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# THE CITY WATER RESILIENCE APPROACH

# ACKNOWLEDGEMENTS

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The CWRA is a joint effort developed in collaboration with our project partner, the Stockholm International Water Institute (SIWI), along with city partners in Amman, Cape Town, Greater Miami and the Beaches, Mexico City, Kingston upon Hull, Greater Manchester, Rotterdam and Thessaloniki, and with contributions from 100 Resilient Cities and the Organisation for Economic Co-operation and Development (OECD).

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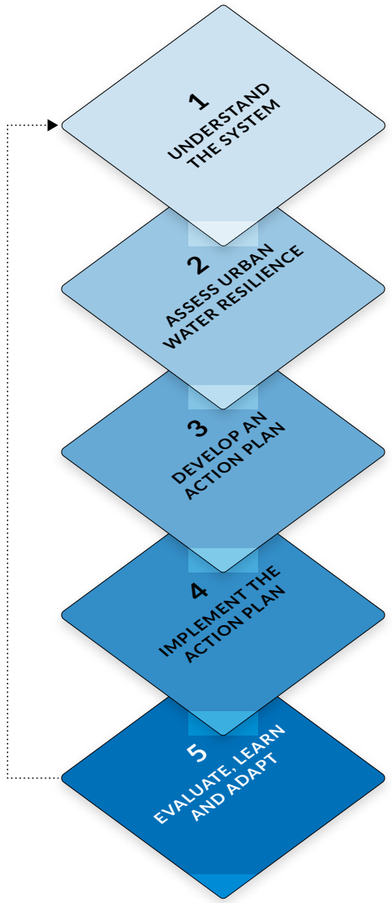
# 1 EXECUTIVE SUMMARY

With cities worldwide expected to grow an estimated 2 billion residents by 2050, there is an urgent need for urban water management that ensures consistent, adequate and high-quality water services for all. However, the scale and complexity of this need presents new challenges to decision-makers in government, civil society and the private sector.

The City Water Resilience Approach (CWRA) responds to a demand for innovative approaches and tools that help cities build water resilience at the urban scale. The CWRA was developed to help cities grow their capacity to provide high quality water resources for all residents, to protect them from water-related hazards, and to connect them through water-based transportation networks ("provide, protect, connect").

The approach is the result of fieldwork and desk research, collaborative partnerships with subject matter experts, and direct engagement with city partners. Based on this research, the CWRA outlines a process for developing urban water resilience, and provides a suite of tools to help cities grow their capacity to survive and thrive in the face of water-related shocks and stresses.






The approach details five steps to guide cities through initial stakeholder engagement and baseline assessment, through action planning, implementation and monitoring of new initiatives that build water resilience:

1 **Understand the system** - in which the city's unique context is appraised to understand shocks and stresses, identify important system interdependencies, convene key local stakeholders and map key infrastructural assets and governance processes.

2 **Assess urban water resilience** - in which the city's current practices are assessed according to the City Water Resilience Framework to identify areas of existing strength and weaknesses that will be addressed by future actions, and establish a baseline against which progress is measured.

3 **Develop an action plan** - where, based on the city assessment, an action plan is developed for realizing interventions that build water resilience. The action plan is based on holistic evaluation of anticipated benefits and costs and prioritization of key projects.

4 **Implement the action plan** - in which actions agreed upon during the previous step are implemented by relevant city actors. In this step, ongoing advice guides how actions are implemented and monitored according to best practices and international experience. In this step, the CWRA provides best practice guidance for how ongoing actions can be monitored to ensure objectives are met, and resources are used appropriately.

5 **Evaluate, learn and adapt** - in which implementation of resilience measures is evaluated and changes in context and stakeholder involvement are analysed to reassess objectives for the next period.

To guide cities through this process, the CWRA offers a suite of resources that target specific challenges or "pain points" identified by cities in their efforts to properly manage water systems and build water resilience:

- The City Water Resilience Framework (CWRF) helps cities evaluate the current areas of strength and weakness in their own urban water systems. The CWRF helps guide cities to build resilience in four dimensions—leadership and strategy, planning and finance, infrastructure and ecosystems, and health and well-being—which are broken down into eight goals, and detailed further in 53 sub-goals. Indicators for each sub-goal allow cities to measure performance and assess the overall resilience of their current water system.
- OurWater is a digital tool that helps cities better understand their local water basin, including the types of shocks and stresses confronted, their impact on natural and man-made infrastructural systems, and the interaction between key stakeholders involved in urban water management.

# 2

# BACKGROUND

As the world's population grows larger and more urbanized, resilient urban water management is critical to ensuring safe, healthy and prosperous cities. Water is an essential condition for human health, a catalyst of economic development, an ingredient in urban place-making and an element in shared culture, heritage and history.

***Partner cities***
Partner cities, clockwise from top left: Mexico City, Miami, Greater Manchester, Cape Town, Rotterdam, Hull, Amman and Thessaloniki

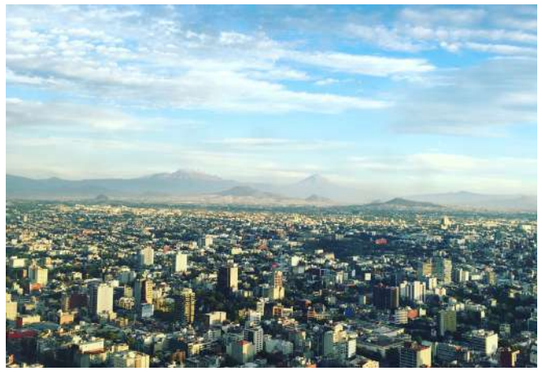
Urban water issues are complex, involving overlapping and interconnected systems and diverse sets of actors. Water services are shaped by financial and political considerations, affected by urban growth, land use planning and environmental management. Given the nature of these relationships, planning for water resilience is neither simple nor straightforward. Cities require tools and approaches that help them understand what drives water resilience and navigate the process of building it.

The City Water Resilience Approach (CWRA) helps cities build the capacity of urban water systems to endure, adapt and transform in the face of new challenges for the benefit of all city residents. It has been developed to guide decisions by a range of stakeholders including government, private sector, academic and civil society actors. Ultimately, the approach will inform how water programmes and projects are planned, designed, delivered and operated to improve outcomes to individuals relying on safe water systems for their health and well-being.

Over the course of twelve months of research, field engagement with eight cities, and consultation with over 700 individual stakeholders, **Arup**—working with the **Stockholm International Water Institute** (SIWI), **100 Resilient Cities** (100RC), **The Resilience Shift**, the **Organisation for Economic Co-Operation and Development** (OECD) and in close collaboration with city partners from **Amman, Cape Town, Mexico City, Miami, Hull, Rotterdam, Thessaloniki, and Greater Manchester**—has identified the critical challenges and opportunities for cities in their efforts to build water resilience.

The CWRA translates this learning into action. It helps cities assess current water management practice, defines a vision for local water resilience, and guides the implementation of key actions.










# WHAT IS WATER RESILIENCE?

The concept of resilience emerged from the field of ecology in the 1970s to describe the capacity of systems to maintain or recover functionality in the event of disruption or disturbance. Since then, the idea has gained purchase in many other academic disciplines, from the natural sciences to the humanities. It is of particular relevance to theorists and practitioners working in the fields of urban development, where the concept of *city resilience* provides insight into managing chronic stresses or sudden shocks that threaten widespread disruption or the collapse of physical or social systems. Resilience has also helped to bridge the gap between disaster risk reduction and climate change adaptation by focusing on enhancing the performance of a system in the face of hazards, rather than preventing those hazards from occurring.

*Water resilience* describes the capacity of cities to function in the face of water-related stresses so that those living and working within the city can survive and thrive. Moreover, because overall city resilience, water resilience and catchment level resilience are mutually interdependent, an assessment of urban water resilience must consider hydrological context (including water basins), built infrastructure, and the socio-political and economical context (i.e. human, social, political, economic, physical and natural capitals) (Arup, 2014). In a similar sense, water resilience must consider the interrelationships between water and other critical urban systems. A holistic approach to resilience is therefore key to designing interventions that make systems resilient (Rechkemmer and Falkenhayn, 2009).

As water allocation, distribution and use happens every day in formal and informal ways, building resilience needs to be grounded in the existing decision-making processes around the socio-political, economical and hydrological urban context (see Case Study 1). Stakeholders working across different levels of water system have specific governance responsibilities, with one actor or institution sometimes taking on multiple governance roles and responsibilities. In building the resilience of urban water systems, it is critical to improve the processes that impact who gets what services, where and how (Allan, 2001). Governance is a core component in building resilience and is reflected throughout each of the CWRA steps, which address who makes decisions and how those decisions are made, who gets to participate in decision-making, and who benefits as a result. To build water resilience, new initiatives must therefore address the duplications, overlaps and gaps in the roles and responsibilities of stakeholders working across multiple levels and sectors, responding to different shocks and stresses and addressing the ways water resource management may be hindered by the governance gaps in policy, administration, coordination, funding, information, and accountability (OECD, 2011).

A water resilient city is one that can survive and thrive in the face of shocks and stresses related specifically to water—ranging from drought to flooding, storm surges, and sea level rise—and adequately mitigate the impact of all shocks and stresses on the urban water system (e.g. the impact of an earthquake on key water infrastructure). Resilience in this context means that the city exhibits the capacity to:

1. Provide access to high quality water resources for all residents.
2. Protect residents from water-related hazards.
3. Connect residents through water-based mobility.

The CWRA provides a model for water resilience and outlines a path for achieving these three capacities.



### Case Study 1: Decision-making across different levels in Cape Town

In an interconnected water system, lack of coordination between institutions working across different levels can pose serious challenges to building resilience. Cape Town's main catchments include the mountain fynbos areas located to the east and north-east of the city. Water to the City of Cape Town (CCT) is transferred from other catchment areas as well, which includes Berg, Riviersonderend and Palmiet Rivers through an integrated water supply system called the Western Cape Water Supply System (WCWSS) (City of Cape Town, 2018). Nearly 14 dams are integrated to the WCWSS, with a collective capacity that feeds Cape Town (City of Cape Town, 2018). Three of these dams (Theeuwaterskloof, Voelvlei and Berg River Schemes) are owned and managed by the National Department of Water and Sanitation (DWS).

## FOCUSING ON RESILIENCE AT THE URBAN SCALE

Water resource management involves large numbers of actors and multiple nested, overlapping, and interconnected urban systems. Water is impacted by energy and transportation networks, and directly affected by land use and waste management practices. It guides economic growth, is driven by local politics and shaped by relationships between local stakeholders.

As a result, water resilience demands action at a large scale, through interventions that affect the myriad systems that impact water service delivery. Because the natural water cycle does not neatly align with administrative or political boundaries, the CWRA encompasses actors existing throughout the urban area, including stakeholders that operate beyond city limits but whose influence is felt by city residents.

While recognising the influence of these actors, the CWRA focuses on the city as the ideal scale for meaningful participation by diverse local stakeholders, including academia, civil society and the private sector. Ultimately, it guides actions implemented at the urban scale and for the benefit of city residents.

In this way, the CWRA strengthens the symbiotic relationship between the city and its catchment, connecting the range of stakeholders and systems that bridge natural and urban systems.

# 3

# THE CWRA VALUE PROPOSITION

With an estimated 2 billion new urban residents estimated by 2050, there is a clear demand for new approaches to providing essential services to city residents (United Nations Department of Economic and Social Affairs, 2018). At the same time, global water crises—from drought to flooding—are the biggest threat facing the planet over the next decade. One-third of the world's population currently lives in water-stressed areas and 10% of the world's population are in low-elevation coastal zones. An increase in the frequency of extreme weather events due to climate change will profoundly impact communities globally. The scale and complexity of these impacts present both a conceptual challenge—to understand and measure a concept as complicated and fundamental as resilience—and a practical one, requiring long-term coordination across multiple stakeholders to undertaken meaningful action in cities.

Because holistic urban water resilience is a new consideration for most cities, there are few rigorous approaches currently available. Even when cities recognize the need for water resilience, they confront significant hurdles in achieving this goal. For one, building urban water resilience requires a shared understanding of what is meant by 'water resilience' and yet cities often lack the time, resources or inclination required to identify a common vision. Once a vision has been agreed upon, clearly defined actions are needed to translate that vision into real and meaningful action. Throughout, new tools are needed to aid cities facilitate the process of building water resilience.

# THE CITY WATER RESILIENCE APPROACH (CWRA) VALUE PROPOSITION

Clearly, there is an urgent need to support cities in their efforts to provide high quality water services to their growing populations. The City Water Resilience Approach (CWRA) addresses this demand by proposing a detailed process for planning, designing, delivering and operating resilient water systems.

The CWRA describes a five-step process that moves from stakeholder engagement and city assessment, to creating and implementing action plans, and then evaluating results to reassess objectives and priorities and inform future programmes. Within each step (described in detail in Chapter 5) the approach outlines a detailed methodology for achieving the goals according to best practices, and a suite of tools that can be used to achieve this goal.

Additionally, the CWRA provides a set of resources to assist with the individual steps along the process, corresponding with the five steps. These are meant to reduce the time and effort required to complete each step and consist of a mix of digital and analogue tools (see Chapter 5). Specifically, the approach responds directly to cities' critical needs in the following ways:

**The CWRA helps cities formulate a clear vision of what urban water resilience means to them,** including what specific conditions must be accomplished to achieve this vision, what efforts will be required to build resilience and what actors are involved in this project. For each city, the CWRA develops a vision plan that guides future actions. This plan is informed by extensive research into what makes up resilience, and builds off review of international best practices, insights from academic scholarship, and practical experience with eight pilot cities.

**The CWRA provides a detailed plan for prioritizing key actions in cities and implementing them** to achieve the city's water resilience plan. Based on an assessment of each city's strengths and weaknesses, the CWRA describes a rigorous, practical and researched process for translating shared vision into reality. The approach helps cities identify key actions and then guides them as they implement and monitor those actions.

**The CWRA provides resources that will help cities carry out each step of the process**. These tools include a mix of analogue and digital tools—including the City Water Resilience Framework (CWRF) and OurWater—that facilitate the critical steps along this process and address the practical problems that cities face.

**The CWRA establishes an extensive and continuously growing body of knowledge on urban water resilience that cities can draw on** to share experiences, identify innovative new approaches, and advance a community of practitioners at all stages of the resilience approach. As the CWRA expands to additional cities, the community of practitioners will benefit from new experiences, and help catalyse partnerships between a range of users and funders.




## WHO CAN USE THE CWRA?

The CWRA is intended for all actors that are committed to building water resilience and who are able to effect change at the urban scale. The approach has been designed for cities of different sizes, located in diverse natural and developmental conditions, and which confront different shocks and stresses.

In fact, the only criteria for leading the CWRA in cities are that local champions have the local knowledge, resources and expertise to bring together a diverse set of stakeholders towards developing and implementing an action plan for their city.

The CWRA is designed for a wide range of adopters, with the recognition that building resilient practices requires diverse voices. While in many cases the appropriate city champion will be city government, local champions might come from specific public agencies or non-governmental actors such as inter-governmental organizations, development banks, public utilities, academia, NGOs, civil society, the private sector and community groups.

The local resilience champion can be a single organization or a team of organizations working together. The champion is identified at the onset of the CWRA process and leads the approach through all five steps, with ongoing advice and support from the advisory team.

*Table 1: CWRA value proposition*

| KEY STAKEHOLDERS | COMMON CHALLENGES | DIRECT GAINS | VALUE |
|---|---|---|---|
| **High-level decision-makers in:**<br>- *City Government*<br>- *Regional/National Government*<br>- *Private Sector* | - Logistical challenge of identifying and convening all relevant stakeholders<br>- Complex, time-consuming process required to agree on a shared plan for resilience<br>- Difficulty communicating benefits of resilience to constituents for buy-in (citizens, corporate stakeholders, board of directors, etc.) | - Suite of resources for identifying and mapping relevant stakeholders, roles and links<br>- Detailed five-step process for achieving end goal, realized according to clearly defined objectives and time horizons<br>- Clear articulation of holistic benefits of resilience to all stakeholders | **The CWRA helps cities formulate a clear vision of what urban water resilience means to them,** including what specific conditions must be met to achieve this vision, what efforts will be required to build resilience and what actors are involved. For each city, the CWRA develops a vision plan to guide future actions. This plan is informed by extensive research into what makes up resilience, and builds off review of international best practices, insights from academic scholarship, and practical experience with eight pilot cities. |
| **Department / organizational heads in:**<br>- *City Government*<br>- *Water Utilities*<br>- *Private Sector*<br>- *Multi-National Government Organizations*<br>- *Regional/National Government*<br>- *Catchment/Basin Authorities*<br>- *NGOs*<br>- *Community Organizations*<br>- *Development Banks* | - Lack of tools to help identify/assess how the city is performing at a high level<br>- No systematic approach to identifying and prioritizing necessary actions<br>- Little cross-organizational agreement on action plan and actors involved to improve performance<br>- Limited opportunities for communication between cities or awareness of innovations being piloted (i.e. what other cities are doing and who can resilience practitioners learn from) | - CWRF shows how city performs in 12 goals of urban water resilience<br>- Develop a coherent vision with targets for resilience<br>- Detailed five-step process for achieving defined objectives according to defined time horizons<br>- New platforms (digital platforms, conferences, etc.) for sharing knowledge across cities | **The CWRA provides a detailed plan for prioritizing key actions in cities and implementing them** to achieve the city's water resilience plan. Based on an assessment of each city's strengths and weaknesses, the CWRA describes a rigorous, practical and researched process for translating shared vision into reality. The approach helps cities identify key actions and then guides them as they implement and monitor those actions. |
| **Department heads *or* technical leads in:**<br>- *Development Banks*<br>- *Multi-National Government Organizations* | - Difficulty finding projects to fund with well-considered actions, clear resilience benefits and broad support from stakeholders | - Action plan prioritizes key projects including potential costs and benefits of projects, with wide stakeholder buy-in | **The CWRA provides resources that will help cities carry out each step of the process**. These tools include a mix of analogue and digital tools—including the City Water Resilience Framework (CWRF) and OurWater—that facilitate the critical steps along this process and address the practical problems that cities face. |
| **End users :**<br>- *Residential Users*<br>- *Commercial Users*<br>- *Citizens/Electorate* | - Limited understanding of individual's role within a wider water system and awareness of opportunities to impact water services in their city<br>- Poor coordination between water providers results in lower quality of water service for end-users | - Mapping of the water system to show role of various actors and how individual users can best influence governance processes<br>- Better coordination results in improved water service<br>- Action plan combining a bottom-up and top-down approach, and focusing on resilience dividends to final users | **The CWRA establishes an extensive and continuously growing body of knowledge on urban water resilience that cities can draw on** to share experiences, identify innovative new approaches, and advance a community of practitioners at all stages of the resilience approach. As the CWRA expands to additional cities, the community of practitioners will benefit from new experiences, and help catalyse partnerships between a range of users and funders. |

# 4

# DEVELOPING THE CWRA

The CWRA is based on a mixed-method research approach that included desk studies to identify current trends in thinking on the subject, and field engagement to better understand the needs of city partners. The following section is divided into three parts corresponding with three phases of research used to develop the CWRA: (i) literature review, (ii) fieldwork and (iii) data processing and analysis.

## LEARNING FROM LITERATURE

The Arup team reviewed literature describing the assets, practices and qualities that help build water resilience; the types of shocks and stresses typically encountered; and commonly used tools, approaches and frameworks. In total, we examined more than 50 academic sources, and 40 sources on shocks and stresses. These included academic literature, government and regulatory reports, and guidance from non-government, non-profit and policy institutions. Based on these investigations, the research team created a database of 750 factors that contribute to the resilience of urban water systems.

The literature review reinforced the need to understand water resilience as a function of interdependent *urban systems*. A systems-based approach to urban resilience differs from an asset-based approach, which focuses on physical assets rather than considering intangible forces that influence human behaviour. Systems-thinking helps account for the important ways governance influences decisions around assets, how socio-cultural systems determine human behaviour, and how these phenomena ultimately impact how physical systems are designed and used in the urban environment. The literature also suggested the need for coordination between interdependent systems operating at different scales.

Workshop in Mexico City

Additionally, the team assessed existing guidance documents, including eight approaches, nine frameworks and 14 tools designed to assess resilience in the context of cities and/or water systems. In this context, *approaches* or implementation programmes describe processes, methods or activities which typically serves to solve a specific problem. Approaches are realized through the use of various resources, including conceptual frameworks and tools. *Frameworks* refer to overarching systems of ideas or concepts that are used to assess or understand an issue. Finally, once broad objectives have been defined, *tools* are used to facilitate the specific tasks required to achieve necessary results.

Based on our review, we concluded that a need exists for a holistic approach (i.e. methodology) to building water resilience. The approach should address the physical and hydrological elements of the city's water system, as well as aspects related to governance, institutions and human behaviour. It should be relevant in the context of economic, physical and social disruption and apply at the full catchment scale rather than to individual systems within a city. Our analysis of the literature also led to key principles that guide the CWRF (see Chapter 6: The City Water Resilience Framework). A detailed description of the CWRA literature review can be found in the CWRA Water Resilience Literature Review, a separate report.



Workshop in Kingston upon Hull

## LEARNING FROM CITIES

To ensure that the CWRA is practical and grounded in the experiences of cities, the second stage of research involved fieldwork in five "Wave 1" cities: Cape Town, South Africa; Mexico City, Mexico; Miami and the Beaches, United States; Kingston upon Hull, United Kingdom; and Amman, Jordan. Fieldwork involved 10 workshops and 38 structured interviews, with 710 participants in five cities. In an additional three "Wave 2" cities—Rotterdam, Holland; Thessaloniki, Greece; and Greater Manchester, United Kingdom—the team provided remote support to city partners leading on-the-ground engagement.

We selected these eight pilot cities because they confront persistent water-related shocks or suffer chronic water-related stresses, and have expressed commitment to co-creating water resilience approaches. The cities represent diverse geographies, face a range of shocks and stresses, and use various political systems. By casting a wide net, we anticipated the need for an approach that works in a range of cities around the world, confronting different challenges in different socio-political contexts.

In each city, the research team carried out workshops, focus groups and key informant interviews with people from the municipal government, utility providers, business and civil society. Site visits helped us better understand the realities of water shocks and stresses in each city, and the tools and approaches currently used to tackle those problems. Across the five cities, we collected data on factors of resilience—the assets, practices/procedures or behaviours that contribute to the resilience of their respective city. Through this process, the team identified a total of 1,577 factors that either helped or hindered resilience building in each city. For a detailed description of engagement in all cities see Annex C: CWRA Fieldwork Report.

## PROCESSING AND VALIDATING RESULTS

To analyse the information collected as part of city missions, we employed a joint *emergent* and *a priori* coding technique to aggregate factors into smaller number of groups. In emergent thematic coding, the coder identifies categories on-the-fly through the process of reviewing raw data. This differs from a priori coding, where the coder defines categories before data is reviewed, and each record assigned its best fit (Blair, 2015). Coupling a priori and emergent qualitative analytic methods enabled the work to build on previous research insights while also remaining open to the possibility of new themes revealed through data exploration.

Through this process, individual positive and negative factors were aggregated into groups called 'sub-goals' that combined related factors—for instance, all pertaining to 'insurance' or to 'flood protection.' Sub-goals were then translated into positive contributors to resilience, and validated against the seven 'qualities of resilience' to ensure they reflect commonly accepted definitions for resilience (Arup and the Rockefeller Foundation, 2014b). Through this analysis, the team identified a total of 84 sub-goals. To this, we added an additional nine sub-goals derived from an Arup literature review, and 21 sub-goals proposed by the Stockholm International Water Institute (SIWI) based on a review of literature on water governance and SIWI's diverse experiences working on global water issues. Sub-goals were aggregated again into larger groups, named 'goals,' representing families such as 'collaborative governance' or 'sustainable funding.' Based on this combined set of goals and sub-goals, the project team conducted a series of internal workshops to develop a draft version of the resilience framework, which outlines the key elements of urban water resilience.

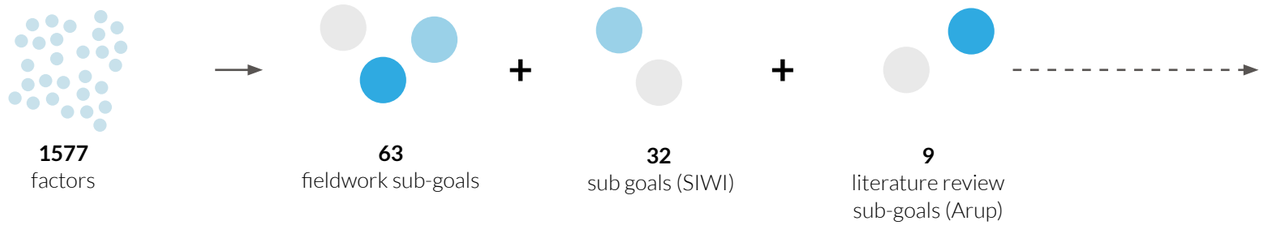
To validate findings from our fieldwork and literature review, the team tested the draft framework with partners from seven cities at the Global Knowledge Exchange (GKE), an event hosted by Arup and the Resilience Shift and held at the Lloyd's Register Foundation in London from August 21-23, 2018. The event provided an opportunity to share lessons learned, and to validate the team's research findings. In a series of workshop exercises held over the course of three days, participants were asked to highlight gaps in the draft framework, identify irrelevant sub-goals or goals, rearrange the location of sub-goals, and suggest clarifications to language where applicable.

GKE stakeholder validation exercises helped inform changes to the CWRF based on general participant feedback and the results of specific workshops. Again, a series of internal workshops tested an updated draft to ensure the framework remained coherent, consistent and intuitive.

The validation process has resulted in the set of 53 sub-goals and 12 goals that comprise the CWRF. As a final step, the team is currently identifying indicators (i.e. quantifiable metrics) for each sub-goal, based on analysis of literature on the topic of indicators, indices and resilience measurement, field experience, and review of global best practices.

