

Chapter 1

Introduction



Leslie Morris-Iveson and St John Day

Uncertainty and interconnecting crises are no longer exceptional. In almost every part of the world, living with water crises is an everyday reality for many. Yet, water supply sustains a functioning society, and as such any threat to it must be countered head-on. Frontline water suppliers, routinely forced to respond and adapt so they can deliver water in the face of all challenges, have found that their task has become much more complex. They must accommodate growing populations that use ever-increasing amounts of water, and do so in the face of climate change, once a distant spectre but now an all-encompassing catastrophe demanding fast and adequate response. As the climate becomes increasingly erratic, water supply becomes increasingly unreliable and intermittent; couple that with long-standing performance issues caused by failing infrastructure or a lack of investment in maintaining and growing services, and it becomes obvious that utility management practices need to improve quickly. The problems of leaks and ageing infrastructure have become ever more demanding, and the coronavirus disease 2019 (COVID-19) pandemic has shown us that reliable and clean water provision is ever more critical to human life.

The front line of water supply has never presented more challenges than it does today. Resilience – the ability to anticipate variability, and deal with, recover from and learn from complex shocks and pressures – has quickly moved to the top of the agenda and has to apply to all water supply operations in all circumstances.

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Solutions and opportunities to improve water security do exist. As well as technologies, there are decision processes, partnerships and other approaches which defy risks and ensure continuity of water flow during crises. The ability to share, interpret and use knowledge and experience supports the development of actions that respond to crises. To support those actively responding to realities on the ground, we need to reflect, learn and better understand how ideas of resilience can be translated into practice.

1.1 ABOUT THIS BOOK

This book is meant for anybody planning and delivering water supply services under increasingly difficult conditions. It spotlights resilience as a subject that needs focused attention because almost a quarter of the world's population now faces water crises (Hofste *et al.*, 2019). It explores actions and interventions on the ground that have advanced the provision of resilient water supply in response to complex challenges. The experiences of frontline water suppliers highlight the emergence of different practices, and the book explores a range of current methods that contribute to making water services more resilient.

From the moment we set out to create this book, we saw the vital importance of giving a voice to practitioners delivering water services on a day-to-day basis. Without knowledge of their local experiences, government institutions, the private sector and civil society cannot develop resilient service delivery models that can be supported and replicated elsewhere. Consequently, this book should interest everybody engaged in trying to strengthen the supply of water services in a range of locations and contexts. It will also be of interest to those undertaking professional qualifications because they will need to apply a strong thinker–practitioner approach.

The book draws on a range of locations and contexts to highlight the challenges being faced and adaptations being implemented; it covers industrialized nations with apparently high performance levels, robust institutions and utilities, as well as low- and middle-income countries, some of which are directly affected by armed conflict or decades of underinvestment. The experiences represented vary considerably, as do the available resources and institutional capacities.

In the process of editing this book, we have come to understand that much is being achieved in the struggle to provide safe water to entire populations in challenging circumstances, that building in resilience to climate change and other threats is evolving, and that much can be learned from sharing experiences. We have listened to others, who might be in vastly different situations, describe their choices and implementation of action. However, we do recognize the scale of the challenge. None of those to whom we have spoken would claim that their work has overcome the challenges faced; nor would any claim to have developed a fully resilient system.

The implications of demonstrating a range of contexts can be described in three different scenarios.

The first is seen in industrialized nations, whose water suppliers and institutions may already be operating relatively efficient water supply systems with high performance levels. The systems in which they operate will, therefore, be adjusting to some significant and specific risks. There might be an adequate level of resources, in terms of technical capacity and funding (including longer term financing to keep the options running), to ensure the options are sustainable. It is interesting to see how such initiatives might contribute single-handedly to these specific risks, and to understand the actual and potential direct effects of new practices and/or infrastructure.

The second scenario, seen in several countries, involves water supply delivered through largely inefficient systems, where practitioners are trying to improve performance levels at the same time as striving to strengthen the enabling conditions for more resilient water services. These locations might demonstrate how practitioners deploy and balance different approaches, according to needs on the ground, while at the same time improving water services that adequately meet the needs of populations today and into the future. In this scenario, the process of building systems includes developing system-level capacity (human, financial, technical).

The last scenario involves countries in which water supply services are partially or entirely lacking. In these locations, building resilient water supplies is complex, challenging work that will take many years, even decades, to achieve. Actions taken are often primarily community based, and capacity building of national institutions and securing greater human, equipment and financial resources are a continuous struggle.

