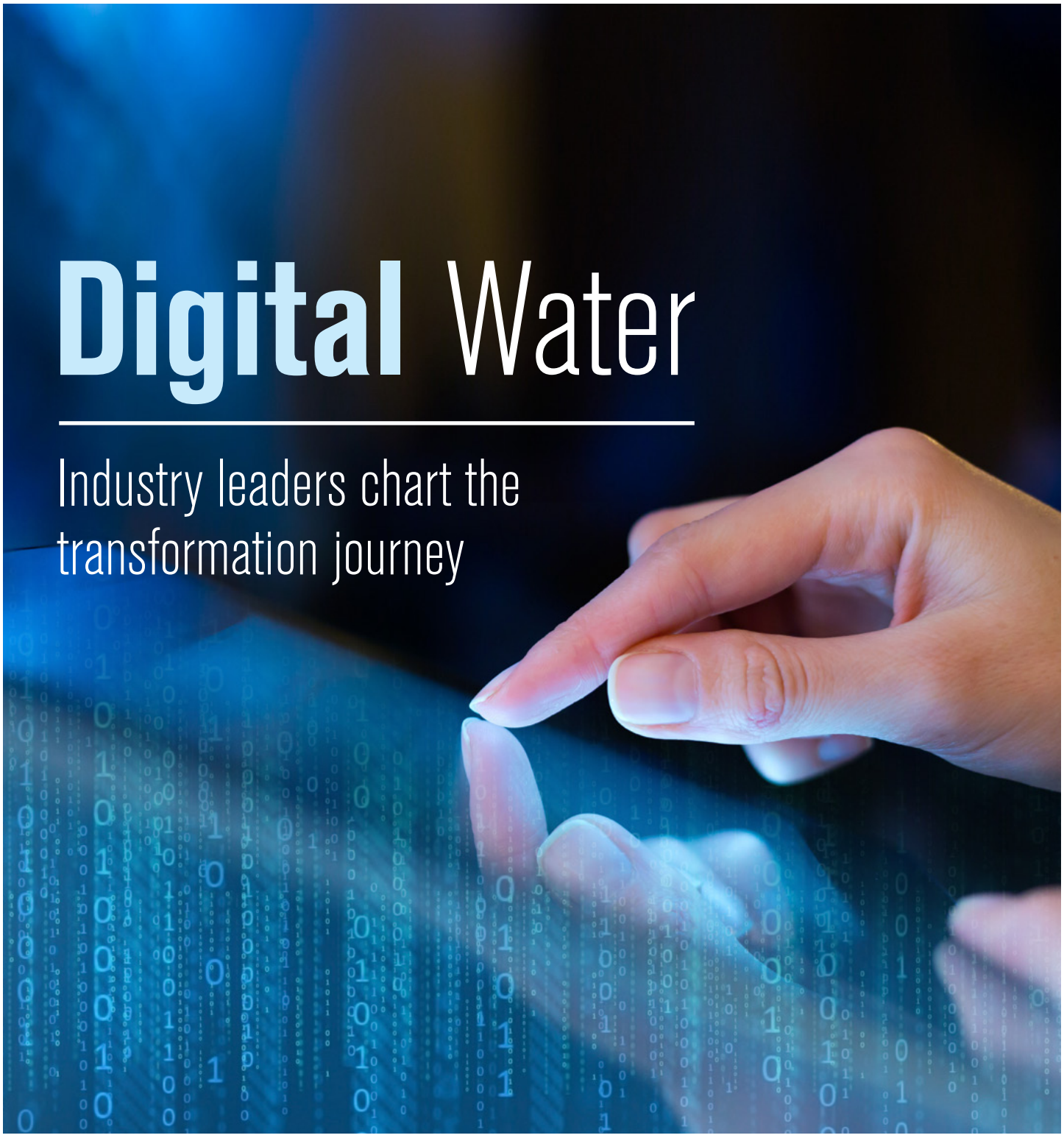
the international water association



Digital Water

Industry leaders chart the transformation journey

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the international water association

Digital Water

Industry leaders chart the transformation journey

This report was produced in collaboration between
the International Water Association and Xylem Inc.
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Foreword

from the International Water Association

The digital revolution is firmly embedded in our daily lives from how we interact with each other, to how we manage our finances. The digital revolution is also having a major impact on the water sector, enabling the transition towards a 'one water' approach, doing more with less and ultimately decoupling economic growth from water consumption.

Part of the International Water Association's (IWA) 5-year Strategic Plan 2019 - 2024, recognises the need for innovation to address global water challenges. As such, we at IWA are excited about the publication of "Digital Water: Industry leaders chart the transformation journey". The paper offers utilities a roadmap to assess where they are in their digital journey, and what steps they can take in order to cultivate their digital maturity. The paper also lays the foundation of the newly launched IWA Digital Water Programme, which is a gateway for water utilities to access knowledge on research, technology and innovation in the digital water space.

With increasing global change pressures, cities of the future will experience difficulties in efficiently managing scarcer and less reliable water resources. Against such mounting global pressures, the dawn of the digital water economy will prove transformational in enabling the water sector and its customers to transition towards a new paradigm for urban water management. Development plans will allow direct implementation of radically different system configurations: where surface water, groundwater and stormwater are combined as potential sources; where innovative solutions are applied that allow source separation of wastes and implementation of reclamation schemes (wastewater recycling, nutrient and energy recovery schemes); and where mixed land-use development promotes cascading water uses.

IWA is inspiring the international water sector to adopt a smarter approach to water management. Smart by design: adaptive 'off-grid', distributed systems that provide diversity, and modularity, characteristics critical for resiliency; Smart Use: combining concepts of water fit for purpose (different grades for different uses), and resource recovery and reuse (of water, energy, and nutrients from wastewater); and Smart (Digital) Control: IoT supporting data-driven models that can help integrate and optimise smart pumps, valves, sensors and actuators, and enabling each device to "talk" to each other, or for that matter to a customer's smartphone, and send real-time information to be accessed and shared via the cloud.

The IWA has an opportunity to leverage our worldwide member expertise, to guide a new generation of water and wastewater utilities during their uptake of digital technologies and integration into water services. The IWA can provide the platform that helps utilities recognise emerging digital technologies and solutions, how they can be integrated across the utility value chain, help them learn from it, and help them adapt and embrace change to create value.

Having been involved in the water sector and IWA for over 20 years, it is exciting to be encouraging our sector to embrace digital innovation, as we're certain it will prove transformational in positioning the water sector and its customers for resilience and efficient economic development, finding sustainable pathways for people and systems to persist, adapt, and transform in the face of change.

Kalanithy Vairavamoorthy
Executive Director of the International Water Association

Foreword

from Xylem Inc.

Global water challenges are placing more pressure on water managers and the communities they serve than ever before. Issues like water affordability, scarcity, resilience in the face of severe weather patterns from climate change, and water quality concerns are impacting water systems and citizens all over the world.

Yet, at the same time, there have never been more reasons to feel optimistic about our water future. Digital innovation is creating unprecedented opportunities to leverage data and analytics to inform better system-level choices today and improve future outcomes for watershed management, operations, maintenance, capital planning and customer service.

This decision intelligence is transforming and optimising water, and the results that "early adopter" utilities are achieving are powerful and game-changing. From reducing combined sewer overflows by a billion gallons a year, to cutting non-revenue water losses dramatically, water operators are reinventing water management, creating water, energy and cost efficiencies that a decade ago were unimaginable.

We know the technology exists today to solve many of the most urgent water challenges of our time. Now we need water stakeholders to come together to accelerate the adoption of these digital solutions – so more water systems and the communities they serve can reap the benefits.

Xylem Inc. is a global water technology company on the forefront of water innovation. As the largest pure-play technology provider in the sector, offering solutions across the water cycle, we are committed to helping convene the conversation about the power and promise of digital water.

It has been our great honour to work with the International Water Association and Water Foundry to engage in this in-depth examination of data and water. By bringing together insights from 40 utilities from around the globe that are embracing digitalisation, this paper helps create a roadmap for all water managers looking to begin or advance their migration.

No one can solve water alone. By tracing the digital journey and capturing the experiences of dozens of utility pioneers, we are starting a dialogue and building a body of knowledge that can inform and inspire water managers from around the globe.

The digital journey of water is gaining momentum. By coming together to share our learnings and commitment to change, water stakeholders can accelerate this transformation, and we can help solve water and create a more sustainable world.

Patrick Decker
President and Chief Executive Officer at Xylem Inc.

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Executive Summary

"Digital water is already here" is the clear message after interviewing utility executives and leading experts from around the globe. From big data solutions to advanced management of the distribution network to digital customer engagement programs, nearly all utilities we talked to have begun the digital transformation journey. While the transformation is not always easy, with aging infrastructure, inadequate investment, changing climate and demographics, digital water is now seen not as an 'option' but as an 'imperative.'

The foundational elements of water services – resource sustainability, infrastructure management, and financial stability – have been under threat for years. The business-as-usual practices in the water and wastewater sector cannot be relied on to sustain services. A more sustainable and secure water future means moving to the next generation of water systems, which includes embracing digital solutions and the enabling conditions that can support their effective implementation.

Just as digital technologies are transforming many aspects of our world – from our cities, to our homes and our personal lives – they are also transforming water. How will digital technologies transform our relationship with water – not just the water and wastewater utility sector but how all stakeholders connect to and manage water?

This paper – largely based on interviews, surveys and inputs from nearly 50 utility executives and over 20 subject matter experts – examines how digitalisation is transforming the water sector through the experiences of water and wastewater utilities. The aim of this report is to provide an overview of the current state of digital in the water sector, the value potential for digital solutions, and the lessons learned from those on the digital journey. By creating a comprehensive body of knowledge from 40 utilities at various stages in their digital water journey, the paper can serve as a critical tool for water decision makers and for all those interested in advancing global water security and sustainability.

Chapter 1: Defining Digital Water outlines the building blocks of what is digital water including the data, technologies, and practices that drive value across the water and wastewater utility value chain. This includes an overview of the organisational and technology structure of a digital utility, an expanded view of the value chain to include customer engagement and water supply, and an exploration of the ecosystem of digital experts and solution providers around water and wastewater utilities.

Chapter 2: Digital Technology's Impact on the Economics of Water and Wastewater outlines the wide-ranging impact of adopting digital solutions, including the value realised internally within the utility (e.g., process optimisation, reduced capital expenditure, etc.) and the value realised externally to the utility (e.g., regulatory compliance, increased transparency and governance, etc.). A broader perspective is then taken to bring forward the deeper shifts in the water sector that are connected to this digital transformation across workforce, cities and homes.

Chapter 3: Navigating the Digital Journey then examines the digital journey leveraging insights from 40 leading utilities worldwide, including in-depth interviews with 15 utility executives. This intelligence is distilled into a Digital Water Adoption Curve that serves as both an assessment tool and as a roadmap to guide utilities on moving through the digital adoption journey. This curve begins with utilities at an immature digital development phase and expands through to utilities that are digitally sophisticated, having embedded digital in the culture and decision making processes of the organisation. There are a number of lessons learned from utilities in their digital journey, but two of the most important include the need to set a digital ambition at the CEO and Board levels; and the need to start small and experiment.