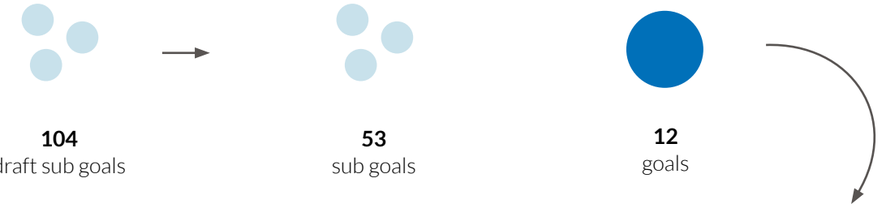
*Combining sub-goals from fieldwork, experience and literature*

### BUILDING INDICATOR POOL

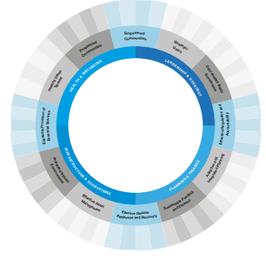



*Refining and validating initial indicator pool*

### WHERE WE ARE NOW




This data processing and validation process resulted in a framework for resilience, which consists of four dimensions, twelve goals, and 53 sub-goals (see Structuring the CWRF). For a detailed description of how factors were processed following fieldwork engagement and public workshopping see Annex A: CWRF Data Processing Methodology.



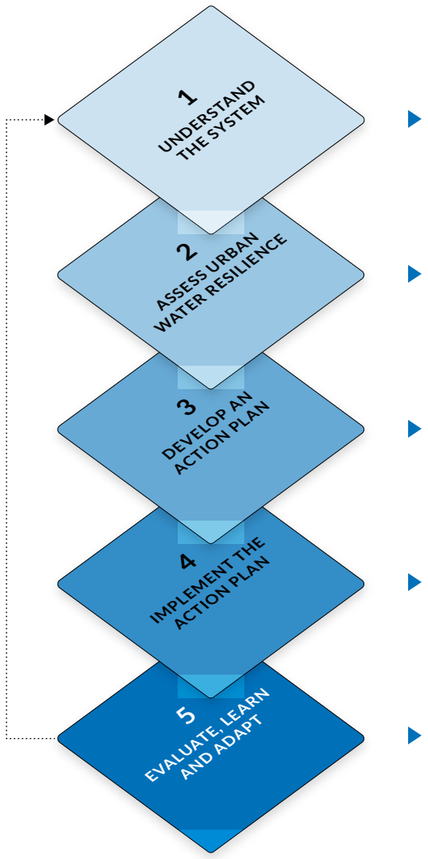
# 5

# THE CITY WATER RESILIENCE APPROACH

The result of the research process—combining a review of literature, interviews and workshops with key stakeholders, input from outside experts and observations of field conditions—is the City Water Resilience Approach (CWRA), which is presented in detail in this section.

The desktop study confirmed the demand for a broad approach or implementation process to guide action, as well as specific tools or frameworks to help cities carry out that process. The CWRA includes a mix of activities, frameworks and tools used to address this demand.

The CWRA outlines five key steps, with activities under each step, including the methodologies and resources to be used in each step. These resources include the City Water Resilience Framework (CWRF) and other governance analysis resources, along with workshop and programming activities recommended to develop an improved understanding and approach to building urban water resilience. The approach recognizes the need to understand urban water systems from a holistic perspective, and the need for in-depth analysis to improve understanding of governance of urban water resilience for achieving better outcomes.




1. Establish a city champion
2. Collect background information
3. Multi-stakeholder inception workshop

**Resources:**
- OurWater

1. Research data collection
2. Assessment and diagnosis process
3. Findings report
4. Validation workshop

**Resources:**
- CWRF
- Stakeholder responsibility matrix

1. Interpretation of results
2. Prioritizing
3. Develop a Joint Action Plan

**Resources:**
- Governance analysis
- A CWR action plan toolbox

1. Develop a monitoring and evaluation mechanism
2. Engage facilitators and coaches
3. Evaluation of the baseline assessment

**Resources:**
- A CWR action plan toolbox
- Workshop facilitator's guide book

1. Evaluate the implementation of resilience measures
2. Analyse changes in context and stakeholders' involvement
3. Re-assess objectives for next period



# 1 UNDERSTAND THE SYSTEM

Clearly defining the urban water system according to a holistic view is a fundamental first step in undertaking a resilience assessment for a city. The two major components comprising this step are:

1. Defining the basin(s) upon which the city depends
2. Engaging with the individuals and organisations that have jurisdiction over different elements of the water cycle in these basins

Urban water systems are complex. Cities draw upon larger catchment areas extending beyond administrative boundaries, connected to one or more water basins that cross cities, states or even national boundaries (Bahri, 2012) beyond the city's control. This often leads to spatial-scale misalignment between the boundaries of urban water governance and the wider water systems on which the water system depends.

Understanding the basin extent, and stakeholders located within, is a critical first step. Industry, the environment and citizens present competing demands within the city and across the Basin. For example, in the case of flooding, one cannot understand and mitigate risk without considering the upstream basins that contribute to flows through the city. Cities located in water basins that cross national borders, confront governance, technical and political challenges, which are beyond the influence and control of city authorities. For example, the roles and responsibility for negotiations, cooperation, coordination over the transboundary water resource management (TWRM) often lie under the mandate of the ministry of water resources, basin authorities or the ministry of foreign/external affairs. However, city-based authorities such as municipalities or utilities and even end-users have no control over transboundary water issues and their engagements in TWRM is often limited or absent.

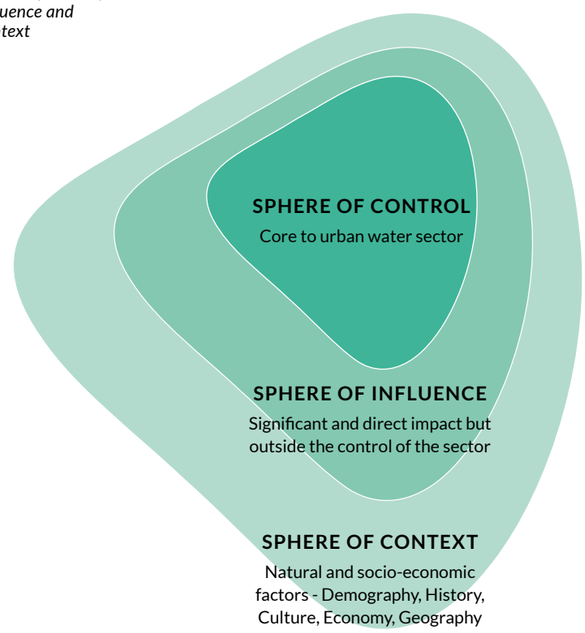
Along with these complexities, interdependencies exist between the city water system and other systems (e.g. energy, agriculture and food supply, land, forest, communications and transportation) that impact and are impacted by the water sector. Each of these sectors has their own priorities, policies and programmes, and often there is a lack of coordination and interactions among stakeholders. These conflicting interests and lack of policy coherence often lead to poor management and hinders achieving development goals.

It is important to note that the stakeholders in the system are responsible for certain water governance functions that happen within a set of broader institutional factors (where the city can influence but do not completely control), as well as long-term structural or contextual factors such as history, culture and demography, economy and geography, which define the control and influence boundaries of the stakeholders (Figure 1) (Jiménez et al, 2016). Mapping the stakeholders by different governance functions (Table 2) across these spheres of control and influence will help identify all the responsible actors for each of those governance functions, including those that are core to the sector and those which may affect or be affected by the sector.

A multi-level, multi-sector stakeholder approach is grounded in a good-faith, shared understanding which will help create the spaces to share diverse knowledge, reflections, learning and innovation, further improving the capacity to building resilience. This multi-stakeholder approach refers to actors and institutions working across levels (local, regional, national and transboundary) and sectors, including public, private, civil society and communities, as all stakeholders of the wider urban water system engage with the city stakeholders. This multi-stakeholder approach is important throughout the process of CWRA to communicate, identify gaps, identify priority areas, and effectively develop, plan and implement a resilience strategy.



*Sphere of control, influence and context*




### Sphere of control, influence and context

The spheres of control, influence and context provide critical thinking around different governance functions, institutions and actors responsible for managing the water system and other interdependent and interlinked systems. This approach helps in identifying the stakeholders that have primary roles and responsibilities for a particular governance function in the urban water sector (sphere of control), along with the stakeholders that do not have the mandate and control over that function in the sector but may directly or indirectly impact the sector's performance (sphere of influence) and are equally important. The outer sphere (sphere of context) describes the broader and long-term structural factors such as demography, history, culture, economy and geography. The spheres of control and influence, will be context-specific, and may vary greatly from one city to the next based on the stakeholders involved in the process. This critical thinking around the spheres provides the necessary guidance to bring all the relevant stakeholder to the discussion, which is crucial towards meeting an effective outcome that may otherwise be ignored or go unseen.

***Table 2:*** *Mapping stakeholders by governance function, showcasing a typical drought example*

| KEY FUNCTIONS | GUIDING GOVERNANCE QUESTIONS: DROUGHT |
|---|---|
| Preparedness and Planning | Is there a disaster preparedness plan for drought? Does an early warning system exist? If so, who is responsible for this planning? |
| Coordination | Do you have a coordination mechanism in place in case of drought? Who is involved? Who are the stakeholders with whom you need to collaborate and coordinate? |
| Policy and Strategy | Do you have a strategy for drought management? Do you have an operational plan for implementation of the strategy? Who is responsible in this policy making and who is involved? Which actors are responsible for implementation of the strategy? |
| Financing | Are there regular funds directed to drought management? Who is responsible? |
| Regulation | Do you have applicable exceptional regulations in case of drought? Who is responsible? |
| Capacity Development | Do you have sufficient human and technical capacity to manage drought? Who is responsible for providing the finance, the technical capacity development? Which stakeholders are involved in these capacity development programmes and which are the target groups? |
| Monitoring, Evaluation and Learning | Do you have a systematic process of collecting evidence, evaluating, analysing and using this evidence for managerial decisions to adapt and improve policies and programmes. Which actors are responsible and involved? Are civil society and community networks part of the monitoring and evaluation? |
| Immediate Response Procedure | Do you have the provision for immediate response to drought? Which actors are responsible? |

1

# ACTIVITIES

### ESTABLISH A CITY 'RESILIENCE CHAMPION'

This initial activity aims to engage with a city 'resilience champion' that is motivated and has the leadership, convening power and responsibilities to be able to push forward the initiative during the initial stage. The local resilience champion can be a single organization or a team of organizations working together. The champion is identified at the onset of the CWRA process, and leads the approach through all five steps, with ongoing advice and support from the advisory team as needed. It is important that the resilience champion take into consideration the following information:

- Human, technical and financial resources are secured for carrying out the five-step process.
- A clear understanding among the team of the entire process, including the city water resilience idea, the CWRA and its objectives, to ensure that the team, with help from internal/external facilitators, can provide necessary support to the stakeholders throughout the process.
- The resilience champion will also coordinate and facilitate the data collection through the OurWater webtool along with identifying and coordinating with user groups, etc.
- The champion will take the lead in facilitating the entire process through a transparent, inclusive and accountable way.
- The champion will be responsible for conducting the preliminary data collection process and validating it, by referring to different methodologies and tools recommended under this activity, to collect background information and organize a Multi-Stakeholder Inception Workshop.

### COLLECT BACKGROUND INFORMATION

The city resilience champion will collect background information through preliminary desktop review, interviews with key stakeholders and focus group discussions, along with developing an understanding of the urban water system and the institutional landscape governing the system, by using the following tools:

- Definition of the water system: basic schematic drawing of key elements of the water system and their relationships.
- Mapping of the institutional landscape governing water using the OurWater webtool: mapping of stakeholders and their responsibilities, with jurisdictions over elements of the water system and basic representation of key functions related to the water system. This mapping can be performed by water related subsector if relevant, (e.g. water supply, wastewater treatment, natural and urban environment management).
- Characterisation of shocks and stresses using the OurWater webtool: basic schematic representation of shocks and stresses to understand how they affect different parts of the system and its interdependencies with other systems.
- Mapping the network of stakeholders: While the mapping of the institutional landscape helps identify the key stakeholders in the water system, the mapping of stakeholder networks is an important aspect of governance to get an in-depth understanding of the institutional arrangements, through a stakeholder network diagram. Often there are large number of authorities involved in water resource management decisions, without a clear understanding of their roles and responsibilities for 'who does what, at what level and how' (OECD, 2011), and the stakeholder network diagram will help map the link between the stakeholders in terms of the roles performed.

### MULTI-STAKEHOLDER INCEPTION WORKSHOP

A multi-stakeholder inception workshop allows the resilience champion to convene the water system partners around a common understanding of the city water resilience idea, and validate the background information and data collected through an inclusive, transparent and a collective sense-making workshop. The workshop should provide the city the opportunity to:

- Present and validate the background information (water systems, stakeholder mapping and network, characterization of shocks and stresses).
- Discuss the scope, motivation and objective of CWRF in building resilience capacity.
- Identify other potential partners to be engaged in the process. Based on the thinking around the spheres of control and influence, map the stakeholders by the governance functions, discuss if inclusion of other potential stakeholders could help in strengthening the discussion and who might be key to address some of those governance gaps; and agree on the partner engagement strategy. This exercise will also help build on the findings from background data collection and validating that information.
- Discuss and plan for Step 2 of the CWRA, 'Assessing City Water Resilience' to introduce the CWRF, its objectives, indicators and goals.

### CITY CHARACTERISATION REPORT

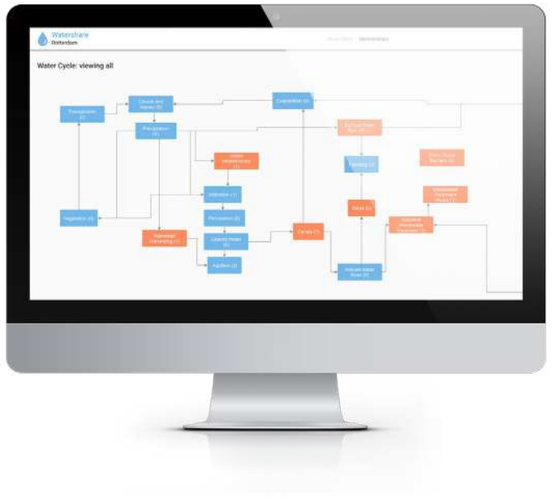
Through desk review and workshopping with city stakeholders, the resilience champion works with local stakeholders to develop a City Characterisation Report that outlines key shocks and stresses encountered in the city, identifies stakeholders and describes ongoing programmes, projects and policies. This document summarizes actions at the start of the CWRA process and can be referred to in future phases to identify initial actions taken, and inform which actions are taken as part of Step 3: Develop an Action Plan.

## 1 METHODOLOGY

Step 1 is performed through desktop review, interviews with key stakeholders and focus group discussions using a snowball sampling methodology (in which key issues and actors are identified as the study progresses based on a growing body of knowledge). To understand the system, the OurWater webtool and multi-stakeholder inception workshop help identify relevant stakeholders, interdependent urban systems and shocks and stresses that affect the city.

## 1 RESOURCES

The OurWater digital tool is designed to help cities better understand their local water system, including the types of shocks and stresses confronted, the impact of various hazards on natural and man-made infrastructural systems, and the interaction between key stakeholders involved in urban water management. OurWater allows users to input information about the infrastructure and governance processes they participate in, and to map relationships between stakeholders throughout the entire water system. By answering key questions about the number, type and interaction between assets and actors that make up the water system, the tool addresses a fundamental challenge in many cities, where water governance functions are often siloed, and limited coordination, collaboration and knowledge sharing exists between actors working in the water system. In crowd-sourcing these tasks, OurWater creates a platform for city-wide information supplied by users across multiple sectors and levels of government.




*The OurWater digital tool*



## DEVELOPING RESOURCES FOR RESILIENCE

To help cities enact the multi-step CWRA process, we have developed a suite of resources, including digital and analogue tools and frameworks, with additional resources planned for the following steps of the approach. In developing these resources, the project team first identified guiding qualities to inform this work, based on field research and inputs from project partners:

**1. Practical**—New resources developed to advance the CWRA should be low-cost in terms of the time and resources demanded of users, and the level of technological sophistication assumed. If they are not, users will find more convenient alternatives or will return to the methods they used before.

**2. Flexible**—Cities confront different challenges and have access to different types of resources. Tools and frameworks should therefore be flexible enough to work in diverse contexts. Because the CWRA has identified a range of possible lead actors in cities, new tools must be made easily adoptable by multiple users, including government, inter-governmental organizations, development banks, public utilities, academia, NGOs, civil society, the private sector and even community groups. Tools should be designed for inputs from a wide range of actors, and can be deployed by any of the type of actors described above with the interest and resources to do so.

**3. Consistent**—The desire for flexibility should be balanced with a need to maintain a consistent view of resilience. For instance, in developing the CWRF (see The City Water Resilience Framework), the team recognized the important of putting forth a coherent view of what drives resilience, in the form of 12 goals and 53 sub-goals. While the CWRF allows for flexibility in the ways that cities achieve these goals (i.e. the specific solutions adopted), the goals themselves are the result of extensive collaborative research and will not change between cities.

In moving from general principles to specific tools and frameworks, Arup worked closely with project partners to better understand the needs and challenges that cities confront. Each new addition therefore targets a specific challenge or "pain point" identified by cities in their efforts to properly manage water systems and build water resilience. Initial engagement with city partners, and user testing in the five Wave 1 pilot cities—Amman, Miami, Cape Town, Mexico City and Hull—and validation at the Global Knowledge Exchange 2018 refined these resources and informed decisions around design, functions and user interface.

# 2 ASSESS CITY WATER RESILIENCE

In this second step, the preliminary assessment initiated in Step 1 will be completed using the City Water Resilience Framework (CWRF). The CWRF supports cities and governments to gather information in a structured way and assess current practices, providing cities with a comprehensive, credible, and technically robust means to assess and monitor their water resilience to inform decision-making. The CWRF operationalizes resilience by providing a means for measuring cities' progress through qualitative and quantitative indicators, with the intention of guiding future actions. This framework will help structure cities' thinking around water resilience, including what elements are hindering and what is required in building resilience. Step 2 results in a Water Resilience Profile report that summarizes analysis from the water resilience assessment.

During Step 2, cities will complete the following tasks:

- Assess their present-day performance and their trajectory towards a more resilient future
- Identify governance gaps in designing and implementing successful city water resilience policies and regulations
- Facilitate a process of engagement with and within cities to generate dialogue and deeper understanding around city water resilience
- Identify clear objectives and a common vision for building water resilience in the city

## 2 ACTIVITIES

### RESEARCH AND DATA COLLECTION FOR THE ASSESSMENT PROCESS

As part of this step, the resilience champion shares the City Characterisation Report findings from Step 1 with all participants of the stakeholders and other potential partners. The champion collects relevant data from stakeholders through interviews, workshops and focus groups. It shares the guidelines on the CWRF stating the timeline of the assessment process with the stakeholders. Internal/external support is provided to guide stakeholders on the assessment process and CWRF where needed.

### ASSESSMENT PROCESS USING CWRF

With the research and data collected, the stakeholders conduct the baseline assessment on an agreed timeline. The baseline assessment takes place over the course of several weeks, using a mix of qualitative and quantitative indicators, and through a combination of workshops and expert interviews. Throughout this process, the city resilience champion regularly interacts with the stakeholders to address key concerns in understanding and using CWRF.

### DIAGNOSIS AND WATER RESILIENCE PROFILE REPORT

The resilience champion will coordinate with the stakeholders and collect findings of the assessment. Following this, the team will develop a City Water Resilience Profile report with the main findings, which will be shared with all partners and stakeholders engaged in Step 1. The aim of this diagnosis activity is to identify areas where resilience improvements are required. It is fundamental to generating the right options to address vulnerabilities. From these options an intervention, or suite of interventions, can be prioritised based on the broad objectives identified initially. The core team shares the report with relevant stakeholders for their review and incorporates their comments into a revised final report to be circulated before the validation workshop.

### VISIONING EXERCISE AND VALIDATION WORKSHOP

A multi-stakeholder workshop will facilitate dialogue and deeper understanding of the Water Resilience Profile report. The profile will be revisited and revised as needed based on the workshop conclusions. The workshop provides the city with the opportunity to:

- Present the key findings of the Water Resilience Profile report .
- Facilitate an exercise designed to conduct an in-depth governance analysis to discuss on the identified governance gaps through CWRF and assess how to improve those governance gaps. This exercise will help identify who are the primary decision-maker(s), who implements those decisions, who monitors actions, who is responsible for coordination, who approves the budget and which actors benefit from or are otherwise affected by these decisions. This activity will be aided using a Stakeholder Responsibility Matrix (SRM) modified and developed based on the Responsibility Assignment (RACI) matrix. The SRM analysis will help in indicating the roles of stakeholders under each of the governance functions. For example, for the governance function 'finances' and the stress drought management, the SRM will help identify which actors are responsible for approving the finances for a drought management plan, which actors are accountable for this function (Table 3). This further helps in identifying which governance functions are well resourced within a city, where there are overlaps, and where there are gaps and challenges. The findings from this assessment process will help different stakeholders to discuss and identify which are the areas they need to strengthen to build resilience, what role each of them plays, who should do what, and how each of them can contribute towards implementing an effective city water resilience strategy.
- Based on the analysis and findings of the assessment, the stakeholders will identify and discuss areas that need to be addressed and prioritized. This initial discussion could involve identifying broad areas to be taken forward in the next step of prioritisation.
- This step results in a visioning exercise that outlines shared objectives for building resilience in the city, and describes clear goals during the short, medium and long-term time horizons.

2

## METHODOLOGY

Data collection for the assessment can be conducted in different ways depending on the city context and stakeholders involved. Where partner engagement is already well-established and where information is easily accessible, a rapid review and data collection may be conducted, followed by a stakeholder consultation workshop to collectively make sense of knowledge from different partners, assess the city resilience and reaching a consensus. The resilience champion leads data collection and will document the outcomes of this discussion.

In other cases where partner engagement is more challenging and access to relevant information is limited, the data collection may be a time-consuming process, and more in-depth and rigorous data collection methods, desktop review, surveys and interviews with key stakeholders and focus groups may be required. The assessment report will be submitted by the resilience champion, followed by the validation workshop.

2

## RESOURCES

The City Water Resilience Framework (CWRF) helps groups of stakeholders assess the current status of local urban water resilience in their city. It corresponds with the second step of the CWRA approach. For more detail, see The City Water Resilience Framework.

A Stakeholder Responsibility Matrix (SRM) based on the widely used RACI matrix describing parties responsible, accountable, consulted and informed for each action. The SRM analysis will help in indicating the roles of stakeholders under each of the governance functions.

*Step 2 resource: City Water Resilience Framework (CWRF)*

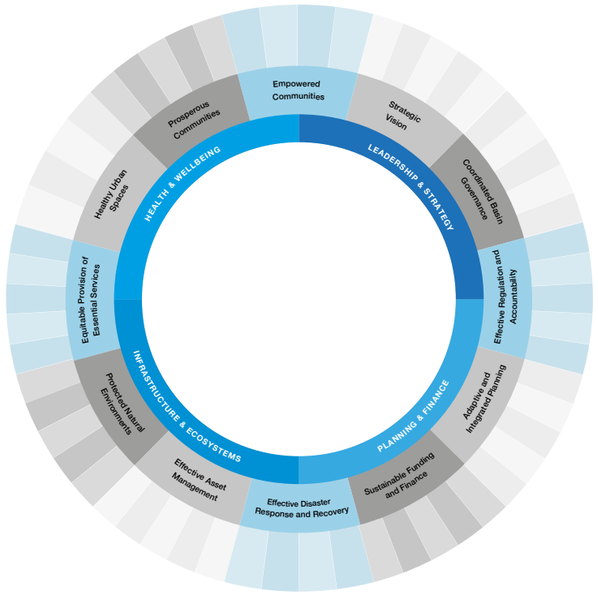



*Table 3: Stakeholder responsibility matrix per governance functions*

| REGULATOR | APPROVAL | ACCOUNTABLE | LEADING | CONTRIBUTOR | INFORMED |
|---|---|---|---|---|---|
| Actors that sets the legal frameworks and rules for that function | Actor that approves the main outcomes of the function (the policy, the plan, the strategy, the budget etc.) | Actor responsible for responding to the decisions taken in that function | Actor that leads and coordinates the action, starts, and drives it throughout, and coordinates the process. This actor typically makes the submissions for approval | Actor is an active participant in the process and can provide inputs that shape the final outcomes | Actor is informed but does not have the opportunity to provide inputs to the process |

# 3 DEVELOP AN ACTION PLAN

***Steps 3-5 will be co-developed in partnership with cities in later project phases, during which additional detail will be added and new resources identified. The following sections provide a high-level overview of these steps, including critical considerations for each.***

In Step 3, the city will turn the diagnostics and assessments conducted in previous steps into actionable initiatives and projects. Exploring the results, the city can evaluate its challenges and opportunities, and initiate closer study of priority areas. The Water Resilience Action Plan will identify new projects based on the objectives defined in Step 2. Potential projects will be prioritized by all stakeholders involved in the assessment process in order to identify the most important actions to be taken.

The plan should build off existing actions that are already being undertaken or are planned over the short, medium and long term, respecting and supporting plans already undertaken by the city, which may be described in city master plans or sector planning for urban water strategy, disaster management plans, etc. For an example of how resilience might be integrated into an existing master plan, see Case Study 2.

