Water Resilience Assessment Framework

Corporate Guidance

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Project Partners

Several organizations form part of the broader WRAF project. Organizations played different roles in conceptualizing, drafting, communicating and supporting the project. We are grateful to all project partners for their contributions and continued engagement in this work.

Pacific Institute; CEO Water Mandate; Alliance for Global Water Adaptation (AGWA); International Water Management Institute (IWMI); World Resources Institute (WRI)

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BHP

Project Overview

The project was launched in 2019 with seed funding from BHP, initially to develop a common water accounting framework. The scope evolved to speak more directly to climate change and focus on water resilience, given the urgent and critical need to build long-term resilience in basins around the world.

The Water Resilience Assessment Framework (WRAF) was launched at the Stockholm World Water Week 2021 and is available to download here.

This document is part of the series of sector-specific guidance documents to implement WRAF. It is focused on corporates and other users of goods and services from the water system. The other sector-specific guidance documents in this series are “WRAF for utilities” and “WRAF for river basin authorities and planning managers”. These guidance documents will be revisited and adapted over time.

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

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Glossary

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

Basin: A basin or river basin follows the same principles as a catchment of capturing water across a geographical zone, however at a wider scale.

Catchment: The geographical zone in which water is captured, flows through and is eventually discharged at one or more points.

(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 the 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.

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 supports the goals of the selected resilience strategy.

System: The catchment around a facility or community and the interconnected system components. The system components are further categorized as socio-economic, institutional, governance, infrastructure, management and biophysical components that influence that catchment.

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

System scale: 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 catchment and then beyond, to key elements of that system that may exist outside of a catchment - 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.

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. Catchment Water accounting provides these accounts at the catchment scale and is 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 the 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.

The resilience approach is about making effective decisions in an evolving system.

Executive Summary

The climate crisis, political upheavals, pandemics and other shocks and stresses are causing abrupt, gradual and long-term changes in water systems around the world. These changes are increasing both in intensity and frequency. These changes will not only impact water quantity and quality but also the access to and provision of other water-related goods and services. These drivers have exposed the vulnerabilities of the entire water system and laid bare our global connections and inter-reliance. Decisions need to be made considering such uncertainties to build long-term resilience at every level of our water systems. The resilience approach is about making effective decisions in an evolving system. A resilience mindset helps stakeholders to plan not just how to bounce back (recovery) from shocks and stresses, but also how to bounce forward (adapt or transform).

When uncertainties around our water systems cause targets on climate, water quality and quantity, equity, economic, etc. to shift and decision-making processes to change, resilience is the conceptual tool for survival. The Water Resilience Assessment Framework (WRAF), published in 2021, supports resilient decision-making to avoid shocks and stresses from becoming crises. It provides a high-level framework that is comprehensive yet flexible enough to be adapted and applied to any stakeholder or sectoral perspective.

The WRAF provides a foundation for sector-specific application and this WRAF - Corporate Guidance is the first in a series of detailed documents guiding implementation. Others in the series include guidance for water utilities and basin managers/planning authorities (regional and national).

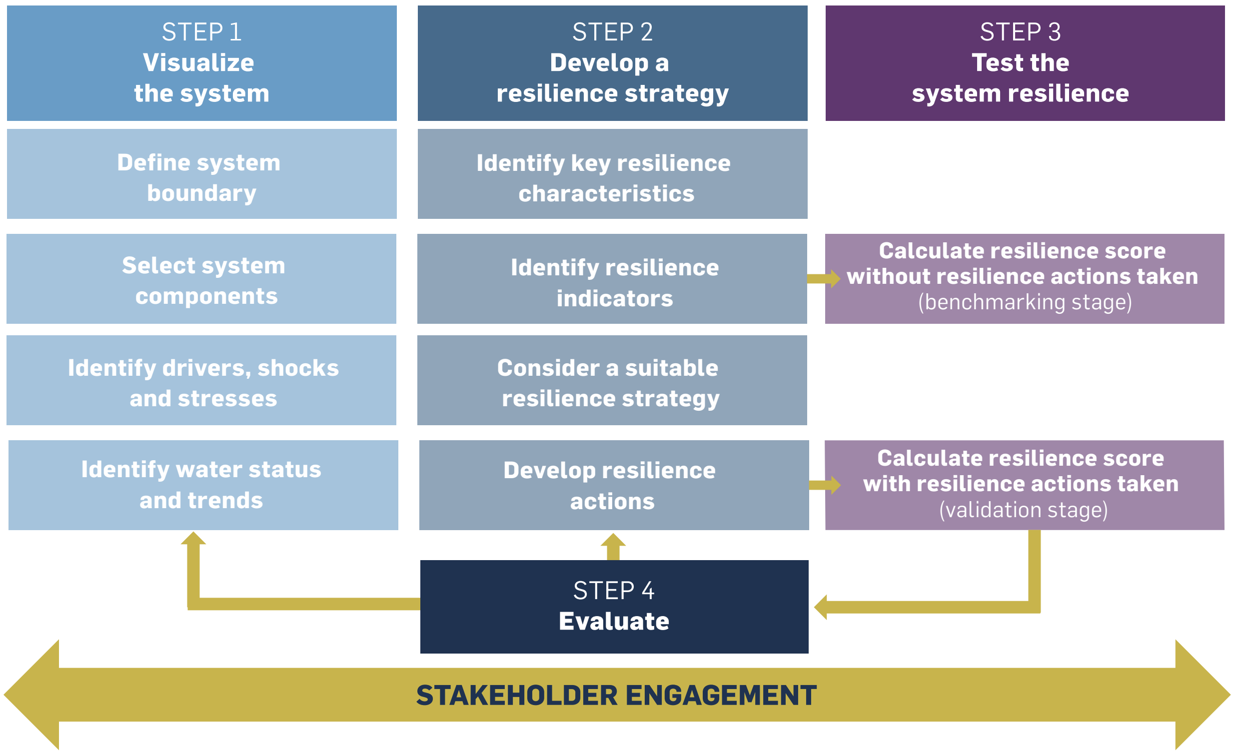
The private sector can play a critical role in building system resilience, as businesses can drive resilience at the local level (on-site resilience), through their supply chains (supply chain resilience) and beyond their operation (system resilience). This guidance provides a standard approach to measuring and enhancing resilience across different businesses and provides a set of 'Water Resilience Indicators' and a 'Resilience Scoring Tool' (ReST) for corporates. **This guidance can be applied by a range of private sector actors, from small, medium and micro enterprises (SMMEs) to large multinational corporations across any sector.**

On-site resilience refers to the state of water resilience at the local site and operations

Supply chain resilience refers to site-level water resilience across organizations and locations connected by the supply chain of the business

System resilience refers to the overall resilience of the water system and considers all the interconnected components that are external to site operations but influence the catchment.

Building on the WRAF, this guidance presents key resilience steps for companies, aligning them with corporate water stewardship practices and other approaches that enhance operations over the long term and deliver benefits to customers, communities and the environment. Practical examples are provided throughout the guidance document to showcase how a step could be implemented in practice.



Building long-term water resilience is essential for a company aiming to mitigate or adapt to current and future shocks and stresses. Resilience thinking and its application is still nascent in many sectors and geographies, and it is hoped that this guidance will encourage companies to engage with the water systems critical to ensuring sustained business operations over time, and to plan for future trends, possibilities and risks. The detailed guidance on WRAF for corporates is a step forward for businesses to start embedding resilience into their policy and practices.

Introduction: Why should businesses engage in water resilience?

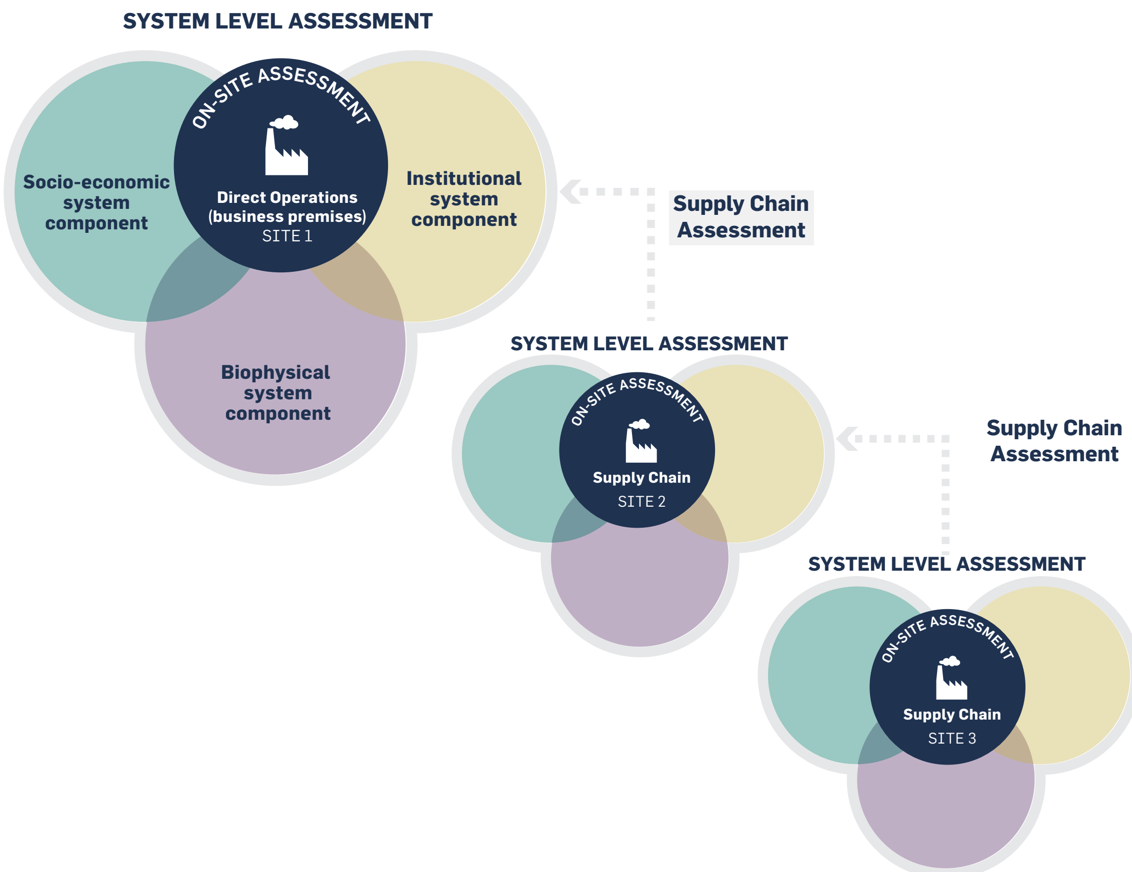
The climate crisis, political upheavals, pandemics and other shocks and stresses are causing abrupt, gradual and long-term changes in water systems, and these changes are increasing both in intensities and frequencies. As water demand increases, these impacts will be experienced by all water users, including the corporate sector. By 2030, it is estimated that global water demand will exceed available renewable supplies by 56%, requiring as much as 1% of global GDP to resolve a gamut of shared water challenges (Strong et. al., 2020).

The Water Resilience Assessment Framework (WRAF) provides a way for a range of stakeholders and water users to engage with and improve the resilience of their water systems, in the face of increasing shocks and stresses (Chapagain et al., 2021). This guidance document illustrates the application of the WRAF for businesses and provides practical steps to applying the WRAF at a corporate level to assess and improve the resilience of the water system a business operates in.