Chapter 4: Accelerating Digital Water Adoption looks at what is needed for uptake and integration of digital water in utilities. External pressures from customer needs, market competition, and increasing water scarcity along with internal demand for efficiency, cost-savings, and improved risk management, are forging the way for water utilities into the digital future and opening the door for digital technologies to address both new and old challenges within the water sector.

Chapter 5: Concluding Remarks on the Digital Water Journey closes out the report by reflecting on the impressive progress made to date by many in the water sector towards extracting value from digital technologies and summarising key findings. As stated in the beginning, "digital water is already here." However, we recognise that the water sector is incredibly diverse and there is significant progress to be made, both in expanding the number of utilities taking part in the digital journey and in accelerating the impact from digital solutions. This is where the International Water Association (IWA) – and the broader water industry – has a significant role to play.

This paper should ultimately serve both as a guide and as a source of inspiration as the water sector works together to embark on the journey of solving our toughest challenges with digital solutions. From proactively managing our aging infrastructure, to ensuring water quality from source to tap, to advancing water equity, and much more, we have the proven solutions to address these challenges in an effective and affordable way. There has never been a better time to be a utility professional than today.

1 Defining Digital Water

Digital Water. Smart Water. Internet of Water. Water 4.0. There are many terms being used to describe the exciting transformation currently taking place in the water sector. Regardless of the specific term used, it is important to define this compelling transformation in the broadest sense possible to truly understand the potential at hand.

1.1 The building blocks of digital water

The story of Cape Town, South Africa is one that has been told countless times as a worst case scenario – a countdown to 'Day Zero,' the day a city runs out of water. As Cape Town continues to struggle to address its water shortage, similar challenges are arising across the globe. Sao Paulo, Brazil faces challenges in water supply. Shenzhen, China faces challenges with untreated sewage discharges. Miami, United States, faces challenges with sea-level rise. Jakarta, Indonesia faces challenges with groundwater depletion. This list goes on and on.

In the face of such extreme water challenges, water and wastewater utilities have been compelled to turn to new and innovative solutions: digital technologies. Umgeni Water, a water utility in Durban, South Africa, has used digital technology to better manage its water resources and protect its customers from the same fate as Cape Town residents. Hydrologic models paired with monitoring devices have allowed the Durban water utility to optimise storage levels in dams and reservoirs. Likewise, the Las Vegas Valley Water District has harnessed digital technology to reduce non-revenue water, improving conservation and optimising water supply for customers. In Shenzhen, water quality monitoring sensors and hydraulic modelling systems implemented by Shenzhen Water Group have resulted in vast improvements to surface water quality. Moving forward, as global stressors continue to exacerbate current water challenges, digital solutions will be necessary for addressing the various problems utilities face to ensure adequate, reliable services to customers.

Digital technologies offer unlimited potential to transform the world's water systems, helping utilities become more resilient, innovative, and efficient, and in turn helping them build a stronger and more economically viable foundation for the future. Exploiting the value of data, automation, and artificial intelligence allows water utilities to extend water resources, reduce non-revenue water, expand infrastructure life cycles, provide the basis for financial security, and more.

The water sector's value chain links the environment and water resources to a utility, the utilities to their customers, and the customers back to their environment. From physical infrastructure to water quality to customer service and beyond, digital water can be integrated at every key point across the water cycle.

It is important to note that the value chain for water extends beyond the boundaries of a utility to include water sources (e.g., the watershed and other sources) and users (e.g., the public sector and industries). This is reflected in the *IWA Action Agenda for Basin-Connected Cities*, which outlines the rationale and provides a framework to harmonise urban, industrial, agricultural and ecological demands within a watershed.

Deploying these digital solutions across the expanded view of the value chain, and within the steps of the value chain, is easier said than done. Utilities are complex organisations, with multiple departments that each come with their own objectives, organisational layers, networks of physical assets, and siloes of data systems. Figure 1 further establishes the key components of the technology inputs and solutions within a water and wastewater utility organisation.

pumps
dams
turbines
sensors
buoys
pipes
mixers
aeration
valves
communication
meters

Sources & Environment

- Watershed
- Surface, Groundwater and Water Reuse
- Wastewater Effluent

Collection, Treatment & Distribution

- Water Collection, Treatment and Distribution
- Wastewater and stormwater Collection and Treatment

End Customers

- Residential
- Agricultural
- Commercial and Industrial
- Water for Nature

EXAMPLE CRITICAL PHYSICAL ASSETS

EXAMPLE DATA SILOES

Sources & Environment	Collection, Treatment & Distribution	End Customers
SCADA & Telemetry	*Enterprise IT Systems*	*Customer Information Systems*
Hydraulic Model	*Network Monitoring & Management*	*Meter Data Management*
Integrated Resource Plan	*System Modelling & Production Forecast*	*Billing System*
	Maintenance / Work Management	*Customer Engagement Channels*
	Capital Planning	

EXAMPLE TRANSFORMATIVE DIGITAL SOLUTIONS

Remote watershed integrity

Proactive remote monitoring across multiple parameters (temperature, flow, pH, nitratets, etc.) at multiple depth levels.

Process optimisation

Quality sensors combined with algorithms to optimise the treatment processes, reducing capital & operational costs.

Digital customer engagement

Transform the customer interaction model across web, mobile, social, connected home, and in-person.

Predictive maintenance

Connected equipment & maintenance solutions to reduce downtime & failures of critical equipment & pipelines.

Digital water products & services

Expanding the utility value proposition to deliver new services around water management.

Digital workforce

Utility professionals trained in digital technologies and leveraging digital field work systems to improve planning and scheduling, logistics optimisation, and more effective management of work tickets.

Interactive demand management

Leverage customer analytics and smart meter technologies to align demand with supply, and identify anomalies such as customer-side leaks and potential non-paying customers.

Data integration layer

Flexible cross-enterprise integration layer, modular applications architecture and an integrated presentations layer.

Digital twin

Data integration, analytics, and visualisation capabilities to help utility managers gain control of the intelligent systems they've deployed.

Figure 1. *Technology Inputs and Solutions of a Digital Water and Wastewater Utility*

"We aim for Shenzhen to be the first city in China with high-quality direct drinking water from the tap. To do this we must improve the management across our drinking water network by introducing water quality monitoring sensors, and by using IT, IoT, and the integration of data to increase our proactive monitoring of the network."

Junwei Jin *Deputy Director (Network Department) of Shenzhen Water Group, China*

With increasing complexity in water systems and management, there is growing potential and need to adopt transformative digital solutions. For example, remote sensing and digital twin technologies provide connectivity between a utility and its diversified water supply. Various digital technologies then provide connectivity within a utility's operations. Customer service and customer analytics tools are then positioned to bridge the gap between a utility and its customer and initiatives such as open data platforms and citizen science projects can provide connectivity from the customer back to their water supply. These solutions all leverage the latest in enabling technologies: cloud, mobile, intelligent infrastructure, sensors, communication networks, and analytics and big data.

1.2 The enabling technologies of digital water

There are many digital solutions that are part of a utility, and even more technology providers and start-ups which are facilitating their design, installation, and operation. Many of these solutions leverage the latest innovations seen across industries, advanced sensors, data analytics, blockchain integration, and artificial intelligence. Given the accelerating rate of innovation in these foundational technologies, below is a snapshot of the exciting innovations at this moment in time.

Sensors, monitoring and forecasting

Sensors, remote sensing, geographic information systems (GIS) technologies, and visualisation tools are becoming key elements to managing water resources at service area, watershed and regional scales. Remote sensing/imaging technologies such as satellites and drones, used separately or together, provide data for mapping water resources, measuring water fluxes and utility asset management. Data from such technologies can better prepare water resource managers and utilities for incidences of heavy storm water flow (e.g., altering operations to prevent sewage overflow), indicate when conservation practices should be enacted during periods of drought, and ensure all treated water is delivered to customers. In addition, satellite data can be used to provide water quality data (e.g., turbidity, algal blooms, etc.) and hydrological forecasts, which, when used in conjunction with in situ measurements, allow utility operators to prepare for and react to water quality issues and other challenges.

New and existing sensors, both fixed and mobile are being used to provide near real-time data on water quality, flows, pressures and water levels, among other parameters. Sensors can be dispersed throughout systems to aid daily operations by optimising resource use (e.g., chemical use for water treatment), detect, diagnose and proactively prevent detrimental events (e.g., pipe bursts, water discoloration events, sewer collapses/blockages, etc.), and provide useful information for preventative maintenance and improved longer term planning for water utilities (e.g., by helping to prioritise repairs and replacements for aging infrastructure). Likewise, sensors can provide evidence for pipe corrosion and alert home owners and utilities when water quality standards are not being met. In addition, smart meters record customer water usage, providing a clear picture of water consumption and conveying data to both consumer and utility, allowing for improved water management.

The power of data processing

Machine learning and artificial intelligence (AI) are used to process the sensing and data from other technologies but also to optimise the workforce and ensure customer needs are met. AI technology can recognise patterns in data and "learn" over time, updating algorithms as new information is presented. When paired with software as a service (SaaS) platforms, sensors, and communication networks, AI allows for the strategic and cost-effective operation of utilities, including better planning and execution of projects, better tracking and understanding of resource-loss in real time, more efficient collection and distribution networks, and maximum revenue capture and customer satisfaction. In this way, machine learning/AI technology help address the key issue of being data rich yet information poor in the water industry. Other AI services include chat bots which can be used to answer customer inquiries on demand, ensuring reliable, 24/7 service and enhancing customer satisfaction.

Augmented, virtual, and digital twin reality

Augmented and virtual reality (AR and VR) technologies provide their own, unique contributions to digital water. AR and VR technology has the potential to support decision making in the field by providing holographic representation of pipes, cables and other assets, and offering immersive, scenario-based training for employees. Digital twin technologies merge GIS, sensors, and VR applications to generate working replicas of physical systems that combine physical data (satellite images) with real-time, in-situ data (sensors/internet of things) to simulate utility functions. Digital twins provide utilities with an ability to visualise and monitor current conditions as well as ask questions and predict real-world scenarios.

Blockchain applications for water

Blockchain applications have the potential for direct, secure transactions between resource providers and consumers, peers, utilities and other players in the water sector. There are already several blockchain projects and trials occurring in the water industry, some of which are in conjunction with energy applications. Examples include: a project to integrate distributed energy and water systems in Fremantle, Australia and an Australian government funded project to develop a blockchain enabled system to monitor water trading and automatically update state registries. In the U.S., a water treatment technology provider announced it was creating a new blockchain protocol to make payments for international water treatment plant developments.

