REGIONAL PROCESS
OF THE AMERICAS

WORLD WATER FORUM 2024

THE CARIBBEAN
SUB-REGIONAL REPORT

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IDB

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WORLD WATER FORUM **2024**

THE CARIBBEAN SUB-REGIONAL REPORT

10TH WORLD WATER FORUM

Water for shared prosperity

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ACRONYMS

Acronym	Meaning
ACS	Association of Caribbean States
AI	Artificial Intelligence
APUA	Antigua Public Utilities Authority
BOT	British Overseas Territory
BVI	British Virgin Islands
BWA	Barbados Water Authority
CAF	Development Bank of Latin America
CARDI	Caribbean Agricultural Research and Development Institute
CariCOF	Caribbean Climate Outlook Forum
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum of African, Caribbean, and Pacific States
CARPHA	Caribbean Public Health Agency
CAWASA	Caribbean Water and Sewerage Association Ltd.
CCCCC	Caribbean Community Climate Change Centre
CCRIF-SPC	Caribbean Catastrophe Insurance Facility-Segregated Portfolio Company
CDB	Caribbean Development Bank
CDEMA	Caribbean Disaster Emergency Management Agency
CDRU	Caribbean Disaster Relief Unit
CEC	Contaminants of Emerging Concern
CHTA	Caribbean Hotel and Tourism Association
CIMH	Caribbean Institute for Meteorology and Hydrology
COP	Conference of Parties
COTED	Council for Trade and Economic Development
CRED	Centre for Research on the Epidemiology of Disasters
CReW	Caribbean Regional Fund for Wastewater Management
CROSQ	Caribbean Regional Organisation for Standards and Quality
CSGM	Climate Studies Group Mona

Acronym	Meaning
CTO	Caribbean Tourism Organization
CUBiC	Caribbean Uniform Building Code
CVQ	Caribbean Vocational Qualification
CWSA	Central Water Services Authority
CWUIC	Caribbean Water Utilities Insurance Collective
CWWA	Caribbean Water and Wastewater Association
DOE	Department of Environment
DOWASCO	Dominica Water and Sewage Corporation
EBITDA	Earnings Before Interest, Taxes, Deductions and Amortization
ECLAC	Economic Commission for Latin America and the Caribbean
EFR	Environmental Flow Requirements
EIB	European Investment Bank
EU	European Union
FAO	Food and Agricultural Organization
FTC	Fair Trading Commission
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GESI	Gender and Social Inclusion
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Development Cooperation)
GLAAS	Global Analysis and Assessment of Sanitation and Drinking Water
GoD	Government of Dominica
GoG	Government of Grenada
GoJ	Government of Jamaica
GWI	Guyana Water Inc
GWP-C	Global Water Partnership - Caribbean
HADR	Humanitarian Assistance and Disaster Response
HLF	High Level Forum
IAEA	International Atomic Energy Authority
IBC	International Building Code

Acronym	Meaning
IBT	Increasing Block Tariff
IDB	Inter-American Development Bank
IDF	Intensity-Duration-Frequency
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
INDRHI	National Institute of Hydrological Resources
INRH	National Water Resources Institute
IPCC	Inter-Governmental Panel on Climate Change
IWCAM	Integrating Watershed and Coastal Area Management
IWEco	Integrating Water, Land and Ecosystems Management
IWRM	Integrated Water Resources Management
IWWM	Integrated Water and Wastewater Management
JICA	Japan International Cooperation Agency
KoN	Kingdom of the Netherlands
LAC	Latin America and the Caribbean
LBS	Land Based Sources of Marine Pollution
LECZ	Low Elevation Coastal Zones
LINK	Local and Indigenous Knowledge
ML	Machine Learning
Mm3	Million cubic metres
MOC	Massive Online Course
MPU	Ministry of Public Utilities (Trinidad and Tobago)
NAWASA	National Water and Sewage Authority
NRW	Non-Revenue Water
OAS	Organization of American States
OECS	Organisation of Eastern Caribbean States
PAHO	Pan American Health Organization
PES	Payment for Environmental Services
PUC	Public Utilities Commission
R&D	Research and Development

Acronym	Meaning
RBC	Royal Bank of Canada
RCM	Regional Climate Modelling
RCP	Representative Concentration Pathway
RSAP	Regional Strategic Action Plan
RSS	Regional Security System
RWH	Rainwater Harvesting
SASAP	Sectoral Adaptation Strategy and Action Plan for the Water Sector
SDG	Sustainable Development Goals
SIDS	Small Island Developing States
SST	Sea Surface Temperature
UCL	United Kingdom Agency for International Development
UKAID	United Kingdom Agency for International Development
UNEP-CEP	United Nations Environment Programme-Caribbean Environment Program
UNICEF	United Nations Children's Fund
US$	United States Dollar
USAID	United States Agency for International Development
USVI	US Virgin Islands
UWI	University of the West Indies
WASA	Water and Sewage Authority
WASCO	Water and Sewage Corporation
WASH	Water Sanitation and Hygiene
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WIMS	Water Information Management System
WWT	Wastewater Treatment

EXECUTIVE SUMMARY

The Caribbean Subregional Report presents a diagnosis centred around the themes and topics of the World Water Forum. It identifies the challenges and obstacles facing the Caribbean and showcases experiences that are taking place to address these challenges. The development of the Caribbean's Subregional Report has been the outcome of extensive stakeholder engagement. It draws on a broad array of material, reports, journal articles and professional experience and expertise. The Report represents a comprehensive consensus that reflects the present state of the Caribbean Water Sector, its challenges, and the responses that are contributing to a water secure Caribbean.

The Caribbean is a heterogeneous Region of 32 countries and territories and is commonly considered to consist of the island states, the South American coastal states of Guyana and Suriname, and Belize in Central America. The inhabitants of the Region are among the most globally diverse, with a range of native languages, cultures, ethnicities, religions, and have varied political and legal systems reflecting their historical legacy and development as dependencies and independent nations. The Spanish speaking countries of the Region, have closer affinities to Central America in contrast to the predominantly English-speaking Caribbean. Furthermore, there are islands that are not sovereign states but have varying degrees of autonomy over their internal affairs. These realities pose developmental challenges for the Region and the governance of its resources, including water resources. Non-sovereign countries are on the periphery politically, economically and financially of the states of which they are part and lack the same degree of autonomy that they would otherwise enjoy. This affects not only their own internal agency but also reciprocal relationships with and between fellow Caribbean neighbours. Legal, linguistic and cultural differences pose additional hurdles to inter-Caribbean collaboration.

Many Caribbean countries consist of small island states, making them more susceptible to natural and climate change induced hazards. They have limited land area, and a significant portion of their population and infrastructure is concentrated along coastlines, increasing exposure to coastal hazards and increasing social vulnerability. On average over time, countries in the Caribbean suffer yearly losses due to storm damages equivalent to 17% of their GDP. Since 2010 the countries have shown persistently weak economic growth, averaging only 0.8%.

ECONOMY AND POPULATION

The smaller Caribbean islands are heavily dependent on tourism as their main economic sector. Extreme weather events, exacerbated by climate change and climate variability impacts the tourism sector, damaging facilities, causing disruption, and affecting livelihoods dependent on the sector. The reliance on imported goods makes countries vulnerable not just to disruptions to supply chains but also to increases in import and manufacturing costs of vital goods. The open nature of Caribbean economies renders them

vulnerable to external shocks. The limited economic base together with the continued and cumulative economic impacts of natural disasters have contributed to limiting the financial and economic capacity of Caribbean Small Island Developing States (SIDS) to implement adaptive measures to address the impacts of climate change and climate variability.

The population of the Region is nearly 46.5 million people. Three countries (Cuba, Dominican Republic and Haiti) account for nearly 75% of the total. Although there is a continuing overall trend of population increase there is a regional disparity. The populations of Belize, Dominican Republic, Guyana, Haiti and Suriname are projected to continue growing into the 2070's, while the population of the smaller, insular countries are projected to start to decline from around 2030. Dominica and Saint Vincent and the Grenadines have already experienced declines in population. A declining workforce has consequences for government revenues and expenditures, which if not addressed will pose additional challenges to investments in infrastructure and services such as water supply and wastewater management.

CLIMATE AND CLIMATE CHANGE

The Caribbean is considered to be "ground zero" in the global climate emergency given the exposed location, relative isolation, and small size of many of the territories. The range of climate threats include more pronounced sea-level rise, increased frequency of extreme weather events, such as hurricanes and tropical storms, increased rainfall and flooding, dangerous high temperatures, warmer sea surface temperatures, coastal erosion and saltwater intrusion, and longer dry seasons and shorter wet seasons. Between 2000 and 2019, The Bahamas and Haiti ranked among the top ten countries and territories that were most affected by extreme weather events globally.

Since 1900 there has been no significant observed baseline trend in rainfall, but the number of consecutive dry days is increasing, as well as the amount of rainfall during extreme rainfall events. By the 2050s the region is up to 6% drier, up to 17% drier by 2100 with between 25% and 35% less rainfall by the end of the century. There has been an increasing trend in very warm days and nights for the Caribbean as a whole and the trend will continue with increases of 0.86°C to 1.50°C by the 2050s. The past trend in warming of sea surface temperatures (SST) is expected to continue in the future, with increases of 1.76 ± 0.39°C per century in the wider Caribbean. The projected range of increases in sea levels is 0.17-0.38 m for 2046 – 2065 and to reach or exceed 1m across the Caribbean by the end of the century. There is expected to be a shift towards more frequent category 4 and 5 hurricanes and a 20-30% increase in associated rainfall intensities. The effects of the increase are expected to be to impact access to and cost of insurance, contribute to outward migration, reduce tourism numbers, and divert government funding away from social and developmental programmes towards recovery costs.

WATER RESOURCES AVAILABILITY

Information on the state of water resources in the Caribbean is variable (Farrell, Nurse, & Moseley, 2007). All countries have monitoring networks that measure either groundwater levels or surface water flows. Jamaica is one of the few countries with a record of hydrological monitoring going back to the 1950s, Trinidad and Tobago started just before 1970, and Saint Lucia in the 1980s (Fletcher-Paul, Madramootoo, & Thomas, 2007). Water availability, the total renewable volume per inhabitant per year, vary from a high of 344,542 m3 for Guyana to a low of 278 m3 for Barbados. Withdrawals as a percentage of the total renewable resource vary between a low of 1.3% for Belize to a high of 87.5% for Barbados. On these measures, Barbados and Saint Kitts and Nevis can be classified as both water scarce and being highly water stressed. Most countries can be

classified as having low water stress -i.e. utilising less than 25% of their total renewable water resources and having more than 1000 m3 of total renewable water resources per person per year.

Water resources and availability are being influenced by anthropogenic changes such as the conversion of undeveloped land areas through deforestation, urbanisation, urban sprawl and unplanned and informal settlements, changing rainfall runoff characteristics and drainage patterns. Studies have indicated that for at least one catchment in Belize the combination of land conversion and climate change could reduce runoff volumes by 51%. The Bahamas, Barbados and Jamaica rely heavily on groundwater resources as their source of water supplies but over abstraction has resulted in saline intrusion.

Climate change impacts are also anticipated to negatively affect groundwater aquifer yields. For Barbados there is some evidence that climate change could reduce aquifer recharge by up to 50% under the worst climate scenario. In other countries reduced recharge will result in reduce dry season base flows in streams and rivers. Water quality issues can impact water resource availability. In Belize City, sea level rise and lower base flows would lead to the saltwater interface migrating upstream and affecting the intake of its water treatment plant.

WATER SUPPLY AND MANAGEMENT

With few exceptions, responsibility for the provision of water and wastewater services is with the government though the ownership models differ. In some countries water services are provided by a government department, in others by a government authority or statutory corporation established by an Act of Parliament. In other cases, water services are outsourced to private entities. Few countries have a hybrid model of service provision with public and private water service providers. It is only in the larger countries such as Belize, Dominican Republic, Guyana, and Jamaica that there are separate arrangements for urban and rural water services.

Most Caribbean water utilities have financial and operational challenges. Their ability to cover their operating and maintenance costs is constrained by tariffs being set at levels that do not allow them to cover these costs. This is further exacerbated by the inability to pass on fluctuations in the cost of energy. However, in countries where seawater desalination is the source of water supply e.g. The Bahamas, Cayman Islands, Turks and Caicos Islands, water tariffs are set at levels which cover operational costs. In most cases capital expenditures are financed through the central government or by loans that have government guarantees. For all countries with the possible exception now of Guyana, the ability to fund capital works is constrained by government indebtedness, and a reluctance to raise tariffs and pass on the operating and maintenance cost of providing water services to customers.

WATER DEMAND

Reliable data on water demand and consumption that is easily accessible is scarce across all countries. Part of the reason for this is that the primary purpose of measuring water consumption is for billing and not to inform management decisions. Analysis of trends in demand and consumption tends to be undertaken as either part of academic research or on a project-by-project basis. Countries which utilise surface water resources often experience demand being constrained by supply limitations during the dry season. This is less of an issue with respect to those countries utilising groundwater though prolonged dry periods often cause supply issues. Problems with meeting water demand are exacerbated by the generally high levels of Non-Revenue Water (NRW) losses. Reported levels of NRW ranged from a high of 73% of production to a low of 20%.

CIRCULAR ECONOMY

At present very little wastewater is collected and still less treated - hence the volume of water that could be available for reuse is limited. To increase the volume would require significant investment in collection and treatment systems; an estimate by the then Caribbean Environmental Health Institute (CEHI) gave a capital investment figure for the Caribbean of US$21 billion (CEHI, n.d.). Barbados, Jamaica and Trinidad and Tobago have introduced water quality standards for wastewater reuse as a first step to encouraging reuse for agriculture and landscaping. Attention has been turning to the role of Rainwater Harvesting (RWH) in increasing water resilience particularly during disaster events. In Jamaica, the government is supporting RWH through a rural water resilience programme, Barbados is revising regulations and plumbing codes to support their utilisation. Antigua and Barbuda has long required the installation of RWH tanks for domestic purposes. Grenada has also included the support and promotion of RWH in its Green Climate Fund G-CREWS project.

WATER FOR FOOD

Moving agriculture beyond subsistence and scaling up production has proved to be a difficult task for the smaller Caribbean States. Areas that are under irrigation are generally flood or sprinkler irrigated, for which the irrigation efficiency is less than 40%. Flood irrigation is the predominant practice in Guyana and Suriname whilst in Jamaica up to 20% of irrigated areas is under sprinkler irrigation. In countries where the cost of water for agriculture is considered high, drip irrigation is often practiced. Tariffs for agricultural water are low and vary greatly across the region; for Antigua and Barbados the rate is US$1.7/m3 and US$1.8/m3 whilst in Jamaica and Trinidad it is US$0.02/m3 and US$0.15/m3 respectively. For the Dominican Republic and Guyana, the charge is US$4.75-24/ha and US$1.11/hectare/month respectively.

SANITATION

Access to improved sanitation is generally high across the Region, except for Haiti, with percentage access in the high 80's going up to 100% in some instances. However, 52% of households in the insular Caribbean lack sewer connections and only 17% have acceptable collection and treatment systems and less than 2% of urban sewage is treated before disposal. Few countries have centralised or decentralised sewerage services by a wastewater service provider. Dominican Republic, Trinidad and Tobago and Jamaica have the highest coverage rates of 49%, 30% and 22% respectively, most Caribbean countries have access levels of 5% or less.

It has been estimated that between 70% and 80% of domestic wastewater is discharged into the environment partially treated or untreated. The Land Based Sources of Marine Pollution Protocol came into force in 2010 committed governments to making major improvements in wastewater management. Countries have wastewater discharge standards as part of their environmental regulations; however, application and enforcement are often an issue. Progress is being made in providing more wastewater services in municipal areas. Guyana is to invest some US$40 million to provide additional wastewater services in the capital Georgetown. In Jamaica, the Soapberry Wastewater Treatment Plant operated through a public-private partnership is looking at the feasibility of making treated water from the plant available for irrigation purposes.

HUMAN DEMANDS

Over 95% of the population of the Caribbean is using improved drinking water. However, analysis of trends in consumption or of non-domestic demand are seldom undertaken. The levels of per person consumption varies widely across the Caribbean, between 420 litres per person per day in Trinidad and Tobago, 280 litres per person per day in Belize,

200 in Barbados, 172 in Jamaica, 165 litres per person per day in Grenada, and between 50-100 litres per person per day for persons reliant on harvested. These are averaged national level figures and do not reflect differences across income and residential groups or water supply systems nor variations across seasons. The Covid-19 pandemic reduced hotel water consumption and resulted in other changes in consumption patterns. In Barbados, there was 10% increase in consumption accompanied by a 60% decrease in hotel consumption and a 20% decrease in commercial consumption.

Limitations on supply has been an issue in the Region. Barbados is utilizing about 87.5% of its available water resources, Saint Lucia has a water supply deficit of approximately 35%, and Nevis of 40%, Trinidad has had a water supply deficit since 2000, Jamaica is projected to experience deficits in supplies to areas of important economic activity, in Dominica, Grenada and Saint Vincent and the Grenadines demand exceeds supply during the dry season due to reduction in stream flows. Ageing water infrastructure and low pipeline replacement rates are thought likely to contribute to challenges in meeting human demand for water in the future.

PREVENTION AND MANAGEMENT OF HAZARDS

The Caribbean Disaster Emergency Management Agency (CDEMA) covers 19 Caribbean countries, and its primary responsibility is the coordination of emergency response and relief. CDEMA offers training and capacity building to participating states. It also has a risk information database of disaster across the Region. Other projects it is actively engaged with include the Safe Schools programme and the development and use of early warning systems in collaboration with the UNDP, Red Cross and Red Crescent Societies and the European Union. The Caribbean Institute for Meteorology and Hydrology shares information from its early warning network, produces long range climate forecasts and sector specific climate and provides climate services for the Caribbean. The Regional Security System was created out of a need for a collective response to security threats.

The Caribbean has developed the Caribbean Catastrophic Risk Insurance Facility (CCRIF), a parametric, multi-country multi-hazard risk pool facility that offers governments low-cost premiums to insure against specific natural disasters. The facility provides governments with liquidity in the immediate aftermath of a disaster when funding is critical. Typically, payments are made within 10 days.

