UNITED ARAB EMIRATES
MINISTRY OF FOREIGN AFFAIRS
OFFICE OF THE MINISTER

الإمارات العربية المتحدة
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RIPPLE EFFECT

Water Scarcity - The hidden threat to global security and prosperity

Foreword

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Few things are as fundamental to human life as access to water, and throughout history, overcoming water scarcity has been an essential driver of human progress and development. This has been true everywhere, but especially in the Middle East and North Africa, where water scarcity has been a persistent challenge and an ever-present feature of life for millennia.

Today, the UAE and its neighbors in the MENA region continue to rank amongst the most water-stressed nations on earth. Alarmingly, however, the problem of water scarcity is now spreading to many other parts of the world, accelerated by factors including climate change, population growth and continued economic development, all of which increase demand for water, while simultaneously reducing the availability and dependability of its sources.

This accelerated growth in global water scarcity is a dangerous development that demands an urgent and decisive response from the international community. In the absence of effective action, global water scarcity is projected to have a series of devastating consequences, including human suffering and loss of life, mass migration, geopolitical instability and even armed conflict over water. No nation will be immune from the cascading effects of unmitigated water scarcity, which makes this a truly global issue.

However, it is the view of the UAE Government that the seriousness and immediate urgency of the threat posed by water scarcity has not been fully recognized around the world. As a result, the international community is falling dangerously behind in its efforts to confront this challenge, with potentially grave outcomes. Moreover, as this paper argues, a failure to address the threat of water scarcity could also undermine global efforts to address other comparable and related threats, including climate change and future pandemics, thereby multiplying the cost of inaction.

Informed by this analysis, the UAE intends to launch a multifaceted initiative to confront the issue of global water scarcity. As a nation on the frontlines of the impending water scarcity crisis, and as a longstanding advocate for international dialogue and cooperation, the UAE is determined to raise global awareness of this issue and to help mobilize a decisive and coordinated international response to the threat that it poses to humanity. As part of this initiative, the UAE is also committed to improving its own water sustainability, including through expanded water conservation and education. More information on the initial elements of this multipronged initiative is provided at the end of this paper.

Most importantly, the publication of this discussion paper represents an open invitation to other members of the international community to work with us to help shape and advance a new and concerted global effort to address scarcity. We look forward to engaging and collaborating with governments, universities, research organizations and companies from around the world to address this growing challenge for the benefit of current and future generations. As we do so, let us draw inspiration from the many generations that came before us, each of which relied in their own way on the power of innovation, determination and cooperation to successfully overcome the same timeless challenge that we face today.

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Executive Summary

This discussion paper has been prepared by the Government of the United Arab Emirates to foster greater awareness of the growing scale and urgency of the threat of global water scarcity, and to call for a more coordinated international response to this rapidly intensifying challenge.

Global water scarcity is a complex and worsening issue that requires an urgent, comprehensive and coordinated response from the international community. According to certain measures, four billion people currently experience water scarcity at least one month per year, and this figure is only expected to grow in the years ahead.

A business-as-usual scenario in the face of rising global water scarcity could have immensely negative medium- and long-term implications. These include loss of life, food insecurity, economic underdevelopment, humanitarian crises, involuntary migration, geopolitical instability and the potential for armed conflict over water. Despite these potentially dire scenarios, water scarcity does not currently receive the same levels of public attention and financial investment as other comparable risks such as climate change and future pandemics, thereby hampering the development of effective solutions.

This discussion paper examines global water scarcity and its main causes, highlights various implications of water scarcity already evident in parts of the world, and most importantly identifies some potential solutions. It also identifies specific criteria for how different responses to water scarcity can be evaluated, compared and potentially deployed.

Importantly, this discussion paper also reaches the hard but undeniable conclusion that existing approaches to addressing water scarcity will not be enough to prevent a range of unacceptable scenarios and cascading effects from occurring. We suggest therefore the need to move quickly as an international community to find transformative new solutions to this complex and growing challenge, as we have done and are continuing to do in response to related risks such as climate change and pandemics.

Informed by this analysis, the UAE intends to launch a multifaceted initiative to boost international cooperation, increase investment and accelerate the pace of innovation aimed at addressing water scarcity. The UAE is also issuing an open invitation to individuals and organizations from all sectors and all parts of the world, as well as to other similarly-disposed nations, to work together and accelerate efforts to address this urgent challenge.

Ultimately, there is unlikely to be a silver bullet solution. A combination of regionally appropriate solutions will be required to move the needle on global water scarcity, and all stakeholders – governments, the private sector, researchers and entrepreneurs, philanthropists, international organizations, and all of us as individuals – have a crucial role to play in overcoming this pivotal threat to global security and prosperity.

Part 1. Defining the Problem

1.1 WHAT IS WATER SCARCITY?

The term “water scarcity” is generally defined as a mismatch between the availability of water and the demand for water in a particular area or region. This mismatch can be the result of many different factors.

Various metrics have been developed to measure and define relative water scarcity. One of the earliest and most widely used is the Falkenmark Water Stress Indicator (Falkenmark et al., 1989), developed in 1989 by Swedish hydrologist Malin Falkenmark. This expresses the level of water scarcity in a certain region as the amount of renewable freshwater available for each person therein each year. Under the Falkenmark Water Stress Indicator, a country or region is said to be experiencing water stress if the amount of renewable freshwater is below 1,700 cubic meters per person per year.

When a country or region falls below 1,000 cubic meters of renewable freshwater per person per year, it is said to be experiencing water scarcity, and when that amount drops below 500 cubic meters of renewable freshwater per person per year, it is said to be experiencing absolute water scarcity.

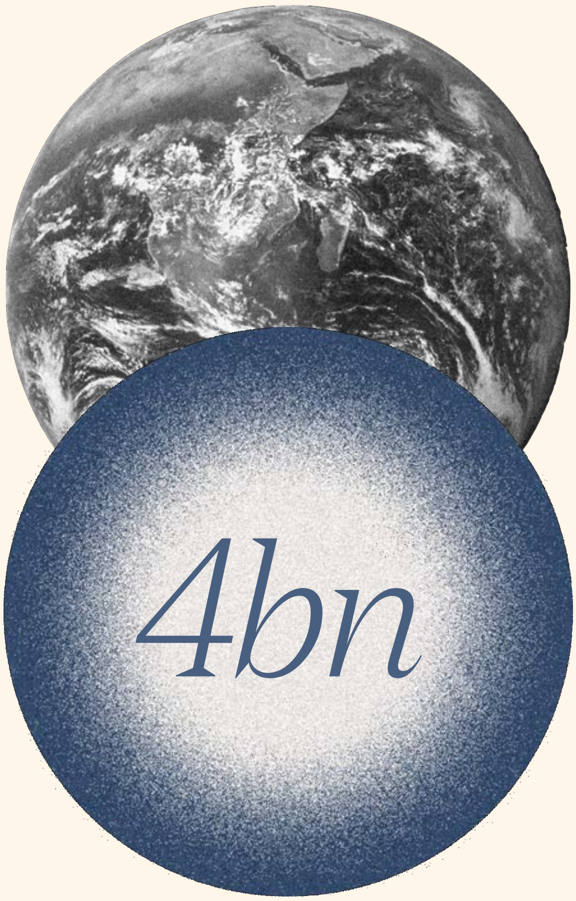
The analysis in this report is based on an adjusted version of the Falkenmark Water Stress Indicator that takes into account additional factors such as climate- and culture-driven differences in regional or national water demand, the effects of pollution and geological limitations on water access, and the existence of artificial water sources such as desalinated water.

Part 1. Defining the Problem

1.2 HOW WIDESPREAD IS WATER SCARCITY?

Water scarcity is already an endemic problem impacting individuals and communities across the globe.

*Certain measures of water scarcity have shown that **4 billion** people currently live under water-scarce conditions at least one month per year (Mekonnen & Hoekstra, 2016).*



This situation is only expected to worsen in the years ahead.

*According to the UN, current and future drivers of water scarcity could result in a scenario in which by 2025 over **1.8 billion** people are living in countries or regions with absolute water scarcity, and **two-thirds** of the global population are living under water stressed conditions (UNESCO, n.d.).*

Further, *by 2050 the global fresh water deficit is projected to be over 3,200 km³/yr,* with severe water scarcity likely to be found mostly in arid and semi-arid regions such as the western United States, northern China and the Middle East.

