# Water Resilience Assessment Framework

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For more information and resources relevant to the project, please visit:
https://ceowatermandate.org/resilience-assessment-framework/

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**Project**

This project was launched in 2019 with seed funding from BHP and initially oriented around the development of a common water accounting framework, with the scope evolving to speak more directly to climate change and thus a focus on water resilience. The general Water Resilience Assessment Framework has been developed by the project team. It will be further elaborated on with sector/stakeholder specific guidelines as an outcome of engagement with key stakeholders, incorporating common practices where available and developing shared understanding where divergence occurs so that it can be applied by all water users, water managers and decision makers, in all water contexts, and at all water system scales.

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# Glossary

**(Resilience) actions:** Interventions made by stakeholders to support enhancing the resilience strategy.

**(Resilience) characteristics:** Specific aspects of resilience to be considered to ensure resilient actions align and support the selected resilience strategy.

**Indicators:** Qualitative and/or quantitative metrics to track the impacts of the actions on resilience of the system and/or stakeholder(s).

**Resilience:** The ability of an individual, institution or system to respond to shocks and stresses and survive and thrive despite the impacts of those shocks and stresses.

**Resilience strategy:** A systematic approach to enhance resilience by understanding and addressing shocks and stresses. There are three categories of resilience strategies: persistence, adaptation and transformation.

**Scale (of the system):** Water systems are not uniform and differ in size and scope. The spatial, temporal and institutional elements that are included in the system inform the scale of the system. A system scale can range from the individual or institution—such as a company, organization, community or utility—to a basin and then beyond, to key elements of that system that may exist outside of a basin—such as the data, electrical and water grids, supply chain networks, and distribution networks. Impacts at different scales can affect the resilience of stakeholders and systems.

**Stakeholder:** A stakeholder can be a person, group of people, sector, company, agency, community or organization that influences or is influenced by the use and governance of a common set of resources. Ecosystems can also be stakeholders, though they may need to be represented by a proxy, such as via expert opinion or a legal representative.

**Stress test:** The process of assessing the impact of actions intended to build resilience under a range of plausible future scenarios. The stress test clarifies how well the actions respond to shocks and stresses as well as support the goals of the selected resilience strategy.

**System:** A set of interconnected socio-economic, institutional, governance, infrastructure, management and biophysical components that function as a whole.

**System boundary:** The spatial and temporal limits of the system, as defined through stakeholder goals and interests.

**Water accounting:** A detailed account of the total water resources (e.g., water available for abstraction, rights to abstract, actual abstraction, water quality, water to support ecosystem services and environmental flows, and other relevant measures of water) within a system. Basin water accounting provides these accounts at the basin scale and are important for water users within this system.

**Water status:** The historic and current water in the system as defined through qualitative and quantitative variables, such as water quantity and quality, storage, uses and other eco-hydrological characteristics. Water accounting is the core process in establishing water status of the system.

**Water trends:** The course of future water states, predicted using quantitative or qualitative approaches, based on ongoing or projected drivers impacting water status.

# Executive Summary

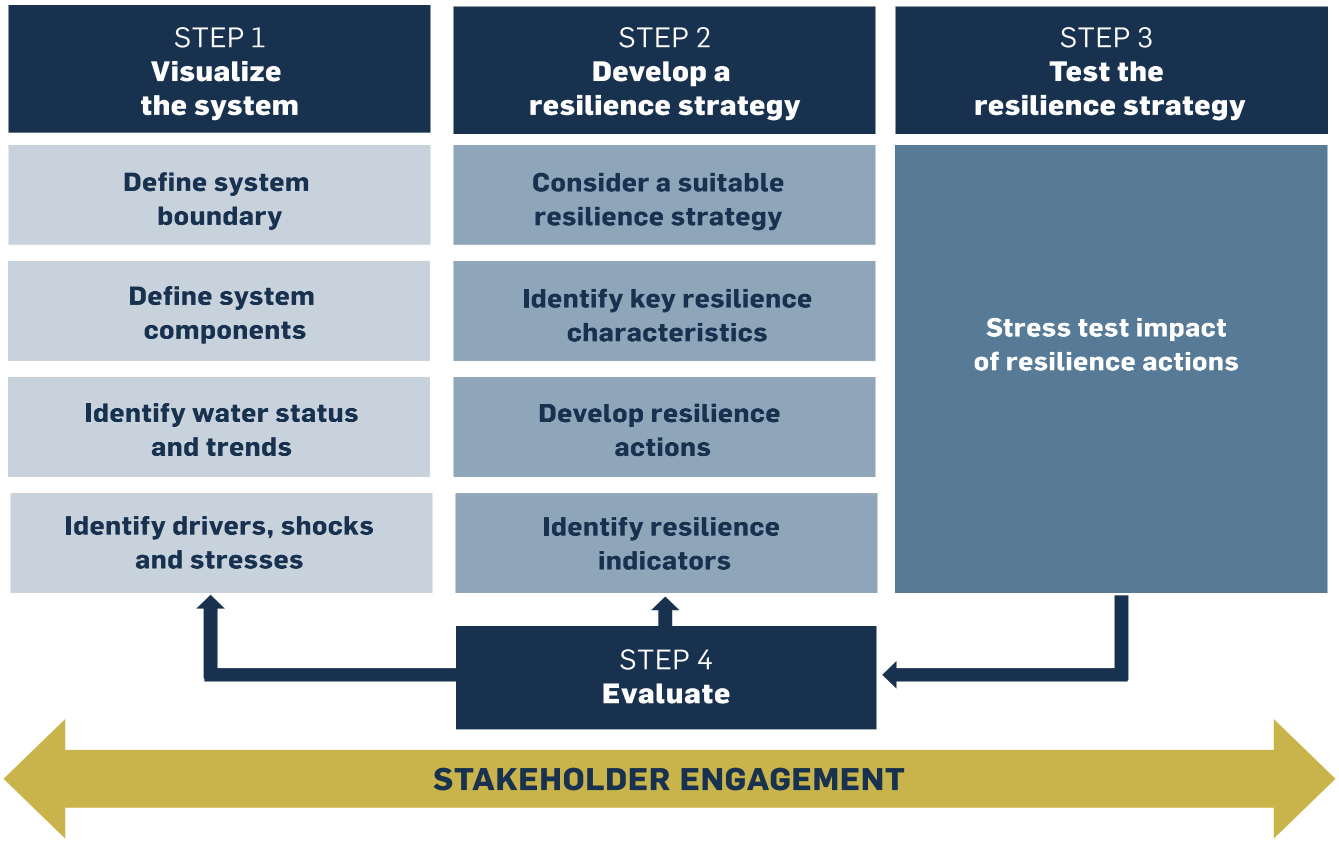
A traditional saying in China is that the water that holds the boat afloat is the same that sinks it. In the context of climate change, water is both a threat and a solution for most climate impacts. Climate change is driving many types of water challenges, such as water scarcity and abundance, worsening water quality, and shifts in timing of the hydrologic cycle. Shocks and stresses, both predictable and unforeseen, affect the resilience of water systems and the stakeholders that rely on them. Specific guidance on how to understand system resilience and measure systematic changes and intervening actions can ensure a more resilient future for all.

The Water Resilience Assessment Framework (WRAF) is intended to inform resilient decision-making to avoid shocks and stresses from becoming crises. The WRAF emphasizes water resilience, not only because water is vital for life, but also because water is embedded in nearly every aspect of our daily lives and the systems that enable and fuel our economies—often in ways we cannot see and do not regularly think about. As such, the WRAF is a method to be used, either individually or collectively, along with existing water-management processes and approaches to gain insight into how we measure progress towards building long-term water resilience.

The WRAF is an iterative process that consists of four key steps:

1. **Visualize the system.** See the system through which water moves, and where risks and opportunities exist under different shocks and stresses. This step helps identify system boundaries and relevant system components for specific assessments, define the current status of relevant system attributes, and identify drivers, shocks and stresses for which resilience strategies need to be formulated.
2. **Develop a resilience strategy.** The WRAF proposes three categories of resilience strategies: persistence, adaptation, and transformation. In this step, an appropriate resilience strategy is selected to reflect the context of the system as a whole or individual system components. Next, a key set of resilience characteristics should be selected. To operationalize this chosen set of characteristics, suitable actions must be designed and implemented. Finally, identifying a series of resilience indicators can help track and monitor the effectiveness of the actions and the resilience of the system.
3. **Test the resilience strategy.** Here, a stress test based on resilience indicators determines the effectiveness of the potential actions in building long-term system resilience.
4. **Evaluate.** Because the WRAF is an iterative process, the framework requires revisiting and refining previous steps based on the result of the stress test. More than one cycle of developing and testing actions, identifying characteristics and selecting a strategy may be needed to conclude the WRAF process.

The Water Resilience Assessment Framework




Our intent with the WRAF is to foster a cycle of building, growing and reinforcing resilience, so that the strengths of one institution may encourage and support others to build long-term resilient systems. The WRAF aligns with the steps of common water accounting, risk assessment and other existing approaches, illuminating the connections among the dynamic hydrologic, economic and social systems that make up a basin-scale water system, and enables effective, meaningful action for water security for all. The WRAF does not move a system to a more resilient state, but rather provides steps an organization can take to improve resilience. A variety of actors and agencies must undertake aligned activities to reach a desired state or achieve a particular outcome at scale. Any action taken to improve system resilience can trigger a chain of reaction in the system dynamics, requiring a revisitation of the original process goals. Each action can improve resilience at a specific scale, contributing to broader resilience across systems.