### Case Study 2: Aligning resilience strategy with existing action in Greater Miami and the Beaches (GM&B)

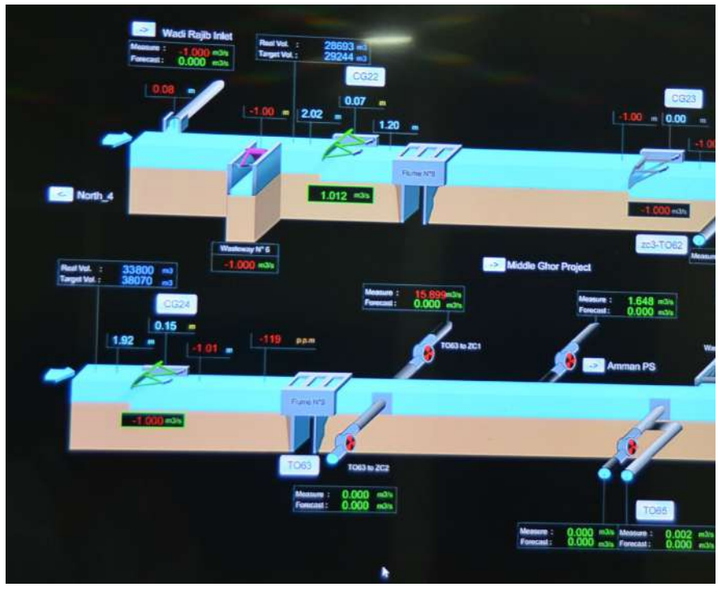
The Greater Miami and the Beaches (GM&B) collaboration provides an excellent opportunity for planning and strategizing through improved coordination among the cities to build resilience and address disasters and uncertainties. The GM&B Preliminary Resilient Assessment (PRA) report, as part of the 100 Resilient Cities project, highlights that the key actions of City of Miami to build a resilient city includes Sea Level Rise Advisory Committee established in 2015; revision and updating of the City of Miami's stormwater master plan while implementing stormwater upgrades in highly vulnerable areas and rapid action plan for flood risk mitigation of critical infrastructure and strengthening flood risk mitigation in the Future Land Use and Coastal Management elements of the City's Comprehensive Neighbourhood plan (100 Resilient Cities, 2017). Such existing plans needs to be explored to assess if any of the newly discussed topics and aspects could be included in the Action Plan.



## 3 ACTIVITIES

#### INTERPRETATION OF RESULTS:

Following the assessment and diagnosis process, the core team will identify other governance gaps. In this step, results are interpreted using guidelines provided in the City Water Resilient Action Plan Toolbox. The Action Plan document will be developed with the objective to provide guidance to stakeholders on how to interpret results from Step 2 and turn them into actionable initiatives. The toolbox will include governance analysis resources to map stakeholders by governance functions for a particular shock or stress. The governance function involved (e.g. planning and preparedness, policy and strategy, etc.) will differ for different shock and stresses. For an example of integrated coordination, see Case Study 3. Governance analysis will help identify key gaps and improve governance functions.




### Case Study 3: Jordan National Center for Security and Crisis Management (NCSCM)

Jordan has a National Center for Security and Crisis Management (NCSCM), which is in charge of the overall coordination and planning to address potential shock, and for disaster risk reduction in the country. It was found that there was a need for a governance arrangement (particularly related to drought management) which led to the creation of a national drought management committee responsible for drought management planning and implementation, a unit under the Ministry of Water and Irrigation (MWI). This was accompanied by drafting of a drought policy and drought management plans. For other shocks, additional specific coordination and managements units are in place.

### IDENTIFICATION OF PRIORITY AREAS:

Prioritisation areas will be identified to collectively agree on an action plan to build resilience. Prioritisation areas are those with most opportunity and agreement for future action based on common consensus and resilience objectives identified in the previous step, in light of the CWRF assessment.

Building on the City Characterisation Report validated in Step 2, the resilience champion will revisit the discussions from the validation workshop to address prioritized opportunities and challenges, as well as providing additional inputs, including:

- Revisit and define the partner engagement strategy.
- Initiate a closer study of the priority areas identified in Step 2.
- Map projects and programmes to link priorities with the existing policy framework, strategies and plans of each of the stakeholders. This will be done through mapping programmes and projects by collecting information on the current programmes which respond to one or more shocks or stresses, their contribution to one or more governance functions for resilience in urban water sector, their CWRF classification and the role of different organizations within the programme. This information will be used to help the city understand the gaps in the existing programmes and prioritize.
- Agree on selection criteria for identifying projects included in Action Plan.

### DEVELOP JOINT ACTION PLAN THROUGH A MULTI-STAKEHOLDER WORKSHOP:

Based on the in-depth analysis of the priority areas and the short list of actions identified as part of the previous step, the core team will work with all stakeholders to identify a list of actions based on priority areas identified in the previous activity, and considering ongoing actions currently implemented in the city, identified during Step 1. Key elements that will be discussed in this workshop include:

- Reaffirmation of objectives
- Prioritization of activities, i.e. what joint actions can be taken to improve resilience
- Costs and benefits associated with each action according to a holistic assessment that includes consideration of social, economic and ecological benefits
- Definition of timelines i.e. short-term, medium-term and long-term and actions associated with each timeframe
- Critical actors involved in each potential action
- Existing capacity (human, financial and technical) to develop, implement and monitor actions, and ways to improve capacity where needed
- Activities to monitor and evaluate actions as part of the Action Plan.

One important element of Step 3 will be identifying a mechanism for monitoring progress through the process. This mechanism, developed in the multi-stakeholder workshop, will provide information about progress and hindrances, towards effective results. Regular monitoring of programmes and plans will allow informed decisions on whether and how to adjust and adapt those programmes to meet goals.

Based on the results of the multi-stakeholder workshop, the resilience champion will draft a final Action Plan summarizing results from the workshop and sharing it with the stakeholders for review and comments.



3

## METHODOLOGY

For this step, an initial interpretation of the result can be conducted by the core team through an in-depth governance analysis as guided under the City Water Resilient Action Plan Toolbox, as well as the efforts to revisit its partner engagement strategy, and closer study of the identified priority areas. A facilitated workshop is recommended to facilitate dialogue and ensure stakeholders' ownership and accountability of the action plan developed.

3

## RESOURCES

**A Workshop Facilitator´s Guide** document that provides recommendations on how to conduct a multi-stakeholder workshop to collectively create a robust action plan.

**A City Water Resilient Action Plan Toolbox** consists of tools to help cities prioritize key actions.

# IMPLEMENT THE ACTION PLAN

In this step, the core team will implement the city's Water Resilience Action Plan. Rather than a static road map, the Action Plan is dynamic and can be revisited and adapted over time. A monitoring and evaluation mechanism included within the Action Plan will allow the plan to be continuously evaluated and fine-tuned as priorities are addressed and initiatives are implemented.

## ACTIVITIES

In Step 4 the city implements the Action Plan developed as part of Step 3. For the resilience champion, this entails working closely with actors identified in the previous step to provide support in the form of expertise and coordination between actors involved.

As part of Step 4, the resilience champion will ensure that stakeholders share the implementation and monitoring and evaluation reports on regular basis. The results of the resilience action plan monitoring and evaluation should be aligned with the sector's annual report which are discussed in regular joint ministerial review meetings. This will help facilitate the resilience discussion around the broader sectoral issues, and the opportunity to align the city water resilience objectives with the national priorities.

The processes of monitoring and evaluation must be supported by regular facilitation and coaching, either through internal or external support, to follow-up and reflect upon the city water resilience efforts. The Action Plan Tool Box and the Facilitators' guide will provide key recommendations and guidelines on the implementation process along with monitoring and evaluation mechanisms.



## METHODOLOGY

This step is realised through frequent interaction and continuous engagement with the stakeholders, with regular flow of information exchanges and feedbacks, and developing progress reports.

## RESOURCES

The Action Plan Toolbox and the Workshop Facilitators' Guide described previously will provide key recommendations and guidelines on the implementation process along with monitoring and evaluation mechanisms.

# 5 EVALUATE, LEARN AND ADAPT

Learning, transforming and adapting are key elements in the process of building resilience. The CWRA Step 5 follows up on implementation, with actions based on monitoring performed as part of Step 4. The activities, tools and methodology for this step will evolve as the CWRA progresses and is co-developed with city partners.

As part of Step 5, to ensure that the process is active the resilience champion will continue its engagement with key stakeholders and conduct an evaluation following the baseline assessment within 2-3 years to assess progress and identify challenges.

An important part of this step is the analysis of changing contexts and stakeholder involvement. Unexpected challenges, risk and difficulties may arise due to resistance to change from different levels; change in leadership through different electoral processes; fluctuating roles and responsibilities of stakeholders; lack of motivation from resilience champion; or data gaps, time and budget constraints etc. All of these factors may have adverse effects in the process and the overall implementation of the action plan. The core team should ensure that such changes and risk are assessed and monitored, and possible solutions are explored to address these challenges in a timely manner. When such instances are monitored, reported, and documented, stakeholders can learn from these experiences, and the system becomes more adaptive and better prepared to respond to future unforeseen challenges.

This step will entail reassessing objectives for the next period. Based on the results and progresses of the ongoing implementation, monitoring and evaluation process, stakeholders will re-assess the objectives and priorities of the resilience action plan at regular intervals to ensure that it continues to meet its resilience goals.



***Table 4:***
*Governance functions for resilience*

| KEY FUNCTIONS | DESCRIPTION |
|---|---|
| Policy and Strategy | Policymaking is the process whereby policies and strategies are developed. These contain the set of principles, priorities to achieve certain sector outcomes through a set of procedures, programs and/or mechanisms that provide the basis for water resources and water services management. |
| Coordination | Coordination is the process of promoting and ensuring cooperation among diverse stakeholders, across different levels of central, regional and local government departments, between different sectors, including public and private institutions, civil society, communities, external support agencies and eventually with transboundary partners. It entails proactive information sharing, frequent interaction and discussion, and decisions for policy setting, strategizing and planning, as well as related to implementation and monitoring stages. |
| Preparedness and Planning | The capacities and knowledge developed by governments, professional response organisations, communities and individuals to anticipate and respond effectively to the impact of likely, imminent or current hazard events or conditions. Planning is the process of data collection and analysis, formulation of actionable plans and estimation of costs and timeline. The typical outcome is a time-bound roadmap with estimation of human and financial resources (in place). Planning includes the deliberative and decision-making process towards developing key priorities, and the level of stakeholder engagement through which those priorities are selected for intervention. |
| Financing | The ability to raise funds from different sources, and cover for the short and long-term costs expenditures (capex and opex) of service delivery and resource management. |
| Budgeting | Budgeting answers questions such as: Do you have sufficient human and technical capacity to manage drought? Who is responsible for providing the finance, the technical capacity development? Which stakeholders are involved in these capacity development programmes and which are the target groups? |
| Service Delivery and Resource Management Arrangements | Through this function the arrangement for different aspects of service delivery and resource management is provided, describing who owns the infrastructure, who can operate them, who is responsible for service provision, and how services are provided in different settings. |
| Regulation | Regulations are rules or governmental orders designed to control or govern behaviour, and often have the force of law. They set standards, establish rights and responsibilities, monitoring mechanisms, and penalties. They include organizational responsibilities for the core regulatory process, and links between regulators and those they regulate. Regulation includes the capacity to enforce agreed standards and impose sanctions for non-compliance. |
| Capacity Development | Capacity development refers to the process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions. |
| Monitoring, Evaluation and Learning | Monitoring is a systematic process of collecting evidence and using that information to track progress of an ongoing intervention, which further contributes towards achieving desired outcomes. Evaluation is an exercise to systematically and objectively assess progress and the achievement of an outcome, which may include assessment of an activity, project, programme, strategy, policy, topic, theme, sector, operational area or institution's performance. Evaluation helps determine the relevance, impact, effectiveness, efficiency, and sustainability of the intervention. Learning includes the processes whereby stakeholders analyse and use evidence for managerial decisions to adapt and improve policies and programmes. |
| Immediate Response Procedure | This function describes the provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. It can be of an immediate, short-term, or protracted duration. |
| Post Recovery | Post recovery refers to the provision of a plan or strategy for reconstruction, rebuilding, rehabilitation, restoring coping mechanisms and facilitating necessary adjustment to reduce the risk post-disaster. |

# 6

# THE CITY WATER RESILIENCE FRAMEWORK

The City Water Resilience Framework (CWRF) assessment aligns with the second step of the CWRA approach, helping cities assess strengths and weaknesses in their water systems, and generate a Water Resilience Profile to guide future action.

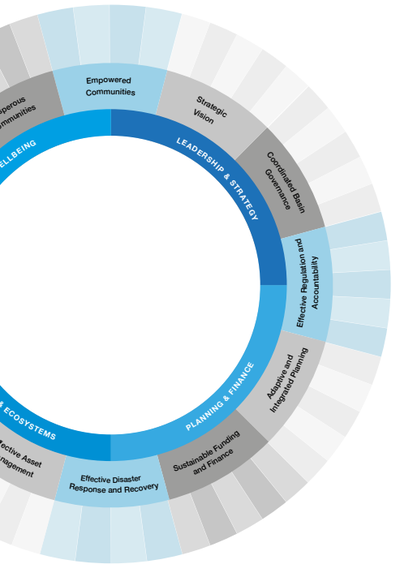
The CWRF can be used by a range of urban actors—including city government agencies, civil society, NGOs, development organizations, private sector organizations and academic institutions involved in water management for the urban basin. Any of these can lead the assessment. The framework responds directly to cities' critical needs in the following ways:

**The CWRF brings together diverse stakeholders to agree upon a shared vision of urban water resilience in their city.** The framework provides a clear definition for resilience, and the specific elements that contribute to water resilience. Rather than prescribe specific solutions, the CWRF helps cities identify the range of potential strategies that might be appropriate for them. The assessment process results in a vision statement that will guide cities throughout the multi-year project of building resilience.

**The CWRF allows cities to measure progress through key indicators associated with each sub-goal.** By evaluating performance against quantitative and qualitative indicators, cities can identify specific areas of strength to support, weakness that should be addressed. The assessment baselines cities' ongoing efforts against future actions, to measure progress over time.

**The CWRF results in a Water Resilience Profile that helps cities identify and prioritize key actions and the actors best positioned to implement those actions.** Based on detailed assessment of each city's strengths and weaknesses, this profile helps translate a shared vision into an implementation plan based upon broad stakeholder agreement and common objectives.

**The CWRF encourages a model of best practice** for urban water management based on research and examples of best practice from diverse cities around the world.




## INTERPRETING THE CWRF

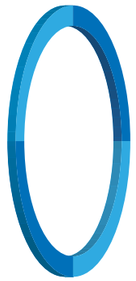
The CWRF diagram identifies four distinct but connected dimensions of resilience, and a series of increasingly specific requirements (goals and sub-goals) for building resilience in each dimension.

The lens can be read as a process diagram that moves clockwise from the top of the circle, following a rough timeline for project planning. The sequence of decisions begins with highest order goals related to empowering communities as a prerequisite for all resilience measures undertaken and ends with goals related to neighbourhood-level interventions that benefit city residents. Moving along the circle, the framework continues to long-term vision and strategy as a necessary pre-condition for planning and finance of water resilience programs. These goals result in effective implementation around critical infrastructure and ecosystems and the enactment of green and grey infrastructure. Finally, the cycle concludes with goals related to health and wellbeing, a dimension that describes how interventions manifest to help individuals survive and thrive.

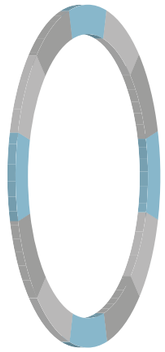


# CWRF STRUCTURE

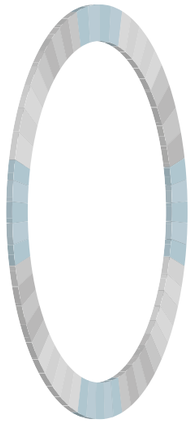
*The CWRF lens establishes a model for city water resilience.*



**4**
**DIMENSIONS**



**12**
**GOALS**



**53**
**SUB-GOALS**

The CWRF consists of three rings—dimensions, goals and sub-goals—that describe a holistic model for city water resilience.

The innermost ring consists of four **dimensions**, critical areas for building resilience.

Within each dimension are **goals** that indicate what needs to be achieved in that category. For instance, to build resilience in the area of Leadership and Strategy, our research suggests two key areas—long-term strategic vision and coordinated and collaborative governance. Hybrid goals are used where goals could logically be placed in more than one dimension and suggest how critical elements of water resilience often fall within multiple areas of influence.

**Sub-goals** identify the critical elements for realizing each goal. They provide additional detail and are referred to in guiding concrete actions that help realize their respective goals. Because each city confronts unique challenges, solutions appropriate to one city are not necessarily appropriate to another. As a result, sub-goals represent aspirations but do not stipulate specific solutions. For instance, while the framework affirms a universal need for "transparent financial decision-making procedures," it allows for a variety of strategies and mechanisms for achieving that aim (through participatory budgeting, regular auditing, legal statutes, etc.) based on what might be most appropriate given local context. The outermost layer of the CWRF wheel consists of **indicators**, a list of metrics used to measure how each city performs in each category. In answering indicator prompts, individual cities identify areas for improvement in cities' own water governance, measure their own progress over time, and make comparisons with peers around the world.

*Table 5: CWRF value proposition*

| KEY STAKEHOLDERS | COMMON CHALLENGES | POTENTIAL GAINS | VALUE |
|---|---|---|---|
| **High-level decision-makers in:**<br>- *City Government*<br>- *Regional/national Government*<br>- *Catchment/Basin authorities*<br>- *Private Sector* | - Competing actors/interests make it difficult to prioritize critical actions<br>- Difficulty communicating benefits of resilience to constituents for buy-in (citizens, corporate stakeholders, board of directors, etc.)<br>- Difficulty understanding and framing city water resilience from a holistic perspective | - Unified, shared vision agreed upon by normally competing interests<br>- Vision statement developed from profile to articulate outcomes and holistic benefits | **The CWRF brings together diverse stakeholders to agree upon a shared vision of urban water resilience in their city.** The framework provides a clear definition for resilience, and the specific elements that contribute to water resilience. Rather than prescribe specific solutions, the CWRF helps cities identify the range of potential strategies that might be appropriate for them. The assessment process results in a vision statement that will guide cities throughout the multi-year project of building resilience.<br><br>**The CWRF allows cities to measure progress through key indicators associated with each sub-goal.** By evaluating performance against quantitative and qualitative indicators, cities can identify specific areas of strength to support, weakness that should be addressed. The assessment baselines cities' ongoing efforts against future actions, to measure progress over time.<br><br>**The CWRF results in a Water Resilience Profile that helps cities identify and prioritize key actions and the actors best positioned to implement those actions.** Based on detailed assessment of each city's strengths and weaknesses, this profile helps translate a shared vision into an implementation plan based upon broad stakeholder agreement and common objectives.<br><br>**The CWRF encourages a model of best practice** for urban water management based on research and examples of best practice from diverse cities around the world. |
| **Department/organizational heads in:**<br>- *City Government*<br>- *Utilities*<br>- *Multi-National Government Organizations*<br>- *Private Sector*<br>- *Regional/national Government*<br>- *NGOs*<br>- *Community Organizations*<br>- *Development Banks* | - Complex, time-consuming process required to agree on a shared plan for building resilience<br>- Lack of available tools to measure city performance in clear / objective ways<br>- Little agreement around action plan for project implementation | - Resource for identifying and convening relevant stakeholders and coming to consensus on shared vision plan<br>- City Water Resilience Profiles benchmarks city performance | |
| **End users**<br>- *Residential Users*<br>- *Commercial Users* | - Limited opportunities to participate in shaping water resilience planning in their city<br>- Poor coordination between water providers results in lower quality of water service for end users | - New opportunities to participate in vision-making through broad and diverse stakeholder participation<br>- Better coordination among actors results in improved water service | |

# CWRF GOVERNING PRINCIPLES

The result of the research process—combining a review of literature, interviews and workshops with key stakeholders, input from outside experts and Arup observations of field conditions—is the City Water Resilience Framework, which is presented in detail in the following section. The framework distils a set of critical themes identified in our research, and is guided by four key principles:

## MULTI-DIMENSIONAL

Our research suggests a need for a holistic and multi-dimensional approach to building water resilience. The four dimensions of the CWRF – leadership and strategy, planning and finance, infrastructure and ecosystems, health and well-being – propose a new approach to measuring and building resilience. Similarly, the goals and sub-goals identified through our research process touch on elements of governance, planning, finance, infrastructure, the environment, place-making and community development.

## URBAN FOCUSED

Because water systems are part of complex, overlapping and interdependent urban systems, efforts to build water resilience should extend beyond the household or neighbourhood level. The CWRF is designed for urban scale interventions, understanding that water resilience requires influencing the myriad systems that impact water service delivery, and that natural hydrological processes do not always align with strict administrative or political boundaries.

## ACTION-ORIENTED

The CWRF helps identify specific, concrete and meaningful areas of intervention that can lead directly to project road-mapping. The framework is embedded within a larger approach (the CWRA) that outlines a process of planning and realising interventions. Moreover, in developing the framework, we recognize that cities need comprehensive evaluative tools but often operate in resource-constrained environments: they may lack the technical support, funding or time required to complete an exhaustive evaluation. As an action-oriented framework, the CWRF prioritises key issues related to water resilience, limits the number of indicators required for baseline assessments, and feeds directly into city action-planning.

## MULTI-SECTORAL

The CWRF is not intended for specific sectors or types of user: both the assessment process and the actions informed by the assessment may be carried out by a range of partners, including city government, local water utilities, civil society, private sector organizations and other actors capable of exerting influence at the urban scale. At the same time, a set of principles embedded into the framework—stipulating the need for collaborative approaches, meaningful citizen participation, transparent governance and other elements we understand to be fundamental in building resilience—means that the approach will not be unintentionally (or intentionally) biased by the local partner.

# DIMENSIONS OF RESILIENCE

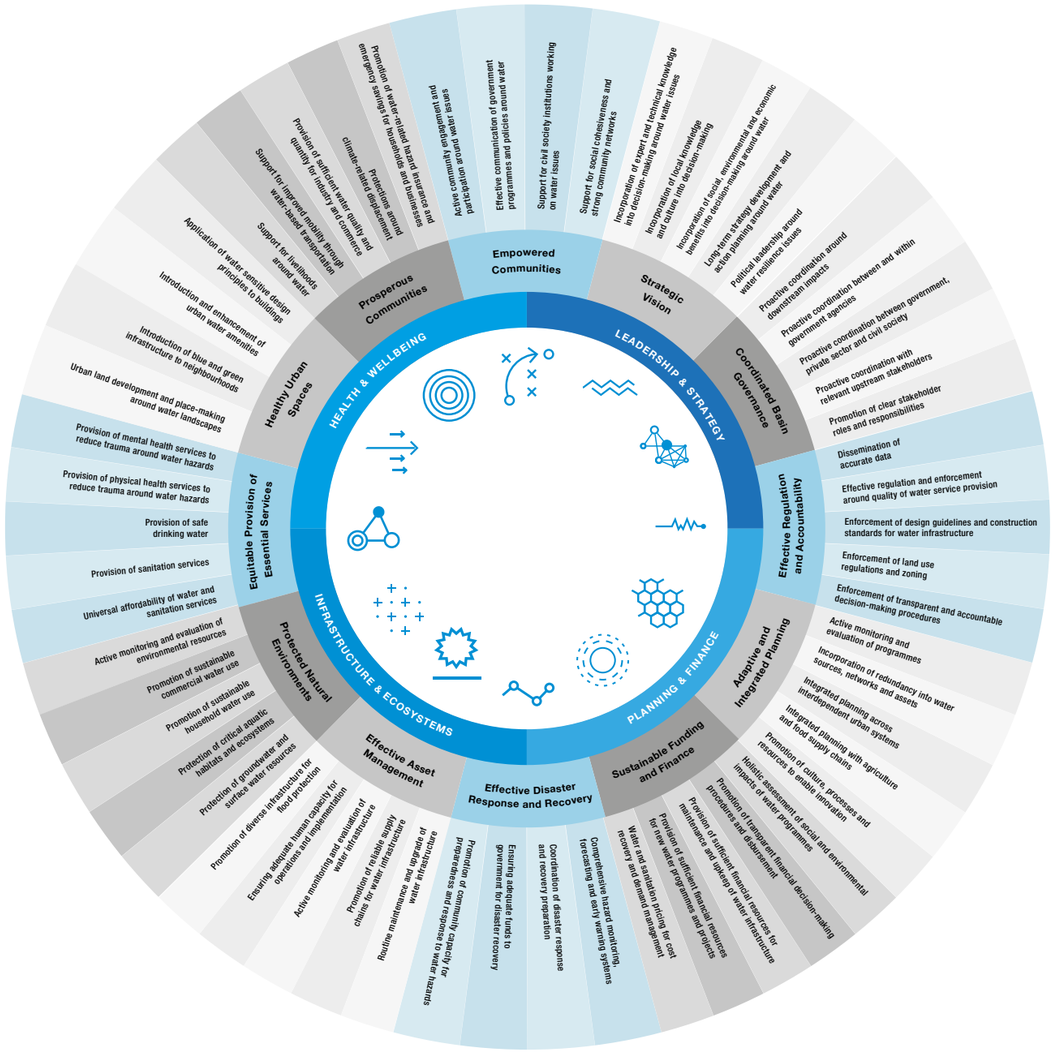
The framework is structured around four high-level dimensions that describe the resilience of an urban water system. Dimensions organise the resilience assessment and guide future action. They describe a fluid relationship between key elements of the water system and illustrate how each element relates to the others.

