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The Digital Journey of Water and Sanitation Utilities in the Caribbean

Current State and Opportunities

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WITH THE COLLABORATION OF

SOURCE OF INNOVATION

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Executive Summary

This paper builds on previous research in the Latin American and Caribbean (LAC) region to provide an overview of the digital transformation process ongoing in the water and wastewater utility sector of Caribbean countries. The research team provides background information regarding the challenges facing water and wastewater utilities in the region, explains how digital tools can address those challenges and describes current progress being made toward implementing digital tools. The report includes additional insights obtained through interviews with key water utility leaders and operators in the region.

Digital transformation in water utilities can provide numerous benefits for the utilities themselves and the customers they serve. There are many factors that impact an organization's ability to implement digital strategies, such as access to infrastructure and capital, cultural expectations, awareness of new and innovative technologies, and technical skills. The Caribbean region has experienced growth in its residents' ability to access internet resources and cellular data, and most countries report that over 80% of their population has access to the internet or cellular data.

The methodology of the paper included conducting research as well as author interviews with Caribbean utility leaders. The research identified two pressing challenges: access to financial capital and access to skilled labor. It also revealed opportunities to focus on improving sensing systems for water assets, the speed of internal information communication, closing the Knowing-Doing gap, and using digital technologies to improve customer education with regard to water and wastewater issues.

The paper also provides potential creative investment approaches for Caribbean utilities. These include new ways to engage with development banks, private microproject funds, and public-private partnerships to improve operational efficiency and revenue generation for utilities in the region. The target audience is anyone interested in the Caribbean utility sector, with a particular focus on stakeholders in the innovation ecosystem.

Abbreviations

AI	Artificial intelligence
AR/VR	Augmented Reality/Virtual Reality
CAPEX	Capital Expenditure
CRM	Customer Relationship Management
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
IDB	Inter-American Development Bank
IoT	Internet of Things
IVR	Interactive Voice Response
IWA	International Water Association
LAC	Latin America and the Caribbean
LSS	Lean Six Sigma
NRW	Non-revenue Water
OPEX	Operational Expenditure
SCADA	Supervisory Control And Data Acquisition
SDG	Sustainable Development Goals
W&S	Water and Sanitation
WasS	Water as a service
WSS	Water Supply System

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Introduction

This report provides a foundation for the digital transformation of water and sanitation (W&S) utilities in the Caribbean and demonstrates the potential for value creation by adopting digital transformation. It provides a background on the value of digital transformation and its status, challenges, and trends. It also offers a sampling of recent deployments in the Caribbean region that demonstrate ways to embrace and scale digital technology adoption.

The report explores the potential for digital transformation and investment opportunities and shares examples of potential partnerships and collaborations to facilitate the transformation pathway. The digital imperative for Caribbean utilities is part of a more significant megatrend, and leaders in the water sector recognize the considerable benefits of adopting digital technologies.

In this report, we answer the following questions:

- What digital tools are accessible for water and wastewater utilities in the Caribbean region?
- What is the current state of digital transformation in the Caribbean's water and sanitation sector utilities?
- What are the opportunities for digital transformation in the Caribbean?

The authors also offer tangible examples and actionable insights for Caribbean utility professionals, wherever their organizations stand along the journey to a data-driven, fully connected, and digital organization.

The objective of the report is not to recommend one specific type of technology over another but to highlight the types of available and affordable solutions that could help address the challenges water and wastewater utilities face in the Caribbean.

Digital innovation is essential to achieving UN Sustainable Development Goal 6 that states: "Ensure availability and sustainable management of water and sanitation for all" (United Nations Department of Economic and Social Affairs, 2023). The main challenges innovation faces in the Caribbean's W&S sector have implications for research, development, and governance.

This report aims to raise awareness of the state of digital transformation in the Caribbean and highlight opportunities for improvement. The target audience is anyone interested in the Caribbean utility sector, with a particular focus on stakeholders in the innovation ecosystem. These stakeholders include practitioners and regulators but could also include academics, non-governmental organizations, entrepreneurs, suppliers, and civil society.

1

What digital tools are accessible for water and wastewater utilities in the Caribbean region?

This section explores the foundations of digital transformation in the Caribbean region and tools that may be available to water and wastewater utilities, providing definitions, background on the region, driving forces in play, and highlights of the importance of digital transformation.

THE BASICS OF DIGITAL TRANSFORMATION

Digital technologies offer significant potential to transform the Caribbean's water systems, helping utilities become more resilient to water quality and scarcity issues and providing opportunities to innovate and support economic development and a means to operate efficiently. Empowering organizations to identify, transform, automate, and visualize data allows water utilities to extend resources, reduce non-revenue water (NRW), expand infrastructure life cycles, and provide the basis for financial security.

Innovation is essential to achieve SDG 6 (Grievson et al., 2022). The main challenges innovation faces in the W&S sector in the Caribbean can be divided into three categories: governance efforts, research, development, and innovation (RD&I); and water, sanitation, and solid waste utilities (Minatta & Basani, 2020). Digital transformation is critical for innovation in utilities (World Economic Forum, 2018).

The Inter-American Development Banks' (IDB) previous report on the Digital Journey of Water noted that digital transformation is a broad term (Féry, 2022) referring to "the process of using digital technologies to create new — or modify existing — business processes, cultures, and customer experiences to meet changing business and market requirements."

Digital technologies have the potential to assemble more complete, current, and accessible information on water supply and demand than ever before. Such an assembly could consist of several activities, including but not limited to:

- Detecting leaks using remote sensors and real-time AI and automatically sorting field interventions into a priority hierarchy (FIDO Tech, 2022).
- Designing water network extensions using digital twins (simulations), 3D models, and optimization tools (SWAN Forum, 2021).

- Automatically informing customers via mobile app in cases of network water quality issues or in-house leaks identified through smart meter technologies (Dropcountr, n.d.).
- Using surveys, call center data, and intelligent chatbots to identify major complaints and proactively improve customer engagement strategy (VertexOne, n.d.).
- Using 3D printing to quickly produce spare parts in the field.
- Leveraging operational data (energy, failures, temperature, etc.) for predictive maintenance.
- Using digital twins to coordinate with other actors active in the urban space for planning and designing the systems and networks differently.
- Supporting the utility workforce with alternate reality and virtual reality (AR/VR - "metaverse") applications (World Economic Forum, 2018).
- Achieving customer engagement using a unified communication approach with integrated customer data.

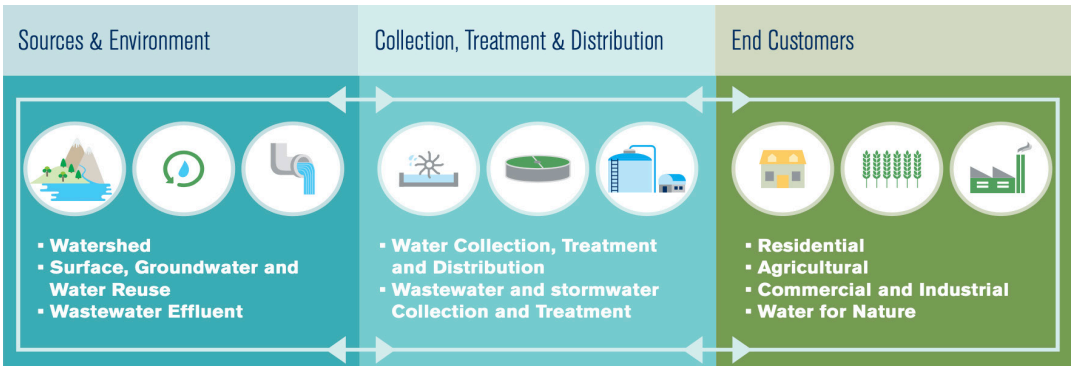
The International Water Association (IWA) provides a simplified illustration of the systems in place (Figure 1) for the utility sector that include:

I. Sources & Environment

II. Collection, Treatment, and Distribution

III. Engagement with End Customers

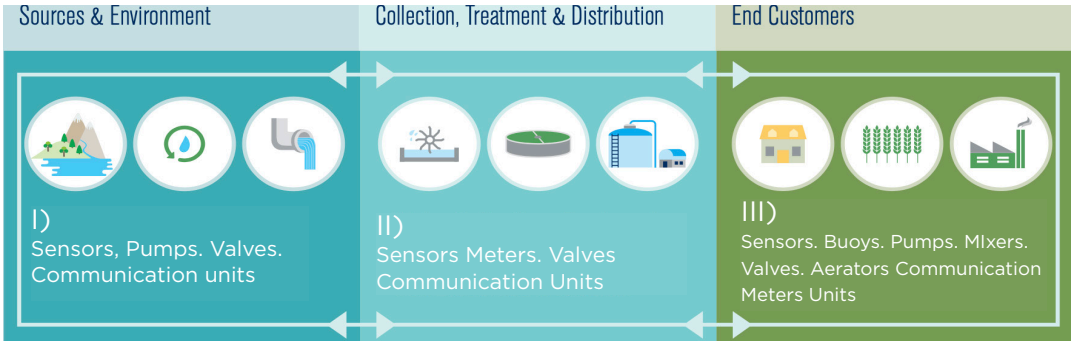
Figure 1: Utility water systems value stream



Source: Sarni et al., 2019, IWA.