A variety of stakeholders may be engaged throughout the WRAF process. Special effort should be made to engage with the stakeholders who have the most impact on the water system and the water users most reliant on these resources, as well as the most vulnerable and frequently overlooked communities and stakeholders.

The general WRAF presented in this document is a high-level framework that can be adapted and applied to any specific stakeholder or sectoral perspective. It is deliberately designed to not be overly prescriptive, allowing opportunities for context-specific inquiry. It is an invitation for stakeholders within a water system to explore the boundaries of these insights, strengthen system-wide understanding and collaborate to build resilience.

The WRAF will be expanded and elaborated on through a forthcoming series of sector-specific guidance documents that will be published in a sequence leading to the selection and implementation of pilot test cases.

# Introduction

Climate change, population growth, other anthropogenic impacts and extreme events are reshaping our world and our sense of normalcy. These present new challenges and opportunities, many of them uncertain and hard to predict. To address these challenges and to make the most of these opportunities, we need to prepare our cities, businesses, utilities and farms for significant change. There's now an imperative to build more resilient systems, both individually and collectively, that are adaptable and dynamic. The Water Resilience Assessment Framework (WRAF) aims to support these resilience-building efforts.

## SETTING THE SCENE

Water has been identified as the single most strategic resource and focus for resilience—even though water is often the least familiar resource for most stakeholders to manage (Sadoff and Muller, 2009; Smith et al., 2019). Organizations need help building long-term water resilience strategies that reflect known and unknown risks, as well as identifying and acting upon emerging opportunities. Perhaps the most useful way to illustrate the need for water resilience is through a story of collective resilience learning and action.

> **"Organizations need help building long-term water resilience strategies that reflect known and unknown risks, as well as identifying and acting upon emerging opportunities."**

In 2017, many groups in South Africa began to sound alarms about an approaching "Day Zero," when the region around Cape Town, a major urban area and economic center, would run out of managed water supplies as a result of extreme drought. Through active interventions to manage shortfalls, with broad public cooperation, the drought ended, and the immediate crisis ceased. While Day Zero was a short-term crisis, it provoked a collective reassessment of how to build and maintain resilience far into the future.

Day Zero also served as a harbinger and exemplar of how to solve unprecedented, wicked water and climate problems. Although many media sources described Day Zero as a potential disaster of extreme water scarcity, what was less reported at the time was the evolution and development of shared water resilience solutions, including changes in who has access to water (and under what conditions), how water is valued, how water is stored and distributed, and new governance and infrastructure arrangements. Many businesses, households and public institutions developed their own approaches to sharing water in more equitable, flexible ways. Instead of a debilitating crisis, Day Zero became a catalyst for positive change.

Indeed, ownership of the crisis shifted over time from a handful of public officials to include many stakeholders, perhaps most notably in the private sector. Many businesses that initially reacted with frustration rapidly began to see that public responsibility ended when pipes entered or left private facilities. These businesses began focusing on water used in operations, such as for manufacturing or cleaning. Many even probed further: are water risks embedded in other processes, such as the electrical grid, data and transport networks, and extended supply chains? Do our customers and suppliers have water? These insights reflect seeing water risk—and water resilience—as embedded in systems. Perhaps most importantly, some businesses ultimately realized that if their own employees lacked domestic water—as well as the water needed for the healthcare, energy, even the education of staff and their families—that businesses could not function effectively.

Before the Day Zero crisis, Cape Town had a strong record around sustainability as "balance." Water was mostly a resource that could be seen and touched. Risk was owned and managed by individual institutions. After Day Zero, many across the region had come to understand that even a carefully balanced situation can become destabilized by new events, that water is often deeply embedded in systems, economies and communities, and that some risks needed to be shared and negotiated across institutions, sectors and landscapes. Managing risk in isolation or even at the expense of the larger community was ultimately self-defeating for individual institutions. Sharing risks across a system also means sharing solutions throughout the system. Indeed, Day Zero has fed a broader consensus about how to engage all stakeholders to ensure that whole communities are resilient.

**"While water scarcity was the triggering event in South Africa, climate change is driving many types of water challenges, such as water abundance, worsening water quality and shifts in timing of the hydrologic cycle."**

Cape Town's experiences are powerful examples for communities around the world. While water scarcity was the triggering event in South Africa, climate change is driving many types of water challenges, such as water abundance, worsening water quality and shifts in timing of the hydrologic cycle. All of these challenges affect the resilience of whatever system we work and live in.

Since 2019, Covid-19 has served in some ways as a climate change-like stress test for economies and countries far beyond South Africa. While highly efficient and optimized institutions worked well under stable, predictable conditions, Covid-19 shocked many systems in ways that have some similarities to climate change shocks like increasingly frequent or extreme cyclones, droughts and floods. Health care systems, for instance, that employed a "just-in-time" approach rather than stockpiling ventilators and medical masks found that efficient systems may not be resilient. Preparation and anticipation were key virtues.

As the Day Zero and Covid-19 examples illustrate, there is a need to anticipate both the known and unknown shocks and stressors affecting a system and plan to address them. Building resilience into systems is critical.

## CORE CONCEPTS: SUSTAINABILITY AND RESILIENCE

Water sustainability, established as a policy priority by the Brundtland Commission in the 1980s, refers to the ability of a community or system to meet the water needs of the present without compromising the ability of future generations to meet their own needs. Water sustainability is broadly recognized as a long-term goal achieved by meeting economic, social and environmental objectives for water and includes notions of inter- and intra-generational equity.

Climate change alters our understanding of what future needs may be, for ourselves and future generations. Resilience is a newer concept and assumes that uncertainty about the future is an especially important issue to address directly. Ecosystems, governance and decision-making systems sometimes go through major adjustments, and not all of these are easy (or possible) to predict. Thus, resilience is about making effective decisions in an evolving rather than a stable system, with imperfect knowledge of the future. Resilience as a framework helps to plan not just how to bounce back, but also how to "bounce forward," when necessary, into new conditions (Huang and Fan, 2020).

The concept of resilience has been around for decades and spans many disciplines—engineering, psychology, organizational management, disaster studies and ecology (Grove, 2018). Since 2000, the number of scientific publications on resilience in relation to the environment has increased exponentially across the natural sciences, social sciences and humanities, and in interdisciplinary journals (Folke, 2016). As a result, many definitions of resilience exist, some of which are in contradiction with one another. Walker and colleagues (Walker et al., 2004) and the Stockholm Resilience Centre state that resilience is the capacity to deal with change and continue to develop. The Intergovernmental Panel on Climate Change (IPCC), describes resilience as maintaining "function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation." (IPCC, 2014).

Despite being a well-established concept distinct from sustainability, resilience is nascent as a practice and is not widely reflected in existing policy or guidelines. When translated into practice, resilience is how we make effective decisions despite uncertainty, change and disturbance. On the other hand, managing resilience is not a completely new concept since we have already managed and adapted water systems' services throughout time. The WRAF supports resilience by helping institutions with three processes: visualizing the current state of the system, defining and measuring different characteristics of resilience, and formulating appropriate strategies to advance resilience.

Resilience can be considered across multiple scales, starting with individual resilience and institutional resilience (e.g., a company, organization, community or utility), through to system resilience, which includes networks where water is embedded and connects institutions, individuals and ecosystems (e.g., electrical and data grids, healthcare institutions, supply chains and transport systems). Importantly, impacts at different scales can affect the resilience of stakeholders and systems.

## AIM OF THE WATER RESILIENCE ASSESSMENT FRAMEWORK

The WRAF is designed to support the development of strategies and actions to build and enhance resilience. The WRAF is intended to inform resilient decision-making that prevents isolated stresses and shocks from expanding into full-blown crises, and to lead to clear indicators of movement towards or away from resilience. The WRAF emphasizes water as the keystone of resilience, not only because water is vital for life, but also because water is embedded in most processes, products and institutions, often in ways we cannot see and do not regularly think about. As such, the WRAF is a method to be used either individually or collectively along with existing risk management and water management approaches to gain insight into how we measure progress towards resilience.

The WRAF builds on the lessons of common water accounting methodologies, which traditionally illuminate the connections among the dynamic hydrologic, economic and social systems that make up a basin-scale water system to enable effective, meaningful action for water security for all. What is also important to realize is that most if not all estimates of water status are based on limited historical trends or just a snapshot of current status. Traditional water accounting doesn't provide a dynamic approach that allows for shifts in policies and actions as the overall system changes. Indeed, in a time of rapid climate and socio-economic change, traditional water accounting is like trying to drive forward while only looking in the rear-view mirror. Knowing where we've been is useful but not sufficient in new, unfamiliar terrain (particularly with oncoming traffic). The WRAF helps navigate these changing conditions through understanding the larger system, selecting an appropriate strategy, and monitoring and evaluation.

## INTERSECTION WITH OTHER APPROACHES

The WRAF supplements existing practices and/or approaches in water accounting, stewardship and resilience. The WRAF adds an overlay of resilience to traditional water accounting or water stewardship techniques, and provides an on-ramp to more complex water and climate resilience processes. The WRAF's approach for developing resilience indicators aligns with those used for many traditional water frameworks, which remain relevant for day-to-day decisions, efficiency, optimization and more. For example, the WRAF is designed to complement public policy aims beneath the UN Sustainable Development Goals, and offers a way to pursue these goals through a process that also supports water system resilience. See Table 1 for the intersection of the WRAF and existing practices. This table is not exhaustive, but provides an indication of additional approaches and how the WRAF complements those approaches.