This guidance outlines the corporate application of the WRAF, suitable for an individual site or a local coalition of organizations across supply chains or water systems. These scales should be familiar to many businesses and align with the application of the guidance on "Setting Contextual Water Targets at a Site Level" (UN Global Compact CEO Water Mandate, Pacific Institute, CDP, The Nature Conservancy, World Resources Institute, WWF, 2019) and the "Alliance for Water Stewardship Standard 2.0" (AWS 2020). This guidance is designed to complement and build on many of the existing corporate water stewardship materials and traditional risk-based information. For an overview of alignment and complementarity with these approaches, see the WRAF (Chapagain et al., 2021).

The WRAF can be implemented at multiple levels within a business (site, supply chain and system levels). Site level implementation of the WRAF uses the system boundary pertinent to the specific site only and helps to understand the on-site resilience of businesses for their direct operations. Supply chain implementation of the WRAF entails the assessment at site level, and or system analyses for all the locations in the value chain. The system level assesses the resilience of the catchment around a site, or a supply chain, as well as the socio-economic, institutional and biophysical components that affect the catchment (Figure 1). For companies beginning their Water Stewardship Journey (CEO Water Mandate, 2022), implementing the WRAF first at the site level can be relatively easy and cost-effective. In many cases, data may already be available and can be used for the WRAF process, other water stewardship approaches and for reporting purposes. From the site level, the authors propose extending the WRAF process to either the supply chain or the system level as feasible.

FIGURE 1. MULTIPLE LEVELS IN IMPLEMENTING THE WRAF FOR CORPORATES



Undertaking the WRAF at the on-site level includes:

- Understanding the key water challenges across operations.
- Measuring and assessing key resilience variables directly under the control of a business.
- Developing an action plan to enhance resilience for continued operations; and
- Assessing how building site level resilience depends on what happens at the system level where they operate and vice versa.

Undertaking the WRAF at the supply-chain level includes:

- Working with key suppliers to assess and improve the resilience of their upstream activities that feed raw inputs into operations.
- Helping to create a group of stakeholders to collectively implement the WRAF across a specific geography; and
- Advancing the WRAF among industry associations to collectively develop awareness and understanding of water resilience across sectors.

Undertaking the WRAF at the system level includes:

- Engaging with a broad range of private sector organizations and other stakeholders to address collective action objectives; and
- Working with utilities and basin managers to advance resilience policy and practice and ensure equitable provision of water-related goods and services.

Business resilience is interconnected with the systems it operates in. While a business may pursue the WRAF alone, it may also work with multiple stakeholders to implement the WRAF, creating a shared vision of current and future conditions and prioritizing resilience actions. This can also help to create more effective, long-lasting outcomes.

The WRAF can also be implemented across different spatial boundaries, such as single or multiple catchments (from local to transboundary) or within varying institutional scales (from metropolitan decision-making to national decision-making entities). The authors encourage businesses to apply the WRAF in priority geographies.

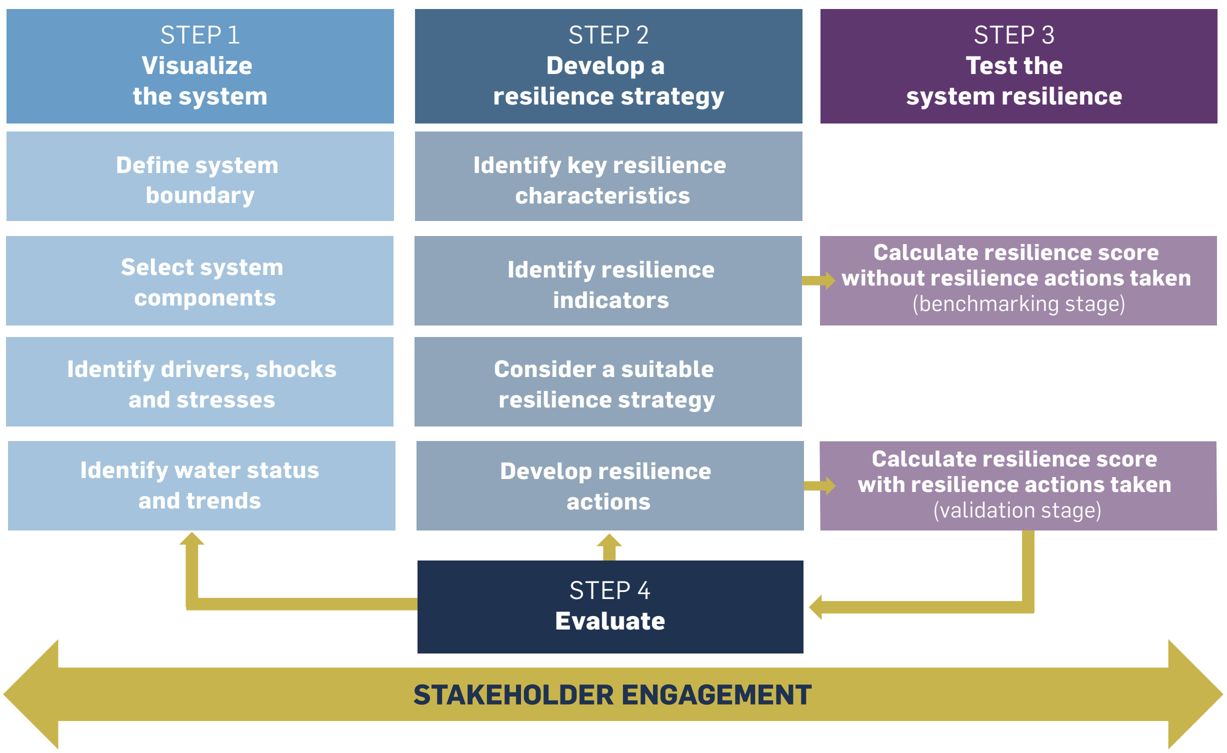
The objectives of this corporate guidance are to:

1. Provide stepwise guidance for businesses to apply the WRAF to build their water resilience across site, supply chains and system levels; and
2. Provide a useful set of resources to perform the various steps of the WRAF, including resilience indicators, actions, relevant tools and methods.

Steps for Corporates to Operationalize the Water Resilience Assessment Framework

The Water Resilience Assessment Framework (WRAF) provides an overarching framework, and this document presents the steps from the framework (Figure 2) and adapts them to best align with corporate water stewardship practices and other approaches. Although it is suggested to follow the steps sequentially, businesses may perform substeps concurrently or in a different order depending on their priorities, resources and capacity. In the following sections, we elaborate on all the steps in the WRAF in detail and provide an example from a sand mining company located in the Ayeyarwaddy River Basin in Myanmar (see Step in Practice at the end of each step).

FIGURE 2: THE WATER RESILIENCE ASSESSMENT FRAMEWORK FOR CORPORATES



Source: adapted from Chapagain et al., 2021

Stakeholder engagement is a necessary element that underpins the WRAF process and sector-specific steps. Most businesses define the system boundary as the catchment they operate in and include only the stakeholders relevant to that boundary. For the WRAF process, other stakeholders who are influenced or impacted by what happens in that catchment should be included as well. In collecting the information for Step 1, businesses will likely find themselves asking for data from a local utility or regional water manager or working with communities to understand impacts and incorporate key considerations. Stakeholder engagement throughout all steps of the WRAF will improve overall outcomes for the entire system and community.

The following list (Chapagain et al., 2021) presents different stakeholders to engage:

- National and state government, regulators and policymakers.
- Utilities and other local authorities.
- Community groups, including civil society organizations, communal water schemes, etc.
- Indigenous, 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.
- Experts, consultants, practitioners and other organizations working in the fields of water and resilience.
- Recreational and sporting groups.
- Energy-generation companies.
- Navigation services; and
- Transport and logistics companies.

Stakeholders can be engaged through one-on-one discussions, workshops, in-person or online presentations, surveys and other approaches. The nature of engagements will depend on the type of business, particular WRAF step, ease of engagement and other factors. An inclusive stakeholder engagement process is an important and effective first step in the design and implementation of the WRAF.

STEP 1: VISUALIZE THE SYSTEM

1.1 DEFINE SYSTEM BOUNDARY

Defining the boundaries of the water system(s) in which a business operates is essential for effectively collecting information and identifying the relevant system components and stakeholders, key drivers of shocks and stresses, as well as the water status, trends and the impact of business decisions on communities and the environment. The assessment boundary could extend from a local catchment to across a sub-basin, basin, or group of basins. The system also implies a set of interconnected socio-economic, institutional, governance, infrastructure, management and biophysical components that influence and impact the selected area. Businesses can define their system boundary depending on their priorities and the level of resilience assessment (site, supply chain or system level) they are undertaking.

Practically, a business could define the system boundary as a single facility and prioritize data collection on localized factors within the catchment(s) that the facility relies upon for water and the area affected by operations and discharge. In aligning business efforts with nearby stakeholders (e.g., other businesses, the local municipality, or water utility), this system boundary may also include key inputs and outputs of local communities as well. This approach is a common practice as seen in:

- Alliance for Water Stewardship – guidance on defining a catchment (AWS, 2020)
- Setting Site Water Targets Informed by Catchment Context – A Guide for Companies (UN Global Compact CEO Water Mandate et al., 2019)

1.2 DEFINE SYSTEM COMPONENTS

Upon defining the boundaries of the system for a facility or geography, a business must identify individual and shared water challenges in a system. There are several frameworks useful for categorizing these water challenges, such as the Sustainable Development Goals (UN, 2015), Contextual Water Target guidance (UN Global Compact CEO Water Mandate, et al., 2019) and the Alliance for Water Stewardship Standard 2.0 (AWS, 2020) (Table 1). These sources offer a starting point to identify shared water challenges. Context-specific challenges can be added to this list based on local considerations.

TABLE 1: SHARED WATER CHALLENGES IDENTIFIED IN DIFFERENT APPROACHES, CHALLENGES AND GOALS.

Challenge category	Contextual Water Target Challenge	Sustainable Development Goal	Alliance for Water Stewardship Standard 2.0
Water access	People and communities lack sufficient access to safe and affordable water, sanitation and hygiene	SDG 6.1 & 6.2: universal and equitable access to drinking water, sanitation and hygiene	Safe water, sanitation and hygiene for all
Water quality	Water that presents health threats to human and/or ecosystems. Water that is unfit for its intended use due to quality impairments	SDG 6.3: Improve water quality and reduce pollution	Good water quality status
Water quantity	Demand (human and environmental) for water exceeds the available supply indicating water resources are out of balance.	SDG 6.4: Increase water-use efficiency and ensure sustainable withdrawals	Sustainable water balance
Water governance	Political, social, economic and administrative systems which affect the use, development and management of water resources are ineffectual, corrupt, underfunded, or otherwise inadequate	SDG 6.5: Implement integrated water resource management	Good water governance
Water-related ecosystems	Water-related areas of environmental, cultural and spiritual significance are degraded and there is a loss of freshwater ecosystems.	SDG 6.6: Protect and restore water-related ecosystems	Important water-related areas
Extreme weather events	People and communities are at risk of catastrophic impacts due to extreme water-related weather events such as droughts and floods.	SDG 11.5: Reduce deaths and loss from disasters, including water-related disasters	NA
Climate change	The frequency and intensity of extreme weather events and other impacts are increasing due to climate change.	SDG 13.1: Take urgent action to combat climate change and its impacts	NA

To address the challenges in a system, a company should identify relevant system components and subcomponents related to this challenge. The WRAF uses three system components, namely socio-economic, institutional and biophysical components, each with several subcomponents (Table 2). The components and subcomponents influence the nature, scope and scale of challenges. For example, high water demand is influenced by rapid population growth (subcomponent demographics under the socio-economic system component), declining annual rainfall (subcomponent climate and weather systems, under the biophysical system component) and several other subcomponents.