Part 1. Defining the Problem

Using estimated future renewable water supply and projected population growth, without adjusting for climate change-related effects, Figure 1 shows current baseline water scarcity compared with projected water scarcity under business-as-usual conditions by 2050.

Among other things, Figure 1 illustrates the potentially severe impact of water scarcity in northern latitudes in particular, with the most extreme instances of current and future water scarcity projected to occur between 5°N and 55°N specifically. This region includes a significant proportion of the global population, with countries lying in this area being home to approximately 6.2 billion people impacted by water scarcity.

When considered from this perspective, water scarcity emerges as an increasingly widespread issue affecting a growing portion of the world's population, making it a peer threat alongside other global risks such as climate change and potential pandemic emergence.

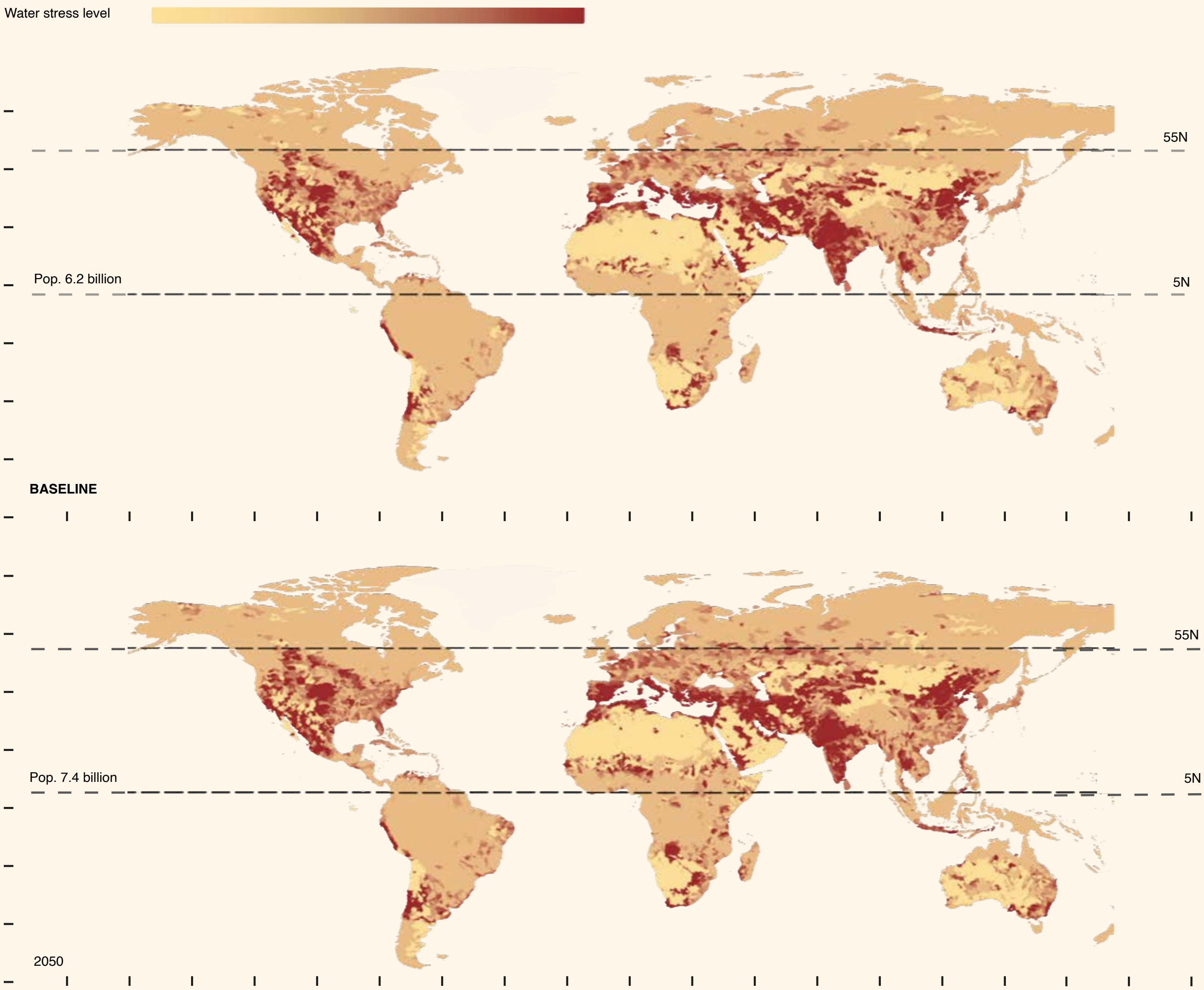


Figure 1. Top: Current Baseline Water Scarcity. Bottom: Projected Water Scarcity Under Business-As-Usual Conditions by 2050.

Source: World Resource Institute's Aqueduct tool 4.0 (2023)

Part 1. Defining the Problem

1.3 WHAT ARE THE CAUSES OF WATER SCARCITY?

While water scarcity is widespread, its causes vary and can include a combination of human and environmental factors.

Human drivers of water scarcity include waste, pollution and overuse of water, as well as population growth, whether organic or as a result of rural-urban migration. Direct human-caused water scarcity often arises where water is not being appropriately valued for various reasons, or where the total demand for water simply outstrips the local supply. Among other things, unregulated water use, unsustainable agricultural practices, and shifts in consumption patterns to more water intensive foods can all contribute to increased water scarcity.

Environmental drivers of water scarcity include drought, natural or anthropogenic climate change, including shifts in temperatures resulting from the emission of greenhouse gases into the atmosphere, as well as shifts in precipitation patterns resulting from large-scale deforestation. For regional or national governments, these environmental factors can be particularly challenging and must be treated as effectively de facto conditions, since they cannot currently be addressed by independent, localized action alone.

Alarmingly, several powerful macrotrends are expected to further exacerbate and in some cases create amplifying feedback loops in relation to these existing drivers of water scarcity. Perhaps chief among these macrotrends is the phenomenon of anthropogenic-driven climate change, which refers to long-term shifts in temperatures and weather patterns as a result of human activity (UNESCO, 2020).

Climate change

Climate change threatens to unleash a number of supply-side and demand-side disruptions, such as increasing wet and dry seasonality (e.g. flooding and drought cycles). Terrestrial water storage (water held in soil, snow, and ice) is diminishing which will impact both surface water flows and groundwater stocks (World Wildlife Fund, n.d.), even as increasing global temperatures increase demand from human and natural systems (e.g. increasing evapotranspiration from plants) (United Nations, n.d.). Meanwhile, sea-level rise threatens to increase saline intrusion into existing freshwater aquifers. In aggregate, these disruptions are expected to further reduce the volume and dependability of traditional freshwater sources.

Population growth

Population growth, particularly in already water-stressed regions, represents another macrotrend that is expected to worsen global water scarcity through the simple division of an already constrained (and potentially shrinking) resource into an increasing number of portions. Unfortunately, many of the world's most water stressed regions also feature some of the world's highest population growth rates.

Part 1. Defining the Problem

Demographic change

Finally, demographic change – including the rapid growth of the global middle-class and the accelerating pace of urbanization, both of which tend to increase per capita resource demands – represents another macrotrend that is expected to exacerbate water scarcity.

*As global wealth increases, demand for water is expected to increase with the potential for industrial demand due to socioeconomic changes to rise by **20-30% by 2050,** illustrating the vital importance of improved water treatment and reuse, particularly by industry (Greve et al., 2018).*

As the global middle class expands and more households procure amenities such as flushable toilets, washing machines and cars, there is a high risk that the roll-out of reclamation, treatment, or other efficiency-enhancing infrastructure, will not keep pace with these increasing demands for water.

Taken together, these trends suggest that in the future, a climate-impacted and potentially volumetrically-reduced and less dependable supply of freshwater resources will be called upon to do more than ever, as the demand-side impacts of population growth and socio-economic development take hold in many parts of the world.

The end result is likely to be a significant increase in global water scarcity.