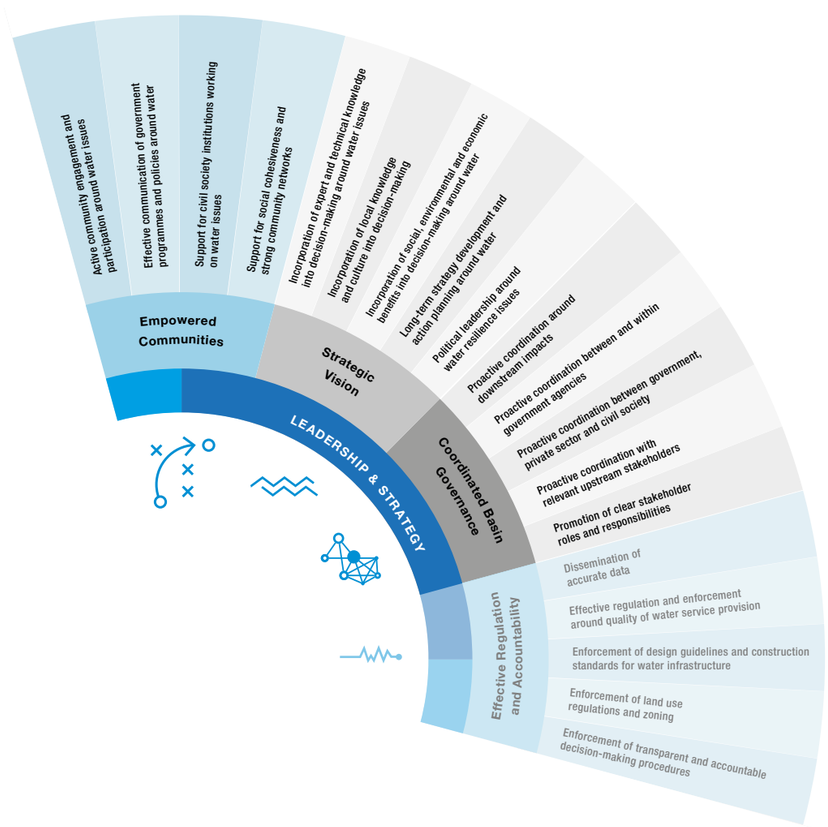
The first dimension outlines the need for effective **leadership and strategy** that drive long-term decision-making around water resources and services, and collaborative decision-making between key actors. This dimension overlaps with **planning and finance**, which describes integrated processes around designing, regulating and funding water programmes and projects. These elements focus on coordination across interdependent urban systems to plan for and respond to shocks and stresses, including the need for effective disaster response, a shared goal with the dimension **infrastructure and ecosystems**. Infrastructure and ecosystems describes the natural and man-made elements that make up the water system, including natural features such as water sources and ecosystems, as well as water treatment plants, distribution networks and all the various grey infrastructure that helps cities provide, protect and connect citizens through water.

Such elements are critical in ensuring the **health and wellbeing** of city residents and relate to the final dimension on the framework wheel, describing the basic conditions that sustain human life—access to water, sanitation and healthcare—and the ways water can be a driver of attractive, vibrant and prosperous communities. In its emphasis on empowered local communities as a key ingredient of resilience, this dimension overlaps with leadership and strategy, completing the circle.

The goals that constitute each dimension and the sub-goals that make up each goal are described in detail in the following pages.





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# LEADERSHIP & STRATEGY

*This dimension relates to the need for effective leadership and long-term strategies that drive decisions around water resources and services. Because elements of the water cycle are frequently managed across a fragmented landscape of governance and regulation, integrated and evidence-based decision-making is essential. Leadership around water resilience is often, but not necessarily, the domain of government operating at the municipal, regional or national level, and the goals and sub-goals outlined in this dimension consider the need for inputs from a range of stakeholders.*



## EMPOWERED COMMUNITIES

Empowered communities are situated at the top of the wheel, suggesting their essential role as a pre-condition for urban water resilience. This goal describes a need for strong community input to guide decisions around water, to assess decisions made and provide meaningful feedback on actions. Empowered communities are necessary to inform and provide feedback on all decisions made towards improving urban water management.

**Active community engagement and participation around water issues**

Mechanisms exist and are used by citizens to push for resilience initiatives, actively participate in decision-making activities and to provide feedback and challenge decisions related to water resilience through grassroots or citizen-led initiatives, including design and implementation of projects.

**Effective communication of government programmes and policies around water**

Updated and accurate information about water use best practices, programmes and projects, and disaster preparedness is made available to residents through different channels, in local languages, gender-sensitive and reader friendly formats.

**Support for civil society institutions working on water issues**

Support in the form of financial and information resources and broad public engagement exists for local non-government institutions (civil society, academia, media) working on water issues, to generate debate around policies, implement initiatives and programmes around local water issues, and inform public policy.

**Support for social cohesiveness and strong community networks**

Communities are socially cohesive, with support for strong ties between residents that help disseminate information and resources, and enables them to learn from each other, self-organize and collectively act in times of need.

## STRATEGIC VISION

This goal refers to the need for consistent strategic vision that guides all decisions around water resources. Water resilience is often included as an afterthought in political decisions or incorporated late in planning processes. The goal of Strategic Vision focuses on government's role in incorporating water resilience into long-term urban planning, with substantial and meaningful input from other stakeholder partners.

**Incorporation of expert and technical knowledge into decision-making around water issues**

Key decision-makers and technical staff involved in water resilience planning and implementation have access to knowledge resources. Avenues exist for sharing technical knowledge between subject matter experts to ensure programmes make use of best technical knowledge.

**Incorporation of local knowledge and culture into decision-making** Local, indigenous knowledge and cultural attitudes are incorporated into decision-making to ensure that planning practices are fully informed, effective and appropriate to local contexts.

**Long-term strategy development and action planning around water**

A shared vision for long-term goals and priorities is established to guide projects and programmes that build water resilience with consistency over time.

**Incorporation of social, environmental and economic benefits into decision-making around water**

Long-term strategic planning takes into account a range of potential benefits from increased water resilience, including gains to society and natural environment.

**Political leadership around water resilience issues**

Strong political leadership around water resilience issues exists to push resilience as a priority issue in government decision-making.

## COORDINATED BASIN GOVERNANCE

Coordination among decision-makers is a requirement for effective governance. This goal describes the need for collaboration between government agencies working at different scales (local, municipal, regional, national, etc.), and agencies or departments functioning in parallel roles at the same scale. Coordinated and Collaborative Governance also refers to the need for partnerships between diverse stakeholders, and meaningful avenues of knowledge-sharing between government, civil society and the private sector.

**Proactive coordination between and within government agencies**

Communication and coordination exists between different government agencies operating at various administrative levels (including local, municipal, state and national agencies) and within government agencies (including between managerial and technical staff) to define and implement water priorities.

**Proactive coordination between government, private sector and civil society**

Mechanisms and platforms exist and are used to promote dialogue and deliberation between government and non-government water related actors (including civil society, business and the private sector) around water and resilience issues.

**Promotion of clear stakeholder roles and responsibilities**

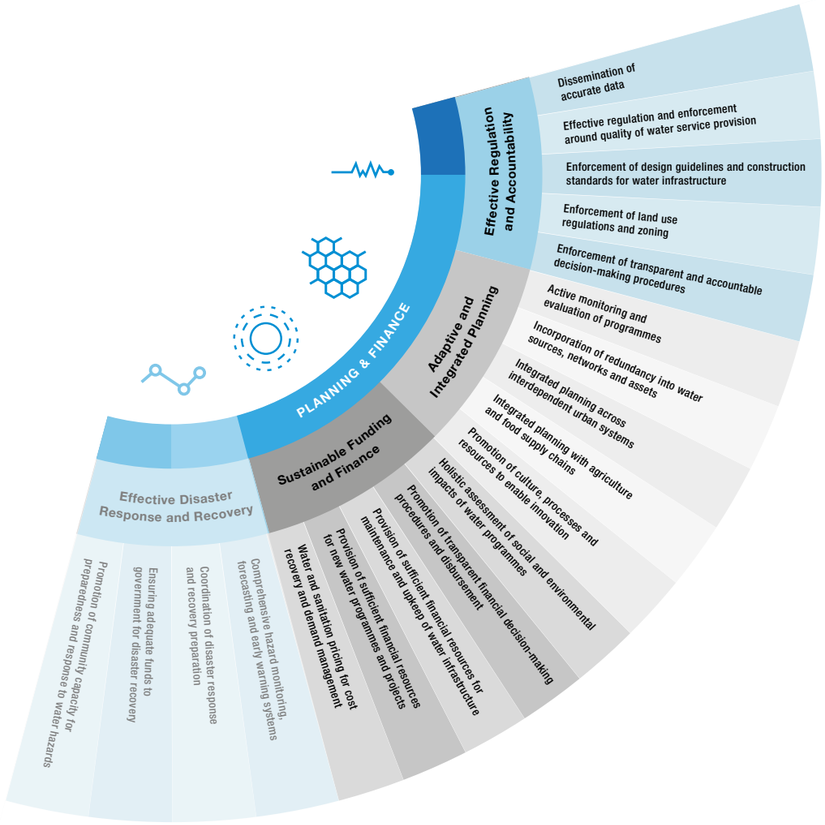
Laws, policies or norms exist to clearly define roles and responsibilities among relevant water stakeholders.

**Proactive coordination with relevant upstream stakeholders**

Mechanisms are in place for communication and coordination between city stakeholders and relevant upstream stakeholders to mitigate impacts from upstream water, energy and land uses and other activities.

**Proactive coordination around downstream impacts**

Mechanisms are in place to assess and mitigate negative effects of urban water use on downstream areas, including through coordination with relevant downstream stakeholders, monitoring and reporting, environmental impact assessments and stakeholder consultation.

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# PLANNING & FINANCE

*This dimension relates to the need for integrated processes around planning, regulating and funding water resilience programmes and projects. Flexible and efficient processes are required to encourage collaboration across interdependent urban systems, to regulate and enforce rules, and to ensure that programmes aimed at building water resilience are sustainable over the long-term.*



## EFFECTIVE REGULATION AND ACCOUNTABILITY

The goal of Effective Regulation and Accountability describes the need for a clear set of enforceable rules and regulations around activities that affect water resources within the urban water basin, including the pollution, land-use planning and technical standards. A hybrid goal, it bridges the two dimensions of Leadership and Strategy, and Planning and Finance.

### Dissemination of accurate data

Accurate data is made available to key decision-makers in government, private sector and civil society to inform programmes, policies and research and establish current baseline conditions.

### Enforcement of design guidelines and construction standards for water infrastructure

Clear technical standards and design guidelines for critical infrastructure assets and buildings are determined based on accepted best practices with input from technical experts, to ensure high performance, efficiency and resistance to natural hazards.

### Enforcement of land use regulations and zoning

Regulations exist and are enforced to control land use and urban expansion, specifically to reduce growth in high-exposure and water-poor areas.

### Enforcement of transparent and accountable decision-making procedures

Governance procedures are made clear and open to all stakeholders, with disclosure about who makes decisions, what actions will be implemented as a result, why decisions have been made, and how they will be decided and implemented.

### Effective regulation and enforcement around quality of water service provision

Regulations exists and are enforced to ensure delivery of water services, including continuous provision of sufficient quantity of high-quality water for consumption and other uses, and effective communication between service providers.

## ADAPTIVE AND INTEGRATED PLANNING

This goal refers to strategies for integrated programme and project planning that can adapt to change and which allows for transformation in the wake of shocks and stresses. The goal encompasses coordination between organizations and sectors related directly and indirectly to how water services are provided in the urban area.

### Active monitoring and evaluation of programmes

Active monitoring and evaluation tracks ongoing programme implementation and outcomes, to allow for course corrections to programmes as needed, evaluate outcomes and provide lessons learned for designing future programmes.

### Incorporation of redundancy into water sources, networks and assets

Water-related infrastructure assets and networks are made sufficiently redundant so that assets can continue to function when individual components are damaged or destroyed. Where appropriate, diverse sources of water supply are developed to ensure redundancy in the type, location and scale of water supply sources, and to minimize the impact of threats to individual sources.

### Integrated planning across interdependent urban systems

Coordination exists between water agencies and other critical urban systems such as energy, telecommunications, waste management and transportation for information sharing and cooperation on topics related to water resilience, resulting in actions that reduce risk from shocks and stresses.

### Integrated planning with agriculture and food supply chains

Coordination between water agencies and actors involved in food production and supply — including agriculture and aquaculture — for information sharing and cooperation on topics related to water resilience, to reduce the impact of water-related shocks and stresses on urban food supply.

### Promotion of culture, processes and resources to enable innovation

Mechanisms and resources encourage innovative programmes and projects across government and non-government sectors related to water, including rapid prototyping and pilot programmes.

## SUSTAINABLE FUNDING AND FINANCE

This goal refers to the need for sufficient funding for programs and projects related to building water resilience, and processes that ensure that money is raised and spent in a transparent and efficient way. While typically led by government, innovative approaches to project finance should allow for private and civil society stakeholders to participate in funding and financing initiatives.

### Holistic assessment of social and environmental impacts of water programmes

Proposed water projects and programmes are evaluated using holistic cost-benefit analysis that considers a range of social and environmental impacts.

### Promotion of transparent financial decision-making procedures and disbursement

Open financial procedures ensure that funds are disbursed and used in a clear and transparent way, including clear procurement processes that ensure water infrastructure contracts are awarded fairly and efficiently.

### Provision of sufficient financial resources for maintenance and upkeep of water infrastructure

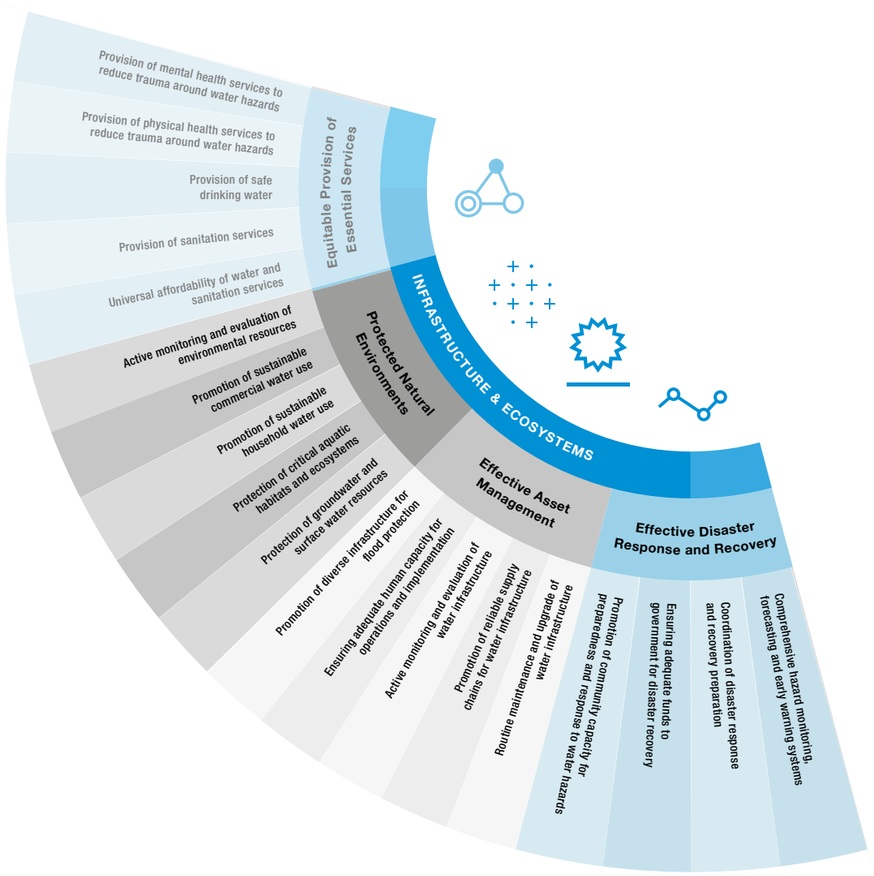
Adequate funds are made available in a timely and efficient way to support ongoing water projects and programmes, including maintenance of critical infrastructure.

### Provision of sufficient financial resources for new water programmes and projects

Adequate funds are made available in a timely and efficient way to finance new capital projects and programmes that support water resilience. Financial planning ensures that costs and funding are consistent over time.

### Water and sanitation pricing for cost recovery and demand management

Water pricing is in place to ensure both affordability for vulnerable people and cost recovery for long-term system maintenance, and manage demand by discouraging excessive use.

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# INFRASTRUCTURE & ECOSYSTEMS

*This dimension relates to the infrastructure and ecosystems that enable cities to provide critical water services and that protect residents from water-related hazards. Infrastructure and Ecosystems describes efforts to protect and enhance man-made and natural assets, and to ensure assets are properly operated, maintained and monitored for optimal performance.*



## EFFECTIVE DISASTER RESPONSE AND RECOVERY

Cities must be able to respond in a quick and effective manner to minimize the impact of disaster events. This goal lists the elements that contribute to this aim by ensuring coordination across actors, and describing effective disaster management and recovery practices. As a function of both effective planning and robust physical infrastructures, this is a hybrid goal bridging Planning and Finance and Infrastructure and Ecosystems.

### Comprehensive hazard monitoring, forecasting and early warning systems

Hazard monitoring and modelling, forecasting and risk assessment predicts the likelihood of hazards and anticipate their potential impact, including spatial analysis of where impacts are most likely to be felt. Early warning systems provide adequate advanced warning to government, institutions, businesses and residents so they can evacuate or prepare for hazards in-situ.

### Coordination of disaster response and recovery preparation

Detailed disaster response and recovery coordination exist, with plans and procedures that are current (have been updated recently), collaborative (integrating all relevant city agencies and emergency responders), well-rehearsed and properly funded.

### Ensuring adequate funds to government for disaster recovery

City and local authorities, government departments and agencies and other public authorities have access to funding or to affordable disaster insurance sufficient to allow recovery and continuation following shock events or persistent stresses.

### Promotion of community capacity for preparedness and response to water hazards

Mechanisms exist and are used to support and engage local institutions, civil society organisations, and communities in early warning systems and response to shocks and stresses.

## EFFECTIVE ASSET MANAGEMENT

This goal describes the need to build and maintain high-quality man made and natural assets, including grey, blue and green infrastructure. It outlines best practices around design and upkeep to ensure that assets continue to function in the face of shocks and chronic stress.

### Active monitoring and evaluation of water infrastructure

Active monitoring and evaluation of hydro-infrastructural assets and networks ensures data is current and accurate to help improve performance and reduce likelihood of failure.

### Ensuring adequate human capacity for operations and implementation

Sufficient numbers of trained and knowledgeable staff exist to operate key infrastructure, including for both technical and managerial responsibilities.

### Promotion of diverse infrastructure for flood protection

Built ("grey") and natural ("green") flood protection infrastructure protect key infrastructural assets, neighbourhoods, residences and businesses by reducing or eliminating the impact of fluvial, pluvial, reservoir and coastal flooding.

### Promotion of reliable supply chains for water infrastructure

Supply chains servicing key water infrastructure can withstand and recover from shocks and prolonged stresses, to ensure availability of mechanical equipment, chemicals and other materials.

### Routine maintenance and upgrade of water infrastructure

Existing infrastructure is regularly maintained and upgraded as needed to reduce likelihood of failure.

## PROTECTED NATURAL ENVIRONMENTS

This goal speaks to the need to harness the natural environment as a resource for ensuring water and sanitation services, high quality amenities, and protection against water shocks and stresses.

### Active monitoring and evaluation of environmental resources

Active monitoring and evaluation of natural assets and the environment ensures data is current, accurate and widely available.

### Promotion of sustainable commercial water use

Programmes exist to encourage sustainable water use for significant commercial users including agriculturalists, energy suppliers, manufacturers, tourism industries and others.

### Promotion of sustainable household water use

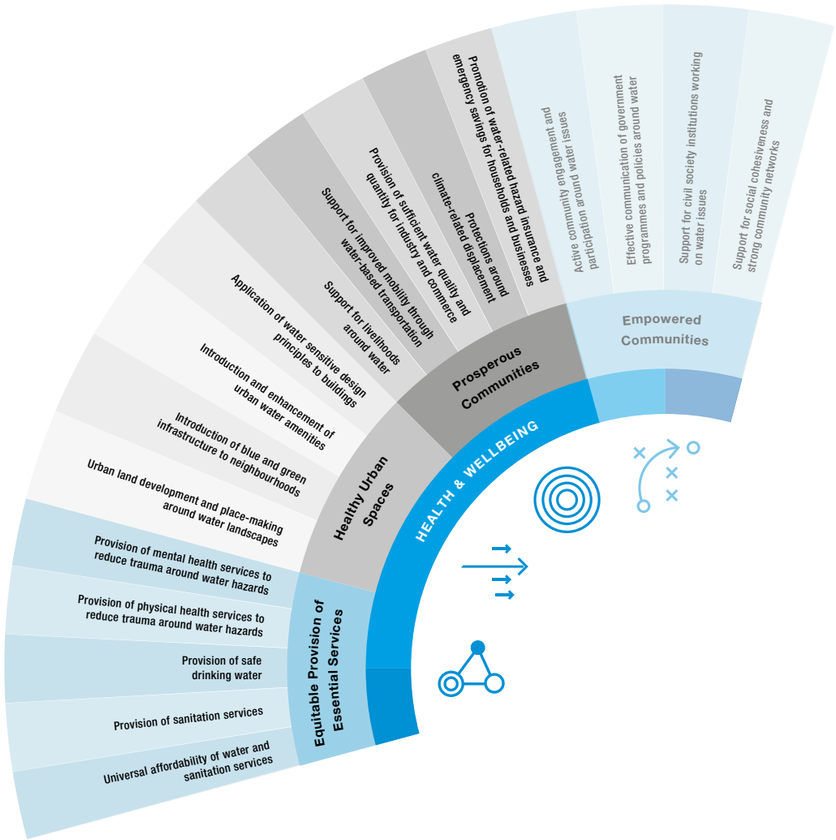
Households and businesses use water resources in an efficient manner including, where appropriate, by adopting water-saving measures such as water-saving appliances, water rationing, and use of recycled water for non-essential purposes that do not include human consumption.

### Protection of critical aquatic habitats and ecosystems

Policies and programs exist to protect critical natural ecosystems such as wetlands and forests related to water supply, water retention, water quality management, and flooding attenuation.

### Protection of groundwater and surface water resources

Protections exist to reduce or eliminate pollution and discharge into surface and groundwater sources, reduce groundwater depletion and permit aquifer recharge to ensure high quality water for human consumption, recreation and other needs.

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# HEALTH & WELL-BEING

*This dimension relates to the health and well-being of people and the role of water in ensuring that all urban residents can survive and thrive. It addresses the basic conditions that sustain human life—access to water, sanitation and healthcare—but also describes opportunities to harness water as a driver of attractive, vibrant and prosperous communities.*



## EQUITABLE PROVISION OF ESSENTIAL SERVICES

Essential water services include affordable water and sanitation, as well as protections against water-related shocks and stresses such as flooding and drought. This hybrid goal relates to the need to ensure that services are widely available to all users relying on the urban water system.

**Provision of mental health services to reduce trauma around water hazards**

In the wake of a shock or ongoing hazard events, mental health services are made available to residents to reduce psychological impacts.

**Provision of physical health services to reduce trauma around water hazards**

In the wake of a shock or ongoing hazard events, health services are made available to residents to reduce impacts on health, including treatment of disease, malnutrition, contact with polluted water, etc.

**Provision of safe drinking water**

Households, business and institutions have continuous access to safe drinking water irrespective of season, time of day or geographic location within the urban area.

**Provision of sanitation services**

Households, business and institutions have access to improved sanitation (hygienically separating human excreta from human contact) and households do not need to share facilities.

**Universal affordability of water and sanitation services**

Safely managed water and sanitation services are made affordable to all users regardless of economic status.

## HEALTHY URBAN SPACES

The goal of Healthy Urban Spaces describes the need for initiatives that foster safe and attractive urban spaces for a range of users through water. It refers to the influence of water as a driver of place-making and urban regeneration, and as a vehicle for improving the physical fabric of urban communities and access to key amenities.

**Application of water sensitive design principles to buildings**

Design principles are broadly adopted to incorporate considerations of water supply, wastewater treatment and runoff into building design, in order to increase water efficiencies and minimize environmental degradation.

**Introduction and enhancement of urban water amenities**

Recreational facilities that enhance quality of life—including pools, beaches, wetlands, vistas, fountains, and other natural water features—are made accessible to all residents.

**Introduction of blue and green infrastructure to neighbourhoods**

Blue and green infrastructure is introduced to help enhance existing natural assets' ability to mitigate impact of shocks and stressors and improve quality of neighbourhood spaces.

**Urban land development and place-making around water landscapes**

Water is incorporated as an element in place-making to enhance physical environments, catalyse investment and help create public spaces that promote health, happiness and well-being.

## PROSPEROUS COMMUNITIES

This goal refers to a need to focus on the health of local economies, support for diverse livelihoods, and access to economic opportunity for those living and working in urban communities. This goal differs from "Sustainable Funding and Finance" in its emphasis on building prosperity for local residents and its focus on community-scale economic development initiatives rather than infrastructure and programme finance.

**Promotion of water-related hazard insurance and emergency savings for households and businesses**

Households and businesses have access to sufficient savings, accessible and affordable disaster insurance or relief funds to allow recovery and continuity following shock events or persistent stresses.

**Protections around climate-related displacement**

Policies exist that minimize displacement of vulnerable populations resulting from water-related shocks and stresses (including climate gentrification). When displacement is necessary, policies ensure that resettlement is equitable, fair and adequately compensated.

**Provision of sufficient water quality and quantity for commercial uses**

Businesses and industry have access to enough water, at an appropriate level of quality, to function and grow.

**Support for improved mobility through water-based transportation**

Water is used as a means of transportation, increasing urban mobility and connecting residents to opportunities and resources.

**Support for livelihoods around water**

Jobs and skills are developed, and new opportunities created for developing livelihoods around water.

# SELECTING RESILIENCE INDICATORS

*Selecting appropriate indicators is critical for ensuring that the CWRF represents an effective assessment of city water resilience. As part of the team's research, we reviewed current best practices around the use of indicators in creating tools and frameworks for assessing resilience. These guidelines inform how specific indicators for each CWRF sub-goal are selected. For the full review of the use of indicators in measuring resilience and bibliography see Annex B: Indicators Review and Best Practices.*

## WHAT ARE INDICATORS?

Indicators are a means of "encapsulating a complex reality in a single construct" (Vincent, 2004) by measuring related conditions or component parts when direct measurement is not possible. They "provide information either on matters of wider significance than that which is actually measured, or on a process or trend that otherwise might not be apparent (Hammond et al, 1995)" (Vincent, 2004). Indicators may come from pre-existing data sources (e.g. census information) or be collected by surveyors (e.g. surveys, interviews and focus groups), and may describe information collected for the household, community, or national levels.