FLOODS AND DROUGHT

The nature of flood hazards varies across the Caribbean. Guyana and Suriname are more prone to slow onset riverine flooding that can be widespread and last several weeks. The larger islands experience a mixture of flash flooding associated with tropical cyclones, and general and riverine flooding. Those islands characterised by relatively small land areas and steep topography are more prone to flash flooding associated with heavy rainfall and tropic cyclone activity, though inundation times are relatively short. Belize is prone to flash flooding in the south while the centre and north experience riverine flooding and longer periods of inundation. The Bahamas are particularly prone to storm surges and coastal flooding associated with hurricane activity.

In 2011 it was observed that in most Caribbean states rainfall intensity – duration – frequency (IDF) curves are not readily available and there were no countries with nationally consistent flood hazard maps. Since then, the Caribbean Development Bank is supporting a project with CIMH to update IDF curves for its Caribbean members.

Droughts have a more regional character than flooding, affecting several territories. The Caribbean

has over the last few decades experienced several drought events, with many seemingly linked to years with El Niño events. The 2013-2016 drought was the most severe experienced by the Caribbean, as virtually the entire Region experienced a Pan-Caribbean drought. Rainfall records show that for many areas in the Greater Antilles, even during the wet season, dry spells are frequent and therefore pose a high risk to agriculture and ecosystems. Drought early warning is one of the evolving climate risk management success stories in the Caribbean, particulary since the drought of 2010.

REDUCING VULNERABILITY, INCREASING RESILIENCE

Key to increasing resilience is financial and economic capacity, not just of governments but down to the level of individuals as well. There have been advances made in providing financial resources through risk pooling mechanisms such as CCRIF and the expansion of its portfolio to cover the water sector. Through CCRIF-SPC support has also been provided to support the installation of monitoring devices that feed into early warning systems. Most countries have passed laws related to the preparedness and management in the event of disasters, so that there is an extensive body of law across the Caribbean that addresses disaster risk management.

All countries have some form of planning control regulations, and requirements for environmental impact assessments. However, how well they are regulated and enforced does vary between countries. Accompanying planning controls are building codes which are also intended to ensure the safety of occupants. Due to the Region's high exposure to climate events and historic disaster losses, many countries in the Region already have building codes in place that incorporate measures to mitigate the impact of natural disasters. Examples include: the Caribbean Uniform Building Code, the International Building Code and International Residential Code. Regionally, CDEMA and the Caribbean Regional Organisation for Standards and Quality developed a regional code of practice to inform the resilient construction of houses.

Water utilities are taking measures to ensure that there is sufficient reservoir storage in the event of supply interruptions, the installation of back-up generators and renewable energy systems for pumping. In addition, they can call on support from other utilities and organisations such as Operators Without Borders. Challenges in locating and accessing spare parts needed for repair because of disasters are also being addressed through the H2Bid (Data Sharing Platform) supported by the IDB.

COOPERATION

Only seven countries have separate or independent dedicated water resource management agencies, and their capabilities vary greatly from very challenged. Notably absent are formal institutional arrangements for cooperation and collaboration between agencies responsible for water management and those responsible for land management. The preferred means of collaboration is the use of Memoranda of Understanding/Agreements, more usually the approach to coordination and collaboration is one of informal arrangements. However, the GEF-IWEco project is promoting the integration of water, land and ecosystems management and the implementation of a regional framework for IWRM. The Framework is to be presented to the Council for Trade and Economic Development- Environment (COTED-Environment) for formal endorsement.

HYDRO-DIPLOMACY

There are a few bi-lateral agreements that Caribbean countries have with respect to the limited number of transboundary water resources. Guyana has shared river basins with Brazil, Suriname and Venezuela and shared aquifers with Suriname. Suriname has shared aquifers with Guyana and river basins.

Dominican Republic and Haiti share both river basins and aquifers and Belize has shared river basins and aquifers with Guatemala and Mexico. There are in place cooperation mechanisms around the shared resources of Belize and Mexico, and between Dominican Republic and Haiti. The situation with respect to management and cooperation of transboundary resources is complicated by territorial disputes between Belize and Guatemala and between Guyana and Venezuela.

FINANCIAL RESOURCES

How much to charge for water services must consider a range of factors, some of which may compete against each other. Jamaica though has introduced K and X factors in billing: the K-factor goes towards capital works, the X-factor is a deduction for efficiency improvements. Most countries have adopted an Increasing Block Tariff (IBT) structure with the aim of ensuring affordability for those on low incomes and to encourage water use efficiency among customers with higher water consumption. Because of the low penetration of metering in Trinidad and Tobago, unlike most of the Caribbean countries, it has a tariff for residential customers based on property tax.

A study made a comparison across 14 Caribbean utilities of the cost of 15m3 of water per month for a residential consumer. The cost varied from US$60 per month in the Cayman Islands to a low of US$4.4 per month with the average being US$20 per month. Countries make a distinction between residential customers and others, charging higher rates for non-residential customers, except where agricultural water is recognised as a separate category of consumption. Each country has its own customer classification, reflecting differences across countries. Centralised sewer systems are the exception rather than the norm with the cost and ability to finance wastewater systems among the reasons for this situation. For example, a feasibility study to sewer the west coast of Barbados, which would serve some 50,000-70,000 people estimated the capital cost to be approximately US$300 million at 2008 prices. Where there are sewer connections, sewerage charges are levied through a variety of means: a flat rate, a charge based on a percentage of the water supply volume or determined by the number of water fixtures on a property.

A wide range of institutions provide various forms of financial services and support to governments in the Region, in addition to the expenditures by national governments and regional projects. Starting in 2021, the Caribbean has instituted an informal coordinating mechanism through the CWWA, the Regional Strategic Action Plan for Water–Implementation Monitoring Committee (RSAP-IMC). The RSAP lists investments in water related projects across the Region of nearly US$400 million plus a further US$458 million for the Climate Infrastructure Fund through the CDB. These amounts do not include country level funding.

SCALING UP AND INNOVATIVE FINANCING MECHANISMS

Given the scale of the investment challenges and the weak financial and economic position of many Caribbean countries new approaches to water financing are needed. In this respect the Caribbean has been something of a leader in exploring alternatives. As a Region the Caribbean has been at the forefront of pushing for greater support to counter the existential threat of the effects of climate change. These include:

- Disaster pause clauses
- The Bridgetown Initiative
- A Blue-Green Investment Corporation
- Debts Swaps
- Payment for environmental services
- Carbon Credits
- Renewable energy savings funding water services infrastructure
- Revolving Funds

• Caribbean Water Utilities Insurance Collective

The Caribbean Region's access to climate financing has been low because of the difficulties in developing bankable projects, limited capacity and expertise for project preparation, qualification requirements to access climate funds often being beyond the administrative capacity of the countries, and the fixed costs of project evaluation and appraisal. The challenges are even greater when it comes to private financing. The multifaceted nature of climate finance operations, which include finance, legal, environmental and budget aspects, requires the involvement of several departments across the public administration leading to costly and lengthy preparation periods.

Service providers are often hampered by an absence of medium to long term infrastructure planning. This is more prevalent where there is an absence of independent financial and economic oversight.

KNOWLEDGE AND INNOVATION

No water utility has a Research and Development programme and collaborations with academia are often limited. There are few incentives, regulatory or otherwise, universities are not geared to handle scientific research, and research funding opportunities are very limited. From time-to-time water utilities may partner with academia, facilitated where there is an academic institution present in the same territory. Universities in the Region find it challenging to undertake water sector related research. Water utilities do not have a culture of working with academia or recognise that there are benefits in doing so. Most research funding is from sources outside of the Region and consequently the focus tends to be on challenges facing the funding countries, offering few opportunities for Caribbean researchers to bring local research needs to the fore.

Much of the research that takes place is not carried out by groups of researchers but by individuals. The notable exception is the University of the West Indies Mona, Climate Modelling Group which has established a world class reputation for climate research. A further challenge is that it can be difficult to transition research into development and the rolling out/commercialisation of an innovation. Again, universities in the Region have very little experience of this and do not have the resources or infrastructure in place to nurture and support new start-ups.

TECHNOLOGIES

The adoption of new technology in the water sector of the Caribbean has been slow. Many water utilities have implemented Supervisory Control and Data Acquisition (SCADA) systems to control and monitor the state of their systems and have incorporated GIS technology. However, very few have installed smart meters to provide automated readings that are transmitted to utility companies for billing, leak detection, water conservation initiatives, and analysis for operational optimisation purposes. The limited uptake and practical difficulties around implementation mean that the opportunities to utilise advances in artificial intelligence (AI) and underlying techniques such as Machine Learning to inform better water resource and operational management are being delayed.

TRADITIONAL/INDIGENOUS KNOWLEDGE

Local and Indigenous Knowledge (LINK) is derived from the close relationship with nature, a relationship based on understanding the local environment and oral traditions that preserve detailed and rigorous knowledge of local water bodies sometimes dating back centuries. There are indigenous communities in Belize, Dominica, Guyana, Saint Vincent, and Suriname some of whom still maintain traditional practices, reliant on their knowledge of the environment.

Concerns expressed by LINK communities revolve around the effects of climate change on water

sources and on traditional livelihoods – subsistence agriculture and access to forest resources. Community elders are trying to navigate new realities but there appear to be tensions with younger community members. The gradual expansion of access of rural communities to improved water supplies particularly in Belize and Guyana has effected a change away from the use of traditional sources of water. That said there continues to be a tradition of using natural sources of water, such as springs, amongst communities that identify as Kalinago (Dominica), Garifuna (Belize and Saint Vincent) and Rastafarian for personal use and personal hygiene.

SCIENCE TO POLICY INTERFACE

The Caribbean has been fortunate to have developed two formal opportunities for the promotion of the science policy interface: the Caribbean Water and Wastewater Associations Annual Conference and associated High Level Forum for Ministers and the more recent Global Water Partnership-Caribbean's biennial Water Science Symposium. The HLF allows presentations to be made by water professionals on topics of interest, for ministers to be updated on the latest national and regional developments and to invite them to share their thoughts and development directions in their respective countries. It is a unique opportunity to share experiences and ideas for addressing water issues affecting the Region and individual countries. The Caribbean Science Symposium is a virtual symposium with a mix of paper presentation, opportunities for youth and water entrepreneurs to share and showcase their ideas, and for open discussion with water professionals, policy advisors and politicians.

EDUCATION AND TRAINING

There are nearly 100 institutions of higher learning across the English, Spanish, French and Dutch speaking Caribbean, public and private. So, accessing a place at a university to study for an undergraduate degree is usually not an issue. However, the number offering postgraduate degrees in water, wastewater or related subjects is limited. A few students opt to study outside of the Region, for example, attending IHE Delft Institute for Water Education. The cost of taking a postgraduate degree poses a significant barrier. Increasingly, prospective students are turning to on-line, distance education offerings. However, with a limited number of employment opportunities available in the sector, persons are either compelled to leave the Region or go into jobs with little connection to the studies. Those who attend institutions outside of the Region may well choose not to return. For those who can pursue a career in the water sector, the opportunities for continuing their professional training and development are limited. One of the reasons for this is that apart from professional registration there are few requirements for continuing education and training. Compounding this is that there are few regional accredited programme offerings.

The situation is appreciated and over the last few years efforts are being made to try to address the situation through efforts by funded projects, the GEF-CReW+ Academy, GWP-C, CWWA, CAWASA, and Caribbean WaterNet. The UWI and the Caribbean Institute for Meteorology and Hydrology also provide both vocational and academic training respectively. However, challenges remain such as the cost of enrolling, often having to live away from home while studying, and receiving recognition for professional development.

WATER INFORMATION SYSTEMS

There has been increasing interest in implementing water information management systems (WIMS) among most countries that do not have systems in place, and among those that do to upgrade their systems. This is reflected in the inclusion of WIMS in the GEF-IWEco project and the GEF-CReW+ project. Under the GEF-IWEco project two countries expressed an interest in developing WIMS. Under

the GEF-CReW+ project funding is being made available for WIMS for Grenada, Jamaica, Saint Lucia, Saint Vincent and the Grenadines and Trinidad and Tobago. However, there is not a consensus as to what data should be included in WIMS and how to integrate them with climate and other sources of water management-relevant data. There are practical challenges regarding data collection, monitoring, sharing and institutional arrangements which are being worked through.

In respect to public access to information, only 11 countries in the Caribbean have ratified the Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean: the Escazú Agreement. Its objective is to guarantee the rights of access to environmental information, public participation in the environmental decision-making process and access to justice in environmental matters.

THE CARIBBEAN SUB-REGIONAL REPORT

INTRODUCTION

The World Water Forum is the leading global event on water and sanitation, with the mission to "promote awareness, create political commitment, and drive action on critical water issues at all levels, to facilitate efficient conservation, protection, development, planning, management, and use of water in all its dimensions in an environmentally sustainable manner for the benefit of life on Earth." The 10th World Water Forum will occur in Bali, Indonesia, from May 18 to 24, 2024.

The contribution of the Americas region has been organized by the Inter-American Development Bank, which is acting as the regional coordinator for the Americas. The Regional Process has been informed by regional dialogue on matters relevant to this hemisphere. It has been broad and participatory, involving representatives of non-governmental organizations, businesses, users, academia, and youth from across the four subregions. The four subregions are: North America, Central America and Mexico, the Caribbean, and South America. Each of the four subregions have been tasked to prepare reports on water and sanitation in their respective regions. These will be consolidated into an America's report to the World Water Forum.

The Caribbean Subregional process is being coordinated by the Caribbean Development Bank. The Subregional document prepared as the contribution to the America's Report presents a diagnosis on the themes and topics of the Forum. It identifies the challenges and obstacles facing the Caribbean Subregion and showcases experiences that are taking place to address these challenges. The format and overall content focus of the reports was set by the World Water Forum and supplemented by an annotated table of contents. The table of contents was reviewed by regional stakeholders to ensure that the challenges peculiar to the Caribbean would be properly reflected in the Subregional Report.

In preparation for the development of the content of the report, two regional meetings were held. The first meeting was held in conjunction with the Caribbean Water and Wastewater Association (CWWA) Annual Conference in Georgetown, Guyana. This allowed detailed interaction with a broad range of water sector professionals drawn from across the Caribbean Region, identifying the key challenges facing the Region and highlighting national and regional responses. This was followed up by further engagement with national focal points,

regional organisations active in the water sector and other stakeholders to gather data on ongoing water sector activities, projects and programmes and to solicit case study material for inclusion. The gathering of information on the status of projects and programmes served a dual purpose. Not only was it to inform the report but also to be input for the Regional Monitoring Committee, chaired by the CWWA, of the Regional Strategic Action Plan for the Water Sector in the Caribbean to Develop Resilience to the Impacts of Climate Change (RSAP). It is of interest to note that the RSAP was an outcome of the Caribbean's Report to the 8th World Water Forum in Brazil in 2018.

The development of the Caribbean's Subregional report has been the outcome of extensive stakeholder engagement. It draws on a broad array of material, reports, journal articles and professional experience and expertise. The draft document was shared with national focal points, representatives of regional organisations, funding agencies, and academics. Their reviews and extensive inputs have resulted in a comprehensive document that reflects the present state of the Caribbean Water Sector, the challenges faced and the responses that are contributing to a water secure Caribbean.

1. REGIONAL CONTEXT

KEY MESSAGES

- The Caribbean is one of the most diverse regions in the World.
- It is among the most vulnerable regions to the impacts of Climate Change. Climate change is expected to decrease rainfall, increase drying conditions and sea surface temperatures, and increase the strength of tropical hurricanes.
- Many of the countries are small open economies, heavily dependent on tourism, the fragility of which was highlighted by the Covid-19 pandemic.
- The Region is dependent on food imports.
- The frequency and scale of natural disasters exerts a significant drag on economic development and the ability to fund investments.
- Many of the countries will experience population declines within the next 10 years and an ageing population.
- There a numerous strong, regional institutions tackling climate change and disaster risk management.

1.1 Background

The Caribbean is a heterogeneous Region of 32 countries and territories and consists of the island states in or around the Caribbean Sea, the Bahamas and the Turks and Caicos Islands in the Atlantic Ocean, the South American coastal states of Guyana and Suriname, and Belize in Central America, see Figure 1. The island states can be further sub-divided

by geographical location into three regions: The Greater Antilles towards the north, the Bahamian Archipelago in the northeast, and the Lesser Antilles to the east and south-east of the Caribbean Sea. The Region's circumstances and developmental profile were strongly influenced by its varied colonial histories, layered on top of its geographic diversity. Remnants of colonial hegemony are still very apparent throughout. Consequently, the inhabitants of the Region are among the most globally diverse, with a range of native languages, cultures, ethnicities, religions, and have varied political and legal systems reflecting their historical legacy and development as dependencies and independent nations. Territorial disputes between some neighbouring States in the Region's Central and South American members such as Belize and Guatemala, and more recently Guyana and Venezuela are rooted in their respective colonial histories and could have implications for transboundary water management. In geopolitical terms, the Spanish speaking countries of the Region, have closer affinities to Central America in contrast to the English-speaking Caribbean. Further, islands such as Sint Maarten, Guadeloupe, and Martinique are not sovereign states and are administered, with some autonomy, as part of the respective European countries governing them, The Kingdom of the Netherlands and France. And then there are Puerto Rico and the US Virgin Islands, which are part of the United States of America. Altogether these conflicting realities pose developmental challenges for the Region and the governance of its resources, including water resources.

Figure 1: United Nations Population Fund. (n.d.). *Map showing UNFPA Caribbean countries of operation [Map].* Retrieved from https://caribbean.unfpa.org/en/where-we-work-1

The Caribbean Region is among the most vulnerable to the impacts of climate change and climate variability due to a combination of geographical, environmental, and socio-economic factors (Portner, et al., 2022). The Region is not only on the receiving end of the impacts associated with anthropogenic climate change and climate variability but will experience them sooner and more severely than many other parts of the world (Taylor, Stephenson, Chen, & Stephenson, 2012; Cashman & Nagdee, 2017; Mycoo & Roopnarine, 2024). It is doubly vulnerable. In the first instance, its location in a tropical zone means it is subject to storm and hurricane activity as well as climatic anomalies such as El Niño and La Niña events. It is also vulnerable to earthquakes, volcanic eruptions, mass movements (landslides) and debris flows, and tsunamis (Roopnarine, et al., 2021). In the second instance the Region is socio-economically vulnerable for a variety of reasons (OECD, 2019).