Part 1. Defining the Problem

1.4 WHAT ARE THE POTENTIAL CONSEQUENCES OF INCREASED WATER SCARCITY?

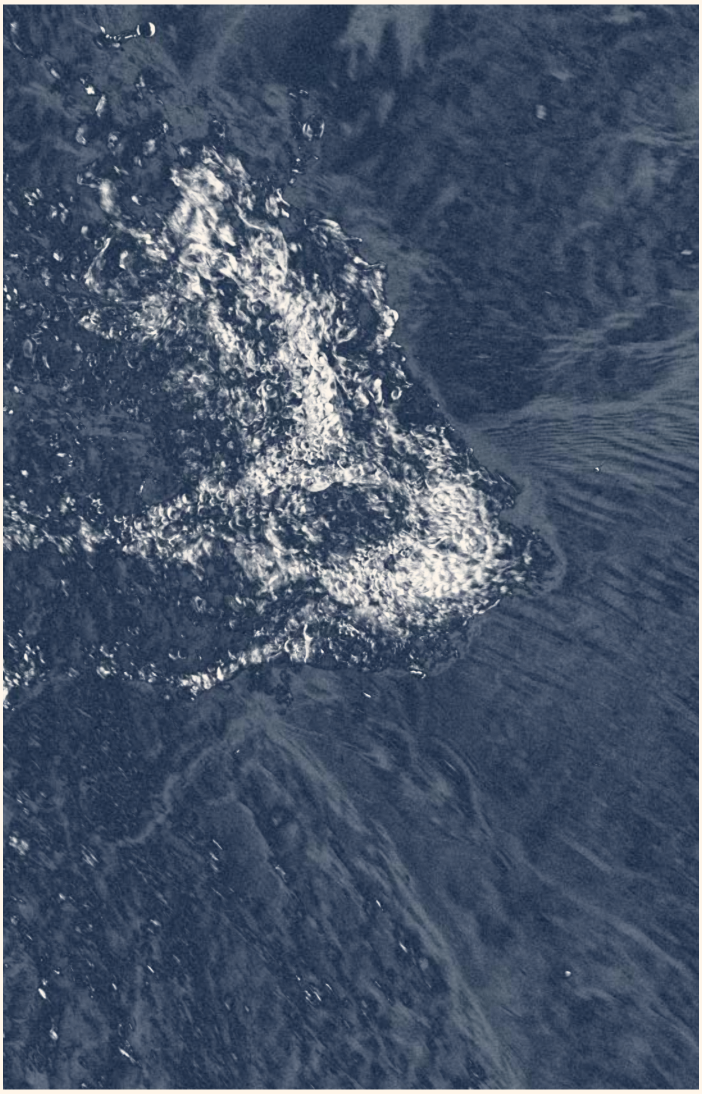
Left unchecked, global water scarcity is projected to lead to a series of consequences that have the potential to affect every country on earth, including water-stressed and non-water stressed nations alike. In fact, given water's indispensable role, not just in agriculture, but also in manufacturing and energy production, it has been posited that a failure to address water scarcity could put in jeopardy virtually all of the UN's Sustainable Development Goals (SDGs). At the scale of fully-realized risk, the challenge of unmitigated water scarcity threatens to become a tier-one threat to human life and prosperity, alongside other acknowledged global threats such as climate change and potential future pandemics (Mazzucato et al., 2023).

First and foremost, increasing water scarcity has a devastating impact on the populations that are directly affected by it. This can manifest in a number of ways, including negative health impacts, loss of livelihoods, loss of life, and eventually mass migration. This is not a theoretical risk.

*The World Bank (2021) has estimated that 10% of recent increases in migration are due to water deficits, and the UN estimates that water stress could displace **700 million people** by 2030, significantly exceeding the estimated numbers of refugees stemming from recent and ongoing international conflicts.*

The geopolitical implications of water scarcity and water-related migration are also potentially grave.

*The Global Commission on the Economics of Water (2023) reported more than **202** water-related conflicts between 2020 and 2022 in its Phase 1 Review and Findings report, and security analysts have consistently warned about the potential for nation-state conflict to arise over water disputes.*



Part 1. Defining the Problem

Compounding matters, rising water scarcity has the potential to exacerbate other species level global threats, including climate change and future pandemics. For example, if the previously-referenced estimated shortfall of 3,200 km³/yr of freshwater demand were met exclusively from additional desalination sources (and assuming 3 kWh/m³ of produced fresh water), the additional lifecycle CO2-equivalent emissions would range from as much as 10.2 billion tons/year (roughly equivalent to 20% of total current GHG emissions) from an all-coal portfolio of electricity generation assets to as little as 250 million tons/year (roughly equivalent to 0.5% of total current GHG emissions) from an all renewables/nuclear portfolio of generation assets. Not only do these figures illustrate the very material potential impacts of water scarcity on efforts to limit climate change, but they also point to the need for energy-intensive alternative water sources to be paired with the most sustainable energy solutions possible. As it stands, and at a current global average of ~475 tons of CO2e/GWh, meeting the above gap would result in roughly 4.6 billion tons of additional CO2-equivalent emissions per annum (roughly 9% of total current GHG emissions). Obviously, the release of additional GHG emissions on such a scale would significantly undermine global efforts to address climate change.

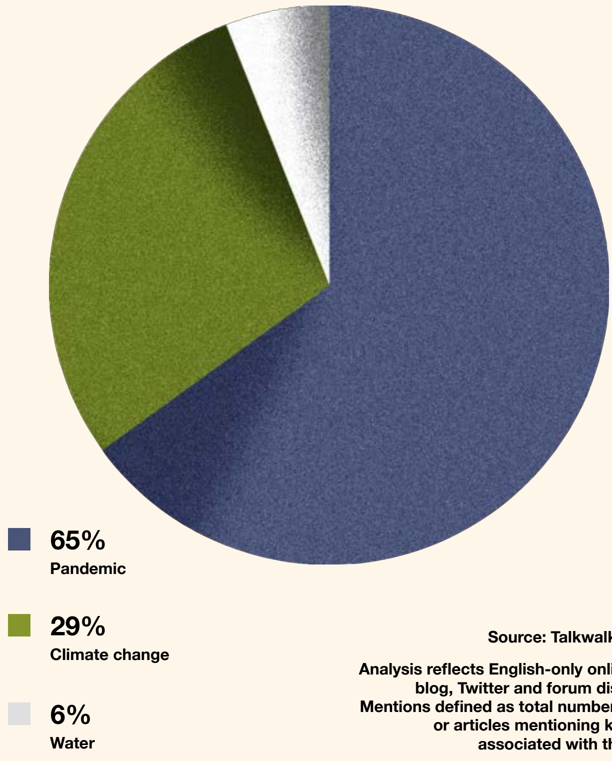
The emerging link between water scarcity and the potential for future pandemics is also concerning. Water scarcity drives migration of both humans and animals, and as traditional water sources are depleted, the threat of increased human encroachment on virgin habitats or the abandonment by non-human species of their traditional habitats will potentially increase the likelihood of novel contact and the chances of zoonosis (the transmission of an infectious disease between species from animals to humans). In fact, an analysis published by the US-based Brookings Institution (2021) describing potential strategies to avoid future pandemics cited earlier research suggesting that human encroachment on natural habitats posed the largest threat of zoonosis, accounting for an estimated 30% of its emergence.

Part 1. Defining the Problem

1.5 WHERE DOES WATER SCARCITY CURRENTLY STAND ON THE GLOBAL AGENDA?

Despite these potentially dire scenarios, global water scarcity does not currently attract the same levels of public attention and financial investment as other comparable risks. The following chart, which analyses public and media discussion of pandemics, climate change and water in the last year, suggests that water scarcity currently generates a fraction of the public and media attention as that generated by these other global threats.

Pie chart showing the relative share of public and media conversations on pandemics, climate change and water, globally
(31st July 2022 - 21st July 2023)



Source: Talkwalker / 2023

Analysis reflects English-only online news, blog, Twitter and forum discussion. Mentions defined as total number of posts or articles mentioning key words associated with the topics.

Mentions are one thing, money is another, and recent data suggests that there is also a significant deficit in the amount of financial capital being deployed to address issues related to water scarcity.

Despite the importance of water resource management for sustainable development and economic prosperity, the water sector as a whole remains severely underfinanced. Recent estimates put the global financing gap in the water sector at between USD 182-664 billion annually. Ensuring universal access to water and sanitation by 2030 – UN's Sustainable Development Goal #6 – may require more than USD one trillion in investment per annum, or around one percent of global GDP, and the progress towards this goal remains alarmingly off track (UN, 2023).