**TABLE 1. Selected existing water management approaches complemented by the Water Resilience Assessment Framework**

| Category | Existing Examples | WRAF Complementarity |
|---|---|---|
| **Water Accounting** | IWMI Water Accounting+<br><br>Corporate Water Accounting and Reporting<br><br>Water Footprint Accounting | The WRAF is intended to build on the benefits of water accounting, illuminating the connections among the dynamic hydrologic, economic and social systems that make up a basin-scale water system, and enable effective, meaningful action for water security for all. For all groups, the WRAF goes beyond traditional water accounting to help identify broader dependencies of the water system. |
| **Corporate Water Stewardship** | Alliance for Water Stewardship Standard<br><br>Contextual Water Targets<br><br>Science-Based Targets for Water | This framework helps visualize the corporate water risk in the light of stresses and shocks and pushes the risk reduction lens a step further. The resilience lens and indicators encourage corporations to address root causes of existing shared water challenges directly while preparing a response better suited to future shocks and stresses. The WRAF does not make existing practices obsolete. |
| **Water Resilience** | World Bank Resilient Water Infrastructure Design<br><br>City Water Resilience Approach | The WRAF complements existing water resilience approaches and adds additional capacities to assess, measure and increase the resilience of individual stakeholders and of the larger system. The WRAF also functions as a gateway for newer audiences to begin to understand water resilience even with resource constraints. |

## LIMITATIONS AND CAVEATS

This general WRAF document provides a high-level overview. It does not provide detailed specifics relating to defining characteristics, actions and indicators, as these are highly dependent on the nature of the organization (e.g., utility versus a private company), the sector (e.g., mining versus forestry), and the geography (e.g., water stressed versus water abundant). Many of these attributes are already considered in existing approaches (see previous section on intersection with other approaches) and can be incorporated into the WRAF.

The WRAF can be tailored to meet the perspectives of the user, taking either a top-down approach (e.g., basin/system managers or policymakers) or bottom-up approach (e.g., individual stakeholder or group of stakeholders). In many cases, individual stakeholders will need other sector- and institution-specific tools to test hypotheses, understand particular institutional issues and concerns, and reference indicators, regulations, and institutional contexts that may be important to local conditions. It is important to note that there could be trade-offs between different components in any system, and it may not be possible to enhance the resilience of all system components simultaneously.

**Fully assessing the resilience of a stakeholder's operations is beyond the scope of this framework. Instead, the WRAF allows the user to understand and respond to the resilience of the system they operate in, specifically with respect to the water-related services required for continued operations.**

**The WRAF can help stakeholders engage with their water system, providing ways to improve its resilience. The WRAF is not designed to assess the individual, internal resilience of a stakeholder nor move a system to a more resilient state.**

There are two main limitations to the application of the WRAF. First, the WRAF is not equally applicable for all stakeholders; different stakeholders have different roles and impacts within the water system. These different roles may alter both the costs and resources of implementing the WRAF, as well as the incentives and benefits to operating within a resilient system. The WRAF is intended to be simple and actionable in terms of resource investment, but full implementation of the WRAF may still be a resource-intensive process for some stakeholders. Second, the WRAF is built on a foundation of existing knowledge and may be subject to knowledge gaps and data limitations. In its simplest form, the information and data required to perform the WRAF may be limited or inaccessible. A similar challenge may be a knowledge gap in stakeholders' understanding and willingness to participate in resilience activities. Developing a resilient water system cannot be done alone, and knowledge of resilient practices or willingness to participate is a precursor to effective collective action. The best response to data limitations and lack of understanding should not be to wait, but to act immediately to overcome those obstacles. Data limitations may be tackled with best available alternatives and knowledge or understanding that gaps will not be solved by inaction.

# The Water Resilience Assessment Framework

This section presents an overview of the WRAF. It describes a set of logical steps in determining system components and boundaries, selecting and developing resilience strategies and their implementable resilient actions, and testing the impact of the actions to enhance the resilience of the system. Finally, the framework provides a means to evaluate and, if needed, revise choices taken during the previous steps.

## KEY CONSIDERATIONS IN FORMULATING THE WRAF:

- Basins are an important aspect of the ability to assess and visualize water, but the water system can transcend basins, especially for water resources that have been "hidden" in energy, transport, telecommunications or otherwise. Our ability to prepare for and cope with shocks and stresses will be much higher simply by understanding how water is embedded and distributed within a water system.

- New and unfamiliar risks and opportunities are appearing, often amplified, modified or buffered by climate change. Their unfamiliarity may be the most important element to address—and the biggest obstacle for preparing for such risks and opportunities. We can anticipate these emerging risks and opportunities in most cases by proactively applying new tools and metrics.

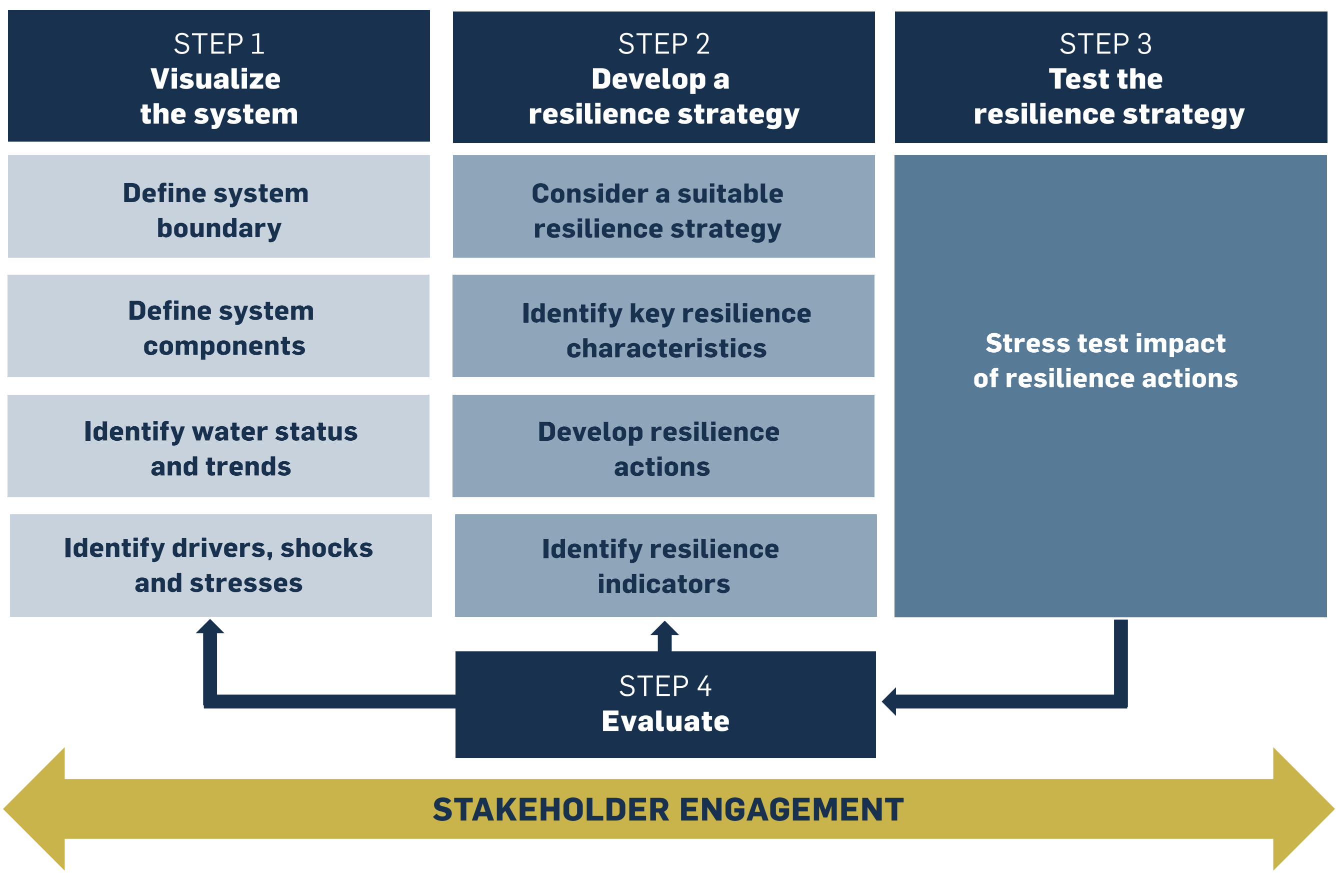
- Traditional approaches to optimizing our water use as a means of reducing water risks generally may be counterproductive and increase our sensitivity and risk exposure to new or more extreme threats—and we will not know unless we more expansively assess our exposure.

- It is important to identify the types of changes we are facing and foreseeing in our water systems and how those changes affect critical system processes. The scale, direction and longevity of those changes in a particular system tell us if we need to prepare for continuity, gradual shifts or abrupt transitions, which in turn informs our strategies for managing the system.