Practitioners and decision-makers must focus on immediate actions that will achieve the basics of adequate water provision, but how are they to make a water supply system more resilient when the network of people, institutions, infrastructure and resources necessary to deliver sustainable services does not yet exist? This book aims to share insights into frontline practitioners' actions and initiatives when they are pressured to improve water supply services and keep them working.

Some of the cases represent major changes in methods of water supply, such as the transition from fossil fuel to solar as an energy source in rural Iraq, although the scale of their achievements is currently limited. Some focus on strengthening high-quality service delivery work; examples include sound analysis, planning, design and construction, all coupled with high-quality supervision, as in Tajikistan. Others focus on more specific, though still important, aspects of making water services fit for the future; one such example is the reduction of water demand in Suffolk to address impending water scarcity.

All the cases are linked with a common thread: water suppliers are trialling and implementing innovative practices with the aim of attaining two objectives – to supply adequate water to growing populations and to make the supply system resilient to current and future challenges. These approaches will continue to

adjust and adapt, guided by changes on the ground and by actors' and institutions' growing ability to develop capacities to absorb shocks so they can return systems to a pre-crisis situation. A summary of each chapter's content is provided at the end of this introduction.

Contributors to this book are all *practitioners*, professionals working for cities and local authorities, water utilities, water catchment (or basin level) management institutions and other government institutions, as well as for non-governmental organizations (NGOs), wider water service support institutions and partners. We hope that, by bringing all these practitioners' experiences and insights together in this book, we will not only help contribute to a realistic understanding of what 'working towards resilience' looks like in practice, but also stimulate informed interactions between service providers and service authorities. The book does not aim to provide an exhaustive rendering of the entire picture – the scope, scale and innovation of events far exceeds its capacity to do so – but provides a glimpse of useful cases. Above all, the book aims to contribute to practitioners' already vibrant learning and collaboration and to promote further understanding of the need to build resilience into critical water services.

1.2 WATER SUPPLY RESILIENCE: CONCEPTS AND CONSIDERATIONS

This section defines some of the terms and concepts used in the context of this book.

Resilience, the main theme of this book, can be described as the ability of the water service as a whole to anticipate variability, absorb and recover from different shocks as they happen and return to a pre-crisis or even achieve an improved position, and learn from the experiences.

The threat of water supply shocks is significant, as unmanaged shocks seriously disrupt water services, shutting down supply for hours, weeks or even permanently. Where excess risks are experienced and where water services are insufficient, a 'tipping point from high to low services and collapse' (Krueger *et al.*, 2019) can occur. The *tipping point* (or *threshold*) refers to the point at which disruption to the status quo and opportunities to transform the water service become much more difficult.

Institutions and systems with *adaptive capacity* are more able to accept the inevitability of unpredictability. They know that shocks and changes will occur and will be better equipped to plan, deliver and adapt water services, constantly inter-linking and innovating to accommodate the changing set of conditions.

Concepts relating to threats to and resilience of water supply are most vividly illustrated in the recent Cape Town Day Zero water crisis 2018, described in Chapter 2, where the impacts of severe drought conditions over three years led to major water shortages. As late as 2014, the six dams feeding the city were full. However, the effects of severe drought led water levels to decline drastically, eventually falling below 13.5% capacity (City of Cape Town, 2018). In early

2018, it was predicted that if no changes were made (or no additional rainfall recharged the dams), Cape Town would experience ‘Day Zero’, a day when the city would run out of water. This led to the initiation of severe water demand restrictions. Since the disaster of running out of water was avoided, the city has put a municipal-approved strategy into place to manage and diversify bulk water and reconcile supply and demand, as a way to build resilience into water supply. The multitude of actions described are all measures to adapt to future unpredictability.

Water service resilience can possibly be compared (or confused?) with sustainability. As WaterAid has described (2011) sustainability is defined by Len Abrams *et al.* in *Sustainability Management Guidelines (2000)* as: ‘Sustainability is about whether or not WASH services [...] continue to work over time. No time limit is set on those continued services [...]’. Note that ‘sustainable’ describes something ‘long-lasting’. Resilience describes something that has the characteristics that will allow it to overcome challenges and consequently last well into the future. We acknowledge that the term resilience is sometimes contested. There can be doubt about terminology such as *climate resilience* and different viewpoints as to how the term is used alongside the concept of sustainability. To what extent do development interventions really tackle current and future challenges? And what has been learned about planning to make infrastructure and services more resilient? These are questions at the centre of this book.

The focus of this book is on water services: the provision of water by suppliers, alongside the policies and institutional arrangements that enable water to flow, to households, businesses, industries and other user groups.