The IWA report on digital transformation contains a discussion of how digital and physical assets connect to create data, which powers utilities. Examples of physical assets are provided in the below table (Figure 2) according to where they are in the utility value stream.

Figure 2: Utility technology opportunities in the value stream



Source: Sarni et al., 2019, IWA.

Translating physical assets into digital assets requires collecting, storing, transforming, and visualizing information. Many of these systems are traditionally siloed and require manual intervention to transform data into meaningful insights. Traditional methods of data integration across multiple platforms include operational and network management, capital planning, customer engagement and billing, and hydraulic monitoring. Digital transformation enables utilities to integrate these data silos into cross-functional units of measurement to allow for higher-level functions such as predictive maintenance, omnichannel customer engagement, visualization layers, digital twins, and remote watershed integrity management.

As presented in our 2022 report, The Digital Journey of Water and Sanitation Utilities in Latin America and the Caribbean, by Guillaume Féry, the driving forces for transformation are:

- ***Increasing efficiency:*** An example of this could be the ability to automate customer support services based on leak detection data or energy usage.
- ***Cost management:*** An example of this could be identifying workforce management or NRW loss sources.
- ***Improving regulatory compliance:*** An example of this could be a reduction in discharge limit issues or biosolid refinements.

Digital transformation is changing the way Caribbean utilities perform their societal function. Emerging digital technologies can increase performance in water treatment operations (i. sources & environment), water production (ii. collection, treatment & distribution), and customer service (iii. end customers). The authors suggest adding internal systems, data science and cybersecurity as a fourth segment to the value stream as cross-functional technologies (iv. cross-function). This final segment adds detail to the digital transformation of each of the first three groups of technologies.

We want to reiterate, however, that digital transformation does not focus only on technology. It impacts leadership, engagement, and organizational culture (Minatta & Basani, 2021) as well as includes measures to manage security concerns and other risks. As stated in Féry's 2022 report, digital transformation encompasses a complete organizational focus in terms of strategy and vision, people and culture, process and governance, and technology and capabilities.

BACKGROUND ON WATER AND WASTEWATER CHALLENGES IN LATIN AMERICA AND THE CARIBBEAN

According to monitoring statistics associated with the SDG, only 74% of the population in the Latin American and Caribbean (LAC) region have access to safely managed water services, and only 31% have access to safely managed sanitation. This translates to 165 million people and more than 440 million people, respectively, who lack access to safely managed W&S services (Minatta & Basani, 2022).

The investments needed to meet the SDG targets in safe water and sanitation (clean water and sanitation for all) are estimated to be more than three times their current level, amounting to at least US$14 billion per year until 2030 (Financing SDG 6, n.d.). These investments do not include the resources needed to improve water resource management, urban drainage and solid waste. Nor do the figures account for resources needed by other streams such as hazardous and healthcare waste, and construction and demolition waste.

The SDG goals cannot be achieved without adopting innovative solutions and models at the technological, institutional, financial, and social levels to allow acceleration of access to safe drinking water, sanitation, and solid waste services throughout LAC.

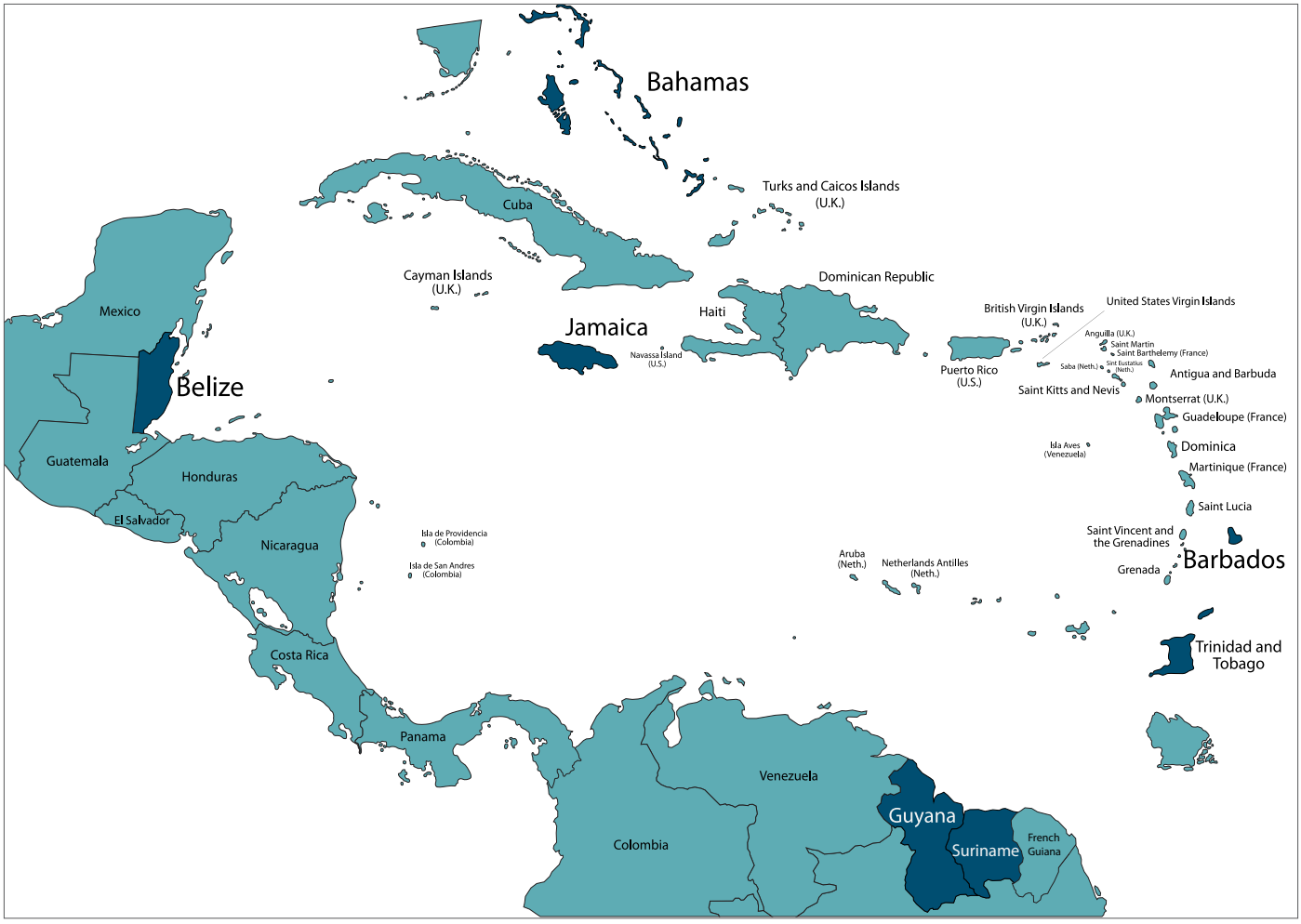
The potential impact of adopting innovative solutions for service provision is substantial. In general, for utilities, the technological digital transformation of systems and processes can reduce operating expenses up to 25% (Minatta & Basani, 2022). Reducing operational expenses helps resolve one part of the equation for water utilities to meet SDG goals because it allows the utilities to allocate funding to projects that increase access to W&S services for additional communities in the region.

At the international level, digitization initiatives in the sector have already resulted in operating gains of up to 25% and have reduced water supply failures by around 30% and the duration of pipe bursts repairs by 8%, also increasing the reliability of data to almost 99% thanks to the immediacy of precise sensor readings (Minatta & Basani, 2022). These impacts are directly tied to the utilities' ability to provide the necessary infrastructure to meet SDG goals while more effectively delivering services to their customers.