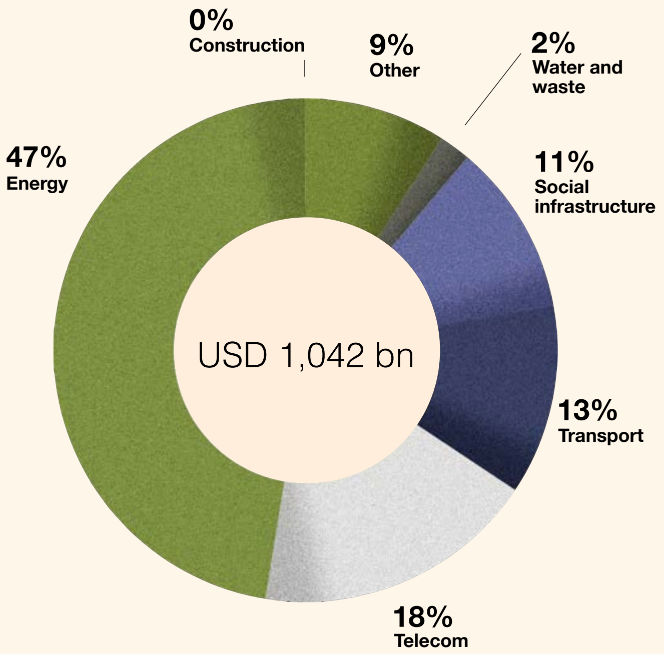
*In one UN survey, more than **75%** of developing countries reported insufficient funding for their national water, sanitation and hygiene plans (UN-Water, 2022).*

The financing problem is acute in developed countries as well, with all EU member states reportedly needing to increase their annual expenditure on water and sanitation by at least 20 percent to achieve compliance with common European standards (OECD, 2022).

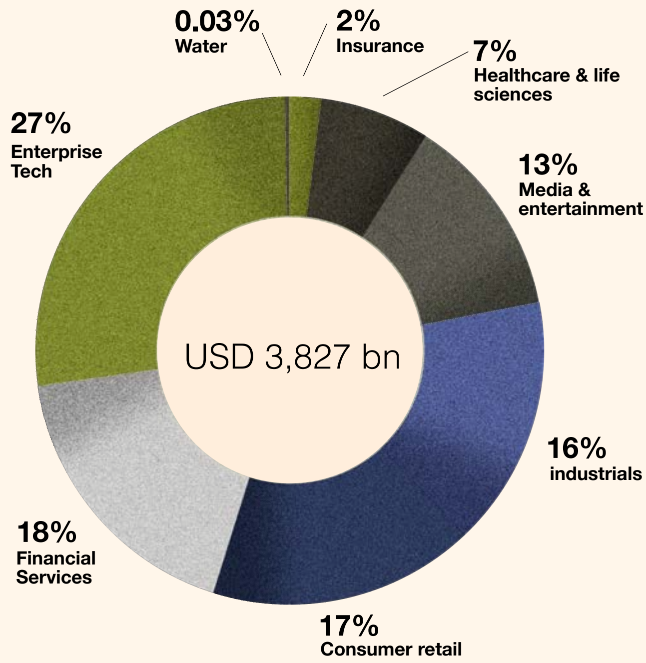
Part 1. Defining the Problem

From an economic standpoint, water remains an underinvested sector, and neither public sector players, nor international donors, nor private capital markets have proven ready to allocate sufficient resources to address water-related challenges. In most developing countries, user tariffs are insufficient to cover the ongoing operational and maintenance costs of local water and sanitation systems. The amount of Official Development Assistance dedicated to water and sanitation has also declined since 2019. Institutional investment in the water sector remains insufficient to bridge this financing gap. In 2020, water and waste-related investments represented only USD 22 billion, or around two percent of the total infrastructure portfolio of institutional investors domiciled in the OECD and G20 countries (OECD, 2020). Compared to sectors such as IT or financial services, water and sanitation also remains a marginal target for venture capital investment. For example, in a list of more than 1,200 'unicorns' – private companies with a valuation of over USD one billion – the water sector is represented by a single company (CB Insights, 2023).

A. Investment* in infrastructure by sector



B. Unicorn startups by sector



***Holdings of institutional investors domiciled in OECD and G20 countries as of February 2020**

Source: A – OECD (2020); B – CB Insights Tracker (2023)

1.6 OUR OBLIGATION

It is important to note that this is not an either/or situation. We do not have to make a choice between reducing water scarcity, addressing climate change, preventing future pandemics or minimizing the threat of armed conflict. We can, and must, be doing all of these things in parallel. As noted above, water scarcity is closely related to each of these global risks, and a failure to address water scarcity will undermine our efforts to address or prevent the others. We do not have to choose, because we do not have a choice.

Part 2. Potential Solutions

2.1 MAIN APPROACHES TO ADDRESSING WATER SCARCITY

The purpose of the first section of this discussion paper is not to argue that the worst-case scenarios of global water scarcity are inevitable. On the contrary, the world has many tools at its disposal that, if deployed in a timely and coordinated manner, have the potential to slow and eventually reverse the trend of increasing global water scarcity. As we turn our attention to these options, there is much that we can learn from the global response to existing threats such as climate change and pandemics. Although significant gaps remain in our response to both of these challenges, they do demonstrate the impact that can be generated by high levels of global awareness combined with coordinated local, regional and international action involving stakeholders from the public, private and non-government sectors.

In general, potential solutions to water scarcity can be divided into three main categories:

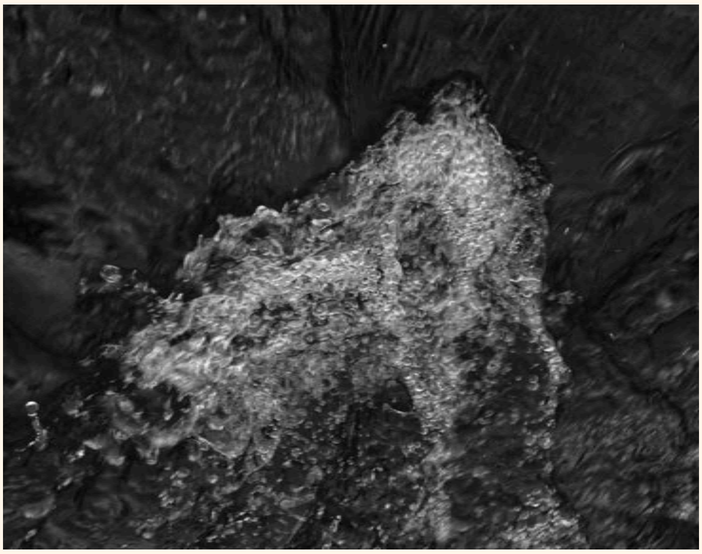
1. Supply-side approaches, which have the potential to increase the total amount of water that is available to a particular community.
2. Demand-side approaches, which have the potential to reduce the total amount of water that is used by a particular community.
3. Governance-based approaches, which have the potential to optimize how individual communities price, allocate and use the limited amount of water that is available to them.

2.2 SUPPLY-SIDE APPROACHES

Traditional supply-side approaches mainly rely on built-infrastructure investments that increase water storage capacity (e.g. by building and expanding reservoir capacity), transport water from areas with less scarcity (e.g. inter-basin transfers), or reduce water loss from storage and conveyance systems (e.g. by reducing leakage from pipes and canals).

Other supply-side approaches, including technologies that exploit unconventional sources of water, such as seawater desalination, domestic wastewater reuse, industrial water treatment and reuse, artificial recharge of aquifers and cloud seeding, are increasingly being tested and applied in areas with highly constrained renewable freshwater resources. For example, global desalination capacity has increased by about 7% per year over the last decade, with the largest growth occurring in the relatively arid regions of southern Europe, the Middle East, and northern Africa.

Less conventional supply-side approaches also include technologies that rely on natural infrastructure to gather, store, and purify water. They include approaches such as managed aquifer recharge methods that use wetlands to capture surface water runoff and source-water protection policies that preserve upland forests. Other innovative supply-side approaches include atmospheric water capture and agricultural soil amendments, such as super absorbent polymers that can increase the water retention capacity of more porous soils.



Part 2. Potential Solutions

Measures to reduce water pollution also provide important supply-side benefits. By improving water quality, they increase the amount of water that is available and usable without requiring expensive treatment. For example, the World Health Organization (2022) reports that more than two billion people worldwide rely on drinking water sources affected by microbial contamination, suggesting that efforts to improve sanitary treatment of wastewater discharges could play a critical role in improving public health outcomes and alleviating global water scarcity at the same time.

Investment in water infrastructure can increase the efficiency of water supply and distribution (i.e. reduce water loss) and improve water quality. However, across the world aging infrastructure is hampering the reliability and efficiency of water access. The World Bank (2010) has previously estimated that the cost of renewing water infrastructure and climate change adaptation could cost $28 and $20 billion annually, respectively. It is worth noting that this estimate was made prior to the economic disruption caused by the COVID-19 pandemic, which may have even further undermined the ability of many countries to bear such costs.