The WRAF is an iterative process that consists of four key steps (Figure 1):

1. **Visualize the system. See the system through which water moves, identify key system components and the processes connecting them, and highlight where risks and opportunities exist under different shocks and stresses.**
2. **Develop a resilience strategy. Select an appropriate resilience strategy to reflect your context,identify key resilience characteristics and actions relevant to the system under consideration, and select appropriate resilience indicators.**
3. **Test the resilience strategy. Assess the effectiveness of the potential actions on resilience characteristics to build long-term system resilience.**
4. **Evaluate. Revise the resilience strategy and understanding of the system as needed.**

**FIGURE 1: The Water Resilience Assessment Framework**




Each of the steps presented in Figure 1 are described in more detail in subsequent sections of this document. For each step, stakeholder engagement is useful to ensure that all actors are considered and included in decision-making. While the steps should be performed sequentially, the order of the sub-steps within each step can be adjusted based on specific stakeholder needs.

## STEP 1: VISUALIZE THE SYSTEM

The process of tracking and building resilience begins with "seeing" the system in which an organization is situated. The system refers to a set of interconnected socio-economic, institutional, governance, infrastructure, management and biophysical components that function as a whole. The connections between different parts of that system may not be obvious or intuitive, which, in itself, is an important insight. To improve our understanding of system linkages, we need to define the system boundaries (which includes identifying stakeholders), system components, water status and trends, and identify how these are influenced by shocks and stresses.

### STEP 1.1: DEFINE SYSTEM BOUNDARY

The first step in the WRAF is to define the system in which an organization is situated. For those familiar with and already engaged in traditional water accounting (see step 1.3), setting the system boundaries is a common first step of the process, typically based on the hydrological basin or, more locally, a sub-basin.

However, unlike in water accounting, the WRAF proposes that the watershed or basin may not be the primary unit of analysis. The system boundary may also be relatively small (e.g., within a property boundary) or extremely large (e.g., national or even international value chains). Even small property boundaries are often connected to larger systems, which might not be obvious. It is essential that water managers realize the extent of their system boundaries, even if they undertake resilience actions at a smaller scale.

The system boundary can change over time (e.g., become larger or smaller), as important water-sensitive drivers are identified for a stakeholder or group of stakeholders. These temporal considerations are also important for defining the system boundaries, since institutional relationships and infrastructure lifespans may lock in or limit options and decisions, especially where vulnerabilities are exposed when conditions shift. It is therefore important to regularly assess, or reassess, the temporal characteristics of systems (see step 2.2).

To assess resilience, the system boundary should be inclusive of not only the water supply, wastewater, and water-management services that may currently be provided to an institution or area of interest, but also of the broader set of components that require water as an input. Defining system components will help elucidate where boundaries must be drawn (e.g., AWS Standard 2.0). Supply chains, transport networks, and data and electrical grids are common examples of system components that often have strong, implicit water sensitivities that can link institutions in even quite distant basins. There may however be limits to what could or should be included by stakeholders. Water uses such as irrigation, manufacturing processes and energy production may cross hydrological boundaries, even oceans, prompting distant stakeholders to experience shocks and stresses (see step 1.4) that they may not even realize are connected to water (e.g., a drought affecting cocoa or coffee production on one side of the world can impact global demand for these commodities).

#### Step In Practice

Denver Water (a utility service) in Colorado, USA, receives the majority of its water supply from forested ecosystems on the eastern slopes of the Rocky Mountains, well beyond their service area's physical boundary. This forest functions as vital infrastructure for the utility and bolsters their system's resilience. In the WRAF process, Denver Water would likely include these distant forested ecosystems within its system boundary.

## STEP 1.2: DEFINE SYSTEM COMPONENTS

In the WRAF, examples of system components are categorized across socio-economic, institutional and biophysical aspects (Table 2). Biophysical aspects tend to have greater influence on a larger number of stakeholders. Components are also not confined to just one category. For example, although physical/built infrastructure has been included under the biophysical category, this aspect, like water resilience more generally, is transversal and can be included under each component; the financing aspects of infrastructure are socio-economic and the management of infrastructure is institutional. This may be the case for other components too.

**TABLE 2: Examples of system components across primary categories**

| Socio-economic | Institutional | Biophysical |
|---|---|---|
| ▪ Demographics<br>▪ Economic status<br>▪ Level of development<br>▪ Social connectivity<br>▪ Cultural and indigenous knowledge systems | ▪ Level of regulatory compliance<br>▪ Legal frameworks<br>▪ Maturity of governance systems<br>▪ Management structures<br>▪ Corruption, accountability and transparency<br>▪ Legacy inequalities | ▪ Natural infrastructure<br>▪ Physical/built infrastructure<br>▪ Landscape elements<br>▪ Climate and weather systems<br>▪ Biodiversity status |

Not all system components will be relevant across all contexts. It is therefore critical to understand the system components based on a specific geography, project conditions and/or the stakeholders involved. The sectoral guidance documents will provide more concrete examples of the types of system components relevant to specific sectors.

### Step In Practice

Many companies are looking to build long-term resilience and improve water security by investing in nature-based solutions. Danone, for example, has invested in nature-based solutions in the Rejoso watershed in Indonesia. Unsustainable practices throughout the watershed led to serious water shortages, erosion and poor water quality. These challenges were, in part, caused by excess chemical application and inefficient water use by farmers, a general intensification of agriculture due to higher food demands from population growth, as well as increased water extraction from urbanization. Danone partnered with local NGOs, academic institutions and local farmers to understand the system components, including the different communities and organizations located within the watershed and their dependence on the water resources, governance and management structures, existing infrastructure and landscape elements. Defining the system characteristics enabled the company to develop a broader set of actions to enhance system resilience.

## STEP 1.3: IDENTIFY WATER STATUS AND TRENDS

Once the system boundary is established and key system components are identified, water managers can begin understanding and tracking the status and trends of water in the system. Water status is the historic and current state of key attributes of water in the system such as water quantity and quality, storage, uses, connectivity and other eco-hydrological characteristics. Water trends refer to the ongoing or predicted future water status based on historical data using quantitative or qualitative modelling approaches. It also reflects predicted changes due to ongoing, planned or probable shifts in the policies or activities impacting the system.

Creating water accounts can be done in multiple ways. For example, a hydrologist may build a water model (e.g., mass balance model), while other institutions may opt for another approach such as water accounting. The WRAF can work with modelling and/or accounting approaches, though in most cases both assume that a basin or watershed is the primary unit of analysis, which is not necessarily the case in the WRAF.

For basin authorities and other groups that manage water at larger scales, water accounting may already be a common practice, complete with well-established or even legally codified approaches, timelines and variables. For these entities to apply their water accounting approach and metrics within the WRAF, it may take the form of providing context for stakeholders or finding/creating a more common language for water metrics between the diversity of stakeholders within the basin, or other applications relevant to their context.

Companies or other organizations that traditionally focus on water accounting within their own fence-lines or at smaller scales can build on their current work by contextualizing their water use and impacts within the larger system. For many, water accounting will be an entirely new process, but even taking initial steps to create water accounts for a system will help to generate the basic and necessary information needed for building resilience.

### Step In Practice

There are numerous examples of water accounting methods, tools and practices that are used to assess water status and trends. These assessments can be done through the creation of local and global datasets on water availability both in quantity and quality, access, and use (e.g., WA+, FAOSTAT, WaterStat). In many cases, these approaches are designed for specific sectors, or to address specific water resource challenges. For example, the framework presented by Huink and colleagues (2019), which has been applied across five river basins in Europe, helps to synthesize basin-level information on climate change impacts to support policymaking on climate adaptation, water resources and agriculture. Many other approaches may be used for the WRAF process, and the selection will vary based on factors such as the challenges faced within the system, the stakeholders involved and data availability.

## Step In Practice

In 2013, The Rockefeller Foundation pioneered 100 Resilient Cities to help cities build resilience to the physical, social and economic challenges that are a growing part of the 21st century. The resilience assessments identified key drivers, shocks and stresses and provides a roadmap to building long-term resilience. The notion of a resilient city becomes conceptually relevant when chronic stresses or sudden shocks threaten widespread disruption or the collapse of physical or social systems. The 100 Resilient Cities framework provides a few example cities where the shocks and stresses are identified for their unique context. For example, in Surat (India), the key drivers are frequent large-scale flooding, a weak flood and wastewater disposal system, and a weak health monitoring system (Bhoite et al., 2014). In Cape Town, where many of the stresses currently faced are the legacy of segregation and discriminatory practices of South Africa's apartheid system. Apartheid planning processes promoted spatial segregation, disconnecting neighborhoods and limiting transportation within the city.

### STEP 1.4 IDENTIFY DRIVERS, SHOCKS AND STRESSES

Once the water status and trends have been identified, significant drivers, shocks and stresses need to be determined that would impact the level of services available from the system. Shocks and stresses could be either incremental (e.g., temperature and precipitation changes over time, long-term droughts) or sudden (e.g., flooding, earthquakes, fire, terrorism and epidemics). Drivers can include a broad range of elements that may be interacting with climate change, such as demographic change, economic trends or regulatory shifts. Water resources, as human-managed natural systems, are influenced by extreme weather events such as coastal storms and heatwaves, geological events (e.g., earthquakes and landslides), cybersecurity breaches, terrorist attacks, the damages of violent conflict, and disease epidemics/pandemics. Sound water-system resilience design should also consider and plan for such extremes, at a minimum to understand system requirements, options and costs, and to inform decision-making on resilience investment.