Many Caribbean countries consist of small island states, making them more susceptible to rising sea levels, storm surges, and extreme weather events. They have limited land area, and a significant portion of their population and infrastructure is concentrated along coastlines, increasing exposure to coastal hazards (Cashman & Nagdee, 2017) and increasing social vulnerability. Furthermore, the Region is prone to hurricanes and tropical storms, the projection being that although the number of cyclonic events might not change significantly, there will be a greater number of category 4 and 5 hurricanes with climate change (CSGM, 2020). These extreme weather events can cause extensive damage to infrastructure, disrupt economies, and displace communities. On average over time, countries in the Caribbean suffer yearly losses due to storm damages equivalent to 17% of their GDP (UNDP, n.d.). The Caribbean is already experiencing rising temperatures, leading to heat stress and increased demand for cooling systems and negatively affecting agriculture, fisheries, and public health (CSGM, 2020). Coral reefs are sensitive to changes water in temperature and pH, rising temperatures have already brought on coral bleaching events and it may be too late for many Caribbean coral reef systems to survive, with adverse implications for fisheries, tourism, and coastal protection.

Many of the smaller Caribbean islands are heavily dependent on tourism as their main economic sector. Extreme weather events, exacerbated by climate change and climate variability impacts the sector, damaging facilities, causing disruption, and affecting livelihoods dependent on the sector. The reliance on imported goods, including food and fossil fuels, makes countries vulnerable not just to disruptions to supply chains but also to increases in importation and manufacturing cost of vital goods. At the same time fluctuations in commodity prices of exported goods and the impact of geopolitical tensions adversely affect local economies. The open nature of Caribbean economies renders them vulnerable to external shocks. The limited economic base together with the continued and cumulative economic impacts of natural disasters have contributed to limiting the financial and economic capacity of Caribbean Small Island Developing States (SIDS) to implement adaptive measures to address the impacts of climate change and climate variability. The situation is compounded by limited technical resources and the often-prohibitive cost to smaller economies of implementing adaptive measures such as early warning systems, resilient infrastructure and sustainable land-use practices. High debt levels divert resources away from critical development projects and social programmes, impacting long-term economic growth. According to the Inter-American Development Bank, the Caribbean average of debt to GDP ratio fell from 99% in 2020 to 77% at the end of 2023 (IDB, 2023), though opinions vary a sustainable level of debt is suggested to be 60% by some experts. On the plus side, there are signs of increased investment through developmental

agencies and the progressive adoption of policies to address climate change and disaster risk reduction measures.

The ability of Caribbean nations to respond to the challenges imposed by climate change over the coming decade will be largely shaped by the scale and severity of climate change, something over which the Region has extremely limited control, and macroeconomic conditions, over which they have limited room for manoeuvre. Regional cooperation and international support will play a crucial role in responding to climate change and fostering sustainable economic development to bolster the Region's ability to adapt. These factors have a material impact in shaping the prospects of the water sector in the Caribbean and its ability to manage the challenges of protecting water resources and maintaining water services while managing climate change and variability.

1.2 DEMOGRAPHIC FACTORS

Table 1 provides an overview of the population, Gross Domestic Product (GDP) and main economic sectors across Caribbean countries. The population of the Region is nearly 46.5 million people. Three countries (Cuba, Dominican Republic, and Haiti) account for nearly 75% of the total and six (the first 3 plus Jamaica, Puerto Rico, and Trinidad and Tobago) for 90%. What the table does not show are the demographic trends. There is a continuing overall trend of population increase as shown in Figure 2. There is a disparity in population growth between different countries of the Caribbean, with the populations of Belize, Dominican Republic, Guyana, Haiti and Suriname expected to continue to grow into the 2070's while the population of the rest are projected to start to decline from around 2030, Figure 2. In these countries they are undergoing increasingly rapid population ageing with the proportion of older persons (60 and over) increasing from 10% in 2000 and projected to reach 25% by 2050 (Quashie, et al, 2018), see also Figure 3. This is a consequence of the demographic transition from high to low levels of fertility and mortality giving rise to a rapid ageing of the Region's population, while life expectancy at birth has increased. Within the next 10 years some countries will start to see their population decline, indeed some countries such as Dominica and Saint Vincent and the Grenadines have already experienced declines in population, others e.g. Barbados, Grenada, and Jamaica are projected to follow. Outward migration also has implications for the pool of skilled and professional labour. As Quashie, et al (2018) have observed few countries have yet to put measures in place to enable older persons to continue in the workplace or address the problem of youth unemployment. According to a report by the CDB youth unemployment rates in the Caribbean are among the highest in the World, 20%of young men are unemployed and 30% of young women as compared to around 10% for persons over 30 years of age (OECS, 2020). A declining workforce has consequences for government revenues and expenditures, which if not addressed will pose additional challenges to investments in infrastructure and services such as water supply and wastewater management.

Table 1: Population and Macroeconomic indicators (UNDESA, 2022) (World Bank, 2023)

Country	Status	Population (x 1000) UNDESA	GDP/capita US$ World Bank	Main Economic sectors
Anguilla	BOT	16	12,200	Tourism & Financial Services
Antigua and Barbuda	Ind	94	26,356	Tourism
Aruba	KoN	106	48,750	Tourism
The Bahamas	Ind	412	40,942	Tourism & Financial Services
Barbados	Ind	282	18,210	Tourism
Belize	Ind	410	11,189	Agriculture and Tourism
Bonnaire	KoN	24	26,300	Tourism
British Virgin Islands	BOT	31	34,200	Tourism & Financial Services
Cayman Islands	BOT	69	84,279	Tourism & Financial Services
Cuba	Ind	11,194	7,291	Tourism, pharmaceuticals and health-related services
Curaçao	KoN	192	27,302	Tourism & Financial Services
Dominica	Ind	73	13,510	Agriculture and Financial Services
Dominican Republic	Ind	11,332	22,841	Mining, Agriculture, Manufacturing, Tourism
Grenada	Ind	126	17,082	Tourism
Guadeloupe	RF	395	24,668	Tourism and Agriculture
Guyana	Ind	814	42,090	Oil & Gas, Agriculture, Mining
Haiti	Ind	11,724	3,306	Agriculture
Jamaica	Ind	2,825	11,939	Agriculture, Manufacturing, Tourism
Martinique	RF	367	24,623	Tourism
Montserrat	BOT	4	16,199	Government Services
Puerto Rico	USA	3,260	40,511	Manufacturing, Financial Services, Tourism
Saba	KoN	2	24,000	Tourism
Saint Barthélemy	RF	11	43,626	Tourism
Saint Martin/Sint Maarten	RF/KoN	32 & 44	49,540	Tourism
Saint Kitts and Nevis	Ind	48	33,982	Tourism
Saint Lucia	Ind	180	17,835	Tourism
Saint Vincent and the Grenadines	Ind	103	17,212	Tourism and Agriculture
Sint Eustatius	KoN	3	33,400	Tourism
Suriname	Ind	623	17,773	Mining
Trinidad and Tobago	Ind	1,544	27,515	Oil & Gas, Financial Services
Turks and Caicos	BOT	46	24,471	Tourism & Financial Services
US Virgin Islands	USA	98	39,552	Tourism

Status Key:

BOT	Ind	KoN	RF	USA
British Overseas Territory	Independent	Kingdom of the Netherlands	Republique Francaise	United States of America

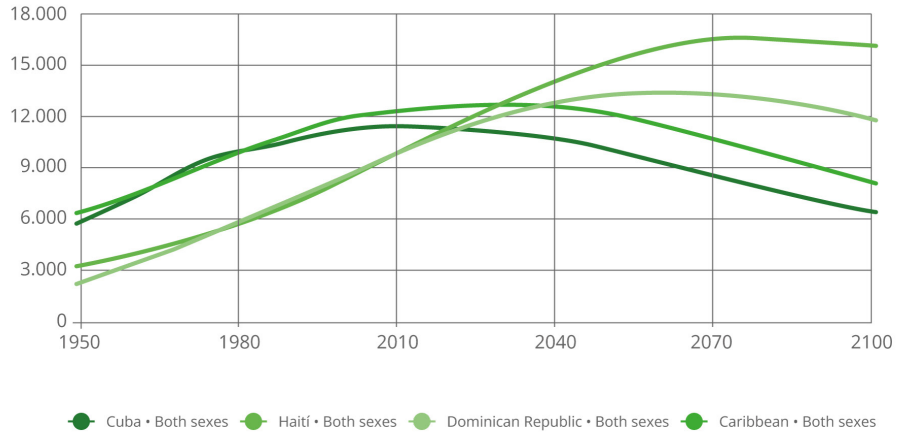


Figure 2: Economic Commission for Latin America and the Caribbean. (n.d.). Interactive demographic indicators [Interactive data tool]. Retrieved April 14, 2025, from https://www.cepal.org/en/subtopics/demographic-projections/latin-america-and-caribbean-population-estimates-and-projections/interactive-demographic-indicators

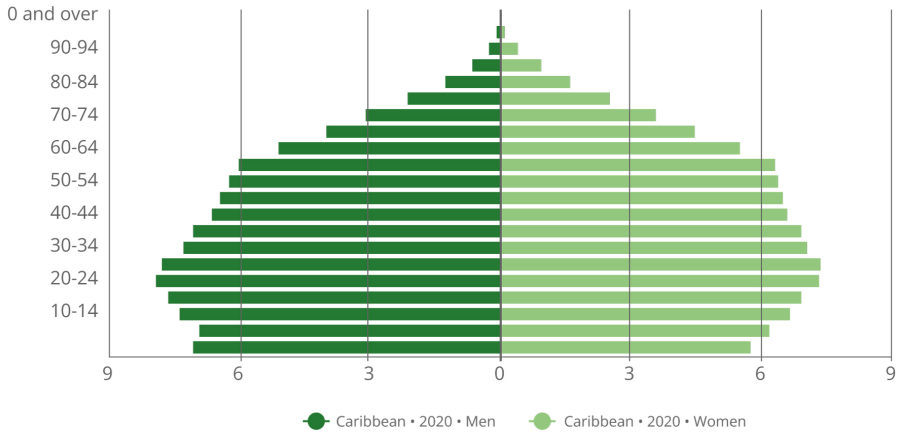


Figure 3: United Nations Economic Commission for Latin America and the Caribbean (ECLAC). (n.d.). *Population by age for Caribbean countries, excluding Cuba, Dominican Republic and Haiti* [Interactive graphic]. CEPAL. https://www.cepal.org/en/subtopics/demographic-projections/latin-america-and-caribbean-population-estimates-and-projections/interactive-demographic-indicators

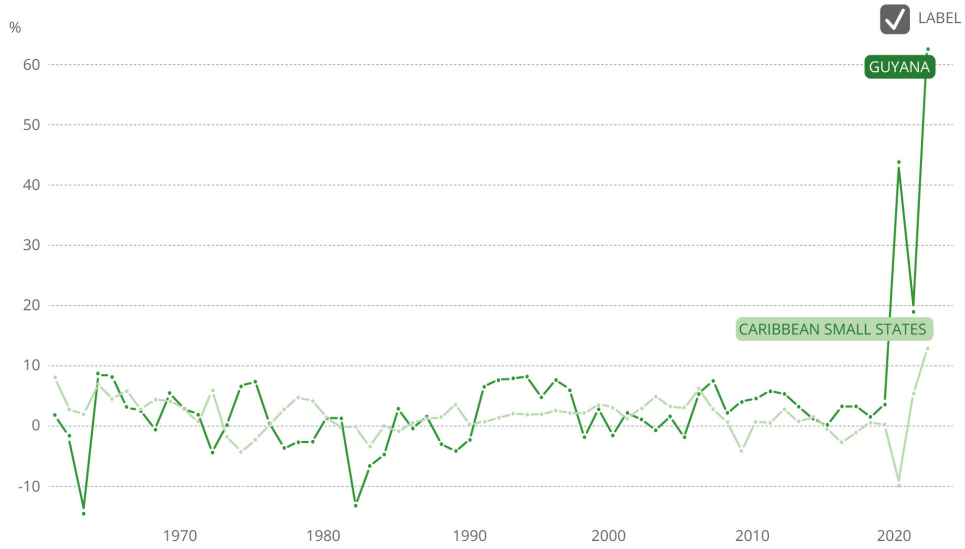
It has been projected that by 2050, 80% of the population of the Caribbean will be living in urban areas (Mycoo, 2022). An average of 84% of the Caribbean's population lives within 25 kilometres of the coast and 33% lives in low elevation coastal zones (LECZ) which comprise areas less than 10 meters above sea level (Cashman & Nagdee, 2017). Currently, coastal capitals, ports, airports and road infrastructure, housing, and industries are concentrated in the coastal zone (Cashman & Nagdee, 2017). These conditions create challenges for the provision of a range of services such as urban infrastructure, housing, transport, employment, education, healthcare and supporting services such as water and sanitation (Donovan & Turner-Jones, 2017). The ability of countries to provide these services are going to be worsened by the impacts of climate change on human populations, natural resources, and socio-physical infrastructure. Fortunately, there are initiatives in some territories that have begun to address the issues such as Jamaica's National Squatter Management Programme, Trinidad and Tobago's Neighbourhood Upgrading Programme, and Barbados' Population Commission.

1.3 MACROECONOMY

There is general agreement among economists that the Caribbean Region has and continues to face challenging economic conditions. Long-standing low growth and lack of competitiveness are the primary structural challenges, conditions which have contributed to high levels of national debt and trade deficits for many of the small island states. High levels of indebtedness hamper the ability of governments to invest in infrastructure and social programmes. Inefficient labour markets and a lack of diversity of natural resources restricts the economic potential of the Region. Given the constraints the Region's efforts to reduce poverty by improving social services have been notable, though challenges remain. Adequate access to services remains an issue in many states along with high levels of youth unemployment and migration of skilled workers out of the Region.

As a generalisation, Caribbean economies can be distinguished by being tourism dependent or commodities based, see Table 1. Commodities based countries include Suriname, Trinidad and Tobago and Guyana whilst tourism-based economies include Antigua and Barbuda, Aruba, Saint Lucia, The Bahamas, and Barbados where 30% or over of GDP is associated with tourism. Other countries such as Belize and Jamaica for example have a mix of tourism and commodities. According to the World Travel and Tourism Council (World Travel and Tourism Council, 2022) eight out of the ten most tourism-dependent countries globally were in the Caribbean Region. In 2015 tourism contributed directly and indirectly 32% of GDP averaged across countries and accounts for over 30% of total employment. Natural disasters such as hurricanes and the COVID-19 pandemic have demonstrated how sensitive the Region and its economy is to disruptions in the tourism industry. This level of dependence ties economic fortunes not just to those of the countries of origin of visitors but also to the fluctuations in their business cycles. The same holds true for commodities as well. In their study of economic growth in the Caribbean, Fuentes et al (2015) found that whilst being a large economy matters for growth, small countries have to be even more disciplined in their policies because their small size makes them much more susceptible to negative shocks to the growth process. Figure 4 shows the changes over time in GDP per capita growth, indicating that the highest rate was 6.1% in 2006, before the financial crisis. Guyana is a current exception due to the impact of its more recent oil discoveries and is something of an outlier at present.

Figure 4: World Bank. (n.d.). *GDP per capita growth (annual %)* [Data set]. https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?locations=S3-GY



Since 2010 the countries have shown persistently weak economic growth Figure 4, which creates uncertainty. Annual Gross Domestic Product (GDP) growth rates average only 0.8% compared with 4.7% in other small states. Low growth has two key sources: structural imbalances and lack of competitiveness and are mirrored in the Region's persistent current account deficits and high levels of public debt. In 2015 the Region's total debt service payments represented, on average, 33% of total government revenues, although more recently debt levels among several countries have begun to decline. However, the high cost of debt servicing continues to greatly reduce fiscal space and the ability to fund development priorities such as water infrastructure. Important in this respect is the impact of climate change from frequent disasters that reduce both output and government revenue, and that demand high levels of expenditures (IMF, 2016; OECD, 2019). Figure 5 provides a snapshot of the position of some countries with respect to debt-GDP ratios, inflation and growth in GDP.

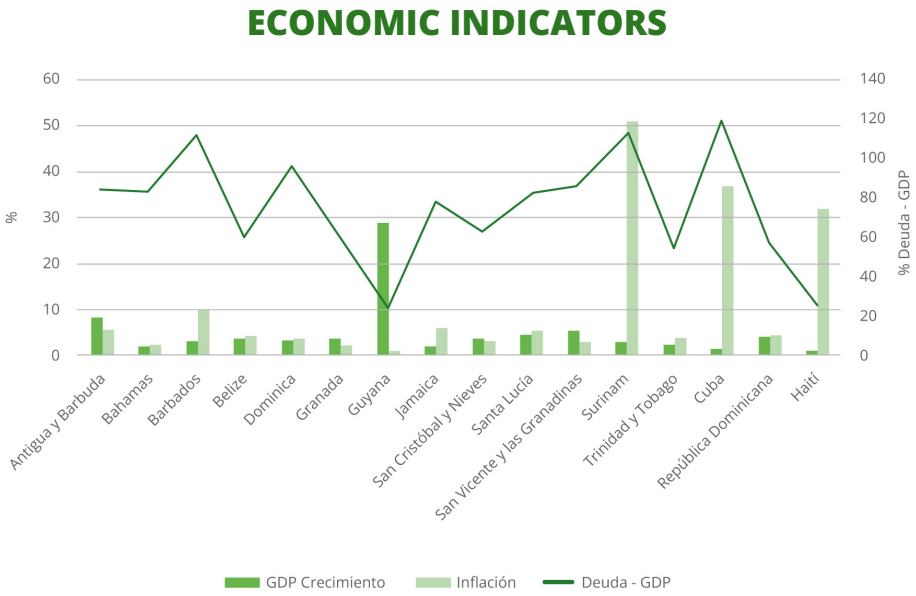


Figure 5: World Bank. (2024). *Overview of GDP growth, inflation and debt-GDP ratios of some Caribbean countries* [Data set]. https://data.worldbank.org/

According to ECLAC (2023) most Caribbean countries experienced positive growth in 2021. This was stronger among service than commodities producers as tourism bounced back, though growth would decline as the post COVID bounce back subsided. In January 2023, the Caribbean Development Bank (CDB) forecast regional growth of 5.7% based on a revival of tourism arrivals and investments in the energy sector. It also noted though that there were risks and uncertainties associated with the impact of conditions in advanced economies on the Region. For example, factors such as higher global inflation rates, fixed exchange rates with the US dollar and higher fuel and food prices pose a threat to regional economies.

