalination technologies. Those systems use not only RO, but also electrodialysis and high-performance solar stills.

Purification and sensing

Clean water supplies depend on effective water purification and wastewater treatment. Constant vigilance is required. For example, aging infrastructure or changing environmental conditions can contaminate drinking water with heavy metals. In response, researchers are focusing on new technologies to remove lead, arsenic, uranium and other elements from water. At MIT, Tim Swager, a professor of chemistry, is designing polymers that can selectively remove mercury and lead ions from water. Julia Ortony, a professor of materials science and engineering, has made self-assembling nanoribbons that capture arsenic. And Zachary Smith, a professor of chemical engineering, is applying metal-organic frameworks to selectively remove boron, an essential micronutrient for both plants and animals which becomes toxic at high concentrations.

Industrial micropollutants are also a target of novel technologies. These harmful chemicals often have low concentrations. Conventional water treatments don't remove them. Alan Hatton, a professor of chemical engineering at MIT, has created chemically tunable electrodes that capture specific organic pollutants. Professor Patrick Doyle, also in chemical engineering, is developing a special hydrogel for water treatment. This gel can be "tuned" to selectively absorb organic contaminants from industrial and agricultural wastewater.

Low income areas that lack reliable water infrastructure need affordable, open-sourced technologies to test and clean water. Susan Murcott, an environmental engineer at MIT, has devoted her career to accessible technologies for water, sanitation and health in developing countries. Most recently, she has created a low-cost, portable test kit for *E. coli* in drinking water. She has deployed these kits in Nepal by working with J-WAFS, the MIT-Nepal Initiative, led by history professor Jeffrey Ravel, and the Nepalese NGO Environment and Public Health Organization (ENPHO). This new kit is poised to reach millions of Nepalese citizens who are otherwise threatened by waterborne disease.

MIT researchers in mechanical engineering and MIT D-Lab (an MIT center that approaches international development with a design mindset) have worked in both rural northern India and in Delhi's slums to develop an affordable water filtration system. Their technology exploits the natural filtration capabilities of xylem tissue from coniferous trees. The research team formed these technologies into culturally adapted products by working closely with on-the-ground partners. And they have released the design as an open-source technology. The result? Small entrepreneurs in India will soon commercialize the xylem-filtration devices, manufacturing them locally and selling them in their communities.

Women from a mountainous village in the Bageshwar district of Uttarakhand, India, participate in a design workshop facilitated by J-WAFS-funded researchers from MIT D-Lab and the MIT Department of Mechanical Engineering in order to develop prototypes for a wood xylem-based household water filter. The workshop was conducted to uncover the needs and design preferences of potential users for the household water filters the team is developing.

Water management

Ensuring greater resilience for our water systems will require comprehensive water management. At the urban scale, one key aim is to improve stormwater management. Ground water should be replenished, and run-off of pollutants into surrounding ecosystems should be prevented. In 2017, a team of MIT civil engineers and landscape architects released design frameworks for urban stormwater wetlands that achieve these goals. Their designs provide natural water treatment, flood protection, water storage, wildlife habitat, and attractive urban parklands. Reducing waste in our existing water systems is also essential. Water efficiency standards, such as for low-flow toilets and showerheads, have resulted in enormous water savings where they have been adopted. In arid climates, grass lawns are being replaced by xeriscapes to eliminate landscape irrigation. Effective detection and control of leaks in urban water pipes cuts waste: in many parts of the world, water leakage from buried pipes amounts to 20 to 50 percent of the initial supply! One MIT startup, WatchTower Robotics, deploys floating robots to inspect water pipes from the inside. Technologies like this can detect leaks that may otherwise be very difficult to locate and can identify problems with pipes before they are catastrophic. An estimated 240,000 water main breaks per year in the U.S. alone waste over seven trillion liters of treated drinking water. Preventive maintenance can save water, energy and money. Conserving water also means achieving greater circularity in our consumption through wastewater reuse. In California, the Orange County Water District's groundwater replenishment system reclaims wastewater that would previously have been discharged into the Pacific Ocean. The wastewater is treated by microfiltration, RO, ultraviolet light and hydrogen peroxide, making water clean enough to meet state and federal drinking water standards. The clean water is pumped into injection wells and recharge basins. These replenish the deep aquifers of north and central Orange County's groundwater basin, from which potable supply is drawn. Likewise, Singapore's National Water Agency, PUB, has been extremely effective in rallying public support for water reuse. Used water is treated to a potable standard and branded NEWater. Five NEWater recycling plants supply 40 percent of Singapore's current water need. PUB expects to increase NEWater capacity to meet up to 55 percent of water demand by 2060.

Outlook

Assuring safe, sufficient and sustainable water for everyone is among the 21st Century's most urgent challenges. Water supply is a daily hardship for billions of people already. Climate change and population growth are expanding water scarcity and water-driven conflict. We need to bring our best efforts, not only in engineering and technology, but also in integrated water management and collaboration across disciplines, institutions, states, and nations. Working together, we can secure the future of our communities and farms and the prosperity of our economies for decades to come.

Business/Sustainable water management by companies

Creating Water Resilience

Businesses have a key role in addressing the world's water challenges. The CEO Water Mandate mobilizes business leaders to understand and advance water stewardship—for the good of their companies and their communities

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PETER SCHULTE

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Water is perhaps the most vital natural resource on the planet. It is necessary for human survival and a critical input into our food, manufacturing and energy systems. It also sustains the ecosystems and climates upon which both our built and natural world rely. Today, the world's water resources are increasingly under stress, threatening ecosystems, economies and society more broadly. According to the World Economic Forum, water crises have been among the top five global risks in each of the last seven years.

Humans withdraw about four thousand cubic kilometers of water globally every year. This is triple what we withdrew 50 years ago, and withdrawals continue to increase at a rate of about 1.6 percent per year. More than two billion people live in river basins where water demand outstrips supply, known as water-stressed areas. By 2050, that number is expected to jump to five billion. Currently, over 80 percent of the world's wastewater is discharged back into rivers, streams and oceans without any treatment, causing widespread damage to ecosystems and contamination of critical human water sources. Often, humans are unable to reliably access physically available water supplies due to inadequate infrastructure and weak governance. Today, 2.1 billion people still lack access to safe drinking water and 4.5 billion people lack safely managed sanitation services. Every year, approximately 340,000 children under five die from diarrhea-related disease, most commonly caused by inadequate access to drinking water, sanitation and hygiene (WASH).

Underlying all the world's water challenges are the looming repercussions of our changing global climate. Climate change introduces a huge amount of uncertainty to water supply reliability in the future. Higher temperatures mean snowpack melts more quickly, meaning more intense floods and longer droughts. The number of people at risk from floods is projected to hit 1.6 billion in 2050, with USD 45 trillion worth of assets at risk. On the other extreme, it is estimated that global water demand will increase 55 percent by 2050 and 3.9 billion people will live in river basins under severe water stress.

Water-related risks to business

These water challenges not only pose grave threats to our ecosystems and communities, but to businesses and our economy more broadly. Companies that fail to address the many water risks facing their business put themselves in danger of:

- Operational and supplier disruptions

NATURAL AND ARTIFICIAL
A big ice cube, with small pieces of plastic of green PET bottles, fished from the ocean.

- Higher operational costs
- Loss of legal or social license to operate
- Heightened absenteeism among workers
- Diminished investment
- Miss money saving opportunities.

Operational and supplier disruptions

Many of the world's business industries—food, beverage, apparel, chemicals, mining and metals, semiconductors, and many others—are heavily reliant on water as a key input into their production processes and often a key ingredient in their products. If the river basins in which they operate run out of water, they simply cannot continue production in that location. If a company's suppliers face the same challenges, it may be left without a reliable source of key inputs and still have to halt production. In 2016, companies reporting to CDP reported USD 14 billion in water-related impacts to their businesses in that year alone, with over a quarter of all reporting companies already reporting detrimental water-reporting impacts to their business.

Higher operational costs

Even when water remains available to companies in times of severe water stress, it may still come at a high cost to the business. In many situations, water stress forces utilities to raise the price of water in order to motivate conservation. It can also mean higher energy costs, as there is less water available to run hydropower plants and less water to cool processes in thermo-electric plants. Likewise, if river basins are so polluted as to make fresh water supplies unusable, businesses will face much higher pre-treatment costs for their water inputs. In 2015, drought in hydropower-dependent Brazil raised water costs for General Motors by USD 2.1 million and electricity costs by USD 5.9 million.

Loss of legal or social license to operate

Even if there is physically enough water for companies to continue production and prices remain stable, companies can also still lose their license to operate if they are perceived as unduly contributing to water-related challenges. They can lose their legal license to operate if local regulators deem their activities out of step with local policy or detrimental to the good of the basin. They can lose their social license to operate if activism from local communities makes business in that area untenable.

Heightened absenteeism among workers

Companies are also increasingly seeing the great risks caused by insufficient access to WASH services at the workplace and at home for their workers. If workers do not have sufficient WASH services, they are much more likely to become ill due to water-borne diseases or have to stay home to take care of ill children, thus leading to greatly diminished productivity for companies. Diarrheal diseases were the fourth largest source of hospital admissions and tenth largest cause of death at Newmont Mining, Ghana. Investment in their sanitation systems led to a 30-40 percent reduction in the avoidance of USD 28,000 in medical costs per year in one mining community.

Diminished investment

Companies that fail to manage their water risks will more and more see heightened skepticism and caution from potential investors. Today, 650 investors with combined assets under management of USD 87 trillion urge companies to both report their water-related risks and impacts, and to take action to mitigate them, via CDP.

Miss money saving opportunities

Water costs money, so using less water can be a quick way to decrease operational costs. For example, the UK beverage company Diageo plc reduced the volume of its water withdrawals by nearly one million cubic meters in 2014 and estimates the associated cost savings at USD 3.2 million (CDP Water Report 2014).

Corporate water stewardship—what and how?

Water stewardship is an overarching, dynamic framework for understanding and addressing the water risks and challenges described above. Through stewardship, businesses learn about the impacts caused by their operations, identify and manage the risks facing their operations, engage suppliers to improve their performance (and in doing so, manage the company's own risk), and promote sustainable water management in river basins of strategic importance to the business, while also contributing to the achievement of the Sustainable Development Goals. While there are common elements to most stewardship strategies, there is no one-size-fits-all approach to corporate water stewardship. Each company has unique risks—and therefore unique solutions and strategies—based on its industry sector and the particular circumstances of the river basins in which it operates. With that said, most corporate water stewards implement a short list of core activities spread across five main categories of action:

1 | OPERATIONS: Managing water use,

In the top five global risks

In the rankings of the severity of the impact of risks over the next 10 years contained in the Global Risk Report 2020—the report on global risks that is published every year before the World Economic Forum in Davos—the water crisis is in fifth place, preceded by failure to mitigate and adapt to climate change, weapons of mass destruction, severe loss of biodiversity and collapse of the ecosystem and extreme weather events.

Top 10 risks in terms of Likelihood

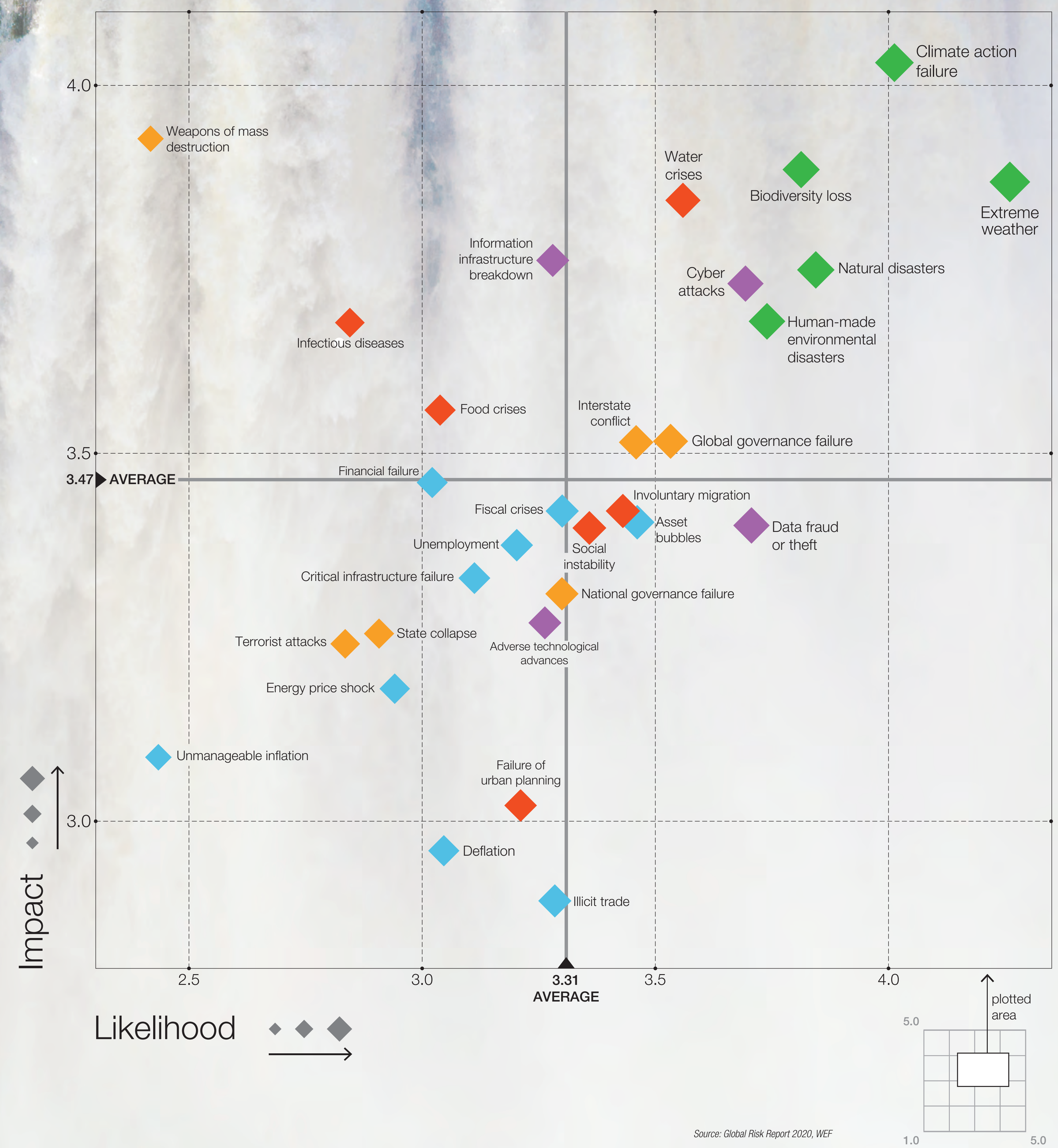
1. EXTREME WEATHER
2. CLIMATE ACTION FAILURE
3. NATURAL DISASTERS
4. BIODIVERSITY LOSS
5. HUMAN-MADE ENVIRONMENTAL DISASTERS
6. DATA FRAUDOR THEFT
7. CYBER ATTACKS
8. WATER CRISES
9. GLOBAL GOVERNANCE FAILURE
10. ASSET BUBBLES

Top 10 risks in terms of Impact

1. CLIMATE ACTION FAILURE
2. WEAPONS OF MASS DESTRUCTION
3. BIODIVERSITY LOSS
4. EXTREME WEATHER
5. WATER CRISIS
6. INFORMATION INFRASTRUCTURE BREAKDOWN
7. NATURAL DISASTERS
8. CYBER ATTACKS
9. HUMAN-MADE ENVIRONMENTAL DISASTERS
10. INFECTIOUS DISEASES

Categories

- ECONOMIC
- ENVIRONMENTAL
- GEOPOLITICAL
- SOCIETAL
- TECHNOLOGICAL



Source: Global Risk Report 2020, WEF

wastewater and WASH services in owned-and-operated sites

2 | CONTEXT: Assessing river basin and value chain circumstances to understand risk and impacts

3 | STRATEGY: Incorporating water considerations into core business strategies and functions

4 | ENGAGEMENT: Connecting with key partners to manage the root causes of water risk

5 | COMMUNICATION: Engaging stakeholders to garner feedback on water practices.

Operations

Operations activities refer to improving water management practices at companies' owned-and-operated facilities. They generally span: 1) ensuring all employees have access to drinking water, sanitation, and hygiene; 2) measuring and monitoring water performance; and 3) driving water use efficiency and wastewater treatment. Facility managers often implement these techniques simply as good practice for employee health, efficiency and cost reduction before a broader corporate strategy is developed. Many of these practices are low-cost, easy to implement and have short returns on investment. Key operations actions include: Using water meters to detect leaks and eliminate wasteful uses; Regularly testing wastewater quality; Developing facility-level KPIs related to water use and pollution; Developing water management plans for every operation; Implementing water-efficient processes, technologies, and behaviors; Managing chemical inputs and treat and reuse wastewater; Ensuring clean and sufficient drinking water, sanitation and hygiene at the workplace.