In building water resilience, the means of identifying and measuring the impacts of drivers, shocks and stresses should be defined. The analysis of the impacts of anticipated shocks and stresses on water trends will inform stakeholders as to which system components are least to most critical to the functioning of the whole system. A stakeholder wanting to identify potential drivers, shocks and stresses needs to explore the parts of the system that are most relevant to them, such as:

- Hydrological and ecological systems, including natural water storage systems such as dams, rivers, groundwater, snowpack and glacial resources.
- Weather extremes and other directly climate-related events, including fire, seismic and volcanic patterns.
- Regulatory frameworks and management systems, especially those that may explicitly or implicitly define a "normal" condition that restricts flexibility or re-normalization.
- Supply chains, fundamental service systems such as energy, transport and healthcare, and the operational conditions of critical infrastructure.

Generally, the drivers, shocks and stresses impacting water systems can be categorized into operational, socio-economic and climate and environmental change (See Box on next page).

## CATEGORIES OF SHOCKS AND STRESSES

**Operational**: Routine disruptions in operation impact water service provision, including power outages, communications breakdowns, staff loss and mechanical failures. These operational components of the systems are commonly designed with either back-ups or redundancies in the system itself. In the face of increasing extreme events, disruptions may become more common and significant. For instance, consider how a cybersecurity breach could impact communications or power systems or how a natural disaster or disease outbreak could impact staffing.

**Socio-economic**: Gradual increases in water demand driven by economic and demographic growth, increased cooling demands from energy and industry, heightened volatility in water use, or resource availability under changing temperatures, and variability in precipitation all have important implications for water-system storage, as well as provisioning and regulatory services. These incremental changes, as well as uncertainties related to variability and demand volatility, should inform water system configuration and capacity provisions, particularly in areas of rapid change.

**Climate and environmental:** Changes in climate and environmental conditions have profound implications for water systems, which have been modified and managed relative to historic levels of water availability and variability. Changes in climate are commonly expressed in shifts in precipitation, snowpack, seasonal temperature ranges and evapotranspiration. Climate change may also result in more frequent water extremes, such as protracted droughts and flooding events. Non-climate environmental changes (e.g., changes in land use, biodiversity and habitat loss, soil moisture retention, and sediment, nutrient, chemical and thermal conditions) influence water capture, flow regime, quality regulation, and the provision of environmental, recreational and cultural services.

Stakeholders often experience shocks, stresses and system changes via three general patterns:

1. **Short-term disruptions,** but no major shift in mean conditions relative to the past;
2. **Gradual long-term disruption,** often gradual changes in mean conditions, such as increasing or decreasing annual precipitation or sea-level rise; and
3. **Sudden long-term disruptions,** more radical change that can lead to major adjustments in a system.

The appropriate type of system changes will be determined by factors such as the urgency of addressing disruption, severity of disruption, cost of making changes, number of stakeholders impacted, and impact on other system elements. The type of change experienced or anticipated will guide the selection of a resilience strategy (see step 2.1).

Some of the most important risks to consider are bottlenecks, such as critical infrastructure that may have narrow operational parameters, and therefore are at risk of more widespread failures. This may also include inappropriately situated social infrastructure, such as schools, hospitals and retirement villages. Such risks arise from the system's lack of redundancy, robustness and flexibility (see step 2.2).

## STEP 2: DEVELOP A RESILIENCE STRATEGY

A resilience strategy is a systematic approach to understanding and addressing drivers, shocks and stresses. This section will explore how to select a relevant resilience strategy, as well as the corresponding characteristics, actions and indicators appropriate for the context and conditions of a system.

### STEP 2.1: CONSIDER A SUITABLE RESILIENCE STRATEGY

Resilience assumes that conditions impacting the functioning of a system are always changing. Understanding how the system is changing, or how it is anticipated to change, as well as the relevant actors and policies in a particular location or context, will inform the resilience strategy selected.

There are three categories of resilience strategies: persistence, adaptation and transformation. These correspond, respectively, with the three types of system changes (short-term disruptions, predictable long-term changes and disruptive shifts) identified in step 1.4. These strategies could relate to the system as a whole (e.g., shifting from surface water supplies to groundwater supplies) or to a particular component of the system (e.g., irrigation systems, energy sources, legislation). For example, existing formalizations of resilience in engineering design are dependent on assumptions of climate and hydrologic stationarity and of well-characterized uncertainty, rendering them obsolete relative to our current understanding of the uncertainties (Boltz et al, 2019). They propose a "Resilience by Design" approach to managing critical infrastructure under such uncertainties. The formulation generates water system design options that provide resilience capabilities at minimum cost, and specify the optimal choices for performance persistence, adaptability and transformability over a wide range of possible futures.

One system component may fall under an adaptive strategy while other components could be considered under either persistent or transformative strategies. There may also be opportunities for hybrid strategies at the component level. Additionally, individual stakeholders within the system can adopt different strategies, depending on the needs of each individual or group, their power to impact the system, and the context of their system. Overall, this could create a variety of strategies across the system.

## CATEGORIES OF RESILIENCE STRATEGIES

**Persistence**. The term persistence aligns with returning to a stable state after some disturbance or shock. Persistence is about the functions and processes of an institution or system continuing unchanged or with a brief interruption. Success under a persistence strategy looks like returning to the pre-shock conditions as quickly as possible. Most existing resilience plans focus on persistence. Persistence is also the explicit or implicit goal for most sustainability programs.

**Adaptation**. Adaptation differs fundamentally from persistence by assuming that tomorrow (or next month or next year) will be different than now, and that most of these changes are gradual and predictable (within certain bounds). In practical terms, successful adaptation means tracking change over time, especially gradual change, and taking the necessary action to address current and anticipated changes. Long-term changes to the system such as population growth, sea-level rise, variability in precipitation, and urbanization are all good examples of shocks and stresses that support adaptation strategies. In practice, an adaptation strategy often means worrying about facility scale issues in the short term and looking ahead to when you may pass a threshold that leads to more significant kinds of changes. These changes may include adjusting supply chains, adding a backup system, or moving facilities and operations to less exposed or sensitive locations.

**Transformati**on. Sometimes, big hard-to-predict shifts occur. While adaptation guides you to prepare for incremental, often gradual change, a transformation strategy is a result of a fundamental shift in a system (e.g., little or no rainfall for many years) or a significant change in the needs of a system (e.g., a need to shift from surface water to groundwater). While most parts of the world are now in a persistence or adaptation context, some regions are already well advanced in experiencing quite novel conditions, such as high-altitude areas (e.g., Andes, Himalayas), high latitude areas (e.g., Scandinavia, Russia, Canada), and regions very sensitive to inundation (e.g., low-lying coastal areas, small islands, river deltas). A transformation strategy typically requires reconsidering fundamental aspects of an institution and its relationships and operations, such as around the nature of the operations, what functions are managed by the institutions and where those functions occur, and potential supply chain vulnerabilities and strategies. Awareness of system vulnerabilities and opportunities is especially important, as disruptions in one part of the system may ripple and even amplify across other aspects.

## Step In Practice

Dams, reservoirs, rivers and lakes interact with multiple system components, such as agriculture, drinking water supplies and aquatic transportation. Under a drastically low rainfall scenario, a transformation strategy at the farm level could be selecting to convert land-use practices from agriculture to solar energy production or conservation. An adaptation strategy could be applied to specific agricultural management practices such as planting drought-resistant crops or altering irrigation practices. Similarly, an adaptation strategy for navigation services may consist of building additional canal locks to maintain or improve water depth. A persistence strategy could be applied for drinking water supplies by prioritizing it over agricultural water use. These chosen strategies can be changed based on the level and types of disruptions, the context of the system, stakeholder changes, etc.

## Step In Practice

In 2012, California became the first state in the USA to formally recognize the human right to water. While not originally tied to resilience, one of the key programs operationalizing this aspirational goal has been the Safe and Affordable Funding for Equity and Resilience Program within the State Water Resources Control Board. The program seeks to advance the delivery of safe, accessible and affordable water for millions of Californians who currently lack such services. Inclusivity is a key characteristic of the program's design, through intentional stakeholder outreach and engagement and an advisory group made up of public water system and local agency representatives, NGOs, and public residents from disadvantaged communities.

## STEP 2.2: IDENTIFY KEY RESILIENCE CHARACTERISTICS

Knowing the overall resilience strategy is critical but insufficient. The resilience strategy defines how to track changes over time but not how to ensure that persistence, adaptation or transformation (or a combination of the three) is effective and successful. Identifying the resilience characteristics is required to ensure that the strategy can be operationalized. There are six resilience characteristics to consider:

1. **Robust**—performs reliably and effectively under a wide range of conditions;
2. **Redundant**—has spare capacity intentionally created to accommodate disruption, extreme pressures or demand surges;
3. **Flexible**—can be altered and adapted in response to potential damage or adjusted to take advantage of opportunities;
4. **Integrated**—components are linked and coordinated;
5. **Inclusive**—has mechanisms for broad consultation and engagement of diverse individuals and communities, including the most vulnerable groups; and
6. **Just and equitable**—ensures that all stakeholders within a system are provided with equal water access, rights and allowances.

Not all the characteristics are relevant in all systems. The key characteristics should be selected based on the resilience strategy and system considerations.

## STEP 2.3: DEVELOP RESILIENCE ACTIONS

Resilience actions are interventions made by stakeholders to operationalize the resilience strategy. These actions should be considered across policy (e.g., internal and external drafting of operating rules, guidelines and regulations), changes in practices (e.g., improving water efficiency and reuse, investing in nature-based solutions, behavioral practices), and system configuration (e.g., prioritizing or enhancing some system components over others during crisis periods). These actions align with the key resilience characteristics selected in step 2.2, based on the strategy selected in step 2.1.