While sanitation is not covered widely in this book, we recognize that systematic resilience and sanitation is of vital importance for populations, alongside water supply, especially where needs are not met. We also recognize that sanitation provision and wastewater treatment are intimately connected to water supply, in that they are also provided by the same service providers. When sanitation is inadequate at a household or community level, this is a risk in itself. Where wastewater is untreated, particularly when in close proximity to water supply, it can contaminate valuable reserves of water. The term sanitation is also often associated with the process of treating and disposing of wastewater. As water companies become more proficient at supplying larger quantities of water, increased volumes of wastewater will become an issue of growing importance. The mandates of water utilities will need to evolve to prevent wider public health crises.

1.3 WHY RESILIENT WATER SUPPLY NEEDS TO BE PART OF THE NEW NORMAL

Throughout the world, pressures (situations which develop over time) or shocks (sudden-onset events), all have the potential to disrupt water supplies and exhaust

institutional resources. Natural disasters, water scarcity, and deteriorating infrastructure represent some of the many crises being faced. These crises are complex and multi-dimensional on an individual level. However, in an ever-more connected world, they have the potential to interconnect and cascade. These changes are exacerbated significantly by the climate crisis in which immediate impacts are worsening by the day, presenting unprecedented challenges for the water supply sector. The scale and complexity of these challenges demand that service providers urgently consider the resilience of their water supply systems: how services are and will be impacted by these changes; and how customers' actions and behaviours must also be part of the changes that are necessary.

The risk of water and sanitation service failure due to climate change is increasing (Howard *et al.*, 2016), with water services gradually declining as a result of not being able to bounce back following successive shocks. Entrenched problems are now inevitable, whether sudden or continuous, and will have the effect of undermining sustainability and resilience. Climate change exacerbates water availability, and variability will only increase and become more frequent and severe. Droughts and floods are examples of increased water variability that present shocks to water systems. Drought hugely impacts on water services, not only lessening availability for supply, but degrading water quality due to diminished flows and reducing the flushing rate of water bodies. Flooding can physically destroy water infrastructure, but can also contribute to saline intrusion and water pollution where inundation of water sources occurs, flooding of infrastructure including latrines, and poor water quality due to sedimentation. Rising temperatures are making dry regions drier, and lead to less water being available for water supply, as high levels of evapotranspiration increase the risk of drought or prolong periods of drought. When water use increases in drought-prone areas, groundwater and surface waters are depleted. Extreme temperatures can also contribute to water quality problems, for instance, increasing algal blooms.

Climate change is a very clear driver of change to water supply provision, but population growth, increased water demands and land degradation are all concurrent and overlapping trends alongside climate change. Climate change should be viewed alongside other pressures and factors that currently undermine sustainable service delivery. In many countries, serious disruptions to infrastructure and service delivery already occur, regardless of the impacts of climate change. Immediate actions and measures are required to improve performance levels and are fundamental if service providers are to respond to climate change pressures.

Water scarcity in particular has become an unprecedented global threat to water provision, requiring immediate and long-term sustainable solutions. As populations increase, causing an increase in the demand for water, water scarcity can become endemic during the dry season, or periodically throughout the year. In conditions of water scarcity the resilience solution has often been to focus on harnessing available water resources through the construction of reservoirs, dams and more

efficient supply systems. However, physical infrastructure must also be accompanied by sound stewardship of water resources and management arrangements need to be continuously reviewed.

In the UK, known for its high average rainfall, the threat of water scarcity led Sir James Bevan, Chief Executive of the Environment Agency, to warn of the ‘jaws of death’ in a speech in 2019, to describe a situation where, in the near future, there will not be enough water to meet needs (Bevan, 2019). The speech warned of a situation where water demand increases as the population, homes and business increase, while available water to supply those demands decreases, compounded by the effect of climate change. In the UK contexts, a range of different approaches are being implemented in the drier regions as described in later chapters, including managing water demand in Suffolk and Essex and working collaboratively in partnership across sectors to safeguard a sustainable supply of water, including on specific watershed restoration projects as described by Water Resources East in East Anglia.

Challenges faced by, but not limited to, low- and middle-income countries when attempting to make water supply more resilient are considerable. Water supply infrastructure may be old and crumbling or absent altogether. Major water supply systems may have suffered from a chronic lack of strategic planning and the finance needed to make improvements over many decades. Water companies and institutions may not have the resources and may struggle to perform essential maintenance functions, resulting in reduced supply efficiencies and low levels of customer satisfaction. These companies often also struggle to generate revenue and attract investment finance, and receive limited government support. In these cases, interventions must focus on being both appropriate and effective so they contribute to building resilient services in an incremental manner. If the right interventions are not identified or delivered professionally then they will not stimulate the necessary change.