TABLE 2: EXAMPLES OF SYSTEM SUBCOMPONENTS ACROSS PRIMARY SYSTEM COMPONENTS

SOCIO-ECONOMIC	INSTITUTIONAL	BIOPHYSICAL
• Access to funds and resources • Demand management • Knowledge system • Available resources (capex and opex) • Economic ability (affordability) • Social connectivity • Cultural and indigenous knowledge systems	• Governance (financial ability, willingness, competency, transparency, maturity, etc.) • Regulations (practicality, maturity, compliance, etc.) • Legal frameworks (allocation, operation and management) • Corruption, accountability and transparency • System operation management	• Supply (diversity in sources, reliability and adequacy) • Supply (system capacity and suitability to switch sources) • Built infrastructure (capacity to operate, technology, reliability and capacity of structures, connectedness, etc.) • Natural infrastructure (capacity, connectedness, quantity and quality) • Climate and weather systems • Landscape elements • Biodiversity (aquatic and terrestrial)

Table 2 provides examples of relevant system subcomponents for businesses but is not intended to be an exhaustive list. Rather, the subcomponents should be adapted based on context, sectors and geographies and provide a foundation for identifying data and information required to establish water status and trends. Companies are encouraged to identify as many subcomponents as needed to reflect the nature of the system(s) in which they operate.

1.3 IDENTIFY DRIVERS, SHOCKS AND STRESSES

With water challenges and relevant system components selected, the next step is to identify the drivers, shocks and stresses that could change the system. Begin with known and/or pre-existing chronic and acute shocks and stresses or system drivers. Shocks and stresses could be either incremental (e.g., temperature and precipitation changes over time, long-term droughts) or sudden (e.g., flooding, coastal storms, earthquakes, fire, cybersecurity breaches, terrorism, violent conflict, epidemics/pandemics, etc.). Drivers can include a broad range of elements that may be interacting with climate change, such as demographic change, economic trends, or regulatory shifts. Sound system resilience design should also consider and plan for such extremes and their drivers as relevant, at a minimum to understand system requirements, options and costs, and to inform decision-making on resilience investment.

Building off current shocks and stresses, a company should also examine potential future shocks and stresses. Together with listing the drivers currently present, the possible shocks and stresses that could damage or remove the ability of the system to perform its current functions should be identified. This is a theoretical exercise, and a business can also prioritize possible shocks and stresses that are highly probable or could be particularly devastating with severe consequences to its continued functioning and operations.

Current and future shocks and stresses may have significant implications for site, supply chain, or system level resilience within a company. Impacts across these three levels can also result in reverberating impacts for communities served by or in the surrounding area of a company, as well as the local environment. For instance, in a drought-stressed region, if a company decides to build resilience by investing in measures to secure water supplies through additional withdrawals or source diversification using water more than its agreed quota, it may unintentionally leave small businesses or economically stressed community members with insufficient water access. Engaging with stakeholders early in Step 1 can help identify other social stresses such as existing inequities and head off unintended consequences.

1.4 IDENTIFY THE WATER STATUS AND TRENDS

The drivers, shocks and stresses in conjunction with the relevant system components will inform the status and trends of 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 modeling approaches. It also reflects predicted changes due to ongoing, planned, or probable shifts in the policies or activities impacting the system.

The WRAF proposes a sliding scale to assess trends of changes in the attributes of the system. The scale goes from 'worsening conditions' to 'no change', to 'improving conditions. These trends are reported across all the relevant system components.

When possible, these data and information should be measurable and quantitative, but qualitative expert assessments may substitute when necessary. It is essential that these data and information be relevant to the local context and trusted by stakeholders. When possible, information and data should be publicly accessible or determined in a verifiable manner. Primary data can be gathered from a local utility or regional water agency, stakeholder surveys, or existing relevant literature. This approach for data and information collection is similar to those recommended in the guide for companies to set the Contextual Water Targets (UN Global Compact CEO Water Mandate et al., 2019) or in the Alliance for Water Stewardship Standards 2.0 (AWS, 2020).

STEP 1 IN PRACTICE

In this guidance document, we take the readers through the key steps of the WRAF with an example from a hypothetical sand mining company situated in the Ayeyarwaddy River Basin in Myanmar. While the example may be hypothetical, the status, trends, drivers, shocks and stresses are based on the existing conditions and context of the basin.

The Ayeyarwaddy River is one of the longest free-flowing rivers in Southeast Asia and the basin is home to two-thirds of the country's population. Five of Myanmar's largest cities are in this basin and more than 34 million people live in this basin. It is also one of the most biologically diverse regions in the world, however, the diverse range of intense economic activities also exert pressure on the basin resulting in flooding, bank erosion, pollution, sedimentation, navigation challenges, degradation of aquatic ecosystems, reduction in fish species, etc. (WWF, 2018).

Natural erosion in the river's headwaters feeds the delta with sand and gravel sediments. A recent boom in construction in Myanmar has exponentially increased the extraction of sand from the delta of Ayeyarwady. It is estimated that about 20 million tons or about 10 percent of the total sediment flowing through the river is extracted every year (WWF, 2018). It is estimated that in 2017 the construction sector was worth about US $4 billion, accounting for 5.7 percent of gross domestic product (GDP) (World Bank, 2018). In this example, a sand mining company operating in the Ayeyarwaddy Delta wants to apply WRAF to its business and develop an action plan to enhance its long-term water resilience.

To start the WRAF process, the mining company convened a multi-stakeholder workshop involving representatives of the local communities, various local and international non-governmental organizations, academia, local businesses, utility providers, government institutes and the internal stakeholders of the company. The mining company can also collect the data and responses using survey instruments, literature studies, or through consultations with other organizations.

STEP 1.1 DEFINE SYSTEM BOUNDARY

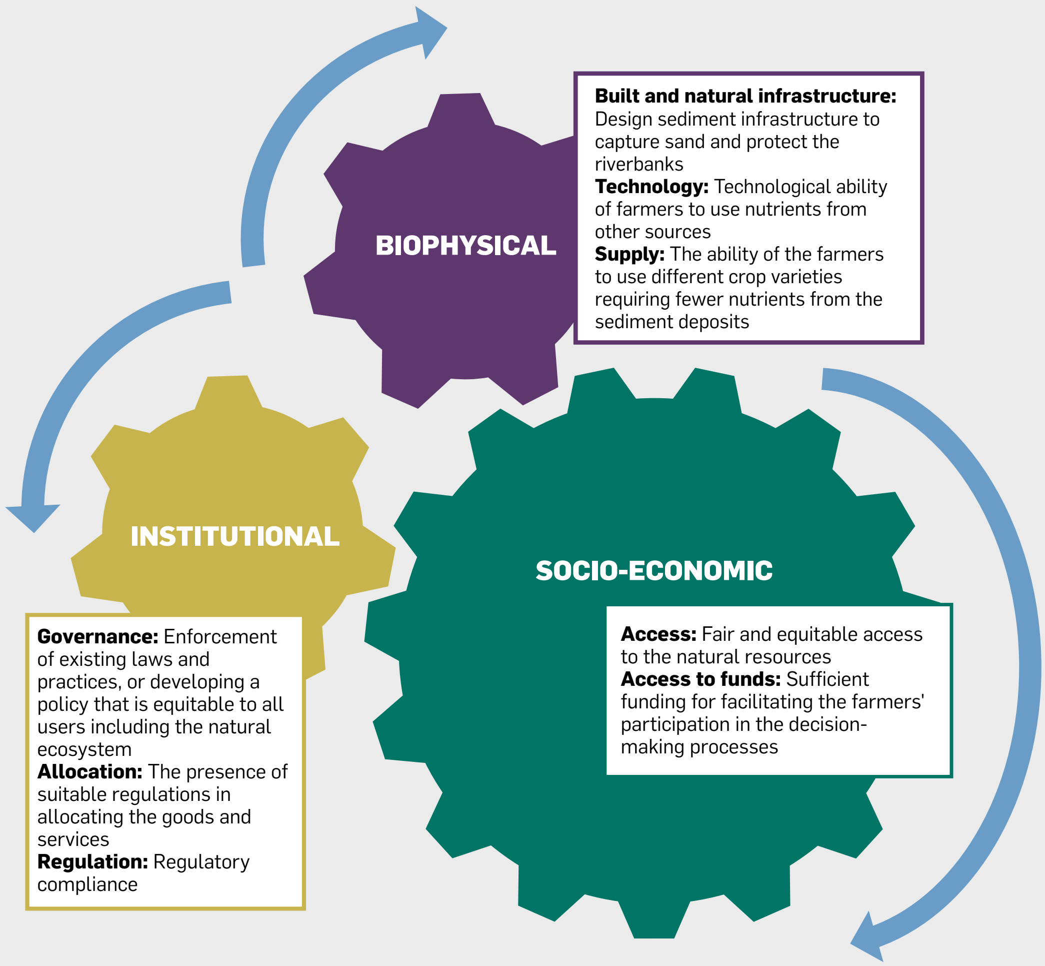
The workshop attendees define their system boundary as the area within 20 km around the sand mining sites in the delta. This boundary indicates the operational area of the mining company and is a suitable scale to undertake a site-level resilience assessment. If the mining company undertakes a supply chain or system level resilience assessment, they would need to reconsider the boundaries beyond the 20 km radius which could include upstream of the river where natural erosion occurs, and stakeholders in the supply-chain using the sand either for local or national construction activities, or those who export the resource to other regions.

STEP 1.2 DEFINE SYSTEM COMPONENTS

There is growing awareness that dredging causes changes in local hydrology and flood regulation. On land, mining sand and gravel causes erosion that leads to significant soil loss and habitat changes. Combined, these activities impact biodiversity, food security, water supplies, infrastructure, landscape and protection against extreme weather events.

The mining industry competes with agriculture, particularly smallholder and subsistence farmers, as sand mining could starve the delta of sediment and endanger the river's ecosystems and the livelihood of 34 million people living in the basin. The reduction in sediment, which feeds fish and fertilizes crops, also starves the delta of the nutrients needed to sustain the country's food supply. The reduced flow of sediment is weakening the mangrove cover increasing vulnerability to tropical storms and rising sea levels. Sand mining is projected to increase as development continues, even as environmental scientists warn that the current rate of sand mining in this region is already unsustainable.

STEP 1.2 DEFINE SYSTEM COMPONENTS



There is immense pressure on the government and policymakers to address the negative impacts of sand mining and develop new regulations requiring environmental impact assessments before beginning new mining operations and limiting the sizes of boats that mine sand and gravel. However, due to poor institutional capacities and law enforcement, the delta region continues to degrade, and the surrounding communities and environment still experience negative impacts.