The CDB emphasized that to foster growth and development, comprehensive debt management strategies, effective public financial management, and enhanced access to adequate and affordable financing are essential.. Key priority actions were the strengthening of governance capacity to deliver through implementation of cross-sectoral policies and programmes, technical proficiency and mainstreaming environmental sustainability and climate change (CDB, 2024). The Region's challenges are structural and related to the need to digitalize at a greater speed as well as accelerate the development of human capital necessary to handle such a transition (OECD, 2020). Further efforts are needed to determine how to finance the energy transition to renewables, which is critical to dealing with climate change.

It is problematic to forecast where macroeconomic growth might come from in a Region as diverse as the Caribbean. According to the IDB (Rosenblatt, Mooney, & Clayton, 2023), the tourism sector is likely to continue to grow. It identifies several potential opportunities for long-term growth. These include

'Near shoring' or 'Friend shoring' of services sector, and design and manufacturing facilities resulting in economic diversification. Renewed efforts to reduce the extra-regional food import bill could increase the scope for agriculture in countries without a strong agricultural base, and along with regional integration combined with investment and new technologies could expand and diversify agricultural production in those countries with a stronger tradition in the sector. Investments in alternative energy sources such as solar and wind, and perhaps hydrothermal power could open new opportunities on the back of lower energy costs and reduce dependence on imported and volatile hydrocarbon supplies. Investment in the blue and green natural assets of the Caribbean is another promising opportunity. In terms of their impact on water, the picture would also be mixed.

Tourism is to an extent a water intensive industry, especially hotels so continued growth could have an adverse effect on water resources and services. Agricultural growth is likely to lead to growth in water demand, which could be large and a major challenge for many countries to provide. The differences in water endowments across countries will shape how this is handled; expect countries like Antigua and Barbuda, Barbados, Saint. Kitts and Nevis to have a very different potential response that say Guyana and Trinidad and Tobago. The establishment and growth of new economic sectors will also increase water demand, but the scale will depend on the scale and type of enterprises. On the other hand, Blue-Green growth would have, by its nature, a more positive impact on water resources and services.

The potential impact of alternative development trajectories on ecosystem services and by extension, water is explored in the Grenada's "National Ecosystem Services Assessment, Chapter 6: Scenarios and pathways to a sustainable future" (Cashman, et al., 2023). This demonstrates the inter-dependence between economic pathways, water resources and water consumption and that projecting into the future is fraught with uncertainty.

1.4 FOOD SECURITY

The Caribbean imports between 60% and 80% of its basic food requirements, to meet its domestic food needs, as well as to feed a significant number of visitors for its highly dependent tourism sector (FAO, IFAD, PAHO, UNICEF & WFP, 2021). Over the past 20 years agriculture's share of GDP has declined as has the number of persons employed in the food production sector. Up to the late 20th century, the Region's economy was dominated by agricultural exports such as sugar, bananas cacao, spices, etc. The discontinuation of preferential trade arrangements played an important role in shifting economic focus. As the economy of the Region has evolved, there has been a shift in the contribution of agriculture to local food supply to an emphasis on the export of traditional food crops. As a result, food imports have grown significantly to meet the demands of an urbanised population and changing food consumption preferences. Local food production has not been able to cater for changing consumer tastes. This is in parallel with providing for hospitality and related services industry. Estimates by the World Bank and FAO (2008) suggest that for the Organization of Eastern Caribbean Countries, only 32% of the tourism sector demand is met from local sources with the rest being imported. In OECS countries the food import dependency ratio ranges from 55% to 95% (OECS, 2022). The high level of dependency on food imports makes the Caribbean and the tourism sector in particular extremely vulnerable to food supply shocks, with wider economic and social implications, given the pivotal role of tourism in these economies.

Furthermore, much of the Region's agriculture relies on rain fed agriculture; irrigation of food crops is the exception rather than the norm. In recent years, climate variability in the form of extreme rainfall

events resulting in flooding, heat waves and droughts have highlighted the vulnerability of the sector to climate change. For those countries, such as Belize, Guyana and a lesser extent Jamaica and Trinidad and Tobago, where agriculture is an important economic sector, increasing attention is being paid to the need for irrigation infrastructure and alternative sources of water (e.g. reuse of treated wastewater), potentially increasing competition for water resources, which will be adversely affected by climate change. Surveys conducted in 2023 have highlighted the potential future extent of food insecurity. According to these surveys, 3.7 million people in the Region were food insecure, and 42% of households had been affected by climate hazards in the preceding 12 months (WFP, 2023). This is a reminder of the importance of the Region's agenda to reduce imports by 25% by 2025, strengthening food systems so that they are resilient and adaptive to shocks, and building on measures to address the affordability, accessibility, and availability of livelihood inputs (CARICOM, 2022). The Region is at risk of losing international markets due to the nature of its agricultural practices, limited regulation, and use of fertilizers and pesticides, though countries are looking to start to implement policies and standard to deal with this.

1.5 CLIMATE AND CLIMATE CHANGE

The climate in the Caribbean is predominantly tropical, characterized by warm temperatures, high humidity, and distinct wet and dry seasons. The Region experiences consistent warmth throughout the year with minimal temperature variations typically ranging from 25°C to 31°C throughout the year. Coastal areas usually have milder temperatures than inland regions. There has been a trend of increasing temperatures across the Caribbean since 1900 (Figure 6).

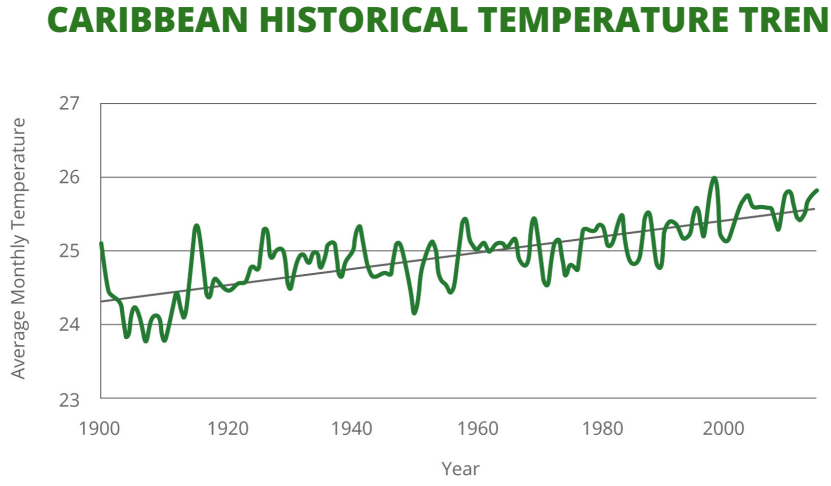


Figure 6: Climate Studies Group Mona (CSGM). (2020). *Historical temperature trends across the Caribbean* [Report]. https://www.mona.uwi.edu/physics/csgm/home

The wet season typically occurs from May/June to November, coinciding with the hurricane season. However, there are variations across the Region with some countries experiencing an early and a late wet season with a drier midsummer period (July-August). Generally the Region experiences a bimodal rainfall pattern with lower rainfalls during December through to March, Figure 7, for the location of the six regions referred to see Figure 8 (CSGM, 2020); area 1 Belize, area 2 Cuba, area 3 Jamaica, Cuba and The Bahamas, area 4 Greater Antilles, area 5 Trinidad, Tobago and the Eastern Caribbean, area 6 Guyana and Suriname.

Heat stress on the environment is much higher during the wet season, especially during drier spells as this affords little relief from intensely humid heat by rain and cloudiness. During this period, tropical storms and hurricanes bring heavy rainfall and strong winds. The dry season usually spans from December to May, characterized by lower rainfall and more stable weather conditions. Tropical storms and hurricanes bring intense rainfall, strong winds, and storm surges, impacting the Region's weather patterns and posing a risk to coastal areas.

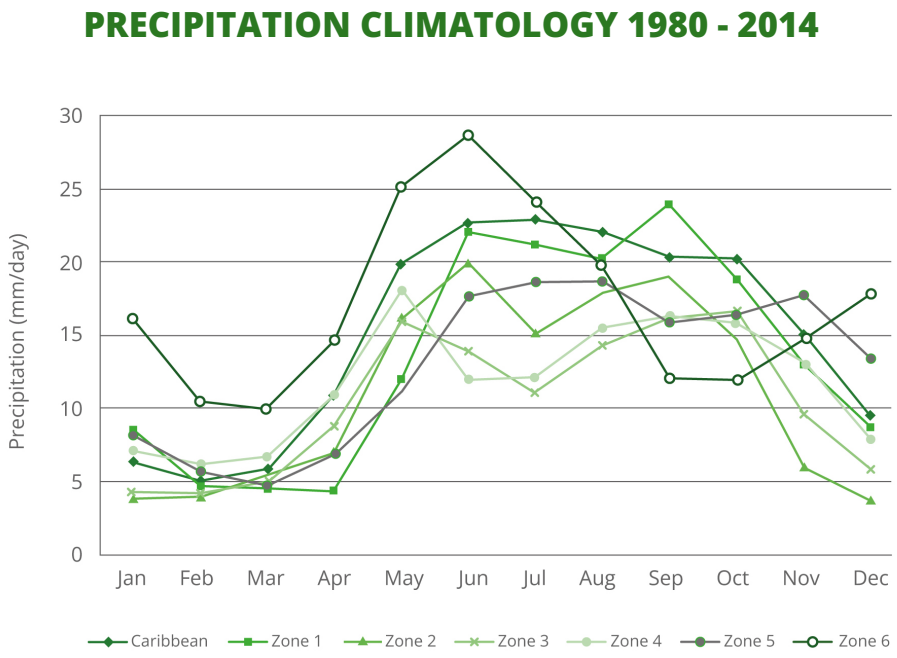


Figure 7: Climate Studies Group Mona (CSGM). (2020). *Precipitation climatology 1980–2014* (See Figure 8 for the location of areas) [Report]. https://www.mona.uwi.edu/physics/csgm/home

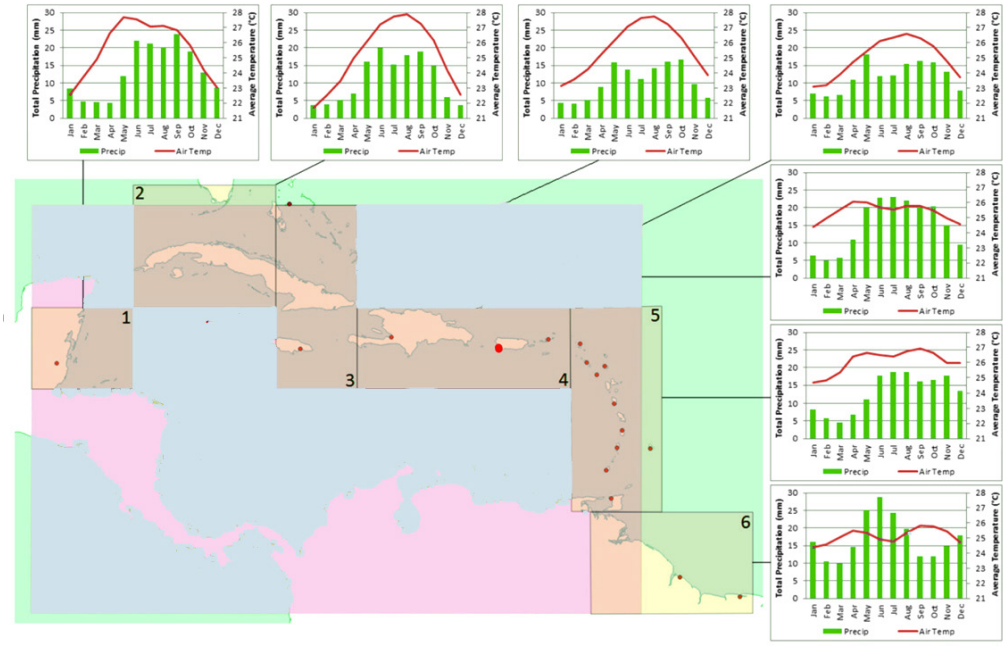
Due to the diverse topography of the Caribbean islands, there are climate variations in and across countries. Specific weather conditions vary among individual islands, and factors such as altitude, proximity to the equator, and ocean currents influence local climates. Coastal areas may experience milder temperatures compared to mountainous interiors, and the windward sides of islands receive more rainfall than the leeward sides. The Caribbean's climate supports a diverse range of ecosystems, including tropical rainforests, savannahs, and coral reefs.

The Caribbean is considered to be "ground zero" (United Nations, 2022) in the global climate emergency given the exposed location, relative isolation, and small size of many of the territories. The range of climate threats include more pronounced sea-level rise, increased frequency of extreme weather events, such as hurricanes and tropical storms, increased rainfall and flooding, dangerous high temperatures, warmer sea surface temperatures, coastal erosion and saltwater intrusion, and longer dry seasons and shorter wet seasons (CSGM, 2020).

Some of the most at-risk countries include low-lying islands, such as Anguilla, Antigua and Barbuda, and The Bahamas and other islands with low-lying areas such as Barbados, Jamaica and Trinidad, among others, whose surfaces are only a few meters above sea level (Eckstein, Kunzel, & Shafer, 2021). Several other islands, including Haiti and Dominica for example, lie inside the so-called "Hurricane Alley" in the Atlantic Ocean. Between 2000 and 2019, The Bahamas and Haiti ranked among the top ten countries and territories globally that were most affected by extreme weather events.

According to the Climate Studies Group Mona (CSGM) (CSGM, 2020) the Caribbean can be divided into six

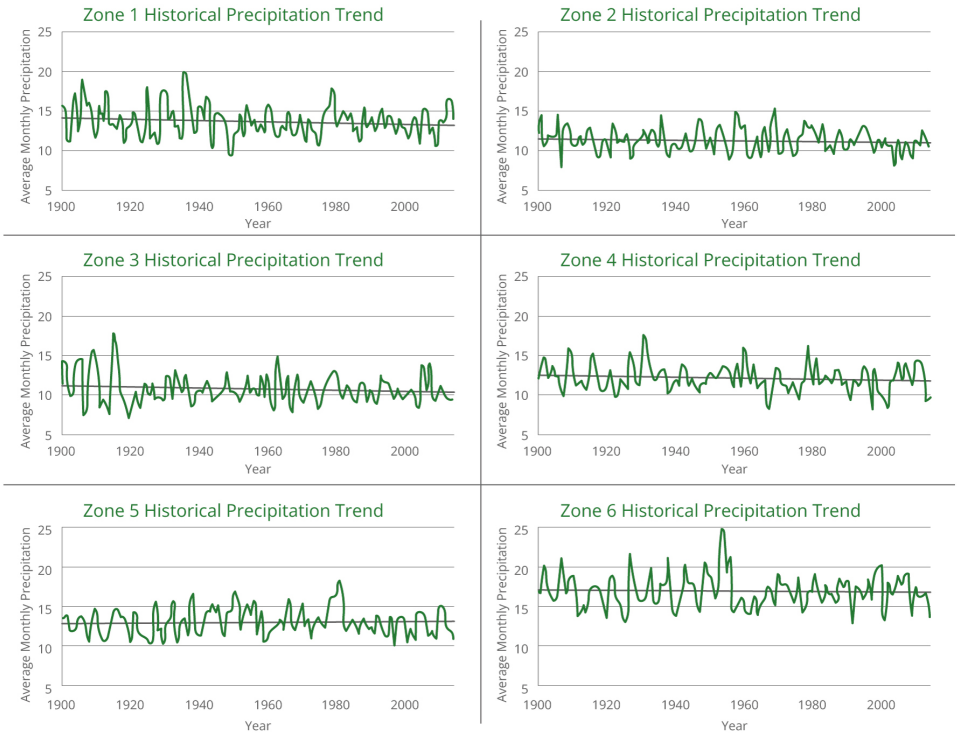
Figure 8: Climate Studies Group Mona (CSGM). (2020). *Map of the Caribbean domain and the six rainfall zones* [Map]. https://www.mona.uwi.edu/physics/csgm/home



rainfall zones, based on the pattern of rainfall received, see Figure 8. The central Caribbean which includes the Greater and Lesser Antilles receives less rainfall than the other western and southern zones with at least 70% of rainfall occurring during the wet season, across all six zones. Since 1900 there has been no significant observed baseline trend in rainfall; year on year variations account for up to 90% of the observed variability (CSGM, 2020), Figure 9. That said the number of consecutive dry days is increasing, as well as the amount of rainfall during extreme rainfall events – short duration-high intensity events are increasing, often causing extensive flooding (CSGM, 2020).

Looking ahead, the Region is projected to gradually dry through to the end of the century, with less intensity in the north but more in the south and southeast. By the 2050s, the Region could be up to 6% drier, and by the end of the century, up to 17% drier. Regional Climate Modelling (RCM) projections indicate up to 25% and 35% less rainfall by the end of the century. Belize, the Lesser Antilles, and the southern Caribbean are projected to be the most impacted by drying, while the central Caribbean will be less affected. In the far north and northern Caribbean, mean annual rainfall changes suggest slightly wetter conditions through to mid-century, though even in the far north Caribbean, the rainy seasons are projected to dry from as early as the 2020s (CSGM, 2020).

Figure 9: Climate Studies Group Mona (CSGM). (2020). *Historical trends in precipitation across the Caribbean* [Report]. https://www.mona.uwi.edu/physics/csgm/home



Temperatures across the Caribbean have been increasing over the last several decades, consistent with global warming trends. There has been an increasing trend in very warm days and nights for the Caribbean as a whole. The warming trend will continue, with temperature increases ranging from 0.86°C to 1.50°C by the 2050s. Maximum temperatures are expected to rise slightly more than minimum temperatures, affecting all seasons.