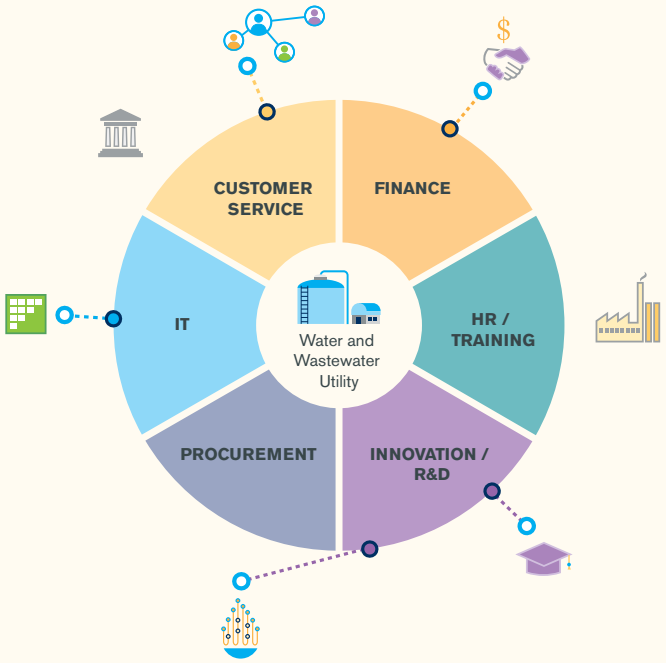
Taken together – remote sensing technologies, advanced in-situ sensors, AI, machine learning, AR/VR, digital twins, and blockchain – are the foundation of what digital water is, and as new, digital technologies are emerging, several market players, organisations and associations are emerging as key stakeholders, representing who digital water is.

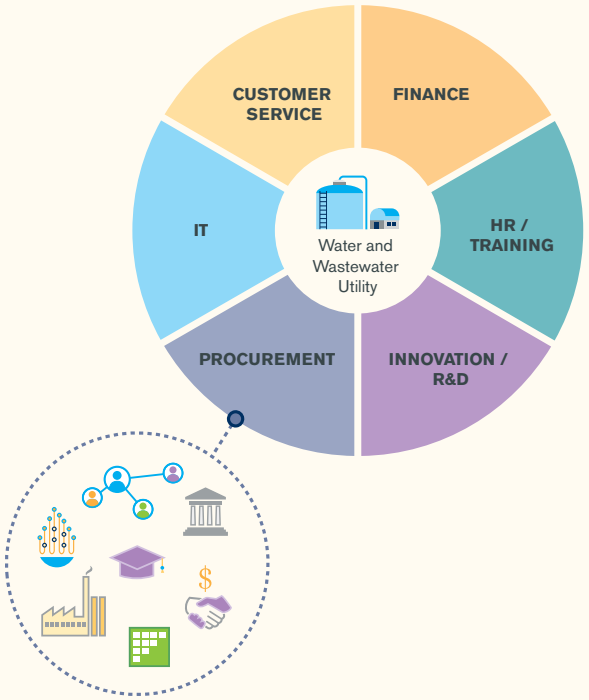
Transactional

Weak or ad-hoc links with organisations that focus on digital solutions driven by scoped projects or needs from within the water utility.

Transitional

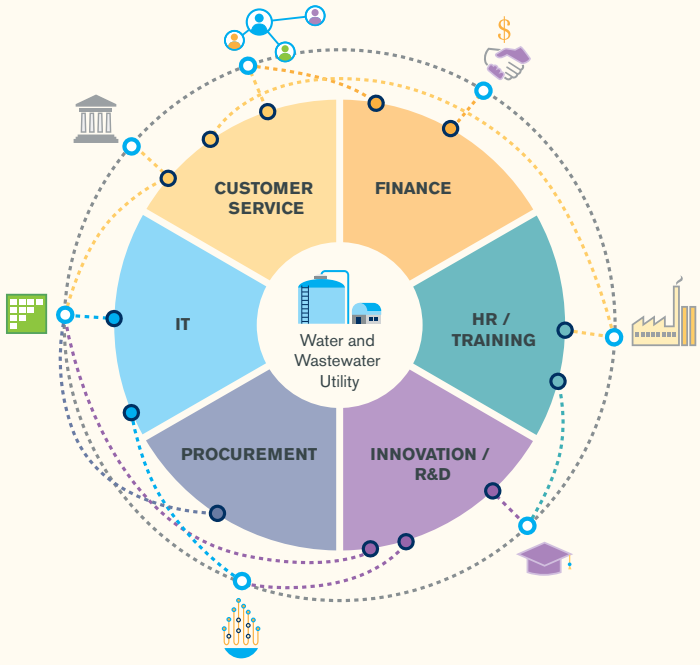
Stronger linear relationships with digital solution providers that are driven by utility leadership or key utility functions such as procurement and IT.





Dynamic and Fluid

Open engagement ecosystem with digital inputs from across stakeholders both external to the utility and with other utilities.



Note – the lines are representative and not a complete map of the relationship between stakeholders

Figure 2. *Evolution of the Digital Water Ecosystem*

Professional associations such as the IWA are supporting the digital transformation of the water and wastewater sector across their value chain.

The IWA Digital Water Programme specifically intends to provide roadmaps and guidance, aiding utilities' transition to the next generation water systems and a more sustainable, secure water future.

In addition, IWA has a number of Specialist Groups that contribute to enabling and supporting this transformation including: *Hydroinformatics*, *Instrumentation Control and Automation*, *Modeling and Integrated Assessment*, and *Strategic Asset Management*, among others.

Specialist Groups provide a platform for information sharing and peer collaboration from which IWA members engage with, learn from, and further expand the ecosystem of digital water.

To learn more, visit https://iwa-network.org/

1.3 The ecosystem of digital water

Water and wastewater utilities are at the centre of a greater ecosystem of digital water comprising their value chain and associated stakeholders. Each utility is unique in its digital journey and needs, and therefore has its own tailored ecosystem of digital water stakeholders. Generally, each ecosystem includes stakeholders from across the water and wastewater spectrum such as private and public utility peers, governmental bodies, technology solution providers, academic institutions, consultancies, industry associations and technology accelerators. How a utility interacts with its ecosystem varies depending on its digital adoption phase (see section 3.1), but it is evident that as utilities adopt digital solutions, they are evolving from having a limited, linear ecosystem to one that is more complex and interconnected, as outlined in Figure 2.

As shown in Figure 2, the 'Transactional' digital water ecosystem is the most basic model and is characterised by ad-hoc engagement with digital water technology solution providers, industry associations, academics, etc. As utilities begin to embrace digital water solutions, transitional ecosystems are formed by utility leadership (e.g., CEO, Board, etc.) or utility functions (e.g., IT, procurement, etc.). At the next stage of evolution, leading utilities have an established dynamic and fluid ecosystem of digital stakeholders where utilities become catalysts for mobilising these stakeholders to collaborate, pilot, and scale these impactful digital solutions.

No matter the complexity of water or wastewater utilities' ecosystems, there are a handful of stakeholders cited as central to a successful ecosystem. For example, global water infrastructure and technology companies hold a primary role within digital water ecosystems as they are the experts with market-tested solutions. Business solutions providers, SaaS providers, and communications providers comprise just a few examples of other companies a digital utility interacts with. Likewise, utilities are increasingly partnering with start-ups and water technology hubs and accelerators as a means to generate and benefit from innovative platforms and new technologies.

Academic institutions, industry associations, and water technology hubs and accelerators hold a stance as primary stakeholders due to their role in bringing together collaboration on and learning around novel research of methods and technologies as well as providing tools and platforms for adopting such technologies. Also, there is an ecosystem of investors including: angels, venture capital, family offices and socially responsible focused funds that are engaged in identifying and scaling innovative digital water technology solutions.

Not to be forgotten is the role of the public sector in the water and wastewater utility's digital ecosystem. In most countries, local and federal governments provide the ultimate oversight over utilities, generating the standards and regulations that dictate how a utility conducts its operations. Water and wastewater utilities are constantly interacting with the public sector regarding funding and industry requirements.

1.4 Navigating the definition of digital water

This broadened view of 'digital water' – covering the organisational structure of a digital water and wastewater utility, the landscape of upstream and downstream end users, and the expansive digital water ecosystem – can at times seem daunting to navigate. However, utilities are not alone. Through engagement in professional and industry associations, and in peer-to-peer dialogue with other water and wastewater utilities, this broadened view turns from a web of complexity to a map of opportunities. In successfully navigating this map, there is the potential to transform the economics of water and wastewater management.

Table 1. *Digital Water Value Creation Overview*

Community Benefits

INCREASED AFFORDABILITY

- Improved long-term affordability of rate structure
- Greater transparency in the use of proceeds from water tariffs
- Reduced likelihood of bill shock, non-payment and cut-offs

CUSTOMER EXPERIENCE

- Increased customer engagement and responsiveness to customer inquiries
- Reduced disruptions in water service
- Reduction in the volume of disruptive construction projects

ENVIRONMENTAL PROTECTION

- Reduced risk of sewage overflows into the environment
- Reduced GHG emissions from utility operations
- Improved conservation and management of critical water resources

Operational Benefits

PROCESS EXCELLENCE

- Data-driven operations and decision making reduces errors
- Speed in decision making due to efficient data analysis and processing

PREDICTIVE MAINTENANCE

- Reduced number of emergency call-outs
- Reduced downtime of critical assets

REGULATORY COMPLIANCE

- Reduced incidences of failure and overflows
- Reduced risk of non-compliance resulting from network water quality issues

Financial Benefits

REDUCED OPERATIONAL EXPENDITURE

- Optimised operations reduce energy and maintenance costs
- Reduction in costs and risks associated with ad-hoc field maintenance

INCREASED CAPITAL EFFICIENCY

- Improved cash flow as a result of targeted rehabilitation of faulty infrastructure
- Reduced liability and costs from unexpected water main breaks and sewage overflows

INCREASED REVENUE

- Targeted interventions with faulty meters increases revenue
- Value-added digital services available to bulk water customers

Long-term Resiliency Benefits

INCREASED RESILIENCE

- Improved operational flexibility from changing climate and demographics
- Increased safety through rapid customer engagement on public safety concerns

WORKFORCE DEVELOPMENT

- Improved cross-department collaboration through systems integration
- Reduced safety risk to workforce through fewer emergency call-outs

BRAND AND INNOVATION

- Elevates utility brand and engagement in the water industry
- Enables the utility to more easily pilot and adopt latest technologies

2

Digital's Impact on the Economics of Water and Wastewater

"Incorporating digital technologies in the water sector not only offers value to the customer and utility, but to the country's overall economy as well."

Dan Naidoo *Senior Manager: Strategic Support at Umgeni Water, South Africa*

Taiwan has a history of drought and water shortages, an especially severe drought in 2002 triggered the Taipei Water Department to turn to digital solutions. "Since [the turn to digital solutions such as] the use of sensors, smart meters, and pressure control systems has improved water conservation, providing relief to a water-stressed city. As a result, the greater Taipei area has not experienced a water shortage in 17 years," cites Chen Jiin-Shyang, CEO of Taipei Water Department.