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Context

Context activities involve developing a deeper and more dynamic understanding of the water context in which a company operates. This includes assessing the degree of water stress in the river basins in which they operate, the effectiveness of water governance in those areas and the broader water-related circumstances of their value chains. Key context actions include: Assessing the degree of water stress facing their operations; Prioritizing operations based on degree of stress; Developing a robust understanding of specific water challenges in priority operations; Conducting comprehensive water use assessment for company and its value chain; Assessing suppliers' exposure to water stress; Prioritizing suppliers based on severity of stress.

Strategy

Water stewardship is often most effective and most valuable when it is systematically integrated into a broader business strategy, rather than tacked on as a CSR or philanthropy function. For many businesses, water is such an important input into its operations and those of its suppliers that a strategy to ensure sufficient and consistent supplies of it is not only helpful but arguably required for long-term business viability. Integrating water management into business strategy means many things, including: Setting water-related performance targets; Creating accountability measures and incentives for water-related goals; Establishing a water task force among upper management to track and address water issues; Developing water assessment and action policies that are applied across a company's facilities.

Engagement

Truly transformational, comprehensive stewardship practice requires companies to actively engage with others who share the same water challenges (e.g., other businesses, NGOs and government agencies) and value chain actors (e.g., suppliers and consumers). Many of the most pressing and impactful water challenges are impossible to fully address alone. Companies must work with others with whom they share water resources to ensure those resources are managed sustainably and equitably. Engagement activities are among the most challenging and complex of stewardship but are often the most impactful and important. They include: Preparing for action and identifying potential partners; Conducting impactful, mutually beneficial collective actions; Engaging governments to encourage robust water governance; Establishing communication and trust with suppliers and consumers; Raising water awareness among suppliers and consumers; Incentivizing improved stewardship performance among suppliers and consumers.

Communication

Developing and maintaining continuous dialogue with key stakeholders is critical to all stewardship efforts. It helps companies to truly understand the water challenges they face and to develop solutions that will be effective and find favor among those closest to them. Examples of common communication mechanisms include internal employee memos, annual online and print reports, community forums, contracts, and online suggestion / feedback mechanisms.

The UN Global Compact's CEO Water Mandate

Acknowledging the severity and urgency of the world's water challenges and the critical role business has to play in addressing them, in 2007, the United Nations Global Compact and UN Secretary-General launched the CEO Water Mandate. This special initiative was created out of the acknowledgement that global water challenges create risk for a wide range of industry sectors, the public sector, local communities, and ecosystems alike. As such, cross-sector collaboration is the most effective and credible path to water security. The private sector can be a critical partner in this effort.

Over a decade later, the Mandate—implemented by the Global Compact in partnership with the Pacific Institute—remains a leading player advocating for and facilitating corporate water stewardship around the world and supporting the achievement of Sustainable Development Goal 6 on Water & Sanitation. The Mandate advances corporate water stewardship in many ways, most prominently: Garnering formal commitments to action from companies around the world, defining good practices and developing tools that support businesses' stewardship efforts and facilitating action on-the-ground. The Mandate is now endorsed by more than 170 companies worldwide including: AB InBev, Coca-Cola, Danone, Diageo, Dow Chemical, Ecolab, Ford Motor Company, General Mills, H&M, Hilton, Mars, Microsoft, Nestle, Netafim, Nike, PepsiCo, PVH, Radisson, Siemens, Unilever, and many others. By endorsing the Mandate, companies publicly commit to advancing water stewardship across six commitment areas:

1 | DIRECT OPERATIONS: Ensuring their owned-and-operated facilities are sustainable

2 | SUPPLY CHAIN & WATERSHED MANAGEMENT: Leveraging stewardship practice throughout their value chains and in the river basins in which they operate

3 | COLLECTIVE ACTION: Working with a broad coalition of stakeholders to enact lasting, comprehensive and equitable stewardship solutions

4 | PUBLIC POLICY: Supporting governments in their efforts to drive effective water governance

5 | COMMUNITY ENGAGEMENT: Working with communities most affected by a company's operations and water challenges more broadly

6 | TRANSPARENCY: Regularly reporting publicly about their risks, impacts and response strategies.

Once they have endorsed the Mandate, companies must publicly report on their progress toward water stewardship on an annual basis, in what are known as Communications on Progress (COPs). The Mandate is governed by the Steering Committee, which oversees the initiative's strategic, administrative, and financial arrangements. The Steering Committee is composed of:

- Ten corporate representatives from diverse geographies who serve staggered two-year terms. Corporate representatives will be drawn from Action Platform participants only.
- One representative of the UN Global Compact Office
- Special Advisors representing different stakeholder interests and spheres
- Patron sponsors of the Action Platform—Water Security through Stewardship.

The Secretariat makes decisions based on a consensus model. When consensus cannot be reached, a simple majority vote decides matters.

A CROSS-CUTTING CHALLENGE
Global water challenges pose a risk to a wide range of industrial sectors, the public sector, local communities, and ecosystems. In the photo, two technicians examine pipes.

Tools, publications and projects

Over the last 13 years, the Mandate has published a variety of guidance documents and tools meant to help businesses and others understand water challenges and implement meaningful solutions. Some of the Mandate's most notable publications include:

- Guide to Responsible Business Engagement with Water Policy (2010)
- Water Action Hub (2012)
- Guide to Water-Related Collective Action (2013)
- Corporate Water Disclosure Guidelines (2014)
- Guidance for Companies on Respecting the Human Rights to Water and Sanitation (2015)
- Guide for Managing Integrity in Water Stewardship Initiatives (2015)
- Guide to Setting Site-Level Targets Informed by Catchment Context (2019).

The Mandate is also actively involved in a number of place-based efforts, including Businesses for Water Security in the Noyyal-Bhavani and the California Water Action Collaborative.

The Mandate is always looking to help more companies understand their water risks, the specific responses that will be most strategic for their companies and how their company can help achieve the Sustainable Development Goals and water resilience in basins around the world. Endorsing the Mandate is an aspirational pledge; the initiative welcomes companies of all sizes and all levels of water stewardship maturity so long as they commit to continuous improvement.

Impacts/The repercussions of the water crisis on countries and companies

The True Value of Water

We can meet our climate targets if we act on water, we can fix our broken food system if we act on water and we can meet our low-carbon energy needs if we act on water

TOM WILLIAMS

He leads the World Business Council for Sustainable Development's (WBCSD) work on water, facilitating the engagement of large multinational member companies on a range of issues related to water. For the last 15 years, he has worked on global issues related to water security, with a range of private and public sector stakeholders.

Too little, too much and too polluted water: most countries suffer with one of these problems, and some have all three. For the tenth year in a row, the WEF Global Risks Report highlighted the water crisis as a top five risk in terms of impact. Yet over this time, the global water crisis has worsened— punctuated by apocalyptic stories of "Day Zero" (Cape Town, South Africa), pollution (Flint, Michigan, U.S.) and floods (Southeastern Africa). The 2018 UN Progress report on SDG6 concluded that the world is not on track to meet its water targets: hundreds of millions will still be without access to safe and reliable water supply and sanitation, demand for freshwater will outstrip supply and wastewaters will continue to pollute the environment in 2030.

What compounds this risk are the dependencies and impacts of water for big systems: food, energy and climate, for example. More food to feed a growing population requires more water, transitioning to a low-carbon economy has water use implications and the main means by which climate change impacts manifest is through floods and droughts. Yet despite this bleak outlook, there are opportunities, solutions and synergies to fix our water problems. If we can galvanize political will, create "water-coherency" across environmental, economic and social policies and establish fit-for-purpose water governance, we can →

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Tomaso Clavarino is a documentary photographer. His work is regularly published by magazines and media including *Newsweek, The New York Times, The Guardian, Der Spiegel, The Washington Post, Vanity Fair,* and *Gruppo L'Espresso*. He also carries out more personal projects relating to social issues, communities and their identity. His projects have been exhibited and projected in various galleries, festivals and public spaces.

THE GREEN DESERT
According to FAO, food production will have to increase by 50 percent by 2050 to accommodate the expected population increase. This is a difficult challenge, especially on a planet where arable land is constantly decreasing. In Jordan, which has fewer water resources than any other country in the world bar one, and desert covering three quarters of its territory, a unique pilot project has been set up to bring agriculture to a place where, at first glance, it seems impossible for it to exist. In the desert behind Aqaba, in the south of the country, an Anglo-Norwegian team, directly supported by the King of Jordan, has devised an ingenious mechanism whereby the solar energy produced by photovoltaic panels desalinates sea water, which in turn is used to irrigate plants. Using the wind that blows continuously from the north, waste water is used to cool greenhouses in an area of Jordan where, in summer, temperatures reach 45 °C. Plants are watered more than necessary and the surplus water is used to irrigate the more resistant plants planted outside the greenhouse. This is a model which, if implemented, could also help drastically reduce Jordan's general food import rate, which is currently 98 percent.

Water scarcity: the effects

The negative impact of the water crisis on trade and the economy is increasingly evident in both developing and developed economies. The latest water report published by CDP states that, in 2018, the water-related financial losses of 2,114 companies totaled $ 38.5 billion. The mining, energy, biotech and pharmaceutical sectors are the most affected. But water stress does not only affect companies: the GDP of different countries is also conditioned by the sustainable use of water, 70% of which is currently used by the agricultural sector.

THE IMPACT ON COMPANIES

LOSSES IN 2018
SECTORS WITH LARGEST FINANCIAL IMPACTS (BILLION DOLLARS)
MOST COMMON IMPACTS
MOST COMMON RESPONSES

38.5 billion dollars

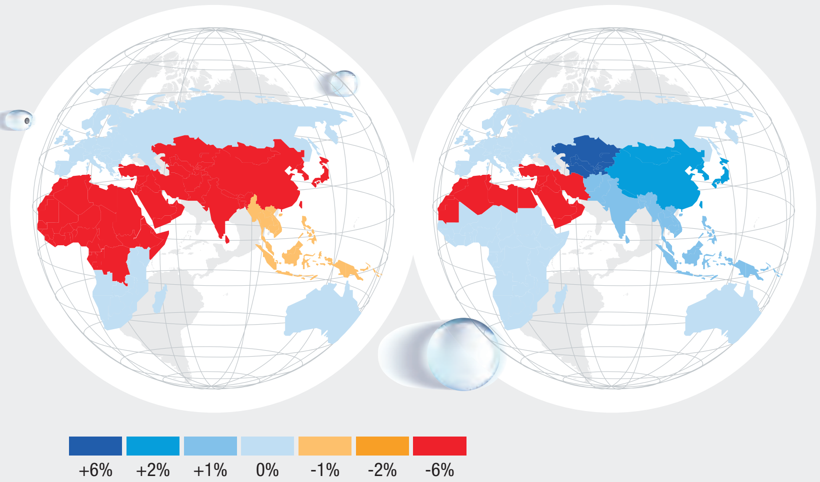
Is the total of water-related financial losses suffered by companies in 2018.

Source: CDP Global Water Report 2018

MINERAL EXTRACTION	POWER GENERATION	BIOTECH, HEALTH CARE & PHARMA
20.5	9.5	3.5
Increased operating costs	Increased operating costs	Reduction/disruption in production capacity
Adopt water efficiency, water re-use, recycling and conservation practices	Engage with regulators/policymakers	Adopt water efficiency, water re-use, recycling and conservation practices
Reduction/disruption in production capacity	Impact on company assets	Constraint to growth
Pollution abatement and control measures	Infrastructure maintenance	Amend the Business Continuity Plan
Fines, penalties or enforcement orders	Increased compliance costs	Increased operating costs
Engage with regulators/policymakers	Increased capital expenditure	Secure alternative water supply

THE IMPACT OF WATER SCARCITY ON GDP

Water scarcity, exacerbated by climate change, could cost some regions up to 6% of their Gross Domestic Product (GDP) by 2050. (In the graph, the impact of water scarcity on GDP by 2050 is calculated compared to a basic scenario without scarcity).



Source: World Bank

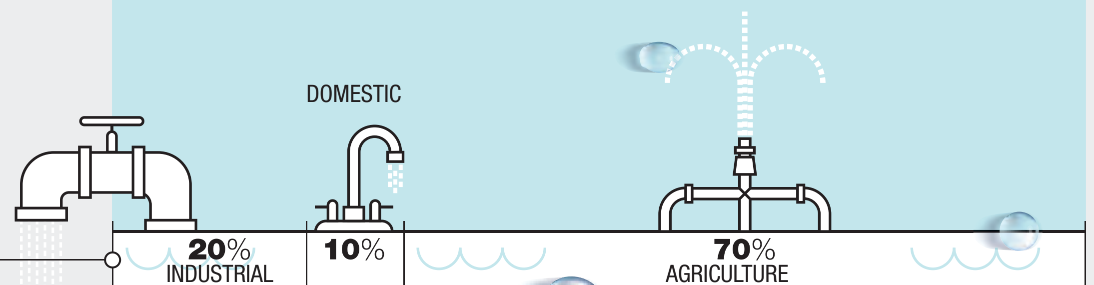
THE IMPACT OF AGRICULTURE

We only have access to a small part of the water available on our planet. And 70% of this small part is used by agriculture.

Source: FAO

97.5% saltwater

2.5% freshwater



At the beginning, on pages 70 and 71, two technicians are shown working in the greenhouse used for hydroponic cultivation, which is a method of growing plants without soil. On the right are the external tanks for the desalination of sea water from the Gulf of Aqaba: the desalinated water is then used to irrigate the plants. Below, a Chinese technician checks the operation of the lamps used in hydroponic cultivation inside the greenhouse.

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unleash the finance, technology and institutions to fix our wicked water problems.

Water risk and opportunity for business

The negative impact of water on business and the economy is increasingly apparent in developing and developed economies. For example, in 2018, low water levels in the Rhine due to the warm summer and low rainfall disrupted shipping channels and contributed to reducing German GDP by 0.7 percent. In India, it's estimated that a business as usual response to the water crisis will lead to an eventual 6 percent loss in the country's GDP by 2030.

Business face physical and non-physical risks driven by competition for water, pollution, regulation, and climate change. Water scarcity or flooding, as well as regulatory, financial and reputational risk can lead to business disruption. At the same time, investing in sustainable water management offers opportunities to gain a competitive advantage. In its most recent water report, CDP reported that the cumulative water-related financial losses of 2,114 companies in 2018 was USD $38.5 billion. Such figures are also resonating with the investor community, who are demanding more detailed and specific information about climate-related risks such as water. Furthermore, investors are requesting more context specific information about companies' water risks and opportunities, since water risks and their impacts are manifestly different depending on the location and prevailing socio-economic and environmental conditions.

Three areas where business, as part of a collective effort with other business, government and civil society, has a significant role to play are wastewater, agriculture and household water efficiency.

Wastewater: A source of water, energy and nutrients

Most of the data related to the global status of water and sanitation is shocking: billions lack access to safe drinking water and adequate sanitation (WASH), demand for freshwater is projected to outstrip supply and 80 percent of all wastewater is discharged directly into the environment without treatment. While universal access to WASH and securing freshwater supplies are intrinsically complex challenges requiring systemic change and huge investment within a generally weak governance setting, the wastewater challenge is more shocking when one considers the opportunity it presents.

A recently published paper highlighted that, theoretically, full recovery of major nutrients—nitrogen, phosphorus, potassium—from global wastewaters could offset 13.4 percent of global demand for them in agriculture. Furthermore, the energy potential and water included in →

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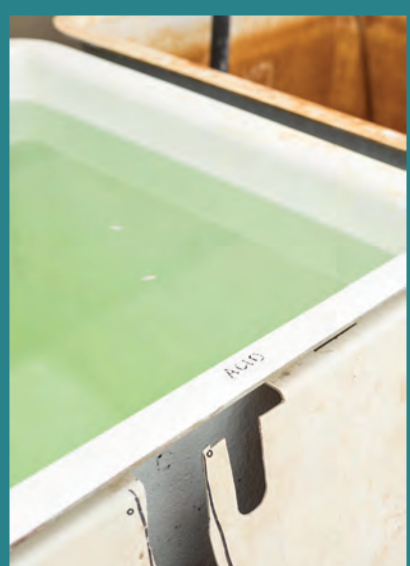

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Top left, the exterior of the greenhouse with plants grown and irrigated with surplus water. On the right, a detailed photo showing some of the plants planted outside the greenhouse, in desert soil, and irrigated by surplus water coming from inside the greenhouses. Below left, one of the collection tanks and, on the right, the ventilation control panel.

wastewater make it a rich resource to tap if the right regulatory and market conditions can be created.
An example that illustrates the potential scale and benefits that can be realized if the regulatory and market conditions are right is Aquapolo in Brazil. At its inauguration in 2012, Aquapolo was the largest water reuse project in Brazil. The plant was developed and financed through a public-private partnership including Braskem, the largest petrochemical company in Latin America; Sabesp, the public water operator for Sao Paulo and Foz do Brasil, a waste management company. The facility has the capacity to produce 1,000 liters per second of reused water, supplying a petrochemical complex located in São Paulo. Braskem, which uses approximately 65 percent of Aquapolo's capacity, has signed a 41-year contract for this supply, guaranteeing revenue to cover operating costs. While serving the growing demands of industry, the project also enabled an increase in the supply of drinking water for human consumption, which during the water crisis of 2014-2015 is estimated to have saved over USD 50 million. Business working with the public sector to deliver economic, environmental and social benefits at scale is the opportunity that we need to unlock.