The past trend in warming of sea surface temperatures (SST) is expected to continue in the future, with increases of 1.76 ± 0.39°C per century in the wider Caribbean. By the end of the century, years of coolest projected SSTs fall within the range of the warmest years in the present (CSGM, 2020).

Since 1950 there has been a regional rate of increase in sea levels of 1.8 mm per year a trend which is showing some evidence of increasing. Larger sea level increases have been observed for the post 2000 period during which hurricane intensity and sea level inter-annual variability have both increased. The projected range of increases in sea levels is 0.17-0.38 m for 2046 – 2065 with an upper limit of 1.5m under the worst-case Representative Concentration Pathway 8.5. By the end of the century, sea level rise is projected to reach or exceed 1m across the Caribbean (IPCC, 2021).

Since 1995 there has been a significant increase in the frequency and duration of Atlantic hurricanes and an increase in category 4 and 5 hurricanes see Figure 10, accompanied by increases in rainfall intensity and peak wind intensities. Whilst there is expected to be little change in the frequency of hurricanes there is expected to be a shift towards more frequent category 4 and 5 hurricanes and a 20-30% increase in associated rainfall intensities.

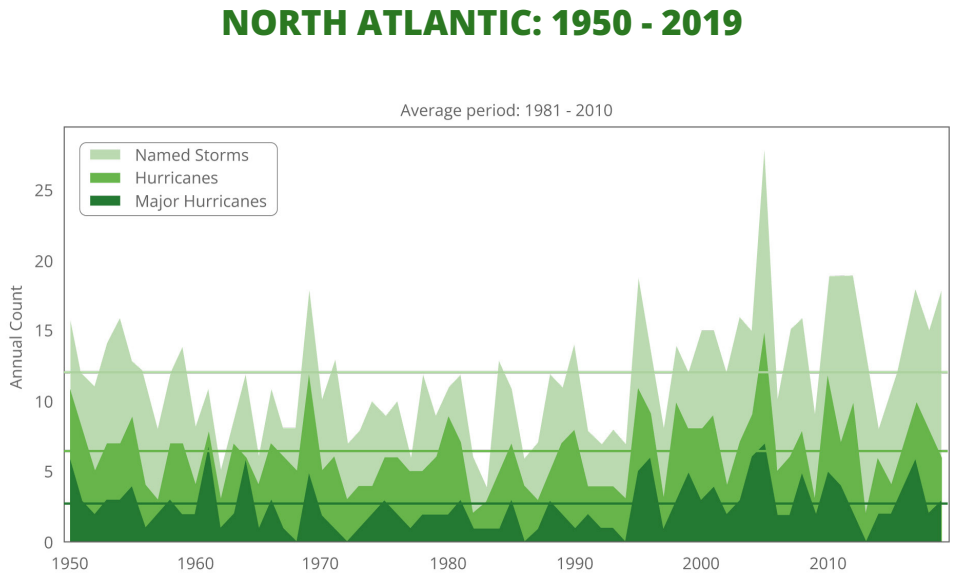


Figure 10: Climate Studies Group Mona (CSGM). (2020). *Historical record of cyclonic activity in the North Atlantic, 1950–2019* [Data set]. https://www.mona.uwi.edu/physics/csgm/home

The combination of less frequent but more intense rainfall, the drying trend, increases in the number of consecutive dry days and increases in temperatures and the incidence of extreme temperature events pose a significant challenge and threat to the Region's water resources. The combination of trends has adverse implications for stream and river flows, run-off volumes and associated erosion and groundwater recharge, all of which will affect water availability. On top of this, rises in sea level will impact coastal aquifers through saline intrusion and can increase adverse saline effects on soils e.g. in Belize, Guyana and Suriname. The understanding from the limited amount of hydrological modelling that has been carried out suggest significant decreases in water availability and sustainable water supply. Although there is limited evidence, climate changes can be expected to alter domestic and non-domestic consumption patterns. Agriculture and food production, which has already experienced the impact of increased adverse weather conditions, will be particularly affected. It is anticipated that there will be increasing demands for the provision of supplementary irrigation, which could place further stress on scarce water resources if not properly managed or alternative sources of water such as reuse of treated wastewater are not developed.

1.6 INSTITUTIONAL FRAMEWORKS

The Caribbean Region has several regional institutions that facilitate cooperation, integration, and collaboration among its member countries. These institutions span various areas, including economic development, political cooperation, security, and cultural exchange. The Caribbean Community (CARICOM) consisting of 15 Member States and 5 Associated States, is one of the most significant regional organizations in the Caribbean, established in 1973 with the goal of promoting economic integration, cooperation, and coordination among its member states. CARICOM addresses a wide range of issues, including trade, education, health, and disaster management.

The Organisation of Eastern Caribbean States (OECS) was formed in 1981, and currently consists of eleven Eastern Caribbean countries, with a focus on economic integration and cooperation in various sectors, including education, health, and the environment.

The Association of Caribbean States (ACS) was established in 1994 to promote cooperation and regional integration among countries in the Caribbean Basin. It encompasses countries from the Caribbean Sea, Gulf of Mexico, and the Atlantic Ocean, currently a total of 37. The ACS addresses issues such as sustainable development, trade, and disaster risk reduction.

The Caribbean Forum of African, Caribbean, and Pacific States (CARIFORUM), is a subgroup within the larger framework of the African, Caribbean, and Pacific Group of States (ACP). It was established to promote cooperation and dialogue between the Caribbean Region and the European Union (EU). Membership comprises the CARICOM member states along with the Dominican Republic. The primary objectives include promoting economic cooperation, sustainable development, poverty reduction, and regional integration among its member states. The partnership also focuses on addressing issues related to trade, investment, and development cooperation.

The groupings mentioned are primarily political, promoting cooperation and development. In addition, there are several other, more technically focused bodies that have more limited remits.

The Caribbean Disaster Emergency Management Agency (CDEMA) is responsible for coordinating disaster response and management in the Caribbean. It helps member countries prepare for and respond to natural disasters, such as hurricanes and earthquakes.

The Pan-American Health Organization (PAHO) is the specialized international health agency that works with countries throughout the Region to improve and protect people's health. It engages in technical cooperation to fight communicable and non-communicable diseases and their causes, to strengthen health systems, and to respond to emergencies and disasters. PAHO's work is complemented by the Caribbean Public Health Agency (CARPHA) which has an Environmental Health and Sustainable Development Division that undertakes projects associated with IWRM.

The Caribbean Development Bank is a CARICOM institution and the multilateral development finance agency solely focussed on the Caribbean. It currently has 19 Caribbean countries as members. Multilateral support is also provided by agencies such as the Inter-American Development Bank (IDB) and the World Bank. Bilateral agencies include the German Development Cooperation (GIZ) and the Japan International Cooperation Agency (JIPA).

The University of the West Indies is the world's only regional university. It has four physical campuses and a virtual one. In addition, it has a presence in all CARICOM countries. As described later it provides undergraduate and postgraduate education. Notably, the Mona Campus in Jamaica houses the Climate Studies Modelling Group, which is a world class centre for climate studies. The UWI is a CARICOM institution with its headquarters in Jamaica.

The Caribbean Institute for Meteorology and Hydrology (CIMH) is a regional institution dedicated to advancing meteorological and hydrological sciences in the Caribbean. It plays a crucial role in providing weather and climate-related information, research, and training to support the resilience and sustainable development of the Caribbean nations. It aims to improve the capacity of its member countries to cope with and adapt to weather-related hazards, including tropical storms, hurricanes, and other climate-related challenges. It operates and maintains weather and climate observation networks to collect essential data to monitor atmospheric and hydrological conditions, contributing to more accurate forecasts and early warning systems.

The other major player is the Caribbean Community Climate Change Centre. This was established by CARICOM and became functional in 2005. Its purpose is to represent the Region on matters related to Climate Change and be a lead negotiating body for the Region. Its functions include providing information for decision-making, project development and support, training, and developing joint ventures and funding. It is an Accredited Entity to the Green Climate Fund.

The political and technical entities mentioned above are complemented to a certain extent by two main professional associations, the Caribbean Water and Wastewater Association (CWWA) and Global Water Partnership–Caribbean (GWP-C). Both are regional, non-governmental organisations whose objectives include promoting the sustainable development and management of water resources, fostering cooperation and collaboration among water professionals, and advocating for policies that ensure the efficient use and protection of water. Both organisations focus on capacity building and knowledge sharing. GWP-C promotes Integrated Water Resources Management and can call on a global network for support. CWWA works with the Caribbean Water and Sewerage Association (CAWASA) which primarily provides training to its water utility members.

The above constitutes a core set of entities, each of which has an interest, influence and/or role to play in the governance of water in the Caribbean. The conglomeration of entities mentioned constitutes a dense network of epistemic and advocacy-based

communities, exerting varying degrees of influence over developmental policies, programmes and policies in the water sector. Formal organisational networks of association are underlain by informal and personal networks, the influence of which on water management thinking should not be dismissed.

Some examples of the diversity of institutional frameworks governing water sectors include the following. Jamaica has a well developed framework which includes a government unit within the Ministry of Economic Growth and Job Creation dedicated to water policy and monitoring coordination; a national integrated water resources management council; independent environmental, water resources management, and economic regulators; a national water utility, a rural water supply company and private water services providers. Dominica has a national water corporation, no water resources management unit, an environmental department but no economic regulator. Grenada has a national water authority; a government department overseeing environmental regulation; and is developing a water resources management unit and revitalising its economic regulation arrangements. Saint Kitts has a government department responsible for water supply, a government department overseeing environmental regulation and no water resources management or economic regulation.

2. WATER SECURITY AND PROSPERITY

KEY MESSAGES

- Maintaining water availability in the face of Climate Change will be an increasing challenge as recharge is adversely affected and water distribution systems continue to age. Reducing levels of non-revenue water loss is a key response to maintaining supplies.
- The quality, completeness and accuracy of water quantity and quality data is a continuing concern and hampers the development of evidence-based decision-making.
- System of data collection and monitoring of water quantity and quality need to be improved.
- Water scarce countries are increasingly reliant on desalination for their water supplies.
- Countries are implementing the separation of water resource management from water service provision. Similarly, there is increasing interest in economic regulation of water services.
- Most water service providers are government owned, the exceptions are where desalination is a major source of supply and provided by the private sector.
- Low water tariffs and ineffective regulation are adversely affecting the financial and operational efficiency of water service providers. Capital investment relies on government transfers and on government-backed loans.
- The level of wastewater management is low, but there is increasing interest in ways to improve wastewater services.
- Making water available for food production, in the face of Climate Change

2.1 WATER RESOURCES AVAILABILITY

Information on the state of water resources at both the national and regional is variable for several reasons including: no designated responsible agency; a lack of trained and available personnel; incomplete water monitoring network coverage; inadequate budgets for operation maintenance and capital works, and lack of analysis of available data. In many countries, monitoring networks have been relatively recently installed; Jamaica is one of the few countries with a record of hydrological monitoring going back to the 1950s, Trinidad and Tobago started just before 1970, and Saint Lucia in the 1980s. As a result, there is often a lack of time series data and coverage on which to make estimations. The most comprehensive source of information on water resources was gathered by the Food and Agricultural Organization (FAO) through engagement with Caribbean governments and published in 2015. The available information on water availability being the total renewable volume per inhabitant and the withdrawals as a percentage of the total renewable is shown in Table 2 below and in Figure 11.

Table 2: Water Availability (Source FAO Aquastat)

Country	Total renewable water resources per inhabitant (m3)	Withdrawals as % of total renewable water resources
Anguilla	No data	
Antigua and Barbuda	531	8.5
Aruba	No data	
The Bahamas	1,780	No data
Barbados	278	87.5
Belize	54,659	1.3
Bonnaire	No data	
British Virgin Islands	No data	
Cayman Islands	No data	
Cuba	3,366	23.9
Curaçao	No data	
Dominica	2,778	10
Dominican Republic	2,166	39.6
Grenada	1,777	7.1
Guadeloupe	Sin datos	
Guyana	344,542	3.3
Haiti	1,230	13.4
Jamaica	3,655	12.5
Martinique	No data	
Montserrat	No data	
Puerto Rico	2,482	19.5
Saba	No data	
Saint Barthélemy	No data	
Saint Martin/Sint Maarten	No data	
Saint Kitts and Nevis	451	50.8
Saint Lucia	1,634	14.3
Saint Vincent and the Grenadines	901	7.9
Saint Eustatius	No data	
Suriname	168,760	4
Trinidad and Tobago	2,744	20.3
Turks and Caicos	No data	
US Virgin Islands	No data	

The figures in the Table are 'headline' figures and should be treated carefully as they may mask the localised nature of the occurrence, distribution and make up of available water sources and resources. For example, Antigua and Barbuda is on one measure water scarce but 70% of Antigua's water supply is from seawater desalination, which increases the total supply of water but is not accounted as 'renewable'. In theory, the majority of Caribbean countries, particularly the small insular countries do not have a water resources availability problem. On the measures presented only Barbados and Saint Kitts and Nevis can be classified as both water scarce i.e. having less than 1000 m3 of total renewable water resources per person per year and being highly water stressed i.e. utilising more than 75% of the total renewable water resources. Most countries can be classified as having low water stress i.e. utilising less than 25% of their total renewable water resources and having more than 1000 m3 of total renewable water resources per person per year. Belize, Guyana and Suriname are the exceptions as they have abundant water resources and small populations. However, these headline figures are misleading as they do not take into account variations between the wet and the dry season, inter-annual variability and geographic variability across countries due to factors such as topography and microclimates.

These values have to be contextualised, i.e. they are based on rainfall and not actually water that can be (or is) captured and harnessed, the source of water may not be where the demand is, the expense to harness, treat and distribute may not be feasible, etc. Also, this availability does not account for the future impacts of Climate Change.

TOTAL AVAILABLE WATER RESOURCE (m³) VS WATER STRESS (%)

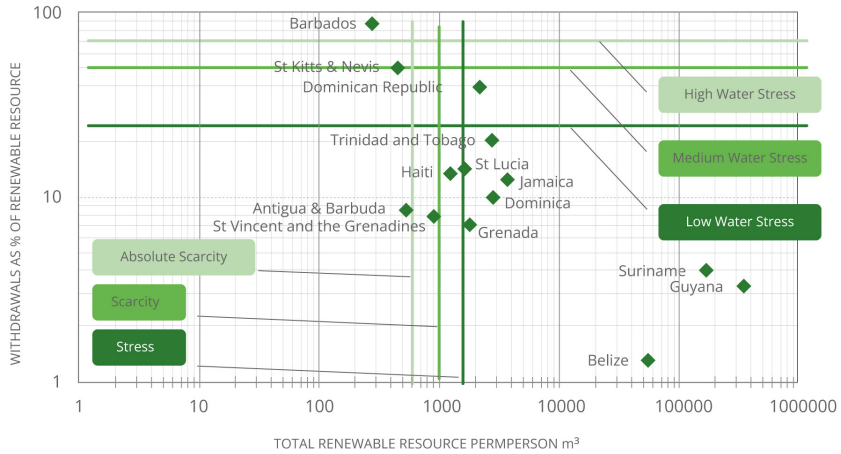


Figure 11: Food and Agriculture Organization of the United Nations (FAO). (n.d.). *Available water resource (m^3 per person) vs. water stress (%), selected countries* [Chart]. FAO Aquastat. https://www.fao.org/aquastat/

Figure 11 uses information from FAO Aquastat and plots two metrics, water withdrawals and a % of the renewable water resources and renewable water resources per person. It suggests that there are three groups of countries. The one consists of Belize, Guyana and Suriname which do not have water resource availability challenges, at the national aggregate level. On the other end of the spectrum there are Barbados and St. Kitts and Nevis, both of which face significant water availability challenges. Then there is a middle group which are not as well-endowed as the first group but should not on these aggregate measures be able to meet their water requirements. However, what these figures do not show is the accessibility of the resources on the one hand and on the other the efficiency and effectiveness with which countries utilise their water endowments. Moreover, the existence and availability of disaggregated data for Caribbean countries and territories complicates the development and use of metrics that would inform a more nuanced understanding of water availability and scarcity.

It is not the total average volume through a year but rather the seasonality of availability that is of importance. The ability to manage the cyclical nature of water availability is a function of the nature of the resource (groundwater or surface water) as well as infrastructural deficiencies; high rates of non-revenue water, insufficient supply network capacity to meet demand, inadequate storage capacity. Some countries that experience a high degree of seasonality in their rainfall patterns and uneven distribution of resources in time and space have invested in storage systems. The United States and Australia have built over 5000 m3 of water storage per person while other countries like South Africa, China and Mexico can store about 1000 m3 per inhabitant. Few countries in the Caribbean have dams for water supply and for those that have, the equivalent figures are shown in Table 3. For those countries such as Barbados which use groundwater as an important source of supply, aquifers function as storage.

Table 3: Storage Volume per inhabitant
(Authors calculation based on FAO Aquastat data)

Country	Storage volume per inhabitant m³
Antigua and Barbuda	59.15
Cuba	389.61
Dominican Republic	63.26
Grenada	0.18
Jamaica	1.93
Saint Lucia	14.47
Trinidad and Tobago	46.83

Water resources and availability are being influenced by anthropogenic changes (O'Connell, 2017). The conversion of undeveloped land areas through urbanisation, urban sprawl and unplanned and informal settlements continues to change the rainfall runoff characteristics and drainage patterns, altering the character of stream and river flows. Development of the Port of Spain-Arima urban corridor in Trinidad and Tobago has been shown to have impacted the Caroni River Basin (Williams Cashman and Cooper 2023) increasing flood risks, decreasing dry season base flows and higher sediment loads.

Conversion of forest areas – Nature's Water Towers - to pasture and crop cultivation are also having negative effects on river flows which, if not addressed, could have serious implications for future water availability. Martin-Arias, et al. (2022) indicated that for two northern Belize river basins a combination of climate change and deforestation could reduce runoff volumes by 51% (Belize River) and 65% (Rio Hondo) respectively by 2050. The devastating effects of catchment conversion can be most clearly seen in Haiti where denuding of hill sides has resulted in slope instability, mud flows and catastrophic flooding, as happened in Gonaives in 2008 (NASA Earth Observation, n.d.; Smith & Hersey, 2008).