These actions should complement and build on any water accounting, sustainability, security, risk reduction or stewardship activities already taking place (see Table 1). Actions can be prioritized based on level of impact, timelines, cost to implement, availability of resources, etc. Actions can be undertaken individually or jointly through a collaborative project. For example, a farmer can individually opt to change overhead irrigation to a drip irrigation system. Alternatively, a group of stakeholders may collectively adopt a water stewardship partnership to protect and manage source water in the upper reaches of a basin.

As with resilience strategies and characteristics, resilience actions are context specific and should be based on the conditions and direction of the system. The forthcoming sector guidelines for the WRAF will explore actions for specific sectors.

### Step In Practice

The Water Resilience Coalition is an industry-driven, CEO-led coalition of the UN Global Compact CEO Water Mandate that aims to elevate global water stress to the top of the corporate agenda, build water resilience through collective action in water-stressed basins, and secure ambitious, quantifiable commitments for companies. Members and partners urge other industry leaders to join by signing a pledge and working toward the coalition's three overarching 2050 commitments:

- **Net-positive water impact**: Deliver measurable net-positive impact in water-stressed basins where members operate, focusing on the availability, quality and accessibility of freshwater resources. Net-positive water impact is achieved when a water user's contributions exceed its impacts on water stress in the same region.
- **Water-resilient value chains**: Develop, implement and enable actions and strategies to support leading impact-based water resilience practices across the global value chain.
- **Global leadership**: Raise the ambition of water resilience through public and corporate outreach, as well as inspire other industry leaders to join the coalition.

## STEP 2.4: IDENTIFY RESILIENCE INDICATORS

Resilience indicators assess the degree of success for a chosen set of resilience actions that support the selected characteristics. Traditional indicators measure water quantity and quality and correspond to how we manage and analyze engineered water systems; however, these indicators alone do not provide an indication of water resilience. Likewise, measures of access, efficiency and cost-benefit ratios reveal information about today, but little about how these qualities will perform if core assumptions about availability, seasonality or climate variability change. The WRAF looks at two levels of indicators:

1. Overall system resilience; and
2. Resilience of specific stakeholders, including an individual sector, organization or community.

### Step 2.4.1 Identify system-level resilience indicators

To track and monitor the resilience of a system or a stakeholder, the first step is to benchmark (i.e., determine the current state of) the system using selected characteristics and relevant indicators at the system level. These indicators are likely to evolve and develop over time. The WRAF focus on three broad categories of system-level resilience indicators (see the box below).

#### CATEGORIES OF SYSTEM-LEVEL RESILIENCE INDICATORS

**Biophysical (climate, ecology and hydrology):** These are indicators of high importance at the system level, as they define many other boundaries and limits. Categories of indicators include the flow regime and the seasonality of water bodies, habitat and waterbody connectivity throughout the system, and the level of temporal and spatial modification of the eco-hydrological systems, such as from infrastructure development, runoff patterns, frozen water resources (snowpack and glaciers) and groundwater recharge conditions. Trends and impacts from extreme climate events are often important to understand here. Where physical transportation of water between basins occurs, the distinct climatic, ecological and hydrological characteristics of several watersheds may need to be considered.

**Institutional (regulatory, legal, governance and management):** In most cases, several levels of decision-making and action are present, and may not all be in accordance with one another. Often, there may be discord between national, state/provincial and municipal governments, or between public and private sector actors. Ideally, institutions should consider the coherence of policy and practice across scales and political and governance boundaries. Likewise, governance and management systems are also based on transparent, relevant and accurate monitoring and analytical systems that can provide more direct feedback for decision makers about trends and shifts in the system overall. Groups such as the Organisation for Economic Cooperation and Development (OECD, 2018) and United Nations Economic Commission for Europe and International Network of Basin Organizations (UNECE and INBO, 2015) have defined effective guidelines describing indicators and risk assessment schemes that focus on the flexibility, formality and enforcement mechanisms of these arrangements.

**Socio-economic (social, cultural and economic):** Indicators in this group focus on issues of equity, social, cultural and economic value systems, and the formal and informal ways in which decisions are made within and across a system. Indicators here include the social cohesiveness of a community, the willingness or ability to pay for certain services, levels of traditional, cultural or scientific knowledge or education, and economic status. Social resilience has long been the focus of systems thinking. Importantly, socio-economic indicators should encompass as broad a spectrum of society as possible, including vulnerable or disadvantaged communities. These indicators are relevant at both the system and stakeholder level.

### Step 2.4.2 Identify stakeholder-level resilience indicators

Many stakeholders will want to develop and track resilience indicators that are tailored to a specific business, governance context or operational setting. These indicators include those at a smaller scale, often within a set boundary (e.g., within a community or site). These indicators should focus on areas of special interest and significance to the institution, sector, community or stakeholder in question. Some examples may include:

- The quality, quantity and reliability of water arriving at a site for production purposes, measured as economic and ecological indicators;
- Assimilation capacity of the natural system or wastewater network for effluent discharge, measured as institutional, economic and ecological indicators; and
- The ecological integrity and health of a key freshwater system, measured as social, economic and ecological indicators.

Because indicators are often highly context and sector specific, they are not provided in the general WRAF. The sector-specific guidance documents will, however, include a set of indicators relevant to the selected sectors.

## Step In Practice

A similar process of using indicators has been developed by the City Water Resilience Approach, which helps cities evaluate the strengths and weaknesses in their water systems. It helps cities build resilience in four areas—leadership and strategy, planning and finance, infrastructure and ecosystems, and health and well-being—which are broken down into eight goals, detailed further in 53 sub-goals. Indicators for each sub-goal allow cities to measure performance and assess the overall resilience of their current water system.

## Step In Practice

For many public sector systems as well as many prominent water bodies, quantitative models that are used for stress testing may already be available in engineering departments, consulting firms, or with local universities and researchers. In some cases, such analyses can be explored through readily available software, such as Microsoft Excel, while in other cases, more specialized and technical software will be required, such as WEAP, HydroSHEDS or R (an open-source statistical computing and modeling program). Even in complex systems, a relatively small number of efficacy criteria are considered best practices.

A more qualitative approach might use a whiteboard or survey instrument and a group of stakeholders and decision makers from the system in question, perhaps supplemented with expert opinion and readily available datasets. Workshops and other group exercises can support such efforts. By showing the system and comparing the strength of connections and the responses between its different parts, a workshop analysis can generate an effective hypothesis to test real-world system responses and/or lead to a more formal quantitative model.

## STEP 3: TEST THE RESILIENCE STRATEGY

Stress testing is a well-established process for considering how a system, institution or sector may perform under adverse conditions. For the WRAF, stress testing helps to determine the relative impact and utility of resilience actions under a range of plausible future scenarios (Verbist et al., 2020). The impacts of these actions are measured by the resilience indicators. The stress test clarifies how well the actions respond to shocks and stresses, as well as how effectively they support the goals of the selected resilience strategy. The stress test can also be used to compare and evaluate different actions to determine which produce the most effective results.

The stress test can be either a quantitative or qualitative process, depending on the amount and quality of available data, confidence in future trends, technical assistance availability, timeframe, and the level of risk that stakeholders face and find acceptable. A quantitative stress test, for instance, might define a set of numeric indicators and specific conditions for success/failure for those indicators. An underlying model of the system and how the components of the system respond to particular resilience actions, as well as shocks and stresses, could reveal the relative performance of a range of resilience actions, such as new infrastructure, crop insurance plans, or new operating and governance regimes.

Step 3 helps further develop actions and can inform both quantitative and qualitative approaches, including both "hard" interventions (such as proposing new infrastructure) and "soft" interventions (e.g., incentivizing or regulating consumption, altering the timing of events or changing governance relationships). Sometimes, a single effective solution emerges, such as adding a secondary energy or data system that does not have the same embedded water risks as the current sources. More often, a suite of solutions is developed, which may be concurrent, reinforcing or supplementing one another, and/or sequential and developing over time as conditions and needs evolve.