More people = more food = less water

At a global level, a significant proportion of water—up to 90 percent in some parts of Asia—is allocated to agriculture, and this is where big gains can be made for water efficiency. Staple crops such as rice, wheat and sugar are water intensive and are often grown in places where water is scarce. This is the consequence of a global food system that provides unhealthy diets and agricultural policies that incentivize over-abstraction of freshwater for irrigation. For example, in some states in India, water abstraction is free, the energy to pump it is subsidized and farmers are given a guaranteed price for selling rice when other crops might be more suitable. The 2019 EAT-Lancet report, which pointed the way towards a food system that provides healthy diets for all within planetary boundaries, highlighted a combination of halving food waste and loss and improving farming practices to improve water efficiency by 30 percent. Improved farming practice for water efficiency often translates to irrigation but ignores the great potential offered by maintaining the soil health that is important for water retention and broader watershed management approaches that establish allocation thresholds and mechanisms to share water across users. An irrigation system that operates without established thresholds and usage data is nearly useless.

Farmers are the most important stakeholders for water management. Yet all over the world small-holder farmers, whom the World Bank estimates at 2 billion, find their livelihoods threatened. Access to finance is low, yields can be erratic, sometimes due to climate induced changes to weather patterns that disproportionally affect those that rely on rain-fed agriculture (95 percent of farmed land in Sub-Saharan Africa is rain-fed) and advisory services are not readily available. Technology, particularly mobile phone-based, can be a great enabler to unlock these challenges. Simply providing weather data to farmers can help them to better prepare their seeding schedule. Remunerating and incentivizing farmers to use less water, potentially coupled with carbon mitigation and sequestration incentives, can be a win-win for government and farmers. Critical to this is valuing water by ensuring that the environmental, social and economic values of water are included in decision making.
Where water is free, it is not valued. When we put a true value on water, it can drive decision making that protects and conserves freshwater.

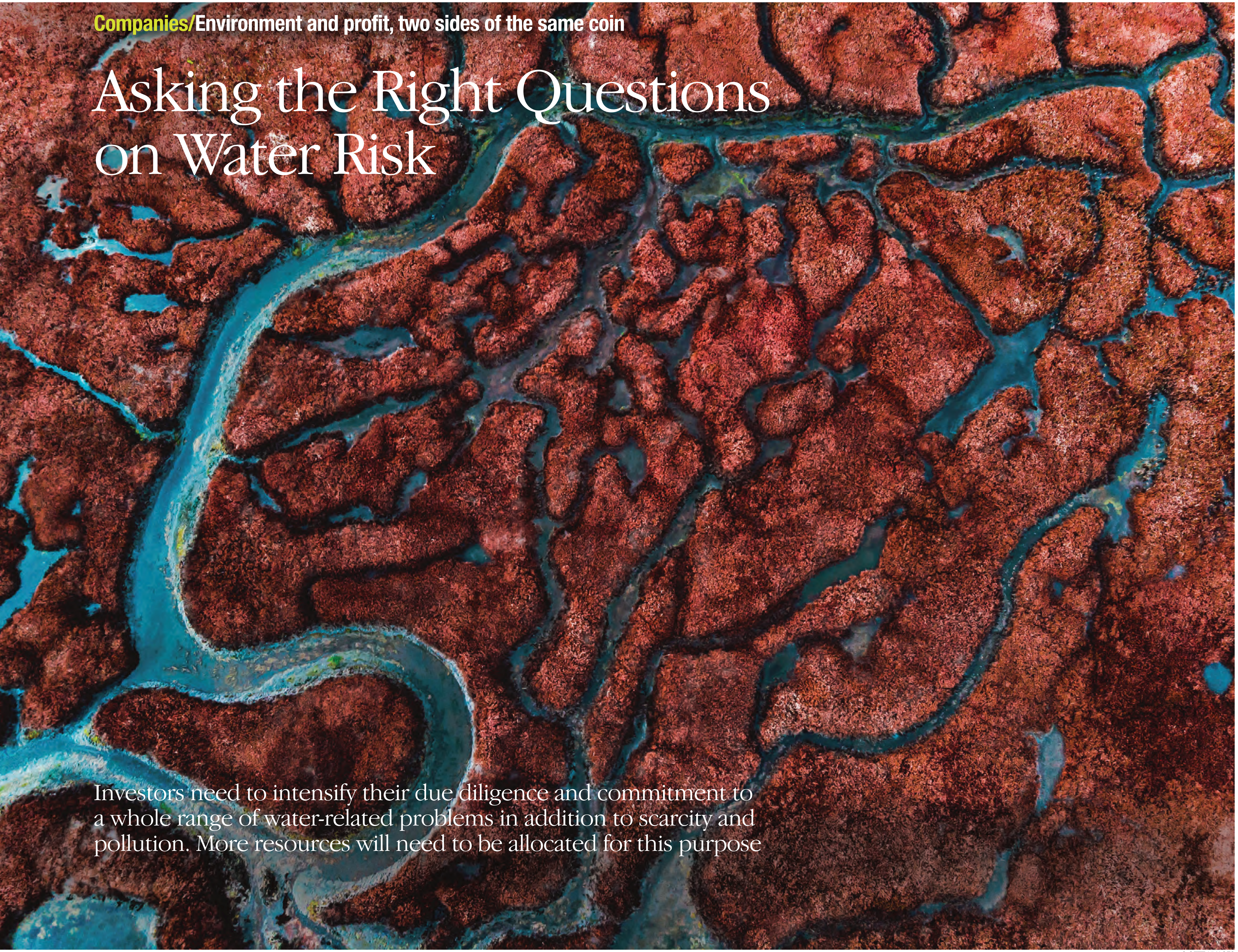
Making 50 liters feel like 500 liters

Approximately 15 percent of greenhouse gas (GHG) emissions related to buildings can be attributed to water use, for appliances and fittings in the laundry, bathroom and kitchen. Water efficiency in the household translates to energy efficiency and GHG mitigation. Average per capita water consumption in the home ranges from over 500 liters (L) per day in some cities in the U.S. to 100 L per day in some European cities. During the recent Day Zero emergency in Cape Town, residents were restricted to 50 L per person per household per day, creating a burden for everyday life activities such as cleaning, cooking and hygiene. But what if 50 L a day wasn't a burden and felt like 500 L? Is it possible? Yes. First, homes are plumbed in a linear way: water comes in, used water goes out, and in the middle, large amounts of energy are used to heat and transport. What if we closed the loop at a household or neighborhood level? Grey water is reused for toilet flushing, heat exchangers are fitted to shower units and rainwater harvesting tanks collect and store water for various uses. It's all possible. And there are great innovations from several companies that offer brands to wash clothing at lower temperatures with less water, widgets to decrease water flow from taps and products to wash hair without water. While domestic water only accounts for approximately 10 percent of our total water use, behavior in the home that is more water efficient can resonate beyond the four walls of our abode. Changing societies' relationship with water through improving our understanding of water required for consumer goods, including food, will be the great lever to solving our water crisis.

What is the challenge to be faced?

The world is facing a future of unprecedented water challenges, including floods and droughts. At the same time, a growing population, economic development and climate change increases the demand for water. Water scarcity will negatively affect human health and wellbeing, environmental sustainability, regional stability and economic performance. A world in which society and business value water is one where big system transformations are accelerated through actions on water. We can meet our climate targets if we act on water, we can fix our broken food system if we act on water and we can meet our low-carbon energy needs if we act on water. Water is the great connector, but history tells us it is also the greatest victim of political apathy, incoherent policies and weak governance. In this critical year, with new global biodiversity targets to be established and climate ambitions to be urgently raised, we must make sure that water is central to the mix of solutions.

The road that connects the research center with the port of Aqaba, where sea water is extracted to be desalinated using solar power produced by photovoltaic panels. The research center is located in a desert area of Jordan where, in the summer, temperatures reach 45 °C.



Companies/Environment and profit, two sides of the same coin

Asking the Right Questions on Water Risk

Investors need to intensify their due diligence and commitment to a whole range of water-related problems in addition to scarcity and pollution. More resources will need to be allocated for this purpose

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EDOARDO BORGOMEO

He is an honorary research associate at the Environmental Change Institute, University of Oxford. He works with UN agencies and development banks on strategies and projects to enhance water management and climate adaptation in low-income countries. His book: *Oro Blu: Storie di acqua e cambiamento climatico* was published in February 2020 by Laterza.

For many businesses and investors, 2020 started with a wake-up call. Larry Fink, the CEO of Blackrock, the world's largest asset management firm, signed an annual letter to chief executives urging them to act on climate. Fink's message is clear: if businesses are to thrive under climate change, then environmental and social concerns need to be put on par with the quest for financial returns. And Fink is not alone. In the World Economic Forum's Global Risks Report of 2020, the top five global risks in terms of likelihood are environmental. These include extreme weather events, failure of climate change mitigation and major biodiversity collapse.

Among these top global risks, one of them, water, has been on the World Economic Forum's list for ten years in a row, and since 2011, freshwater crises have remained among the top five most pressing issues. This is cause for concern, because it means that over the past ten years, too little has been done by governments, investors and businesses to mitigate this evident water risk.

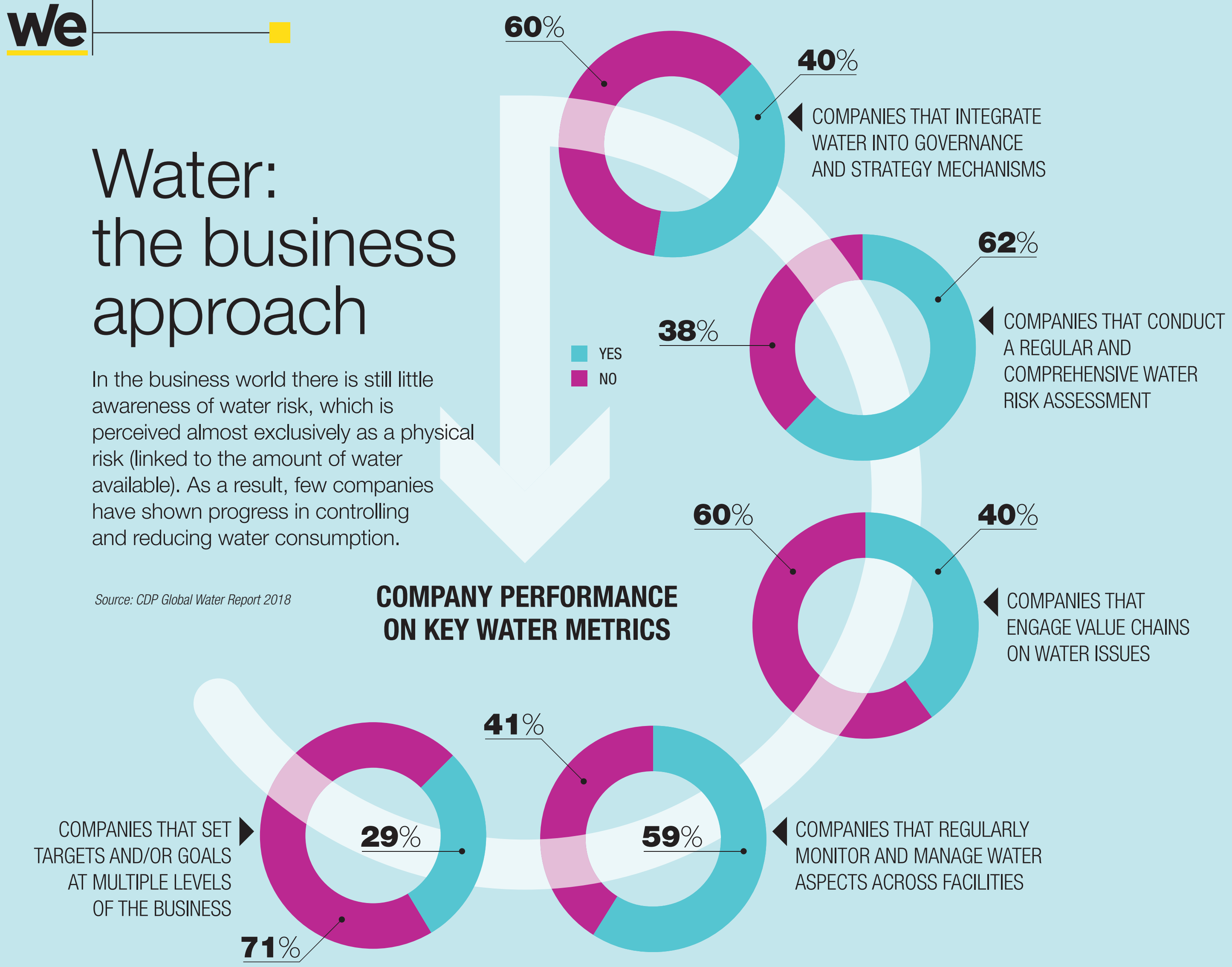
Perhaps the reason for this lack of engagement is that the supply of water has always been a problem for societies, and that results in fatalism about our ability to do much about it. From the Book of Genesis to the Shatapatha Brahmana, world religions are replete with myths about great floods. Even in language, water often involves a source of risk. For example, the word rival comes from the Latin rivalis, which meant a person who uses the same stream as someone else, a person who could easily become an enemy, a competitor, a threat. Water also appears to be a greater risk in times of accelerating climate change, and water will be the claws and teeth of climate change, now and in the future. We face numerous risks related to water, risks that include floods, droughts, polluted rivers, drained wetlands and the loss of freshwater biodiversity.

The fact that there are many water risks is not the reason we are not doing enough about them. Perhaps the reason millions of people still die because of lack of safe access to water and sanitation and billions of dollars are lost to water risks is our failure to ask the right questions. We try to predict when the next water crisis will occur without examining the conditions that lead to crisis. We fail to see that the story of water is more hopeful than oil, and in modern history states have not fought over water. Water is not just floods and droughts but is also food security and energy production. Successful water management is at the heart of some of civilization's greatest achievements, from public health to the marvels of Dutch polders. →

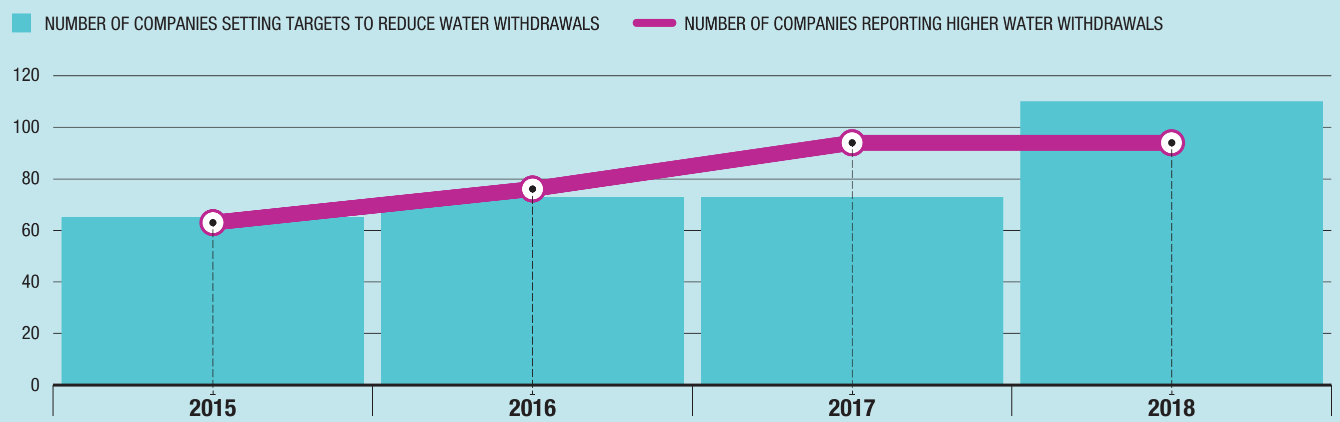
Water: the business approach

In the business world there is still little awareness of water risk, which is perceived almost exclusively as a physical risk (linked to the amount of water available). As a result, few companies have shown progress in controlling and reducing water consumption.