2.3 DEMAND-SIDE APPROACHES

Demand-side approaches can broadly be described as water conservation efforts. They include technology-based approaches, such as the adoption of drip or other precision irrigation methods in agriculture, dry cooling systems in electricity generation plants, and water-efficient appliances in households. They also include behavioral changes that reduce water use, such as converting to deficit irrigation methods in agriculture, reducing household water use and cutting back on landscape watering in urban and suburban areas. Demand-side approaches can also include public information campaigns and education initiatives for all ages to encourage water conservation.

2.4 GOVERNANCE-BASED APPROACHES

In addition to specific technologies and behaviors, addressing both supply- and demand-side water scarcity requires effective governance and consideration of alternative policy approaches. Particularly in the last 20 to 30 years, there has been growing consensus around the need for integrated water resources management (IWRM). IWRM emphasizes the interconnectedness of water resources and water use across sectors (particularly within watersheds), and advocates for inclusive and coordinated management among stakeholders.

Within an IWRM framework, a range of alternative policy approaches can be considered for addressing water scarcity. In addition to the previously described water infrastructure investment approaches, both regulatory and nonregulatory approaches are also options, particularly for promoting demand-side water conservation. Regulatory approaches cover a wide range of mandatory measures. They include, for example, imposing water use restrictions, requiring adoption of water-saving technology in agriculture and industry, and establishing water efficiency standards for in-home appliances. Regulatory enforcement is also crucial, as the illicit use of water, including the overexploitation of groundwater through illegal wells, can continue to be a driver of water scarcity in even highly regulated environments.

In contrast, nonregulatory approaches rely on incentives and information to achieve water conservation. They include taxes and fees on water use, subsidies for water-saving technologies, and even “nudges” that rely on social norms to promote water-saving behaviors, including encouraging more sustainable food consumption patterns. Approaches that combine mandatory and voluntary elements are also an option, such as water-trading markets, which establish an overall limit or cap on water use but then allow individual actors to trade water rights within these limits according to market-determined prices.

Water pricing plays a pivotal role in relation to water use. Setting appropriate water prices is crucial in managing demand, promoting conservation, and ensuring the sustainable use of water. Economically, pricing water accurately encourages consumers to value it responsibly, reducing wastage and optimizing usage. Moreover, revenue generated from water pricing can be reinvested in water infrastructure, bolstering long-term water security. However, policymakers must always remain sensitive to the potential impact of water pricing on vulnerable communities in order to advance sustainable water management in a fair and inclusive manner.

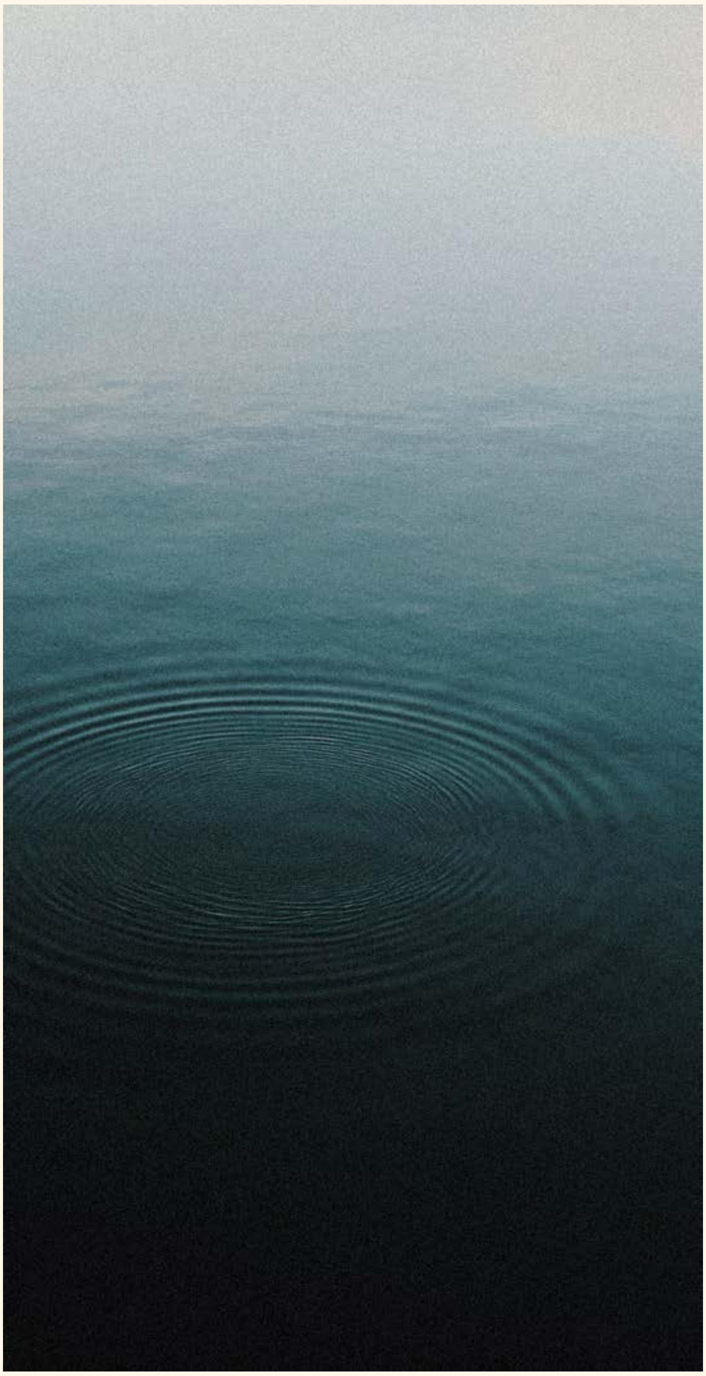
Part 2. Potential Solutions

2.5 A TRIPLE BOTTOM LINE FRAMEWORK FOR EVALUATING POTENTIAL SOLUTIONS

There is no one-size-fits-all approach to addressing water scarcity, and what works in one jurisdiction will not necessarily be applicable in another. For example, the countries of the Nile River Basin and the western US states that depend on water from the Colorado River Basin are all facing challenges related to the cross-border nature of water, but the solutions to these challenges are likely to be very different. Similarly, the supply-side solutions available to countries such as Singapore and the UAE, both of which have invested significantly in their desalination capacities, will be very different to those available to countries that do not have access to the sea. As was the case in relation to several public health measures introduced during the COVID-19 pandemic, compliance with and resistance to water demand-side management policies is also likely to vary significantly from place to place. Water price sensitivity can vary significantly between different neighborhoods in the same city, or even different houses on the same street.

Given the many options that are available for tackling water scarcity, a key challenge is finding a reliable way to systematically evaluate and compare them in order to identify the solutions that are best suited for the conditions in a given place. This includes acknowledging the various trade-offs that arise with each potential solution. That is why instead of ‘picking winners’ or recommending specific solutions, this discussion paper seeks to propose a framework that individual jurisdictions can use to evaluate potential options to address water scarcity and decide on which ones to prioritize.

The Triple Bottom Line (TBL) framework, which distinguishes between economic, environmental, and social objectives, offers a well-established starting point for such an evaluation. However, several evaluation frameworks have been developed that expand on the TBL logic by proposing additional and more detailed criteria for assessing water management options specifically.[1]



1 For details, see Wilcox et al. (2016), Hadjikakou et al. (2019), Escobedo Garcia & Ulibarri (2022), Cole et al. (2018), and Rygaard et al. (2014).

Part 2. Potential Solutions

Table 1 proposes six main criteria for evaluating potential solutions for addressing water scarcity. The first three groups—economic, environmental, and social—correspond with a traditional TBL approach.

In addition to the three TBL criteria, the evaluation framework outlined in Table 1 includes risk-based, functional and innovation criteria. A detailed explanation of the scope and limitations of these six criteria and the rationale behind each of them is provided in Appendix A.