FOCUS ON THE CARIBBEAN

While safe drinking water and sanitation issues face LAC in the broadest of contexts, this paper is focused on the Caribbean. For the purposes of this paper, the "Caribbean" consists of the countries included in the IDB Caribbean group, and countries with cultural affinity (in dark blue). These are displayed below in blue (Figure 3).

Figure 3: Caribbean IDB countries



Source: Developed by the authors. https://www.mapchart.net/americas.html

To provide context to these countries, the table below specifies population, gross domestic product (GDP), and GDP per capita (Table 1)

Table 1: Country statistics

Country	Population (2023)	GDP (USD)	GDP per Capita (USD)
Bahamas	396,914	$11.2M	$28,240
Barbados	287,708	$4.9M	$17,034
Belize	430,000	$1.8M	$4,163
Guyana	790,329	$7.7M	$9,764
Jamaica	2,973,462	$13.6M	$4,587
Suriname	591,798	$2.8M	$4,836
Trinidad & Tobago	1,403,374	$24.0M	$17,097

Source: CARICOM, 2023.

The water sector is a critical component of the Caribbean region's economy, as the following table shows, providing water supply for households, agriculture, and tourism activities. The Caribbean is a water-scarce region, with most countries relying on rainfall for their water supply. Climate change is projected to increase rainfall variability and intensity, leading to droughts and further water scarcity (Nekesha B. Williams & Ken D. Thomas, 2012). The region is also vulnerable to water pollution, coastal erosion, rising sea level, and severe weather, all of which add to innovation's importance in the water sector.

Table 2: Access to water and sanitation services in the region

Country	National Piped Water Coverage (%)	Sewer Connection (%)	Wastewater Treated (%)
Bahamas	97	21	n/a
Barbados	99	3	3
Belize	86	9	n/a
Guyana	92	8	n/a
Jamaica	84	23	8
Suriname	79	1	n/a
Trinidad and Tobago	94	20	n/a

Source: IDB, 2021.

Table 3: Individuals using the internet (% of population)

Country	% of population with access to internet	% of population with access to cellular data
Bahamas	94.3	90.9
Barbados	85.8	74.9
Belize	62	96.6
Guyana	84.8	83.9
Jamaica	82.4	98
Suriname	70	85
Trinidad and Tobago	79	90

Source: Developed by the authors. https://www.mapchart.net/americas.html

The digital economy has become a prominent booster of economic development and innovation. However, internet infrastructure and the percentage of the population with access to cellular data are other factors that must be considered with regard to the ability to implement digital technologies (Rong, 2022). The chart below displays these metrics by country (Table 3) (Bianchi, 2023).

In terms of water and wastewater utilities, all of the researched countries have both drinking water and sanitation systems in place that support a portion of the population. Each country is in a different stage in the process of digitization of its drinking water and sanitation systems, which will be described in further detail below.

DRIVING FORCES OF DIGITAL TRANSFORMATION IN THE CARIBBEAN

While each country in the Caribbean has unique strengths and challenges in its digital journey, some common themes must be highlighted.

Challenges facing the region

The Caribbean region faces several common challenges shared across most countries. To begin with, these are tropical countries, and most are islands, which means most, if not all, face challenges with potable water. Utilities' ability to implement digital technologies is also impacted by such issues as access to reliable widespread infrastructure capital financing and skilled technical labor, and severe weather.

While most utility service providers are also interested in implementing digital innovation, actual implementation in many areas, especially rural ones, is lacking due to the challenges of physical and digital infrastructure. Smart meters are infrequently in place, and attempts to map an entire ecosystem occur sporadically or only for research purposes. Global utilities are working to install hundreds of millions of smart water meters, with up to 700 million such connections expected by late 2030. Greater China, North America, and Europe are expected to experience the most growth in this with 31%, 29%, and 28%, respectively (Singh & Arnott, 2022). Meanwhile, digital metering in Caribbean countries is much lower, with Jamaica adding 450,000 meters in 2017 (Nhede, 2018).

Another challenge is that these countries generally have insufficient supply-side innovation support. There is a lack of innovative startups to support utilities in the region and limited budgets and/or technical expertise to identify, pilot, and implement innovations. However, there are several innovation ecosystem actors (Minatta & Basani, 2022) working on digital transformation, including universities and development banks (e.g., IDB).

An additional challenge is a lack of culture focused on innovation in the industry and the region. As noted in *The Technology Fallacy*, innovation is not simply a new line of code or product, but rather a system of beliefs, habits, values, attitudes, and leadership to foster innovation (Kane et al., 2022).

Finally, COVID-19 had a huge impact on these countries. Many of them are heavily reliant on tourism for a major portion of their GDP. While COVID-19 served as an accelerator of technology adoption in other parts of the world, its economic impact slowed digital transition innovation in the region in recent years (IDB, 2022).

Strengths for future digital transformation

Despite the many significant challenges among Caribbean countries, they share numerous strengths. For instance, many of these countries have a relatively small population (CARICOM, 2023). This means that, unlike large countries such as the United States, small- and micro-scale and/or off-grid solutions can be designed and built-in capital-efficient ways.

Many of these countries also have dense urban populations, meaning large portions of the populace have an opportunity to connect to municipal drinking water and sanitation solutions (CARICOM, 2023).

Finally, as the world moves into a "post-COVID-19" era, these countries are seeing significant amounts of tourism return, thus enabling investments in the sector (Garcia, 2021).

WHY DIGITAL TRANSFORMATION IS IMPERATIVE FOR CARIBBEAN UTILITIES

The Caribbean utility sector faces several unique digital challenges as well as those faced system-wide by LAC. *The Digital Water Journey* notes that LAC is becoming more urbanized, digital, and connected (Sarni et al., 2019). The subset of LAC, which is the Caribbean, is experiencing similar trends. Smartphone use has increased significantly as has access to the internet, especially in younger, urban centers of the countries. Utilities need to leverage these trends to improve water and sanitation through digital transformation by connecting hardware to digital assets and better engaging customers through omnichannel approaches.

In the next section of the report, we will delve more deeply into the current state of Caribbean digital transformation by examining individual countries and highlighting their strengths and potential areas for opportunity. We will look at both drinking water and sanitation through key trends in digital transformation.

What is the current state of digital transformation in the Caribbean's water and sanitation sector utilities?

The status of digital transformation in the Caribbean water supply system (WSS) is still in its early stages of development. While some of the countries in the region have begun to adopt digital technologies and tools to improve water management, most of the region continues to implement and scale these solutions ahead of potential technology adoption.

The research team interviewed various decision-makers in the Caribbean WSS space. Some examples of digital transformation they are involved with are found below. Interviews were conducted via teleconference meetings with the following organizations and members of their leadership teams, whose details and responses can be found in the Appendix:

- Barbados Water Authority
- Belize Water Services Ltd.
- Guyana Water Inc.
- Jamaican National Water Commission
- Suriname Water Company

While there is currently limited information publicly available for the Bahamas, the forward-thinking mentality of Barbados has the water authority analyzing how it interacts with its customers' data. The utility's water supply system already integrates supervisory control and data acquisition (SCADA) practices in four water supply plants. Now the utility is hoping to obtain the same level of data synchronization in its customer profiles. Internal business processes are primarily performed using digital technologies, and the utility's overarching goal is to transition all physical processes into digital solutions when it makes sense (Clovine, 2023).

In Belize, there is a call center with an Interactive Voice Response (IVR) to help with billing, technical support, and incident reporting. The utility is rolling out a new billing/customer relationship management (CRM) system within the next year.

Most of Guyana's water production is still manually tracked, including metering.

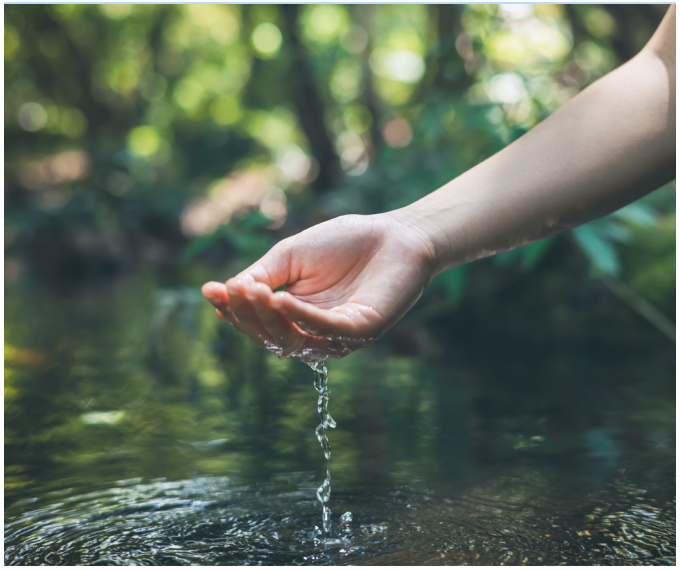
During the interview with the Jamaican utility, the authors learned about that country's projects for advancing the ability to measure water withdrawals for the utility's customer base (Barnett, 2022). By investing

in a smart water network with Internet of Things (IoT) sensors to monitor water quality and distribution, as well as advanced analytics to optimize water treatment and distribution, the utility can provide customers with more accurate billing information, trace leaks, and cut down on NRW. The next phase of the smart meter project rollout is set to link the meters for seamless communication to ensure internal systems and communications with customers, and develop a communication network across the utility's water supply systems.