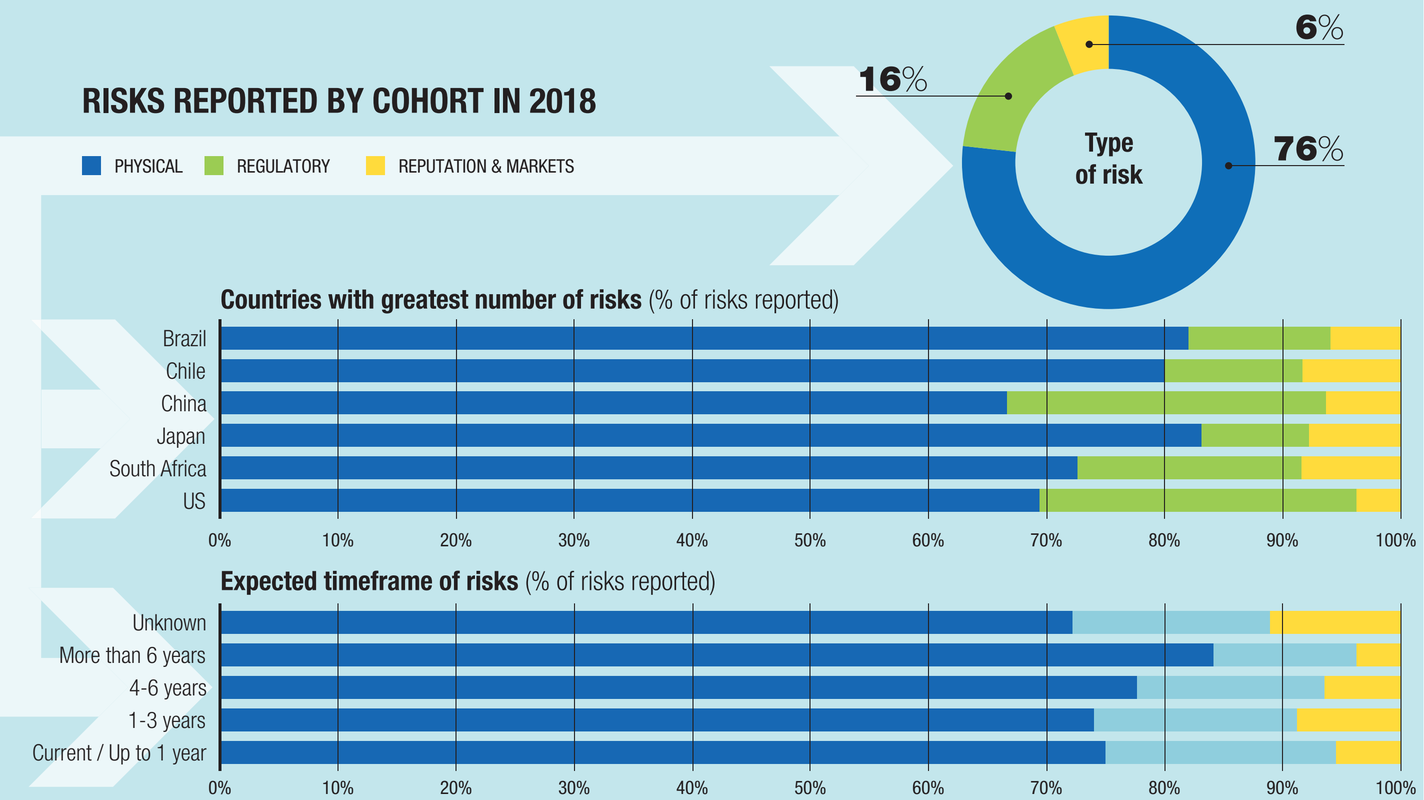
Source: CDP Global Water Report 2018



WATER WITHDRAWALS REPORTED BY COHORT IN 2018



RISKS REPORTED BY COHORT IN 2018



To ensure that water ceases being a top global risk, we need to rethink our understanding of water risks so that we can work with water to create value, mitigate climate change and adapt to some of its inevitable impact. This is particularly important for businesses and investors, as failure to understand and mitigate water risks can have costly consequences that extend across supply chains. In Thailand in 2011, massive floods and inadequate management responses resulted in 884 deaths and damage to 1.5 million homes and 7500 industrial plants. In addition, the indirect damage to the global economy was massive. Computer prices spiked owing to shortages of hard drives, and motor vehicle production was similarly hit, with Toyota losing 2.3 billion dollars because of interrupted production in its Thai factories.

What businesses typically do

To date, most businesses have focused on reporting their physical water risks and enhancing their operations to mitigate them. The most recent report from the Climate Disclosure Project, a global environmental disclosure system for businesses, looked at 296 large corporations and their water risk. Of these businesses, 75 percent reported only two water risks: water quantity and quality, that is, too little water, or dirty water. To address these two issues, businesses improve water use efficiency, augment water treatment capacity and diversify their water supplies.

Some businesses, however, don't even bother with water risks. In 2018, institutional investors invited some 1,536 of the world's largest publicly listed companies to disclose their water-related information through the Climate Disclosure Project. As the recent report Treading Water suggests, only about half responded and even fewer showed progress in monitoring and reducing their water use. In fact, most businesses actually showed that their water consumption was increasing. There has been an almost 50 percent rise in the number of businesses reporting higher water withdrawals, including energy companies who already account for more than 15 percent of freshwater withdrawals around the world.

This data shows that businesses' understanding of water risks is incomplete. Despite reporting and target setting efforts, water risks are still underestimated and poorly accounted for by businesses and investors. The focus on reporting and disclosures is perhaps a distraction from the need to take a broader look at water and the role of business in valuing it. In order to improve there are four questions companies and investors should ask related to water risk.

HELP FROM FORESTS

Trees can contribute significantly to mitigating water risks. In New York State, large expanses of forest are protected to provide clean water to the Big Apple. This avoided the need for a water purification plant costing $10 billion, which would have cost $100 million a year to run. In the photo, a glimpse of Central Park, New York.

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Four questions to ask about water risk

Mitigating water risks is not just thinking about the physical quantity and quality of water. Water risks arise when people's access to water is compromised or the water needs of ecosystems are not guaranteed. Therefore, companies first need to ask with whom are we sharing the water? Water is a shared resource, so companies need to consider the water context where they operate, what water scientists call the river basin. At the most basic level, this implies understanding not just one's water risks, but also the risks faced by other actors in a river basin and their ability to mitigate them. Trees, for example, can help mitigate water risks. In the State of New York, large forests are protected in order to provide clean water to New York City. This decision eliminated the need for a $10 billion water-treatment plant that would have cost $100 million per year to run. For reasons such as this it is no longer sufficient to simply undertake water use efficiency and pollution reduction activities. Companies will have to align their targets with public policy and demonstrate to investors that their activities contribute to the water security of other users in a river basin.

Developing a robust understanding of water risks is complex and will also require the use of new tools, metrics and analytics. Climate change adds uncertainty to business and investment decisions, making traditional risk assessment approaches inappropriate for our times. Investors and companies alike need to consider the best approach to quantify water risks and the way in which new data and models can help. Traditionally, assessments of water risks have been based on estimates of future water availability and needs, and these estimates are based on past observations, which means that we look at how much rain or well water there was in the past and then assume that there will be as much in the future. Typically, this results in risk estimates based on "normal" conditions. However, under rapid climate change the future will be significantly different from anything previously imagined. For two examples, we will have to leave more water in rivers for aquatic ecosystems to thrive, and we will have to estimate more erratic rainfall. Therefore, businesses need to expand their risk estimation procedures to take into account these changing patterns in the data and use all available information, not just past historical records.

Advanced computational methods and visualization can help in this effort. These approaches can be used in conjunction with existing scenario analysis exercises carried out by companies, to quantitatively understand impacts and responses. Water utilities already use these approaches to assess water risks to their business and to inform their investment planning. In London, for example, thousands to millions of different scenarios of water quantity and quality were used to inform the city's water utility infrastructure investment plans. These computer-simulation based approaches help utilities identify both water risks and the robust options that can mitigate them. When it comes to assessing water risks, the knowledge and experience accumulated in the water sector can guide efforts in other business areas, notably energy and food. As these sectors gear up to understand their water risks, they need to tap into these advanced computer simulation techniques to improve the risk estimate.

More than numbers alone: the multiple values of water

Not all information relevant to understand water risk can be reduced to numbers. Water is embedded in social and cultural relations and is often sacred. In 2019, more than 100 million people gathered for the Kumbh Mela to bathe in the sacred waters at the confluence of the Ganges, the Yamuna and the mythical Saraswati rivers. So a third question relates to the importance of mapping the multiple values attached to water and demonstrating ways in which business activities can protect—and in some cases enhance—these values. Across the world we see unsustainable water abstraction. The draining of the Aral Sea is a well-known example, but around the world more than 35 percent of our wetlands have been lost due to excessive abstraction. These trends reflect that water's environmental services are undervalued relative to other economic values, and this failure to recognize the environmental services linked to water engenders greater water risks. Hence, the immateriality of water needs to become material to the reporting and disclosure efforts of companies, who should clarify how their activities impact water's multiple values, not just its ability to generate economic returns as a factor of production.

Finally, without internal controls, internal audit and board oversight, corporate water risk assessments and disclosures—whatever the standard or framework used—are not worth much. To understand water risks companies need to look at their internal processes, raise the profile of water issues in their agendas and request strong board oversight on water risks.

Current business actions on water risks are insufficient. They fail investors, as they do not properly assess risks to business activities and returns, and they also fail society. When it comes to achieving the sustainable development goal of clean water and sanitation for all, simply reporting water quantity and quality risks and optimizing water use in business operations alone will not suffice. The world is nowhere near achieving this goal of sustainable development , and companies need to increase their effort if they are serious about their claims. For too long, companies have made do with incomplete and dishonest reporting of sustainability issues including water, a carelessness that would not be tolerated in financial reporting. Investors need to step up their due diligence and engagement across a range of water issues, not just water scarcity and pollution. At the end, this will require using more of their resources to understand and take action on water risks.

Best practice/FAO's mitigation efforts

The Crisis at Lake Chad

Lake Chad is an essential resource for its neighboring communities, and a combination of factors have seen its levels dwindle perilously. In 2014, the UN Food and Agriculture Organization stepped in with several humanitarian programs designed to provide support to those displaced and offer medium- to long-term solutions to the problem

AL HASSAN CISSE

He is the FAO Representative ad interim in Nigeria. Previouly, he was the Head of FAO sub office in Northeast Nigeria, based in Maiduguri, Borno state. A role he still combines with the present responsibility. In the course of his career, he has worked for World Vision, Action Aid and Oxfam International in Senegal and other parts of West Africa.

In every facet of human existence, water is the center of life. Whether in agricultural production or in the home, water is indispensable. In northeast Nigeria and communities in neighboring countries bordering the region, Lake Chad provides this precious natural resource and is a vital source of livelihoods for those who have come to depend on it. This has been the case since time immemorial, until a few decades ago, when communities around the Lake Chad basin began to face increasing challenges with regard to both water and its associated livelihoods.

Lake Chad's water levels are dwindling as a consequence of climate change, its exploitation as an irrigation water source and population growth, further compounded by the instability produced by the various conflicts in the region. All of these factors affect the plight of the region's inhabitants. Recently, the governments of the countries bordering the lake—Cameroon, Chad, Niger and Nigeria—came together to chart a way forward with the aim of revamping the→

Lake Chad

Located in northern Central Africa, it borders four countries: Chad, Nigeria, Niger and Cameroon. The Lake Chad Basin, which covers almost 8 percent of the African continent, extends over seven countries: Algeria, Cameroon, the Central African Republic, Chad, Libya, Niger and Nigeria. Since the 1960s, its water capacity has decreased by 90 percent due to the overuse of water (also linked to agricultural activity in the surrounding communities) and the effects of climate change.

- WATER
- FORMER SHORELINE
- VEGETATION

© FAO/DAVID TSOKAR

FOR AN EASY ACCESS
To facilitate access to water in the Lake Chad region, FAO supports projects involving the construction of water systems with collection points equipped with taps. The photo shows one of the projects carried out in agreement with Eni.

An agreement for clean and safe water

Eni and FAO signed a Collaboration Agreement in February 2018 to promote access to clean and safe water in Nigeria. The project aims to contribute to humanitarian interventions for internally displaced persons (IDPs) and host communities affected by the crisis in the North East/Lake Chad region, which has resulted in unprecedented population movements and a prolonged interruption of agricultural, breeding and fishing activities.

lake. While this is ongoing, affected communities have continued to struggle with persistent water issues, even as violent conflicts and mass forced migrations took center stage.
The livelihoods of those living in communities in the Lake Chad region are anchored in crop production, artisanal fishing and other minor agro-related enterprises. These activities combined have not only generated conflict over water access but have also led to a significant decrease in water levels due to the unsustainable use of this resource.

UN efforts

In 2014, the Food and Agriculture Organization of the United Nations (FAO) began implementing humanitarian interventions to provide livelihood support to those displaced by the insurgency and other violent crises in the region. The protracted crisis and the challenges faced by affected communities required emergency support in all spheres including food, water and access to energy. FAO's efforts focus on building resilience to address medium- to-long term development needs and on identifying durable solutions.
Given that agriculture is the primary vocation of millions of people in the Lake Chad basin including northeast Nigeria, declining water availability for both domestic and agricultural purposes has created extensive needs for the millions of people inhabiting the region.
One example is the establishment of water schemes in selected communities to serve the micro gardening and domestic needs of both displaced persons and host communities. The water schemes are powered with photovoltaic systems with a tank capacity between 25 to 50 m². To ensure the water is clean, boreholes are equipped with reverse osmosis systems. The depth of the boreholes varies between 80 and 150 meters, depending on the geophysical survey report of the location. To ensure ease of access, water is piped to about three fetching points with eighteen faucets. During project implementation, the local authorities provided support towards training and sensitizing educators and host community members on water management and practices aimed at ensuring long-term sustainability.
The project addresses the states that make up the northeast—Adamawa, Yobe, Borno, Gombe, Bauchi and Taraba—and aims to contribute to access to water in identified Internally Displaced Person (IDP) camps/host communities in different Local Government Areas (LGAs) where needs are highest.

Credible partnerships for SDGs focused intervention

To address this problem the joint project implemented by FAO and Eni subsidiaries in Nigeria aims to provide Access to Water to IDPs from the region who have been displaced to all parts of the northeast and even as far as the nation's capital. Borne out of its commitment to address the needs of the over seven million people displaced by the Boko Haram conflict, the Government of Nigeria requested oil and gas companies operating in the country to support sustainable programs to assist affected communities. This is aligned with "The Buhari Plan on Rebuilding the North East," which is the blueprint for comprehensive humanitarian relief and socio-economic stabilization in the region.
The Access to Water project seeks to provide water to conflict affected populations and bring beneficiary communities closer to attaining the Sustainable Development Goals (SDGs) including SDG1 (no poverty), SDG2 (zero hunger), SDG5 (clean water and sanitation) SDG13 (climate) and SDG17 (partnership for the goals).
Within two years of signing a Collaboration Agreement in 2018, a total of sixteen water schemes were completed in the Federal Capital Territory (FCT) and Borno, Adamawa and Yobe States. In FCT, all the completed five water schemes have been commissioned and handed over to beneficiaries. In Borno, the epicenter of the insurgency and the state most affected by the Lake Chad crisis, the Bama water scheme has been commissioned and handed over to the beneficiaries. Biu, Chibok, Damboa and Gwoza are currently in use by communities but not formally handed over due to security reasons. In Adamawa state, five water schemes are currently operational and await commissioning and official handing over. In 2019, one water scheme was completed in Yobe state and provision of another 4 water schemes is planned in relevant communities in Yobe within the framework of the partnership between Eni and FAO. In Borno state, more than 14,000 people have access to the boreholes in Bama, Biu, Chibok, Damboa and Gwoza. In Bama alone, more than 3,500 people are benefiting from the boreholes delivered through the Access to Water project. The intervention will improve sanitation and help restore the livelihoods of those affected by improving access to water for small-scale irrigation during the dry season. The intervention is geared towards ensuring sustainable food and nutrition security in the midst of drought.
Moreover, FAO, with the support of the Economic Community of West African States (ECOWAS), organized a series of stakeholder meetings on the "Development of Fisheries and Aquaculture Regional Policy and Strategy Framework" for member countries with the intention of providing an intra-regional framework to address the challenges and safeguard the livelihoods of communities in the region. One major outcome of these consultative meetings was a review of the report on the contribution of national fisheries and aquaculture policies and strategies to food and nutrition security and the charting of a path to protect artisanal fishing.
Fisher folks operating in the Lake Chad region are for the most part not protected by government policy. The absence of guidelines, regulations and the right framework exposes them to several challenges. The belief is that, once operational, the policy will protect artisanal fishing communities, enhance food and nutrition security, and boost the incomes of fisher folks in rural communities as well as their livelihoods.

China/A turning point

Taming the Nine Dragons

Recognizing the continued importance of water, China has invested significantly in managing the development of its water resources. But it will have to do more, and its success in doing so will be central to developing a more balanced and sustainable growth path

China currently has more dams than any other country in the world, with the capacity to store over 800 billion cubic meters of water, allowing it to supply a total of 618 billion cubic meters in 2015. In the picture, the Three Gorges Dam, in Hubei.

MARCUS WISHART*

A Lead Water Resource Specialist for China at the World Bank Group, Marcus Wishart has more than 25 years experience working on the management of integrated water resources development in more than 20 countries across Africa, Asia, Australia, the Pacific, Latin America and the Caribbean. He currently leads a collaboration with Gu Shuzhong of the Development Research Center of the State Council in China looking at the value of water in the construction of an ecological civilization.