In the situations described above, capital expenditures and ongoing costs required to keep water flowing are constantly increasing to meet growing needs. Unplanned urban sprawl, for example, is a particular challenge. Migration from rural to urban locations is a major trend throughout the world (United Nations Economic & Social Council, 2018) as people search for jobs and improved income security, leading to the emergence of informal settlements. Freetown in Sierra Leone has more than 70 unplanned settlements. Water companies like Guma Valley Water Company may be mandated to serve these populations, but they often lack the resources, infrastructure and finance to extend services and protect critical water and land resources. In addition, it is often the case that those wanting to improve their income security by moving to cities have little or no means with which to pay for water, resulting in water providers being unable to collect full payment for supplying water to these communities.

Against these challenges, water companies and mandated authorities will need to respond by building resilience into their services and infrastructure. In order to do

this, customers, service providers and governments will need to work together to rapidly respond to existing and future challenges. Any planned changes will need to be relevant and implemented effectively.

1.4 IMPLICATIONS FOR PEOPLE WHEN SERVICES ARE NOT RESILIENT

Everyone, from individuals to households, needs water that is reliable, clean and safe to use, to support basic needs and public health. People also want to be assured that they will have reliable water supply today and for future generations, without harming the ecosystems which they rely on. As recently brought into clear focus during the response to COVID-19, many water utility companies set about connecting customers previously not able to directly access clean water due to their limited ability to pay, in recognition of the protection a reliable water supply provides in the fight to prevent the further spread of the pandemic. In the UK, as a direct result of the role water utilities played in quick and effective service provision during the pandemic (ongoing at the time of writing), the UK Government, including the Water Services Regulation Authority (Ofwat), requested that service providers expand their ambition and play their part in green economic recovery efforts, for a more resilient future (DEFRA, 2020).

When services are not resilient, the resulting impacts can be either short or long term and greatly affect how populations access water. Water services can often emerge as intermittent supply (i.e. water that is supplied for less than 24 hours a day, or water that is supplied at irregular periods of time during crises). Water trucking – or water delivery through trucks – can be the result when solutions fail, during drought or during crises. This is an example of a band-aid solution, normally used for emergencies, that has now become the new normal in some parts of the world. Supplying water intermittently or through modes which are unsustainable and costly (such as water trucking) are undesirable and provide a means of service which is unsatisfactory and unrelatable for those who receive it. In many cases, water is not provided at all. When services are insufficient, a variety of coping mechanisms emerge at the household. This can include storing and hoarding water, bartering and bargaining for water at different points of the day when there are needs. Those who have the means buy booster pumps, or drill private boreholes. Women are often affected the most in low-income settings, being responsible for caring for household members, and the elderly and sick and their hygiene needs.

Water crises, in varying forms, often disproportionately affect the most vulnerable in society. Delivery of water and sanitation services themselves confer resilience on people by providing the health and wellbeing benefits of a clean supply of water, safe removal of insanitary waste and the associated hygiene benefits. The provision of clean water and sanitation services supports coping capacities during the most critical times, such as when populations are dealing

with disasters. Again, in low-income countries especially, lack of access to a clean water supply at or near their home particularly affects women and children, who are often the collectors of water when it is not supplied directly to their homes. This lack of access to a clean water supply has impacts on health, education and, ultimately, life opportunities.

Access to clean water and adequate sanitation is a universal human right, recognized by the United Nations General Assembly, through Resolution 64/292 (Resolution adopted by the United Nations General Assembly, ‘The Human Right to Water and Sanitation’, A/RES/64/292, 28 July 2010, available at: <https://undocs.org/en/A/RES/64/292>), which applies during crises, but also during all other non-crisis periods. The Resolution states that water is to be provided in a non-discriminatory manner and determines that states bear the primary responsibility to respect the right to adequate water and sanitation provision for all individuals within their territory. These rights have been further enhanced through the determination that *‘the water supply for each person must be sufficient and continuous and safe and acceptable, physically accessible and within safe reach for all sections of the population, taking into account the needs of particular groups, including persons with disabilities, women, children and the elderly....’* Water services must also be affordable, allowing access to all, whatever their means.