These identified challenges help prioritize relevant system components and subcomponents. For example, reduced sediment flows impacting the nutrient balance for farmers can influence several system components and subcomponents as shown in the graphics above.

The sand mining company should undertake a similar assessment for the remaining challenges identified in Step 1.1.

STEP 1.3 IDENTIFY DRIVERS, SHOCKS AND STRESSES

During the workshop, the sand company identified several shocks, stresses and drivers of change to the system within their selected boundary. Workshop attendees also identified the state of the shocks and stresses related to each identified system component and subcomponent.

System component	System subcomponents	Drivers of change	Chronic/incremental shocks, stresses	Acute shocks and stresses
Socio-economic	Access to funds	Demographic change (influx of low-skilled migrants)	High poverty levels	Regulatory shifts in policy on migration
Institutional	Governance	Changes in legal frameworks affecting the basin's ecosystems	Low maturity of legal frameworks Low institutional capacity and poor law enforcement	Regime shift Revolution around worker's rights
Biophysical	Built and natural infrastructure	Increased mining activities	Low fertilizer application rates on surrounding farms	Drought Monsoon flooding

STEP 1.4 IDENTIFY THE WATER STATUS AND TRENDS

By collecting and processing relevant data and information to understand the status and trends of the system, the mining company can make informed decisions to meet their goals while also meeting the needs of the surrounding community or environment. In the workshop, the attendees were asked to collect data and information relating to the status and trends of the water system. For example, when addressing the challenge of 'reduced sediment flows impacting nutrient balance in the water used by rice farmers, the workshop attendees identified that the following data and information could be collected under different subcomponents for status and trends in the following tables:

Water status		
Socio-economic component	**Institutional component**	**Biophysical component**
Economic status: Poverty and low economic development lead to the over-extraction of resources from the basin for low profits **Livelihood opportunities**: The marginalized communities will have no alternative ways of coping if livelihoods are affected if the ecosystem services in the basin decline **Livelihood opportunities**: Livelihoods are not diversified properly to make use of the various water sources and their availability patterns effectively **Access**: People have also been relying on the existing irrigation system and the municipal water supply in addition to taking water directly from the natural sources **Access to funds and capacity**: Marginalized communities are not able to effectively participate in both top-down and bottom-up decision-making processes **Regulation**: Regulatory frameworks favor businesses to use the available ecosystem services without proper safeguards for the marginalized communities	**Governance**: Legal frameworks affecting the basin's ecosystems are not mature, have low institutional capacity and have poor law enforcement **Governance**: Local governance and CSOs are available and willing to monitor and address the threats to the basin's ecosystems **Governance**: Governance is highly centralized and decision-making processes to manage and protect the ecosystems in the basin are mainly made top-down **Governance**: Collaboration among the different stakeholders is not inclusive enough for collective action in the basin **Governance**: There is a systemic lack of just and equitability at the institutional level already **Regulation**: There are large international conservation NGOs that advocate the centralized government for land use planning to protect the natural resources **Regulation**: The approach that the large international conservation NGOs take also includes the perspectives of the local communities and marginalized groups	**Natural infrastructure**: The delta region shows loss of biodiversity and health of the aquatic ecosystems etc. **Supply**: There will be fewer or no alternative sources of water during the dry season **Supply**: The water resources are recharged during monsoon periods from the upstream or inter-basin transfer **Built infrastructure**: The riverbanks are not protected against erosion and there are no erosion-control measures in the upper catchment **Built infrastructure**: The riverbanks do not provide enough freeboards (embankment heights) to protect against flooding **Built infrastructure**: There are only a few isolated engineering measures in place to stop bank and catchment erosion, thus, there is no infrastructure connectedness **Built infrastructure**: The technological ability to run advanced new erosion-control measures is not yet tested in the system

STEP 1.4 IDENTIFY THE WATER STATUS AND TRENDS

Water trends		
Socio-economic component	**Institutional component**	**Biophysical component**
Economic status: the impacts of pandemics and the conflicts in the area will push many more people into poverty, leading to the over-extraction of resources from the basin's ecosystems. Trend: Worsening **Livelihood opportunities**: there is expected to be increased financing and international support for livelihood diversification in the region. Trend: Improving **Livelihood opportunities**: the proposed "livelihood diversification support program" does not have clear plans for rural families to construct a diverse portfolio of activities and social support capabilities that will allow them to make use of the various water sources and their availability patterns effectively. Trend: No change **Access**: there will be more investments in public water supplies and irrigation systems. Trend: Improving	**Regulation**: the country's political situation deteriorates; the legal frameworks will not improve. Trend: Worsening **Governance**: local governance systems and the roles of civil society organizations are expected to diminish. Trend: Worsening **Governance**: the central government has plans to further centralize decision-making and decisions will continue to be made in a top-down manner (i.e., limited inclusiveness in decision-making). Trend: Worsening **Governance**: the buildup of distrust between the central government and other governance systems will further hinder collaboration. Trend: Worsening	**Built and Natural Infrastructure**: the increased economic activities will continue to degrade the basin's ecosystems; the conditions will be sufficient to provide the current levels of ecosystem services. Trend: No change **Supply**: due to climate impacts, the area is expected to become drier, and the existing alternative sources of water are expected to diminish. Trend: Worsening **Supply**: discharge from upstream tributaries and catchment and inter-basin transfers are expected to decrease due to changes in climate change and land use. Trend: Worsening

STEP 2: DEVELOP RESILIENCE STRATEGY

In this step, a business can identify the key resilience characteristics relevant to its system using appropriate resilience indicators. The characteristics and indicators will inform which resilience strategy is selected that will support developing a set of feasible resilience actions. Once Step 2 is completed, it will provide the current state of resilience for key challenges identified in Step 1 and a feasible set of resilience actions to improve its resilience per system component and subcomponents.

2.1 IDENTIFY KEY RESILIENCE CHARACTERISTICS

There are six resilience characteristics of a water system:

- **Robustness:** The system performs reliability and effectively under a wide range of conditions.
- **Redundancy:** The system has spare capacity intentionally created to accommodate disruption, extreme pressures, or demand surges.
- **Flexibility:** The system can be altered and adapted in response to potential shocks and stresses or adjusted to take advantage of opportunities.
- **Integration:** The system components are linked and coordinated.
- **Inclusiveness:** The system has effective mechanisms for broad consultation and engagement of individuals and communities, including the most vulnerable.
- **Just and Equitability:** The system ensures that all stakeholders within a system are provided with equitable water access, rights and allowances.

Characteristic selection will depend on the nature and needs of a particular business or area of operations being tested for resilience. A company wishing to undertake a comprehensive analysis of its resilience may select all six characteristics or prioritize only a few to focus on at first. An individual facility with a history of water reliability issues might select the resilience characteristics 'Robustness' and 'Redundancy' to meet their immediate resilience goals. A system with limited stakeholder trust and prior governance issues can consider selecting 'Inclusiveness' and 'Just and Equitability' resilience characteristics.

However, focusing on only one or a few resilience characteristics may not produce long-term resilience for the business. For example, adding redundancy (additional capacity) may help reduce the immediate stress in the system, it may result in an unjust and non-equitable system for other stakeholders that could trigger negative outcomes for the business in the long run. Where possible, all resilience characteristics should be considered when undertaking the WRAF process.

The information from Step 1 will inform the selection of the appropriate characteristics. The priority water challenges in the system, as well as current status and trends, should point towards which characteristics require greater resilience. In addition, it is necessary to consider the critical functions and services of the system for stakeholders.

As the WRAF is designed to be an iterative process, this step may be revisited after reviewing subsequent steps or updated as the WRAF is repeated at a later time.

2.2 IDENTIFY RESILIENCE INDICATORS

With the resilience characteristics selected, a business should identify relevant resilience indicators to measure these characteristics. This guidance provides two tiers of resilience indicators. Tier 1 provides a snapshot indicator that can be used to assess a resilience characteristic at a high level. Tier 2 indicators allow a business to undertake a more granular assessment of the selected characteristics for each system subcomponent. A comprehensive list of Resilience Indicators and their description is available to download from the Resilience Scoring Tool for corporates (ReST) (a sample of which is presented in the Appendix A). The ReST is intended to be used by the business, and thus they need to collect all the data relevant to the components/subcomponents within their direct operations and supply chains and at system level as needed.

After identifying the selection of indicators, a company should conduct an initial stress test (Step 3) using the ReST to assess the current state of resilience in their system (benchmarking stage). An example of such a test, for resilience characteristics 'Robustness', at the benchmarking stage is presented in Table 3.

Developed by the project team, the Resilience Scoring Tool (ReST) for corporates is a user-friendly Excel tool that can be used to select key resilience indicators, based on relevant system components and subcomponents under each of the resilience characteristics. This tool follows a traffic-light scoring system - green indicates a high or good score; yellow/orange indicates an average score; red indicates a low or poor score. Based on expert knowledge and available metrics, appropriate score ranges for each indicator are built into the ReST. Users will select the score that best represents the outcomes from their benchmarking or validation stress tests. The ReST can be used for both Tier 1 and Tier 2 resilience assessments, depending on the needs of the users. For more information on the methodological approach used in this tool, please see the Appendix B.

At this stage, both Tier 1 and Tier 2 indicators have been assessed and show significant areas for improvement (yellow and red scores) (Table 3). Attention should be paid to the indicators receiving the lowest or weakest scores – these indicators will inform the selection of a suitable resilience strategy and appropriate actions to improve overall resilience. These indicators may be used as they are (see Appendix A), or businesses may modify these to suit a specific context or geography.

TABLE 3: AN EXAMPLE OF A BASE LINE RESILIENCE STRESS TEST (BENCHMARKING STAGE) FOR RESILIENCE CHARACTERISTIC 'ROBUSTNESS'

Using Tier 1 indicator for the selected resilience characteristics 'Robustness', the resilience score is Medium'. However, when investigating. However, when investigating Tier 2 indicators, more nuances are identified, helping a company select an appropriate resilience strategy and suitable actions. Scores range from **low (red)**, **average (yellow)**, to **high (green)**, however, there may be more quantitative indicators behind these more qualitative scores.