Water has been central to China's successful social and economic development throughout millennia. Historic symbolism provides an important foundation that has been forged with contemporary approaches to the management of water to create a unique governance system. The dual nature of water to nurture life but also become turbulent and destructive initially gave rise to a sense of mystery leading to the early view that dragons inhabit and dominate water. Such veneration ensured that the precious source of water was protected and captured in ancient axioms such as "drink the water, remember its source." In contemporary times, the so-called Nine Dragons (九龙治水) have been used to describe the challenges of cross-sectoral coordination and inter-jurisdictional cooperation among the ministries and commissions responsible for managing various aspects related to water in China.

Towards a new era

Today, China is facing a watershed moment both in terms of socio-economic development and efforts to construct an "ecological civilization." Since the introduction of reforms that shifted the country to a market-based economy, China has emerged as the world's second largest economy—its share of the world economy has increased from 1.5 percent in 1978 to 15 percent today. During this same period, per capita income has increased more than thirtyfold, from USD 300 in 1978 to an estimated USD 10,276 in 2019, lifting more than 850 million people out of poverty with the goal of eradicating extreme poverty by the end of 2020. No other country has achieved as much in such a short period of time in recent history. However, this rapid economic ascendance to upper middle-income status has brought with it a number of challenges, including rapid urbanization, uneven regional development, challenges to ecological and environmental sustainability and issues of inequality.

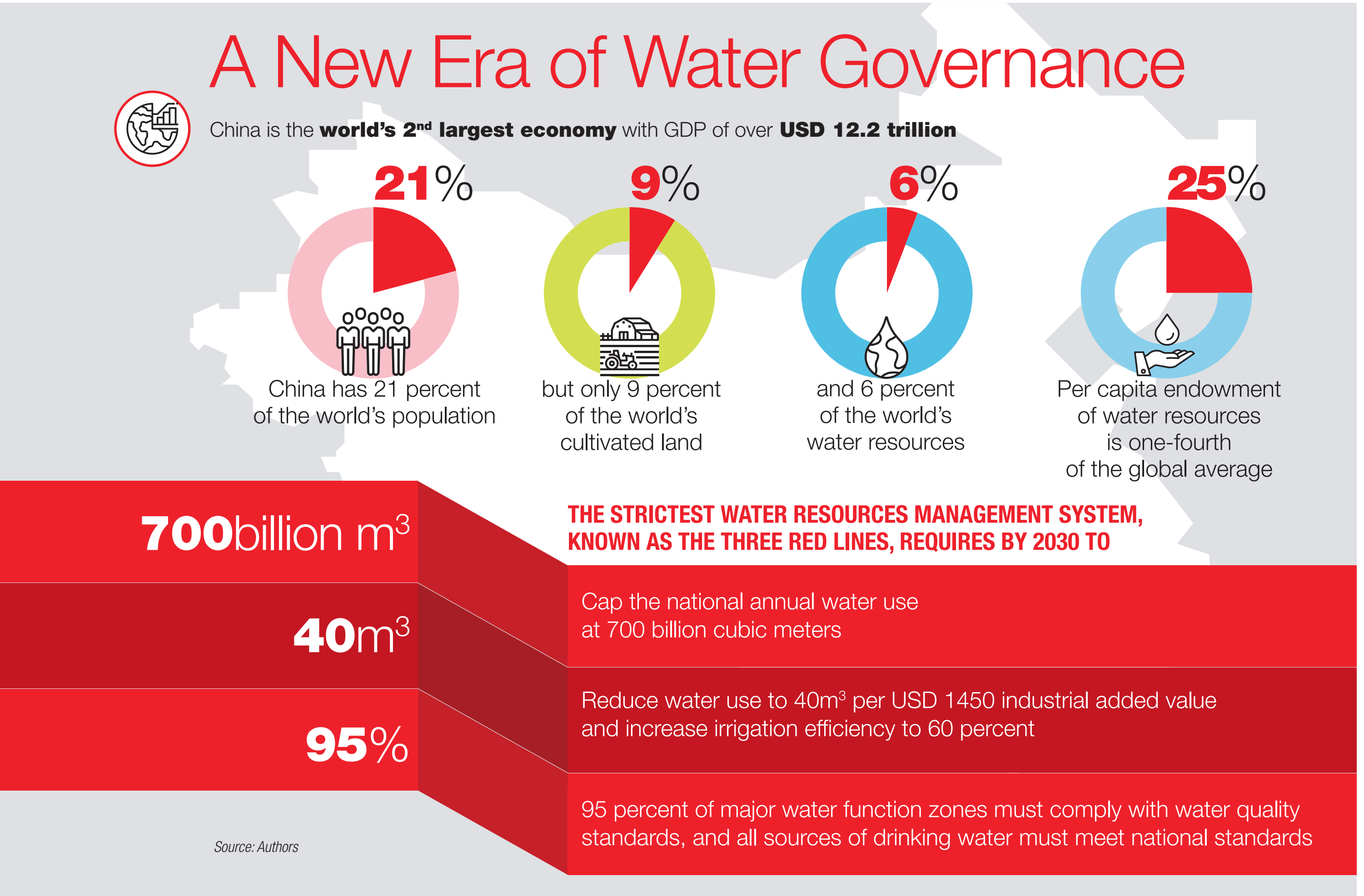
China's success has been underpinned by significant investments in infrastructure, improving the provision of electricity, water, telecommunication and other services required to sustain a modern economy. Through these investments, China has reportedly contributed more than half of the infrastructure investment in Asia and almost 30 percent of the global infrastructure investment between 2007 and 2015. Among other achievements, these efforts contributed to China reaching all of its Millennium Development Goals (MDGs) and made a substantial contribution to global achievements— accounting for 19.5 percent of the 2.6 billion people who gained access to improved water supply and 26.2 percent of the 2.1 billion people who gained access to improved sanitation during the MDGs.

Recognizing the continued importance of water, China has invested significantly in managing the development of its water resources. Today, China has more dams than any other country in the world, dams that store over 800 billion cubic meters of water with the national total water supply capacity having reached 618 billion cubic meters in 2015. This represents a five-fold increase from the total when the People's Republic of China was established. Hydropower capacity exceeds 341 million kilowatts and water services have increased to 97 percent of the urban population, with 76 percent of the rural population having gained access. More than 413,000 kms of flood control structures have been built in all of the major river basins, providing protection for more than 500 million people and about 47 million hectares of land area. Notwithstanding these significant achievements, China still has serious water-related problems.

Shortages and floods, the role of politics

Despite being the world's second-largest economy and most populous country, China possesses only six percent of the world's freshwater resources with availability per capita one-fourth the global average. China's water resources are unevenly distributed across space and time, with water shortages especially acute in China's energy-producing regions. For instance, the Yellow River Basin accounts for two percent of China's renewable water resources, 13.3 percent of arable land and almost 50 percent of total coal reserves, while contributing eight percent of the national GDP and supporting nearly nine percent of the national population. Over 50 percent of China's coal fired power stations, which require substantial amounts of water for cooling purposes, are located in water-stressed regions. In some areas the development of water resources already exceeds renewable capacity and several large cities face severe water shortages. Water use efficiency is also relatively low, with measures of GDP per cubic meter and industrial value added both lower than global averages. Water pollution meanwhile continues to impose serious economic, ecological, and health-related costs.

Reflecting the duality of water, the high level of exposure to flooding in China is estimated to cost on average about one percent of gross domestic product (GDP) per year, with rough- →



ly 80 percent of agricultural and industrial added value and more than 67 percent of the population located in flood-prone areas. This includes 90 percent of large and medium cities, with direct flood damage in more than 150 of these cities estimated at around USD 22.5 billion (RMB 160 billion) in 2015. These losses are expected to increase with a warming climate, and this outcome will have global implications, impacting markets and industries around the world.

China has introduced a number of initiatives to address these complex challenges. At the central level, the government is embarking upon a transition to a more balanced and sustainable economic growth model. This is built around an emphasis on sustainable resource management, environmental protection and ecological conservation and reflects a shift in societal values and increasing demands for improved environmental quality. These policy measures are embedded in China's 13th Five-Year Plan (2016-2020) and the 19th Party Congress Report (October 2017), which called for a "beautiful China" founded in a new era of "ecological civilization." This new era will pursue productivity and innovation-driven development, rebalance consumption and services and further open the economy, increase equitable access to basic public services and reverse environmental degradation. These guiding policies highlight the development of services and measures to address environmental and social imbalance and include specific targets to reduce over-exploitation of water resources and pollution, increase energy efficiency, improve access to education and healthcare and expand social protection.

The Sponge City project

Within the urban environment China has launched the Sponge City initiative, an important transition and contribution to the realization of an ecological civilization. Sponge cities take a comprehensive planning approach to maximize the use of nature-based solutions to address flooding, improve community and environmental wellbeing and increase adaptation to climate change. In the Sponge Cities initiative, thirty pilot cities have been selected and the goal is to have 80 percent of urban areas across the country sponge-like by 2030. In support of these efforts, cumulative investments in sponge city projects in Beijing, Shanghai, Shenzhen, Wuhan and other areas are expected to reach RMB 1.9 trillion (USD 300 billion) by the end of 2020. Most of this initiative relies on government programs to provide financial support for implementation.

The three red lines of the new governance

A series of innovative reforms have also been implemented to address specific technical and institutional water-related challenges, including water scarcity, water pollution, ecological degradation and the increased risk and impact of floods and droughts. In 2011, the Government passed the No. 1 Central Government Document on *Accelerating Reform and Development for the Water Sector* which focuses on key water resource issues and targets to be achieved within 10 years. The central vision of this agenda was the development of a "system for rational allocation and efficient utilization of water resources" and "a system for governance of water resources." These objectives and principles are in turn reflected in *Three Red Lines*, designed to establish specific targets that cap total water use, promote water use efficiency and control water quality.

The first of the red lines relates to water withdrawals and caps total water use at 700 billion cubic meters (bcm) by 2030. In 2014, withdrawals in China were estimated at just over 600 bcm per year compared to over 760 bcm per year in India, the world's largest freshwater withdrawal, and the United States at 480 to 490 bcm per year. Redline withdrawals at 700 bcm would be equivalent to around 24 percent of China's total renewable water resources. While the total withdrawals are nearly three times global averages, there are a number of influencing factors, and China's water withdrawal per capita is lower than that for other upper middle-income countries.

The second of the red lines relates to water use efficiency and targets industries to reduce their water use per RMB 10,000 (USD 1,450) of industrial added value to 40 cubic meters of water by 2030. The more general measure of water productivity, defined as GDP per unit of water use, shows that water productivity in China is around USD 13.71 per cubic meter. This is below the average for low income (USD 17.26 per cubic meter) and lower middle-income countries (USD 19.66 per cubic meter) and nearly three times lower than that of other upper middle-income countries, which average around USD 37.36 per cubic meter. While there are a number of contributing factors to be considered, this is also true when compared with countries that have a similar endowment in terms of water resources per capita.

To improve water quality, the third red line and the *Action Plan for Prevention and Control of Water Pollution* issued in 2015 have been coupled with innovative economic approaches. These include pilots for trading water and pollution rights and a comprehensive water resource fee-to-tax reform, one that imposes volumetric pricing mechanisms levied on the use of surface and ground water to encourage efficient use and effective conservation of water. A system of "River and Lake Chiefs" has also been established to strengthen enforcement and accountability regarding water use control, water quality protection and restoration of degraded waterways. With more than 1.2 million river chiefs having been appointed since their introduction in 2017, this system makes senior officials at the provincial, city, county and village levels responsible for addressing water pollution in each stretch of every major lake and waterway, including resource protection, shoreline management, pollution prevention and control and ecological restoration. The river chief system has also created a platform for collaboration that has proven useful in facilitating cross-sectoral coordination and improved inter-jurisdiction cooperation.

Old imbalances and new ambitions

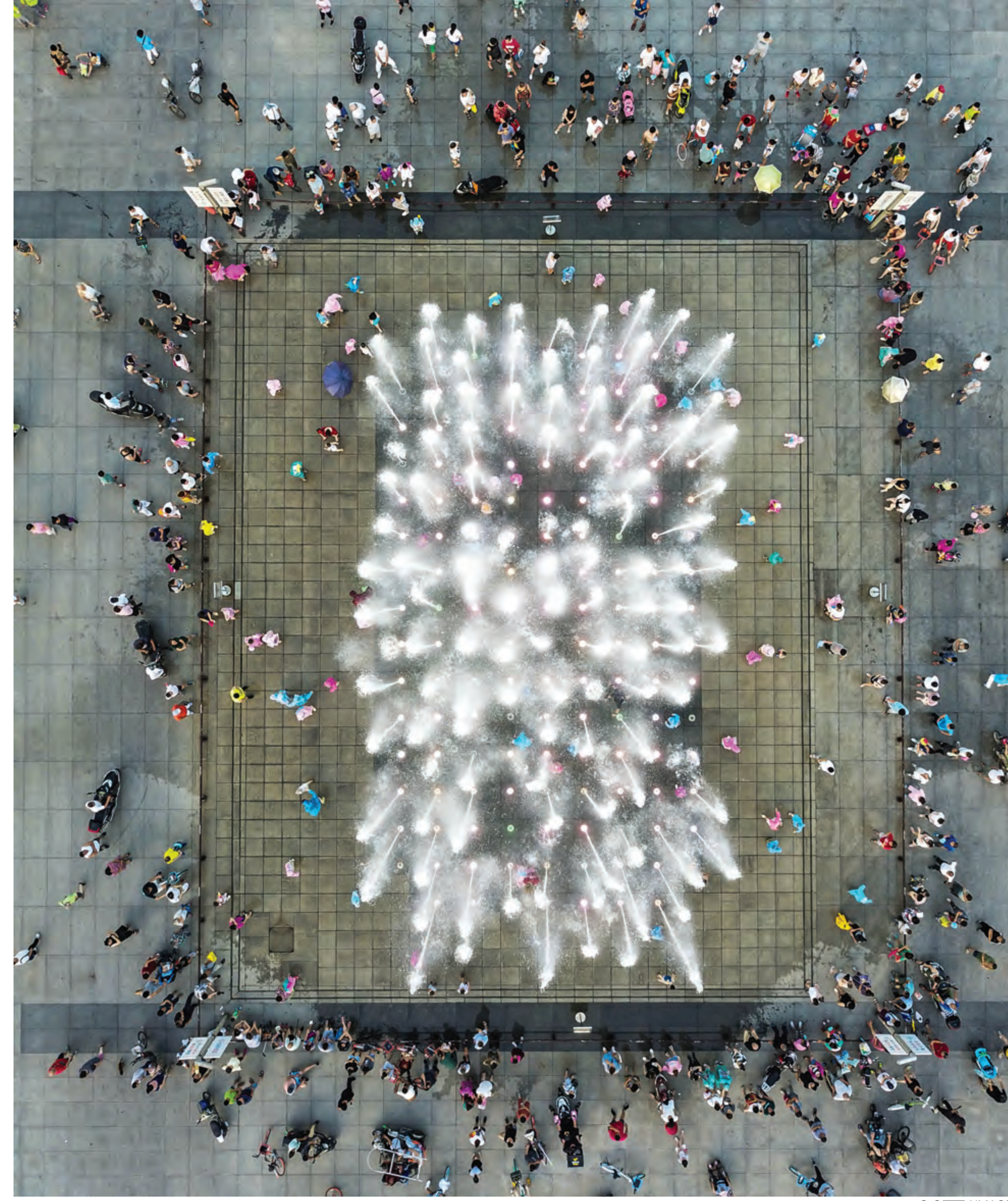
In combination, the Three Red Lines and the accompanying regulatory infrastructure form the foundation of China's current water policy. These are among the world's most ambitious attempts to define strategic water policy objectives. While infrastructure will continue to provide an important foundation for social and economic development, China is today an upper middle-income country facing a number of complex development challenges. Among them, China's rapid economic growth has exceeded the pace of institutional development, market reforms are incomplete, and per capita income and other indicators remain below the average of OECD countries. There are important institutional and reform gaps that need to be addressed to ensure a sustainable growth path, effective policy design and implementation and improved coordination between branches of government. Furthermore, the next generation of reforms will not only need to sustain the hard-won gains but increasingly focus on productivity increases and innovation, coupled with institutional improvements that can respond to new challenges. Among others, these reforms will need to respond to the changing nature of society and meet increasing demands for improved environmental quality, which emphasizes sustainable resource management, environmental protection and ecological conservation.

China's future development trajectory will be determined by the ability of its key policy decisions to address the important institutional and reform gaps that can ensure a sustainable growth path. As the country embarks upon a new era of ecological civilization, significant investments have already been made and China is reevaluating and adjusting its traditional resource- and emission-intensive development trajectory. This transition to a slower but more balanced and sustainable growth entails shifting from an investment and export-led economy based on labor-intensive manufacturing towards one led by domestic consumption, services and productivity. This requires the decoupling of economic growth from resource consumption and environmental degradation, as well as improving equitable access to basic public services and addressing aspirations of an increasingly prosperous society. Improving water governance and keeping the so-called Nine Dragons (九龙治水) at bay will continue to be central to the success of this transition.