Guyana has experienced a distinct rise in extreme rainfall events over recent years and recent research indicates increasing extreme rainfall and more severe dry conditions are affecting both river flows and aquifer recharge, though the extent of the potential impact has not been investigated in detail (Maclean, et al., 2015; Stennett-Brown, Stephenson, & Taylor, 2019).

Countries such as The Bahamas, Barbados and Jamaica rely heavily on groundwater resources as their source of water supplies. In Barbados 85% of the supply is from groundwater, in Jamaica the figure is 84%, and for Trinidad and Tobago and Saint. Kitts the figures are 24% and 70% respectively (Cashman, 2014). Jamaica's groundwater resources are significant at 10.663 Mm3/day compared to Trinidad's 0.477 Mm3/day, Barbados' 0.205 Mm3/day and Antigua's 0.002 Mm3/day. Over pumping of coastal aquifers in Jamaica and Antigua has resulted in 'up-coning' and saline intrusion. Among the reasons put forward for over-pumping has been a lack of monitoring and a general lack of sustainable management. Further, deficiencies in managing abstraction through inadequate licensing and regulation have allowed poorly controlled abstraction. It has been anticipated that climate change impacts on rainfall patterns, increases in temperature, and the general drying across the Region will affect not just surface water flows but also reduce groundwater recharge. For Barbados for example, work by Gohar, Cashman, & Ward (2019) and Payne, et al. (2023) suggest that climate change could reduce aquifer recharge by up to 50% under the worst climate scenario. In other countries such as Dominica, Grenada, Saint Lucia, and Saint Vincent, which hardly utilise their groundwater resources (Cashman, 2014), reduced recharge will also manifest itself through reduced dry season base flows in streams and rivers.

Water quality issues can impact water resource availability, and such quality issues vary between countries. Generally, Jamaica has good water quality though there are problems with pollution from bauxite mining as well as from improper sewerage disposal. High nitrate levels have been recorded in the Liguanea aquifer in Kingston Saint Andrews (Mandal, Gordon-Smith, & Harris, 2021) making it unusable for water supply. In Barbados, nitrate levels of around 8 mg/l have been found in water supplies from Barbados' main supply aquifer. This decline is attributed to a combination of agrichemical sources and improper domestic sewage disposal. However, due to a reduction in the cultivated land area and the use of chemicals, nitrate levels have been decreasing in recent years.In Trinidad there have been issues with high iron concentrations in groundwater as well a high chloride levels in coastal aquifers, and high turbidity during extreme rainfall events leading to water treatment plants having to shut down. Trinidad also has a water quality issue associated with runoff from unlicensed quarries leading to high sediment loads in rivers. In Belize City it is anticipated that in the Belize River sea level rise and lower base flows resulting from climate change will lead to the saltwater interface migrating upstream and affecting the intake of its water treatment plant. In addition, eutrophication conditions are being increasingly experienced in the northern New River watershed.

2.2 WATER RESOURCES MANAGEMENT

Table 4 provides an overview of the bodies responsible for water resources management across the Caribbean countries. Nine countries have an entity of some sort with responsibility for water resources management and of these those with a degree of autonomy include Cuba, Dominican Republic, Jamaica, Saint Lucia, and Trinidad and Tobago. A further three are said to be in the process of establishing autonomous bodies, The Bahamas, Belize, and Grenada. However, six countries rely on desalination for their water supply, given the absence of surface or groundwater resources. In most of the countries water resources management continues

to be part of the national water utilities. In eight of the countries, mostly from the insular Caribbean, responsibility for water resources management remains with the water utilities.

Table 4: Water Resources Management Agencies (authors compilation)

Country	Water Resources Management Agency
Anguila	Anguilla Water Department.
Antigua and Barbuda	Antigua Public Utilities Authority (APUA).
Aruba	Water-en Energiebedrijf (WEB) Aruba has no water resources as such and relies on desalination.
The Bahamas	Water and Sewage Corporation – steps are being taken to introduce a water resources agency.
Barbados	Barbados Water Authority.
Belize	National Hydrological Service (Water and wastewater services provided by Belize Water Services).
Bonaire	Water-en Energiebedrijf (WEB) Bonaire.
British Virgin Islands	Water and Sewage Department – supplied by four desalination companies. (Ocean Conversion, Aqua Design, Seven Seas Water, TSG Global).
Cayman Islands	Water Authority – Cayman under the Ministry of District Administration and Lands. Country relies on desalination.
Cuba	National Water Resources Institute (INRH). Water services provided by local authorities.
Curaçao	Curacao Water & Power Company, relies on desalination for water supply
Dominica	Dominica Water and Sewage Corporation.
Dominican Republic	National Institute of Hydrological Resources (INDRHI). Water services provided by local government service providers.
Grenada	National Water and Sewerage Authority. There are plans to establish a separate water resources management unit.
Guadeloupe	Water Office.
Guyana	National Hydrometeorological Service. Water and wastewater services provided by Guyana Water Inc.
Haiti	Ministry of Environment (MDE) – appears to focus mainly on regulation of water quality.
Jamaica	Water Resources Authority. Water and wastewater services provided by National Water Commission as well as private companies.
Martinique	Water Office.
Montserrat	Montserrat Utilities Limited (MUL).
Puerto Rico	Not known
Saba	Public Entity Saba under the Ministry of Infrastructure and Water Management. Relies on desalinated water.
Saint Barthélemy	Relies on harvested rainwater and desalination.

Country	Water Resources Management Agency
Saint Martin/Sint Maarten	Relies on desalinated water.
Saint Kitts and Nevis	Saint Kitts Water Services Department Nevis Water Department – has a Water Resources Management Unit
Saint Lucia	Water Resources Management Agency, part of the Ministry of Agriculture. Water and wastewater services are provided by Water and Sewage Corporation (WASCO).
Saint Vincent and the Grenadines	Central Water and Sewerage Authority (CWSA), a Water Resources Management Unit is part of the Engineering Division.
Saint Eustatius	Ministry of Infrastructure and Water Management.
Suriname	Suriname Water Company (SWM). Responsibility for water resources management is split between the Ministry of Natural Resources (controls the exploitation and management of all natural resources) and the Ministry of Public Works (monitoring of water resources quality and quantity)
Trinidad and Tobago	Water and Sewage Authority (WASA) – the Water Resources Agency is part of WASA which provide water and wastewater services..
Turks and Caicos	Department of Environment and Coastal Resources (DECR) and Water and Sewerage Board, Provo Water Company Ltd. Relies on desalinated water
US Virgin Islands	Division of Environmental Protection within USVI Department of Planning and Natural Resources

Apart from those countries relying on desalination, water resources management might be said to follow a common trajectory. This starts with no management effort, a state that all countries have gone past. Then water utilities take steps to monitor water resources as a means of informing their water supply operations. Countries such as The Bahamas, Barbados, Grenada, Dominica, Saint Kitts and Nevis, Saint Vincent and the Grenadines can be considered to be at this stage. The focus here is on monitoring the water sources used by the utility rather than on management, and in-house expertise reflects this. The next stage is the separation of water monitoring functions from water supply functions with an emphasis on data collection at the national level. Countries such as Belize, Guyana, Saint Lucia and Trinidad and Tobago could be at this stage of development. The agencies tasked with water resources monitoring often face resource challenges that constrain their efforts. The final stage would be water resources management where data collected is used to inform management of the country's water resources. The expertise base is broader, and capabilities are greater than for the other stages. Countries such as Cuba and Jamaica can be considered to be in this position. This tentative schema does not consider the situation of those countries such as Guadeloupe, Martinique, Puerto Rico, Sint Maarten/Saint Martin, and the US Virgin Islands which are overseas territories and hence fall under different jurisdictional arrangements.

2.3 WATER SUPPLY AND MANAGEMENT

2.3.1 ORGANISATIONAL ARRANGEMENTS

CWith few exceptions, responsibility for the provision of water and wastewater services is with government though the actual ownership model differs. In some countries such as Anguilla, British Virgin Islands, and Saint Kitts and Nevis water services are provided by a government department. In other countries services are provided by a government authority or statutory corporation established by an Act of Parliament. This arrangement provides a degree of separation from government but provides very little autonomy. In other cases, water services, although still a government responsibility, are

outsourced to private entities. Examples of this arrangement can be found in those countries which rely on desalination for their primary source of water supply. Few countries have a hybrid model of service provision in which there are both public and private water service providers. The Bahamas and Jamaica are examples of private provision alongside the national water service provider, Jamaica also has a public rural water company. Haiti is another example of alternative arrangements for water service provision such a local water committees and regional service provision, as a response to the incapacity of government agencies to provide a public water service. Apart from these two countries and Belize, there are no separate arrangements for urban and rural water service provision. Service provision in Cuba is the responsibility of the country's 14 provinces and 140 municipalities through their respective water and sanitation directorates. In the Dominican Republic drinking water and sanitation services are provided by nine different decentralized government institutions that cover different areas of the country. In countries like Antigua and Barbuda and The Bahamas, self-provision is allowed, particularly in the case of hotel and tourism facilities.

The responsibility for ensuring the provision of water supply services is a government responsibility. How countries have chosen to realise this differs across the Region, often dictated by availability and sufficiency of water resources on the one hand and the ability to provide the necessary resources on the other. By and large a centralised model of government provision is the norm. Where there are differences to this model it is as a result of available resources not being sufficient to provide the service or the size of the country is such that some form of decentralisation has evolved; Cuba, Dominican Republic, and to a lesser extent Jamaica are examples. Similarly, separate rural water supply arrangements are a feature of the larger countries, but not all with Guyana and Suriname being examples.

A feature of government ownership of water utilities is that there is little independent economic regulation. Developed economic regulation of water utilities is more common in overseas territories where it forms part of national government arrangements, such as in Guadeloupe and Martinique. Belize, Guyana, Jamaica and Saint Lucia are something of an exception as they have functioning economic regulation structures being Public Utilities Commission for both Belize and Guyana, the Office of Utility Regulation and National Utility Regulation Commission (Saint Lucia) respectively. In Barbados there is the Fair Trading Commission which regulates the BWA in terms of standards of service but does not, as yet, have a tariff setting role. In other jurisdictions, efforts to bring water into an economic regulation framework have been slow on uptake. A common feature of economic regulation, where it is in place or potentially being put in place is that it covers not just water utilities but other utilities as well. A further feature is that the regulators are not totally independent as their decisions are subject to ministerial approval. Over the last ten years of so, greater efforts have been made to introduce economic regulation of water utilities, though for many countries this is work in progress; Antigua and Barbuda, Bahamas, Barbados, Dominica, Grenada are examples of countries where there have been proposals in this regard.

2.3.2 WATER DEMAND

Data on water demand and consumption in Figure 12 has been taken from the FAO Aquastat website, the figures given are either estimated or are inferred and therefore may not represent the actual water withdrawals. Data for many Caribbean countries was acquired through questionnaires sent to respective countries which therefore means it was populated based on local input. Therefore, without proper monitoring and data collections frameworks these figures remain very subjective. For example, a 2008 study of Barbados' water demand indicated that

domestic demand amount to 48% of withdrawals whilst agriculture made up 26% and tourism 12% (Cashman, Cumberbatch, & Moore, 2012) compare this with figures from 2020 which indicated that domestic withdrawals amount to 67% of the total and agriculture 16% of the total. Compare this with the FAO figures from 2015, these give withdrawals by agriculture in Barbados to be 67% and only 25% is domestic withdrawals. In other words, there is a wide discrepancy in reported figures. The point being that estimated figures have to be treated with care as reasonably accurate figures of withdrawals by sector are often not collected.

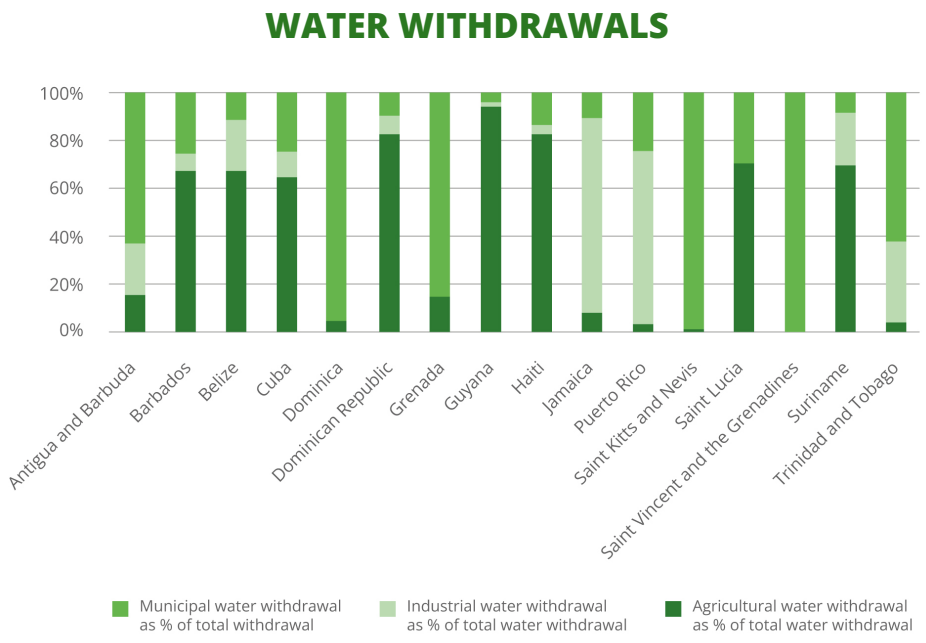


Figure 12: Food and Agriculture Organization of the United Nations (FAO). (n.d.). Water withdrawals by sector [Data set]. FAO AQUASTAT. https://www.fao.org/aquastat/

For those countries where tourism is a major economic sector, agriculture has often declined in importance, and this is reflected in the relative contribution to water demand. Domestic and tourism-based water demand take the greatest proportion of water supply withdrawals. For the countries in which agriculture is a major activity such as Belize, Cuba, Guyana, Haiti and Suriname, it takes a significant proportion of water withdrawals. In countries with a more mixed economy such as Jamaica, Puerto Rico and Trinidad and Tobago industrial demand is more significant.

Countries such as Dominica, Grenada, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago, which utilise surface water resources, experience constrained demand[1] during the dry season. Levels of constrained demand of up to 50% of normal have been reported. This is less of an issue with respect to those countries utilising groundwater but even here, prolonged dry periods often cause supply issues. Problems with meeting water demand, particularly during the dry season are exacerbated by the generally high levels of Non-Revenue Water (NRW) losses from transmission and

1 Constrained demand is where the demand is constrained by what can be supplied. Demand would be higher if there were more abundant supplies.

distribution systems. Figures presented by Jansen, Burkhard and Jones (2021) show that for ten water utilities surveyed levels of NRW ranged from a high of 73% of production to a low of 20% - only two of the 10 had levels of NRW below 30%.

BELIZE'S WATER DEMAND

Estimating Belize's water demand illustrates some of the practical difficulties involved. Only Belize Water Services customers are metered and hence their consumption can be measured. Belize Water Services serves approximately 290,000 out of a population of around 440,000. The rest are supplied by village and community schemes, for which there are no records of production or consumption. Many industrial undertakings have their own source of water. Similarly for the agricultural sector. Obtaining a water abstraction license is at the moment voluntary and there are no enforceable requirements to keep records of volumes abstracted. Therefore estimating the country's water demand with any degree of certainty is challenging.

Challenges Estimating Water Demand – An example from Belize

There has been little analysis of trends in water consumption, the factors affecting consumption (e.g. rainfall, income levels, etc.), and levels of demand across countries in the Region. The reasons for the lack of analysis are varied but it does mean that it has a detrimental impact on evidence-based decision-making. However, there are trends which will influence consumption and demand. With few exceptions, population levels are expected to have declined by 2050 though levels of urbanisation are expected to increase. There is an established trend that per capita consumption among urban populations tends to decrease over time. Thus, for many countries it might be expected that domestic water consumption will either remain unchanged or decrease. Commercial and industrial consumption, ceteris paribus, is likely to show a similar trend to domestic consumption, especially as governments faced with the impact of climate change encourage water use efficiency. Tourism demand is expected to continue to increase, especially in the countries that are most economically dependent on tourism. Agricultural water demand can be expected to increase, especially in response to a drying climate. Overall, water demand is expected to increase, by up to 30% (Rodriguez, et al., 2022). Whether this can be met given the impacts of climate change without resorting to growth in desalination is yet to be seen. Over the past decade, 68 new desalination plants have been built across the Region, with a capacity of 0,782 Mm3 of water per day. Urgent efforts to address NRW losses would have a significant positive impact on the ability to meet future demands. Potentially, reuse of treated wastewater could also contribute to meeting future water demands but realising this is at least a decade away.

2.3.3 WATER SUPPLY MANAGEMENT

Many Caribbean water utilities have financial and operational challenges. In terms of financing, the ability of water utilities to cover their operating and maintenance costs is constrained by tariffs being set at levels that do not allow them to cover these costs. Independent economic regulation not only underpins service standards but also promotes the adoption of a tariff system that enables the utilities to perform and be rewarded (or even sanctioned) relative to performance. The inability to pass on fluctuations in the cost of energy, which along with staff costs make up a large proportion of operating costs, adversely

affects the ability of utilities to adequately fund their services. In countries where seawater desalination is the source of water supply, for example, Cayman Islands and Turks and Caicos, water tariffs are set at levels which cover operational costs. In most cases capital expenditures are financed through central government or by loans that have government guarantees. For many countries, the ability to fund capital works is constrained by government indebtedness, and a reluctance to raise tariffs and pass on the operating and maintenance cost of providing water services to customers. For many countries tariffs barely cover the cost of operating expenses and therefore, in most cases cannot cover capex.

Quality of service refers to the reliability, continuity, and responsiveness of the services provided and also includes the quality of water provided and the quality of wastewater that is collected and disposed. Among the utilities approached for the study, only 3 provided data (Belize, Jamaica and Suriname). It was inferred that either many water utilities did not have much data or for utilities that do have data, it was not consolidated and made available. On this measure it was assumed that most water utilities do not place sufficient emphasis on quality of service (Jansen, Burkhard, & Jones, 2021).