Trinidad and Tobago's Water and Sewerage Authority has a customer service system that supports online billing and payments.

While the examples above show that digital transformation is possible in the region, they also highlight the challenges to proceeding from one level of transformation to the next. Actions that need to be taken to accelerate the adoption curve are initially costly and time-consuming (Sarni et al., 2019). Suriname, for example, is implementing technology at a relatively basic level. Its utility offers digital solutions for essential business functions; however, the systems currently in place for CRM, billing, etc., are not yet integrated. Communication around billing and service is primarily done through paper notifications, and the utility uses social media networks such as Facebook to post various service updates to their customers. Suriname has three production stations that can be operated remotely and one SCADA surface water production system up and running, which are pilot projects (Ashwinie, 2022).

By taking a deeper dive into each country and its WSS operations, we can further see the current situation and progress made to increase the use of digital technologies. Growing the digital technologies used for operational water and wastewater treatment is as imperative to digital transformation as technologies implemented for internal systems are involved in the day-to-day processes of the system. The section that follows shows how each country has been able to integrate technologies into its everyday systems.



WATER TREATMENT OPERATIONS (I. SOURCES & ENVIRONMENT)

Traditional water treatment operations use testing and operational methods that are expensive, resource-heavy, and time-consuming. These methods rely on field instrumentation and analysis from wastewater testing labs. New digital technologies, such as sensors and the data they create, can provide treatment plants with new and valuable opportunities. Data collection is becoming easier, allowing real-time monitoring of an increasing number of parameters. Table 4 below provides a snapshot of digital water treatment operations by country.

Table 4: Digital water treatment operations

Country	Traditional Water Treatment Operations	Digital Water Treatment Operations
Bahamas	No publicly available information at this time.	No publicly available information at this time.
Barbados	The Barbados Water Authority operates 42 facilities and 28 pumping stations. Currently, SCADA is about 95% implemented for its water production system.	The utility has several new facilities under construction that will be included in its SCADA integration. It has also implemented a smart metering system across its customer base that is alleviating the need to manually read water meters.
Belize	A small portion of the service area has a sewage collection system in place.	No digital water integrations are in place.
Guyana	Most of the country's water production is still manually tracked, including metering at sources.	Telemetry data is inconsistent due to the lack of reliable internet connections to treatment plants. The water utility does have some tablets used on-site at facilities to help with data entry.
Jamaica	Technological advances are not currently a priority for this system.	Jamaican wastewater treatment only covers about 25–30% of the population. Its priority is enabling the water production system for the island.
Suriname	No water treatment services are provided.	No water treatment services are provided.
Trinidad & Tobago	No publicly available information at this time.	No publicly available information at this time.

Source: Developed by the authors.

WATER PRODUCTION OPERATIONS (II. COLLECTION, TREATMENT & DISTRIBUTION)

Traditional water production systems refer to the methods used to extract, treat, and distribute water before the integration of modern technology. These systems rely on manual quality testing and monitoring techniques for treatment and distribution as well as water quality reporting. Table 5 that follows provides a description of the digital water production operations by country.

Table 5: Digital water production operations

Country	Traditional Water Production Operations	Digital Water Production Operations
Bahamas	No publicly available information at this time.	No publicly available information at this time.
Barbados	The Barbados Water Authority operates 42 facilities and 28 pumping stations. Currently, SCADA is about 95% implemented for its water production system.	The Water Authority has several new facilities under construction that will be included in their SCADA integration. It has also implemented a smart metering system across its customer base that is alleviating the need to manually read water meters.
Belize	Groundwater wells and river treatment plants are mostly traditionally operated.	Newer desalination plants have SCADA systems in place.
Guyana	Nationwide, water supply facilities include about 178 groundwater wells and eight surface water sources. Most water production is still manually tracked, including metering.	Telemetry data is inconsistent due to the lack of reliable internet connections to treatment plants. The water utility does have some tablets used on-site at facilities to help with data entry.
Jamaica	There are challenges with the dispersion of the system, and the utility is looking at visibility challenges across its operations.	Jamaica's largest current project is a new smart water meter system that would cover 90% of its customer base. The utility began looking at the network from a GIS perspective and is gradually mapping that network.
Suriname	Suriname still has a significant portion of its operations that are handled manually, including measuring water quality in its surface water production facilities.	Suriname has three pilot production stations that can be operated remotely and one SCADA surface water treatment production station. The utility is receiving funding and training from the Belgian company that built the production stations.
Trinidad & Tobago	No publicly available information at this time.	No publicly available information at this time.

Source: Developed by the authors.

CUSTOMER SERVICE (III. END CUSTOMERS)

Utilities are longstanding institutions within the communities in which they were created. Thus, many systems currently in place were designed based on approaches in use long before the digital transformations of the past 30 years (US Environmental Protection Agency, 2021). "Traditional" systems of engagement refer to the methods and strategies used by water companies to interact with and assist customers in a non-digital manner. Examples of traditional customer support systems for water providers include telephone support, in-person support at a physical location, snail mail correspondence, and fax.

Digital customer support systems for water providers, on the other hand, refer to the use of technology to interact with and assist customers through digital channels for purposes of billing, communication, important alerts, and other customer exchanges. Incorporating new tools and techniques into customer support promotes digital strategy and vision, skills, innovation, governance, and digital service mastery.

Digital customer support systems for water providers offer several benefits over traditional systems, including increased efficiency and speed of communication, improved accessibility for customers, and the ability to handle a larger volume of support inquiries simultaneously. Digital support systems can also provide water companies with valuable data and insights into customer needs and preferences, which can then be used to improve overall customer satisfaction and the quality of service provided.

Examples of digital customer support systems for water providers include live chat, email support, social media support, online portals for customers to manage their accounts, and virtual assistants. Current approaches for the Caribbean countries studied in this paper appear in Table 6 below:

Table 6: Digital support systems

Country	Traditional Support Options	Digital Support Options
Bahamas	Call center with IVR to help with billing, technical support, and incident reporting.	Using their online customer accounts, paperless billing via online portal, and notification system, customers are able to pay bills, submit complaints, and request service. An independent mobile app also provides access to customer accounts to report outages, pay bills, check balances, report outages, and contact a customer service agent.
Barbados	Customers can check bills via a call center IVR system and are notified of events through email.	The Barbados Water Authority is developing a mobile app to allow customers to access their accounts, pay bills, report incidents, and view their account status. Customers can also view important service updates on the website regarding ongoing emergency repairs.
Belize	Call center with an IVR to help with billing, technical support, and incident reporting. A new billing/CRM system will be rolled out over the next year.	Using their online customer accounts, paperless billing, and notification systems, customers are able to pay bills, submit complaints, and request service. The Belize Water Authority also uses social media (Twitter, Facebook) to notify customers of important information such as incident and repair work underway and how it will impact customers.
Guyana	Call center with IVR to help with billing, technical support and incident reporting.	Using their online customer accounts, paperless billing, and notification system, customers are able to pay bills, submit complaints and request service. An independent mobile app also provides access to customer accounts to report issues, pay bills, check balances, report outages, and contact a customer service agent. However, the application has poor reviews for customer experience.
Jamaica	The Jamaican National Water Commission has a contact center with automated voice support.	The utility offers online customer accounts, paperless billing, and a notification system. Customers can use their online accounts to pay bills, submit complaints, request service, and chat with a web agent.
Suriname	Most of Suriname's customer support system is still via paper-based notifications and billing.	The utility has social media accounts to notify customers of important information.
Trinidad & Tobago	In-person customer service centers that can handle customer service issues.	Trinidad and Tobago's Water and Sewerage Authority has a customer service system that supports online billing and payments.

Source: Developed by the authors.