RESILIENCE SCORE USING TIER 1 RESILIENCE INDICATOR

Tier 1 indicator	Without resilience action
Percentage of time that the system withstands shocks and stresses and provides the required level of water-related goods and services	MEDIUM

RESILIENCE SCORE USING TIER 2 RESILIENCE INDICATORS

System component	System subcomponent	Tier 2 indicator	Without resilience actions
Socio-economic	Access to funds	Economic ability to fund operations and maintenance of the system	POOR
	Access to funds	Economic ability to fund new or enhanced infrastructure in the system	POOR
Institutional	Regulation	Level of regulatory compliance	MEDIUM
	Regulation	Maturity of the legal and policy frameworks informing water use	MEDIUM
	Regulation	Practicality and applicability of the legal and policy frameworks	EXCELLENT
	Governance	Maturity of governance/management systems	MEDIUM
	Governance	Ability and willingness of the governance system to pay for Capital spend on infrastructure development	LOW
	Governance	Ability and willingness of the governance system to pay for operating and maintenance of the infrastructure	MEDIUM
	Operations/ management	Level of competency of system operators/managers	MEDIUM
	Knowledge systems	Level of knowledge and capacity to understand and implement resilience science and practices	MEDIUM
Biophysical	Supply	Degree of diversity measured as the % of water obtained from each source	LOW
	Supply	Degree of reliability of quantity of water from different sources.	MEDIUM
	Supply	Degree of reliability of the quality of water from different sources.	HIGH
	Built and/or natural infrastructure	State of built infrastructure/level of maintained infrastructure	POOR
	Built and/or natural infrastructure	Ability of infrastructure to withstand shocks and stresses	GOOD
	Built and/or natural infrastructure	Ability of the constructed/natural ecosystem to provide goods and services	EXCELLENT
	Technology	Access/availability to technology for the system to operate reliably and effectively	EXCELLENT
	Technology	Knowledge and capacity to operate the available technology reliably and effectively	EXCELLENT

2.3 SELECT A RESILIENCE STRATEGY

A resilience strategy offers direction and ambition for businesses to improve their resilience. The WRAF proposes three resilience strategies (or a combination of these), namely persistence, adaptation and transformation. These strategies can be applied independently for each component or subcomponent at the selected level of assessment for each resilience characteristic.

For example, a company looking to improve its resilience score regarding 'Robustness', following a Tier 1 assessment, can investigate adopting a persistence strategy. However, after a more granular assessment using Tier 2 indicators, the company may select to persist across its socio-economic component versus adapting its institutional component. The final option is to persist, adapt or transform everything across a site, supply chain, or system. Selecting a resilience strategy based on the ReST will allow for clearer prioritization of actions.

In selecting a strategy there may be challenges and caveats to consider. Perhaps system robustness is strong and merely needs to persist, but the concerns of stakeholders require a transformational approach to improve the resilience characteristic 'inclusiveness'. There may be times when the priorities of different stakeholders are at odds with each other, and a hybrid strategy option may be more feasible to meet everyone's needs. In selecting a resilience strategy, businesses should also not overlook low-hanging fruit or simple opportunities that may have substantial long-term benefits but limited immediate return. Further, businesses should be clear-eyed about past, current and future expectations based on what information is available. Selecting an overly optimistic strategy may reduce immediate resource needs at the long-term expense.

RESILIENCE STRATEGIES

The following resilience strategies have been adapted from the WRAF (Chapagain et al., 2021).

Persistence: A persistence strategy expects a site, and the surrounding system will perform similar functions in the future as are currently delivered. There may be shocks and stresses that temporarily disrupt ordinary functions, but these are short-lived and after these disturbances, the system returns to business as usual. A persistence strategy emphasizes shoring up key weaknesses in the site and system against shocks but does not radically re-envision current operating practices.

Adaptation: An adaptation strategy expects the site and system will face a future that is substantively different from the status quo. These changes occur gradually but meaningfully eliminate the status quo as viable in the future. An adaptation strategy emphasizes maintaining current needs while simultaneously preparing for more drastic future changes.

Transformation: A transformation strategy expects the site and system face major, unrecognizable future conditions. Drastic changes in the context have already occurred and are expected to accelerate. A transformation strategy emphasizes reconsidering at a fundamental level the operations of a site and functions of the system and may require new technological and socio-economic structures.

As the selection of a strategy depends on several factors, informed by the outcome of the baseline resilience assessment (at the benchmarking stage), a business can explore suitable resilience strategies by answering the following sample questions:

- What are the resilience goals or priorities of the business?
- Which resilience strategy best aligns with these goals and priorities?
- Do these goals also support ongoing efforts for building resilience for communities and the environment? If not, what would need to change so that they align with business goals and deliver multiple benefits to communities and nature?
- What are the current and future status and trends of the system?
- How will anticipated shocks and stresses influence the status and trends, or how will these affect business operations?
- Following the benchmarking stress test, which resilience characteristics and system components and subcomponents are performing poorly?
- What are the most effective resilience actions the business can take in the short, medium and long terms?
- Who - outside of the business - will these resilience actions impact? Are there any stakeholders that may be negatively impacted? What can be adjusted to mitigate these impacts?
- How much capacity does the business have in addressing the system resilience on its own? Or is collective action a more effective option?

Following the selected strategy, a business can start developing resilience actions to improve its overall resilience across selected characteristics and components as indicated in the stress test at the benchmarking stage.

2.4 DEVELOP RESILIENCE ACTIONS

Following the selection of an appropriate resilience strategy, resilience actions must be developed such that the selected resilience characteristics of the system can be improved. While the resilience scoring tool and strategy direct actions, the following considerations can support the action selection process:

- If the resilience score at the benchmarking stage is poor regarding one or more specific indicators, the business should prioritize immediate improvement in these areas.
- If the resilience score at the benchmarking stage is moderate or good, it may require improvements to address future shocks, stresses and trends.
- Regardless of the outcome of the resilience scoring at the benchmarking stage, a company may look to develop actions to future-proof themselves based on resilience characteristic priorities.
- Potentially new or revised water-related policies or legislation may require actions to meet them.
- An unexpected shock or challenge is experienced, and the company needs to address this.

Stakeholder engagement is a key part of all steps of the WRAF, however, in selecting the most appropriate resilience actions, engagement is particularly important as external stakeholders may have greater insight into the feasibility and consequences of different actions. In particular, stakeholders should be consulted who would either be beneficial in the development and implementation of actions or who stand to be impacted by actions. These stakeholders may include government agencies, other businesses, NGOs, local communities, academic institutions, funding agencies, etc. At the system level, well-developed resilience actions will frequently take the form of collective action, rather than just one business implementing them independently. The Alliance for Water Stewardship Standard 2.0 (AWS, 2020) offers a robust framework for stakeholder identification and engagement.

Depending on the specific context and nature of the business or sector, the business can develop resilience actions specific to their case based on the resources and information available. For an alternate discussion and resource on the types of resilience actions available, see Rodina et al., 2019.

STEP 2 IN PRACTICE

The workshop attendees were asked the following questions to be able to proceed with subsequent steps of the WRAF:

- What are the resilience goals or priorities of our mining business?
- What are the current and future status and trends of the system?
- How will anticipated shocks and stresses affect business operations?
- Which resilience characteristics are performing poorly?
- Which resilience characteristics are the topmost priority for the company in the short term and what is the state of relevant indicators now?
- How much capacity does your business have in addressing the system resilience on its own?
- Can our company explore collective action opportunities to leverage and scale-up resilience across the catchment?

STEP 2.1 IDENTIFY KEY RESILIENCE CHARACTERISTICS

To select relevant resilience characteristics, the workshop attendees decided to prioritize one key challenge from the list of questions as well as those identified in Step 1. This challenge relates to reduced sediment flows impacting the nutrient balance for farmers can influence several system components and subcomponents, which inform the selection of suitable resilience characteristics.

System component	System subcomponent	Relevant resilience characteristics
Socio-economics	Access (fair and equitable access to the natural resources)	Inclusiveness Just and Equitability
Institutional	Governance (enforcement of existing laws and practices) Governance (developing a policy that is equitable to all users including the natural ecosystem)	Robustness Inclusiveness
Biophysical	Built and natural infrastructure: (design sediment infrastructure to capture sand and protect the riverbanks)	Robustness Flexibility

The characteristics selection presented in this table is for one of the challenges identified for the mining company (Step 1.2). This process must be repeated for all the challenges prioritized by the mining company. Given its resources, the mining company may prioritize one characteristic over the others to start building resilience. Where resources allow, multiple characteristics can be addressed at the same time to expedite its resilience journey.

STEP 2.2 IDENTIFY RESILIENCE INDICATORS

To address the reduced sediment flows impacting the nutrient balance for farmers a range of resilience characteristics are identified by the sand mining company, namely 'Robustness', 'Flexibility', 'Inclusiveness', and 'Just and Equitability'. In the workshop, the participants helped select resilience indicators to measure the current state of resiliency. Based on the stakeholder responses and information on local conditions, the company was able to conduct a baseline stress test (benchmarking stage) to ascertain its current level of resilience across different resilience characteristics. After the Tier 1 assessment, the company found that the two resilience characteristics, 'Robustness' and 'Flexibility', scored poorly, while 'Inclusiveness' and 'Just and Equitability' received average scores.

Resilience characteristics	Tier 1 indicator	Without resilience actions
Robustness	Percentage of time that the system withstands shocks and stresses and provides the required level of water-related goods and services	**Low**
Flexibility	Degree of willingness and inbuilt capacity in the system to guide planning, investment, and operations	**Low**
Inclusiveness	Level of inclusion of diverse stakeholders in decision making, operating, and maintaining the system	**Medium**
Just and equitability	Degree of provision of fair and equitable water-related goods and services for all users in the system	**Medium**

Given its limited resources and capacity, the company has decided to focus on only 'Robustness' and 'Flexibility'. Its resilience score, across Tier 2, indicates it is performing poorly across all relevant indicators selected.

Resilience characteristic: Robustness

System component	System subcomponent	Tier 2 indicator	Without resilience actions
Socio-economic	Access to funds	Economic ability to fund new or enhanced infrastructure in the system	**Poor**
Institutional	Regulation	Level of regulatory compliance	**Poor**
	Regulation	Maturity of the legal and policy frameworks informing water use	**Low**
	Governance	Maturity of governance/ management systems	**Low**
	Governance	Ability and willingness of the governance system to pay for capital spending on infrastructure development.	**Poor**
	Governance	Ability and willingness of the governance system to pay for operating and maintenance of the infrastructure	**Poor**
Biophysical	Built and/or natural infrastructure	State of built infrastructure/level of maintained infrastructure	**Poor**
	Built and/or natural infrastructure	The ability of infrastructure to withstand shocks and stresses	**Poor**

Resilience characteristic: Flexibility

System component	System subcomponent	Tier 2 indicator	Without resilience actions
Institutional	System management/ operations	Decision-making ability to guide planning, operations, and investment	**Poor**
	System management/ operations	Degree of flexibility in production and operation	**Low**
	Governance	The presence of suitable legislation and policies to allow the use of alternative types of water in system operations	**No**
Biophysical	Technology	Technological ability to secure supplies as and when needed from different sources	**Poor**
	Supply	Ability to switch between different components of the systems	**Poor**

STEP 2.3 SELECT A RESILIENCE STRATEGY

Through the Resilience Scoring Tool (ReST) for corporates, the four assessed resilience characteristics come out as low or medium for the sand mining company, suggesting that a persistence strategy may not be suitable to enhance resilience for these two poorly performing characteristics. Significant changes in the system components and subcomponents are needed. Hence, the sand mining company could select an adaptation or transformation strategy. To decide which of these strategies would be most appropriate, decision-makers used the outcome of the questions posed at the workshop. The set of questions related to strategy selection were presented in the following table.