Financial performance for a water utility is usually measured with indicators for profitability, liquidity, and efficiency of the capital structure. Only six utilities provided data on five measures. On the measure of Earnings Before Interest, Taxes, Deductions and Amortization (EBITDA) the average margin was 12% (Good is between 5% and 20%) and net income margin was -5%. The highest return on assets measure was 8.7% with the lowest being -11%. Of the eight utilities that provided figures half of them had negative returns on equity. The debt to assets ratio indicates how much of a utility's assets are financed with debt. With the exception of Jamaica's National Water Commission, utilities in the sample tend to have a debt to asset ratio below 40%, which is low for water utilities and indicates that they may be able to take on more debt to finance fixed assets (Jansen, Burkhard, & Jones, 2021).

Based on measures of operational efficiency, the study concluded that most water utilities in the Caribbean need to improve their operating efficiency. The measures considered include reducing levels of leakage, staff productivity, gross accounts receivable days, and collection rates. Staff per 1000 customer connections is a commonly used metric with a figure of between 5 and 6.5 being considered good. Reported figures ranged from 12.5 to 4.4 with an average of 6.8. Staff cost as a percentage of operational expenditure ranged from a high of 62% in the case of Suriname to 11% in the case of the Bahamas, with an average of 35%. In addition to staff costs, electricity costs are also a key component of operational costs, except for Guyana and Jamaica electricity costs were found to be at or below 12% (Jansen, Burkhard, & Jones, 2021).

2.4 CIRCULAR ECONOMY

The water sector is said to utilise an 'Take-Use-Discharge' (Mbavarira & Grimm, 2021) strategy in the linear operational model. Water is captured and abstracted from various sources, treated, transferred and used by various consumers, and then returned to the environment. The concept of water in a circular economy aims to transition from the linear to a circular model where water is repurposed and reused to reduce the abstraction and consumption of 'new' water introduced into the system, mimicking the natural water cycle. The aim is to reduce water consumption, recover and reuse materials from wastewater including biosolids, heat and minerals, and reducing adverse environmental impacts. In doing so it enhances resilience to climate change. One of the critical components of the circular water

economy is water resource recovery. This involves treating wastewater and other water sources to remove contaminants and restore water quality so that it can be reused. This conserves water resources and reduces the need for new water sources, reducing the environmental impact of water extraction. Another critical aspect of the circular water economy is water resiliency. This involves improving the ability of communities and systems to withstand and recover from water-related shocks and stresses, such as drought or flooding. This can be achieved through water storage, rainwater harvesting, and improving water distribution systems.

At present very little wastewater is collected and still less treated (Emanuel, 2010); figures from UN Water's SDG 6 Portal for which data are available indicate the following percentage collected and treated: Cuba 62% and16%, Dominican Republic 20% and 9%, Guyana 3% and 1%, Jamaica 23% and 9%, and Trinidad and Tobago 20% and 19%. Hence the volume of water that could be available for reuse is limited and to increase the volume would require significant investment in collection and treatment systems. In parallel with this are the regulatory requirements that treated wastewater would have to comply with before reuse could be considered. However, circumstances and attitudes are changing. Barbados, Jamaica and Trinidad and Tobago have introduced water quality standards for wastewater reuse as a first step to encouraging reuse for agriculture and landscaping. In most cases this is a voluntary standard and uptake is hampered by a lack of suitable infrastructure to utilise treated wastewater as a source. In Jamaica the Soapberry Treatment Plant, a public-private partnership, treats wastewater to a tertiary level for reuse (Silva, 2015); Trinidad and Tobago also has recent tertiary level treatment plants. There are plans in Barbados to upgrade the two sewage treatment plants to tertiary treatment level and to utilise the treated wastewater for agriculture and managed aquifer recharge. Under the GEF CReW + project, 12 participating Caribbean countries efforts and pilot projects are being undertaken to address wastewater management issues and encourage reuse. The project is supporting institutional, policy, legislative and regulatory reforms for Integrated Water and Wastewater Management (IWWM) such as the development of wastewater reuse standards e.g. for Trinidad and Tobago, sustainable financing options for IWWM such as revolving funds and credit enhancement facilities, and the provision of innovative small-scale, community-based solutions for IWWM as pilot demonstration projects. The overarching aim is to create the enabling conditions, provide the basis for expanding wastewater management and support the development of a circular economy. In Antigua and Barbuda with GEF funding the McKinnon's Wastewater Treatment Plant was upgraded to facilitate the reuse of the effluent for landscaping, sustainable livelihoods, and animal husbandry. The few other examples of wastewater reuse initiatives in the Region seem to be primarily targeted towards horticulture. For instance, some hotels have used treated wastewater effluent for golf course irrigation (Peters, 2015).

Apart from water reuse, consideration of further resource recovery has been hampered by the availability of technology and financial sustainability ensuring the covering of operational costs and return on investment. Generally, the volumes of sewerage generated and collected are low as indicated by the numbers of persons connected to centralised sewage systems. This means that for biogas for example the volumes that could be generated are low and would not be able to generate sufficient feed material to generate power at an affordable cost given the investment required. Further, the technology for

the recovery of other resources is not available in the Caribbean, would be costly to import and again the volumes would be low. A further, emerging, challenge is that more advanced treatment processes will require higher level technical skill sets and management capabilities, and consistent monitoring. All aspects for which there are deficits at present. Innovative ideas such as combining treated sludge with other feedstock for biogas reactors have been considered by the private sector with encouragement from International Financial Institutions, but to date no project has yet got off the ground. The production of biosolids from wastewater treatment plants as fertilizer has also been considered.

Rainwater harvesting RWH is widely practiced throughout the Caribbean, mostly focused on capture at the household level. The Caribbean Environmental Health Institute had estimated that up to 500,000 people in the Caribbean at least partially depend on rainwater harvesting, notably in Antigua and Barbuda, the Bahamas, the US and British Virgin Islands (USVI and BVI respectively), the Turks and Caicos and the Grenadines (of both St. Vincent and Grenada) (CARPHA, 2024). The drivers of the use of RWH are varied. In the Grenadines it is driven by the lack of viable alternative sources of water, in Antigua and Barbuda it is driven by regulations and building codes, in The Bahamas by challenges with the local water supply systems. The former Caribbean Environmental Health Institute and Global Water Partnership-Caribbean developed guidelines and standards to inform the design, installation, and management of RWH systems. With the high levels of water supply coverage, rainwater harvesting at the household level is treated as only being necessary where there were few or no other alternatives, for example, on Carriacou and Union Island in the Grenadines. More recently though attention has been turning back to the role that it could play in increasing water resilience particularly during disaster events when there are interruptions to water supply. In Jamaica, the government is supporting RWH through a rural water resilience programme, the introduction of RWH Guidelines given to planning agencies, municipalities and the National Environment and Planning Agency, to ensure that they are installed in the most appropriate manner. Barbados has planning regulations requiring the installation of rainwater tanks in new developments and is in the process of revising regulations and plumbing codes to support their utilisation. Antigua and Barbuda has long required the installation of RWH tanks for domestic purposes. Saint Lucia's Sectoral Adaptation Strategy and Action Plan for the Water Sector (Water SASAP) (2018-2028) includes interventions to use and promote RWH as a climate adaptation and resilience strategy. Grenada too has included the support and promotion of RWH in its Green Climate Fund G-CREWS project. These examples highlight the evolution in thinking around the role that RWH can play, particularly around resilience during climate related emergencies. However, challenges remain around public health and vector borne diseases, ensuring water quality, and maintenance of systems. As in the case of Jamaica, regulatory changes are needed to underpin the safe and appropriate use of RWH systems.

2.5 WATER FOR FOOD

As noted in section 1.4, the Caribbean imports a significant amount of its food needs, creating challenges for both food security[2] and food sovereignty[3] (Gordillo & Jeronimo, 2013). According to the Food and Agriculture Organization (FAO) (2021), as much as 67.5% of the Caribbean's population is currently living in moderate to severe food insecurity as compared to a global average of 27.6 per cent. Traditionally, agriculture has been focused on a plantation type economy in which agricultural commodities were produced for export, supported in part by parallel subsistence agriculture. The negative effects associated with this situation include

2 Food security is when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. FAO. (2003). Trade Reforms and Food Security; Conceptualising the Linkages. Rome: Food and Agriculture Organization.

3 Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through socially just, ecologically sound and sustainable methods, and their collective right to define their own policies, strategies and systems for food production, distribution and consumption. Friends of the Earth. (2024, May 10). Food Sovereighty. Retrieved from Friends of the Earth International: https://www.foei.org/what-we-do/food-sovereignty/

having to pay for imported goods in hard currency rather than local currency, limited bargaining power and control over quality and food safety, market fluctuations in prices and supply, market disruptions, unfavourable terms of trade, high food costs, and poor nutritional outcomes. To address the situation, governments have sought to increase local food production, the latest initiative being to reduce extra-regional agri-food imports by 25% by 2025. This follows an earlier attempt (2005) 'Strengthening Agriculture for Sustainable Development', called the Jagdeo Initiative after the then President of Guyana. This initiative sought to remove constraints to the development of agriculture in the Caribbean and encourage the growth of food production.

Moving agriculture beyond subsistence and scaling up production has proved to be a difficult task for the smaller Caribbean States, particularly in the Eastern Caribbean. The reasons include climate variability, access to land, access to capital and access to water. Agriculture requires water and most areas under cultivation are rain fed with only a small proportion under irrigation of any sort. Those areas that are under irrigation are generally flood or sprinkler irrigated, for which the irrigation efficiency is less than 40%, a waste of water. Irrigated agriculture is supported through the National Irrigation Commission in Jamaica and the National Drainage and Irrigation Authority in Guyana, and by a government ministry in Suriname. Flood irrigation is the predominant practice in Guyana and Suriname whilst in Jamaica up to 20% of irrigated areas is under sprinkler irrigation. In countries where the cost of water for agriculture is considered high, drip irrigation is often practiced. Among the Caribbean Development Bank's Borrowing Member Countries, Barbados, Haiti, and Jamaica have the largest percentage of area with irrigation infrastructure (3%, 2%, and 2%, respectively) (FAO & CDB, 2019), while Guyana, Haiti, Jamaica, and Suriname have the largest net area equipped with irrigation facilities. Among the countries with irrigation infrastructure, Haiti, and Trinidad and Tobago report the highest rates of underutilization: 28% and 15% respectively. Water consumption rates per hectare are highest in Guyana, Haiti, Jamaica, and Trinidad and Tobago (FAO & CDB, 2019). Tariffs for agriculture water are low and vary greatly across the Region; for Antigua and Barbados the rate is US$1.7/m3 and US$1.8/m3 whilst in Jamaica and Trinidad it is US$0.02/m3 and US$0.15/m3 respectively. For the Dominican Republic and Guyana the charge is US$4.75-24/ha and US$1.11/hectare/month respectively.

Across the Region, Water used for irrigation can come from 'unsafe' sources, where water quality is not monitored or regulated. If programmes are actually realised to increase food production to address food security and sovereignty issues, then there will have to be an increase in area under irrigation. Climate change with its impact on water availability and increased temperatures will just add further to that imperative. This being the case, there is likely to be growing competition for water resources and at present few countries have the regulatory instruments (e.g. licensing and allocation mechanisms) in place to resolve competition issues or realistic water pricing policies to encourage water use efficiency. More work needs to be done to understand what the implications of agricultural expansion and climate change are for water resources and availability and how best to support food security and sovereignty.

2.6 WATER-ENERGY INTERLINKAGES

In countries like Anguilla, Barbados, Guyana, Jamaica and Saint Lucia, the water utilities are major energy consumers. Recognising this some of the utilities have started to investigate the use of renewable energy to offset their electricity needs, with Barbados probably having advanced the furthest in terms of installed capacity.

The hydropower potential of the Eastern Caribbean Islands is not very large. The major issue here lies in the Caribbean islands not having enough mountains or enough rainfall to sustain hydropower plants. The focus is mainly on small hydropower plants as illustrated by the fact that only Dominica and Saint Vincent and the Grenadines have developed hydropower plants. A further challenge is seasonality - in Saint Vincent the generating capacity is 5.6 MW but reduces to 2 MW during the dry season. The combination of factors makes it unlikely that there will be any significant moves to increase installed hydropower generation in these islands.

In comparison to the situation of the Eastern Caribbean countries the continental Caribbean countries of Belize, Guyana and Suriname do have significant hydropower potential. Both Belize and Suriname have tapped into their hydropower potential supplying 40% of Belize's power (GoB, 2021) and 60% in Suriname (Republic Bank). The three major hydropower dams in Belize also provide flood control. In Cuba there are two multi-purpose dams which generate power and supply water for irrigation. Haiti has 3 hydropower dams and in Dominican Republic only 4 of the 16 hydropower dams are not multipurpose, supporting irrigation, water supply and flood control. Although there have been feasibility studies in Guyana so far, no concrete steps have been taken. In Barbados, a private investor explored the development of a pumped storage hydropower facility, and concluded it was not feasible.

Attention is also being given to realising the geothermal potential of Eastern Caribbean countries (Koon-Koon, Marshall, Morna, McCallum, & Ashtine, 2020), which will require a source of water for the steam generated to drive the turbines. So far only Guadeloupe has installed a geothermal plant – 15 MW. The six islands of Dominica, Grenada, Montserrat, Saint Lucia, Saint Kitts and Nevis, and Saint Vincent and the Grenadines all have untapped geothermal potential. The countries vary in their stage of developing the potential, with Dominica having established a geothermal development company.

In terms of offsetting the cost of producing, treating and distributing potable water, and collecting, treating and disposing of wastewater, it is expected that the focus for renewable energy will continue to be on developing solar power generation.

2.7 WATER SECURITY AND DEVELOPMENT

Water security is going to be impacted by three fundamental drivers of change: demographics, economy, and climate change. With a few exceptions, over the next 20 years the population of Caribbean countries can be expected to plateau and, in some cases, decline (Loop News, n.d.). This has already started to happen in Dominica and Saint Vincent and the Grenadines. This trend is accompanied by an ageing population and, without intervention there will be a decrease in the number of those in work supporting those not of working age. At the same time, living standards have increased. Both trends will exert an influence on water consumption patterns. In terms of economy, the open nature of Caribbean economic activity offers little insulation against external shocks and changes. Weak economic performance limits the ability to provide services and increases the hard choices as to how limited government revenues are to be spent. Given the reliance of the water sector on government support, weak economic performance could have a disproportionate adverse effect on the provision of water services unless there are changes in how the sector is financed. Climate change and climate variability will directly affect water availability, directly impact water infrastructure through extreme events, and indirectly through its impact on economic performance and hence the ability to invest in water infrastructure. Many utilities in the Caribbean are

playing "catch up" with development where in many cases the primary investment priority is providing water supply coverage to unserved/underserved areas rather than building in future resilience and addressing the ageing and deterioration of existing infrastructure

Other challenges include how water utilities are embracing new technologies and priorities to increase water use efficiency, by consumers as well as themselves. In this context, Caribbean countries will have to consider how to achieve a greater degree of integrated planning, spanning more than just the water sector, reflecting on how water services can be managed and delivered in ways that are responsive to the emerging challenges, and minimise costs.

APPLICATION OF TECHNOLOGY IN SAINT KITTS

The Saint Kitts Water Services Department has installed 20 automatic water level measuring devices in its treated water storage tanks. This enables the Department to monitor storage levels in real-time and better manage water distribution and reduce reservoir overflows. Overall it has improved system reliability and resilience in meeting water consumption needs.

Preventing water wastage and improving supply

3. WATER FOR HUMANS AND NATURE

KEY MESSAGES

- 70% of domestic sewage enters the Caribbean Sea untreated.
- An average of only 17% of households across the Caribbean are connected to a wastewater collection and treatment system.
- Most households use septic tanks for the management of their wastewaters.
- Countries have signed up to the Land Based Sources of Marine Pollution Protocol, providing the policy environment to tackle inadequate wastewater management.
- Countries are upgrading their wastewater standards and some are introducing treated wastewater reuse standards.
- Financing is an issue but innovative financing mechanisms are being developed to lower the cost of provision.
- Collection of data on water and wastewater coverage is inadequate and is usually only carried out as part of population censuses.
- Although access to piped water supply is high, countries experience challenges in meeting water demands particularly during the dry season due to restrictions on resource availability and high levels of non-revenue water loss.
- There is a gap in work determining the presence of Chemicals of Emerging Concern and microplastics in source waters and supplies.
- Biodiversity is being significantly impacted by pollution and levels of abstraction.

3.1 WATER QUALITY

Poor water quality affects public health, ecosystems, and economies. Various factors contribute to degraded water quality, ranging from human activities to natural processes (Lin, Yang, & Xu, 2022). Understanding the drivers of poor water quality is crucial for implementing effective management strategies and safeguarding water resources for current and future generations. The drivers of poor water quality in the Caribbean include: pollution from agricultural activities; urban runoff, stormwater runoff and industrial effluent discharges; deforestation and land-use changes; inadequate sanitation and improper waste management practices; and invasive species and pathogens (GWP, 2014) (CReW+, n.d.). Other drivers include ecosystem alteration and climate change through rising temperatures, altered precipitation patterns, and extreme weather events. Addressing these drivers requires comprehensive strategies that integrate pollution prevention, sustainable land management, climate resilience, and improved water governance – in other words Integrated Water Resources Management.

Many countries in the Caribbean use the WHO Drinking Water Guidelines as their standard, as this makes more sense than to try to develop their own. In any case few have the technical capacity to do so. Even though the WHO Drinking Water Guidelines are used, they have not been adopted under secondary legislation to legalise their standing as the regulatory standard for the various parameters. Countries have also developed their effluent water quality standards, the approach adopted being to set limits on water quality parameters, and not adopt an ambient standard approach whereby the status of the receiving waters are taken into consideration. Under the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Area, the Land Based Sources of Marine Pollution Protocol (LBS Protocol) seeks to mitigate marine pollution to the Convention area from land-based sources of pollution, specifically targeting domestic wastewater and agricultural non-point sources of pollution. Annex II outlines and established the process for developing regional standards and practices for the prevention, reduction and control of the sources and activities and Annex III established specific regional limitations for domestic sewage. The Protocol came into force in 2010. While there are standards, the ability to regulate and enforce them continues to be a problem across the Caribbean. This is particularly so with respect to wastewaters and effluents discharges.