TABLE 1. CRITERIA AND INDICATORS FOR EVALUATING POTENTIAL WATER SCARCITY SOLUTIONS

MAIN EVALUATION CRITERIA AND SUBCRITERIA	EXAMPLES OF INDICATORS
Economic criteria	
Cost-benefit impacts	Net present value of benefits or cost-benefit ratio
Economic output and growth impacts	Change in local, regional, or national gross domestic product
Affordability	Cost-to-income ratio
Employment impacts	Net change in jobs created or unemployment rate
Fiscal impacts	Change in government revenues net of receipts
Environmental criteria	
Change in water balance	Changes in water flow or storage at points across a water network
Water quality impacts	Change in pollutant concentrations at points across a water network
Air quality impacts	Change in air pollutant emissions or concentrations in potentially affected areas (e.g., due to changes in energy use)
Habitat and biodiversity impacts	Changes in size and connectivity of fish and wildlife habitats
Net change in carbon emissions	Changes in carbon or carbon dioxide (CO_2) emissions net of change in carbon capture or sequestration
Social criteria	
Community acceptance	Percentage of population with a favorable opinion of the approach
Political feasibility	Changes in risks of political resistance or intergroup conflict
Health impacts	Changes in risks or prevalence of adverse health outcomes
Equity impacts	Disparities in impacts (positive and negative) across population subgroups
Risk-based criteria	
Reliability	Risk or frequency of failure, shortfall, or disruption
Vulnerability	Magnitude of failure or disruptions
Resilience	Expected duration of disruptions Subjective rating of approach's ability to withstand and recover from external shocks
Robustness	Subjective rating of approach's ability to perform satisfactorily under a range of conditions
Functional criteria	
Scalability	Upper and lower limits on feasible size of project or approach
Technical feasibility	Availability of required expertise to implement the approach
Durability	Expected lifespan of the project or approach
Compatibility with and between systems	Number and types of connections between systems that require compatibility
Innovation	
Current research	Level of global research being conducted to enhance the technology or process
Potential for breakthrough	The magnitude or significance of a potential breakthrough

Source: Adapted from Rathnayaka et al. (2016).

Part 2. Potential Solutions

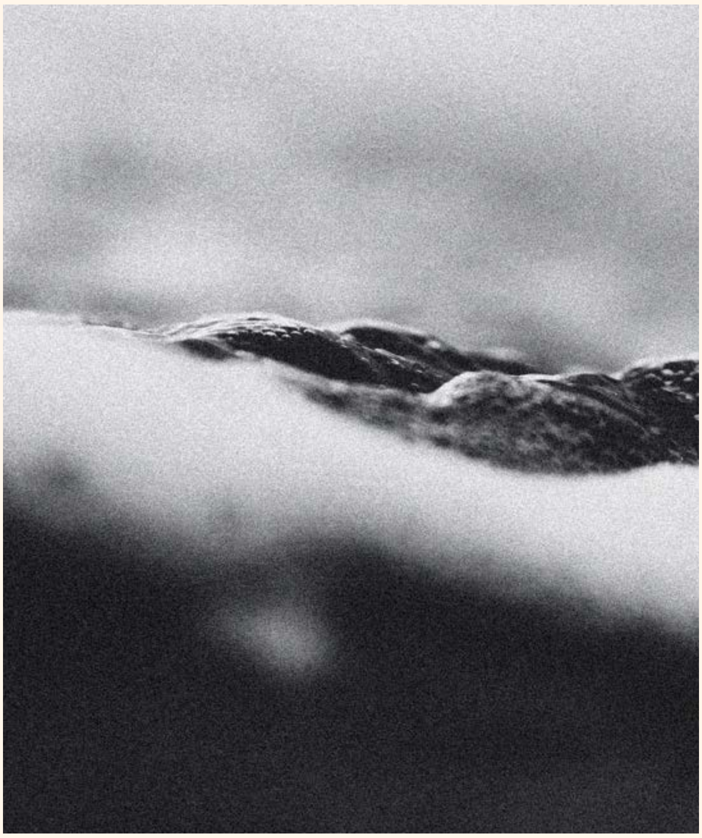
2.6 THE REALITY

The hard truth that we must accept is that at their current levels of use, the various solutions that we have at our disposal today will be inadequate to prevent rising water scarcity from causing a range of unacceptable scenarios and cascading effects. To be clear, this is not an excuse for defeatism or inaction. On the contrary, policymakers and others should do all that they can to slow the pace of increasing water scarcity, and the adapted TBL framework above provides a useful tool for evaluating and comparing options that can enable us to do that. However, in order for us to adequately address this challenge in a sustainable way, and to prevent the worst-case scenarios from becoming a reality, transformative new solutions and a rapid increase in targeted activity will be required.

It is the view of the UAE Government that the keys to unlocking these new solutions will come in the form of increased investment, accelerated technological innovation and expanded international cooperation.

We have witnessed the impact that these multipliers have had in response to comparable risks such as climate change and pandemics. As imperfect as these responses may have been and continue to be, there is no doubt that the combination of financial investment, technological innovation and international co-operation has enabled transformative innovation and coordinated action to occur in a relatively short period of time.

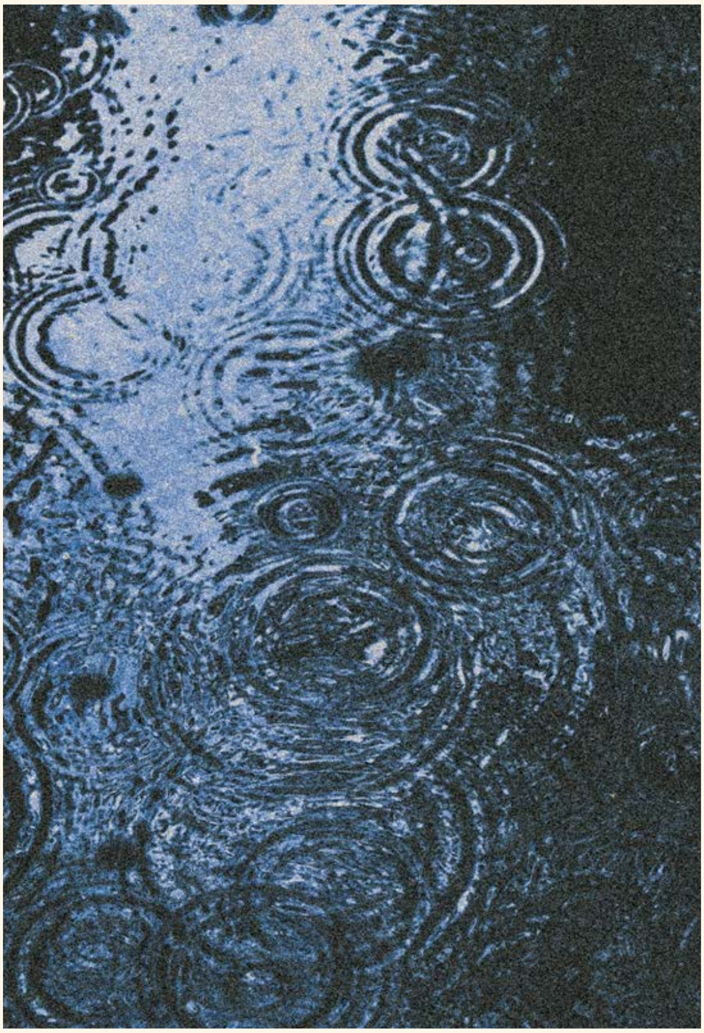
We are now in a position to learn from these experiences, improve on them, and tap into the various networks that have been formed in response to these issues in recent decades (and in some cases in recent years), in order to accelerate the development of transformative new solutions to the looming threat of global water scarcity.



Part 3. A Global Call to Action: Harnessing the power of increased investment, accelerated technological innovation and expanded international cooperation

3.1 THE NEED FOR GLOBAL ACTION

As this discussion paper has argued, while already a pressing global issue, the scale of the threat posed by water scarcity is set to expand, driven by the effects of climate change and demographic trends including population growth and socioeconomic development. Without meaningful action, the effects of water scarcity could eventually jeopardize virtually all of the UN Sustainable Development Goals (SDGs) and thus put at risk the welfare of a large portion of the global population (Mazzucato et al., 2023). This future cannot be allowed to materialize, and it is therefore incumbent upon the international community to collectively raise the profile of water scarcity and meet that challenge with the type of decisive and coordinated response that it demands. This includes the allocation of greater resources, particularly via channels and networks that have been demonstrated to accelerate innovation such as government-sponsored research grants and pilot funding programs, as well as the mobilization of early-stage risk capital from angel and venture sources. It will also require coordinated policy action from governments around the world and changes to certain water-intensive industrial and agricultural practices. From where we stand today, such a comprehensive and accelerated approach will be needed if the world is to address this issue in a way that prevents the worst potential impacts of water scarcity.