The Taipei Water Department is just one example of the numerous compelling business reasons for water and wastewater utilities to adopt digital technologies. Scarcity, security and resiliency have now become critical drivers for water and wastewater utilities to deliver services to the public and private sectors. With this in mind, it is important to focus the limited capital and labour on the quality and reliability of essential services, while simultaneously investing in technologies, human resources, and initiatives to meet future demands. This makes it crucial for utilities to ensure that every dollar is being spent in the most effective way possible – maximising the value each project delivers to the utility, its customers and society.

2.1 The value case for digital water

The value created by the use of digital technologies across this expanded view of the water and wastewater utility, as captured in the previous section, is diverse. Often cited sources of value include 'decreased operational expenditure,' 'increased workforce efficiencies,' 'increased customer engagement and satisfaction,' and 'becoming an industry leader.'

As illustrated in Table 1, the potential sources of value created by the adoption of digital solutions are diverse and impactful, across the utility, the community and the environment. Within the utility, the value of digital solutions is not only felt across operations and financials, but also across areas such as the workforce and the utility brand.

Of course, each utility situation is unique, and each digital solution has a unique set of value drivers for the utility in both the near-term and the long-term. Below are a few examples of digital solutions which deliver impact across these areas of value.

Community Benefits

- **Increased affordability:** Optimised capital and operating expenditure (as addressed by the digital solutions listed above) – combined with digital solutions such as customer-centric data analytics and scenario modelling for affordability – holds the potential to build a rate structure with long-term affordability, reduced bill shock and non-payment, and reduction in cut-offs to vulnerable customers.

- **Customer experience:** Similar to 'reduced operational expenditure' and 'increased capital efficiency,' nearly all digital solutions – which improve utility operations and financials – have a positive impact on the customer experience. Example digital solutions include a real-time digital twin of the water distribution network to optimise capital expenditure and reduce the volume of disruptive construction projects, and advanced metering infrastructure (AMI) combined with data analytics to provide customer engagement on water consumption.

"Ghana Water experienced a 14% increase in revenue after digital technologies increased water bill collection efficiency and provided customers with a menu of payment options that included mobile money payments and direct debit through banks."

Richard Appiah Otoo *Chief Technology Officer at Ghana Water Company Limited, Ghana*

"Digital technologies modify the workforce required to run a water utility, reducing labour, streamlining operations, and minimising human error. VA Tech WABAG, a multinational water technology provider, shared that projects once needing 10-15 operators now, with digitalisation, require only 3-4 operators, freeing up personnel for other, more demanding tasks (e.g., tasks requiring human interaction, emotion, decision making, and complex skill sets)."

Gyanendra S. Saxena *Vice President at VA Tech WABAG, India*

- **Environmental protection:** Efficiencies in operations (as addressed by the digital solutions listed above) – combined with technologies such as a real-time digital twin of the wastewater collection system, intelligent pumping systems, and a network of sensors in the watershed can ensure minimal contamination and maximised conservation of our water sources.

Operational Benefits

- **Process excellence:** Digital solutions leveraging sensors, intelligent equipment, edge computing, and AI optimise individual components of the water and wastewater utility operations as well as connected processes across the water and wastewater utility value chain.
- **Predictive maintenance:** Digital solutions such as algorithmic and in-situ leak detection, asset management platforms, and AR / VR provide preventative and predictive maintenance capabilities that reduce downtime of critical assets and maximise effectiveness and efficiency of operations.
- **Regulatory compliance:** Digital solutions such as a real-time source-to-tap digital twin, powered by online monitoring and water quality models, and decision support and scenario modelling helps drive increased regulatory compliance across the water utility value chain.

Financial Benefits

- **Reduced operational expenditure:** Nearly all digital solutions have an impact on reducing operational expenditure. Example digital solutions include intelligent equipment that self-optimises for lowest energy use, real-time digital twins of the treatment plant to optimise energy and chemical use, and data analytics and decision intelligence platforms that enable efficiencies in decision making.
- **Increased capital efficiency:** Similar to 'Reduced operational expenditure,' nearly all digital solutions have an impact on increasing capital efficiency. Example digital solutions include algorithmic and in-situ leak detection technologies that result in targeted pipe replacement and real-time digital twin of the wastewater collection network to optimise existing assets and avoid capital-intensive construction projects.
- **Increased revenue:** Digital solutions such as Advanced Metering Infrastructure (AMI) and advanced data analytics of the metering network. These solutions can increase meter accuracy, maximise billing potential, meet and exceed customer's needs, and provide the opportunity to sell value-added services.

"Digital solutions are relevant and indispensable in the remote monitoring of the water and sanitation network, as well as in equipment management, the control of water losses, and water quality for human consumption. These solutions are fundamental in building trust with the customers, and in maintaining the highest level of commercial service."

Nuno Campilho *Deputy Director of SIMAS Oeiras e Amadora, Portugal*

Resiliency Benefits

- **Increased resilience:** Digital solutions such as a dense network of sensors, intelligent equipment, real-time source-to-tap digital twin, and data analytics and advanced simulation tools enable a utility to be better prepared to their changing environment. Furthermore, the incorporation of external data sets such as weather and traffic data can improve a utility's ability to adapt operations to changing climate and demographics.

- **Workforce development:** Similar to 'customer experience,' nearly all digital solutions – which improve utility operations and financials – have a positive impact on the utility workforce. Example digital solutions include systems integration across data siloes, which improves cross-department collaboration, data analytics and decision intelligence tools that enable operator piece of mind, and predictive maintenance solutions (as addressed by the digital solutions listed above). The latter, in turn, decreases the need for emergency call-outs.

- **Brand and innovation:** Similarly, nearly all digital solutions have a positive impact on the utility brand and the potential to adopt latest innovations. As adoption of the variety of digital solutions increases, so do the capabilities and culture of utilities, ultimately enabling them to more quickly extract value from future innovations.

As many leading utilities around the world are already realising, the value created by the implementation of digital technologies is undeniable. According to Global Water Intelligence (GWI), potential savings on total expenditure over 5 years (2016-2020) globally for drinking water treatment, distribution, and customer services, metering and billing is about USD 176 billion, while the potential saving in the waste water sector is about USD 143 billion.

2.2 The transformative potential of digital water

Digital technologies have the potential to transform the economics of the water and wastewater sector. Through process optimisation; workforce transformation; enhancing customer engagement; aiding regulatory compliance; increasing sustainability, resiliency and watershed connectivity; and ensuring public health, transparency, and proper governance digital technologies are generating direct savings for utilities and creating both internal and external value across utilities' supply chains. As digital technologies create disruption across the water sector, the digitalisation of water and wastewater utilities will accelerate. The shifts driven by such digital transformations, however, will span wider than traditional utility operations, also impacting the nature of workforce operations, the role of utilities as a part of sustainable cities, the potential of green infrastructure, and customer-utility relationships. Furthermore, digital technologies improve day-to-day water management and build long-term resiliency to disasters and climate change. Such improvements lead to increased water security for the industrial, commercial, agricultural, and domestic sectors, thereby having a direct impact on economic security and growth.

These deeper shifts include:

The 'no-collar' workforce

The emerging 'no-collar' workforce means redesigning jobs and reimagining how work gets done in a hybrid human-and-machine environment. The development of digital technologies now requires the utility workforce to adapt and learn new skills in order to keep up with the pace of evolution within the global economy and systems of commerce. In addition to recruiting new talent proficient in information technology, companies need to train existing employees and attempt to continue to operate and adjust to new systems seamlessly.

Another way to frame the digital workforce is how the 'no-collar' workforce will be incorporated into company operations. In this scenario, robotics and AI will probably not displace most human workers. Instead these tools offer opportunities to automate some repetitive, low-level tasks. Perhaps more importantly, intelligent automation solutions may be able to augment human performance by automating certain parts of a task, thus freeing individuals to focus on more human-necessary aspects, ones that require empathic problem-solving abilities, social skills and emotional intelligence.

VR and AR applications can also benefit the water utility workforce by reducing risk and saving billions in maintenance costs, engineering tests and innovation, and allow users to test or simulate real-world situations without the usual dangers or costs associated with large engineering projects. With VR, asset maintenance professionals can immerse themselves to fully and accurately experience what a situation would be like in real life. VR also allows the identification of design flaws or other potential problems with efficiency, which can then be solved before any problems actually occur.

The demand for workers in the water utility industry is growing at a rapid pace due to the many applications of digital technologies. The role of businesses and of workers has changed and will continue to evolve with water resource management. Human capital is necessary in both physically developing water infrastructure networks as well as installing digital technologies. The ability for workers to interact with VR, AR and AI technologies is crucial and will create a multitude of possibilities for the sector to expand and become more sustainable for future generations.

Resilient and sustainable cities

Water utilities and cities are looking for ways to become more resilient to the impacts of increasingly frequent and severe floods and droughts. Losses due to disasters from natural and man-made hazards are mounting and on average cost governments over USD 300 billion globally each year. Some companies are rising to meet these challenges by providing services through monitoring flooding likelihoods and impacts in real time, helping to avert the human and economic costs of flooding, as well as assist in the aftermath. Smart storm water systems are increasingly becoming available that leverage existing infrastructure. Furthermore, meeting conservation requirements in times of drought is becoming easier thanks to accurate groundwater resource modelling, for example, along with improved conservation habits.

Digital technologies will play a role in planning and redesigning cities to be more resilient. Remote sensing technologies for flood prediction and comprehensive design tools for hydraulic modelling are now available to manage storm water runoff and flooding from extreme weather events. Urban water systems – often vulnerable to extreme weather events, resulting in significant impacts to clean water distribution, wastewater treatment and storm water management – are also adapting microgrid strategies from the power sector. Water microgrids or 'micronets' provide redundancy, fortify against vulnerabilities and can secure the resource supply chain.

Digital and green infrastructure

Digital technology can provide a means to provide real-time monitoring on green infrastructure performance. Cities and utilities that invest in green infrastructure may need a way to capture performance of investments at scale. For example, the City of Chicago, Illinois, wanted to better understand the performance of their bioswales (landscape elements, e.g., ditches, designed to concentrate or remove debris and pollution out of surface runoff water) and porous asphalt during storms. A team was assembled with the goal of better understanding the performance of the city's green infrastructure investments. Monitoring devices were installed on four green storm water management solutions: a bioswale; porous asphalt; a permeable paver and infiltration planter duo; and a permeable paver and tree-pit filter pairing. Over an 18 month period, cloud-based storm water management analysis and control software were used to gather live data on several green infrastructure storm water solutions. During this time, the monitoring system not only provided information to researchers and the city, but was also relaying data on the test areas' performance to the public.

Another example is from Ormond Beach, Florida, where real-time data analysis kept flooding at bay by automating water levels in storage ponds. Before Hurricane Irma hit Florida in 2017, Ormond Beach installed sensors on five lakes that are prone to flooding. When the sensors and software used detected an incoming downpour, the system automatically drained down the storage volume in preparation. The weather-respondent valves on the lakes' drainage system kicked in before the rain hit and helped prevent flooding during the storm.

The smart home and consumer

Digital solutions will also change the relationship water providers have with customers as society increasingly embraces digital technologies in all aspects of their lives (e.g., mobility, communication and entertainment) and it is reasonable to conclude service providers such as water utilities will now be part of the mix.