INTERNAL SYSTEMS (IV. CROSS FUNCTION)

Traditional internal business systems refer to the methods, processes, and tools organizations use to manage and run their operations in a non-digital manner. These internal business solutions include paper-based record keeping, manual data entry, manual invoicing and payment processing, manual scheduling and time tracking, and in-person meetings and communication.

In contrast, digital internal business solutions use technology to automate, streamline, and optimize various business processes. Such systems offer several advantages over traditional solutions, including increased efficiency, accuracy, and speed of processes, better data organization and accessibility, and improved employee communication and collaboration. Using digital tools to improve internal processes helps guide the digital transformation of a utility by improving its digital strategy and vision, culture and leadership, change management, governance, and overall technical capabilities.

Examples of digital internal business solutions include enterprise resource planning (ERP) systems, CRM systems, electronic document management systems, cloud-based accounting software, and online project management tools. Table 7 below describes current approaches for the Caribbean countries researched in this paper.

Table 7: Digital internal systems

Country	Traditional Internal Systems	Digital Internal Systems
Bahamas	No publicly available information at this time.	No publicly available information at this time.
Barbados	Traditional internal systems are being phased out in favor of digital systems.	The Barbados Water Authority currently offers digital billing tools, customer communication, and internal communication between teams. It is still working to get its internal systems to synchronize with each other. The utility is in the process of building out integrations and incorporating digital technologies into all of its internal processes.
Belize	Internal systems still rely on some manual processes for transferring information from the field.	A new billing and CRM system under development will help automate internal systems.
Guyana	Guyana is still working on its digital transformation. As such, a lot of its inventory system is still manually accounted for.	Guyana's water authority was integrated with Oracle business solutions around 2013, and since then, there have been few technical upgrades. The utility still has access to the technology licenses. However, receiving support for those platforms is becoming more difficult as the technology ages.
Jamaica	The Jamaican National Water Commission has developed a system that integrates digital solutions into its internal business systems.	Jamaica's internal systems are relatively advanced for the region. They have digital Customer Relationship Management (CRM), on-premise servers, and digital internal communication tools.
Suriname	Suriname's digital transition regarding internal systems is in progress.	The Suriname Water Company offers digital solutions for essential business functions. However, the systems currently in place for CRM, billing, and internal communication are not synchronized. It is launching a project with a consultant to address this issue.
Trinidad & Tobago	No publicly available information at this time.	No publicly available information at this time.

Source: Developed by the authors.

DATA SCIENCE (IV. CROSS FUNCTION)

Water and wastewater authorities can utilize business data by applying data-driven techniques and technologies to collect, analyze, and interpret data related to the management and distribution of water resources (Tropsa, 2020). These could be digitally integrated, such as by using data collected by smart meters that integrate with data visualization software such as PowerBI to see real-time use rates. It could also be process driven by ensuring all data collected by the utility is stored and analyzed to gain helpful insights. By leveraging data from various sources, such as water usage patterns, weather conditions, and infrastructure performance, water authorities can gain insights into the overall state of their water systems and make informed decisions to optimize operations, improve efficiency, and enhance customer service. Improving data science using digital tools helps utilities make data backed decisions quickly. This ties into a utility's overall strategy and vision, as well as its stage of digital innovation, governance, and digital service mastery, and it can be a positive tool for technology disruption by improving the way decisions are made.

Data science tools and techniques, such as machine learning, predictive analytics, and data visualization, can help water authorities effectively manage and monitor their water resources, ensure the reliability and sustainability of water supplies, and respond to emerging challenges and opportunities in real time. Table 8 below provides an overview of data science practices by country.

Table 8: Data science practices

Country	Data Science Goals	Data Science Practices
Bahamas	No publicly available information at this time.	No publicly available information at this time.
Barbados	Data science is a process that the Barbados Water Authority would like to continue to advance.	The utility currently has some metrics that are used to improve its systems, but its priority is upgrading to a live dashboard that provides important information to its teams.
Belize	There are currently limited data visualization projects or goals in place.	There are currently limited data visualization projects or goals in place.
Guyana	Data science is not currently a priority for Guyana.	Data science practices are not currently a priority, they are more focused on getting data collection practices up and running.
Jamaica	Data science is a business process that the Jamaican water authority is still advancing.	Currently conducting an ICT review to establish a roadmap looking at current trends in the water sector and assess gaps to bring them to a current level and look at the future for technology in their region.
Suriname	There is some distrust of the data that is currently provided by their system.	Software licenses were not renewed from tools that were piloted at different times so there is an issue with the accuracy of data provided.
Trinidad & Tobago	No publicly available information at this time.	No publicly available information at this time.

Source: Developed by the authors.

CYBERSECURITY (IV. CROSS FUNCTION)

Cybersecurity for water and wastewater authorities involves protecting the critical infrastructure and systems used to manage and distribute water resources from cyber threats and attacks as well as developing processes for potential failure of digital systems. This can include securing the digital systems used for water treatment, distribution, and monitoring, as well as protecting the data and sensitive information related to water operations. Cybersecurity is an important piece of the digital transformation puzzle. It considers the overall process and governance of a utility, its technology and capabilities, strategy and vision, and its leadership views on security.

Water authorities must be vigilant in securing their systems from cyber threats, such as hacking, malware, and ransomware, as a breach of their systems can have serious consequences for public health, the environment, and the economy (Cybersecurity and Infrastructure Security Agency, 2021). Implementing robust cybersecurity measures, such as firewalls, encryption, regular software updates, and personnel training is essential for water authorities to ensure the protection and continuity of their water systems and the trust of their customers and stakeholders. Table 9 below describes approaches to cybersecurity by country.

Table 9: Cybersecurity practices

Country	Cybersecurity Goals	Cybersecurity Practices
Bahamas	No publicly available information at this time.	No publicly available information at this time.
Barbados	Digital security is at the top of their list from a risk management perspective. They have recently spoken with a consultant to see where they are at risk due to security gaps.	The utility currently has some digital security features in place. Email has its own secure channel and servers are backed up daily offsite with a cloud backup of essential components. They run a number of antivirus logs and insist that all data is stored on analog devices. They have limited the portable drives to contain and restrict usage outside.
Belize	Cybersecurity is a priority for Belize, and it has a fairly robust system.	Customer data is held on-premise. The utility has a perimeter system for any attempted attacks through network security such as firewalls, internal firewalls, and antivirus software. The utility runs backups on databases every two hours and has offsite cloud storage.
Guyana	Cybersecurity is something the utility would like to increase.	The utility has some openings for cybersecurity roles it is working to fill.
Jamaica	Digital security is currently the major risk facing the utility.	Its cybersecurity process is managed internally with on-premise servers. The utility has also looked into cloud backups.
Suriname	Digital security is currently the major risk facing the utility.	The utility occasionally connects with third-party contractors to evaluate its risks.
Trinidad & Tobago	No publicly available information at this time.	No publicly available information at this time.

Source: Developed by the authors.

What are the opportunities for digital transformation in the Caribbean?

As the research demonstrates, there are a number of opportunities for digital transformation in the Caribbean water and wastewater utilities. Based on research from *The Technology Fallacy*, people prefer to work for a digital leader and many of the researched utilities are lagging in digital transformation (Kane et al., 2022). One common area all the utilities noted was a lack of technical know-how to design and implement advanced digital technologies.

Digital transformation is more than just deploying digital technologies, such as the IoT or AR/VR tools for the workforce. Culture, organizational structure, strategy, leadership, and talent are the drivers to build a digitally enabled organization (Kane et al., 2022). While Caribbean utilities have the intent and are working on the strategy to transform themselves digitally, they are still experiencing a gap in talent (e.g., capabilities, learning culture, etc.). This raises the very question of whether the utilities have a comprehensive digital strategy that aligns with their business or are just implementing disparate technologies?

Interview with Enrique Cabrera, Professor at the Universitat Politecnica de Valencia (February 9, 2023).

As part of our research, we spoke with Professor Cabrera about how utilities can digitally transform and in what ways they can improve digital transformation in the Caribbean. Based on his experience, which includes hands-on research in the region, he provided the following perspective:

> Expectations cannot be the same in the Caribbean as in other places in the world … There is a huge gap in digitalization. The countries are in the early stages. However, digitalization can vastly improve their processes.
>
> A digitally advanced organization is one in which the entirety of the organization is built around digitalization. It is less about the tools implemented and more about whether management of the organization is efficiently and effectively leveraging those tools to run the organization. You can use different tools and processes, but what is paramount is how you manage them.

What is important for the Caribbean is that digital transformation is more about leadership and management than specific technologies. Dr. Cabrera notes that utilities are long-standing organizations with aging assets, and the digital revolution is what will help provide better decision-making frameworks and information to make right-fit solutions.