Indicators can be either objective or subjective. *Objective* indicators typically use quantitative measurements such as economic or demographic information related to employment, income, age, access to education, etc. and may be gathered through official census records as well as surveys. Alternatively, *subjective* indicators record responses from individuals to survey questions. Subjective indicators of resilience "make use of people's knowledge of their own resilience and the factors that contribute to it" (Jones 2018) and "therefore [relate] to an individual's cognitive and affective self-evaluation of their household's capabilities and capacities in responding to risk" (Jones and Tanner, 2017). These indicators can be used independently, or in combination with objective indicators.

Subjective responses can be translated into numerical values for inclusion in an index in multiple ways (CRI Vol. 4):



- **Binary**—that represent a "yes" or "no" answers as a zero or one.
- **Likert Scale**—where numbers between one and five are assigned to responses depending on whether respondents feel "strong agreement," "strong disagreement", etc.
- **Bounded ranges**—that describe specific scenarios describing best and worst scenarios, assigning scores to each (e.g. 1-5), and ask participants to choose which scenario best describes their current state.
- **Thresholds**—in which responders answer open questions about current conditions (e.g. "to what extent does your city provide flood mitigation measures…") with a score corresponding with worst and best outcomes, respectively, but with no specific scenarios defined for scores.

In addition to objective and subject indicators, other indicators include measurements of functionality as a binary yes/no, which are often used to describe infrastructure, including, for instance, whether infrastructure can continue to perform a function in the wake of a disaster (Crown Agents, 2016); and cost-based indicators such as "cost of resilience" or Cost Benefit Analysis that measure resilience through totalling the financial impacts of disasters and/or putting monetary value on cost improvements for resilience activities (Crown Agents, 2016). Using this approach, a higher cost reflects lower overall resilience (Bene, 2013).

# GLOSSARY OF KEY TERMS

**City Water Resilience Approach (CWRA)** – A five-step process to building the resilience of urban water systems. The approach includes a sequence of actions that begins with initiatives to understand and assess the system, and continues through developing, implementing and monitoring an action plan.

**City Water Resilience Framework (CWRF)** – A framework used within the City Water Resilience Approach to assess the city's current resilience. The CWRF uses a set of indicators to help cities identify strengths and weaknesses in their water management, and guides action planning based on this assessment. The CWRF is deployed during Step 2 of the CWRA.

**Dimension** – The four critical areas under which resilience initiatives can be categorized. Dimensions of resilience are represented in the innermost ring of the CWRF lens.

**Factors of Resilience** – As part of the research behind developing the wheel, stakeholders in eight cities were asked to describe the positive and negative factors that contributed to or detracted from resilience in their respective city.

**Framework** – An overarching system of ideas or concepts that are used to assess, plan or decide something.

**Goal** – The twelve objectives to be achieved as cities work towards resilience. Goals represent the second ring of CWRF lens, sitting beneath dimensions and above sub-goals.

**Governance** – The management of a system or organization, including the actors, rules, and norms involved. Water governance refers specifically to the mechanisms through which water services are provided to users, and implies the organizational structures, relationships, norms and actors involved, including stakeholders involved indirectly in water services through interdependent urban systems.

**Hybrid Goal** – Within the CWRF lens, hybrid goals are goals that relate to more than one dimension of resilience and so overlap two different dimensions.

**Indicator** – An indicator helps evaluate a complex reality or condition by measuring related conditions through the use of specific, qualitative or quantitative questions.

**Interdependencies** – Interdependencies describe the relationship between related urban systems and infrastructural assets. For instance, the bi-directional impacts of energy systems on water service delivery is one example of system interdependencies.

**Methodology** – a system of defined methods or activities which serve to solve a specific problem.

**Qualities of Resilience** – Resilient systems exhibit seven critical qualities: reflectiveness, robustness, redundancy, flexibility, resourcefulness, inclusiveness, integration.

**Resilience** – The capacity of cities to function so that all people living and working there survive and thrive in the face of shocks and stresses related to climate change. A resilient water system is one with the capacity to provide high quality water services, protect against water-related hazard and connect citizens through water-based transportation and initiatives.

**Shocks** – A sudden or unexpected hazard event that has the potential to disrupt normal urban functions and threatens human life and property

**Stresses** – Chronic conditions, including both socioeconomic realities such as poverty, urban expansion and pollution, and persistent climactic conditions that can reduce services and impede quality of life over time.

**Sub-goal** – Sub-goals describe the most specific elements of resilience, the most granular objectives, which are critical to achieving the aspirations articulated as goals. Sub-goals are represented in the third layer of the CWRF lens, sitting beneath both dimensions and goals.

**Tool** – Tools are used to reduce the time or cost required to achieve a defined objective or outcome.

**Urban** – Related to the city or surrounding territories directly dependent on the city. Urban water systems include all territories and actors involved in the provision, treatment, distribution of water for urban stakeholders.

**Vulnerability** – The conditions that makes certain groups more heavily impacted by shocks and stresses than others including, for instance, socio-economic conditions such as poverty, low educational attainment, limited access to healthcare and limited access to critical infrastructure.

**Water Basin** – The geographic area in which precipitation collects and drains to a common outlet. Communities within a water basin are tied together by natural hydrological processes, irrespective of administrative or political distinctions.

**OurWater** – A digital tool developed as part of the City Water Resilience Assessment, OurWater helps cities understand and map their water systems by recording and visualizing the relationships between key stakeholders and infrastructural assets.

**Watershed** – see Water Basin.

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# ANNEX A
## DATA ANALYSIS

This document describes the methods used to analyse data collected as part of fieldwork for the City Water Resilience Approach (CWRA), with missions undertaken in five cities between April and June, 2018. This annex outlines the steps taken to ensure rigor and consistency during this process.

Section 1 describes how the project team analysed data from fieldwork collected during missions. The Arup team used observations from these missions to develop a draft City Water Resilience Framework (CWRF), a resource developed as part of this project to help cities assess current actions and identify priority areas for future action.

Section 2 describes the Global Knowledge Exchange 2018 (GKE), a three-day event hosted by Arup with support from the Resilience Shift and the Rockefeller Foundation, and held at the Lloyd's Register Foundation in London from August 21-23rd 2018. This document details two validation workshops facilitated during the GKE, and how the results from those exercises shaped future iterations of the City Water Resilience Framework (CWRF) following the GKE. For an overview of the event, including a full list of attendees and lessons learned, see the Reflections on the Global Knowledge Exchange 2018 report.

# 1. FIELDWORK DATA ANALYSIS

Section 1 of this report describes data collection and analysis for fieldwork undertaken between April and August 2018.

## 1.1 OBJECTIVES

The overarching objective of the data analysis process was to use fieldwork data to draw comparisons across cities about common approaches and obstacles to improving urban water resilience, by aggregating individual observations into generalized principles. These principles include groupings of factors ('sub-goals') and groupings ('goals').

Fieldwork engagements consisted of workshops, focus groups and interviews conducted in Hull, Mexico City, Cape Town, Amman and Miami. Arup staff facilitated engagements, working with the Stockholm International Water Institute (SIWI), 100 Resilient Cities and local city partners.

The analysis methodology borrows from the City Resilience Index (CRI) tool in both the way observations were aggregated, and the terminology used to describe groups of factors at various scales (i.e. 'indicators', 'goals', and 'dimensions'). The CWRA builds on knowledge generated and refined in developing the CRI, which has been disseminated widely, and that uses similar terminology to reduce the learning curve needed for cities to employ the CWRF. Goals and sub-goals that were identified in this process were incorporated into the City Water Resilience Framework assessment tool, which was tested through workshopping with representatives from each city during the Global Knowledge Exchange (GKE) hosted by Arup from August 21-23, 2018.

## 1.2 DATA

Arup and SIWI facilitators recorded and observations in all in-country engagements in a single 'master' spreadsheet, which contained information about the location of engagements, participants, and the positive and negative factors of resilience associated with various shocks and stresses, i.e. the issues that contribute to, or inhibit, resilience in each city. The initial data set consisted of 1,577 separate records, of which 1,348 records contained information about factors of resilience.

## 1.3 METHODOLOGY

The method of analysis uses a combination of 'emergent thematic' and 'a priori' coding techniques to identify key themes. In emergent thematic coding, the coder identifies categories on-the-fly through the process of reviewing raw data, while in a priori coding, the coder defines categories before data is reviewed, and each record assigned its best fit (Blair, 2015). Coupling a priori and emergent qualitative analytic methods enabled the work to build on previous research insights while also remaining open to the possibility of new themes revealed through data exploration.

The following methodology describes how the team developed an initial list of sub-goals and goals (Section 2.1 – 2.4) from stakeholder engagements, and how we then combined this list with other data sources – including a) lessons learned from a review of literature, b) expertise from Arup facilitators – to develop a draft version of goals, sub-goals and dimensions (2.5 – 2.6) to incorporate into the CWRF.



### 1.3.1 GROUPING FACTORS INTO THEMES AND SUB-THEMES

For each record in the spreadsheet, we added one theme and one sub-theme as new columns, based on the positive and negative factors recorded for that record. Where there was not enough information to determine positive or negative factors, a null value was entered. All records were categorised according to a list of twelve themes identified through a literature review (a priori coding). Themes were value-neutral, describing current conditions (positive or negative) rather than aspirations ("stakeholders" rather than "empowered stakeholders") (see "Table 1"). Themes were not used in subsequent stages of the analysis, but were useful to help organize and expedite the grouping of sub-themes. Records were grouped by city and completed sequentially, with one member of the team assigned to each city.

Separately, we assigned a sub-theme to each record (emergent thematic coding). These were not predetermined but reflected loose buckets created for each record. This process ultimately resulted in 77 different sub-themes derived as part of the factors database review. Sub-themes were identified in a new column Sub-Theme 1 in the spreadsheet.

When all records had been reviewed and tagged, records tagged with an "other" sub-theme were re-evaluated and grouped into their best fit theme and/or sub-theme, or combined into new sub-themes.

### 1.3.2 DERIVING SUB-GOALS FROM SUB-THEMES

The team combined overlapping or redundant sub-themes and, where diverse factors were grouped into a single sub-theme, split sub-themes into smaller groups. We renamed the resulting sub-themes as "sub-goals" – measurable, positive factors that contribute towards the resilience of urban water governance (e.g. "effective mechanisms for community engagement" is a sub-goal of "empowered stakeholders"). This process resulted in 61 sub-goals.

*(1) Sub-goals were initially called "indicators" during the process. However, we found that this terminology was confusing, and have changed it subsequently for the sake of clarity. Indicators is now used exclusively to refer to the lowest level of analysis, i.e. the metrics used to measure sub-goals.*

### 1.3.3 VALIDATING SUB-GOALS

***Table 1***

***Initial list of themes used to classify factors in a priori coding***

- Management of assets
- Community role in resilience
- Data and forecasting
- Effective regulation
- Emergency preparedness and response
- Financial resilience
- Governance
- Interdependencies between critical systems
- Multi-stakeholder governance and collaboration
- Other
- Politics and leadership
- Solution design

To ensure that each sub-goal contributes to overall resilience of the system, groups were mapped against the "seven qualities of resilience" (integrated, inclusive, reflective, resourceful, robust, redundant, flexible) (Arup and the Rockefeller Foundation, 2014).

Finally, we validated one quarter of all records (assigned randomly, excluding null values) against the original dataset to ensure that each factor could reasonably be assigned to one of the 56 consolidated sub-goals. A full list of final sub-goals is provided in Table 2.

### 1.3.4 DERIVING GOALS FROM SUB-GOALS

During two internal workshops the team reviewed the initial list of sub-goals and grouped them into broader buckets, which would ultimately become 'goals'. In the first workshop, participants grouped the initial set of sub-goals into twelve buckets (without referring to themes). In the second workshop, a similar exercise was undertaken. However, this time sub-goals from the database analysis were combined with new sub-goals derived two other sources: field experience from the Arup subject matter experts, and conclusions from the literature review. Workshop participants then grouped sub-goals into larger categories. Again, without reference to the initial themes, the workshop teams produced 12-14 category buckets, roughly consistent with the results from the earlier exercise, and aligned with the 12 goals described in the CRI.

Finally, these buckets were renamed as goals, describing positive or desired characteristic contributing to resilience (e.g. the theme of "stakeholders" becomes a goal of "empowered stakeholders").

### 1.3.5 VALIDATING GOALS AND SUB-GOALS

The team reduced a combined pool of 105 sub-goals (the result of the factors database processing, and including new sub-goals introduced during the workshop) to 72 sub-goals by eliminating overlapping or redundant sub-goals and/or breaking apart overly broad sub-goals.

Similarly, we reduced a combined pool of 39 goals to a final list of 12 goals. The initial "long list" of goals was developed with reference to CRI goals, which had been discussed at length during city engagements. At the same time, these goals were validated in internal exercises in which teams grouped sub-goals into logical categories, and were allowed to modify or eliminate goals or propose entirely new goals to best match the group of sub-goals. These and the additional goals provided later by SIWI reflect a combination of fieldwork, literature and previous project experience.

At this point, SIWI introduced an additional 8 goals and 32 sub-goals, developed based on the initial database master list, their own experiences facilitating engagements as part of the CWRF and elsewhere, and in consultation with Arup's initial list of sub-goals. Again, the SIWI list of goals and sub-goals combined with Arup's own list, with similar or redundant goals eliminated, and sub-goals regrouped into the appropriate category. A full list of sub-goals provided by SIWI is described in Table 3.



***Table 2:***
*List of refined sub-goals, derived from sub-themes*

- Accurate baseline data
- Adequate disaster insurance or savings for households and business
- Adequate financial resources
- Adequate human capital and technical knowledge
- Adoption of water catchment and storage
- Adoption of water recycling and savings
- Affordable water supply and basic services
- Appropriate pricing to ensure cost recovery and manage demand
- Collaboration across political parties
- Communication of project co-benefits to users
- Community engagement with resilience issues
- Coordination with agriculture and food production systems
- Coordination with business and economic development
- Coordination with energy systems
- Coordination with housing systems
- Coordination with multiple urban systems
- Coordination with public safety
- Coordination with regional security systems
- Coordination with telecommunications systems
- Coordination with transportation systems
- Coordination with waste management systems
- Data sharing, public access to information and dissemination
- Diverse sources of water supply
- Effective policies to minimize deprivation and risk in vulnerable communities
- Effective regulation of land use and development
- Effective regulation of pollution
- Effective regulation of water supply and environmental impact
- Efficient government bureaucracy
- Emergency preparedness and response enforcement of regulations
- Equal provision of basic services
- Expanded capacity through new infrastructure
- Flexible and innovative project planning
- Forecasting and modelling
- Horizontal communication and coordination across government
- Illegal use of water resources
- Implementation of resilience measures
- Incorporation of local knowledge and cultural attitudes
- Initiatives to reduce psychological impact on residents
- Innovative financing and efficient use of funds
- Innovative technical knowledge sharing
- Long-term planning and continuity of planning programmes
- Maintenance and upgrade of existing infrastructure
- Management, protection and expansion of natural assets
- Measures to reduce groundwater depletion and permit aquifer recharge
- Minimized urban displacement due to water shocks and stressors
- Monitoring and evaluation
- Political leadership around resilience issues
- Presence of empowered institutions with clear resilience mission
- Prevention and management of water-related disease
- Prioritization of key projects
- Public education around water resilience issues
- Robust technical standards and design guidelines
- Stakeholder engagement, public participation and inclusive decision making
- Transparent and accountable governance
- Vertical collaboration within government

*Table 3:*
*List of sub-goals from SIWI*

- Adequate human resources and capacity for citizen participation
- Authorities are accountable to citizens for their actions and decisions taken
- Budget allocated to include vulnerable groups in participation processes
- Citizens are included in the process of designing the participatory procedures
- Clear technical standards and design guidelines
- Communication and dissemination of project co-benefits to users
- Deliberation platforms to reach a consensus among stakeholders
- Diagonal communication and collaboration between government private sector and civil society
- Education for active/meaningful participation
- Emergency, immediate response, post-disaster recovery plans in place
- Equity in access to information (information are available in different languages, gender friendly tools, etc.)
- Established local administrative units to facilitate citizen's participation
- Established strong community networks
- Established strong stakeholder networks (between government and citizen's)
- Established strong stakeholder networks (within the government)
- Experiential and experimental learning to improve understanding and ability to better response to disasters
- Feedback systems/platforms available and accessible by public
- Inclusive citizen's participation (across groups, age, inclusion of minority, vulnerable people) in different stages of decision-making process
- Increase and improve citizen capacity to plan, self-organize and cope with disasters/ uncertainties
- Information systems and platforms to access information by public
- Long term strategic planning
- Mechanisms in place to enforce compliance of rules and regulations
- Mechanisms in place to impose sanctions on authorities if the implemented action is deemed inappropriate
- Mechanisms that enable citizens to get feedback and challenge decisions
- Policies targeted to include vulnerable groups in participation processes
- Presence of participatory advisory councils or committee
- Public hearings take place between local governments and users, or service providers and users.
- Recognition of local indigenous knowledge towards improved decision making
- Sanctions in place for efficient use of water resources
- There are decision making units at different governance level



### 1.3.6 DERIVING DIMENSIONS FROM GOALS

Finally, we assigned goals to one of four dimensions (health and well-being, leadership and strategy, planning and finance, and infrastructure and ecosystems), aligned with the City Resilience Index.

Where goals could reasonably be grouped into multiple dimensions, we situated them in overlapping or 'hybrid' dimensions. For example, the goal "empowered stakeholders", which describes community inputs into governing processes, contributes both to community "health and well-being" and to "leadership and strategy" decisions, and therefore occupies a space between the two.

## 1.4 CONCLUSION

The resulting list of sub-goals, goals and dimensions are the direct result of aggregating and refining factors database, along with some additional sub-goals from a previous literature review and expert input from Arup and SIWI. These were validated at the Global Knowledge Exchange.

# 2. GLOBAL KNOWLEDGE EXCHANGE DATA ANALYSIS

Section 2 outlines data collection and analysis undertaken between August and November 2018. It describes the exercises facilitated by Arup at the GKE to validate a draft of the CWRF, how those workshops were analysed to inform changes to the framework, and subsequent steps taken to analyse and refine the CWRF.

## 1.1 OBJECTIVES

The GKE introduced the City Water Resilience Approach (CWRA), a process for guiding cities from assessment to actions to build urban water resilience. The CWRA has been developed in partnership with eight cities, the five cities previously mentioned, plus as an additional three cities —Thessaloniki, Greater Manchester and Rotterdam—that were engaged remotely. The event reaffirmed a customer value proposition and participants' general interest in project outputs. By creating a forum for city stakeholders to share best practices and reflect on common challenges, the event also advanced a global network of water resilience practitioners and knowledge sharing.

More specifically, workshops held during the GKE validated an early draft of the City Water Resilience Framework (CWRF), a tool for helping cities define a vision for resilience, and measure the current status of water projects in their respective cities. This document describes those workshops and summarizes how the output from the conference were captured, processed and incorporated into an updated version of the CWRF.

## 1.2 GKE DATA VALIDATION EXERCISES

During the conference, two workshops facilitated the evaluation of the current framework and indicators. The workshops were conducted in four groups defined by the cities represented:

- *Group 1:* Kingston upon Hull
- *Group 2:* Miami and the Beaches, Greater Manchester and Rotterdam
- *Group 3:* Cape Town, Mexico City and Amman
- *Group 4:* Global (consisting of representatives from organizations with interests in multiple regions)

These two exercises, the Quadrant Workshop and the Wheel Workshop, are described in detail below.



***Exercise 1:***
*Quadrant Workshop*

**Objectives:**
The objectives of this exercise were to identify which indicators participants felt were more valuable and how realistic they were to measure.

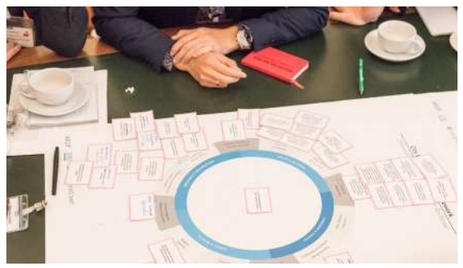
**Description:**
The CWRF has a three tiered approach:
- 4 dimensions, which contain
- 12 goals, which contain
- 84 indicators.

This workshop was conducted in 4 rounds, in which groups placed the indicators of each dimension (printed onto cards) into quadrants against 2 axis – measurability and relevance. The quadrants represented one of 4 positions:
- High relevance, high measurability;
- High relevance, low measurability;
- Low relevance, high measurability;
- Low relevance, low measurability.

**Recording Process:**
During the event, facilitators captured the results from each round, or dimension, by taking a photograph of the Relevance Grid after all indicators had been placed, this would inform the quantitative element of the results. In addition, each group was assigned a rapporteur who captured comments, feedback and discussion which took place during the exercise, this would contribute to the qualitative results of the workshop. In some instances, indicators were excluded from the grid as the group felt they were unnecessary, in cases such as these the rapporteur's qualitative notes would support this decision by capturing why this decision had been made.

**Challenges:**
While some teams had understood the exercise as 4 separate grids, others interpreted it as a spectrum. This meant some of the value couldn't be captured or indicators were put on borders between quadrants. Additionally, some individuals stacked indicator cards, making them invisible to the camera. Finally in some instances teams found the language on the indicators unclear and discounted them, or misunderstood them. While this is valuable feedback on the language, it meant some themes which were valuable were not considered as they weren't properly explained.

***Exercise 2:***
*Wheel Workshop*



**Objectives:**
The objective of the workshop was to identify how indicators were interpreted by stakeholders with respect to context and scope but also the vernacular of differing specialists.

The wheel helped reveal how indicators could be better placed to assist understanding of their purpose, but also served to reveal goals which were more important to participants.

**Description:**
In this workshop participants aligned indicators with the goals they felt best represented them. Indicators were printed on cards, being placed under the 12 goals, seen as the white and grey ring around the CWRF.

**Recording Process:**
As with the first exercise, results were documented by taking a photograph at the end. In addition, participants were invited to write any additional indicators they felt were missing on blank cards and include them in the relevant goal.

**Challenges:**
In this workshop, there was less discussion and so qualitative feedback was more difficult to capture about the reasoning behind the locations of certain indicators or why some indicators were excluded. Additionally, some participants placed indicators in the centre of the circle indicating cross-cutting indicators that could be assigned to multiple goals or dimensions. This did not fit with the initial intention of the exercise but was useful in understanding how indicators were interpreted.

## 1.3 METHODOLOGY

This section describes how information provided as part of the GKE data validation exercises was collected and analysed and then used to modify the draft CWRF presented at the GKE. Because GKE validation feedback was provided in the form of verbal comments and/or notes from participants, some subjectivity was unavoidable in this process. However, by establishing a set of rules for interpreting and processing comments, we attempted to introduce rigour to the process of interpreting this qualitative data.

### 1.3.1 CONSOLIDATING FEEDBACK FROM GKE

As a first step, all photos and notes taken by the facilitators and rapporteurs were consolidated into one folder structure, organised according to group. An Excel spreadsheet was created to serve as a library of results, arranged by the 84 indicators listed as rows, and with columns referring to group and workshop. The comments were extracted from the rapporteur's notes and entered into the cells of the spreadsheet with respect to the indicator they concerned and group they originated from.

### 1.3.2 GKE EXERCISE 1: QUADRANT WORKSHOP

Following consolidation, sub-goals from Exercise 1 were scored and validated to ensure methodological rigour and sub-goals/goals were evaluated based on a set of rules decided upon before the workshop.

#### 1.3.2.1 Scoring and Validating Results of Exercise 1

In the spreadsheet, indicators were assigned a score based on the quadrant each group placed them in as part of Exercise 1: Quadrant Workshop. Indicators were scored as described below:

- 3 = High Relevance/High Measurability
- 2 = High Relevance/ Low Measurability
- 1 = Low Relevance/ High Measurability
- 0 = Low Relevance/ Low Measurability
- 1/2 scores (I.e. 2.5) = Borderline between quadrants

This resulted in each indicator having four scores (one from each group) unless it had been deliberately excluded, hidden underneath another card or otherwise not present. Indicators status as being deliberately or unintentionally excluded was concluded from the notes taken by the rapporteur where possible.

The average, mode, minimum and maximum was calculated from each indicators four scores.

#### 1.3.2.2 Changes to Sub-Goals Based on Results of Exercise 1

Rules were established to determine which sub-goals were removed from the framework based on participant feedback, and which were kept in the framework or revisited with the possibility of modifying. Because feedback was subjective, rules were written so that the majority of sub-goals were marked for further interrogation based on comments by participants.

***Table 1:***
*Criteria used to define actions for discarding, keeping or revisiting indicators according to how relevant and measurable GKE participants believed them to be.*

| CRITERIA | ACTION |
|---|---|
| If more than one group scored as a 0 or 1 | Remove |
| If more than one group scored as a 2 | Revisit |
| If two or more cells are missing | Revisit |
| If no agreement between groups about how to score | Revisit |
| If more than one group scored as a 3 and another group marked as a 0 or1 | Revisit |
| If more than one group scored as a 3 and other groups marked as a 2 | Keep |

In most cases, where sub-goals were revisited as a result of GKE comments, they were renamed, or combined with other sub-goals. In other instances, they were kept as written or removed entirely if thought to be redundant, confusing or less relevant than other sub-goals. In all cases, the action – keep, remove or modify – was noted in the spreadsheet document, and reviewed with the larger group in later workshops.



***Table 2:***
*Criteria used to define placement of sub-goals in goals.*

| CRITERIA | ACTION |
|---|---|
| If more than 2 groups agreed on placement in Goal X | Place in Goal X |
| If 2 or fewer groups agreed on placement in Goal X | Revisit |

### 1.3.3 GKE EXERCISE 2: WHEEL WORKSHOP

Following consolidation, sub-goals from Exercise 2 were scored and validated to ensure methodological rigour and sub-goals/goals were evaluated based on a set of rules decided before the workshop.

#### 1.3.3.1 Scoring and Validating Results of Exercise 2

Sub-goals were associated with a corresponding parent goal based on where each group believed that sub-goal belonged (without seeing Arup's own proposed placement of sub-goals). From the four goals assigned by the participants, the most common was noted, along with the level of agreement for each sub-goal. The level of agreement was scored from 0-4 based on the number of groups who voted for the most common goal. This common goal was then compared to the initially proposed goal and highlighted if there was disagreement between how the sub-goal had been initially categorized, and how GKE participants categorized it.