With new efforts toward sustainability and water conservation efforts, water utility companies are beginning to establish innovative strategies to help engage consumers and restructure the way people think about water use. Research and case studies have shown that consumers are more likely to change their water usage when new strategies are easy to install and access and when water-saving efforts do not considerably change their daily living habits.

The concept of a 'smart home' opens up a wealth of new opportunities for water sustainability. The growing range of technological home applications combines increased awareness with convenience to reach sustainability. For example, a study by Singapore's national water agency PUB found that a person could save up to five litres of water a day using smart shower devices. In another example, the Mackay Regional Council in Queensland has introduced automatic water meter readings to empower customers to better manage their water consumption and save money. The digital meters also alert customers and local authorities to leaks. Having the technology can allow local authorities to repair the issues within a much shorter timeframe, reducing water wastage.

Companies that take advantage of these developments in customer service are benefiting. With new digital technologies such as AI chatbots, customers can ask questions and get answers whenever they want, opening vast possibilities for consumer engagement, providing customer alerts, and also water consumption and conservation information. Utilities that embrace these technologies are improving their customer service and meeting the high demands of consumers.

2.3 Beyond the utility

Digital technologies have exponential growth in capabilities and performance and exponential decline in costs. As a result of these attributes, digital technologies are rapidly scaling in developed and emerging economies. The adoption of exponential technologies allows countries to leapfrog past last century solutions to off-grid, decentralised, and distributed water and wastewater infrastructure. Likewise, the trend of increasing adoption of smart devices and online transactions is accelerating and becoming something that is more and more expected by customers and other stakeholders. These digital transformations within related industry sectors will not only impact the uptake of digital technology by water and wastewater utilities, but will further enable the digital disruption of the water sector.

Digital transformations are already occurring across the market in the ways customers interact with goods and service providers. Customers are increasingly demanding user-friendly, 24/7, multifunctional service; easy access to information; and immediate transaction abilities. Flexibility and on-demand capabilities are increasingly both expected and assumed. With the ability to manage their finances (e.g., online banking), shop (e.g., Amazon), order food (e.g., DoorDash), monitor their homes (e.g., Nest), and schedule transportation (e.g., Uber) already in the palm of their hands, it is only a matter of time before customers realise they have the power to demand the same level of convenience via digital technologies from other sectors. As more industries join the transition to digital, a foundation and culture already embedded in digital technologies holds the potential to better prepare utilities for the future.

Individual industries and companies, however, are not the sole instigators in the shift to digitalisation. Emerging smart city initiatives are creating demand for digitalisation across industries. As cities aim to optimise infrastructure, industries and services through increased connectivity and better engagement of governments, citizens and businesses, digital solutions will need to be at the forefront of meeting new challenges. In that context, the very nature of a water utility can be used as a springboard to a 'Smart City.' Water and sanitation are among the most essential services a city provides and are at the foundation of economic stability. In developed countries, water utilities touch virtually every citizen, home and business, meaning cities can exploit a digital water utility's communication network, customer base and immediate value propositions to demonstrate and communicate the overall benefits and successes of the city being an interconnected enterprise. As urban evolution is pushing cities toward becoming intelligent, connected, ecosystems of sensor-based infrastructure, utilities that have already embedded digital technologies into their operations will be better equipped to fulfil new requirements and hold an active role as a part of smart city initiatives.

New and emerging markets also provide incentives for water utilities to adopt digital technologies. As countries expand and improve upon water services in Asia and the Pacific, regions where the presence of microelectronic and pharmaceutical industries mean digital automation is already highly adopted, digital technologies are likely to be expected and demanded as the water sector expands. Likewise, as the world aims to meet Sustainable Development Goal (SDG) 6 by 2030, new markets in Asia, Africa, Latin America and the Middle East will create a niche for technology to meet rising demand in dense, urban areas and water-scarce regions. In North America and Western Europe, where extensive infrastructure systems already exist, markets for digital technologies are emerging to address the issues associated with aging infrastructure. Overall, a study by GWI predicts global demand for control and monitoring solutions will rise to USD 30.1 billion by 2021, a market that utilities with pre-existing digital platforms will be better prepared to embrace.

Richard Appiah Otoo, Chief Technology Officer of Ghana Water, said it best when describing his utility's transition to digital water, "The world is moving in the direction of technology and Ghana Water cannot afford to be left behind." Ghana Water is one of several utilities worldwide that has recognised the value of adopting digital technologies to prepare for future markets and meet consumer demands. Utilities, like Ghana Water, who start their digital journey now will be better prepared to extract even further value from digital water in the future.

Digital technologies alone will not only create new value for water and wastewater utilities but they will be an enabling force for the adoption of other technologies such as new water source collection (e.g., air moisture capture, water reuse/recycling, etc.) and decentralised water treatment systems (e.g., building and community scale) and actively shift communities from exclusively centralised systems to hybrid solutions that incorporate the advantages of more traditional systems and innovative methodologies powered by digital technologies.

To further highlight the potential of incorporating digital technologies into the water sector, reference can be made to the energy sector's adoption of microgrids and smart-sensing to reduce vulnerability of large-scale plants to climate effects, decrease operational complexity, and provide resiliency, reliability, flexibility and redundancy to the sector. These benefits can also be seen through establishing micronets (water microgrids – decentralised water and sanitation systems). By downscaling plants and treatment facilities to serve smaller regions, monitoring and maintenance becomes easier and less costly, and the installation of new digital technologies is more realistic.

The ultimate reason for heightened interest in scaling digital water technology solutions is the urgent need to ensure access to water for economic development, business growth, and social and ecosystem well-being in the face of increased demand for water and the impacts of climate change. The role of the water utility sector in addressing these needs has never been more critical.

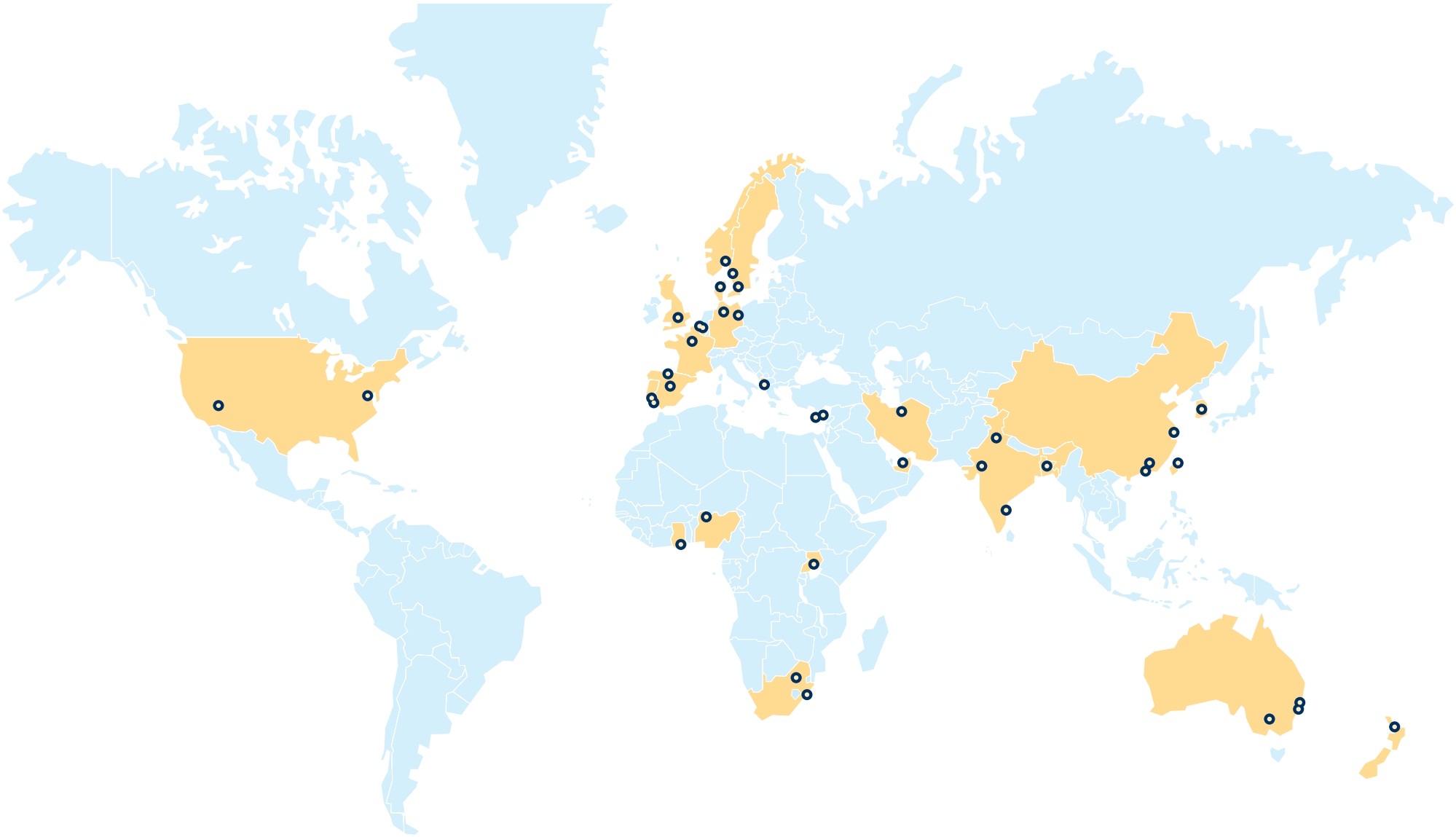


Figure 3. *Geographic Span of Utilities Interviewed and Surveyed*

3

Navigating the Digital Journey

"Countries and utilities who grasp the opportunities of new digital technologies will be able to accelerate progress, and narrow or even leapfrog any gaps in respect to provision of sustainable water and sanitation for all."

Silver Mugisha *Managing Director of National Water and Sewerage Corporation, Uganda*

As utilities implement new digital solutions and update their business models to embrace the digital era, they find themselves at varying levels of digital maturity. There are various types of digital adoption including adoption of analytics to create value out of existing data; adoption of hardware and software to create systems (simulations) based solutions; and building of communications and IT infrastructure, and human capital development to create a "pull" for smart systems.

3.1 The digital water adoption curve

Utilities are at different levels of maturity in adopting these categories of digital solutions and approaches. To understand the state of digital maturity in the water sector, we elicited insights from 40 leading utilities worldwide, speaking to 15 utility executives through in-depth interviews and the remainder through a detailed survey process. Figure 3 shows the global spread of utilities whose input informed our research and aided the development of this report. Please see the acknowledgements for specific utility contributions.

The Digital Water Adoption Curve on the next page in Figure 4, adapted from Gartner 2017, is a synthesised view of how utilities are adopting digital technologies. Generated to be a working tool for utilities now and in the future, the Digital Water Adoption Curve provides a means for utilities to assess where they are in their digital maturation and to have a general roadmap on where to head next.