Part 3. A Global Call to Action: Harnessing the power of increased investment, accelerated technological innovation and expanded international cooperation

3.2 UAE COMMITMENTS TO ADDRESS WATER SCARCITY

Guided by the principles above, the UAE intends to launch a multifaceted initiative to enhance its contribution and demonstrate its resolve to address the threat of global water scarcity. To that end, the publication and broad dissemination of this discussion paper is intended to serve as a global call to action and an open invitation to members of the international community to engage and work together in new ways to address the threat of global water scarcity, and to better support the many individuals and organizations already working to address this issue.

Furthermore, the UAE will:

1 Launch a non-profit initiative dedicated to accelerating the development, testing and deployment of transformative solutions to the multifaceted challenge of water scarcity. Through a combination of prizes and other incentive programs, an innovation fund, targeted philanthropic grants, and the convening of events to support international dialogue, this new initiative will aim to elevate the importance of water scarcity on the global agenda and catalyze the development of a range of actionable and sustainable solutions to this complex challenge. Work has already begun with the highly regarded non-profit XPRIZE to develop a landmark global incentive competition focused on addressing water scarcity via improvements in the economic accessibility and environmental sustainability of technologies capable of making freshwater more available in water scarce regions around the globe.

2 Leverage the combined capabilities of its academic institutions, government agencies and water-related industries to increase research and development, accelerate innovation and facilitate the rapid deployment of promising new technologies that have the potential to address water scarcity in sustainable and affordable ways. In parallel, the UAE will seek to expand educational opportunities in areas relevant to water scarcity and water-related innovation in order to support human capital development in this crucial sector.

3 Introduce domestic policy measures to improve the UAE's own water sustainability performance, including strengthening domestic water conservation initiatives and accelerating the implementation of the UAE Water Security Strategy 2036.

3.3 JOIN THE GLOBAL EFFORT

The UAE wishes to extend an open invitation to like-minded governments, organizations and individuals from around the world to be a part of this multifaceted effort. There are many ways that you can get involved, from using less water at home to supporting organizations working on the frontlines of water scarcity around the world, or applying your own capabilities and resources to the development of practical solutions to this urgent challenge. We believe that by working together, we can raise greater awareness of the urgency of the threat of global water scarcity and strive to accelerate the development and implementation of new, innovative and sustainable ways to bring abundant and affordable water to the world.

To stay up to date on this global effort, please register your interest via email to waterdiscussion@mofa.gov.ae.

Appendix A: Scope and Rationale for Water-Focused TBL Framework

TABLE 1. CRITERIA AND INDICATORS FOR EVALUATING POTENTIAL WATER SCARCITY SOLUTIONS

MAIN EVALUATION CRITERIA AND SUBCRITERIA	EXAMPLES OF INDICATORS
Economic criteria	
Cost-benefit impacts	Net present value of benefits or cost-benefit ratio
Economic output and growth impacts	Change in local, regional, or national gross domestic product
Affordability	Cost-to-income ratio
Employment impacts	Net change in jobs created or unemployment rate
Fiscal impacts	Change in government revenues net of receipts
Environmental criteria	
Change in water balance	Changes in water flow or storage at points across a water network
Water quality impacts	Change in pollutant concentrations at points across a water network
Air quality impacts	Change in air pollutant emissions or concentrations in potentially affected areas (e.g., due to changes in energy use)
Habitat and biodiversity impacts	Changes in size and connectivity of fish and wildlife habitats
Net change in carbon emissions	Changes in carbon or carbon dioxide (CO_2) emissions net of change in carbon capture or sequestration
Social criteria	
Community acceptance	Percentage of population with a favorable opinion of the approach
Political feasibility	Changes in risks of political resistance or intergroup conflict
Health impacts	Changes in risks or prevalence of adverse health outcomes
Equity impacts	Disparities in impacts (positive and negative) across population subgroups
Risk-based criteria	
Reliability	Risk or frequency of failure, shortfall, or disruption
Vulnerability	Magnitude of failure or disruptions
Resilience	Expected duration of disruptions Subjective rating of approach's ability to withstand and recover from external shocks
Robustness	Subjective rating of approach's ability to perform satisfactorily under a range of conditions
Functional criteria	
Scalability	Upper and lower limits on feasible size of project or approach
Technical feasibility	Availability of required expertise to implement the approach
Durability	Expected lifespan of the project or approach
Compatibility with and between systems	Number and types of connections between systems that require compatibility
Innovation	
Current research	Level of global research being conducted to enhance the technology or process
Potential for breakthrough	The magnitude or significance of a potential breakthrough

Source: Adapted from Rathnayaka et al. (2016).

Appendix A: Scope and Rationale for Water-Focused TBL Framework

The main economic criterion focuses on cost-benefit impacts. Its aim is to provide a comprehensive measure, expressed in monetary terms, of the expected net change in societal well-being resulting from the option being considered. In practice, it is rarely feasible to measure and value all positive and negative impacts of a project or policy, but the objective is to arrive at a summary indicator that captures as many dimensions as possible. It can also be important to account for potential overlaps with other criteria. For example, the health benefits of a policy to improve water quality, which may be captured by specific environmental and social criteria, can also be measured in economic terms (e.g. as avoided medical costs) as part of a cost-benefit analysis.

The economic criteria also include other measures, such as impacts on employment levels, domestic product, and fiscal budget balances. They also include considerations of affordability. Although distinct from cost-benefit measures, these criteria address other potentially important economic and financial dimensions of projects and policies.

The environmental criteria include, most importantly, the impacts on water supply-demand balances across the area of interest. Especially when applied within an IWRM framework, this means accounting for interdependencies between upstream and downstream users and systems. It also means accounting for how water withdrawn from surface or groundwater systems is either consumed or returned to the systems (e.g. through runoff or recharge). For example, measures to improve irrigation efficiency can significantly reduce withdrawals by agriculture; however, they may not improve water balances at a watershed scale if they also reduce return flows to downstream users (Grafton et al., 2018).

In addition, the environmental criteria include indirect effects, such as impacts on water and air quality, which in some cases may counteract and even outweigh the water balance benefits. For example, despite providing new sources of freshwater, desalination projects produce brine as a by-product, which can harm local marine water quality and ecosystems. Desalination technologies also typically require significant energy inputs, which can contribute to air pollution and greenhouse gas emissions.

The social criteria address other primarily noneconomic societal impacts and constraints. They include consideration of the acceptability and feasibility of potential solutions within the relevant political, cultural, and institutional contexts. For example, although wastewater recycling via direct potable reuse (i.e. direct reintroduction of highly treated wastewater into the drinking water system) is widely recognized as a safe, technically feasible, and relatively low-cost option for addressing urban water scarcity, it has often faced stiff opposition from the general public and thus requires significant public education and engagement to become a viable option.

Considering the political feasibility of an option also in many cases means weighing the risk of potential conflict within or across borders. History provides many examples of how efforts to control or manage water for one group have become triggers for disputes with other groups.

Social criteria also include equity considerations concerning how impacts—economic and otherwise—are distributed across the affected population. For example, strategies to reallocate water away from low-valued agricultural uses and toward growing urban areas typically need to consider how rural communities will be compensated and whether distinct groups within these areas will be disproportionately affected.

In addition to the three TBL criteria, the evaluation framework outlined in Table 1 includes risk-based and functional criteria. Risk-based criteria focus on how well alternative approaches minimize or mitigate against future uncertainties. Broadly speaking, the reliability and robustness criteria focus on how proposed solutions are expected to reduce the likelihood of disruptions or failures, such as how improving construction methods or using more weather-resistant materials can reduce the frequency of repairs needed within a water distribution system. The vulnerability criterion focuses on reductions in the magnitude of potential system failures or disruptions (e.g. how many fewer households will have their wells run dry during the summer). The resilience criterion focuses on the ability to withstand or recover from large-scale disruptions. For example, how many more days of drought a community will be able to withstand by adding water storage capacity.

Appendix A: Scope and Rationale for Water-Focused TBL Framework

The functional criteria focus on technical limitations and how well they can be avoided. Scalability and durability refer to an option's ability to be reliably and cost-effectively extended over space and time, respectively. Although economies of scale are common in water projects—meaning the average costs per unit of water often decrease as systems expand—it is essential to consider the limits of these efficiencies. For instance, throughout much of the 20th century, large-scale dams and reservoirs were the accepted norm for addressing water scarcity in several jurisdictions; however, many of these projects are now being reassessed and even reversed for various reasons.