Questions	Answers	Strategy options
What are the resilience goals or priorities of our mining business?	To have enough water for the farmers with nutrient-rich sediments in the flows Reduce riverbank erosion due to unplanned sand mining Reduce the adverse impact of sand mining on the aquatic ecosystem and habitat in the delta region	Adaptation
What are the current and future status and trends of the system?	Increasing dryness, decreasing water supply, economic instability, increasing levels of poverty due to decreasing livelihood opportunities, decreasing trust in the governance systems and deteriorating institutional and policy networks.	Adaptation / transformation
How will the anticipated shocks and stresses affect business operations?	New regulations regarding long-term planning will restrict current practices/methods.	Transformation
	Increased flood frequency will amplify erosion and we will be required to invest in additional infrastructures to reduce the erosion.	Adaptation
Which resilience characteristics are performing poorly (Step 2.2)?	Robustness (red) Flexibility (red) Inclusiveness (yellow) Just and Equitability (yellow)	Adaptation / transformation
Which resilience characteristics are the topmost priority for the company in the short term and what is the state of relevant indicators now?	Robustness (Institutional – Regulation – Level of regulatory compliance) (Low)	Adaptation
	Robustness (Institutional – Governance – Maturity of governance/management systems) (Low)	Adaptation
	Robustness (Biophysical – Built infrastructure – State of built infrastructure/level of maintained infrastructure) (Poor)	Adaptation / Transformation
	Robustness (Biophysical – Technology – Access/availability to technology (knowledge, capacity, etc.) for the system to operate reliably and effectively) (Poor)	Adaptation
	Flexibility (Institutional – System management/operations – Decision-making ability to guide planning, operations and investment) (Poor)	Adaptation
	Flexibility (Institutional – System management/operations - Degree of flexibility in production and operation) (Low)	Adaptation
	Flexibility (Institutional – Governance - The presence of suitable legislation and policies to allow the use of alternative types of water in system operations) (No)	Adaptation / Transformation
	Flexibility (Biophysical – Technology - Technological ability to secure supplies as and when needed from different sources) (Poor)	Adaptation
	Flexibility (Institutional – Supply - Ability to switch between different components of the systems) (Poor)	Adaptation / Transformation
How much capacity does your business have in addressing the system resilience on its own?	We can make this a key KPI for our sustainability manager and chief operating officer. We will involve all employees in helping design, implement and monitor our resilience actions and activities. We can increase local stakeholder engagement in decision-making and operations through more inclusive processes.	Adaptation
Can our company explore collective action opportunities to leverage and scale-up resilience across the catchment?	Yes, there are other sand mining industries we could work with. Some farmers are also looking to build their long-term resilience and would be interested in partnering with us	Adaptation

Following this workshop, the sand mining company identified an adaptation strategy, with the possibility of transforming some areas of operation where needed. This decision indicates the need to shift from current operating practices to more resilient ones.

The decision on which resilience strategy/strategies to select will inform how the mining company develops their resilience policy. This policy should have clear guidelines, and appropriate resilience actions, to support their adaptation and transformation strategy objectives. Actions should address the outcomes of the baseline stress test as well as aim to build long-term resilience across different levels (site, supply chain and system). This policy should be reviewed and updated regularly.

STEP 2.4 DEVELOP RESILIENCE ACTIONS

Following the outcomes of the resilience scoring at the benchmarking stage, the sand mining company has developed a series of resilience actions to improve their overall resilience score, in line with their selected resilience strategy. The company prioritized improving the resilience characteristic 'Flexibility' and a set of suitable resilience actions are presented per resilience indicator in the following table.

System component (and subcomponent)	Resilience indicator	Tier 2 resilience score	Suggested resilience actions
Institutional (system management and operations)	Decision making ability to guide planning, operations and investment	**Poor**	Develop technical knowledge at necessary organizational levels to make effective decisions Build organizational capacity by providing appropriate decision-making training Build organizational capacity by hiring additional staff with appropriate skills Develop robust policies to allow managers and system operators to use new technologies
Institutional (system management and operations)	Degree of flexibility in production and operation	**Low**	Assess suitability of equipment to be switched on and off under different scenarios of water availability Develop robust policies to allow managers and system operators to switch to delay some components of production when water is limited so that other areas of work can continue Develop a backup plan in the case of disturbances in supplies
Institutional (governance)	The presence of suitable legislation and policies to allow use of alternative types of water in system operations	**No**	Prepare an inventory of different types of water sources available for operations (i.e., stormwater capture and reuse, use of treated wastewater, etc.) Develop an internal policy to permit the use of different types of water across system operations Support the development of a regional polycentric governance system (i.e., management or governance systems that have multiple centers of authority at different scales)
Biophysical (Technology)	Technological ability to secure supplies as and when needed from different sources	**Poor**	Prepare an inventory of different technologies within the organization to secure additional water supplies Assess technical knowledge and skills within the organization Build organizational capacity by providing appropriate technological training
Biophysical (Supply)	Ability to switch between different types/sources	**Poor**	Assess how different components of the infrastructure are connected and their flexibility in switching between operations of different types and sources Conduct a suitable feasibility assessment to assess the ability to quickly mobilize alternative sources of water Develop connections of different parts of the physical infrastructure such that it can be operated in isolation or in combination with other components as and when needed

STEP 3: TEST IMPACT OF RESILIENCE ACTIONS ON RESILIENCE CHARACTERISTICS

Stress tests reveal how well a system, institution, or sector may perform under different conditions. These tests help to determine the current state of an organization's resilience and the predicted impact of resilience actions under a range of scenarios. The stress test clarifies how well the resilience 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 produces the most effective results.

Stress testing is done at two stages: benchmarking stage (performed using the ReST in Step 2.2) and validation stage (performed in Step 3). Companies should benchmark their initial stress test to assess their current level of resilience. This benchmark will then be used in the validation stage to explore resilience actions, or several scenarios with different sets of resilience actions.

A sample baseline assessment from the first stress test (benchmarking stage) may yield a series of low or average results (Table 4), indicating areas for improvement. Areas that receive high scores indicate a business should monitor and reassess the indicator in the future, but no immediate actions are required. Companies should continuously look for opportunities to improve their overall resilience, despite scoring green across certain indicators or characteristics. Stress testing may be quantitative or qualitative and should be performed for each resilience action.

A company can determine the success of its selected resilience actions by the scores produced in the validation stage of stress testing. An example of the result of such stress tests for the resilience characteristics 'Robustness', is presented in Table 4. Here, the company will see a significant improvement across most indicators, across both Tier 1 and Tier 2. The result of the second stress test shows that additional or revised actions are still needed for some subcomponents.

TABLE 4: AN EXAMPLE OF ADVANCED RESILIENCE STRESS TEST (VALIDATION STAGE) FOR RESILIENCE CHARACTERISTIC 'ROBUSTNESS'.

Using Tier 1 indicator for the selected resilience characteristics 'Robustness', the resilience score is 'High'. However, when investigating Tier 2 indicators, there are some system subcomponents scoring yellow and red, implying that there is still scope for improvement.

Resilience score using Tier 1 resilience indicator

Tier 1 indicator	Without resilience action	With resilience actions
Percentage of time that the system withstands shocks and stresses and provides the required level of water-related goods and services	Medium	High

Resilience score using Tier 2 resilience indicators

System component	System subcomponent	Tier 2 indicator	Without resilience actions	With resilience actions
Socio-economic	Access to funds	Economic ability to fund operations and maintenance of the system	Poor	Poor
	Access to funds	Economic ability to fund new or enhanced infrastructure in the system	Poor	Excellent
Institutional	Regulation	Level of regulatory compliance	Medium	High
	Regulation	Maturity of the legal and policy frameworks informing water use	Medium	High
	Regulation	Practicality and applicability of the legal and policy frameworks	Excellent	Excellent
	Governance	Maturity of governance/management systems	Medium	Medium
	Governance	Ability and willingness of the governance system to pay for capital spend on infrastructure development.	Low	Low
	Governance	Ability and willingness of the governance system to pay for operating and maintenance of the infrastructure	Medium	Medium
	Operations/ management	Level of competency of system operators/ managers	Medium	High
	Knowledge systems	Level of knowledge and capacity to understand and implement resilience science and practices	Medium	High

Biophysical	Supply	Degree of diversity, measured as the % of water obtained from each source	**Low**	**High**
	Supply	Degree of reliability of quantity of water from different sources.	**Medium**	**High**
	Supply	Degree of reliability of quality of water from different sources.	**High**	**High**
	Built and/ or natural infrastructure	State of built infrastructure / level of maintained infrastructure	**Poor**	**Good**
	Built and/ or natural infrastructure	Ability of infrastructure to withstand shocks and stresses	**Good**	**Good**
	Built and/ or natural infrastructure	Ability of the constructed/natural ecosystem to provide goods and services	**Excellent**	**Excellent**
	Technology	Access/availability to technology for the system to operate reliably and effectively	**Excellent**	**Excellent**
	Technology	Knowledge and capacity to operate the available technology reliably and effectively	**Excellent**	**Excellent**

During this stress test, test resilience actions or different scenarios to determine whether the actions proposed will improve the resilience of target indicators and characteristics. In the case of long-term actions, increasing water supplies during lean flows may require a business to reduce demand and invest in storage, or other infrastructure with a long horizon. For shorter-term actions, such as increasing flexibility in operation and maintenance, a company can draft a policy relatively quickly, the impact of which is immediate. Actions with longer time horizons and investments may require more stress testing, but by the end of Step 3, a set of actions should be selected for implementation. World Bank (Hallegatte et al., 2021) presents a similar and in-depth example of stress testing for larger-scale projects. It accompanies the World Bank's Resilience Rating System (World Bank Group, 2021) that can be used for major activities or larger collective action projects.

STEP 3 IN PRACTICE

The sand mining company undertakes a second stress test (validation stage) to assess the impact of a few selected resilience actions out of the full list of resilience actions as available from Step 2.4, as a short-term priority exercise targeting to improve the resilience characteristics 'Robustness' and 'Flexibility' (see Table below). Upon performing the exercise, the business may consult with internal and external stakeholders to examine if the expected new status of the resilience indicators is acceptable or whether they need to add other available resilience actions as developed in Step 2.4.