1.5 IMAGINING A RESILIENT WATER SUPPLY

Taking into consideration the diverse challenges and perspectives mentioned above, we ask the question: what would a more resilient water supply service look like? Intuitively, it would be less prone to recurrent breakdowns and failures. It would also be more resistant to external shocks, such as drought or flooding. It would be robust, but also able to adapt to changing conditions that is to say water would continue to be provided even during drought periods, as an example. This implies not only a focus on robust infrastructure but also a diversity in schemes and water sources to support different performance pathways to spread risk and buffer shocks. Infrastructure that augments supply, or ‘hard’ interventions must be complemented with soft path actions – the many decisions and actions focused on productivity and needs of end users, that all build resilience and sustainability. Actions which foster collaboration in the water catchment, and raising awareness of stakeholders on actions that build resilience is needed. The example of Water Resources East, illustrated in Chapter 4 is an exemplary model of how this can happen in practice – bringing together diverse stakeholders in a water-stressed catchment to not only plan, but also act together.

There is also a consideration of focus and scale; which part of the supply system could be improved to provide the largest positive effect on building resilience into the supplies. This is subject to debate, but there is a stronger understanding of the distinct shocks and pressures facing water supply at the local and regional levels.

Often, smaller and more decentralized actions are the most appropriate as they can be managed locally by the people and institutions most affected by current and emerging shocks and stresses to their water supplies. The example illustrated by Oxfam in Tajikistan as one of the actors in decentralizing water supply in response to a highly centralized and inefficient system, shows us the major challenges in achieving this where governance is weak. This example is illustrated in Chapter 6.

The readers of this book will have their own experiences and views on resilience. We believe a resilient water supply encapsulates all the essential components that are required to maintain water delivery at the desired performance levels. These components include people, their norms and practices, policies, institutions, infrastructure, environmental resources and finance. It is unlikely to be achieved through a single intervention, instead it requires a way of working that recognizes that the working environment is often complex and full of uncertainty.

Concepts such as ‘climate proofing’, ‘adaptive management’ and ‘build back better’, and tools to guide practitioners in understanding water risks and making decisions during times of uncertainty, are all examples of resilience planning in action. (A large number of examples exist, such as: Deltares’ Dynamic Adaptive Policy Pathways, see: <https://www.deltares.nl/en/adaptive-pathways/>; WWF’s Water Risk Filter: <https://waterriskfilter.panda.org>; and WRI’s Aqueduct Water Risk Atlas are a selection of useful examples that provide data or guidance.) Approaches such as vulnerability and risk assessment in the water sector and the water safety planning approach (WHO’s water safety planning approach: https://www.who.int/water_sanitation_health/water-quality/safety-planning/en/), identify and prioritize risks to water supply, allowing targeted actions to be taken by managers. In their own way, such guiding concepts, tools and approaches all aim to protect populations from the future effects of climate change, social and economic adversities and environmental degradation. These are all seen as important approaches to make water resources, physical infrastructure, institutions and finance more sustainable and durable.

Another aspect concerns the *relevance* of interventions. If operators are not addressing the fundamental issues at hand, their approach is likely to be flawed. If water demand exceeds supply for example, and no new water resources have been harnessed and developed, or consumer water conservation and efficiency of use addressed, a water company may never be able to satisfy their customers’ requirements. Consequently, interventions must address critical operational challenges. If the ‘right’ interventions are not implemented to high professional standards this could also have a profound adverse effect on sustainability and resilience. This is a pressing issue in many low-income countries, where the challenges of non-functionality and rapid decline of infrastructure services are well documented. In the future, it is feasible that governments and societies will demand assurances that service providers have the requisite skills to build resilient water services. They will need to be well designed, built and maintained

by people that have the requisite skills, knowledge and experience to do so. This growing demand has been identified by the United Kingdom's Institution of Civil Engineers (ICE, 2018). This means standards of professionalism in planning, designing and implementing water provision services will need to improve.

It is worth highlighting that water supply infrastructure is not maintenance free. All water infrastructure is prone to breakdown or service disruption at some stage. In such difficult circumstances some overarching factors are particularly important. Wherever possible, measures need to be put in place to deliver high-quality, professional services from the outset. If services are poorly constructed then there will be little prospect of them remaining resilient. When breakdowns or interruptions occur, systems need to be put in place to ensure a rapid response. There also needs to be continuous improvements to the wider 'system' – the network of policy, legislation, people, institutions, infrastructure, finance and resources. These improvements need to be guided by a clear investment plan that serves as a directional compass.

Engaging with complexity requires the ability to visualize the issues at hand and break them down into their component parts so that any action focuses on areas of greatest positive impact. Focusing on technology alone to address discrete risks will only solve one side of the problem. Resilience approaches require different processes, including integrated approaches that reflect on the interdependencies between the different risks experienced or predicted.