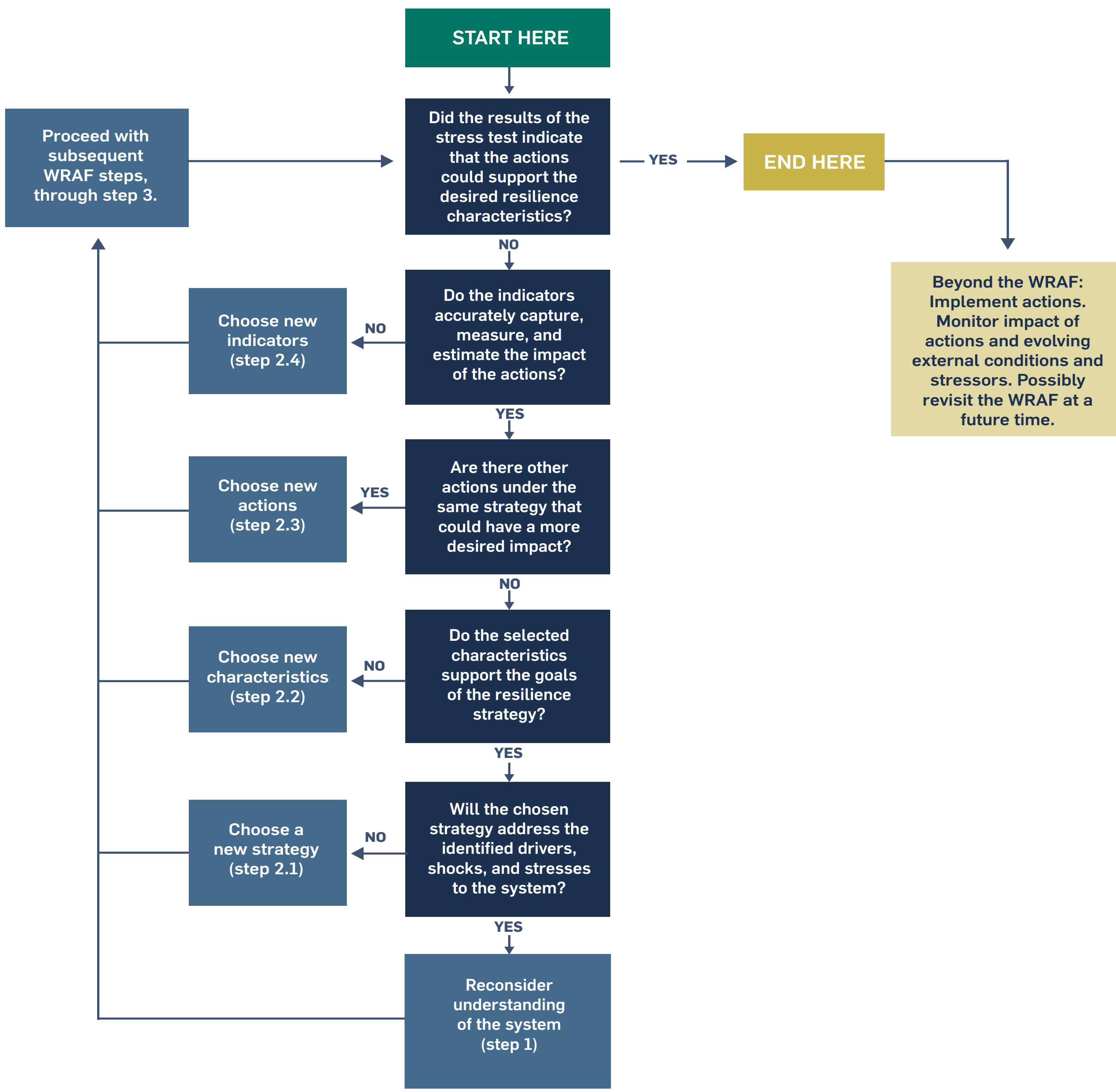
Stakeholders should also develop a set of criteria for evaluating the final set of interventions that have been presented. Here, multi-benefit approaches and multi-criteria analyses can be considered, integrating the indicators decided upon in step 2.4. Lead time for implementation may also be important. Political suitability may be a critical element for public sector solutions, while private sector entities may also be concerned with reputational risks associated with some approaches. Flexibility may be a critical option when the long-term efficacy of a particular resilience solution is in doubt, such as when a transformation strategy is being pursued. The sectoral guidelines will include more specific suggestions for selecting a final solution or solution set.

## STEP 4: EVALUATE

The WRAF is an iterative process and requires revisiting and refining previous steps based on the result of the stress test. Many users may need more than one cycle of developing and testing actions, selecting resilience characteristics, refining resilience indicators, and adjusting the selected strategy based on an improved understanding of the system. A thoughtful application of the WRAF will almost certainly alter how a stakeholder understands the system, definitions of success and failure, and the range of potential solutions and indicators available.

The results of the stress test will dictate what step to feed back or return to. The questions included in the feedback-process diagram (Figure 2) focus on how the results of the stress test affect past steps, and where on the WRAF cycle users should revert back to.

**FIGURE 2: Evaluation and feedback steps in the Water Resilience Assessment Framework**



If the actions still do not build resilience in the system after revisiting all steps of the WRAF, it is best to examine the integrity of the framework. Users should consider the following questions:

- Was the WRAF applied correctly, and all steps followed?
- Could it have been used in a different way?
- Was all relevant information included?
- Is any additional data needed or additional stakeholder engagement required?
- How can additional stakeholders be included in the WRAF process?

After completing the four steps of the WRAF and implementing the resulting actions, over time the level of system resilience should change, as a result of the WRAF and/or external factors. Regular evaluation is required to keep up with these changes in the system. While evaluation is a step in the WRAF, this *additional* monitoring and evaluation component goes beyond the WRAF steps and reflects how the implemented action or actions perform in reality. When the system changes significantly and/or the system is not at the desired level of resilience, the WRAF process can be restarted to address the new challenges to resilience. Often, these changes may reflect a need to shift the strategy from one to another, such as from persistence to transformation or from transformation to adaptation.

## STAKEHOLDER ENGAGEMENT

The WRAF is designed to inform and support decisions among stakeholders to progress towards water system resilience. Stakeholder engagement may come in two forms:

- A group of stakeholders may undergo the WRAF process collectively; or
- An individual user may use stakeholder engagement to complete steps relevant to their immediate resilience goals.

The first option is recommended, because a collective of water users can generate a better understanding of system dynamics, exert more influence, and develop more system resilience than lone actors. If the WRAF is performed by a public or multi-stakeholder group, the steps remain the same, although the process itself may be slower and more consensus driven. Under this process, the WRAF will facilitate a shared understanding around resilience and allow practitioners to develop common, measurable goals and outcomes for either stakeholder and/or system resilience planning.

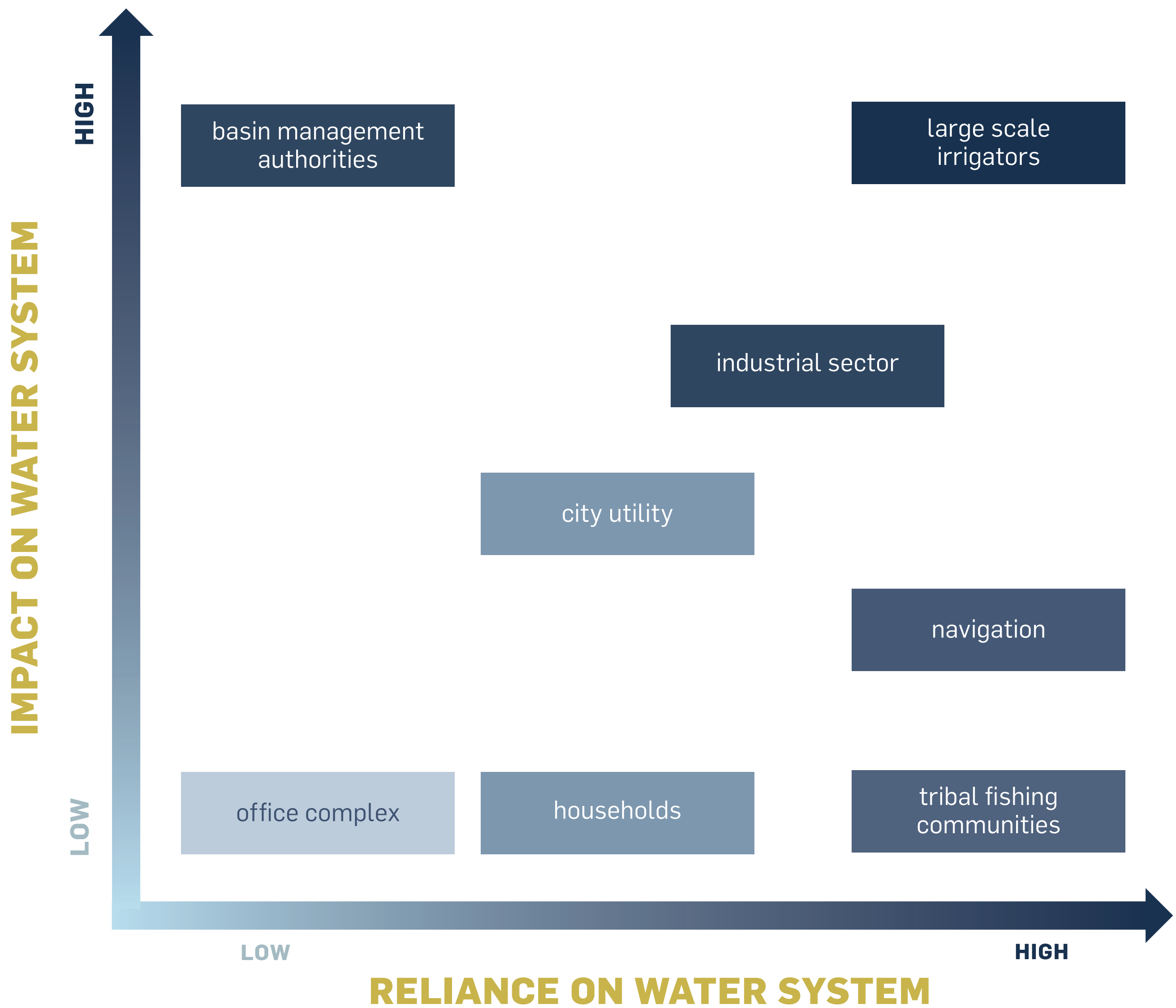
If a water user pursues the WRAF individually, stakeholder engagement is necessary to complete many of the indicated steps. In the simplest form, this engagement may include the collection of information from other water users. For example, step 1.3 (identify the water status and trends) may require outreach to local utilities, state or sub-national planning agencies, and other water users for information and data on the system status. In a more complex form, stakeholder engagement may include convening multi-stakeholder dialogues to set a resilience strategy (step 2.1) and set of actions for multiple water users (step 2.3). Stakeholder engagement, then, is an ongoing process to allow users to complete the steps of the WRAF.