Effective water governance also requires a holistic understanding and critical re-examination of the value associated with the benefits derived from water. These are still lacking in many water related policies in China. Water policy decisions involve inevitable tradeoffs that should not only be based on a holistic understanding of value but that are also adaptive to the changing value of water across time and place. The High-Level Panel on Water emphasized that valuing water holistically means recognizing the full range of direct and indirect benefits and risks associated with water, which may be cultural, spiritual, emotional, economic, environmental, ecological and social. In line with the call to action from the High-Level Panel on Water, China is investing heavily in efforts to improve the valuation of water in order to inform tradeoffs among competing demands. These will be fundamental to ensuring more transparent, efficient and equitable policymaking. Making the multiple values of water explicit will also be central for China to realize sustainable solutions that can reconcile these competing demands, strengthen institutions and investments for resilient water management and inform the goal of constructing an ecological civilization.

ESSENTIAL ELEMENT

For millennia, water has been an essential element of China's social and economic success. This precious resource has always been protected, as shown by the ancient proverb: "When you drink water, remember its source." In the photo, a musical fountain in Shenyang, in the Chinese province of Liaoning.



A global model

Water will continue to be central to the realization of China's sustainable economic prosperity. With many countries facing unprecedented pressure on water resources, the Chinese experience also has the potential to provide important contributions to the global discourse. Estimates show that with current population growth and water management practices, the world will face a 40 percent shortfall between demand and supply of water by 2030. Furthermore, chronic water scarcity, hydrological uncertainty and extreme weather events such as floods and droughts are perceived as some of the biggest threats to global prosperity and stability. The Chinese experience in managing the development of water resources over millennia will have important lessons for other economies, as well as informing efforts to address global risks to economic progress, poverty eradication and sustainable development.

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Europe/The EU's new directive will have a global impact

The European Green Deal Starts with Water

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The measures currently being approved update the quality standards set over 20 years ago, provide for the monitoring of organic substances, pharmaceutical products and microplastics and establish new obligations to guarantee universal access

ROBERTO DI GIOVAN PAOLO

A journalist, he has written for, among others, ANSA, *Avvenire* and *Famiglia Cristiana*. He was Secretary General of the Italian Association for the Council of European Municipalities and Regions, and he is a lecturer at the University of International Studies of Rome.

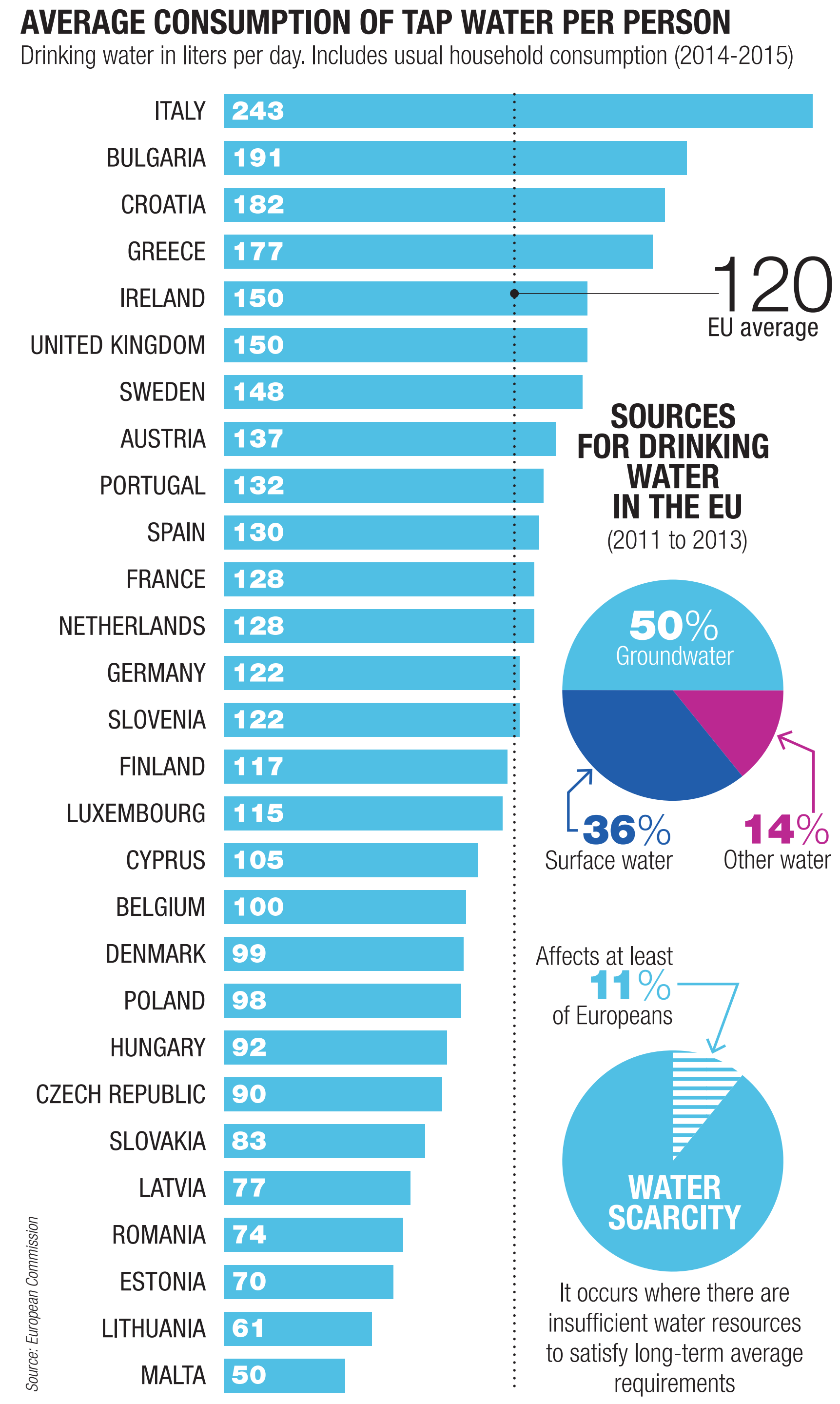
The global political and economic situation will ensure that the Green Deal announced by European Commission President Ursula Von Der Leyen will not remain just a dream.
Donald Trump's failure to show remorse, which, in the event of his re-election to the White House, will lead to the formal withdrawal of the United States from the Paris Treaty, and the economic, health and social crisis which has hit China, give the European Union a potential advantage "on the ground" in making a commitment to sustainability.
This leadership is underscored by funding of one trillion euros from EU budget resources, allocations from the 27 post-Brexit countries and financial commitments made by important stakeholders.
However, whether this is a functional and effective deal remains to be seen once the actual actions taken have been verified.

A concrete commitment: the new rules on drinking water

With regard to water, especially drinking water for domestic use, the EU seems serious. In February, the Commission sent the European Parliament the final proposal for a new directive. The text, which is agreeable to both the Parliament and the Council and will be put to a final vote in March, updates the quality standards for drinking water set over 20 years ago and establishes new minimum hygiene requirements for all materials that come into contact with it, such as pipes and taps, to avoid possible contamination. On these issues specific EU budget areas already provide for investments of millions of euros.
The new rules require monitoring of organic substances, pharmaceuticals and microplastics and establish conditions for access to water for minorities who have limited or no access to it. They also provide financial support that includes money from the European Social Fund for the installation of supply pipes and fountains. Particular attention is paid to the use of water in public places such as restaurants, bars and pubs, and the directive aims to act on the cost lever to limit waste. Significant focus is placed on glass bottling at source and the recycling of bottles to guarantee a decrease in the use of plastic.
The directive is being implemented in an advanced sector where, according to the European Environment Agency, more than 98.5 percent of the tests carried out on drinking water samples respect the standards currently in force in the EU. The directive is considered a "flagship" because it stems from a request made by European citizens in a petition that has collected almost two million signatures in all countries of the Union for guidelines then espoused by the Commission, the Council and the European Parliament. These guidelines provide for the protection of water and its basins as a public asset, guarantee sanitary and healthy water for all and universal access, establishing drinking water, the defense of basins, lakes and rivers, reservoirs and maintenance and distribution structures as the cornerstones of a common European asset in the water sector. This is a sector in which the European Union has been consciously active for over a decade, thinking extensively about good quality water resources and promoting the joint efforts of European and national institutions throughout the water cycle. As early as 2015, a water framework directive indicated the need for coordinated management of river basins, even when they fall within the geographies of multiple countries and regardless of their outlet. Over time, great attention has also been paid to the marine environment, attention demonstrated by the many experiments that have been underway for years on desalination to create drinking water and by the studies and experiments on the use of waves of water, in both marine and internal basins, for energy purposes.
The new drinking water directive is the first revision of all European documents relating to the water sector, including blueprints, white papers, 2012 directives and 2015 and 2016 studies, and it will lead to others. In the foreword, it introduces for the first time the theme of the circular economy, with an impact assessment "which also examined the issue highlighted in the European citizens' initiative and in the consultations, namely the inaccessibility of water for some groups of the population, for example vulnerable and marginalized communities such as the Roma people." Because of democratic availability of the asset, reuse, monitoring and attention to energy consumption represent the fundamental pillars of the directive, the impact of which will go well beyond the 27 countries of the Union. In fact, the measures contained in the directives guide both funding from the EU budget, which allocates about 25 percent of the total to combat climate change and sustainability, but also funding under the Union's collaboration and cooperation programs with the rest of the world and in particular the developing countries of Latin America and Africa.
The directive then revises, in a restrictive sense, the protection of areas suitable for reservoirs with a general approach to defending the land and the surrounding mineral waters. The impact of these measures will also be felt on the market, in particular for mineral spring waters, which must comply with specific rules to ensure the health of local people and communities.

A step forward towards the circular economy

The directive will be included among those in the work program for the EU circular economy action plan "because it is consistent with the European Union's efforts to reduce greenhouse gas emissions and marine litter and with the European strategy for plastic." This approach, according to the Commission, guarantees a European water market management aimed at reducing economic risk and, indeed, relaunches its competitiveness while guaranteeing European citizens more information and transparency on products. In short, the Green Deal seems to be finding its feet. But the water directive is only one piece of a much wider puzzle, albeit a fundamental one. A good start, but only a start.



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Hydroelectricity/Energy from water, figures and prospects

The Real Great Renewable

Hydroelectric power—energy from water—is only renewable source that can compete on an equal footing with fossil fuels and nuclear power

THE SUBMERGED VILLAGE
The bell tower of the village of Curon, half of which emerges from the artificial lake of the Resia Pass, on the border between Italy and Austria, is a reminder of all the rural land sacrificed to electricity, known at the time as white coal.

DAVIDE TABARELLI

He is Chairman and co-founder of Nomisma Energia, an independent research company in Bologna that deals with energy and environmental issues. He has always worked as a consultant for the energy sector in Italy and abroad, dealing with all the major aspects of this market.

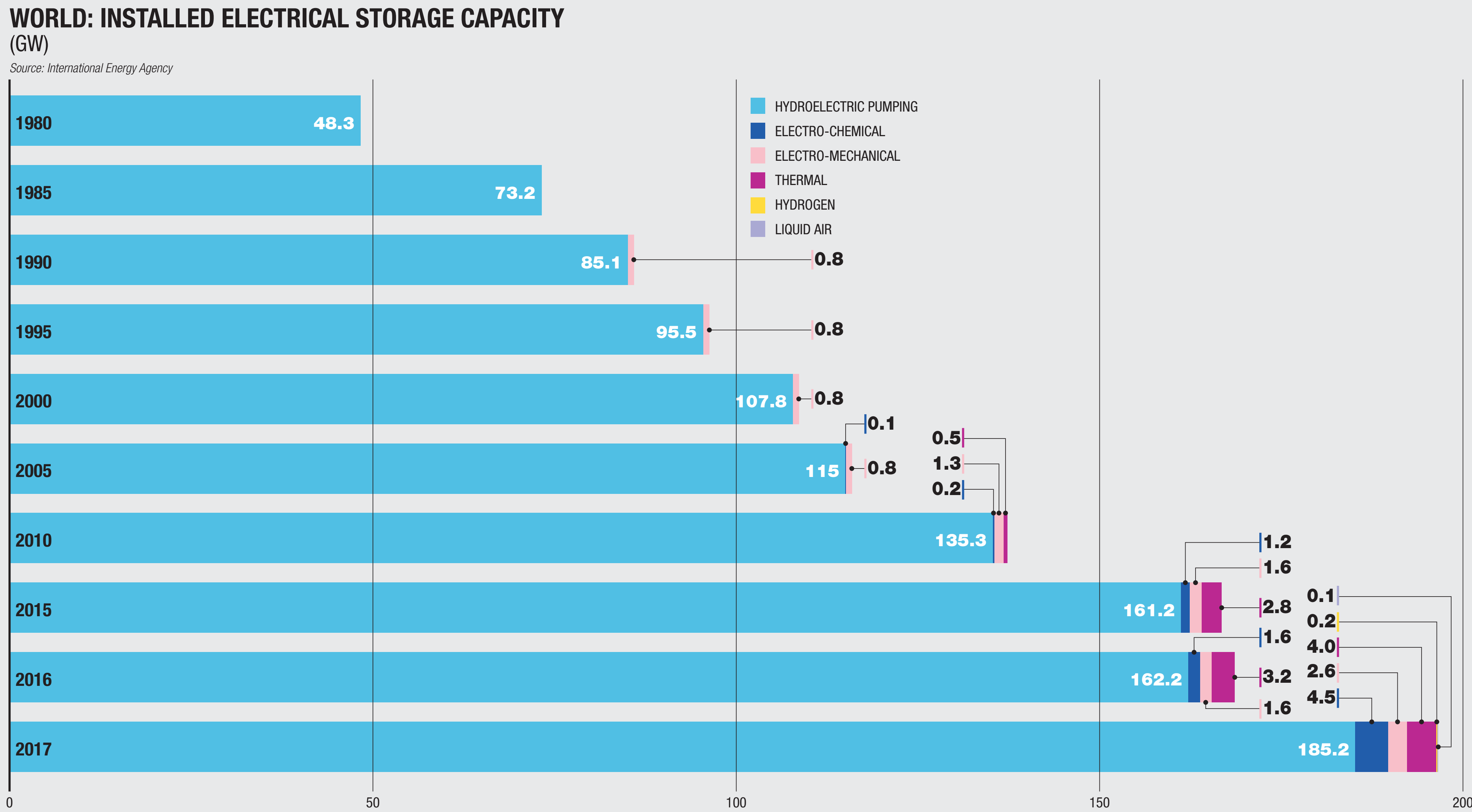
The Mendola Funicular is one of the main attractions of South Tyrol. Since 1903, thanks to electricity, it has carried people and cargo from Caldaro, famous for its wines, up to the pass, rising to an altitude of 800 meters in 12 minutes. At the time it was built, it was a revolution for inhabitants of the area, many of them farmers for whom the same exhausting journey on foot would have taken at least a couple of hours. The funicular was built in eighteen months, designed by Swiss engineer Emil Strub and ordered by the Austrian emperor when the territory was part of the Austro-Hungarian empire. These were the years of the Empire's greatest splendor and years when the Empress Sisi spent her holidays in Mendola.
It was the first funicular in the whole of Tyrol and for years the longest in Europe. It took advantage of the first large amounts of electricity supplied by hydroelectric plants, which were built in ever greater numbers and which, in addition to lighting cities, made possible the first railways, tram lines and funiculars. Then, as today, one of the basic needs of man was mobility, which for the first time was met by new machines, like the funicular, and powered by the electricity that was gradually becoming more abundant. Railway lines were built all over the Alps, many of which are still in operation, and trains forever changed the way people from ancient mountain communities moved around. 120 years later, those efforts can inspire us to use electricity today, possibly from the sun and wind in addition to water, to further develop electric mobility and to replace gasoline and diesel in cars.