#### 1.3.3.2 Changes to Sub-Goal Location Based on Exercise 2

A similar set of criteria guided how sub-goals were placed within goals, i.e. whether they were kept in their original locations along the wheel or moved elsewhere.

Typically, if there was no clear agreement on where the sub-goal belonged, but agreement that the goal itself was relevant and should be kept within the CWRF, the team kept the sub-goal in the most commonly chosen goal, or else in its originally proposed location if there was no agreement between groups regarding which goal it belonged in.

#### 1.3.3.3 Adding New Sub-Goals

Additional sub-goals were proposed by participants during Exercise 2. These were reviewed individually and added to the full list of sub-goals when they were determined to be relevant, meaningful and not redundant to existing sub-goals.

#### 1.3.3.4 Changes to Goal and Sub-Goal Names

Proposed changes to existing goals and sub-goals were evaluated individually and some were renamed in keeping with comments from participants, and according to the following principles, which ensure consistent naming of both goals and sub-goals.

- **Normative** – names should describe ideal or aspirational conditions rather than general categories. For instance, rather than proposing "Urban Planning" as a goal, the framework suggests "Adaptive and Integrated Planning."
- **Concise** – names should be concise. While the goal / sub-goal should be easily understood from the name alone, additional information about each sub-goal can be contained in the description provided for each.
- **Descriptive** – where possible, names should favour descriptive adjectives such as "accurate" and "transparent" over generic adjectives such as "good" or "adequate." In some cases, it may be difficult to agree on wording that is both descriptive and applicable across multiple cities. Still, descriptive language is more easily measured through indicators.

Two additional criteria were used specifically in naming sub-goals:

- **Specific** – sub-goals should refer to specific topics, instead of including multiple related topics. Specificity helps make the goal more action-oriented by limiting the potential number of indicators associated with each sub-goal. For example, "affordable and high quality water services" is less specific than "affordable water services" and will therefore require indicators that measure both the affordability and quality of water, and may necessitate action from multiple actors involved in different aspects of water provision.
- **Action-oriented** – an action is included or implied for each sub-goal. This makes it easier to link each sub-goal to an

intervention, and suggests potential actors to be involved in redressing the problem.

Using feedback from Exercise 2, goals and sub-goals goals were renamed according to the principles described above.

A full review of all goals and sub-goals was then carried out to ensure that all were renamed according to the principles outlined above. Because the framework was developed through an iterative process, and the wheel continued to change after initial GKE feedback was incorporated, sub-goals and goals were often renamed multiple times.

## 1.4 FURTHER CWRF REFINEMENT

GKE feedback represents one critical validation exercise in developing the framework, but not the final step in refining the CWRF. After GKE feedback was incorporated into the framework, an updated version of the framework was validated by the CWRF team through a series of formal and informal internal reviews. During this process, multiple iterations of the CWRF "wheel" were proposed, commented upon and revised.

First, following our analysis of the GKE comments, an Arup team validated results in an internal sub-goal review of all original and new sub-goals generated as a result of the GKE feedback. These were either approved, removed, combined, renamed or tabled for later discussion. A final set of goals and sub-goals were included into the draft framework based on this feedback.

A second internal validation occurred in the form of multiple iterative framework reviews that looked at the draft CWRF in its entirety to resolve the following questions:

- Is the framework comprehensive and complete (i.e. are there any gaps to be filled)?
- Is each goal / sub-goal as important to building resilience as all other goals / sub-goals?
- Are sub-goals correctly assigned to each goal or are they better placed in a different goal?
- Are goals and sub-goals described in a clear, consistent and specific manner?

These questions guided the team as it developed a series of iterations of the framework, commenting on drafts of the CWRF that were circulated within the team over the course of three weeks.

A third validation mapped each sub-goal against the "seven qualities of resilience" (integrated, inclusive, reflective, resourceful, robust, redundant, flexible) to ensure that each sub-goal contributes to overall resilience of the system. Finally, the draft was reviewed by the full project team, including both Arup and project partners, the Stockholm International Water Institute (SIWI), who reviewed the framework with specific emphasis on goals and sub-goals related directly to water governance.

## 1.5 CONCLUSION

The version of the City Water Resilience Framework (CWRF) presented in December 2018 and detailed in the City Water Resilience Approach report document is the final version developed through this process, which builds on fieldwork data, validated and refined through a series of internal and public workshops.

# ANNEX B

## INDICATORS FOR RESILIENCE

Resilience — like other conditions such as happiness, vulnerability and well-being – is difficult to measure directly, but as the concept has become established in the fields of international development and disaster risk reduction, there is increasing need to assess resilience to prioritize resources and action, and benchmark change over time. Given how little agreement there is regarding how to define resilience, it's not surprising that there are few widely used ways for measuring the concept. While there are many examples of measurement approaches, "there is no systematic or consistent representation of community resilience, nor the concepts that comprise it " (Cutter, 2016). Existing assessment approaches, which fall into three general categories – tools, scorecards and indices -- can be used a) to summarize a system's current performance, and make comparisons b) of performance over time, and c) between different geographic areas.

**Tools** include models or equations used to conceptualise resilience, or instruments that outline processes, procedures or resources that can be used to assess resilience. They are often "ready-made mechanisms for assessing resilience through the provision of data, models or specific procedures" (Cutter, 2016).

**Scorecards** prompt respondents with questions gauging levels of risk and responsiveness to disaster events. For example, one prompt used in the UNISDR Disaster Resilience Scorecard for Cities asks "to what extent are risk factors considered within the City Vision/Strategic Plan," which respondents answer with scores ranging from 0 to 5, describing how much or little the strategic plan considers risk. Scorecards provide "an evaluation of performance" towards a goal and include checklists, scorecards, and provide a grade or ranking, typically based on answers to qualitative questions (whereas indicators are often quantitative based) (Cutter, 2016).

**Indices** summarize resilience using a number that aggregates multiple individual indicators. Indices are the most common way of combining indicators, used in approximately two thirds of all frameworks (Arup, 2013). Indices can be used in "determination of baseline conditions, prediction of future trends, and as monitoring and warning systems. Indicators can also be used for making comparisons (across time and space or with targets), performance review, and improving scientific understandings" (Milman and Short, 2008).

Indicators can be selected using either of two approaches: **deductive** i.e. theory-driven indices use indicators that are chosen based on a theory about what constitutes resilience, whereas **inductive** i.e. evidence-based/data-driven indices test a large number of potentially relevant indicators through statistical methods to see which indicators most contribute to that outcome, ultimately landing on a small number of meaningful indicators. An essential weakness in the inductive approach lies in the difficulty of defining what is meant by resilience in the first place. When an outcome is directly measurable, statistical analysis can predict the relationship between variable and outcome with some certainty, yet in the case of "resilience," there is no clear definition of resilience to measure against (Fussel, 2008; Vincent, 2004; Eriksen and Kelly, 2007; Adger et al, 2004).



## TYPES OF INDICATORS

Indicators are a means of "encapsulating a complex reality in a single construct" (Vincent, 2004) by measuring related conditions or component parts when direct measurement is not possible. They "provide information either on matters of wider significance than that which is actually measured, or on a process or trend that otherwise might not be apparent (Hammond et al, 1995)" (Vincent, 2004). Indicators may come from pre-existing data sources such as census information or gathered through surveys, interviews and focus groups, etc. A mix of indicator types may be used, and can describe information collected for the household, community, or national levels.

Objective indicators typically rely on quantitative measurements such as economic or demographic information related to employment, income, age, access to education, etc. and may be gathered through official census records as well as surveys. Subjective indicators record responses from individuals to survey questions. Subjective indicators of resilience "make use of people's knowledge of their own resilience and the factors that contribute to it" (Jones, 2018) and "therefore relates to an individual's cognitive and affective self-evaluation of their household's capabilities and capacities in responding to risk" (Jones and Tanner, 2017). These indicators can be used independently, or in combination with objective indicators. Subjective responses can be translated into numerical values for inclusion in an index in multiple ways (CRI Vol. 4):

- **Binary** – that represent a "yes" or "no" answers as a zero or one
- **Likert Scale** – where numbers between one and five are assigned to responses depending on whether respondents feel "strong agreement", "strong disagreement." etc.
- **Bounded ranges** – that describe specific scenarios describing best and worst scenarios, assigning scores to each (e.g. 1-5), and ask participants to choose which scenario best describes their current state
- **Thresholds** – in which responders answer open questions about current conditions (e.g. "to what extent does your city provide flood mitigation measures…") with a score ranging from 1 to 5 corresponding with worst and best outcomes, respectively, but with no specific scenarios defined for scores.

In addition to objective and subjective indicators, indicators that measure functionality as a binary yes/no are often used to describe infrastructure, including, for instance, whether infrastructure can continue to perform a function in the wake of a disaster (Crown Agents, 2016). Though this judgement may be subjective, it does not relate to "self-evaluation" and so is considered here as a separate indicator category. Another category, cost-based indicators such as "cost of resilience" or Cost Benefit Analysis, measure resilience through totalling the total financial impacts of disasters and/or putting monetary value on cost improvements for resilience activities. (Crown Agents, 2016). Using this approach, a higher cost reflects lower overall resilience (Bene, 2013).

## BEST PRACTICES FOR CHOOSING INDICATORS

Choices about which indicators are chosen and how they are aggregated can result in vastly different index results. For example, different indices of national disaster vulnerabilities often show different indexed scores for the same country, suggesting methodological differences around how indices are developed and what underlying data is used (Fussel, 2009). In some cases, decisions around how to choose and aggregate indicators can also directly contradict findings from key experts (Gall, 2007 cited in Fussel, 2009). To help avoid this eventuality, the following best practice principles are proposed for guiding how indicators are chosen and combined, specifically related to measurement of resilience and vulnerability:

**1. Be specific about how the index will be used.**

Clarification should be provided around what scale the index or scorecard will be applied (municipal, national, international, etc.), what systems or attributes it evaluates, and how it will be implemented (Fussel, 2010). Questions of scale are especially important to consider, as aggregation may smooth over variations within individual communities, and hide pockets of vulnerability (Eriksen and Kelly, 2007).

**2. Agree on a conceptual model used to choose indicators and create indices.**

A first step in measurement is to determine how theoretical concepts are to be measured (Adger et al, 2004). Agreement on a conceptual model entails common understanding of what is meant by resilience, what qualities or capacities constitute resilience and what types of indicators are suitable for measuring it (Fussel, 2010; Eriksen and Kelly, 2007; Cobb and Rixford, 1998). For instance, if vulnerability is understood to be a function of human ecology, expanded entitlements and political economy, indicators measuring food availability, GNP per capita, and infant mortality might be chosen to measure vulnerability (Downing et al, 1995 cited in Adger et al, 2004). The lack of a clear link between indicators and their underlying theoretical basis is a common shortcoming in indicator selection (Adger et al, 2004). Because resilience encompasses multiple related elements, indicators should describe a variety of conditions to account for the multi-dimensional nature of resilience. In her study of community resilience, for example, Cutter identifies indicators corresponding with community resilience, including economic, institutional, transportation and regulatory attributes (Cutter, 2008).

**3. Allow for flexibility when developing an index / scorecard that will be used in diverse contexts.**

The same community characteristic may be more or less important in helping communities cope with change, depending on local context. If a measurement approach will be applied in diverse contexts, it should be sensitive to these realities when selecting indicators. Flexibility around which indicators are incorporated and how they are weighted may make the method more universally applicable (Fussel, 2010).

**4. Balance data needs—including trade-offs between data accuracy and availability—and limit the tendency to bias indicators based on data availability.**

Data quality varies between countries, and (where indicators are used in multiple contexts) it can be difficult to agree upon a universal list of indicators to be applied across different countries.

A related problem is the high costs associated with gathering sufficient data (BRACED, 2018). While it may be tempting to select indicators for which data is available or where costs of gathering data are low, this may bias results. For instance, "ease of measurement may explain why there are considerable indicators regarding physical characteristics of a community, but far fewer measurements for human and social characteristics" (Center For Hazard Research and Policy Development, 2008). In developing good indicators, a combination of data sources will be needed, with particular focus on the household. For instance, data on the use of infrastructure, hygiene behaviour, health and well-being, and equity can only be collected at this level. Available data from census or existing information sources may not allow for an adequate analysis of these issues. On the other hand, conducting a household survey is often resource intensive. There is thus a trade-off between data accuracy and data availability

**5. Be transparent about how indicators are chosen and combined.**

Because choices about which indicators are chosen and how they are weighted will influence index results, these choices should be clearly documented to ensure transparency (Fussel, 2010). To improve transparency, index scores can be represented as multiple sub-indices. For instance, an index that illustrates overall vulnerability might also show system vulnerabilities in social, technical, environmental or economic vulnerabilities as individual sub-indices. By ensuring transparency, decisions about what indicators are chosen and how they are aggregated may be challenged and revisited over time to make sure assumptions are still accurate (Eriksen and Kelly, 2007).

**6. Ensure statistical and methodological rigour in normalizing, aggregating and weighting indicators / sub-indices.**

In addition to clear documentation of the process used to choose indicators, methodological rigour is needed when combining sub-indices, specifically related to how indicators are normalized, scaled and weighted. For example, combining a global "country poverty" sub-index that assigns a value to each country based on total population living below $1 per day (not normalized), with a global "country wealth" sub-index that describes wealth per capita (normalized) would mean mixing two types of index, each calculated differently (Fussel, 2010). A similar methodological problem results from combining indicators that have been normalized using different methods (e.g. as nominal scales, ordinal scales or ratio scales).

Where weights are used, they should be considered carefully to reflect the relative importance of each indicator, as defined by the study team, local experts, key stakeholders, etc. Techniques such as analytic hierarchy process (AHP) and budget allocation (BA) stipulate participatory approaches to weighting indicators through transparent, agreed upon processes (Saisana, Saltelli and Tarantola 2005).

To test results related to how indicators are normalized and weighted, techniques such as uncertainty analysis (UA) and sensitivity analysis (SA) may be used (Saisana, Saltelli and Tarantola 2005).

**7. Choose independent and non-overlapping indicators.**

Careful selection of indicators based on a well-defined conceptual model will reduce the risk of choosing dependent or overlapping indicators. Selecting dependent indicators such as household income and household tax rate effectively double-counts the same phenomenon (Fussel, 2010). Indicators may also be inversely correlated, for example, by measuring an area's median income and poverty rate, as high income will signify low poverty. Another way to reduce redundant or overlapping indicators is through inductive indices that use the statistical methods of Factor Analysis (FA) or Principal Component Analysis (PCA) (Eriksen and Kelly, 2007). Without careful selection of independent variables, there is a risk of circular analysis in which "resilience" is defined according to a set of community characteristics, and those same characteristics are, in turn, used as indicators to measure resilience.

**8. Include indicators that capture a dynamic picture.**

Indicators often capture a snapshot in time, measuring current levels of poverty, education, ecological health, etc. Yet societies are dynamic and constantly changing, and resilience may fluctuate significantly over relatively short periods of time. In addition to static indicators that measure current state (e.g. of a society or infrastructure), dynamic indicators that suggest changing levels of economic access or wealth or health can be included (Eriksen and Kelly, 2007; Leichenko and O'Brien, 2002). Static indicators may still useful in identifying current baselines but offer a different perspective than dynamic indicators that measure change over time.

**9. Limit or eliminate potential for bias by respondents.**

Especially in the case of "report card" type evaluations, respondents may deliberately represent their city or organization in flattering light (Center For Hazard Research and Policy Development, 2008). Subconscious bias may alter how data is collected; for instance, government will have bias in whom they count for census, or how they conduct their counts or sampling, and this may influence the data used (Center For Hazard Research and Policy Development, 2008). To correct for this, the index can specify types of data and sources to be used, encouraging regular reviews of the index, outline steps taken to aggregate indicators, and limit respondents' abilities to mask results through aggregation.

**10. Choose indicators that refer to causes rather than symptoms.**

Identifying indicators that relate to underlying causes will help identify areas for future action. For example, an indicator that documents underlying causes of poor water service such as lack of investment in infrastructure (which leads to poor quality water and ultimately higher water costs) is preferable to one that documents its effects, including high rates of customer dissatisfaction. Choosing causal indicators will point to potential solutions, whereas "if indicators just tell about existing conditions without adding some insight into how they got to be that way, then the reports will not easily lead to action." (Cobb and Rixford, 1998).

**11. Incorporate testing and validation of indicators/indices after they've been selected.**

Indicators should be validated, for example by testing a predictive model against past disaster events. Case studies, expert opinion and in-depth interviews can also be used to validate indices (Center For Hazard Research and Policy Development, 2008). Incorporating these forms of validation can remedy "a serious deficiency in existing studies" related to limited verification of indicators and underlying theoretical frameworks, as well as decisions about how indicators have been weighted and normalized (Brooks et al cited in Fussel, 2010). For example, an index that shows overly high levels of economic vulnerability may be overly influenced by the choice to represent impoverished population numbers in absolute terms, rather than as percentages of total population.

## PROPOSED METHOD FOR CHOOSING INDICATORS

The following steps can help guide indicator selection for use in an index, based on the best practices described above:

1. Articulate goals and uses of the indicators/index, including how it will be used, at what scale, and whether it will be re-purposed for alternative uses.
2. Research focus area to understand underlying causes and key contextual information that will guide selection of indicators.
3. Determine whether an inductive or deductive research approach will be used, and whether subjective or objective indicators are selected.
4. Define resilience in the context of the study, and apply a theoretical framework to define what you are trying to measure. The framework will ultimately provide the basis for identifying the processes that contribute to resilience, defining why certain indicators are selected over others, and weighting and aggregating indicators (Vincent, 2004; Eriksen and Kelly, 2007).
5. Identify indicators using justification from extant literature on its relevance to resilience, and availability of consistent quality data from sources. To this end, the researcher may borrow from existing indices and/or sources (Vincent, 2004).
6. Identify methods for collecting relevant data.
7. Review indicators to ensure independency.
8. Collect data for indicators.
9. Transform raw data values into comparable scales for aggregating within an index. For instance, similar indicators might be normalized using percentages, or per capita rates. Variables are then analysed for significantly high correlation between individual variables and eliminated from consideration when such high correlations are found.
10. Aggregate indicators into an index. Ensure sub-indices are preserved throughout this process so that these can be evaluated individually.
11. Verify index results through case studies, measurement against historic events, or through expert opinions of knowledgeable actors working in relevant fields and/or community stakeholders.

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# ANNEX C

## CWRA FIELDWORK REPORT

# 1. BACKGROUND

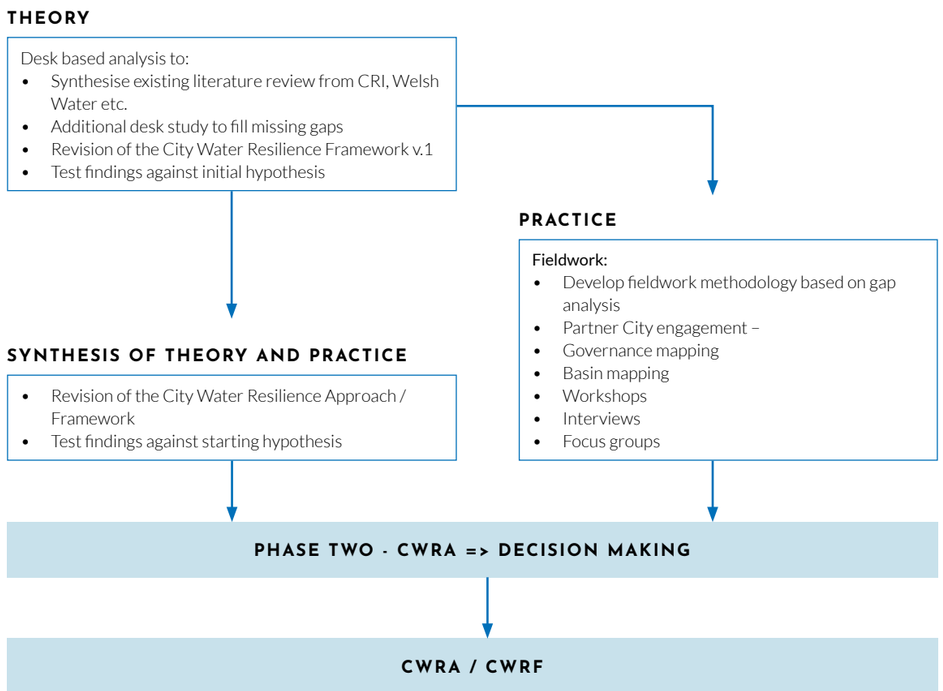
*The City Water Resilience Approach - Fieldwork Report describes (i) fieldwork undertaken in the five partner cities, (ii) the analysis of information and (iii) the key findings from this work. As part of this work, Arup partnered with local city partners to define city water basins, characterise resilience and assess decision-making that is applicable to cities at various scales with diversities of water challenges.*

This work was undertaken by Arup and Stockholm International Water Institute (SIWI), with support from the Rockefeller Foundation and The Resilience Shift, as part of the City Water Resilience Approach (CWRA), a project to develop a common understanding of the characteristics of a resilient urban water system and provide a global standard for water resilience planning. The CWRA helps cities assess complex urban water systems and build resilience against a wide range of risks in the face of an unknowable future.

The findings from the fieldwork analysis filled gaps identified in the literature review to improve upon the CWRA. Additionally, fieldwork helped the project team validate and refine the an early draft of the City Water Resilience Framework (CWRF), a resource that has been designed to help city stakeholders identify the most salient issues of their water system and assess current strengths and weaknesses.

Figure 1 outlines how the fieldwork fits within the overall process for the development of a City Water Resilience Approach.

***Figure 1***
*CWRA Methodology*






# 2 FIELDWORK STRATEGY

Fieldwork activities built an evidence base for the CWRA, in particular by focusing gaps identified during the research stage. Further, through fieldwork activities, the team engaged with partner cities to ensure that it is grounded in the practical experiences of cities and their stakeholders.

The draft version of the CWRF developed during the research stage represents a snapshot in time and forms the foundation of the approach for co-design work with partner cities. The findings of subsequent phases of work will continue to shape the framework throughout the project.

## 2.1 SELECTION PROCESS

Arup held an open competition was held for all members of the 100 Resilient Cities (100RC) network inviting cities to collaborate in the development of the CWRA. Separately, Hull was invited apply to be part of the project based on previous collaborations, and the belief that Hull would be a good partner based on its knowledge of water resilience, ongoing programmes, and the water-related challenges the city faces.

The principal selection criteria were:

- Awareness of city relationship with its urban water basin and urban water risks
- Resources within the city to engage with and contribute development of CWRF to maximise benefit of the CWRF to the wider city network
- Relationship between City Resilience Office and wider city stakeholders

Additionally the team considered the following characteristics:

- Diversity of challenges faced by cities in relation to water
- Arup's experience and relationship with the city
- Existing relationships between the city and members of the CWRF steering committee (in particular World Bank programmes)

Figure 2 gives an overview of the cities that applied to be a CWRF partner city and those that were selected.

***Figure 2***
*An overview of the cities that were selected to be either a Wave 1 or Wave 2 city*

## 2.2 FIELDWORK OBJECTIVES

To ensure that the desired outcomes of the fieldwork strategy resulted in successful delivery of the outputs, a number of objectives were defined for the fieldwork approach through a logical framework. A summary of the principal objectives is shown in Table 1.

## 2.3 APPROACH AND ACTIVITIES

A series of collaborative activities were identified and carried out during the fieldwork. These activities helped to foster a strong collaborative relationship between the city partner team and the Arup team whilst exploring the water resilience needs, knowledge and skills from different stakeholders.

The activities were organised in a chronological order and divided in three main phases:

- **Preparatory Analysis:** remote work done prior to the field mission
- **Field Mission:** two weeks of work in the city
- **Post-Mission:** analysis and reporting done after the field mission

The majority of activities were planned to inform the five-step CWRA and, more specifically, to refine an early version of the CWRF (the framework "wheel"), through workshops, interviews and focus groups. The project team approached these with open minds to facilitate rich and valuable conversations that will enable the team to understand stakeholders' perceptions and needs in relation to water resilience and identify additional water resilience factors most representative of the each city's water system.



**Table 1: Fieldwork Objectives**

| | OBJECTIVE |
|---|---|
| 1 | Defining the city water basin |
| 1a | Define the urban water system, the natural basin that the city relates to and their common water cycle |
| 1b | Map all stakeholders within the city basin and water cycle. (Roles, responsibilities etc.) |
| 1c | Identify and assimilate relevant knowledge and data to support urban water resilience |
| 1d | Identify interdependencies between systems and stakeholders |
| 2 | Understanding urban water resilience |
| 2a | Understand what stakeholders perceive by water resilience and the needs for city water resilience |
| 2b | Identify further factors that contribute to defining 'city water resilience' |
| 2c | Update CWRF v1.0 based on the knowledge obtained from the cities |
| 3 | Co-designing a CWRF concept methodology for implementation |
| 3a | Understand the decision-making process in cities for water |
| 3b | Understand the way in which CWRF can be implemented in its most effective way, aligned with the decision-making process |
| 3c | Embed knowledge and data in the CWRF and its implementation |

**Table 2: Fieldwork Stages**

| | | | |
|---|---|---|---|
| PREPARATORY ANALYSIS | 1. Mapping and data gathering | 1.1 Draft water system maps<br>1.2 Shocks and stresses<br>1.3 Data and knowledge | ≥ 4 Weeks |
| | 2. Stakeholder identification | 2.1 Stakeholder mapping<br>2.2 Review attendance and logistics | |
| FIELD MISSION | 3. City team workshops | 3.1 Briefing / Maps review<br>3.2 Implementation Methodology<br>3.3 Debrief / Next steps | 10 Days |
| | 4. Meetings with stakeholders | 4.1 Interviews<br>4.2 Focus Groups<br>4.3 Workshops | |
| | 5. Site visits | | |
| POST-MISSION | 6. Analysis of Information gathered | | ≥ 8 Weeks |
| | 7. Reporting | | |
| | 8. City testing and feedback | | |

**Table 3: Fieldwork Engagement**

| | AMMAN | MIAMI | CDMX | CAPE TOWN | HULL | TOTAL |
|---|---|---|---|---|---|---|
| **People engaged** | 112 | 164 | 146* | 139 | 150 | 711 |
| **Interviews** | 6 | 7 | 2 | 9 | 14 | 38 |
| **Focus Groups** | 6 | 7 | 5 | 5 | 11 | 34 |
| **Site Visits** | 3 | 5 | 1 | 5 | 2 | 16 |
| **Workshops** | 2 | 2 | 2 | 2 | 2 | 10 |

### 2.3.2 FIELD MISSION

Three different types of activities were carried out during the field mission: i) workshops, ii) stakeholder interview and focus groups and iii) site visits.