1.6 FROM THEORY TO PRACTICE

Resilience on a wide scale can be achieved. One example is taken from The World Bank's Resilient Water Supply and Sanitation Services Report (2018) report, which provides a useful overview of Japan's response to the 2011 earthquake and associated tsunami. The report shows how Japan has used an operational framework to strengthen the resilience of water supply which was effective during the crisis. The framework highlights a number of important factors, including demonstrating that countries need strong legal and institutional frameworks. These are required so that high quality of professional design, construction and supervision standards are followed and contingency funds are set aside for emergency response. Roles and responsibilities for disaster risk management (DRM) must also be set out in detail. In Japan, water supply and sanitation systems planning have formed part of a wider Masterplan, with redundancy built into the system so that water supplies can be re-established rapidly after disasters. There has also been strong emphasis on engineering design, materials, construction quality and routine asset management planning. This should ensure there is routine asset management and vulnerable assets are identified and replaced routinely as a result of adequate capital maintenance expenditure. This plan also places a high level of emphasis on contingency planning, including developing funds and subsidy programmes for assets which

build system resilience. These resources are set aside to improve systems and infrastructure, making them more disaster proof, so that the potential adverse impacts from a major disaster or crisis on the water supply are reduced. This helps to ensure there can be a timely and effective response and minimal system downtime.

The concept of 'Build Back Better' is one example of a resilience strategy aimed at reducing people's vulnerability to natural disasters – post emergency. The strategy forms part of Japan's DRM approach, and it emerged from the United Nation's Sendai Framework for Disaster Risk Reduction in 2015. This includes measures to improve physical infrastructure, social systems, economies and the environment. The idea of building back better is discussed in Chapter 7, in possibly the least resilient of contexts in the world. The chapter looks at making water supply resilient in long-term refugee camps that have been entirely reliant on external aid.

1.7 RESILIENT WATER SUPPLY

A key transition from simply building services to ensuring resilient services is to introduce a conceptual framework and a set of actions to ensure that the required parts of the process are being met. [Figure 1.1](#) broadly illustrates six key areas and some example actions that promote resilient water supplies. The actions were developed from a brief literature review ([GIZ, 2020](#); [UNICEF, 2021](#)) and from our own experiences of the different elements that need to be considered to deliver resilient water supply services. Many of the actions identified focus on environmental sustainability and sustainable water use and are therefore aimed at local, regional or national level as relevant.

Firstly, different actors must collaborate and plan together. Water supply must not be planned in isolation by the engineers who build the services. The critical threats to water supply should be evident, and actors should be able to correctly sequence activities to address risks. This recognizes the need for integrated approaches and reflects the interdependencies between water supply and other sectors that depend on large water quantities. By working with other water user groups, including in the agriculture and industry sectors, to jointly model and plan for future water resource needs, including scenario planning, the impacts of climate change and other pressures on shared water resources can be better mitigated. Crises and disasters happen in many forms and all infrastructure systems will fail at some point. When this happens there needs to be a process of analysis and recovery that can respond rapidly. The response must also ensure support for externalities when the magnitude and exact nature of future shocks cannot be predicted, for instance in Japan, entities responsible for coordination and enforcement of provisions are made clear through legal structures ([The World Bank, 2018](#)). This has enabled quick mobilization of external assistance.

Recognizing the importance of the water resources which are critical to meet water supply demands, actions are needed at the catchment level to ensure