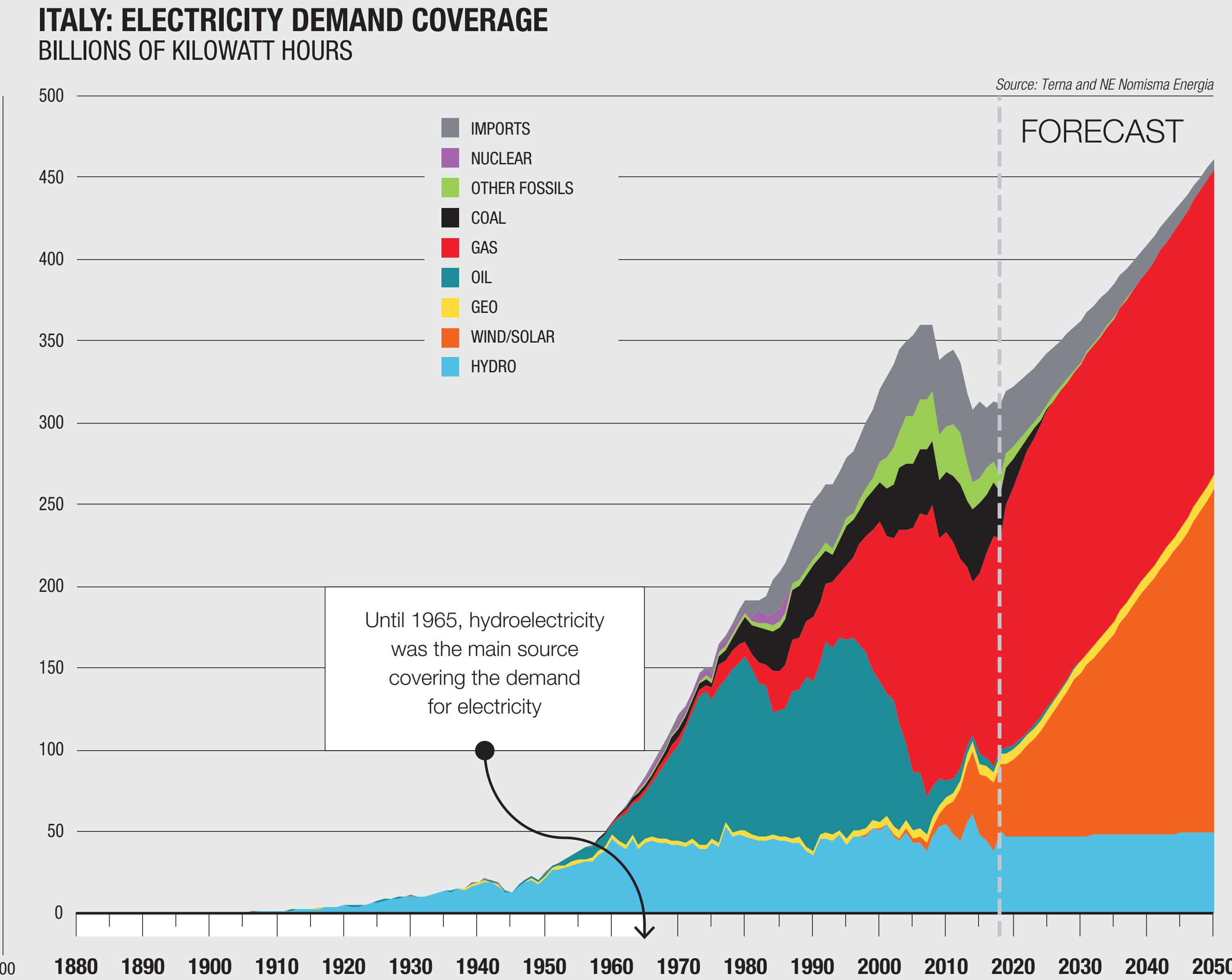
The real renewable source is hydroelectric

Hydroelectric power—energy from water—is only renewable source that can compete on an equal footing with fossil fuels and nuclear power. It perfectly satisfies the need for programmability, allowing instantaneous power to be delivered to the grid and onward to the end user. Electricity is made up of electrons that move at a precise frequency, 50 oscillations per second, the notorious 50 hertz, which must remain the same from the production plant to the end user's appliance. It is a complex system that needs large power plants, while modern renewable energy plants, solar panels and wind turbines have less power and provide intermittent electricity, which means it's not there when the wind doesn't blow or the sun sets. This doesn't apply to electricity from large water basins, where man has built barriers to interrupt the water cycle that starts with the sun making water evaporate from the sea, →

The continuing importance of hydroelectric power

Hydroelectric power will continue to play a major role due to its massive accumulation and ease of access, and that role will be important in speeding up the transition from fossil fuels. Almost all large accumulations of electricty worldwide are hydroelectic.





which then turns into clouds and falls as rain. The raindrops that fall to earth have an insignificant amount of energy. However, when they fall in the mountains, they run downhill and are gradually collected into small streams, these then join together into tumultuous torrents that become mighty rivers and, when they meet a barrier, a dam, they form large lakes where an enormous amount of energy accumulates. Artificial ones are created to ensure the essential height difference and make water fall into a forced conduit, normally a steel pipe inside a tunnel. This makes the water fall onto the blades of a turbine, which turns with an alternator to generate the much-wanted electricity. It is an artifice used to mechanically exploit the simple gravity of water.

Man and water

The connection between man and the energy of water is very ancient and dates to the first great river civilizations of the Euphrates, the Tigris and the Nile in Egypt. Water was used to irrigate, but the pipes made it possible to use energy mechanically. One of the great discoveries made by man was the mill, water-driven versions of which already existed in China in the first century BC, while in Rome, Vitruvius gives an accurate description of a mill in 50 BC. Strangely, it was never widely used in antiquity and only in the Middle Ages, around the year 1000, did it spread throughout Europe, mainly due to the increasing scarcity of serfdom, a more advanced form of slavery that had provided cheap energy to previous civilizations. The watermill, together with the windmill, initially used to grind cereals, was used to forge metals and then, after 1200, to produce textiles. The great economic historian, the Italian Carlo Maria Cipolla, explains that the water mill, together with the windmill and sailing, were the three innovations that provided medieval Europe a foundation for its development and sparked the industrial revolution centuries later. The discovery of the steam engine, which is so closely connected with the initial use of energy from coal, was intended to use steam and mechanical energy in mechanisms that previously operated on water. The disruptive industrial revolution of the 1700s confined the mill to the rural world. However, the main innovation of the second industrial revolution, which began in the second half of the nineteenth century, lay in the way electricity was produced, in the first experiments, using the water from mills that used an alternator instead of a millstone. The effort to harness energy from water was evident in those countries that, unlike Britain and Germany, did not have their own coal mines, the source used to produce steam. Where there were mountains, the Alps, a vast use of hydroelectric power began and continued and accelerated throughout the first half of the 1900s. Currently, there are over two thousand large power plants in the Alps in addition to thousands of very small ones that contribute to the production of what is by far the main renewable source in France, Switzerland, Austria and Italy. But these large dams came at a huge cost, not only because of the financial strain but also because they destroyed entire valley communities, wiping out many towns and villages. The bell tower of the village of Curon, half of which emerges from the artificial lake of the Resia pass, is a reminder of all those rural areas that were sacrificed for electricity, known at the time as white coal, when no fossil fuel like coal was available. Doing the same thing in the Alps today would be impossible, although some are beginning to think about restoration.

The biggest cost of all was to human life. The working conditions in which these dams were built, often in huge caves in the mountains, were terrible in a time with non-existent safety standards. Given the scarcity of large machinery compared to today, a lot of cheap labor was employed, with laborers willing to work exhausting shifts, their free time sometimes limited to no more than the opportunity to eat a meal at the end of a long day. One of the biggest power plants of the Italian electricity system is Santa Massenza, in the province of Trento. It was completed in 1952 and 8,000 workers worked on the project for ten years, 50 of them dying in accidents. The same happened in all the other plants built during those years. Many of those who returned home died young, between 30 and 40 years old, fatally sickened by silicosis, the disease caused by the silica breathed in the tunnels. Nor can we forget the great dam disasters, which are now impossible thanks to sophisticated controls and very high safety standards. In 1963, a landslide that fell into the artificial lake of Vajont, in the province of Belluno, made the lake overflow. The water swept away the settlements below, causing the death of 1,917 people. It was the most serious accident, but only one of many that occurred in the Alps, a sacrifice that shows how urgent it was then to have electricity to give people light and bring power to factories. Both Massenza and Vajont are crowded tourist resorts today.

Today's figures and the potential in Italy

In 2019, hydroelectric production in Italy was 44 billion kilowatt hours, 15 percent of all Italian electricity production, equal to double the second renewable source, solar panels, which accounted for 24 billion kilowatt hours, followed by wind power at 18 billion kilowatt hours. In Italy, for almost a century until 1965, hydroelectricity was the main source used to cover electricity demand, the only major source in the first half of the twentieth century that allowed the first phase of industrialization to take place and which, from the 1950s, fueled the economic boom and lifted millions of Italians out of poverty. Since the 1970s, the electrical system has moved to thermal power plants, initially fired by oil products then by gas, which guarantees the greatest capacity.

The future of energy around the world, and in Italy, is more electricity from new renewable sources. Solar and wind power are the target, but it should be noted that both are intermittent. The ambitious targets for 2030, just ten years from now, require wind power to be doubled and solar power to be tripled. The problem of grid intermittence will be aggravated, particularly because many programmable coal and nuclear generation plants will be closed. This will require us to resort to plants that are able to quickly deliver large amounts of electricity to the grid and only the big old hydroelectric plants can do this. They provide an excellent service because they work just like a water tap, they can be opened and closed at will in a short time. They have long been used to make up for sudden shortages and have become essential in ensuring the stability of the network.

But the great role it will have in the future stems precisely from its essential characteristic, that of being a huge accumulation of energy that is easy to exploit when needed by consumers. The last hydroelectric plants built in the 90s are often of the pumped-storage type, i.e., the water they release during the day, when the demand for electricity is high, is pumped up at night, when there is no demand and when some large plants cannot close because it would be too expensive to turn them on again.

The system was designed for nuclear power plants, and partly for coal-fired ones, which are difficult to turn off when consumption drops at night. In order not to waste the electricity produced, it was used to pump water upwards to be used the next day. Almost all the large-sized energy storage systems in the world are of the hydroelectric type, while all the other solutions—chemical, mechanical, thermal—are still in the experimental phase.

The same logic can be used in the future to deal with the problem of the intermittence of new renewable sources, by pumping huge amounts during the day rather than at night, thanks to the great abundance of electricity generated by solar panels, which can then be consumed in the evening when the demand is high, but the sun has already set. Two decades have passed since the start of the transition to renewable sources and it is clear now that the old hydroelectric plants continue to be central to the stability of the grid and to speeding up the process of abandoning fossil fuels. In Trentino, a few kilometers south of the Mendola funicular, the 22 large hydroelectric power plants, including Santa Massenza, are now owned by the Province and the Australian investment fund Macquairie, a major international financial entity that has found a jewel here to diversify its investments. The kind of recognition that the hundreds of thousands of people who worked with ingenuity and sacrifice to produce hydroelectricity from the Alps would be proud of.

Culture/Restoring the value of a great resource

The Source of Life

The idea of safeguarding water resources is not new, but we need to go further. We need to go back in time to restore that sense of sacredness and reverence towards water that our ancestors in all cultures had developed and maintained for centuries

DERRICK DE KERCKHOVE

Scientific Director of Media Duemila/TuttiMedia Observatory and Visiting Professor at the Polytechnic of Milan, de Kerckhove directed the McLuhan Program in Culture & Technology of the University of Toronto from 1983 to 2008. He is the authof of numerous publications on the digital age, including *The Skin of Culture* and *Connected Intelligence*.

Water is present throughout the cosmos in the form of ice or vapor. It is even relatively common in the vapor state. But of liquid water none seems to exist outside the solar system. Thus, water is the defining and contributing element of life for planets as well as for people. We, however, people with a dwindling sense of the sacred, have taken such elements for granted. "Today water refers mainly to a commodity providing material comfort and prosperity....We expect it to be as clear, colorless, and odorless as we can get it, and then we dismiss it from consciousness. With hardly any effort on our part, it comes gushing from a tap...." The big four, earth, air, fire and water have been desecrated for decades if not centuries and are henceforth rebelling against humankind. Earth depleted of its forests is ceasing to protect and guarantee breathable air, fires rage in desiccated areas and water pollution creates continents of plastic in the oceans. The urgent question is how to reverse that trend. The fact that industry is beginning to take a responsible approach is obviously an example worth giving to both governments and governed. But, alongside industrial considerations about access, volume, quality, sharing, preservation and costs of utilitarian use of water, there is an urgent need to also emphasize water's health, recreational, cultural and symbolical values. It may not be enough for governments to regulate and business to conform, but effective communication strategies should also be devised to remind people how precious water is to each one of us for body and mind.

Our body of water

To begin, we must always keep in mind that water is as essential to our physical survival and well-being as air itself. Following Carl Sagan's famous claim that "We're made of star stuff" it is said that all matter including humans are made of stardust. The other constituent is water. Science tells us that our adult bodies contain between 50 and 70 percent of water. Most of that water sits inside cells. Another part occupies the intercellular space, serving as a reserve for cells and blood vessels. The rest is contained in the blood and lymph and circulates continuously throughout the body. Water builds and feeds cells, carrying nutrients and proteins in our bloodstream and removing toxins from liver and kidneys, all in a complex hydrologic system for intake, usage, purification and flushing. Water is meted in different parts of the body according to specific needs: on the average, the adult brain and heart hold approximately 75 percent of water, lungs 80 percent, skin 65 percent, muscles and kidneys 80 percent, and even bones contain roughly 25 percent water. Water performs various key mechanical functions including acting as a thermostat and regulating body temperature, absorbing shocks for brain and spine and lubricating joints. The brain also needs water to manufacture hormones and neurotransmitters.

The problem is that the human body cannot store water. Indeed, the body permanently eliminates water via excretions (mainly urine), breathing (at the time of exhalation), and especially sweating. In fact, compared to most of our animal brethren, we are some of the most water inefficient beings on the planet. The reason is that we lose quite a bit of water every day and we have no real way to store excess water or replenish our lost reserves short of simply drinking more of it. Unlike many other animals we cannot go long stretches without a supply of fresh drinking water.

To keep the body in good health, water losses must always be compensated by the intakes. Without water of any kind, humans cannot live more than two or three days; if they drink without eating, they can survive for about forty days, provided they make no effort. Scientists all agree on the need but not on the exact amount. Common recommendations average →

the overall amount of water necessary for an adult of average height, living in a temperate region and not providing any particular physical effort, to approximately 2.5 liters per day of which approximately 1 liter is provided by food and 1.5 liters by drink. Thirst is a mechanism by which the body "warns" that it is dehydrated. Some nutritionists advise not to wait until you are thirsty to drink, but others suggest it's better to trust our own bodily response to dehydration and attend to our feeling of thirst before reaching for water. While most people don't observe systematically these health measures, many carry a bottle of water on them or at hand's reach all the time, keeping it by their bed at night.

Trusting tap or bottled water

The reality, at least in the more advanced economies, is that tap water is probably safer health-wise than plastic bottles. And, to support that observation, around two thirds of European and North American populations drink it more or less unconcerned. The majority of the U.S. population drinks tap water on a regular basis: 71 percent drink tap water at least sometimes, while only one in ten (12 percent) say they never drink tap water.

Drinking from plastic bottles could be another problem, not a solution. Per liter consumed, bottled water is deemed to cost 2000 times more than tap water, and the discarded bottles count among the most abundant and damaging environmental hazards to say nothing about the huge costs of transporting it from production to distribution points. While bottled water is very convenient because easily transportable and endowed with different tastes depending on one's favorite brand, it is often no different in substance from tap water and may also contain plastic particles that are not healthy.

Research claims that most bottled water is no different than tap water. Chemicals found in bottled water included endocrine disruptors. Harmful side-effects from prolonged exposure to these chemicals include; stunted growth, early puberty, premature birth, infertility, early menopause, diabetes, heart disease, and cancer.

Water in health, longevity and fitness

Interesting correlations between longevity and regular intake of quality water containing magnesium have been found in areas where a greater concentration of people live healthily to a 100 years and more. The areas that have received most attention are distributed throughout Southern China and the average longevity is attributed to the quality of groundwater, particularly where residents do not benefit from public (softened) water services and resort to natural (hard) water sources rich in oligo-elements. Hard water contains calcium and magnesium also present in large quantities in sea water. By indirect association, magnesium and the myth of The Fountain of Youth are related. Both are supporting longevity and vigor.

Symbolic values

In most ancient cultures, water represents spiritual as well as physical renewal. Over millenia, water has been recognized as a sine qua non support for survival and a symbol of creation, fertility, rebirth, renewal, and food supply. Symbolic aspects are related to birth and fertility (agricultural and human). Water always was and still is the main source of cleaning and cleansing, hence the healing properties that mythology as well as poetry and numerous expressions in common language and culture attest. The greatest virtue of water is that it recreates life seasonally.