As we explore the recommendations for the Caribbean, Dr. Cabrera provides background on the importance of understanding that utilities should not get too far ahead of themselves, understanding instead where each utility finds itself along a digital continuum, building leadership, culture, and processes to advance in their journey.

In this section, the focus will be on actionable areas where utilities can focus based on leading practices in digital transformation (Sarni et al., 2019; Kane et al., 2022).

Focus areas

Sensing Systems

1

Caribbean utilities reported a general shift from a traditional network form to one that is more digitally connected. This includes piloting and, in some instances, implementing smart meters, IVR, and digital billing. However, most of these information-gathering systems were focused internally.

There is a significant opportunity for utilities to increase "sensing systems" to acquire information from outside the organization. These systems are meant to capture data outside the organization to help support internal decision-making and operations (Kane et al., 2022). For instance, there are opportunities to utilize geospatial data from other governmental organizations, public and private entities, and nonprofits. One good example would be collaborating with organizations that can map water quality and quantity in the watershed in real- or near real-time. The value to adding sensing systems is to increase model inputs and provide a holistic picture to leadership to aid in the decision-making process.

Velocity of internal information

2

Due to the global COVID-19 pandemic, many of the utilities created a form of hybrid work model. This means that some collaboration tools, such as Microsoft Teams, are in use to support remote operations. However, many of these utilities recently reverted to in-person models and there is a risk that these collaboration tools will grow stale.

The second opportunity is to increase the velocity of internal information flows within organizations. For example, creating internal knowledge management centers to reduce tribal knowledge in the organization would help in onboarding employees and reduce time spent trying to find information when it is needed. There are several knowledge management tools available, including Monday.com or Confluence (Software Testing Help, 2023).

Information velocity is important because it enables organizations to learn more quickly from past mistakes, make informed decisions with up-to-date information, and develop well-rounded processes to improve efficiencies. There are many ways to increase velocity, but collaboration tools, small pilot projects, and early-stage testing with users (both internal and customers) are all ways to accelerate the speed of knowledge sharing.

3

Close the Knowing-Doing Gap

In the Technology Fallacy, there is a concept known as the "Knowing-Doing Gap." This refers the difference between "knowing" that digital technologies will improve an organization and actually "doing" something about it (Kane et al., 2022).

By closing the Knowing–Doing Gap, utilities are able to transition to actionable steps to implement digital technology. For organizations to do more, utilities can learn from startup companies and iterate that knowledge quickly. This can be completed in three steps:

1. Test small.
2. Test enough.
3. Engage cross-functional teams in testing and disseminate what has been learned quickly, broadly, and system wide.

The purpose is to try new ideas, even some that may seem "crazy," through the use of small pilots. If the pilots are successful, the organization needs to be comfortable testing enough to roll them out strategically. Once rolled out, information sharing across departments enables others to perform the same process. This means that it cannot just be the IT department innovating but rather an organizational culture of iterating on ideas.

The authors of this report have personal experience designing and implementing systems to close the Knowing-Doing Gap, achieved by work with multinational corporations, nonprofits, and government agencies through Lean Six Sigma (LSS) best practices. The principles of Lean Six Sigma focus on setting goals and designing pilot projects to test different ways to meet those goals quickly and at scale. LSS has been implemented in some utilities and aligns well with the pillars of digital transformation in the process and governance pillar (Kosven, 2009).

Use digital customer engagement for education

For many years, the Caribbean has been plagued by poor water quality and service outages (IDB, 2022). As utilities transition to fully connected and digital services, customer engagement as a way to educate customers emerges as an opportunity. A number of the utilities in this research noted that they are currently implementing IVR and electronic bill pay projects. If these tools can be transformed into a way to educate customers regarding service availability, service up- and downtime, and methods for conserving water, more customers could become aware of the impact of the utilities, and the latter could then increase revenue and their number of offerings.

For instance, there are opportunities for utilities to achieve customer interfacing using smartphone apps to connect to customers via technologies such as Dropcountr and VertexOne (Dropcountr, n.d.; VertexOne, n.d.). These technologies offer opportunities to share billing, water quality alerts, notifications of supply interruptions (outages), and other reports directly on customers' smartphones.

Areas that should not be a focus

The cart before the horse

In many of the Caribbean utilities that were the subject of our research, there are infrastructure systems being implemented that need to be in place before more advanced systems can be put into operation. For instance, smart metering for individual customers is still being implemented by a number of utilities. While an organization could implement a systemwide real-time flow monitoring system, smart metering that could provide proxy data for NRW and potential leaks is more fundamental than an advanced flow system. This is an example where a "shiny object" technology might seem fascinating but is actually impossible to implement before laying the digital foundation.

Another example is an advanced AI and visualization system. Digital twins are currently a hot topic in the water world, but there is some question as to whether they will actually help the Caribbean utility meet its stated goals. In our research, we heard that a common problem for Caribbean utilities is running multiple databases that do not speak to each other, leading to a lack of systemic integrations and interoperability. Integrated data systems are necessary to implement AI or a strong data visualization tool. Integrating backend systems before attempting digital twins would provide a better foundation for Caribbean utilities.

Implementing digital tools without properly understanding the needs of an organization and how those tools serve to change how the organization collects, processes, and utilizes data is highly ineffective. For organizations to truly become digital, they must first start with the "why" of going digital before determining how it affects every aspect of the organization (Kane et al., 2022).

Build your own tech

Every Caribbean utility noted that technical know-how and budgetary constraints are major challenges in the face of digital transformation. Trying to build a leading-class software development team is not within the scope of possibility for these utilities. That is not to say, however, that the utilities should not have technical resources on staff. Instead, these individuals should be generalists who are able to work with a number of programs and leverage existing technologies to meet their goals.

For instance, utilities may think it is more secure to build their own on-premise data warehouse. It would take a massive amount of technical expertise (and space) to accomplish this task. Instead, the preferred route would really be leveraging existing third-party cloud resources that technology generalists can manage as is. It will save on costs, technical resources, and when coupled with strong security measures, can be as secure as on-premise systems.

Another benefit of leveraging third-party technology companies is to benefit from collecting and processing significantly larger datasets (Cabrera, 2023). Data is a commodity that many, especially smaller, utilities currently lack. By leveraging third-party systems, anonymized large data sets can be applied to similar problems from other systems. For instance, if a model used in 10 other countries were applied to pipe replacement predictions, the third-party model would likely be more accurate than looking only at one system's data (if that system even has enough data to create the prediction).

Leave it to IT

As discussed in Opportunity #3, the IT department cannot be made solely responsible for digitally transforming the organization. If the IT department is working in a bubble, many digital projects will fail their stated objectives. There are several reasons for this but, at the end of the day, users are the most important factor in the successful rollout of a technology (Sarni, et al., 2019).

Organizations that are digitally strong engage all departments as well as customers in piloting and rolling out digital projects. However, not everyone's voice is equally valuable. Engaging all parts of an organization needs to be strategic. Utilities must create cross-functional groups to identify and pilot ideas before rolling them out across departments. This supports the idea of testing early and often, and accepting the fact that there may be some issues with products when they "go live" (i.e., deploy).

An example of this is the change management component of Evans' Process and Governance Pillar (2017). Strategically engaging all parts of the organization when designing and implementing new processes and technology can serve to identify potential issues and ensure project success. This has been shown to be effective in a number of utilities (Martins, 2014).

Caribbean Utilities: Existing Hurdles

Digital transformation in the Caribbean water and wastewater industry faces several challenges. By focusing on a few we consider major, we are able to see that a lack of modern infrastructure, a shortage of technical expertise, high capital expenditure needs, issues concerning data management and security, and fractured regulatory and policy frameworks are highlighted as significant issues.

Infrastructure is a systematic challenge across the region that varies by country. This includes both physical infrastructure such as pipelines and water treatment facilities, as well as digital infrastructure such as fiber optic networks and cloud computing platforms. To overcome this challenge, the region must invest in modernizing each aspect of its physical and digital infrastructure. Digital solutions that can make positive impacts in the region need reliable infrastructure in order to function. By enabling these technologies, water utilities will be better able to monitor, manage, and optimize their operations in real time, improving the efficiency and reliability of water services.

With the modernization of infrastructure, the region could solve the challenge of technical expertise. There is currently a gap between the technical expertise needed for digital transformations to take place and the number of workers who are choosing other outlets of employment. In Suriname, the oil and gas boom is luring technical workers away by offers of higher salaries, whereas the country is lacking people to manage their water supply system. Water companies are already partnering with outside contractors and receiving training from investment organizations, but to effect real change, the region must invest in developing its human capital, including providing attractive salaries, training, and education opportunities to water sector professionals.