#### Workshops

Workshops were held with higher numbers of attendants and a diverse set of stakeholder groups. These provided the base to interrogate perceptions of resilience, stress test understanding of the city water basin and the interdependencies of the systems within it. Two types of workshops were held in each city:

**Quick Water Resilience Assessment workshop**
Objectives were to:

- Discuss relevant water shocks and stresses to each city
- Identify interdependencies between the water system and other systems
- Identify the most relevant goals for each city and assess them

**Water Governance workshop:**
Objectives were to:

- Discuss what constitutes governance for resilient water systems, who relevant stakeholders are, and how governance issues matter to the city;
- Understand how the City Water Resilience Framework can be a process that helps the city to improve water resilience;
- Get feedback from the participants on how to design the implementation process in the most useful way.

Within the workshops, participants were presented with a flow chart representation of the water system and asked to annotate the chart and add the key stakeholders involved in each component of the system. The exercise resulted in the organogram and stakeholder commentary section of the report discussed earlier.

The joint exercise of mapping the water system and identifying the institutional arrangement of the water system helped all present (including both the project team and participants) understand the water system and various institutional arrangements influencing the city water system. It was also seen as the first step in aligning the objectives of different institutions. These activities helped participants understand the interlinkages of the system as well as how shocks and stresses could impact those linkages.

Outputs from the Water Governance workshop informed creation of OurWater, a digital tool developed as part of the CWRA, to help city stakeholders improve coordination around water issues. In some cities, early versions of the OurWater app was presented to stakeholders for feedback around both the purpose of the tool, and its graphic interface.

#### Focus groups and interviews

The appropriate format for different stakeholders and groups of stakeholders was agreed with each city during the pre-work stakeholder mapping exercises.

Individual interviews were targeted at stakeholders who hold strategic roles and high responsibilities in the city or water related authorities.



Focus group discussions were targeted at specialist and technical groups, community organisations, etc.

Questions were open and aimed to invoke candid responses rather than leading the stakeholder to a preconceived answer based on the team's prior knowledge. During both interviews and focus group discussions, engagements were structured in three parts, though there was some flexibility on the structure of type of questions asked from city to city:

1. Defining the city water basin (Objective 1) via the review of the maps created and its population with the identified shocks and stresses during the first part of the meeting.
2. Understanding urban water resilience (Objective 2) which was formed by a series of open questions.
3. Understanding the decision-making process in cities around water and how the CWRA might be most useful in improving decision-making (Objective 3).

#### Site visits

The project team undertook a number of site visits to provide the CWRF team with additional understanding around the type of challenges and opportunities present in each city.

### 2.3.3 POST-MISSION

#### Data Analysis

Following the fieldwork, the records and observations from the engagements with the five partner cities were compiled into a single 'master' spreadsheet which contained information about the location of engagements, participants, and the positive and negative factors of resilience associated with various shocks and stresses, i.e. the issues that contribute to, or inhibit, resilience in each city. The initial data set consisted of 1577 separate records, of which 1348 records contained information about factors of resilience.

The method of analysis used a combination of *emergent thematic* and *a priori* coding techniques to identify key themes. Coupling a priori and emergent qualitative analytic methods enabled the work to build on previous research insights while also remaining open to the possibility of new themes revealed through data exploration. By aggregating factors of resilience, the project team identified 12 key goals and 53 sub-goals, which were tested and refined through a series of internal and external workshops between July 2018 and October 2018. For more detail on data analysis following fieldwork, see Annex A and Annex B.

## 3 CONCLUSIONS

A particular goal for the fieldwork was to test how well both the CWRA and the CWRF could be applied in different physical systems. Whilst some partners cities lie at sea-level and rely on ports (Thessaloniki, Hull, Miami-Dade, Cape Town, and Rotterdam), others (Amman, Mexico City) are landlocked. Similarly there are differences between shocks and stresses encountered in each city. Whilst Amman, Mexico City and, recently, Cape Town, face intense water scarcity and rely on limited water resources, others rely on diverse water sources and confront persistent threats from coastal flooding and sea level rise. Differences also exist in the governance structures of the partner cities, and factors contributing to and detracting from resilience.

In attempting to create a universal approach that can be used by cities around the world, the CWRA has been developed to account for these differences whilst articulating a common approach to building resilience.

## 3.1 WATER GOVERNANCE

One of the interesting points of comparison was around governance structures in each city, which vary significantly in which level of government is chiefly responsible for providing water (national, subnational, municipal) and how organisations involved in water governance relate to one another.

- Most cities saw responsibilities for water governance shared across different levels of government: national, subnational, and local in a variety of ways. Often aspects relating to environmental protection were national or included national-level ministries for some of the work.
- Because Mexico City Metropolitan Area (MCMA) is almost like a state within Mexico, it has a lot more power than a traditional municipality within the country. On the other hand, Thessaloniki is a more typical city with much of the decisions around its water supply and its interdependencies being decided at the subnational level, which also controls the budget.
- Cities with government-owned utilities include Cape Town, Rotterdam, and Miami-Dade while Thessaloniki, Amman, and Hull had private sector service providers. Inhabitants of Mexico City receive most of their water through government organisations though private companies are contracted to provide support services.
- In all cities, a lack of coordination and collaboration across sectors and between actors resulted in less effective water governance, including lower quality services for residents, and less effective planning around water infrastructure and protections for residents and businesses against shocks and stresses.

## 3.2 CRITICAL INTERDEPENDENCIES

The urban water system does not exist in a vacuum. In fact, one of the main focuses of the City Water Resilience Approach is how the water system within the city engages not just with the full basin it belongs to but also the other sectors that rely on water and that influence the use of water. Despite differences between cities engaged, each with different governance structures and physical settings, a number of interdependencies were significant for multiple cities:

- The connection between water and energy came up for Amman, Thessaloniki, Mexico City, and Miami-Dade County. Both the need for water to generate electricity and the need for electricity to transport water were highlighted.
- Transport was a critical issue for Amman, Hull, and Rotterdam. Amman mentioned that flooding could impact transport roads while Rotterdam was more concerned about rail lines and the port. Hull was likewise concerned about any limitations to the port running smoothly.
- Livelihoods and the Economy was a highlighted interdependency for Cape Town, Rotterdam, Miami-Dade County, and Hull, all of which are port cities that rely on water transportation for moving goods. However, water transport was not the only concern related to livelihoods and economy. In Cape Town the drought affecting farming, tourism, and other businesses caused this linkage to come to the forefront of discussions. Miami-Dade also needs water quantity for its agriculture and urban development.
- Housing, particularly concerns around flooding of personal property was a theme for both Thessaloniki and Rotterdam.
- Cape Town was focused on urban planning and water interdependencies, particularly given flooding. Inadequate solid waste management in Cape Town creates blockages for the combined sewer/stormwater system. Urban planning also came up for Mexico City particularly regarding informal settlements.

## 3.3 KEY SHOCKS AND STRESSES

Cities face different shocks and stresses based on their location, climate, city morphology and resources available. Still, commonalities exist between cities:

- Governance challenges were mentioned as a stress specifically by Cape Town, Rotterdam, Hull, Miami-Dade, Amman, Thessaloniki, and Mexico City. While the specifics of what was inadequate varied in each location, it was clear that many participants in CWRF activities, interviews, and surveys felt that not enough was being done in governance to prevent and/or respond to the key shocks or stresses that the area faced. A common theme was the lack of collaboration and coordination among different governance stakeholders in decision-making, information sharing, and implementation.
- Flooding in its various forms was a serious issue for Cape Town, Rotterdam, Hull, Thessaloniki, Miami-Dade, and Amman. Hull, Thessaloniki, and Rotterdam face fluvial, pluvial and coastal flooding while Miami-Dade faced all those and groundwater flooding. Cape Town faces pluvial and fluvial flooding during the wet season with particular concern in informal settlements built on flood plains. Flash floods are a concern in Amman due to steep hills and high runoff.
- Given concerns around governance, it is not surprising that concerns around budgeting and financial resources follow for many of the cities completing the CWRF. Lack of Investment came up in conversations in Cape Town, Rotterdam, Thessaloniki, Miami-Dade, and Amman. In some cases it was an issue of financial coordination among stakeholders that led to issues funding agreed upon projects. In others, it was lack of interest in funding water resilience issues, and in still other locations there seemed to be interest but no budget.
- Three cities' participants focused on shortfall of critical infrastructure: Thessaloniki, Miami-Dade, and Mexico City. Thessaloniki felt its poor regulations of historic urban development—resulting in a combined sewer/stormwater system—led to inadequate infrastructure during the recent floods as well as staff shortages to run the infrastructure. For Mexico City, the concern was lack of maintenance on the infrastructure. The issue for Miami-Dade is that funding and monitoring practices do not account for the full reality of the situation: salt water intrusion, inflow, and other changing operating conditions.
- Water stress or scarcity was a concern stemming from other shocks and stresses, specifically called out as a shock/stress for Amman, Thessaloniki, Cape Town and Mexico City. In Amman's case, the sheer limitation of water availability overshadows all aspects of its water system. The study of Mexico City particularly looked at water scarcity in informal settlements and vulnerable communities within the area. Thessaloniki is concerned about the availability of water to meet the needs of different groups including industry and nearby agriculture in addition to city residents. Specifically, groundwater depletion or aquifer over-exploitation was mentioned as a stress in Cape Town and Mexico City. Drought was mentioned as an issue in Rotterdam and Cape Town.
- Water quality was a listed stress for Amman, Mexico City, and Miami-Dade. Concerns about the municipal utility's water quality has made Mexico one of the highest bottled water consumers globally, with 71-98% of the country's inhabitants consuming bottled instead of tap water. For Amman this issue was limited to high turbidity issues after heavy rainfall though during those periods sometimes water and sanitation services did not work for up to a week.

## 3.4 FACTORS OF RESILIENCE

While the shocks and stresses highlighted what factors were hindering cities moving towards being more resilient, equally interesting were conversations about what participants saw as helping to build resilience. In some cases, participants could point to work already being done to build resilience. In others, they had a clear vision of what was needed to make their cities stronger to enhance resilience. These factors include both those already in place and those that could strengthen the city if implemented.

- Cape Town, Rotterdam, Amman were very focused on the importance of increasing community awareness, improved communication, and community engagement. Cape Town had successful experience building community awareness during the recent drought. A focus for Rotterdam was to ensure its citizens are aware of the work being done to make the city 'climate-proof' by 2025.
- Improving water governance and water planning strategy came up as key ways to improve resilience in conversations in Cape Town, Rotterdam, Hull, and Amman. The important of collaboration and information sharing between all stakeholders involved in water governance were other key points. These issues also came up in Miami-Dade in discussions about how different aspects of governance need to integrate to better manage the situations as they arise.
- Creating innovative and/or stable funding sources was cited as a critical element in Hull, Miami-Dade, and Amman. This was a focus for Miami-Dade and Amman because of the feeling from the key shocks and stresses that they had more work to do to obtain the needed levels of investment to create urban water resilience. In Hull, participants expressed interest in finding investment at the catchment level to benefit both rural and urban groups.
- Other common factors of resilience cited in all eight cities were the need for resilient infrastructure and routine maintenance and upgrade of infrastructure to ensure continued high functioning of the water system.

## 3.5 SELECTED CASE STUDIES

### Rainwater Harvesting in Mexico City

Because half the world's population now live in cities, creating sustainable urban water systems has a great impact on environmental and social issues. To ensure a future with access to clean water, innovative water saving technologies need to be enacted on a large scale now.

Rainwater harvesting systems promote sustainable water management practices, mitigate the city's flooding problems, relieve poverty, reduce carbon emissions, and provide a reliable source of water for Mexico City and rest of the country.

Isla Urbana is a local NGO that has designed an environmentally, socially, and economically sustainable rainwater harvesting system that collects and cleans rainwater for households, schools, and health clinics. The system is inexpensive, easy to install, and provides individual residences with about 40% of their water supply year-round. Implemented on a large scale throughout Mexico City, this simple technology could provide 30% of the city's water supply and could help give a sustainable source of water to the 12 million Mexicans with no access to clean water.

Since 2009, Isla Urbana has installed more than 7,600 systems, with more than 53,500 beneficiaries and over 330 million of litres harvested.

Isla Urbana's goal is not only to install systems but also to make sure people are empowered to use the system to access a clean and constant water supply. The NGO's success depends contextual and social adaptation as much as its formal design of the product.



### Cape Town Day Zero 2018: Mobilizing Collective Action

In January 2018, the threat of the city running out of water soon became a real possibility. On 18 January, the city announced the imposition of severe water restriction, warning that Day Zero—the day when taps would be turned off and Cape Town residents would have to start queueing for water rations—was now virtually unavoidable, with the predicted date set at 21 April 2018. This concern led to the 'Day Zero' campaign to raise awareness of the issue and drive down consumer demands. The communication was multi-channel including TV, local radio, local newspapers, social media and via loud hailer cars. Credibility was provided to the information provided by the alignment of messages from experts of the Section 80 Water Resilience Advisory committee, who spoke on TV and the radio and wrote articles for newspapers. The campaign successfully conveyed a sense of urgency—that all citizens would be extremely negatively affected if the city reached Day Zero.

The campaign was backed-up by concrete data and information easily understood by Capetonians. It included:

- A dashboard updated weekly to show the anticipated date of Day Zero along with current dam levels and water consumption (CCT, 2018b);
- Widespread information on how to consume only 50 litres per person per day, including posters, a household water usage guide, and an online water use calculator;
- A Water Outlook report that identified key CCT interventions in the short and medium term to build trust and certainty with residents and the business community (CCT, 2018d);
- A city water usage map showing individual properties meeting or exceeding restriction targets creating incentives for behavioural change (City Water Map, 2018).

Three months later (March 2018) despite the absence of rain, the date for Day Zero had been delayed till 2019. This delay was due to many changes in water demand. First, the catchment's commercial agricultural users were shut down once their water allocation was reached. Then, thanks to the Day Zero campaign, a large majority of citizens trusted that there were very few free-riders consuming water above their allocation, which led to a shift in mentality that everyone could contribute to positively impact the crisis. Water consumption was reduced from 930 million litres/day in December 2016, to 630 million litres/day in July and to 520 million litres/day in March 2018 (CCT, 2018b; CCT, 2018d). This drastic decrease in water consumption, along with farmers of a Water Users Association donating 10 billion litres of water to the city, and water production from alternative sources coming on stream. Overall, the campaign resulted in widespread engagement of citizens, hydro-solidarity, and a shift to collective prioritisation of water for human consumption.

However, the 'Day Zero' campaign also had unintended consequences. The campaign was picked up by international media and as a result, there were negative impacts on tourism numbers and foreign direct investment queries in Cape Town.

*Figure 3*
*-Amman, Jordan*

### Jordan's Samra Wastewater Treatment Plant

Al-Samra Wastewater Treatment Plant, operated by Suez, treats all of Amman's collected wastewater and 71% of all wastewater collected in Jordan.3 Treated wastewater discharges into irrigation canals, 90% of which is recycled for agricultural purposes.6 The treatment plant is world class, operating at 80% self-sufficiency in terms of energy consumption.

Phase One of the plant was completed in 2008 under a build-operate-transfer (BOT) finance mechanism backed by the Jordanian government through USAID funding. Only two years after opening, the plant reached capacity, initiating Phase Two of the project, which was completed in 2015 backed by Millennium Challenge Corporation (MCC) funding.

The project continues to be hailed as a regional and global exemplar of successful Public–private partnership financing. The deal aligned the interests of all the parties involved, transferring much of the risk to the private sector. The project sponsors, Suez International and Morganti, raised $175 million USD in debt and equity within the context of extreme political and social turmoil in the region. A lender syndicate led by the Arab Bank offered a 20-year tenure on the commercial loan, the longest a Jordanian bank has ever offered for a limited recourse dinar loan. Financing of the project under local financing offered reassurance to the Ministry of Water and Irrigation, which did not have to take on foreign exchange risk.

The project earned the World Finance Infrastructure award and the WEX Global Award for Innovation in 2013.



## 3.6 REFLECTING ON THE CITY WATER RESILIENCE FRAMEWORK (CWRF)

Many participants felt the CWRF added clarity to discussions around water systems and ultimately helped to create consensus by building a shared vision with everyone working towards a common goal. Facilitating conversations, breaking down silos, and enhanced understanding between diverse stakeholders was one valuable result of the workshop.

Participants found that the CWRF allowed them to share learning and building collaboration with other stakeholders. They said the framework also helps create consensus because everyone works towards a common goal—building a shared vision of resilience. Participants expressed interest in bringing in a wide breath of stakeholders and in mapping out the stakeholders within the water cycle.

Two main questions came up in multiple Wave 1 cities:

1. Who would 'own' the process of implementing the framework?
2. How to get the work done given limited resources?

Additionally, participants expressed the need for a flexible approach that would allow the CWRA to be included into ongoing programmes, projects, and policies.

# ANNEX D

## REFLECTIONS ON GKE 2018

# REFLECTIONS ON THE GLOBAL KNOWLEDGE EXCHANGE 2018

The Global Knowledge Exchange (GKE) hosted by The Resilience Shift and held at the Lloyd's Register Foundation in London from 21 August to 23 August 2018 brought together partners of the City Water Resilience Approach (CWRA) including the eight partner cities and the CWRA steering group. The GKE was facilitated by Arup and the Stockholm International Water Institute (SIWI). The aim of the Global Knowledge Exchange was to bring together project partners to ensure the utility and quality of the CWRA and OurWater projects and to build a global network of water resilience practitioners to share challenges and best practice.

This document describes overall event objectives, information collected and reflections gathered from the three-day event.

For further detail on how the analysis of the data collected at the GKE informed subsequent iterations of the CWRA, see Annex A.

## INTRODUCTION

Water is a key driver for urban resilience and the City Water Resilience Approach has been launched to respond for the demand for tools to diagnose and design for water resilience.
The City Water Resilience Approach supports cities to build the capacity of city water systems to endure, adapt and transform in the face of change. It is designed to help diverse actors – including city government agencies, civil society, private sector organizations and academic institutions – to better understand the relative strengths and vulnerabilities of water systems, identify opportunities to build resilience into all aspects of water management and paths forward for achieving better outcomes. It represents a step forward in helping cities to ensure that their citizens survive and thrive in the face of water-related shocks and stresses.

The City Water Resilience Approach is led by Arup, in partnership with the Stockholm International Water Institute, OECD and 100 Resilience Cities and is supported by The Rockefeller Foundation and The Resilience Shift. It has been developed in partnership with eight cities: Cape Town, Greater Miami and the Beaches, Amman, Kingston upon Hull, Mexico City, Greater Manchester, Rotterdam and Thessaloniki.

## OBJECTIVES

The aim of the GKE was to bring together city stakeholders to ensure the quality and utility of the City Water Resilience Framework and OurWater projects and to build a global network of water resilience practitioners to share challenges and best practice. The objectives of GKE 2018 were to:

- Identify the value cities derive from the CWRA and associated CWRF and OurWater tool and establish a customer value proposition.
- Validate the CWRA, associated CWRF and OurWater tool.
- Co-develop Phase 2 of the CWRA project.
- Begin to build a global network of water resilience practitioners created by sharing best practices and common water challenges.



*Presenting the CWRA at the GKE 2018*

## AUDIENCE

The event was attended by over 40 experts in city water resilience including specialists from Hull, Mexico City, Cape Town, Amman and Miami. City level organisations represented at the conference included:

- Hull City Council and Yorkshire Water;
- City of Cape Town;
- Mexico City;
- City of Amman;
- Miami-Dade Water and Sewer Department;
- Association of Greater Manchester; Authorities Civil Contingencies and Resilience Unit and United Utilities; and
- City of Rotterdam.

National and global level organisations included:

- Ofwat - Water Services Regulation Authority;
- 100 Resilient Cities;
- World Economic Forum
- World Bank;
- Alliance for Global Water Adaptation;
- Stockholm International Water Institute;
- The Resilience Shift;
- Lloyd's Register Foundation;
- OECD.

## ACTIVITIES

An overview of the agenda is included below:

### DAY ONE

The focus of Day One was on:

- Setting the context of the resilience challenges cities are facing in relation to water:
- Understanding the challenges facing our eight global cities and their response:
- Providing an introduction into the CWRA, CWRF and OurWater tool.

The agenda for Day One was:

- Arrival and registration.
- Welcome presentations.
- Water resilience in an urban context – perspectives from around the world: presentations and moderated panel discussions.
- Walking the path to a more resilient water future: Workshop session to co-develop decision support framework with delegates.

### Key Session 1: Water resilience in an urban context – perspectives from around the world

The exchange of knowledge started with presentations from Cape Town, Miami, Amman, Hull and Mexico regarding the critical interdependencies in water resilience in their cities. They are subject to a variety of shocks and stresses, ranging from severe drought to sea level rise and flash flooding. This session set the context for the GKE and aligned perspectives of city water system challenges, outlined approaches to resilience and provided best practice examples.

The five cities shared inspiring success stories.

- **Cayley Green** explained how the Day Zero campaign in Cape Town managed to reduce water consumption by 50% in 3 years.
- Hull's **Alex Codd** highlighted the successful multi-agency collaboration between Hull City Council, Yorkshire Water and the Environment Agency.
- **Debbie Griner** from Miami set out how their robust system to monitor salt front migration works in almost real time.
- Participants heard from the Resilience Shift's **Alexa Bruce** about the remarkable capacity of individuals working in the Amman water sector to respond to cascading interdependencies.
- Finally, **Arnoldo Matus Kramer** from Mexico City shared their water strategy for urban development. It will allow them to balance the needs and growth of other basins that Mexico relies on, and recognise trade-offs of different actions.

This was followed by a lively panel discussion, chaired by **Fred Boltz**, that also included **Diego Rodriguez** (World Bank) and **Tariq Kaawash** (Amman).

### Key Session 2: Walking the path to a more resilient water future

The afternoon session was a workshop to test the approach to step 1 of the City Water Resilience Approach, "Engage with stakeholders and understand their water system" and review the OurWater governance tool.

The session began with presentations by Arup and SIWI on the approach to assessing and improving water governance and the OurWater governance tool. City groups were then taken through Step 1 of the City Water Resilience Approach for their city, including:

- Convening a multi-stakeholder group to undertake the approach;
- Developing an objective for the multi-stakeholder group;
- Mapping the water system and the stakeholders; and
- Understanding stakeholders control-influence context to determine with which partners to engage.

They were also taken through the governance aspect of Step 2 of the City Water Resilience Approach, the Resilience Assessment. This involved identifying the gaps within the governance functions for different shocks and stresses by analysing the stakeholder's role within each governance function. The governance functions analysed included: approval, accountable, leading, contributor and informed. The details of the City Water Resilience Framework in step 2 were covered in key session 3: Assessing water resilience on Day Two.

The session ended with a plenary presentation and feedback session on OurWater, the online governance mapping tool. We are Telescopic presented five possible functionalities of the OurWater tool:

1. Water cycle stakeholder mapping, including stakeholders impact by different shocks and stresses and the different governance functions each stakeholder is responsible for.
2. Understanding the strength of the relationships between different stakeholders.
3. A RACI (responsible, accountable, contributor, informed) table to map the responsibilities of each stakeholder on programmes and identify governance gaps.
4. Assessing the preliminary resilience of the city based on existing programmes and projects.
5. Assessing the resilience of the city using quantitative and qualitative indicators.
6. Assessing the governance of the city using the Organisation for Economic Co-operation and Development (OECD) Water Governance Indicator Framework.



*Ruth Boumphrey, Director of Research at the Lloyd's Register Foundation, presenting at the opening session of the GKE 2018*

*Value proposition workshop*

Feedback was provided by participants on each of the functionalities. Preference was expressed for:

- Function 1 to improve the understanding of the water system and the stakeholders involved.
- Function 4 to ensure that existing plans and programmes were built on.
- Function 5 and 6 to improve the data handling resource needed by cities.

There was a general agreement that there needs to be a consideration of the value of the function versus the time taken to input the data in selecting and designing functions.

#### DAY TWO

The focus of Day Two was on reviewing the City Water Resilience Framework.

The agenda for Day Two was:

- Assessing water resilience: Workshop to develop the goals and indicators of the water resilience assessment tool.
- Evening debate: 'If resilience had real economic and societal value then decisions makers would be implementing it already'.

### Key Session 3: Assessing Water Resilience – Shaping the Tool

The focus of Day Two was on reviewing the City Water Resilience Framework. In city groups, participants reviewed and edited the goals and sub-goals of the City Water Resilience Framework and selected the goals and the sub-goals which were relevant to their city. The definitions of goals and sub-goals are:

- Goal –The twelve objectives to be achieved as cities work towards resilience. Goals represent the second ring of CWRF lens, sitting beneath dimensions and above sub-goals.
- Sub-goal – Sub-goals describe the most specific elements of resilience, the most granular objectives, which are critical to achieving the aspirations articulated as goals. Sub-goals are represented in the third layer of the CWRF lens, sitting beneath both dimensions and goals.

Each group was provided with a set of proposed sub-goals and asked to place each of the proposed indicators on a graph with four quadrants relating to varying degrees of relevance and measurability. From these graphs, participants were asked to select the sub-goals that they would like to include on the Framework for their city.