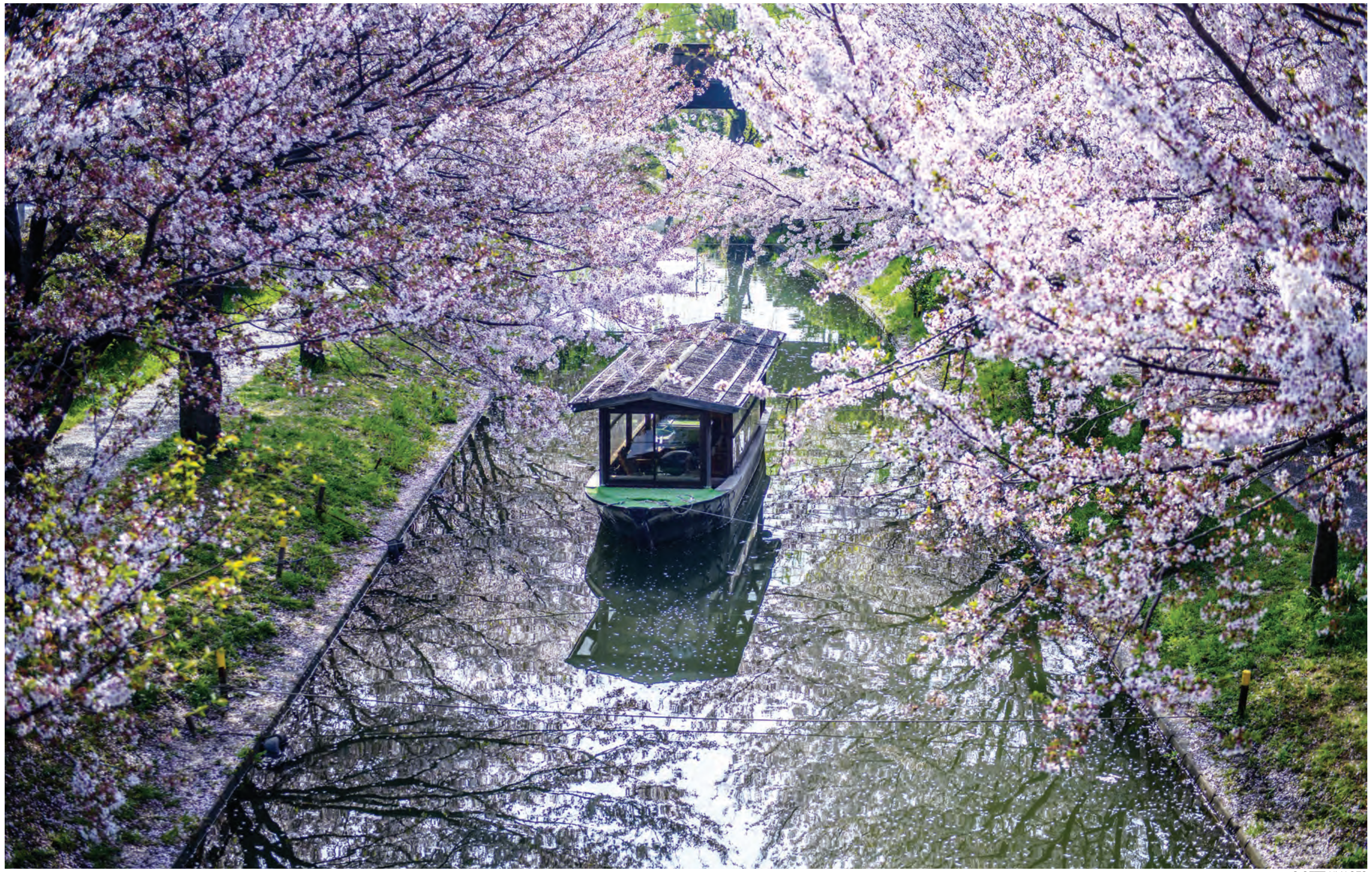
The legend appears first in Herodotus and has inspired a fair abundance of written, sculptural and pictorial renditions, but it really took off in the reports of one Juan Ponce de Léon, a Spanish conquistador who supposedly 'found' it in Saint Augustine, Florida, apparently also believed to be the place of the first settlement of Europeans on the American continent. The connection with magnesium would depend on the abundance of this element in that geographical site, now turned into a park attraction that brings thousands of tourists.

Recreation: our mind on water

Tourism and people's fixation on health still capitalize on beliefs akin to antiquity. For example, people the world over, pay monthly visits to one reputed spa or another. The common expression is "take the waters" to clean body and refresh mind. Such healing powers have much to do with plush settings of bathing and cleansing rituals. The notion of rejuvenation is not quite as magical as that of the Fountain of Youth, but both imply recreation.

Regarding its benefits to the mind, among the most intriguing factoids I have found about water is the claim that living near or by water, even if only a fountain or a brook, is statistically associated with more frequent and improved sense of well-being with respect to other dwelling areas where it cannot be seen or heard. Among the benefits associated with living by the sea or any other body of water hard or soft: fresh air and sunshine often present on beaches, improved vitamin D intake and increased immune function. Some also mention the soothing sounds of brooks, rivers and seashores. Generally, the presence of water contributes a closer relationship to nature. According to poet and author Gary Snyder in "Coming into the Watershed": "The surface (of the earth) is carved into watersheds—a kind of familial branching, a chart of relationship, and a definition of place....Watershed consciousness...is not just environmentalism, not just a means toward resolution of social and economic problems, but a move towards resolving both nature and society with the practice of profound citizenship in both the natural and the social worlds."

SYMBOL OF REBIRTH
In most ancient cultures, water represents spiritual as well as physical renewal. Over millenia, water has been recognized as a sine qua non support for survival and a symbol of creation, fertility, rebirth, renewal, and food supply.



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Economic value of non-strictly utilitarian uses of water

Since the economic value of water will be probably measured by industrial priorities, now is the time to provide foresight and guidance to devise policies that guarantee the continuance of humanistic values attached to water. The question, beyond reducing the dangerously unequal distribution of water on the planet, will be how to respond and equilibrate justly and wisely the needs of both industrial and recreational use.

Allocating water among multiple competing uses will increasingly necessitate tradeoffs among economic, ecological, and societal values. The value of water in recreational uses will reflect trends in water demands and values associated with all water uses occurring in contemporary world. To a large degree, these trends will affect the extent to which water resource planners and policymakers will be able to accommodate multiple water users, and resolve conflicts between recreational uses and nonrecreational uses. Anticipating the need to make tradeoffs between recreational and nonrecreational uses of water in the future will require (1) information regarding the economic value of water in recreational uses (2) information regarding projected demands for water recreation and (3) information regarding projected demands for water for nonrecreational uses. Together, this information can aid in developing and implementing water resource policies that seek to balance the interests of both recreational and nonrecreational water users.

Ian McHarg provided direction for future management actions when he wrote: Clearly the problem of man and nature is not one of providing a decorative background for the human play....it is the necessity of sustaining nature as source of life, milieu, teacher, sanctum, challenge, and, most of all, of rediscovering nature's corollary of the unknown in the self, the source of meaning.

Sparing water usage

Learning to save water requires a mentality revolution, especially in industrialized countries, where water is so easy to access that everyone has become accustomed to consuming it without restraint. It is therefore a question of making all water users responsible, not only the industrial and agricultural actors who consume a lot of water, but also individuals, and to teach them the gestures that help daily save and to save water. An original approach in Costa Rica has registered a modest but visible progress: A set of simple and replicable behavioral interventions use stickers that can be added to water bills at low cost, and test their impact on water consumption in Belen, Costa Rica, using a randomized control trial. A descriptive social norm intervention using neighborhood comparisons reduces consumption by between 3.7 and 5.6 percent relative to a control group, while a plan-making intervention reduces consumption by between 3.4 and 5.5 percent.

Making water sacred again

The idea and the need to respect water at the individual level is not new. Every advanced economy has developed campaigns but to little avail. It is possible that as the reality of climate change eventually comes to the foreground of people's preoccupations, the sense of how casually they treat water will grow and change attitudes, but what is really needed in government and PR businesses thinking is to go way beyond fine tuning personal habits and go back in time, maybe to restore the sense of the sacredness and reverence that our ancestors in all cultures had developed and sustained for centuries for water.

History/What we learned from the 2003 blackout

A Luxury for the Few

In wealthy countries drinking water is taken for granted, but more than two billion people lack access to it. If we don't remedy this, the world will remain hostage to an insurmountable socio-economic divide

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FRANCESCO GATTEI

He is the Americas Upstream Director of Eni. Previously, he was Executive Vice President, Scenarios, Strategic Options & Investor Relations of Eni and before that responsible for the E&P portfolio at Eni, where he also held numerous planning, negotiation and commercial roles in Italy and abroad.

On September 28, 2003, the entire Italian peninsula, with the exception of Capri and Sardinia, found itself in the dark. That night, some trees that had fallen on high voltage lines used to import electricity had caused the gradual shutdown of the national grid. The most surprising thing for people waking up that morning was not the lack of electricity (the day had just begun and the sunlight at the end of September is still strong and lasting), but the total absence of water. And so none of the actions we take in the early hours of the morning could be completed: the 10 liters of water to flush our toilet, the 40 liters used to take a shower, the 10 liters to wash our face and brush our teeth and the small amount needed to fill the coffee machine did not flow as normal. In short, during the first hour of every morning, each of us uses over 60 bottles of water to perform a few actions that we take for granted. And that we repeat during the day, perhaps adding a washing machine and dishwasher. These are so taken for granted that we don't even have a word equivalent to blackout to describe a lack of water. There is no concept of a "dryout." Everything appears stable and guaranteed by the water mains system under our cities. But the availability of abundant, continuous and clean water, accessible toilets and a functioning sewerage system is not a certainty everywhere in the world. Far from it. It is an exceptional luxury, for the few.

The difficulties of collection and the risks of contamination

Over two billion people are in fact estimated to have no access to clean water in their homes and about 4.5 billion do not have adequate toilets. Where water is not available in homes due to the absence of water mains, a "human" aqueduct forms, generally consisting of women and children forced to spend over half an hour collecting water from the nearest source. This movement of people takes away time from studying or other activities and, according to an estimate by the World Bank, involves 200 million hours of work every day, enough to build thirty Empire State Buildings. The final prize is a 20 kg trophy: having to carry about twenty liters of water, which is insufficient to even cover one person's needs (40-50 liters).

Access to water is much faster in richer countries. It takes just a couple of seconds and a few steps to reach a tap in the bathroom or kitchen to turn on an appliance and we have easy access to our daily consumption of 190 liters (240 in Italy!). The only pilgrimage and effort we make is when we decide to buy bottled water from the supermarket, still benefiting from cars and elevators.

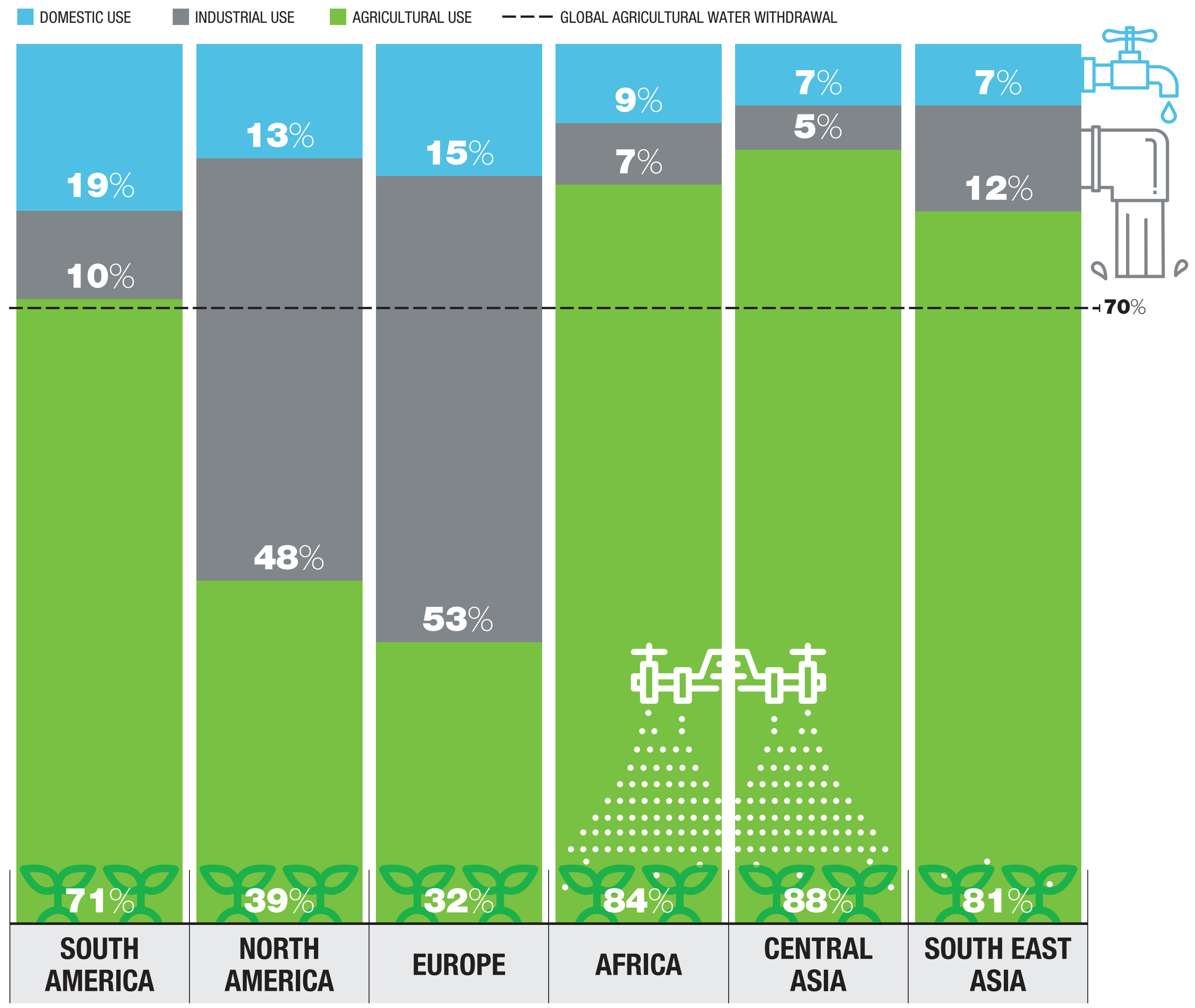
Collection, however heroic an endeavor it may be in some areas of the world, is the least of our problems. The real danger lies in what people drink. Non-purified water is in fact terribly dangerous and is the main cause of disease in the world. According to the WHO, 80 percent of diseases derive from the use of unsafe water. Millions of people die of diarrhea, typhoid, cholera, giardiasis, hepatitis, salmonella and a whole host of other bacteria every year. As Westerners, we only get a taste of this when, as tourists, we are (I would say almost regularly) struck by traveler's diarrhea. We refer to it using ancient and exotic names, including Montezuma and Tutankhamun, but we should use its real name. Underdevelopment.

The contaminated water roulette is repeated 365 days a year for at least one in five people. Diarrhea is estimated to kill over 1.5 million children under the age of five every year. These deaths are cloaked in the silence and indifference of our news circuits and in the absence of demonstrations by our students classes, insensitive (or unaware) as they are to the fate of their peers.

The risk of contagion is not limited to more isolated rural areas but exists in many large cities, where sewage and sanitation services are lacking and the segregation of sewage from drinking water is very fragile. This segregation, and the water chlorination or purification processes, are a recent and decisive achievement for our health. In the U.K. and the U.S., they started in the early 1900s, contributing to a 40 percent reduction in the mortality rate in just over a generation and raising life expectancy by 10 years within half a century. But many countries still haven't achieved similar standards.

India is probably the country where the water and sanitation problem is most chronic. The explosive development of Indian cities has highlighted the inadequacy of the sewer network and amplified the absence of toilets. It is a paradox in a country capable of sending missiles into space but where 50 percent of homes have no toilet and where 2/3 of the rural population prefer to relieve themselves outdoors, considering this to be more pleasant and convenient. Water contamination happens everywhere. Along rivers (3.8 billion liters of waste are estimated to be discharged per day into the Ganges), through unprotected outdoor pits, and even along train tracks, due to the widespread use of carriages that discharge onto the railway. Multiply it all by 23 million passengers per day and it's clear that we are facing a real health problem.

AGRICULTURE VS INDUSTRY: THE WATER USE IN THE WORLD



Different levels of development, different uses

But the use of water doesn't only differentiate our lives at home or on the train. It also characterizes the two sectors that require greater volumes: agriculture and industry. Across the world, 70 percent of surface water is used in agriculture and 20 percent by industry, with just 10 percent ending up in our homes. But these figures are enormously different if we compare rich and developed countries, where industrial use covers half of consumption, with poorer ones, which use 70-80 percent of water for agricultural purposes, with poor yields and high levels of dispersion of the source.

Low water availability also limits development of the industrial system. For example, huge quantities of pure water are needed to produce a microchip measuring just a few millimeters to remove any form of contamination and impurities. A semiconductor factory uses 9 to 15 million liters of pure water per day. Water is also the basis of our electricity grid, which requires 40 percent of the total requirement to operate thermoelectric and nuclear power plants. And even our clothes (1700 liters for a pair of jeans) or some large industrial cycles (a ton of steel requires 300 thousand liters) devour enormous amounts of water.

To conclude, water, like the energy to which it is closely linked, is a particular commodity, which measures the degree of development of a country and relief from poverty. It is paradoxical that such an important element for the survival of thousands of people does not have as much public attention paid to it as other issues. And that its easy accessibility and low cost in rich countries distracts us. Just a few sudden interruptions (such as that of September 2003) allow us to experience for a few hours what is normal life for a large part of the world population.

But the growth in consumption (from one trillion cubic meters per year in the 1950s to four trillion today, with the prospect of a further 30 percent increase in the coming decades) should make us more sensitive to the importance of this source and the need to promote new technologies to allow its more widespread and efficient use. Without water—and energy—for everyone, the world will remain like the train in Snowpiercer, the Korean film based on a dystopian comic. A world where the front carriages are splendid greenhouses and aquariums, populated by a few lucky ones, while the poorest, dirtiest and degraded humanity lives at the back of the train. And where those born at the end of the train cannot expect to move to the front, because "when the foot pretends to be the head, it crosses a sacred border."

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