The curve begins with utilities at an immature digital development phase. It then expands through utilities that have become digitally aware or that have incorporated digital technologies within and between their processes and moves on to utilities with an agile, innovative business structure that have fully embraced digital technologies.

The maturation of a water or wastewater utility along the curve is shown as a utility progresses from having little to no digital infrastructure to having opportunistic, systematic, and transformational digital systems and strategies. In the interviews and surveys of leading utilities, executives were asked to reflect on their organisation and assess their own phase of digital maturity. Responses spanned across the entire Digital Water Adoption Curve spectrum, with some utilities having more conservative beginnings and others already largely embracing the full expanse of digital technologies. With an average adoption level of 'Opportunistic,' it appears that many of the utilities surveyed and interviewed have started their digital water transformation journey.

Those utilities in early development stages are focusing efforts on implementing software platforms (National Water and Sewerage Corporation), new sensors and smart meters (Shenzhen Water Group-China). Likewise, increasing automation for remote control (Berliner Wasserbetriebe-Germany), combining networks (Umgeni Water-South Africa) and enhancing internal infrastructure remain top priorities. Utilities further along in their digital maturation have already incorporated technologies like VR and big data into automated processes and decision making, helping to run smart solutions (Macao Water-China). Others have expanded beyond their organisation to provide services and support to external utilities (AGS Water-Portugal).

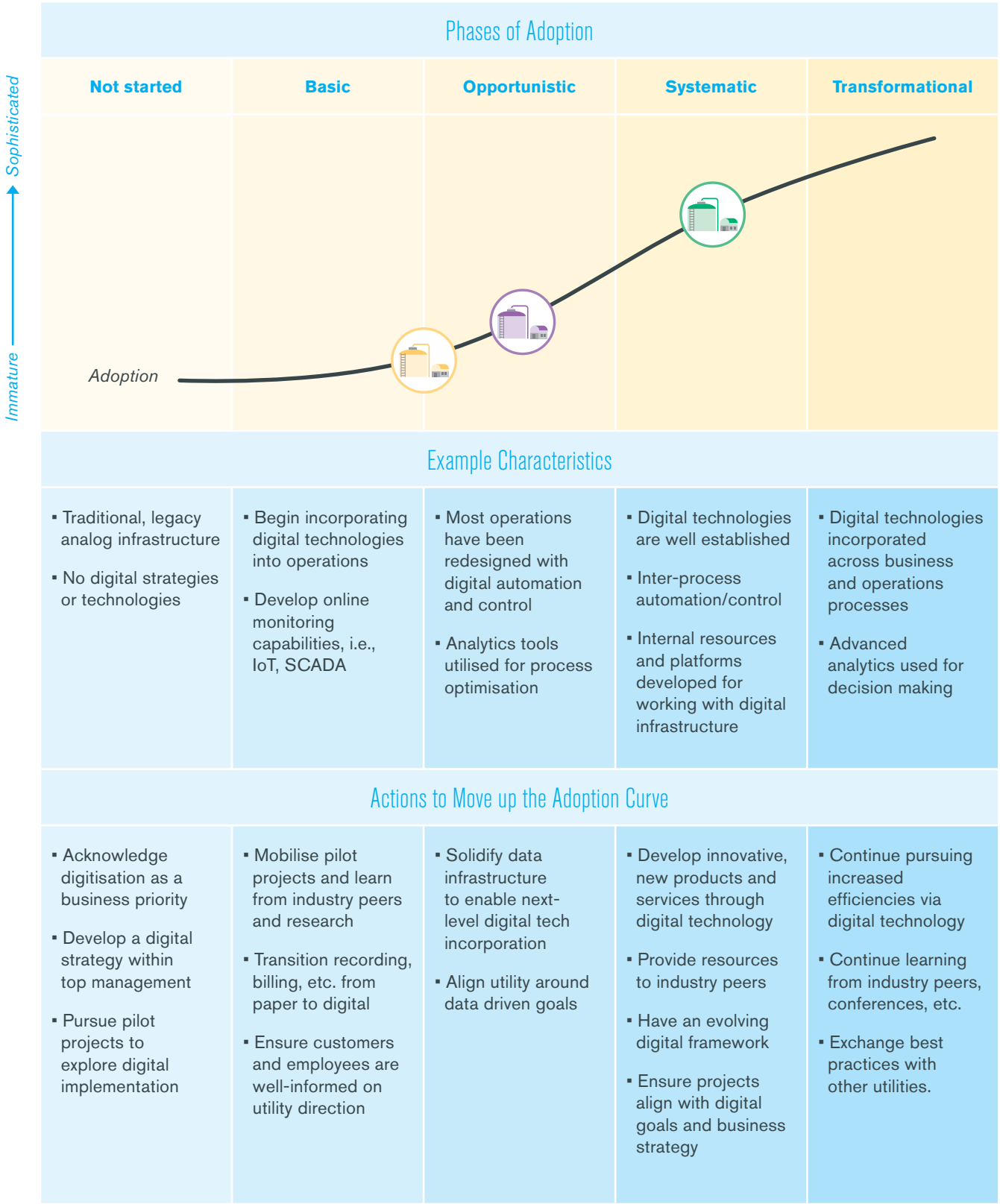


Figure 4. *The Digital Water Adoption Curve*

UTILITY EXAMPLE 1:

- Has deployed online sensors across some parts of its network to monitor water quality
- Is developing a predictive catchment model for supply areas
- Commenced pilot testing stage for the implementation of other digital projects

UTILITY EXAMPLE 2:

- Has implemented SCADA systems, automated processes, and deployed technologies for remote monitoring
- Use GIS, hydraulic networking models, and Virtual Intelligence to inform decision making
- Using cloud services, digitised billing, merged databases, developed a customer service app, and enhanced inter-office communication

UTILITY EXAMPLE 3:

- Have become an internally digitised company with well established digital technologies
- Collect actionable data using digital technologies and use virtual intelligence and data analytics tools to make decisions
- Have developed services and tools to support both their group and external utilities
- Use digital technologies to manage work orders, conduct real-time monitoring, detect and respond to events, optimise processes, generate reports, etc.

Nevertheless, all utilities have room to grow and as future conditions (climate, population, demand, etc.) change and technologies continue to evolve, there will be unending opportunities for the adoption of new and improved digital infrastructure. Utility leaders interviewed shared their efforts and advice on how best to further advance along the Digital Water Adoption Curve, revealing necessary steps for embedding digital technologies within utility operations, providing insights on the source of ambition for digitalisation, and sharing critical lessons learned that helped to initiate and further propel them along their digital journey.

3.2 Lessons from utility peers

The digital water transformation is here. Nonetheless, moving away from traditional methods and infrastructure requires effort and commitment. Based on the input from those interviewed and surveyed, six overarching utility actions have been identified to accelerate the utility journey across the Digital Water Adoption Curve:

Set the ambition at the CEO and Board level: Having the support and leadership of the utility's executive team and board is a critical accelerator to the implementation of digital technologies. Executive barriers will be some of the hardest to overcome, yet, since the digital transformation of utilities will require organisation-wide changes in operations and strategy, board authorisation is key for a utility to embark on their digital water journey. At the Las Vegas Valley Water District, where board leadership has already adopted company-wide goals for innovation and digital solutions, David Johnson explains that, "As a public utility, getting our board to adopt [digital] goals and make them a priority opened up the pathway for us to be able to allocate funding toward projects." He continued by sharing the observation that barriers throughout their digital water journey have been significantly reduced due to strong board level leadership. Consensus was reached across utility executives that top management must understand the risks and benefits of digital technologies, as well as both support and take the lead in driving the adoption of big data and digital infrastructure for projects to be successful.

Build a holistic digital roadmap: As a utility embraces change and begins its digital water journey, it is helpful to have both a strong roadmap for digitalisation and a clear business strategy. Communication and awareness of the direction the company is going are essential. Consensus must be built within the utility on how the digital journey will unfold and maintaining the customer and business outcomes as focal points throughout the digitalisation process is fundamental. Silver Mugisha, Managing Director of National Water and Sewerage Corporation, explained that their "biggest success has been on how we have managed to integrate technological innovation throughout our business processes, especially in an attempt to create an everlasting customer experience". Further, to prepare a utility for success, be sure the roadmap includes educating consumers, politicians, shareholders, management and employees not only on the cost-benefit of digital technologies, but on a utility's intentions for change throughout the digital transformation process. According to Biju George, from DC Water, "The digital strategy has to become a corporate strategy. It's not an option to sit there and let it happen, you have to plan for it. You have to train your employees towards that, you have to relook at every process. You have to design your systems to give you a sufficient amount of data, representing the right diversity (less correlation) you need to make efficient decisions."

Digital strategy at the core of the business

We frequently heard from water utility leaders that success in adopting a digital water strategy was tied to alignment with the business strategy. For example, Dan Naidoo (Umengi Water) stated that the catalyst for digitalisation was needing "to move from centralised systems to decentralised systems to service an expanding customer base" and having "a strategy to embed the digital strategy into the business strategy" was critical for accelerating the adoption of digital technologies. Several other leaders also cited a focus on alignment with their business strategy as a catalyst for adoption of a digital transformation of their utilities: for Gyanendra S. Saxena (VA Tech WABAG) the focus on "business and market driven strategies" was essential in driving adoption of a digital strategy, João Feliciano (AGS) stated that "the catalyst to adopt a digital water strategy was the creation of two to three long-term strategic visions that were committed to data and information strategy" and Meriem Riadi (SUEZ Group) recommended to "define the digital roadmap in a collaborative way with key business stakeholders to identify the top 2-3 digital projects and opportunities delivering the highest business impact."

Build an innovation culture: New technologies and digital solutions are being innovated across the water and wastewater utility value chain. To begin identifying, evaluating and exploring these technologies, there needs to be an organisational curiosity for new technologies. Operators, IT staff, Finance, Technicians, Executives, and others have to be the scouts for initial sourcing.

Digital solutions are continuously evolving and so too must water and wastewater utilities. Exploring and adopting these digital solutions enables a culture of innovation, and once the latest digital solutions are mastered, the utility will be ready to begin the next level of business transformation, thereby creating a cycle of continued digital maturation. Claire Falzone, CEO of Nova Veolia-France, emphasised a need to become more customer-centric as well as being prepared to continuously adapt and evolve – using new technologies – to current and future water challenges.

Leverage pilots for an agile mindset: Pilot projects offer a means to explore new technologies and have a more holistic understanding of their physical and financial effects on operations before committing to large-scale implementation. As Dr. Hamanth Kasan, General Manager of Scientific Services at Rand Water-South Africa notes, case studies, pilot projects and a track record of successes shown by initial testing during pilot projects will help build momentum for moving utilities up the Digital Water Adoption Curve.

Develop architecture for optimising data use: The data collected through digital solutions is only useful if you can structure and extract value from it. Developing a data warehouse, where operational data sets become available to finance, engineering and IT specialists who can use the data to optimise business processes, is a key step in effectively digitalising utility infrastructure. Meriem Riadi, Chief Digital Officer of SUEZ Group, says, "Advancement requires aligning [the] utility around data – converting data to intelligence and business use cases – and, more importantly, developing a culture of data (e.g., an understanding of data, its value and the multiple ways it can be used)."