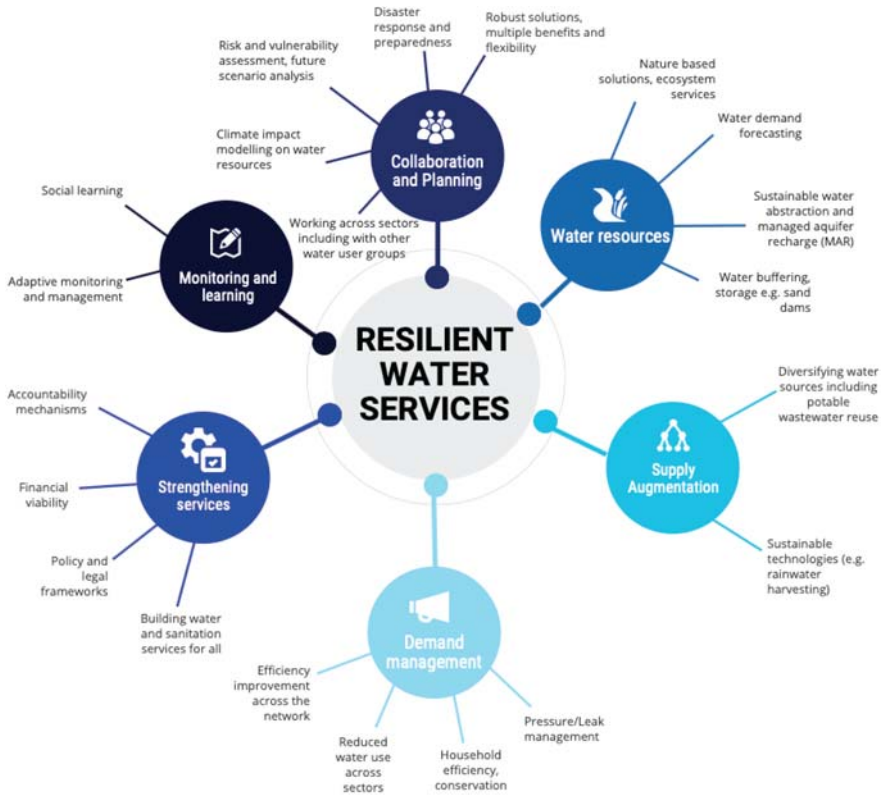


Figure 1.1 Conceptual framework for building resilient water services, with example actions under the six headings. *Source:* Leslie Morris-Iveson and St John Day.

reserves of water are managed sustainably. This includes, for instance, nature-based solutions that manage and restore natural ecosystems that enhance water availability and improve water quality. It is also necessary to understand renewable water availability and demand forecasting, estimating volumes of water that are required to meet future water demand. To provide a buffer against the impact of droughts, implementing sustainable storage methods at the appropriate scale (such as the use of sand dams in rural areas, typically in lower income countries) for water supply during dry periods. Sustainable methods for recharging aquifers (or ‘managed aquifer recharge’ methods) can be achieved by, for example, directing flood waters to naturally recharge aquifers which are being over-used, or to introduce treated wastewater under closely managed conditions and in specific circumstances.

Delivering macro- and micro-scale physical water supply infrastructure based on sound planning, design, construction and supervision is necessary to augment water supplies in response to population growth. Planning is critical as it plays a significant

role in determining the resilience of water services post-construction. Services need to be constructed to high professional standards, based on designs relevant for the location and environment in which they will operate, with critical infrastructure and equipment being renewed routinely. Schemes to augment water supply should be robust but should be planned with a recognition of supply risk, including the specific impacts of climate change, and should thus be designed for sustainability and conservation of valuable water resources. For instance, schemes which capture and store rainwater are a useful complement to schemes reliant on accessing groundwater. Schemes should be adaptable in implementation timing and scaled up (or down) in light of the changing nature of water demand.

In a world where water scarcity is very real, demand management is a necessary component of resilient service provision on both the supply and user sides of the process. Efficiencies need to be built across the system, including the need for the water supply industry to reduce leakages. Improving the efficiency of water use at a household level and water conservation at household, business and industrial levels are important factors in reducing water demanded, contributing to a more resilient system.

System strengthening activities should take place, particularly in settings where water supply needs to be scaled up to meet demand, within the overall aim of providing sustainable access for all in the context of international and national targets to achieve the SDGs, with a strong focus on marginalized groups. This would assist in building adequate institutional capability so that the required service level can be provided in the most cost-effective manner, and so that institutions are able to focus on routine asset management, improvement plans and supporting service providers to be financially viable. This also includes installing a policy and legal frameworks aimed at addressing present and future risks and meeting the needs of the public, prioritizing the most vulnerable. The financial viability of services must also be a central consideration, taking into account the ability of consumers to pay for the service and the cost level. Implicit in the concept of system strengthening is the process of building accountability, with all stakeholders (governments, service providers and regulators) discharging their responsibilities in an effective and transparent manner and service users consuming water efficiently. Without accountability throughout the water supply and consumption process, there will be less likelihood of the necessary continuous and systematic improvements.

Finally, a focus on monitoring, learning and capacity building needs to become ingrained throughout the water supply system. This includes enabling effective monitoring of resilience throughout the water supply process, as well as data collection to allow monitoring of implemented changes and to measure their effectiveness and the need for adjustment to maximize impact. Data collection and continuous learning need to take place so that routine corrective action can be taken based on evidence. This process should take place with an understanding of the particular risk and threats that would impact on the water

supply system. At a minimum, data should include: hydrometric performance, service levels, customer satisfaction and life-cycle costs. Knowledge should be jointly developed and shared openly so that the best options are implemented, and all stakeholders can buy-in at all stages of the improvement process through building a common understanding, lessons learned from any previous service disruption and improvements required for processes moving forward. Without this data collection, monitoring and feedback, service levels are very likely to gradually decline. When crises occur, then wider support systems also need to be mobilized. National and local institutions may have to take on joint management responsibility. In the absence of these foundations for water supply system resilience, the prospect of *building back better* will be severely limited.