System component	System subcomponent	Tier 2 indicator	Without resilience actions	Selected resilience actions	With resilience actions
Resilience characteristic: Robustness					
Socio-economic	Access to funds	Economic ability to fund new or enhanced infrastructure in the system	**Poor**	Develop external or self-sustaining funding mechanisms from the mining operations to support the development of new or enhanced infrastructures	**Good**
Institutional	Regulation	Level of regulatory compliance	**Poor**	Make law enforcement a priority with efficient case handling of non-compliances	**Excellent**
	Regulation	Maturity of the legal and policy frameworks informing water use	**Low**	Refine the existing laws and policy regularly taking lessons learned from their application	**Medium**
	Governance	Maturity of governance/ management systems	**Low**	Refine the existing management practices based on lessons learned from existing approaches	**Medium**
	Governance	Ability and willingness of the governance system to pay for capital spending on infrastructure development.	**Poor**	Secure funding for such activities in the budgeting of the mining sector/industry Provide necessary training to influence the decision-makers on the effectiveness of such funding options	**Good**
	Governance	Ability and willingness of the governance system to pay for operating and maintenance of the infrastructure	**Poor**	Secure funding for such activities in the budgeting for the operation and maintenance of the infrastructure Provide necessary training to influence the decision-makers on the effectiveness of such funding options	**Good**
Biophysical	Built and/ or natural infrastructure	State of built infrastructure/ level of maintained infrastructure	**Poor**	Regularly assess the state of the infrastructure and maintain as necessary	**Excellent**
	Built and/ or natural infrastructure	The ability of infrastructure to withstand shocks and stresses	**Poor**	Either retro-design the infrastructure to withstand such shocks and stresses or think transformation by implementing alternative solutions	**Good**

System component	System subcomponent	Tier 2 indicator	Without resilience actions	Selected resilience actions	With resilience actions
Resilience characteristic: Flexibility					
Institutional	System management/ operations	Decision-making ability to guide planning, operations and investment	Poor	Develop technical knowledge at necessary organizational levels to make effective decisions Develop robust policies to allow managers and system operators to use new technologies	Good
	System management/ Operations	Degree of flexibility in production and operation	Low	Assess equipment to be able to be switched on and off under different scenarios of water availability	Medium
	Governance	The presence of suitable legislation and policies to allow the use of alternative types of water in system operations	No	Prepare an inventory of different types of water sources available for operations (i.e., stormwater capture and reuse, use of treated wastewater, etc.) Support the development of a regional polycentric governance system (i.e., the management or governance systems that have multiple centers of authority at different scales)	Somewhat
Biophysical	Technology	Technological ability to secure supplies as and when needed from different sources	Poor	Prepare an inventory of different technologies within the organization to secure additional water supplies Undertake an assessment of technical knowledge and skills within the organization Build organizational capacity by providing appropriate technological training	Excellent
	Supply	Ability to switch between different components of the systems	Poor	No resilience action selected in the short-term plan	Poor

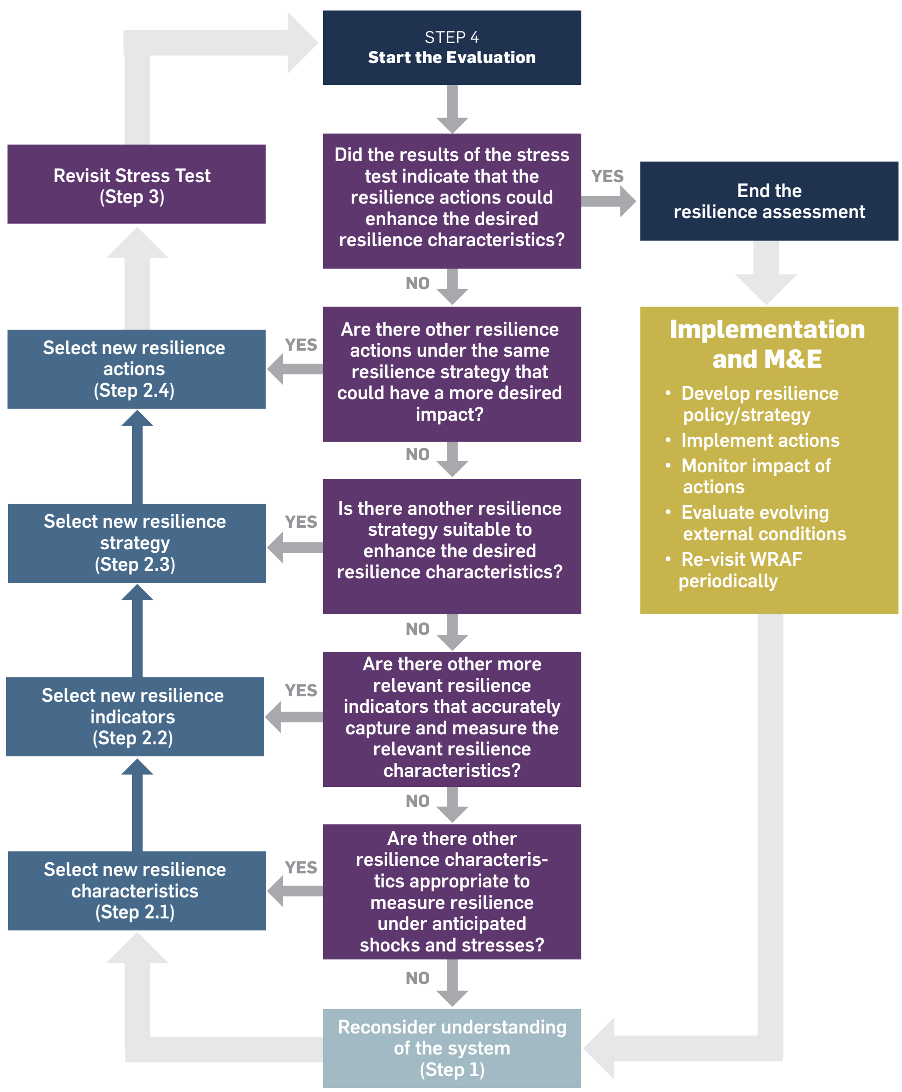
The resilience actions are improving the result of the stress test for several resilience indicators to a varying degree of effectiveness for the current selection of resilience actions under chosen strategies. As the selection of resilience actions follows from the chosen resilience strategies, one must evaluate them properly (Step 4).

STEP 4: EVALUATE THE RESILIENCE STRATEGY

As businesses move into implementation, there is a need to evaluate the impacts of their resilience actions on their resilience using the WRAF. The evaluation and feedback steps presented in Figure 3, helps a business update its indicators, actions, strategy and characteristics. The evaluation of the WRAF should eventually be concluded with businesses implementing resilience actions and monitoring the impacts of these actions. Though a sequential application of the various steps in Figure 3 is desirable, a company may find it easier to do several steps in parallel or prioritize certain sub-steps based on the resources available.

The evaluation in Step 4 should be done regularly, the frequency of which is guided by the changing conditions of the socio-economic, institutional and biophysical subcomponents. Businesses may elect to re-do the WRAF in response to updates to their water system or their own shifting needs.

FIGURE 3: EVALUATION AND FEEDBACK STEPS IN THE WATER RESILIENCE ASSESSMENT FRAMEWORK.



A few examples of monitoring and evaluating corporate water stewardship projects can also be found in a report by TNC and ABInBev (Filoso & Petry, 2021). This evaluation process, suggested in the report, may be comfortably adapted to the proposed resilience metrics and actions within the WRAF.

The WRAF is not a once-off resilience assessment, but rather a framework to inform a continuous process. Many businesses may focus their first WRAF assessment on specific resilience characteristics or narrow boundaries. After developing comfort with the WRAF process, the characteristics assessed, or boundary of the target system may expand. In addition, several scenarios might trigger another round of the WRAF:

1. Changes in system subcomponents: Businesses may identify new, local information that shows problems that had not been accounted for. For example, the emergence of climate-driven drought or new water allocation schemes renders previous models of water availability obsolete.
2. Changes in shocks and stresses: A constantly changing environment may result in new acute or chronic shocks and stresses–such as earthquakes, floods, or other sudden events. A further evaluation of the system is necessary to determine the most appropriate resilience actions, and potentially re-orient activities and resources considering new conditions.
3. Changes in resilience goals: After selecting a resilience strategy, identifying and performing activities and tracking the impact of those activities, a company may reconsider its resilience goals. Certain resilience needs may have been met and other trends became apparent that were not addressed by the current strategy.
4. Changes in internal factors: Operational and internal management changes may re-prioritize internal capacity, resources and objectives. For example, an expansion might require updating the WRAF because a facility has greater needs and reliance on the surrounding system.

Based on these scenarios, businesses may re-evaluate their resilience using the WRAF on a regular timeline. Risk assessments are often performed on three- or five-year cycles and target-setting cycles may run as long as 10 years. The authors do not have a specific recommended timeline for repeat resilience assessments, as this will be context and scenario.

STEP 4 IN PRACTICE

Using the evaluation schematic (Figure 3), the sand mining company, in collaboration with internal and external stakeholders, has decided that the resilience actions for 'Flexibility' do not need any revision at this stage. The next step for the company is to develop the resilience actions for the remaining resilience characteristics ('Robustness', 'Inclusiveness' and 'Just and Equitability') and undertake a stress test at both stages (benchmarking and validation) to evaluate the effectiveness of these actions.

Through this evaluation step, the company can identify new characteristics, indicators and actions to further enhance its long-term resilience. They may also think that their chosen strategy under some characteristics is not suitable for different kinds of shocks and stresses. They may need to revisit strategy selection either choosing a completely new strategy or creating a hybrid version.

The company has also opted to evaluate its resilience periodically and will undertake the WRAF process every three years to address evolving system components, or directly after a significant shock.

Conclusion

The ways businesses have approached water sustainability, stewardship and management have and will continue to evolve rapidly. The addition of resilience principles is not designed to supplant classic water stewardship approaches, but rather to complement and expand these approaches. Developing resilience in the private sector is essential, but, to date, the practice has been limited. This guidance for corporates is intended as a way to get businesses to start the resilience journey and the time to start is now. Resilient thinking is essential to engaging with the uncertainties of our water systems, both present and future. Since businesses are major stakeholders in water systems worldwide, they have a major role in successfully evolving those systems to respond to shocks and stresses.

This guidance presents the key resilience steps a company should take, based on the WRAF, and orders them to best align with corporate water stewardship practices and other approaches. The authors envision that many businesses will take the WRAF and use it first to assess the resilience of a facility or to address the immediate challenges they are facing. More experience and capacity may allow this scope to work outwards into their supply chain or to a wider catchment context. These larger scales may require broader collective action. The foundation of this resilience work has been laid in many of the corporate water stewardship activities businesses already perform. This work may be synthesized with many of the resources provided in this guidance. The resilience indicators and Resilience Scoring Tool presented supplement corporate water stewardship thinking.

Building long-term water resilience is essential for a company aiming to mitigate or adapt to current and future shocks and stresses. Resilience thinking and practice are still nascent in many sectors and geographies, and it is hoped that the WRAF - Corporate Guidance will encourage businesses to engage with the water systems connected with their sites and to think about future trends, possibilities and risks. This guidance is a step forward for businesses to start embedding resilience into their policy and practices.

This document is part of the series of sector-specific guidance documents to implement WRAF. It is focused on corporates and other user of goods and services from the water system. The other sector-specific guidance documents in this series are 'WRAF for utilities' and 'WRAF for river basin authorities and planning managers'. These guidance documents will be revisited and adapted over time.

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Appendix A: Water Resilience Indicators for Corporates

Please visit the Resilience Scoring Tool (ReST) for corporates to understand how to use these indicators in the WRAF process.