Financial investment institutions have a significant role to play in fostering the ability of water companies to deploy large-scale projects in the region. Funding for large capital expenditure projects is typically controlled by the government but operational expenditures are covered by fees. This provides incentives for financial institutions to invest in the region as there is potential for returns. Water companies have been able to implement smaller projects gradually, but this has led to disjointed technologies that do not always connect with each other.

The issue of data management in the Caribbean has been highlighted by the multiple types of technologies that have been introduced over the years. In Barbados, the utility is working on digitizing as many steps as possible for its internal and external communications but is unable to visualize any data due to technological restrictions. However, outside consultants could provide a framework for systems to prevent execution from stalling out. Ensuring the availability, accuracy, and security of data is a critical challenge that must be overcome to successfully implement digital solutions in the Caribbean water sector.

Caribbean water utilities also face the challenge of needing a supportive policy and regulatory environment that encourages and facilitates the adoption of digital technologies. Many countries have different approaches to water management and financing from a government perspective. Some have public water and wastewater companies while others have delegated that responsibility to the private sector. The region must engage with policymakers and regulators to establish a supportive framework to adopt and implement digital technologies in the water sector. There are multiple options that could include offering tax incentives for water utilities that invest in digital technologies and establishing guidelines for data privacy and security. Ultimately, without reliable policymaking and a consistent approach, digital transformation will be hindered by the policy frameworks of the region.

Digital Investment Approaches

A common theme each utility described is a lack of funding for digital transformation projects. As part of this study, the authors wanted to provide creative investment approaches to support digital transformation. Our research focused on conceptual ideas that are being applied elsewhere and are transferable, or rethought ways to leverage existing investment structures.

Development Bank Venture Funds

Most projects being funded in the region are by the Inter-American Development Bank or World Bank using funds focused on the assets being upgraded or replaced (e.g., pipes). One way to scale digital transformation in the region would be to create bank-backed venture funds. Currently, the World Bank supports venture funds, but has not directly created its own venture funds.

These venture funds would be dual-purpose. First, they could create pre-asset digital pilot projects that would encourage digital-first thinking. Second, they could support higher-risk, smaller projects offering higher returns. For instance, instead of creating a project to replace a portion of aging drinking water pipes in a country, the venture fund could first fund a project for a prediction model that uses multiple asset replacement prediction models to leverage past pipe failures to identify which model most accurately determines replacement based on existing data.

Professor Enrique Cabrera noted that the idea could reduce overall project costs for pipe replacement because the model would better target specific areas of pipes based on digital models. The benefit to the banks would be a more efficient capital outlay (meaning additional projects could be funded) while educating the utilities on digital transformation opportunities.

Private Microproject Funds

There are a number of microloan and microgrant nonprofits and companies throughout Latin America, but engaging private technology companies to create funds to pilot digital transformation projects is an opportunity. The benefits of this approach are to engage companies looking to make a larger impact and efficiently test out new digital technologies that have worked in other regions while reducing costs at the Caribbean utilities.

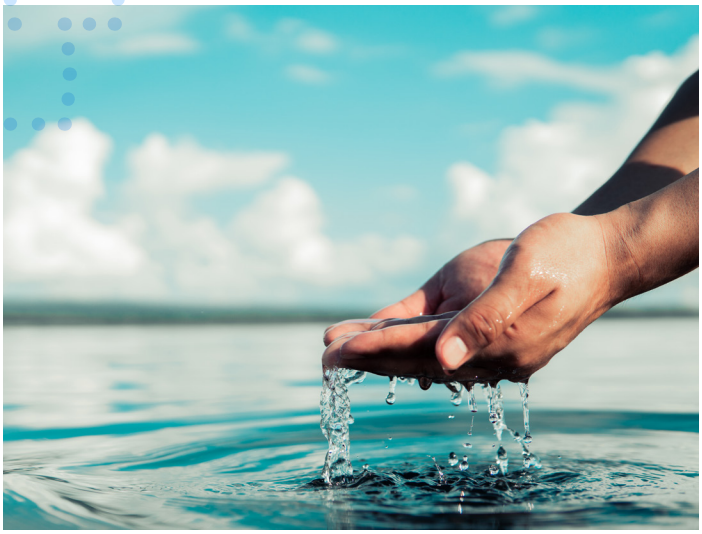
An example of this is Piers Clark, founder of Isle Technologies, who created a fund (Xylem Inc.) to support large-scale pilots (Business Wire, 2022). Xylem, in partnership with water consultancy Isle Utilities, is taking a new approach to funding and scaling breakthrough water technologies, called the "Trial Reservoir." It provides water technology innovators access to capital for pilot projects, with an initial focus on technologies that reduce the carbon emissions of water systems.

Public Private Pilot Projects

The third investment idea is similar to the second idea, but directly engages private entities in free or discounted pilot projects to test their digital technology. Based on the research in this study, several utilities noted that digital technologies available in other regions (e.g., the U.S.) are not being offered or available to them. If the Caribbean utilities could attract public-private partnerships in direct pilot projects to prove the value of the partnership in the region, it could encourage startups and digital innovators to invest in the region while increasing the utilities' knowledge and ability to learn and do more (thus closing the Knowing-Doing gap) with startups.

An example of this could be water- or sanitation-as-a-service, known as Water-as-a-Service (WaaS). Private companies could identify small-scale assets or projects where they could own those assets and determine if higher service levels at similar or lower costs are possible. This would prove that some of these innovative approaches to service delivery in partnership with digital technologies would fit in the region.

Conclusion



Caribbean water utilities are facing a myriad of challenges that are political, physical, technical, or fiscal, among others. Digital transformation can address some of these issues, but these technologies must be deployed with a clear strategy and commitment. Ultimately, utilities have an opportunity to create a digital organization that is connected across the value chain to reduce water security risks, improve customer experience, and extend operational resources.

The transition from paper and pencil to a real-time data-enabled organization is a journey in terms of organization, culture, skills, and level of overall collaboration. It is a process of continuous improvement that requires organizational leadership, strategy, and day-to-day implementation.

Water utilities across the globe have begun their journey to implement digital solutions. From our research, the Caribbean utilities are no exception. However, the Caribbean region offers unique challenges from other regions. While none of the utilities in the Caribbean would currently be classified either as true digital "leaders," they are all at different stages, working at either a basic or operational level of the digital transformation scale. It is important for these utilities to understand where they are on that journey, identify where they want to go, and build a roadmap to get there.

The COVID-19 pandemic has been a catalyst that accelerated the deployment and rapid adoption of new tools and digital platforms. It has enabled business continuity and remote work in the absence of employees in lockdown or quarantine,

as well as maintained interactions with clients who were no longer able to visit offices.

There is a lot to learn from leaders in the space as well as from peers trying to transform their organizations. Utilities can leverage existing innovations around the world, including those found in how other organizations structure their culture and teams, as well as what they design and implement and why.

Finally, because digital transformation is more than simply technology, adoption is key. Technology is only useful if there are users. Testing is important before deploying any technology, to ensure each segment of the business and customer base are engaged throughout the process. Test early and often. By doing this, Caribbean utilities can transition to digital, connected, and data-driven organizations.

References

Ashwinie, H. (2022). Interview by J. Sheehan and T. Cox, 16 December.

Barnett, M. (2022). Interview by J. Sheehan and T. Cox, 9 November.

Bianchi, T. (2023, April 17). Latin America & Caribbean: online penetration by country 2023. Statista. Available at https://www.statista.com/statistics/726145/latin-america-internet-penetration-countries/.

Business Wire. (2022). Xylem and Isle Utilities Partner to Help Water Utilities Pilot and Scale Innovative Water Technology. Businesswire.com. Available at https://www.businesswire.com/news/home/20220111005132/en/Xylem-and-Isle-Utilities-Partner-to-Help-Water-Utilities-Pilot-and-Scale-Innovative-Water-Technology.

Clovine, L. (2023). Interview by J. Sheehan and T. Cox, 18 January.

Cybersecurity and Infrastructure Security Agency (CISA). (2021). Ongoing cyber threats to U.S. water and wastewater systems. Available at https://www.cisa.gov/news-events/cybersecurity-advisories/aa21-287a.

Dropcountr. n.d. Available at https://www.dropcountr.com/ (accessed March 17, 2023).