Collaborate with utility peers: It is important to realise that, as you encounter challenges and explore new digital solutions, you are not alone. Whether you are a large or small utility, established or just emerging, or are located in a developed versus developing country, someone else has faced the same challenges within their digital journey as you. Fortunately, there is openness and a willingness to share information within the water sector and utilities should actively seek out these insights. After all, global utilities share the same goal: to provide safe, reliable water and wastewater services to everyone. Dave Johnson of the Las Vegas Valley Water District cited the support from and their work with water tech hubs/accelerators and their ecosystem of stakeholders coupled with the ability to learn from the power sector (Nevada Power) as important in their digital water technology transformation.

In summary, the new era of digital water utilities is here and already evolving. Developing strong business cases and road maps for the digital journey will aid in gaining the trust and support of customers, shareholders, utility staff and politicians. Be open to learning from other utilities and the surrounding ecosystem, embrace innovation, and share information when possible. As Claire Falzone of Nova Veolia-France encouraged, "If you have any doubt, just try it. Try small at first. This is just the beginning of the digital water journey and if you don't adopt digital technologies, someone else will."

"The dynamic customer and stakeholder expectations, sector transformations and the innovative culture that has been inculcated among the staff facilitated the development of the projects. In addition, the Learning and Innovation pillar which is part of the NWSC 5-year strategic direction has led to the enormous transitions from the analogue way of doing things to innovation of digital water solutions for excellent service delivery."

Silver Mugisha *Managing Director of National Water and Sewerage Corporation, Uganda*

3.3 Building digital into your organisational culture

Digital technologies cannot be sought as simply surface-level solutions. To operate effectively, they must be incorporated into the very backbone of water and wastewater utilities. From physical infrastructure and business services to data management and customer relations, digital technologies can and should become interwoven with all levels of a utility's operations. The journey must begin somewhere, however, and our conversations with utility executives have identified three primary mechanisms by which digital tech can be built into 'organisational DNA'.

First, engaged leadership from within a utility's executive team is fundamental both to developing a foundation of digital technology and advancing an organisation along the Digital Water Adoption Curve. Executives as well as the oversight board must discuss the direction they envision for the utility and how digital technologies could fit within and enhance that vision. Identifying priorities, outlining strategies, developing roadmaps, and allocating funding specifically to digitalisation are critical steps any executive team must take for their utility to transition into the digital era. In tandem, board level approval of such goals, visions and budgets is necessary. Executives and boards alike must then hold each other accountable, ensuring goals are met, resources are allocated effectively, and the utility's mission is upheld.

Second, developing or expanding upon existing roles such as that of Chief Digital Officer (CDO) can ensure digital technologies remain a priority within top management and aid in enabling and accelerating the digital adoption process. The development of a CDO position at the SUEZ Group allowed a leading individual, Meriem Riadi, to create a digital team, develop roadmaps, study the trajectory of digital technology in the water sector, accelerate the delivery of digital projects, and work on innovation more efficiently with partners, adding overall value to the company and increasing the success of digital projects.

Digital projects, however, can still be instigated and gain traction regardless of an individual's role on the executive team or of leadership within top management. In Biju George's case, a single, motivated individual with a curiosity toward and drive for innovation can be just as influential from an operational or middle management standpoint. Before starting his current position at DC Water, Biju worked at several roles, from engineer to management, in Cincinnati's Sewer and Water departments. A fascination with digital technologies led Biju to explore innovative, emerging solutions, ultimately leading Cincinnati Metropolitan Sewer Department and Water Works to become an early adopter of intelligence communications services, software programs that provide actionable information to the utility.

"In the water and wastewater business you are compliance driven, public safety driven and public health driven. So you want to be absolutely sure what you're doing is tested, for one, and will work."

Biju George *Executive Vice President at DC Water, USA*

Biju took the initiative to expose employees to digital innovation, transforming their views on the adoption of new technologies. Likewise, he initiated a sewer digitalisation project and collaborated with vendors to develop products to fit his utility's needs. Meanwhile, Biju created a Watershed Operations division at the Metropolitan Sewer Department and recruited the organisation's CIO to run it – recognising that a technology expert would be best able to learn, engineer and deploy emerging digital technologies. As an executive at DC Water, Biju has continued exploring and instigating the adoption of digital projects. With a track record of success long before his executive influence, however, Biju provides an example of how stamina and a vision for innovation from any individual willing to take on the challenge can propel a utility along their digital journey and embed digital technologies from within.

Third, digital projects can be woven throughout utility infrastructure from within in a bottom-up approach. At Umgeni Water, Dan Naidoo shares that the technical team was driven to pursue digital technologies largely by a need for operational efficiency, optimisation and increased resiliency. Over time, as the use of digital systems and tools spread throughout the utility and returns on investment (ROI) were realised, the ROIs of previous digital projects became the catalyst for further digital investments. In addition, the expansion of digital infrastructure led to the merging of networks across departments as data was collected and shared within the utility. Mr. Naidoo noted that, although projects initially were operationally, efficiency and financially driven, they have since grown within the organisation to reach the CEO/board level and digital transformation has now been embedded into the utility's business strategy at an executive level.

It is important that utilities use caution and thoroughly explore digital technologies (e.g., pilot projects) to understand their uses and effects on operations before implementing at a large scale. Water and wastewater utilities have a responsibility to their customers and digital technologies can have a direct impact on public health and economic stability in their communities. Nonetheless, stakeholders interviewed indicated that the transition to digital technologies in the water sector is both inevitable and necessary. As future utilities begin their digital journey, in-depth interviews with utility executives show that digital projects can be instigated and embedded into a utility's backbone from any level within the organisation. Only when digital technologies are an integral part of water and wastewater utility's DNA, will we be able to solve water and meet the rising challenges and increasing demand of the next century.

4

Accelerating Digital Water Adoption

Every day, billions of individuals go without access to affordable water and wastewater services, millions of litres of clean water leak into the ground, and thousands of litres of raw sewage are released into the environment. These statistics – combined with the significant value potential from adopting digital solutions – means that every minute counts in accelerating the adoption of these technologies. While the adoption of digital solutions will seldom be a smooth journey, there are key enablers that must be leveraged to the fullest extent by the water sector.

"Throughout history we have witnessed a few technologies, which has transformed the water sector, and the waves of innovation in the digital transformation is no different."

Biju George *Executive Vice President at DC Water, USA*

4.1 Key barriers for digital technology adoption

The digital water journey is one containing many hurdles and barriers that at best, slow the implementation of a digital solution, and at worst, prohibits even the piloting of a potentially transformative solution. To speed progress and fully realise the opportunity, there are regulatory, technology and organisational challenges that must be addressed by the water sector.

Systems integration and interoperability

As seen in Chapter 1, water and wastewater utilities are complex organisations with numerous data siloes. In addition, most utilities have legacy systems containing operations critical information, as well as valuable historical context on the changing urban watershed. Across these data siloes and electro-mechanical rotating equipment – often from various suppliers with various communication protocols – there is a growing challenge of systems integration and interoperability. There are solutions to bridge this systems integration, but open architecture and standardisation holds the potential to accelerate adoption of digital solutions.

Human resources impact

The success of digital solutions is often not a function of the technology, but rather of the people and the processes that leverage this solution. Adopting digital technologies can bring up human resources concerns related to skill gaps, workforce transition and change management. As noted in Chapter 2 though, digital solutions can also create value for the workforce by increasing workforce development opportunities and cross-department collaboration. For example, Hamanth Kasan (Rand Water) stated that "culture is important" and that utilities must "overcome fear of data and transparency." As young engineers enter the workforce, the willingness to explore digital technologies is growing. Another way to change culture and overcome the fear of transparency can come from CEO and board level commitment and a clear strategy. A similar challenge and opportunity are utility operational silos. Richard Appiah Otoo (Ghana Water) said that "silo mentality was a problem" that had to be overcome in order to adopt digital solutions. Technology solution providers need to frame all digital solutions with the workforce in mind, and the broader water sector could benefit from additional research on the best practices in workforce development during the digital water journey.

Financing solutions without a clear value proposition

As seen in Chapter 2, digital solutions can deliver impact across a diverse set of value drivers, some of which are well-defined (e.g., reduced operational expenditure) and others that are less well-defined (e.g., increased resilience). With limited budgets, it can often be a tough decision between using budget towards a typical maintenance activity and deploying a digital solution that can drive long-term efficiencies in total asset management. Technology solution providers need to provide a clear definition of the total value created by digital solutions, and the water industry needs to provide additional case studies and proof points for how to account for the less well-defined sources of value. Additionally, new business models that better align the timing of value creation with capital expenditure on a digital solution are needed. There is always a danger of wanting to do everything at once – 'build Rome in one day' explained Silver Mugisha of National Water and Sewerage Corporation. They had to agree on the priority systems and process that would have the greatest impact on their business by digitising them.

Cybersecurity

Cyber-security and customer data protection are critical considerations when deploying digital solutions. To date, this barrier is being addressed by new technology solutions (e.g., cyber-security systems) and by anonymising customer data to maintain privacy. However, continual advancements in technologies, standards and processes are needed to maintain security with our critical water resources.

While these barriers may at times seem insurmountable, talk to any utility executive and you'll find numerous examples where these challenges have been overcome. Take the Berliner Wasserbetriebe as an example. Despite concerns on data, workforce and legacy systems, sewer maintenance at Berliner Wasserbetriebe is already semi-automatic and targeted towards digitally identified condition failures. Robots deployed in Berlin's sewer systems photograph infrastructure, which is then digitally recorded, analysed and sent to operators for maintenance approval – improving the speed and efficiency of addressing maintenance needs. This is just one example of many where perseverance, creative problem solving and executive leadership have been leveraged to overcome barriers in deploying digital solutions.

"One of our main drivers for success has been 'speed'. We have started prototyping work, for example the SCRUM method, where we work together with the operators and start-ups to co-create solutions for digitalisation in water sector. The goal is to optimise the development process, while not really having a defined description of how it should be designed. While this has been a challenge, it has already led to some innovative 'assistance tools'. However, the process requires changes in typical public tender processes to truly enable digital adoption."

Regina Gnirss *Head of Research and Development at Berliner Wasserbetriebe, Germany*

4.2 Accelerating forces for digital adoption

As seen in the previous chapter, many utilities are still finding ways to extract value from digital solutions. This is the result of key enablers, which each utility is leveraging based on their situation and location, to override these barriers.

Water regulations and public policy to encourage digital adoption

New water regulations and public policies are emerging around the world in response to the new normal of prolonged drought (e.g., climate change) and resultant water shortages. For example, the California Sustainable Groundwater Management Act, which mandates the development of long-term water use strategies, is driving the development and adoption of cost effective digital technologies to measure real time water use. Local farmers, cities and water utilities alike must reduce water usage in compliance with new requirements under these laws. Such legal changes will force utilities in water scarce regions to turn to innovative technologies and business models to conserve water while continuing to meet demand. As another example, in the UK, the Water Services Regulation Authority (OFWAT) now mandates water companies to have at least five ways for customers to contact their utility, three of which must be digital. A similar OFWAT program rewards water companies whose customers report high levels of satisfaction and penalise those considered to be under-performing, thereby incentivising process automation and the use of digital technologies to improve water and wastewater services.