TIER 1 RESILIENCE INDICATORS

Resilience Characteristic	First Tier Indicator	Measure	Score Range	Notes on First Tier Indicator	Assessment Level
Robustness	Percentage of time that the system withstands shocks and stresses and provides the required level of water-related goods and services	Low Medium High	Low (<80%) Medium (80-99%) High (>99%)	Does the system continue to operate and deliver desired levels of goods and services even under different conditions/scenarios (e.g., normal versus shock events)? The higher the percentage, the more robust the system is.	Site, Supply Chain and System
Redundancy	Percentage of surplus water-related goods and services from diverse sources present or available in the system	Low Medium High	Low (<2%) Medium (2-5%) High (>5%)	This means that the system has surplus resources or capacity to operate if primary goods/services go down. For example, a company typically relies on surface water. In the case of unprecedented demands or low supplies from surface water, the corporate can still meet demands if they have designed additional systems to secure water, e.g., from groundwater (assuming that the source can meet the demand). The higher the percentage of surplus water-related goods and services, the more redundancy the system has.	Site and System
Flexibility	Degree of willingness and inbuilt capacity in the system to guide planning, investment, and operations	Low Medium High	The score could be based on a value judgement/a qualitative assessment.	The higher the willingness or inbuilt capacity, the greater the flexibility. If there is resistance or unwillingness to change across any of the system components, then the flexibility score will be lower.	Site, Supply Chain and System
Integration	Degree of integration of different components of the water system	Low Medium High	The score could be based on a value judgement/a qualitative assessment.	If all the system components are fully integrated, the score is high. Whereas no or few such connections or coordination would result in a lower score.	Site, Supply Chain and System
Inclusiveness	Level of inclusion of diverse stakeholders in decision making, operating and maintaining the system	Low Medium High	The score could be based on a value judgement/a qualitative assessment.	If the engagement process in making key decisions is inclusive (i.e., all stakeholder groups considered) and if the perspectives of all the stakeholders are adopted, this would result in a higher level of inclusiveness.	Site and System
Just and equitability	Degree of provision of fair and equitable water-related goods and services for all users in the system	Low Medium High	The score could be based on a value judgement/a qualitative assessment.	If most of the available water-related goods and services in the system are fairly distributed to all the stakeholders, this has a higher degree of Just and Equitability. This includes access to water of suitable quality as well as sufficient quantity to meet the demand i.e., WASH.	System

Resilience characteristics: Robustness

System component	System subcomponent	Second Tier indicator	Measure	Score range
Socio-economic	Access to funds	Economic ability to fund operations and maintenance of the system.	Poor Good Excellent	Poor (<70%) Good (70-95%) Excellent (>95%)
Socio-economic	Access to funds	Economic ability to fund new or enhanced infrastructure in the system.	Poor Good Excellent	Poor (<70%) Good (70-95%) Excellent (>95%)
Institutional	Regulation	Level of regulatory compliance	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
Institutional	Regulation	Maturity of the legal and policy frameworks informing water use	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
Institutional	Regulation	Practicality and applicability of the legal and policy frameworks	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Institutional	Governance	Maturity of governance/management systems	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
Institutional	Governance	Ability and willingness of the governance system to pay for Capital spend on infrastructure development.	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Institutional	Governance	Ability and willingness of the governance system to pay for operating and maintenance of the infrastructure	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Institutional	Operations/system management	Level of competency of system operators/ managers	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
Institutional	Knowledge systems	Level of knowledge and capacity to understand and implement resilience science and practices	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Supply	Degree of diversity measured as the % of water obtained from each source	Low Medium High	Low: Access to 1-2 sources Medium: Access to 3-4 sources High: access to >4 sources
Biophysical	Supply	Degree of reliability of quantity of water from different sources.	Low Medium High	Low (<80%) Medium (80-99%) High (>99%)
Biophysical	Supply	Degree of reliability of the quality of water from different sources.	Low Medium High	Low (<80%) Medium (80-99%) High (>99%)
Biophysical	Built and/or natural infrastructure	State of built infrastructure or level of maintained infrastructure	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Built and/or natural infrastructure	Ability of infrastructure to withstand shocks and stresses	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Built and/or natural infrastructure	Ability of the constructed/natural ecosystem to provide goods and services	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Technology	Access/availability to technology for the system to operate reliably and effectively	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Technology	Knowledge and capacity to operate the available technology reliably and effectively	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.

Resilience characteristics: Redundancy

System component	System subcomponent	Second Tier indicator	Measure	Score range
Socio-economic	Access to funds	Emergency financial reserves to operate and maintain the system	Low Medium High	Low (<2% of the overall water-related O&M budget) Medium (2-5% of the overall water-related O&M budget) High (>5% of the overall water-related O&M budget)
Institutional	Governance	Capacity within institutions to govern water systems	None Insufficient Sufficient	The score could be based on a value judgement/a qualitative assessment.
	Operations/system management	Capacity within the institutions to manage the water systems	None Insufficient Sufficient	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Built and/or natural infrastructure	Capacity built into the backup system	None Insufficient Sufficient	The score could be based on a value judgement/a qualitative assessment.
	Built and/or natural infrastructure	Degree of reliability of the backup system	Low Medium High	Low (<80%) Medium (80-99%) High (>99%)
	Built and/or natural infrastructure	Factor of safety in the design, operation and maintenance of the physical infrastructure	Low Medium High	Low (<20%) Medium (20-50%) High (>50%)
	Built and/or natural infrastructure	Ability of the constructed/natural ecosystem to provide goods and services	Poor Good Excellent	Poor (<20%) Good (20-50%) Excellent (>50%)

Resilience characteristics: Flexibility

System component	System subcomponent	Second Tier indicator	Measure	Score range
Socio-economic	System management/ operations	Willingness to consider and adopt alternative types of water in production and operation	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
	Demand management	Willingness to invest in and adopt long-term demand management and efficiency measures	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
	Access to funds	Economic ability to secure supplies from different sources	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
Institutional	System management/ operations	Decision-making ability in planning, operations and investment	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
	System management/ Operations	Degree of flexibility in production and operation	Low Medium High	Low (no to little changes can be made) Medium (slight changes can be made) High (significant changes can be made)
	Governance	Presence of suitable legislation and policies to allow use of alternative types of water in system operations	No Somewhat Yes	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Technology	Technological ability to secure supplies as and when needed from different sources	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
	Built and/or natural infrastructure	Ability to switch between different components of the systems	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
	Supply	Ability to switch between different types/ sources	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.

Resilience characteristics: Integration

System component	System subcomponent	Second Tier indicator	Measure	Score range
Institutional	Governance	Level of integration in decision-making policies, projects or programs that involve different system components	Low Medium High	Low (<50%) Medium (50-80%) High (>80%)
	Built and/or natural infrastructure	Presence of policies and mechanism for financial investment in built infrastructure	No Somewhat Yes	The score could be based on a value judgement/a qualitative assessment.
Biophysical	Built and/or natural infrastructure	Connectedness of different subsystems in a system	Low Medium High	Low (<50%) Medium (50-80%) High (>80%)

Resilience characteristics: Inclusiveness

Socio-economic	Access to funds	Sufficient funding for facilitating stakeholder participation in the decision-making process	Poor Good Excellent	The score could be based on a value judgement/a qualitative assessment.
	Available capacity	Ability of stakeholders to participate in decision-making processes	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
	Knowledge system	Level of integration of Indigenous knowledge into decision-making processes	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
Institutional	Governance	Level of trust existing in the system	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
	Governance	Level of accountability of system operations	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
	Governance	Level of inclusiveness of internal stakeholders in decision making	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
	Governance	Level of inclusiveness of external stakeholders in decision making	Low Medium High	The score could be based on a value judgement/a qualitative assessment.

Resilience characteristics: Just And Equitability

Socio-economic	Access	Level of access to infrastructure	None Insufficient Sufficient	The score could be based on a value judgement/a qualitative assessment.
Institutional	Affordability	Ability to pay for goods and services	Low Medium High	The score could be based on a value judgement/a qualitative assessment.
	Allocation	Presence of suitable regulations in allocating the goods and services	No Somewhat Yes	The score could be based on a value judgement/a qualitative assessment.
	Regulation	Level of regulatory compliance	Low Medium High	The score could be based on a value judgement/a qualitative assessment.

Appendix B: Resilience Scoring Tool - Methodological development

Rationale for development of Resilience Scoring Tool

As resilience science and practice are very recent, traditional water accounting and corporate water stewardship methods and tools need to be better aligned with resilience thinking. There are only a handful of resilience methods and tools developed for specific sectors, contexts and geographies (e.g., CRIDA, Cities Resilience Index, Cluster for Cloud to Coast Climate Change adaptation C5a etc.). As these approaches are not specific to businesses aiming to achieve water-related resilience objectives, a practical tool based on recent development in resilience science for corporates is developed. This Resilience Scoring Tool (ReST) can be used by businesses to explore and build their resilience across on-site operations, supply chains and systems. The tool is designed to complement and build on many of the existing corporate water stewardship materials and traditional stewardship and risk-based information such as AWS (2020), Water Risk Filter Tool, etc.

Method development process

The ReST comprises five elements:

1. Resilience characteristics
2. System components and subcomponents
3. Resilience indicators
4. Impact scoring
5. Assessment level

1. Resilience characteristics

The ReST uses six key resilience characteristics (Chapagain et al. 2021) that relate to the features or qualities present in a water system. The six characteristics were developed and defined by the Pacific Institute (2021). These characteristics can be assessed using appropriate resilience indicators for any relevant system component or subcomponent. Characteristic selection will depend on the nature and needs of a particular business or area of operations being tested for resilience.

2. System components and subcomponents

There are several layers embedded within resilience characteristics, reflected as system components and subcomponents in the ReST. The components and subcomponents influence the nature, scope and scale of challenges to build resilience. The WRAF uses three system components, namely socio-economic, institutional and biophysical components, each with several subcomponents (Table 2). The list of system subcomponents may not be exhaustive, and companies are encouraged to identify additional subcomponents as needed to reflect the nature of the system(s) in which they operate.

3. Resilience indicators

A series of indicators were developed to assess the level of resilience across the identified characteristics, components and subcomponents. These indicators were proposed by the WRAF project team, based on expert knowledge and have been peer-reviewed by the WRAF's Stakeholder Advisory Group (page 2). These indicators reflect the nascent nature of resilience science and may be adapted as the science and practice of resilience improve.

The selection of resilience indicators depends on the scope and the granularity of a resilience assessment required. The ReST groups these indicators under Tier 1 and Tier 2 categories. The list of indicators under Tier 1 category provides a snapshot or a high-level overview of the state of the selected resilience characteristic. This is an initial assessment intended for prioritizing purposes. The indicators under Tier 2 category allow a business to undertake a more granular assessment of the selected characteristics per system subcomponent relevant to the business.

The ReST also provides detailed notes on the suitability, scope and application per resilience indicators proposed in the tool. These indicators may be used as they are, or businesses may modify these to suit a specific context or geography.

4. Impact scoring

To assess the state of resilience using the selected indicators, the ReST provides ranked measures using proposed score ranges. The proposed sets of score ranges are based on expert knowledge and peer-review process and act as the foundation stone for further refinement with lessons learned in the application of the WRAF in future. These score ranges could be slightly adapted based on the local context such as system components and challenges facing the company and system (e.g., the existing institutional constraints and opportunities, legal requirements, socio-economic elements, state of the environment, etc.).

The measure follows a traffic-light system - green indicates a high or good score; yellow/orange indicates an average score; red indicates a low or poor score. The ReST provides a snapshot visualization of the overall resilience of the business. Therefore, the indicators must be assessed twice, first at the benchmarking stage and then at the validation stage using the same measures.

5. Assessment level

Based on the expert knowledge and peer-review process, the ReST helps identify relevant resilience indicators and their applicability across different assessment levels - on site, supply chain and system. These levels of assessment reflect the nature of impacts of internal (within the boundary of a business) and external (system level) variables.

Some resilience characteristics and indicators are only applicable across certain levels of assessment (for example, the resilience characteristics "Just and Equitability" is mainly applicable at the system level) whereas others are applicable across multiple levels (e.g., Robustness and Flexibility).

The project team encourages users of the ReST and WRAF to share any additional system subcomponents, indicators, score ranges, etc. applicable to a specific context. This will support the refinement of the project's methods, tools and guidance documents.

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 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.

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.