Many of these concepts, practices and approaches are described in practice in the chapters of this book, as described below.

1.8 STRUCTURE OF THIS BOOK

In addition to this introductory chapter, this book consists of eight chapters contributed by different authors working in a range of locations and contexts. The contributors have described how their actions are making water institutions apply resilience in practice, addressing the multiple challenges they face. The result is a collection of standalone case studies, but with cross-cutting themes. Some examples highlight the huge challenges service providers face when working in some of the world's most austere environments. Others focus on very specific challenges and the change people are trying to make to deliver resilient water supplies in industrialized locations.

Each chapter describes the context and the specific resilience challenge that frontline practitioners are facing. They provide examples of the corresponding actions and measures being taken to keep services working efficiently. Although institutions may not actively refer to resilience, they may be nevertheless required to adapt, innovate and learn on an ongoing basis. Each chapter aims to provide frontline experiences, as well as highly practical lessons learnt.

Experiences of how institutions in low- and middle-income countries apply resilience in practice are rarely captured, though they generate some important real-world learning to complement the theory and principles relating to water resilience. Experiences from industrialized countries also offer key insights into how resilience has been built into water supply, incorporating a longer-term vision for sustainable water management. The water sector can be categorized in a range of ways (urban/rural, water/wastewater, developing/industrialized contexts), providing the opportunity to draw out cross-cutting issues, learning from what has worked and avoiding what hasn't. This way of looking at frontline experience also provides the opportunity to understand key principles in building resilient water supplies and which aspects of these systems are critical for the success of all resilient systems.

Chapter 2 is written by Dr. Gisela Kaiser and describes the response to the 'Day Zero' crisis in Cape Town from a public, urban, water supplier management perspective. This chapter details the lessons gained from the period in which the city's water supplies were running drastically low, leading to the implementation of intensive demand management and a long-term plan to diversify water supply.

In Chapter 3, Dr. St John Day, Nitin Jain Tom Menjor and Maada K Penge describe ongoing efforts by Guma Valley Water Company to improve the performance of water supply services in Freetown, Sierra Leone. The difficulties of infrastructure and institutional reform are set out following a decade-long civil war and years of underinvestment. They argue that opportunities to invest in critical infrastructure may have been missed. They also describe the key institutional reforms the water company is pursuing to improve service levels and build resilience in the face of growing environmental, social and economic pressures.

Chapter 4 illustrates a widespread domestic demand management campaign undertaken by a water utility in a rural, peri-urban area of Eastern/Central UK. This chapter is written from the perspective of Essex and Suffolk Water (the water utility company), by Dr. Fatima Aja, Tim Wagstaff and Dr. Liz Sharp.

Chapter 5 again looks at the Eastern Region of the UK, where an innovative and sustainable multi-stakeholder platform known as Water Resources East (WRE), consisting of 130 members representing all major water uses in the region, enables collaborative efforts towards large-scale scenario planning and resilient approaches to water management. The chapter is written by members of the WRE team, Nancy Smith, Dr. Robin Price and Dr. Steve Moncaster.

In Chapter 6, Dr. St John Day and Khaled Mokhtar describe efforts over a five-year period to introduce integrated water resource management approaches at catchment level in eastern Sudan. Khaled highlights the importance of building resilient water supply infrastructure in an arid and water-stressed environment, particularly when water provision institutions have suffered decades of under-financing and neglect. The chapter goes on to describe areas of support required from government, donors and service providers in order to build resilience into future water provision systems.

In Chapter 7, Dr. Ryan Schweitzer, Dr. St John Day, David Githiri Njoroge and Tim Forster ask can and should refugees expect water supply services in protracted emergencies to achieve higher performance levels and resilience. The chapter describes the possibilities for local institutions to be able to manage, modify and finance water services in refugee camps, and explores the efforts needed to raise performance levels in situations of long-term displacement.

Chapter 8, written by Dr. Mohammed Al-Khateeb and Dr. Ali Al-Khateeb, explores the Northern Governates (districts) of Iraq, a fragile and conflict-affected rural area in which the impacts of climate change, governance problems and conflict have led to a programme of augmenting water supply through renewable energy.

In Chapter 9, Orkhan Aliyev and Tim Forster describe how economic approaches to resilience through market-based water provision and systems strengthening have improved service delivery in Tajikistan. This chapter also highlights the remaining gaps as the multi-year programme implemented by Oxfam and its partners draws to a close.

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