Data structuring solutions for legacy systems

Water utilities are now dealing with large volumes of data that are both structured and unstructured coming from disparate sources. Most utilities report that accessing data from legacy systems still presents a challenge. The key to maximising the use of big data is accessing the right data when it is needed by the applications. We see an increase in the use of application programming interfaces (APIs), which provide a way for retrieving data programmatically by any software application. Various software applications across the utilities can then use APIs to access the needed data from existing legacy systems, sensors and other applications regardless of data location, utility department or functionality needed. The same data sets can be used and reused for multiple purposes, thereby increasing the value of digital solutions.

Demographical shift towards digital

Perhaps the most powerful enabler will be the digital customer and workforce. Generational changes will force the adoption of digital technologies – because customers and utility professionals will expect and demand that core services such as power and water embed digital innovations into their products and services. Couple this generational force with the emergence of the no-collar workforce, and the move to a digital water utility appears increasingly inevitable.

Situational triggers for the digital journey

Changes in a utility's situation – often triggered by an external event, such as a demographic shift, a significant flood or increased water scarcity – have been commonly cited as a catalyst for triggering the adoption of a digital solution. For example, growing demand in water users combined with labour shortages drove Shenzhen Water Group's digital agenda whereas expansion from metropolitan areas to more remote regions in South Africa fuelled Umgeni Water's desire for process optimisation. For many, the need to improve customer engagement triggered the start of a digital journey, while others were driven by industry competition and the fear of being left behind in a digital era.

Across the water and wastewater utility sector, there is a growing message of urgency to address water challenges and ensure adequate access to water and wastewater services worldwide. There's an imperative to maintain flexibility and develop an ability to adapt to growing populations, urbanisation and climate change. This in itself is becoming the catalyst for change and, moving forward, utility leaders, regulators, associations, etc. will be called on to take the necessary actions to guarantee reliable, sustainable water and wastewater services for their respective populations.

5 Concluding Remarks on the Digital Water Journey

"If you have any doubt, just try it. Try small at first. This is just the beginning of the digital water journey and if you don't adopt digital technologies, someone else will."

Claire Falzone-Allard
CEO of NovaVeolia, France

There is no question that the digital age has arrived. Digital technologies are now embedded in our daily lives transforming sectors such as communications, transportation, entertainment, education, manufacturing and healthcare.

The transformation is inevitable as water and wastewater utilities are now facing new risks from increasing demand, water scarcity, water quality and water security, exacerbated by aging and underfunded infrastructure, out of date public policies and climate change. The adoption of digital technologies will become increasingly necessary to provide improved, more reliable, secure, efficient, and cost-effective water and wastewater services.

While these risks can appear daunting for utilities, digital water technologies hold the promise of enabling water and wastewater utilities to make a much more profound contribution to sustained economic development, business growth and social well-being. It will now be feasible to create water abundance by deploying exponential technologies, of which digital solutions are key. This in turn will ensure SDG 6 can be achieved – securing water and wastewater services for all – and it will advance all other SDGs, which are water dependent.

Yet this digital transformation is not self-fulfilling. Digital water technology adoption requires the engagement and commitment of utility staff and customers as well as incumbents, start-ups and entrants from other sectors across the value chain. These diverse stakeholder groups are now converging in the water sector to scale digital solutions and catalyse the adoption of water solutions.

Digital technologies also bring new challenges such as cyber-security. As a result, for innovative digital technology entrepreneurs to succeed, they must focus on integrating security into solutions, with systematic management of risks to mitigate operational network disruption risks and softer business network risks (theft or loss of data and damage to internal business systems).

The water sector faces a stark choice: resist the rise of digital solutions and struggle to adapt to water challenges, or fully embrace the digital revolution in collaboration with innovators to unlock a new era of water abundance.

5.1 The roadmap forward

Digital technologies are considered exponential. Exponential technologies (e.g., additive manufacturing, alternative energy systems and biotechnology) spur dramatic growth in capabilities and declining costs. However, the adoption of exponential technologies is challenged by linear thinking and experience, as well as how to prioritise and direct funding that can provide long-term solutions. As a result, what we observe with the digital transformation of water is a wide range of levels of adoption from early stage to advanced.

As water and wastewater utilities continue to mature into the digital era, there is a need for a smoother transition to digital technologies to ensure adequate services throughout the utility's digital journey. To aid in this transition, we tapped into the knowledge and experience of utility experts and executives, gathering novel research by conducting interviews and surveys with top water and wastewater utilities around the world. Through their insights and lessons, we were able to develop a roadmap for water and wastewater utilities as they begin and advance along their digital journey, as measured and guided by the Digital Water Adoption Curve. The Digital Water Adoption Curve is meant to be used as a tool for utilities both now and in the future. Other insights from this report provide additional support on how to begin and progress along this curve.

Key Findings

Based on our research, experience, and input from those interviewed and surveyed, eight overarching actions have been identified to accelerate the utility journey across the Digital Water Adoption Curve:

1. Set the ambition at the CEO and Board level: Utility leaders agreed that having the support and leadership of the utility's executive team and board is a critical accelerator to the implementation of digital technologies.

2. Build a holistic digital roadmap and a clear business strategy: Utilities must create internal consensus on how the digital journey will unfold, maintain the customer and business outcomes as focal points throughout the digitalisation process, and educate key stakeholders (consumers, politicians, shareholders, management and employees).

3. Build an innovation culture: Utility operators, IT staff, finance, technicians, executives, and others have to be the scouts for identifying new technologies. However, to drive adoption, utilities must focus on fostering an organisation-wide curiosity and competency for embracing digital innovation.

4. Leverage pilots for an agile mindset: Pilot projects offer a means to explore new technologies, build momentum, and create a more holistic understanding of their physical and financial effects on operations before committing to large-scale implementation.

5. Develop architecture for optimising data use: Developing a data warehouse, where operational data sets become available to functions such as finance, engineering and IT specialists who can use the data to optimise business processes, is critical to creating value from data and effectively digitalising utility infrastructure and connectivity.

6. Cultivate your digital ecosystem: Utilities should leverage insights on digital migration from peers, industry associations, academics and technology hubs/accelerators, who are further ahead of them on the Digital Water Adoption Curve. Fortunately, there is openness and a willingness to share information within the water sector and utilities should actively seek out these insights.

7. Embrace the digital water value case: The digital water value drivers within the utility, surrounding community, and in the long-term, are diverse and transformational, resulting in a compelling case for accelerated adoption. The community, operational, financial, and resiliency benefits created by digital technologies generate exponential value for utilities.

8. The water sector needs to unite around solving key barriers: Key barriers such as interoperability, regulations, culture, and cybersecurity must be addressed by the industry as a whole.

Any platform for the adoption of digital technologies by utilities must begin with a thorough understanding of those technologies, the recognition of specific challenges faced by the utility, and a commitment to executing a strategy to address those challenges with new and innovative technologies and practices. It is important to remember, however, that the technologies will change and that the technologies themselves are not the solution. Rather, their implementation and the various ways in which they create value for a utility will be the solution to some of water and wastewater utilities' greatest challenges (e.g., non-revenue water, storm water and sewage overflow, etc.).

As the water sector embraces digitalisation, utilities must ensure the outcomes of digital projects remain focused on benefits to their business and services provided to their customers. This can be achieved by developing a digital strategy and roadmap, embedding it within the utility's business strategy, and ensuring it is well communicated and adhered to. Gaining the support of top management (e.g., CEO, board, etc.) early on is critical in the development of digital projects as is developing or strengthening an IT/digital technology team. Likewise, utilities must build a strong foundation in fundamental technologies with adequate data centres/ platforms for working with the bulk data digital technologies produce.

From there, utilities will be better prepared to expand upon digital infrastructure as new projects develop, new challenges arise, and new technologies emerge. Following these and other guidelines described earlier in the report is highly recommended as water and wastewater utilities join their industry peers in the digital era.

5.2 International Water Association's role in the digital journey

IWA can influence and facilitate change as it is a place for water professionals from across the spectrum to make these changes happen, including conducting in-depth research and creating thought leadership in creative partnerships, like teaming with global water technology provider Xylem Inc. to produce this report. In a complex dynamic changing world, the Association can build bridges between silos, linking outcomes across sectors, and raising awareness and urgency in the political arena. It is with this mindset and combined with leading-edge scientific breakthroughs, technological developments and creative mindsets that we can challenge the complexities of the water sector now and in the future.

The IWA's 5-year strategic plan recognises the need for innovation in the global water sector to address the challenges associated with global change pressures. IWA realises that transformation cannot take place on its own in a vacuum. The ideas for solutions to these challenges will be fomented and rigorously debated among the IWA's institutions and membership in an open, yet controlled space.

This paper kicks-off the knowledge sharing and generation in the IWA Digital Water Programme. The Programme acts as a catalyst for innovation, knowledge and best practice; and provides a platform to share experiences and promote leadership in transitioning to digital water solutions. By sharing experience on the drivers and pathways to digital transformation in the water industry, the programme is consolidating lessons and guidance for water utilities to start or continue to build their journey towards digitalisation. The ecosystem of IWA members across the water value chain including utilities, regulators, technology companies, software companies, researchers and academia will be at the forefront of embracing emerging technologies to solve urgent and costly issues around water service provision (operation, liability, customer services, etc.).

Through the Digital Water Programme, the IWA will leverage its worldwide member expertise to guide a new generation of water and wastewater utilities on their digital journey towards the uptake of digital technologies and their integration into water services.

5.3 The water industry's role in the digital journey

The ecosystem of stakeholders involved with and impacted by water and wastewater utilities is growing and evolving, spanning across industries, academic institutions, technology providers, and myriad other public and private sector players. No stakeholder will be left untouched by the digital transformation of the water and wastewater sector, and all will share the responsibility to step up to the challenges of the sector and secure our water resources for future generations. Most importantly, it will remain the responsibility of water and wastewater utilities alike to ensure affordable access to reliable, quality services to their customers, no matter the challenges the utility may face.

Water and wastewater utilities maintain the responsibility of providing services critical for human health and the wellbeing of society to communities around the world, services that encompass basic human rights – the rights to water and sanitation. Upholding those human rights will require utilities to embrace a leadership role and forge ahead into a more connected, digital future. Utilities must explore new possibilities and solutions, and branch away from traditional, legacy infrastructure in order to continue providing adequate services for meeting the demands of society. With this report offering both instructions and advice, it is no longer a question of how to become a digital utility, rather, who will be the first to join their utility peers in rising to the challenges and opportunities of the 21st century and beyond. For all the power harnessed by digital technology, no water innovation holds more latent potential than the open human mind.

Water and wastewater utilities must embrace digital solutions.

There is really no alternative.

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