Following this exercise, participants were asked to align indicators with goals to help ascertain the strength of the connection of the indicator with the proposed goals for positive resilience

*Participants mapping out Phase 2 of the City Water Resilience Approach*

*Participants in the Day 2 evening debate*

contribution. They were also asked to review the wording of the sub-goals and annotate any changes relevant for their city.

Each group's selection of goals and sub-goals were recorded. In data processing following the Global Knowledge Exchange, the recorded goals and sub-goals were used to:

- Determine the chosen sub-goals for the City Water Resilience Framework and their position relative to the goals:
- Update the language of the goals and sub-goals to ensure that the correct meaning is communicated:
- Develop our approach to indicator development, for example, whether there is any choice of indicators for cities and whether indicators should be qualitative or quantitative or both.

### Key Session 4: Evening Debate

On the evening of the second day, there was a lively debate of the motion: "If resilience had any real economic and societal value, then decision makers would be implementing it already." The debate featured:

- **Trevor Bishop**, Director of Strategy and Planning, Ofwat;
- Dr. **Juliet Mian**, Technical Director, Resilience Shift;
- Dr. Fred Boltz, CEO Resolute Development Solutions, and Chair, City Water Resilience Framework;
- Dr **Mark Fletcher**, Global Water Leader, Arup;
- Dr. **Ruth Boumphrey**, Director of Research, Lloyd's Register Foundation;
- **Cayley Green**, Senior Resilience Analyst, City of Cape Town;
- Dr. **Diego Juan Rodriguez**, Senior Water Resources Management Specialist, World Bank.

## DAY THREE

The focus of Day Three was on the co-creation of Phase 2 of the City Water Resilience Framework. Phase 2 addresses how we move from the assessment using the City Water Resilience Framework to a prioritised, fundable action plan.

The agenda for Day Three was:

- From assessment to action – value proposition workshop.
- Site visit to Thames Barrier.

### Key Session 5: Value Proposition Workshop

In this session, the value to cities of applying the CWRA and Governance for Resilient Water Systems was explored via facilitated discussion around the following questions:

1. Why are the city and/or other players interested?
2. What should be accomplished and why is this important for the city? For other key players?



*Global Knowledge Exchange participants at the Thames Barrier*

3. What are the specific results from applying the framework that deliver value to the city?

The city groups were asked to map out the methodology for Steps 3 and 4 of the CWRA, related to action plan development and implementation. They were asked to consider the following questions:

1. Who needs to be engaged and how?
2. How do we validate the outputs?
3. How do we ensure the continuity and utility of the efforts?
4. How to connect the plan to the financing options?
5. Are there other key activities driving value?

Exploring these questions collaboratively with the diverse selection of experts present at the GKE allowed for a much deeper understanding of the value created by the frameworks and created opportunity for Phase 2 to be shaped for the end-user.

The outputs of this session informed two aspects of the City Water Resilience Approach. Firstly, brainstorming around the value of the CWRA informed our value proposition to share with cities and funders. Secondly, the process maps for Phase 2 were analysed to develop the CWRA methodology.

### Key Session 6: Site Visit to the Thames Barrier

On the afternoon of day 3, Global Knowledge Exchange participants went on a site visit to visit the Thames Barrier, a project that demonstrates 'resilience in action'. A presentation was provided by **Steve East**, the Engineering Manager at the Thames Barrier, on the genesis of the project, its engineering design and the future of the Barrier.

## KEY LESSONS

The GKE demonstrated a growing recognition of the importance of water in cities. Participants validated the need for the City Water Resilience Approach, and validated the team's findings in each city and reviewed and commented on the City Water Resilience Approach (CWRA). For more specific account of how inputs from the workshop informed the CWRF, please see Appendix B: Data Processing (Post GKE).

There was general acknowledgement around the need for a network of stakeholders to share experiences around water resilience. Knowledge sharing at a global level, including between cities working in similar geographic settings, facing similar challenges and/or operating in similar political or cultural landscapes, was highlighted as one of the key benefits of the Global Knowledge Exchange and there was a desire for this to continue and strength moving forwards.

## ACKNOWLEDGEMENTS

The workshopwas held at the Collcutt Building by kind permission of the Lloyds Register Foundation. The UK's Environment Agency provided access to and information about London's Thames Barrier.

# ANNEX E

## REFLECTIONS ON BELLAGIO

Over the past year, Arup has worked closely with the Resilience Shift (TRS), the Rockefeller Foundation and other partners in developing Phase 1 of the City Water Resilience Approach that will help cities grow their capacity to plan and implement projects to improve water resilience.

Throughout this process, we have relied on the insights of experts committed to addressing cities' most pressing water needs. These insights have been key to the success of our work, and will continue to be as we progress the City Water Resilience Approach into Phase 2 and beyond.

I would like to thank all attendees of the 'Improving City Water Resilience Forum' forum for joining us at the Rockefeller Foundation's Bellagio Centre, and for contributing their insights and experiences. The discussions around water resilience held during the event will benefit our collective efforts moving forward, and contribute to the partnerships that are key to developing pathways to more resilient water future.

**MARK FLETCHER**
*Arup Global Water Leader*

# INTRODUCTION

The City Water Resilience Approach (CWRA) has been launched to respond for the demand for tools to diagnose and design for water resilience.

The CWRA supports cities to build the capacity of city water systems to endure, adapt and transform in the face of shocks and stresses. It is designed to help diverse actors—including city government agencies, civil society, private sector organizations and academic institutions—to better understand the relative strengths and vulnerabilities of water systems, identify opportunities to build resilience into all aspects of water management and chart paths forward for achieving better outcomes. The CWRA works to strengthen all aspects of the water system, not only physical assets but also including those encompassed by the six capitals (human, social, political, economic, physical and natural). It represents a step forward in helping cities to ensure that their citizens survive and thrive in the face of water-related shocks and stresses, and that water systems can 1) provide access to high quality water resources for all residents, 2) protect residents from water-related hazards and 3) connect residents through water-based transportation networks ("provide, protect, connect").

The CWRA is led by Arup, in partnership with the Stockholm International Water Institute, OECD and 100 Resilience Cities and is supported by The Rockefeller Foundation and The Resilience Shift. It has been developed in partnership with eight cities: Cape Town, Greater Miami and the Beaches, Amman, Kingston upon Hull, Mexico City, Greater Manchester, Rotterdam and Thessaloniki.

Between Monday 5 – Friday 9 November 2019, 22 water and resilience practitioners from 19 global organisations convened at the Rockefeller Foundation's Bellagio Centre at Lake Como for a Forum on 'Improving city water resilience.' The Forum was convened by Arup, Resolute Development Solutions and the Netherlands' Special Envoy for Water as part of the City Water Resilience Approach initiative.

Organisations represented at the forum included:

- 100 Resilient Cities
- Arup
- Carbon Disclosure Project
- City of Cape Town Resilience Department
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Global Environmental Facility (GEF)
- Global Resilience Partnership
- Indian National Institute of Urban Affairs
- International Water Association
- Miami-Dade County Office of Resilience
- Stockholm International Water Institute
- Miami-Dade County Water and Sewer Department (WASD)
- Netherlands Enterprise Agency
- Organisation for Economic Co-operation and Development (OECD)
- Resolute Development Solutions
- The Kresge Foundation
- The Resilience Shift
- UK Department for International Development
- The World Bank

The objectives of the forum include:

1 *Understand the City Water Resilience Approach.*

2 *Review and validate Phase 1 of the City Water Resilience Approach and associated Framework and Tools.*

3 *Build partnerships, link programmes and mobilize our collective work to advance city resilience through the City Water Resilience Approach and related efforts.*

4 *Co-create the next steps (Phase 2) of the City Water Resilience Approach*

In this document, we describe the City Water Resilience Approach and associated resources, including the City Water Resilience Framework and OurWater. We also summarise the reflections that we gathered from the 'Improving City Water Resilience' forum and outline next steps.

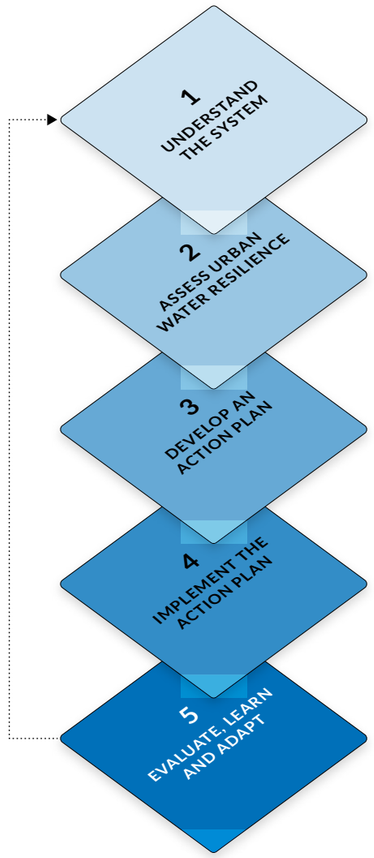
## 1. UNDERSTAND THE CITY WATER RESILIENCE APPROACH

The result of an 18-month research process—combining a review of literature, interviews and workshops with key stakeholders, input from outside experts and observations of field conditions—is the City Water Resilience Approach (CWRA).

The CWRA emphasises five key steps, with activities under each step, including the methodologies and resources to be used in each step. These resources include the City Water Resilience Framework (CWRF), OurWater and other governance analysis resources, along with workshop and programming activities to develop an improved understanding and build urban water resilience. The approach recognizes the need to understand urban water system from a holistic perspective, and the need for a multi-stakeholder approach to achieve better outcomes for urban water resilience.



*The five-step CWRA process*




The CWRA derives from a mixed-method research approach that included desk studies to identify current trends in thinking on the subject, and field engagement to better understand the challenges and needs of city partners. It describes an implementation methodology, a series of activities designed to achieve a city water resilience by understanding the wider urban water system and identifying and engaging the responsible actors, then assessing resilience actions, prioritising actions and developing and action plan, implementation of proposed initiatives, and finally evaluation, learning and adapting the plan. The step-by-step approach of CWRA provides guidance on what steps to take, how to perform those steps and why those steps should be taken.

**The CWRA provides a clear vision of what urban water resilience means for cities,** including what specific conditions must be accomplished to achieve this vision, what efforts will be required to build resilience and what actors are involved in this project.

**It provides a detailed plan for prioritizing key actions in cities and implementing them** to achieve the city's water resilience plan. Based on an assessment of each city's strengths and weaknesses, the CWRA describes a process for translating shared vision into reality.

**It provides resources that will help cities carry out each step of the process** by reducing the time and cost for cities. These tools include a mix of analogue and digital tools—including the City Water Resilience Framework (CWRF) and OurWater.

**It establishes an extensive and continuously growing body of knowledge on urban water resilience that cities can draw on** to share experiences, identify innovative new approaches, and advance a community of practitioners at all stages of the resilience approach. As the CWRA develops even further, it will include experiences of new cities, and ultimately catalyse new partnerships between a range of users and funders through new learning platforms.

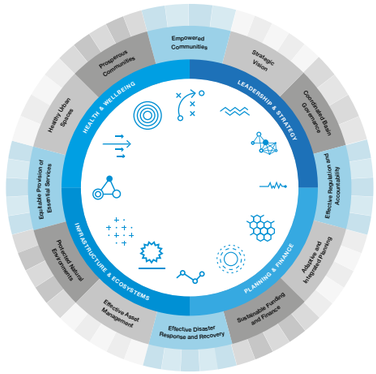
### RESOURCES FOR RESILIENCE

To help cities enact the multi-step CWRA process, Arup has developed a suite of resources, including digital and analogue tools and frameworks, with additional resources planned for the following steps of the approach.

The **City Water Resilience Framework** (CWRF) assessment aligns with the second step of the CWRA approach, helping cities assess strengths and weaknesses in their water systems, and

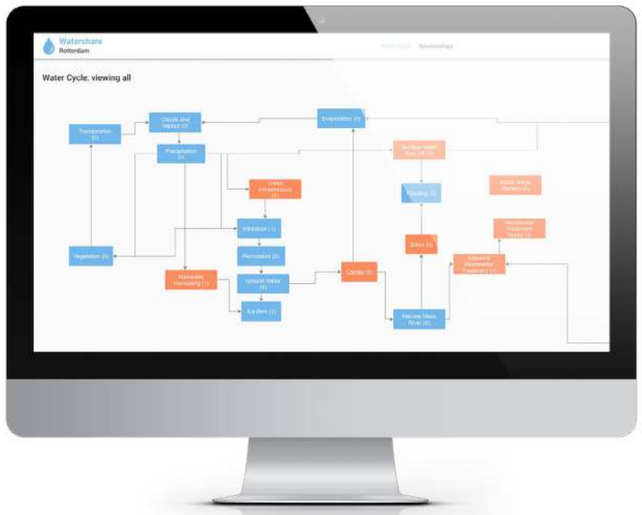
generate a framework of understanding of water resilience to guide future action. The framework brings together diverse stakeholders to agree upon a shared vision of urban water resilience in their city. It helps cities measure progress in building local resilience, and prioritize key actions and identify actors.

Another resource, the **OurWater** digital tool is designed to help cities improve water governance though better understanding of local water systems and the role of key decision-makers. This means improving awareness around the types of shocks and stresses confronted, the impact of these shocks and stresses on infrastructure systems, and the interaction between key stakeholders involved in urban water management. OurWater allows users to input information about the infrastructure and governance processes they participate in, and to map relationships between stakeholders throughout the entire water system. By answering key questions about the interactions between assets and actors that make up the water system, the tool addresses a fundamental challenge in most cities, where water governance functions are often siloed.




*The City Water Resilience Framework*

*A prototype version of the OurWater digital tool*






# 2. REVIEW AND VALIDATE PHASE 1 OF THE CITY WATER RESILIENCE APPROACH

## VALUE OF PHASE 1 OF CITY WATER RESILIENCE APPROACH

The value proposition of the City Water Resilience Approach was explored through the question:

*What is the added value of the City Water Resilience Approach to current resilience diagnosis, design and planning processes?*

*Table 1: Value proposition for the City Water Resilience Approach*

| Improves understanding of the city water system and the shocks and stresses it faces | Influences and inspires a best practice approach to water management | Supports collaboration between multiple stakeholders to take a coordinated approach to planning and implementation | Drives action to improve the resilience of water systems in cities and urban areas |
|---|---|---|---|
| • Identifies and manage future challenges;<br>• Provides a framework of understanding for water resilience;<br>• Share knowledge of the water system; and<br>• Maps governance across the water cycle. | • Expands the boundaries of current water resilience thinking;<br>• Supports becoming an exemplar city that thrives in relation to water;<br>• Has the potential to inspire a 21st century approach to water; and<br>• Captures and shares case studies and examples of resilience best practice. | • Gain a comprehensive understanding of the stakeholders involved in the water system and their objectives;<br>• Encourage cross-sector collaboration on water resilience and breaks down silos;<br>• Have common goals and a common plan<br>• Have a stronger, more co-ordinated voice;<br>• Different jurisdictions working together to attract funding;<br>• Learn from others, both locally and globally / Be part of a global network of water resilient cities;<br>• Extend ownership and responsibility beyond the public utility;<br>• Present one clear, aligned message to the public;<br>• Take account of interdependencies between critical systems and reduce the risk of cascading failures;<br>• Credible approach during to collaboration between the current partners including Arup, Rockefeller Foundation, The Resilience Shift, SIWI, OECD, 100 Resilient Cities, `World Bank and University of Massachusetts Amherst;<br>• Aligns with existing activities in the cities, for example, the City Resilience Framework and Index and the OECD Water Governance Principles and Indicator Framework;<br>• Facilitates city to city, peer to peer learning on water management and resilience;<br>• Seamless integration between catchment, city and utility governance to ensure that the right decisions are made; and<br>• Additional actors outside the utility at the table in a mixed stakeholder environment. | • Assess and test our current plans and processes;<br>• Identify gaps in current plans<br>• Create a portfolio of bankable projects;<br>• Develop evidence-based action plans through a globally recognised process<br>• Incorporate resilience / adaptation in decision-making;<br>• Identify and fill funding gaps;<br>• Enables a holistic approach to stakeholder engagement, institutional mapping and resilience assessment and action;<br>• Incorporates additional benefits (e.g. social and natural capital) into solutions; and<br>• Facilitates monitoring progress using indicators. |

## PHASE 1 OF THE CITY WATER RESILIENCE APPROACH FOR DEVELOPMENT

A peer-review of the City Water Resilience Approach and associated tools was undertaken focusing on the question:

*What are the important areas of Phase 1 of the City? Water Resilience Approach for further development and how might they be addressed?*

The aspects of Phase 1 of the City Water Resilience Approach identified by Bellagio participants for further development are outlined below. The areas for further development will be incorporated in the City Water Resilience Approach at the start of Phase 2 in early 2019.

*Table 2: Areas of the City Water Resilience Approach for further development*

| | |
|---|---|
| **VALUE PROPOSITION** | • Establish the value proposition for the City Water Resilience Approach including understanding the audience, the incentives of undertaking the process and the end goal.<br>• Identify the hooks that donors need to prioritise this initiative.<br>• Identify the differentiators between the CWRA and other tools.<br>• Set out the incentives for undertaking the City Water Resilience Approach. Is there the opportunity to frame the approach in relation to project donors?<br>• For donors, knowledge and reassurance that the investments are the right thing to do.<br>• Show other city interests (for example, investors and credit rating agencies) that the city understands its future |
| **CITY WATER RESILIENCE APPROACH** | • Develop a manual to support the approach<br>• Is any preparation need for stakeholder meetings to get a common understanding?<br>• Explore the incorporation of scenario planning<br>• Provide an outline of the city resource requirement for completing the approach.<br>• Inclusion of a manual of the process<br>• Establish the entry point<br>• Include an explicit step in the approach of sharing knowledge and lessons learnt with other cities.<br>• Include the step of spatially mapping water-related shocks and stresses and infrastructure, not just governance.<br>• Incorporate a step to baseline the score to reflect existing projects and programmes. This could use the Arup actions inventory.<br>• Incorporate reflection and adaptation step into the approach. |
| **CITY WATER RESILIENCE FRAMEWORK** | • Include informality in the framework<br>• Is city an inclusive term? Commonality of language/ Language clarification (framework vs.. tool vs.. approach) / Globally speaking the right language between sectors as well as within.<br>• Strengthen the narrative around the contribution of the goals and sub-goals to resilience. Add a golden thread of uncertainty and adaptive management, resilience to the process in sub-goals<br>• Include best practice examples for each sub-goal to encourage best practice for water management. Ensure that the framework inspires adoption of best practice. |
| **OURWATER** | • Peer review and test the OurWater Governance Tool<br>• Change the name of the tool to reflect governance rather than water resources management.<br>• Explicitly clarify how OurWater contributes to the approach |
| **IMPLEMENTATION** | • Partner or network cities to improve their cross-fertilisation of ideas.<br>• Demonstrate implementation of the City Water Resilience Approach |



# 3. CO-CREATE THE NEXT STEPS (PHASE 2) OF CITY WATER RESILIENCE APPROACH

The Phase 2 Strategy was co-created through two main questions:

*What value do you hope to gain from the Phase 2 effort? How might we strengthen the Phase 2 Strategy to fulfil our expectations?*

## PHASE 2 STRATEGY FOR THE CITY WATER RESILIENCE APPROACH

The Phase 2 Strategy for the City Water Resilience Approach set out five objectives:

**Implement the City Water Resilience Approach Step 2 (Assess Urban Water Resilience) for all eight partner cities.** This includes re-engaging with Wave 1 and Wave 2 city partners and carrying out Step 2 in each city, entailing testing and improving the City Water Resilience Framework and OurWater tool.

**Co-develop the approach for Step 3 (Develop Action Plans) with the Wave 1 cities.** This includes analysing resulting from the City Water Resilience Framework, co-developing a methodology for developing and prioritising plans and programmes, and co-creating City Action Plans for cities.

**Engage new Wave 3 cities** to identify city champions, introduce the approach, and begin to implement Steps 1-2.

**Refine and update OurWater digital tool** based on user testing with cities, to incorporate new functions into the tool and help cities improve local water governance.

**Promote water resilience learning** by setting up a knowledge sharing and learning community between partner cities and a Global Knowledge Exchange between partner cities and steering group members to share challenges, experiences and learning from the resilience journey.

The proposed programme for 2019 for the Phase 2 of the City Water Resilience Approach is described in Table 3.

*Table 3: Proposed programme of work for CWRA development in 2019*

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CWRA Development** | Review Phase 1 and develop CWRF indicators | | | | Action plan methodology co-creation and testing | | | | | | Review following city engagement | |
| **Wave 1 Cities** | City (Re) Engagement and Water Resilience Assessment | | | | | Action Plan Co-Creation | | | | | | |
| **Wave 2 Cities** | | City Re-Engagement | | Water Resilience Assessment | | | | Action Plan Co-Creation | | | | |
| | Resilience Learning | | | | | | | | | | | |
| | OurWater v2.0 | | | | | | | | | | | |
| **Wave 3 Cities** | | | | | | | | | City Engagement | | | |

*Table 4: The value of the Phase 2 strategy and aspects that were identified to be strengthened include:*

| Topic | Value | Areas to Strengthen |
|---|---|---|
| **WAVE 1 AND 2 CITIES** | • Widespread uptake of systematic approach.<br>• Implement in Wave 1 and 2 cities to provide credibility to the process and confidence in scalability and applicability | • Set up an advisory group including the partner cities to provide feedback on the indicator approach and indicators developed.<br>• Implement in five Wave 1 and three Wave 2 cities in 2019. For the five Wave 1 cities, use the information that was collected in the fieldwork and align any subsequent fieldwork and feedback with city schedules. |
| **COMMUNITY OF PRACTICE AND RESILIENCE LEARNING** | • Broaden and strengthen our community of practice.<br>• Knowledge exchange (peer to peer) | • Discuss with other tool developers on alignment (e.g. CRC Water Sensitive Cities, OECD Water Governance Indicator Framework). Workshop in Brisbane to align CRC WSC.<br>• Align with the Sustainable Development Goals.<br>• Develop partner's pack for potential project partners. The partners pack should include a clear proposal of how support can be provided, an outline of the value proposition of the City Water Resilience Approach, an outline of the approach, framework and tools and articulation of the phase 2 and 3 strategy and the visionary end goal. |
| **CWRF AND OURWATER** | • Improved resources for coordination between organizations for better water governance.<br>• Assessment of city progress to date and prioritization of key actions in partner cities | • Align with the OECD Water Governance Indicators<br>• Support other aspects of the City Water Resilience Approach<br>• Map existing available indicators for quantitative and qualitative indicators from existing frameworks and data that cities collect.<br>• Develop comprehensive indicators (qualitative and quantitative indicators)<br>• Include flexibility in the framework, pick from a list of indicators<br>• Include the rationale behind the indicators<br>• Explore the approach to indicators including flexibility, quantitative vs. qualitative and weightings. |
| **DEVELOPMENT OF CWRA** | • Action plans that are complete and well-informed.<br>• Ability to measure and monitor using the tool to determine progress and adapt approach<br>• Efficient use of funds (within the water system) to create resilience.<br>• Promote 21st century approach to water resilience. Case studies to show what good looks like.<br>• Comprehensive identification of strengths and gaps. | • Have a clear monitoring methodology<br>• Develop a 'simple and rapid' or 'lite' version for cities with limited resources.<br>• Prioritise how we act to capture the resilience value/dividend<br>• Total value evaluation, including natural and social capital<br>• Incorporate impact chains<br>• Incorporate multi-criteria analysis approach<br>• Insert an activity of getting initial feedback from the cities on the approach.<br>• Clarify what cities do and what facilitators do.<br>• Raise the profile of the wider benefits of some resilience solutions. |
| **WAVE 3 AND ROLL-OUT** | • Greater certainty of cost of application to cities | • Implement in African cities and Asian cities/global south, which are under-represented in the current cities.<br>• Develop a business plan going forward including resource requirements for the implementation of the framework, how much do cities contribute, where does the remaining funding come from.<br>• Communicate, publish and engage the City Water Resilience Approach and tools widely.<br>• Step by step document for facilitators and cities explaining the approach.<br>• Raise profile for new cities and define entry point for new cities<br>• Define the entry points for new cities joining the initiative.<br>• Capitalise on advantage of overlap with the City Resilience Framework and City Resilience Index.<br>• Develop a financial strategy for city involvement. |



## 4. BUILD PARTNERSHIPS, LINK PROGRAMMES AND MOBILIZE OUR COLLECTIVE WORK TO ADVANCE CITY RESILIENCE THROUGH FUTURE CITY WATER RESILIENCE APPROACH AND RELATED EFFORTS

The 'Improving City Water Resilience' forum at Rockefeller Foundation's Bellagio Center offered the opportunity for new partnerships and for links between programmes to be developed to mobilize our collective efforts to improve city water resilience.

During the event, it was agreed upon that a community of practice with participation by the Bellagio participants would be set up. This community of practice would need to define its terms of reference, but they could include active review of outputs and dissemination of the City Water Resilience Approach. The International Water Association has offered to support the community of practice. It was also suggested that we should invite other experts to join the Community of Practice, for example, American Water Work Association, World Economic Forum and the Utility Climate Alliance, and that we should approach other audiences for the City Water Resilience Approach, for example, insurance companies and credit rating agencies.

Support for the City Water Resilience Approach was offered by participants at the Forum. These include:

- Leveraging existing networks for the piloting and roll-out of the City Water Resilience Approach. These networks include:
  - The Resilience Shift
  - The 100 Resilient Cities network;
  - The Global Platform for Sustainable Cities (supported by the Global Environment Fund, World Bank, Inter-American Development Bank, United Nations Environment Programme and the Asian Development Bank), which currently includes 28 cities;
  - The Carbon Disclosure Project Company and Investor Network.
- Integration with existing plans and programmes, including:
  - Water as Leverage programme;
  - Asian Development Bank Technical Assistance programme, which includes 25 cities in 8 countries; and
  - National Institute of Urban Affairs Water-centric Master planning project.
- Opportunities for further discussion of assistance with The Resilience Shift, UK Department for International Development, 100 Resilient Cities, World Bank and the International Water Association.

We expect that this support, along with other insights shared during the event, will greatly benefit the CWRA and increase the project's impact going forward.