Féry, G. (2022). The digital journey of water and sanitation utilities in Latin America and the Caribbean: what is at stake and how to begin. Available at http://dx.doi.org/10.18235/0004562.

FIDO Tech. (2022). DC Water detects unseen water leak on transmission main using FIDO AI. Available https://fido.tech/case-studies/dc-water-detects-unseen-water-leak-on-transmission-main-using-fido-ai/#:~:text=What%20we%20achieved%3A,of%2024%2Dinch%20transmission%20main.

Garcia, O.G., H. Mooney, D. Rosenblatt, & M.A. Zegarra. (2021, May 25). Imagining a post-COVID tourism recovery. In: Caribbean Development Trends. Available at https://blogs.iadb.org/caribbean-dev-trends/en/imagining-a-post-covid-tourism-recovery/.

Grievson, O., T. Holloway, & B. Johnson. (2022). *A strategic digital transformation for the water industry* (O. Grievson, T. Holloway, & B. Johnson, Eds.). IWA Publishing, London, UK.

Kane, G.C., A. Nguyen Phillips, J.R. Copulsky, & G.R. Andrus. (2022). *The technology fallacy: How people are the real key to digital transformation*. The MIT Press, Cambridge, MA.

Kosven, E. (2009). Lean and Six Sigma principles applied in a water utility. In: International Society of Six Sigma Professionals (ISSSP). Available at https://isssp.org/lean-and-six-sigma-principles-applied-in-a-water-utility/.

Martins, J. (2014). *Management of Change in Water Companies*. IWA Publishing, London, UK.

Minatta, A., & M. Basani. (2020). Innovation in water, sanitation, and solid waste: assessment, perspectives, and opportunities for Latin America and the Caribbean (IDB-TN-1974). Inter-American Development Bank. Washington, DC: IDB. Available at http://dx.doi.org/10.18235/0002514.

Minatta, A., & M. Basani. (2021). Innovación en el sector de agua, saneamiento y residuos sólidos en América Latina y el Caribe: cómo catalizar la cultura de innovación empresarial. Nota técnica BID-TN-2344. Washington, DC: BID. Available at http://dx.doi.org/10.18235/0003793.

Minatta, A., & M. Basani. (2022). Ecosistema de innovación en el sector agua, saneamiento y residuos sólidos de América Latina y el Caribe: relevamiento y modelo de vinculación. (IDB-TN-2565). Washington, DC: BID. Available at https://www.smart-energy.com/regional-news/north-america/diehl-metering-jamaica-smart-meters/.

Nhede, N. (2018, May 16). Jamaica NWC takes smart metering to the next level. Smart-energy.com. Available at https://www.smart-energy.com/magazine-article/diehl-metering-jamaica-smart-meters/.

Cabrera, E. (2023). Interview by J. Sheehan and T. Cox, 9 February.

Rong, K. (2022). Research agenda for the digital economy. *Journal of Digital Economy*, 1(1), 20–31. Available at https://www.sciencedirect.com/science/article/pii/S277306702200005X?via%3Dihub.

Sarni, W., C. White, R. Webb, K. Cross, & R. Glotzbach, (2019, June 11). *Digital Water: Industry leaders chart the transformation journey*. Report, International Water Association. Available at https://iwa-network.org/publications/digital-water/.

Software Testing Help. (2023). Best Knowledge Management Systems: 2023. Available at https://www.softwaretestinghelp.com/knowledge-management-system/.

Singh, N., & M. Arnott. (2022). Water Smart Meters: 700 million connections by 2030 to solve issues related to water scarcity and loss. Available at https://transformainsights.com/research/reports/water-smart-meters.

Smart Water Networks (SWAN) Forum. (2021). Digital twin work group. Developing a common strategy for digital twin adoption. Available at https://swan-forum.com/digital-twin-work-group/ (accessed December 27).

Tropsa, S. (2020, August 27). Applying advanced analytics in the water & wastewater sector. Wastewater Digest. Available at https://www.wwdmag.com/smart-water/article/10939085/applying-advanced-analytics-in-the-water-wastewater-sector.

United Nations Department of Economic and Social Affairs. (2023). Goal 6: Ensure availability and sustainable management of water and sanitation for all. Available at https://sdgs.un.org/goals/goal6.

United States Environmental Protection Agency. (2021, September). Water Utilities as Anchor Institutions. Epa.gov. Available at https://www.epa.gov/system/files/documents/2021-09/anchor-institutions_report.pdf.

VertexOne. n.d. Available at https://www.vertexone.net/about (accessed September 30, 2023).

Water.org. Financing SDG 6. Available at https://water.org/financingsdg6/ (accessed March 12, 2023).

Williams, N., & K. Thomas. (2012). Sustainable water resources in the Caribbean: prospects and challenges. *Water Resources IMPACT,* 14(5), 19–21. Available at http://www.jstor.org/stable/wateresoimpa.14.5.0019.

World Bank. (2022). Water resources management. Available at https://www.worldbank.org/en/topic/waterresourcesmanagement (accessed March 12, 2023).

World Economic Forum. (2018). Harnessing the Fourth Industrial Revolution for Water. Available at https://www3.weforum.org/docs/WEF_WR129_Harnessing_4IR_Water_Online.pdf.

Appendix

Decision-makers in the Caribbean WSS space

Organization	Name
Barbados Water Authority	Leslie Clovine
Belize Water Services Ltd	Alvan Haynes
Guyana Water Inc.	Christopher Chan
Jamaican National Water Commission	Mark Barnett
Suriname Water Company	Hemai Ashwinie

QUESTIONNAIRE

SECTION 1

This section includes a brief assessment of the current state of the water and sanitation sector in the Caribbean (considering the potential for digitalization)

- Can you provide us with an overview of where your organization and country stand regarding digitalization?
- How does your drinking water system work?
- Do you digitally bill customers? (Yes or No)
- Do you digitally notify customers? (Yes or No)
- Do you have ways to communicate with customers digitally? (Yes or No)
- Do you digitally meter customers? (Yes or No)
- Do you digitally track pre-treatment, post-treatment, and water levels? (Yes or No)
- Do you have a digital way to identify water pipes? (Yes or No)
- What other digital technologies have you added to your drinking water system?
- How does your sanitation system work?
- Do you digitally bill customers? (Yes or No)
- Do you digital notify customers? (Yes or No)
- Do you have ways to communicate with customers digitally? (Yes or No)
- Do you have a digital method for tracking hydrological components? (e.g., watershed, biosolids, effluents, surface and groundwater quality, precipitation, evapotranspiration). If Yes, how?
- What other digital technologies have you added to your sanitation system?
- How is SCADA implemented across the system?
- What has been your digital security approach so far?
- Do you use third-party contractors or manage internally?
- Do you use on-premise or cloud servers?
- Do you have backups? If Yes, where are they stored?
- Does your organization have a system or protocol for establishing priorities in terms of initiatives and projects, and which makes decisions regarding innovative proposals?
- Within the organization is there an individual or unit that takes primary responsibility for making those decisions?
- Are there incentives for individual or group creativity when looking at solving problems?

SECTION 2

This section includes a detailed analysis of the current status in terms of digitalization, digital utilities, transformation projects, and smart infrastructure technology in the Caribbean, including an assessment of where "real" demand for digitalization is (which products and services are included):

- What areas display a significant need for further digitalization?
- If budget were no issue, what areas would you focus on?
- What are your biggest risks today that digital solutions could fix?
- Where is the "real" need, and is digitalization really the answer?
- Where is digitalization NOT the right answer? Why?
- What are your biggest risks in implementing digital approaches to your processes?
- What are the main barriers to digitalization right now?
- How does culture affect these barriers?
- How does budget constrain your approach to digitalization?
- How have you tried to add an innovation culture into the organization? What challenges did you face?
- What organizational or operational factors impact the implementation of new workflows or technologies (i.e., accessibility of technology, limited resources for training, etc.)?

SECTION 3

This section includes detailed research on market and technology trends (preferably in the Latin American region and with a specific focus on the Caribbean) as well as interviews with key industry leaders addressing market technology trends, challenges, and opportunities.

Market Technology Trends

- What provides the greatest influence for Latin American/ Caribbean countries to introduce technology solutions?
- Market Technology Challenges
- Are there existing challenges that need to be addressed before implementing new technology (i.e., infrastructure, telecommunications, etc.)?

Market Technology Challenges

- Are there existing challenges that need to be addressed be fore implementing new technology (i.e., infrastructure, telecommunications, etc.)?

Market Technology Opportunities

- If water utilities are willing and able to introduce new digital technologies, what solutions solve the biggest challenges?