Applying the WRAF may require engagement with many of these stakeholder groups, depending on the relevant step(s) and water-related challenges. When conducting stakeholder engagement across groups, it is important to recognize different stakeholders may interpret information, results and actions differently, based on different priorities and world views. The following list (adapted from AWS Standard 2.0) suggests different types of stakeholders to consider in the engagement process:

- National and state government, regulators and policymakers;
- Utilities and other local authorities;
- Community groups, including civil society organizations, communal water schemes, etc.;
- Native, indigenous and aboriginal communities and sovereign tribal nations;
- Small-hold farmers and large-scale, large-hold irrigators, farmers and landowners;
- Domestic water users, private homes and facilities, and public or municipal supplies;
- Industrial water users and high-water usage economic sectors;
- Environmental and conservation organizations;
- Recreational, hunting and/or fishing groups;
- Energy-generation companies;
- Navigation services; and
- Transport and logistics companies.

Any stakeholder or group can be included in stakeholder engagement, and the stakeholders may be considered with respect to their impact and reliance on the system. Special effort should be made to engage with the stakeholders who have the most impact on the water system and the water users most reliant on these resources. Stakeholders with high impact could include high consumptive agricultural water users, basin planners and regulators and municipal utilities. A theoretical example of such a stakeholder engagement matrix is presented in Figure 3 to identify those stakeholders who may be prioritized for outreach during the WRAF. Stakeholders with a high reliance on the water system for their activities could include industrial users with high water withdrawals, indigenous tribes with water and/or fishing rights, and large agricultural water users. Some stakeholders may have both a high impact and high reliance on the water system. Specific attention should also be paid to vulnerable and frequently overlooked communities (e.g., rural communities, minority populations, women and children). Impacted environmental systems should also be seen as a stakeholder, and actions should be taken to ensure their input or priorities in the process.

**FIGURE 3: A theoretical stakeholder engagement matrix to help prioritize stakeholder engagement activities**



### Step In Practice

The Stellenbosch River Collaborative is a formal entity constituted by like-minded actors from across the public, private and conservation sectors, as well as many local communities that are committed to a collaborative governance response to building long-term resilience and water security in the Eerste River catchment, Western Cape Province, South Africa. The collaborative emerged from a bottom-up process, identifying and linking key stakeholders with a shared interest in the environmental, social, political and economic nexus of the watershed. Corporate actors had to engage with other actors in a stakeholder-oriented process which was "beyond their fences" (i.e., outside of the boundaries of their operations), around issues of resilience, water security, and water governance and management. Much of the project's success is based on the Climate Risk Informed Decision Analysis (CRIDA), a bottom-up process based on identifying, mapping and classifying stakeholders to develop resilience. CRIDA uses stakeholder collaboration to define the planning objectives, identifying and analyzing specific water-related issues that need to be addressed, along with intended outcomes.

**Effective monitoring, communication and disclosure should be included throughout the WRAF process. Communication and disclosure of progress will allow for valuable external stakeholder engagement and feedback, and provide opportunities for collective action. More applied guidance and resources on stakeholder engagement will be provided in the sector guidance.**

## Conclusions

Many have remarked that if climate change were a shark, water would be its teeth. Climate change impacts, coupled with population growth, other anthropogenic actions, and extreme events are forcing us to rethink the way we see, value, impact and manage our water systems. As the reality of these impacts are sinking in, there is a growing drive to develop and implement practical solutions to water-related issues. The WRAF has been designed with the understanding that climate risk differs enough from more traditional types of water sustainability frameworks that most institutions require a bridge to operationalize climate resilience. Water sustainability remains important as a framework to guide our actions, but traditional concepts around sustainability are also insufficient to cope with ongoing, or even accelerating, global change.

> **"By combining sustainability and core water accounting practices with resilience, we can both become more resilient individually and contribute to the overall resilience of the water system."**

The WRAF presented here is a high-level framework that can be adapted and applied to any specific stakeholder or sectoral perspective. The WRAF is intended to help a wide variety of institutions build long-term resilience to climate change, as well as other familiar and unfamiliar hazards. The WRAF offers a means for mainstreaming critical resilience insights within public- and private-sector organizations. The goal is to manage water for now and tomorrow, for certainty and uncertainty, under shocks and stresses, as well as include a variety of stakeholders' considerations and perspectives.

This document is only the beginning. The immediate next step is to develop key sector-specific guidance documents to support WRAF operationalization for utilities, urban planners, corporates and basin authorities. These guidance documents will be published in a sequence leading to the selection and implementation of pilot cases. Potential partnerships will be explored in parallel for piloting.

The hope is that by engaging colleagues and partners, this document will be treated as an invitation and a foundation—building a group of collaborators to explore the boundaries of these insights and then incorporating these lessons into a more detailed suite of sector guides and detailed methodology for broader and more robust real-world applications. In many cases, the WRAF will confirm work that institutions are already doing to identify risks and opportunities while highlighting aspects that may need to be reconsidered or better understood. Ultimately, our invitation is intended to start a dialogue so we can learn from each other, to map the emerging landscape of issues for our economies, communities and ecosystems. By building on these learnings and our understanding of systems, and by working collectively, we can build more resilient systems together.

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### About the CEO Water Mandate

The CEO Water Mandate is a United Nations Global Compact initiative that mobilizes business leaders on water, sanitation, and the Sustainable Development Goals for corporate water stewardship. Endorsers of the Mandate commit to continuous progress against six core elements (direct operations, supply chain and watershed management, collective action, public policy, community engagement and transparency) and in so doing understand and manage their own water risks. Established in 2007 and implemented in partnership with the Pacific Institute, the Mandate 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. For more information, follow @H2O_stewards on Twitter and visit our website at ceowatermandate.org.

### About the Pacific Institute

The Pacific Institute envisions a world in which society, the economy, and the environment have the water they need to thrive now and in the future. In pursuit of this vision, the Institute creates and advances solutions to the world's most pressing water challenges, such as unsustainable water management and use; climate change; environmental degradation; food, fiber, and energy production for a growing population; and lack of access to freshwater and sanitation. Since 1987, the Pacific Institute has cut across traditional areas of study and actively collaborated with a diverse set of stakeholders, including policymakers, scientists, corporate leaders, international organizations such as the United Nations, advocacy groups, and local communities. This interdisciplinary and nonpartisan approach helps bring diverse interests together to forge effective real-world solutions. Since 2007, the Pacific Institute has also acted as co-secretariat for the UN Global Compact CEO Water Mandate, a global commitment platform that mobilizes a critical mass of business leaders to address global water challenges through corporate water stewardship.More information about the Pacific Institute and our staff, directors, and funders can be found at www.pacinst.org.

### About AGWA

AGWA's vision is for effective climate change adaptation and mitigation practices to be mainstreamed and enabled within water resources management decision-making processes, policies, and implementation. The mission of AGWA is to provision tools, partnerships, guidance, and technical assistance to improve effective decision making, action, governance, and analytical processes in water resources management, focusing on climate adaptation and mitigation. For more information, visit www.alliance4water.org.

### About WRI

World Resources Institute (WRI) is a global research organization that spans more than 60 countries, with international offices in Brazil, China, India, Indonesia, Mexico and the United States, regional offices in Ethiopia (for Africa) and the Netherlands (for Europe), and program offices in the Democratic Republic of Congo, Turkey and the United Kingdom. Our more than 1,400 experts and staff turn big ideas into action at the nexus of environment, economic opportunity and human well-being. More information at www.wri.org.

### About IWMI

The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society, and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services, and products with capacity strengthening, dialogue, and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change, and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center and leads the CGIAR Research Program on Water, Land and Ecosystems (WLE). Find out more at www.iwmi.org.

### About the United Nations Global Compact

As a special initiative of the UN Secretary-General, the United Nations Global Compact is a call to companies everywhere to align their operations and strategies with Ten Principles in the areas of human rights, labour, environment and anti-corruption. Our ambition is to accelerate and scale the global collective impact of business by upholding the Ten Principles and delivering the Sustainable Development Goals through accountable companies and ecosystems that enable change. With more than 12,000 companies and 3,000 non-business signatories based in over 160 countries, and 69 Local Networks, the UN Global Compact is the world's largest corporate sustainability initiative — one Global Compact uniting business for a better world. For more information, follow @globalcompact on social media and visit our website at unglobalcompact.org.

## THE CEO WATER MANDATE'S SIX CORE ELEMENTS:

### DIRECT OPERATIONS
Mandate endorsers measure and reduce their water use and wastewater discharge and develop strategies for eliminating their impacts on communities and ecosystems.

### SUPPLY CHAIN AND WATERSHED MANAGEMENT
Mandate endorsers seek avenues through which to encourage improved water management among their suppliers and public water managers alike.

### COLLECTIVE ACTION
Mandate endorsers look to participate in collective efforts with civil society, intergovernmental organizations, affected communities, and other businesses to advance water sustainability.

### PUBLIC POLICY
Mandate endorsers seek ways to facilitate the development and implementation of sustainable, equitable, and coherent water policy and regulatory frameworks.

### COMMUNITY ENGAGEMENT
Mandate endorsers seek ways to improve community water efficiency, protect watersheds, and increase access to water services as a way of promoting sustainable water management and reducing risks.

### TRANSPARENCY
Mandate endorsers are committed to transparency and disclosure in order to hold themselves accountable and meet the expectations of their stakeholders.