Finally, an innovation criteria is added. Innovation criteria focus on future enhancements/breakthroughs that could be game changers in technology or processes to address water scarcity. These could span a wide range of improvements such as energy efficiency, cost reduction, sustainability, and environmental impact. The criteria capture to what extent research is ongoing and what is the potential for realizing innovation.

References

Abdul Latif Jameel. (2022). Thirst for investment: Solving the Middle East's water challenges. https://alj.com/en/perspective/thirst-for-investment-solving-the-middle-easts-water-challenges/

Boretti, A., & Rosa, L. (2019). Reassessing the projections of the world water development report. *NPJ Clean Water, 2*(1), 15.

Biswas, A. K., & Tortajada, C. (2019). Water crisis and water wars: Myths and realities. *International Journal of Water Resources Development, 35*, 727-731.

Brookings Institution (2021). 'Research: Preventing pandemics through biodiversity conservation and smart wildlife trade regulation', Felbab-Brown, Vanda, 25 January 2021, https://www.brookings.edu/articles/preventing-pandemics-through-biodiversity-conservation-and-smart-wildlife-trade-regulation/ contains link to Allen, T., Murray, K.A., Zambrana-Torrelio, C. *et al.* Global hotspots and correlates of emerging zoonotic diseases. *Nat Commun* **8**, 1124 (2017). https://doi.org/10.1038/s41467-017-00923-8

CB Insights (2023). The complete list of unicorn companies https://www.cbinsights.com/research-unicorn-companies

Cole, J., Sharvelle, S., Grigg, N., Pivo, G., & Haukaas, J. (2018). Collaborative, risk-informed, triple bottom line, multi-criteria decision analysis planning framework for integrated urban water management. *Water, 10*(12), 1722.

Cooley, H., Phurisamban, R., & Gleick, P., 2019. The cost of alternative urban water supply and efficiency options in California. *Environmental Research Communications, 1*(4), p.042001.

Eke, J., Yusuf, A., Giwa, A., & Sodiq, A., 2020. The global status of desalination: An assessment of current desalination technologies, plants and capacity. *Desalination, 495*, p.114633.

Escobedo Garcia, N., & Ulibarri, N. (2022). Planning for effective water management: An evaluation of water management plans in California. *Journal of Environmental Planning and Management*, 1–21.

Falkenmark, M., Lundqvist, J., & Widstrand, C. (1989). Macro-scale water scarcity requires micro-scale approaches. *Natural Resources Forum, 13*(4), 258–267. https://doi.org/10.1111/j.1477-8947.1989.tb00348.x

Global Commission on the Economics of Water (2023). 'The What, Why and How of the World Water Crisis: Global Commission on the Economics of Water Phase 1 Review and Findings', https://watercommission.org/wp-content/uploads/2023/03/Why-What-How-of-Water-Crisis-Web.pdf

Grafton, R. Q., Williams, J., Perry, C. J., Molle, F., Ringler, C., Steduto, P., Udall, B., Wheeler, S. A., Wang, Y., Garrick, D. & Allen, R. G. (2018). The paradox of irrigation efficiency*. Science, 361*(6404), 748–750.

Greve, P., Kahil, T., Mochizuki, J., Schinko, T., Satoh, Y., Burek, P., Fischer, G., Tramberend, S., Burtscher, R., Langan, S., & Wada, Y. (2018). Global assessment of water challenges under uncertainty in water scarcity projections. *Nature Sustainability, 1*(9), 486–494. https://doi.org/10.1038/s41893-018-0134-9

Gu, A., Zhang, Y., & Pan, B. (2017). Relationship between industrial water use and economic growth in China: Insights from an environmental Kuznets curve. *Water*, *9*(8), 556.

Hadjikakou, M., Stanford, B. D., Wiedmann, T., Rowley, H. V., Kobayashi, Y., Ishii, S., Gaitan, J. P., Johns, G., Lundie, S., & Khan, S. J. (2019). A flexible framework for assessing the sustainability of alternative water supply options. *Science of the Total Environment, 671*, 1257–68.

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., & Bryan, B. A. (2021). Future global urban water scarcity and potential solutions. *Nature Communications*, *12*(1), 4667.

Huang, Z., Liu, X., Sun, S., Tang, Y., Yuan, X., & Tang, Q. (2021). Global assessment of future sectoral water scarcity under adaptive inner-basin water allocation measures. *Science of the Total Environment*, *783*, 146973.

Huckleberry, J. K., & Potts, M. D. (2019). Constraints to implementing the food-energy-water nexus concept: Governance in the Lower Colorado River Basin. *Environmental Science & Policy*, *92*, 289–298. https://doi.org/10.1016/j.envsci.2018.11.027

Hutton, G., & Varughese, M. (2016). The costs of meeting the 2030 sustainable development goal targets on drinking water, sanitation, and hygiene. The World Bank Group.

International Water Association (IWA). (n.d.). *Singapore*. https://iwa-network.org/city/singapore/

Liu, X., Liu, W., Tang, Q., Liu, B., Wada, Y., & Yang, H. (2022). Global agricultural water scarcity assessment incorporating blue and green water availability under future climate change. *Earth's Future*, *10*(4), e2021EF002567.

Mazzucato, M., N. Okonjo-Iweala, J. Rockström and T. Shanmugaratnam (2023), Turning the Tide: A Call to Collective Action, Global Commission on the Economics of Water, Paris.

Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science Advances*, *2*(2), e1500323.

Mendoza-Escamilla, J. A., Hernandez-Rangel, F. J., Cruz-Alcántar, P., Saavedra-Leos, M. Z., Morales-Morales, J., Figueroa-Diaz, R. A., Valencia-Castillo, C. M., & Martinez-Lopez, F. J. (2019). A feasibility study on the use of an atmospheric water generator (AWG) for the harvesting of fresh water in a semi-arid region affected by mining pollution. *Applied Sciences, 9*(16), 3278.

OECD (2020), *Green Infrastructure in the Decade for Delivery: Assessing Institutional Investment*, Green Finance and Investment, OECD Publishing, Paris, https://doi.org/10.1787/f51f9256-en.

OECD (2022), *Financing a Water Secure Future*, OECD Studies on Water, OECD Publishing, Paris, https://doi.org/10.1787/a2ecb261-en.

Patel, S. K., Ritt, C. L., Deshmukh, A., Wang, Z., Qin, M., Epsztein, R., & Elimelech, M. (2020). The relative insignificance of advanced materials in enhancing the energy efficiency of desalination technologies. *Energy & Environmental Science, 13*(6), 1694-1710.

Rathnayaka, K., Malano, H., & Arora, M. (2016). Assessment of sustainability of urban water supply and demand management options: A comprehensive approach. *Water*, *8*(12), 595.

Rygaard, M., Godskesen, B., Jørgensen, C., & Hoffmann, B. (2014). Holistic assessment of a secondary water supply for a new development in Copenhagen, Denmark. *Science of the Total Environment, 497*, 430–439.

Sengupta, S. & Cai, W. (2019). A quarter of humanity faces looming water crises. *The New York Times.* https://www.nytimes.com/interactive/2019/08/06/climate/world-water-stress.html

Tortajada, C. (2020). Contributions of recycled wastewater to clean water and sanitation Sustainable Development Goals. *npj Clean Water, 3,* 22.

References

UAE. (2023). Water. https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/water-

UN-Water (2022). Global analysis and assessment of sanitation and drinking water (2022 report)

UN (2023). Blueprint for acceleration: Sustainable Development Goal 6 synthesis report on water and sanitation

UNESCO, UN-Water (2020). United Nations World Water Development Report 2020: Water and Climate Change, Paris, UNESCO.

UNICEF (n.d.). Water scarcity. https://www.unicef.org/wash/water-scarcity. Accessed June, 24, 2023.

Wilcox, J., Nasiri, F., Bell, S. & Rahaman, M. S. (2016). Urban water reuse: A triple bottom line assessment framework and review. *Sustainable Cities and Society, 27*, 448–456.

World Bank. (2021). Ebb and flow: Volume 1, Water, migration and development.

World Health Organization. (2022). Drinking-water. https://www.who.int/news-room/fact-sheets/detail/drinking-water

World Wildlife Fund. (n.d.) *Water Scarcity |Threats| WWF.* https://www.worldwildlife.org/threats/water-scarcity

United Arab Emirates Ministry of Foreign Affairs, 2023