3.1.1 SANITATION

Access to improved sanitation is generally high across the Region, except for Haiti, with percentage access in the high 80's going up to 100% in some instances, Figure 15. However, in respect of the percentage of the population with access to safely managed wastewater systems the figures drop substantially. About 52% of households in the insular Caribbean lack sewer connections and only 17% have acceptable collection and treatment systems (GEF CReW, 2015) and less than 2% of urban sewage is treated before disposal (Peters, 2015). In Haiti, human waste disposal is the most urgent problem. There are no sewage collection services and only 40% of the population, mostly urban residents, use latrines and septic tanks. Eighty to 90% of the solids from these are dumped illegally into rivers and the sea (UNEP CEP, 2010). Few countries have centralised or decentralised sewerage services by a wastewater service provider. Dominican Republic, Trinidad and Tobago and Jamaica have the highest coverage rates of 49%, 30% and 22% respectively, the majority of Caribbean countries have access levels of 5% or less. Even in cases where there are sewer collection systems the majority do not treat sewage other than screen it before disposal to water bodies.

Although water utilities are responsible for water and wastewater services, the provision of wastewater services has lagged far behind, as highlighted by the low levels of population connected to sewerage systems. The use of septic tanks is the principal means of disposal across the Caribbean. As a result of the low levels of sewerage services, it has been estimated that between 70% and 80% of domestic wastewater is discharged into the environment partially treated or untreated (CReW+, n.d.). There are continuing efforts to address the situation. In 1999, governments of the Wider Caribbean Region agreed to the Protocol on the Control of Land Based Sources of Marine Pollution (LBS Protocol), part of the Cartagena Convention. The LBS Protocol that came into force in 2010 committed governments to making major improvements in wastewater management. Countries have wastewater discharge standards as part of their environmental regulations; however, application and enforcement is often an issue.

In the 2006 State of the Marine Environment Report (GEF-CReW, 2016) highlighted that significant financial constraints exist: there is a lack of adequate, affordable financing available for investments in wastewater management. In response, the Global Environment Facility-funded Caribbean Regional Fund for Wastewater Management (GEF CReW) began in 2011 and was succeeded in 2020 by GEF CReW+ to continue the work. It has to be acknowledged that change is not going to happen overnight and the role of the CReW+ project has been one of fostering incremental change through demonstration projects. Examples that the project has supported include a draft National Wastewater Policy and reforming the Wastewater Revolving Fund in Belize, Technical Regulations for Control of Discharges to Surface Water, Sanitary Sewage and Coastal Waters, legislative changes to wastewater reuse standards in Trinidad and Tobago, Nature based solutions for quarry rehabilitation in Nevis, and a revolving fund for decentralised wastewater treatment in Barbados. The CReW+ Academy, the capacity building component has been offering MOC (Massive Online Courses) topics such as “Development of Project Formulation Skills Focused on Integrated Wastewater Management” and “Compendium of Sanitation Systems and Technologies for the Wider Caribbean Region”.

The LBS Protocol and the CReW+ project have focused primarily on trying to address point sources of environmental pollution, which discharge regulations are also part of. This is understandable as they are relatively more easily tackled, at least in technical though not in financial terms. Yet the more complex problem of diffuse pollution through inappropriate agricultural practice, domestic sewage, and urban stormwater management pose challenges that are difficult to address.

Information on state of wastewater management and sanitation across the Region is patchy. The data portal of UN Water Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS) only contains, incomplete, information on 10 Caribbean countries provided in response to requests for data. In the UN Water Global SDG Indicators Database:

- SDG 6.1.1 Population using safely managed drinking water, 9 countries have data.
- SDG 6.2.1 Open defecation, 21 countries have data.
- SDG 6.2.1 Handwashing facilities, 8 countries have data.
- SDG 6.2.1 Safely managed sanitation services, 6 countries have data.
- SDG 6.3.1 Safely treated wastewater, 6 countries have data.
- No data is available for the other SDG indicators for 24 Caribbean countries.

The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene database does contain more complete information. Even here there are five countries for which there are no data for drinking water, sanitation or hygiene coverage: The Bahamas, Dominica, Grenada, Saint Kitts and Nevis, Saint Vincent and the Grenadines, and the US Virgin Islands plus a further 10 with incomplete information. In other words, comprehensive, good quality data on the state of water, wastewater, sanitation and hygiene across the Caribbean are lacking. The coverage in terms of type of sanitation facility and level of service coverage are shown in the following Figure 13, 14 and 15. However, given the data challenges mentioned above, these figures should be treated with caution. For example, the data suggests that there a few septic tanks in Barbados, which is something that would be disputed by the authorities there. It also suggests that Puerto Rico has 100% sewer coverage, which could also be questioned.

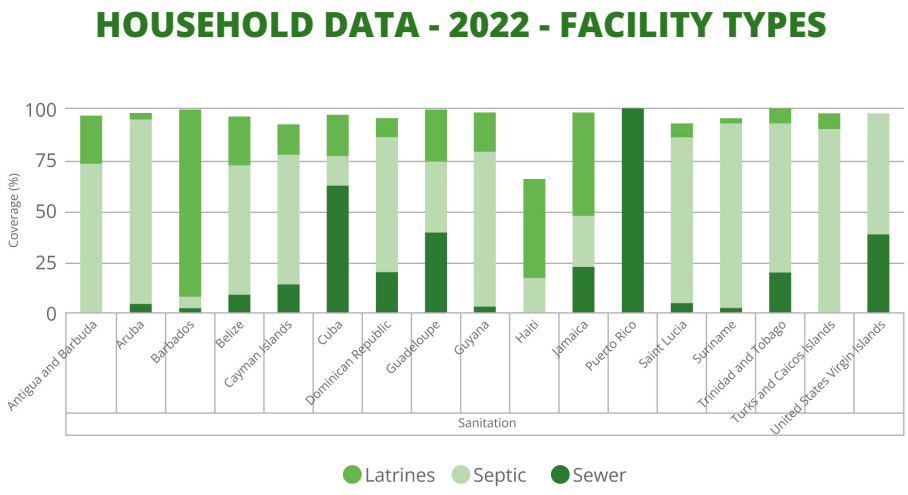


Figure 13: World Health Organization (WHO) & United Nations Children's Fund (UNICEF). (n.d.). *Sanitation coverage by type of facility* [Dashboard]. WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene. https://washdata.org/data/household#!/dashboard/new

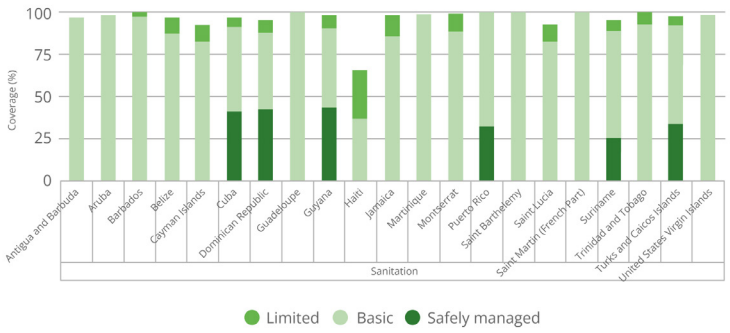


Figure 14: World Health Organization (WHO) & United Nations Children's Fund (UNICEF). (n.d.). *Sanitation coverage by service level* [Dashboard]. WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene. https://washdata.org/data/household#!/dashboard/new

WASTEWATER DISPOSAL FACILITIES IN THE CARIBBEAN (% OF TOTAL POPULATION)

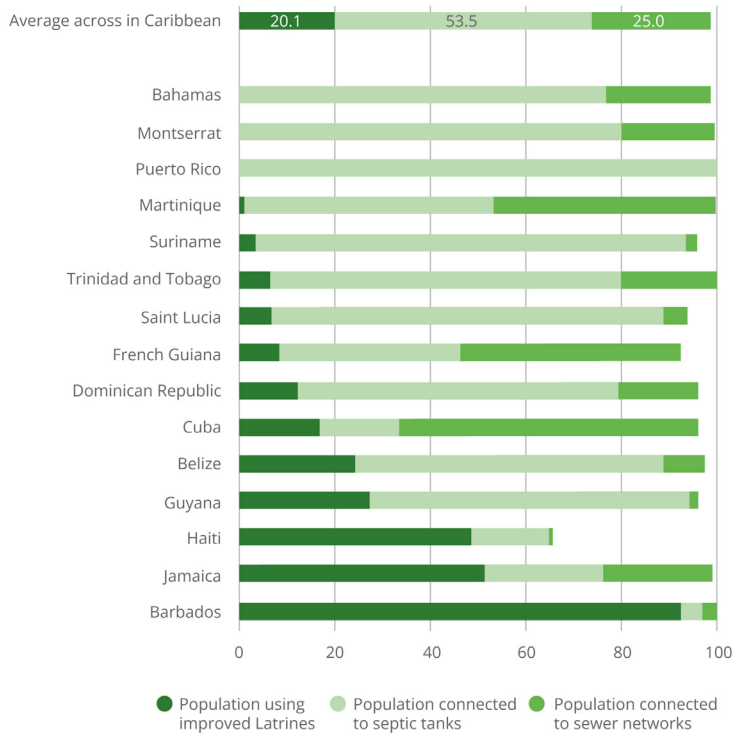


Figure 15: World Health Organization (WHO) & United Nations Children's Fund (UNICEF). (n.d.). Wastewater disposal facilities across the Caribbean [Dashboard]. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene. https://washdata.org/data/household#!/dashboard/new

The challenges of enforcement can be illustrated by an example from Belize. The Belize Environmental Protection Act sets out provision for monitoring environmental water quality and issuing discharge licenses. In Belize's Department of the Environment's 2021-22 Annual Report section on monitoring water quality along the Belize River (DOE, 2021), a major source of water supply, analyses were conducted for compliance on 21 wastewater treatment facilities. Of the 21 tested only 3 met the discharge requirements for the Effluent Limitations Regulation. In Cuba according to a 2006 report there were reported to be only five wastewater treatment plants, and all of them were "inoperative", presumably because of lack of spare parts and maintenance. Since then, the situation has improved, while the systems are overloaded and maintenance continues to be an issue, the plants are at least partly operational (Perez, Cardona, & Solo-Gabriele, 2010). In Trinidad and Tobago, 200 wastewater treatment plants installed as part of housing developments have been effectively abandoned as no arrangements were made for their management and operation. The national water utility, WASA with assistance of the Inter-American Development Bank (IDB) has been preparing an action plan to rehabilitate them and improve the institutional arrangement for the wastewater sector to address the situation.

Progress is being made in providing wastewater services in municipal areas. Guyana is to invest some US$40 million to provide additional wastewater services in the capital Georgetown (NewsRoom Guyana, 2023) and the Barbados Water Authority is about to embark on the upgrading to tertiary level treatment of the two wastewater systems serving the Greater Bridgetown area at a cost of some US$150 million (pers com BWA Managing Director). Grenada, with funding through the UK CIF programme is looking to upgrade the Grand Anse sewage system to beyond tertiary treatment. In Jamaica, the Soapberry Wastewater Treatment Plant is operated by the Central Wastewater Treatment Company Limited through a public-private partnership with the country's water utility the National Water Commission and is looking at the feasibility of making treated water from the plant available for irrigation purposes. It is the smaller economies that are facing challenges in how to provide and extend sewerage services in urban areas. The Jamaica example suggests that there are alternative arrangements that can be employed and that sewerage services do not have to be provided through state owned enterprises.

CARIBSAN: NATURE BASED SOLUTIONS FOR WASTEWATER TREATMENT

CARIBSAN is a cooperative project deploying Nature Based Solutions to address wastewater treatment. Partners include Office De L'Eau Martinique & Guadaloupe, Office International de L'Eau, National Research Institute for Agriculture and Environment France, WASCO, DOWASCO and the Instituto Nacional de Recursos of Cuba. It is a €1.7 million project financed by the European Union INTERREG Caribbean programme, the French Development Agency and the Office de L'Eau.

In Phase 1 a multi-criteria analysis guide for wetlands was developed, 3 implementation sites were selected, technical cooperation among 5 territories, communication & awareness raising, technical training on ecological wastewater treatment solutions.

In Phase 2 construction of the 3 wetland treatment demonstration plants, develop a site selection tool, development of partners' skills in sanitation, and technical support.

CARIBSAN

3.1.2 POLLUTION

Poor watershed management leads to erosion of valuable topsoil erosion and the transport of agricultural pollutants (CARPHA, 2015) through runoff into surface waters, they also are transported into and affect the marine environment (Rogers & Ramos-Scharron, 2021). Poor watershed management not only increases runoff but can increase streambank erosion and landsliding. More intense rainfall events are expected to exacerbate the effects. The Concord watershed in Grenada provides a typical example of the effects of poor watershed management; sedimentation, agrochemical pollution, extensive and soil erosion due to agricultural activities occur near an abstraction location. These have caused sedimentation at the intake and higher cost associated with silt removal through water treatment (Jackson, et al., 2004).

Lack of enforceable or lax development controls also play a role. Given the topography of many Caribbean countries, urban sprawl has led to development creeping upslope further contributing to the alteration of drainage pathways, increased runoff velocities and mobilisation of urban

associated pollutants such as hydrocarbon, litter and plastics. The loss of sediment capturing coastal environments – mangroves and wetlands has exacerbated sedimentation impacts. Managing and reducing pollution requires the combination of land and water management, and involvement of communities. Belize has developed a watershed management plan for the New River Watershed (DOE, 2022) to address the impacts of agricultural activities, deforestation as well as rural and urban growth, and degradation of water quality from excessive pollution from organic materials. The study offers a microcosm of how poor and uncontrolled management of watersheds leads to adverse impacts on water resources, both quality and quantity, resulting in the negative impacts observed on biodiversity and human health.

In Trinidad, erosion, sediment runoff and pollution from active and abandoned quarries are persistent problems affecting watercourses. Many quarries are unlicensed and so subject to no environmental controls, and some are located near sensitive ecological areas. Poor regulation over the years has led to indiscriminate quarrying, resulting in severe land degradation as existing vegetation and topsoil is cleared leading to loss of habitat, wildlife and flora. Watercourses are polluted by large quantities of sediment from erosion and from wash plants affecting both the potable water treatment for a third of the population and coastal water quality badly. Under the Global Environmental Facility funded Integrating Water, Land and Ecosystems Management in Caribbean Small Island Developing States Project (IWEco) several initiatives were implemented to tackle this problem through the adoption of Nature-based Solutions. In Trinidad pilot projects were undertaken at two sites which included site preparation and planting, creation of check dams and fire tracing, nursery development, top-soil conservation and management, mulching and implementing vetiver as a rehabilitation intervention. In addition, on-site land and forest cover investments in a minimum of 40 hectares over the target watershed areas, are expected to contribute to carbon sequestration over the life of the project (IWEco, 2019). In Saint Kitts and Nevis a similar issue was tackled also through IWEco. The project addressed the impacts of acute land degradation in the College Street Ghaut in Saint. Kitts and Quarries and Sand Mining Hotspots on Nevis. The project activities focused on reforestation, wetlands rehabilitation and beach restoration.

In Jamaica, open cast bauxite mining has been practiced for the last 60 years. Open cast mining produces substantial quantities of treated waste material – red mud, and caustic soda used to extract the aluminium ore. It has been claimed that the activities relating to bauxite mining have polluted rivers and underground water sources and that often there is insufficient monitoring of groundwater and surface waters. In the Kingston Metropolitan Area contamination of the Liguanea aquifer by soakaways and poorly maintained septic tanks has resulted in high levels of pollution that have created a 'water quality' drought particularly during dry seasons.

LAND AND ECOSYSTEM DEGRADATION IN THE UPPER SOUFRIERE WATERSHED, SAINT LUCIA

Deteriorating economic conditions within the wider watershed contributed to unsustainable practices increase in erosion in the watershed, an increasing incidence of flooding and poor water quality through inadequate disposal of liquid and solid waste. The project brought together the Forestry Dept., the Sustainable Development Dept., the Solid Waste Management Authority, the Saint Lucia Hotel and Tourism Association, and the community-based Trust for the

Management of Rivers. The interventions included reforestation and rehabilitation of lands and riverbanks , landscape restoration with farmers to sustain livelihoods and introduction of agroforestry promoting biodiversity friendly goods and services. An outcome has been the better management of pollution originating from both sewage and domestic animals in the watershed.

Watershed management

3.1.3 HUMAN DEMANDS

Figures from the UN Water SDG database show that with the exceptions shown in Figure 16, over 95% of the population of the Caribbean is using improved drinking water. Furthermore, in only two countries is the access to piped water supply into the home less than 50%. Figure 17 gives a breakdown access to drinking water supplies by service level. While headline data on water supply and sanitation is collected and reported, usually by way of national population census, finer grained analysis and reporting is usually undertaken on as needed basis. This means that trends in per capita consumption or analysis of non-domestic demand for example are also seldom undertaken, hampered also by difficulties in obtaining accurate demand and consumption data; often only national level information can be found. Linking this with socio-economic data to inform service provision is also seldom undertaken, most likely due to a lack of capacity either at the ministry or utility level. Thus, it is difficult to provide insights into consumption trends. The levels of per person consumption varies widely across the Caribbean, though gathering data on this is challenging. Reported levels vary between 420 litres per person per day (during the dry season) in Trinidad and Tobago (ESL, 2021), 280 litres per person per day in Belize, 200 in Barbados, 172 in Jamaica according to the National Water Commission and 165 litres per person per day in Grenada, and between 50-100 litres per person per day for persons reliant on harvested rainwater (Peters & Monrose, 2015). These are averaged national level figures and do not reflect differences across income and residential groups or water supply systems nor variations across seasons. As a result, this information is not used to inform water supply operations and management scheduling.

ACCES TO PIPED WATER SUPPLY

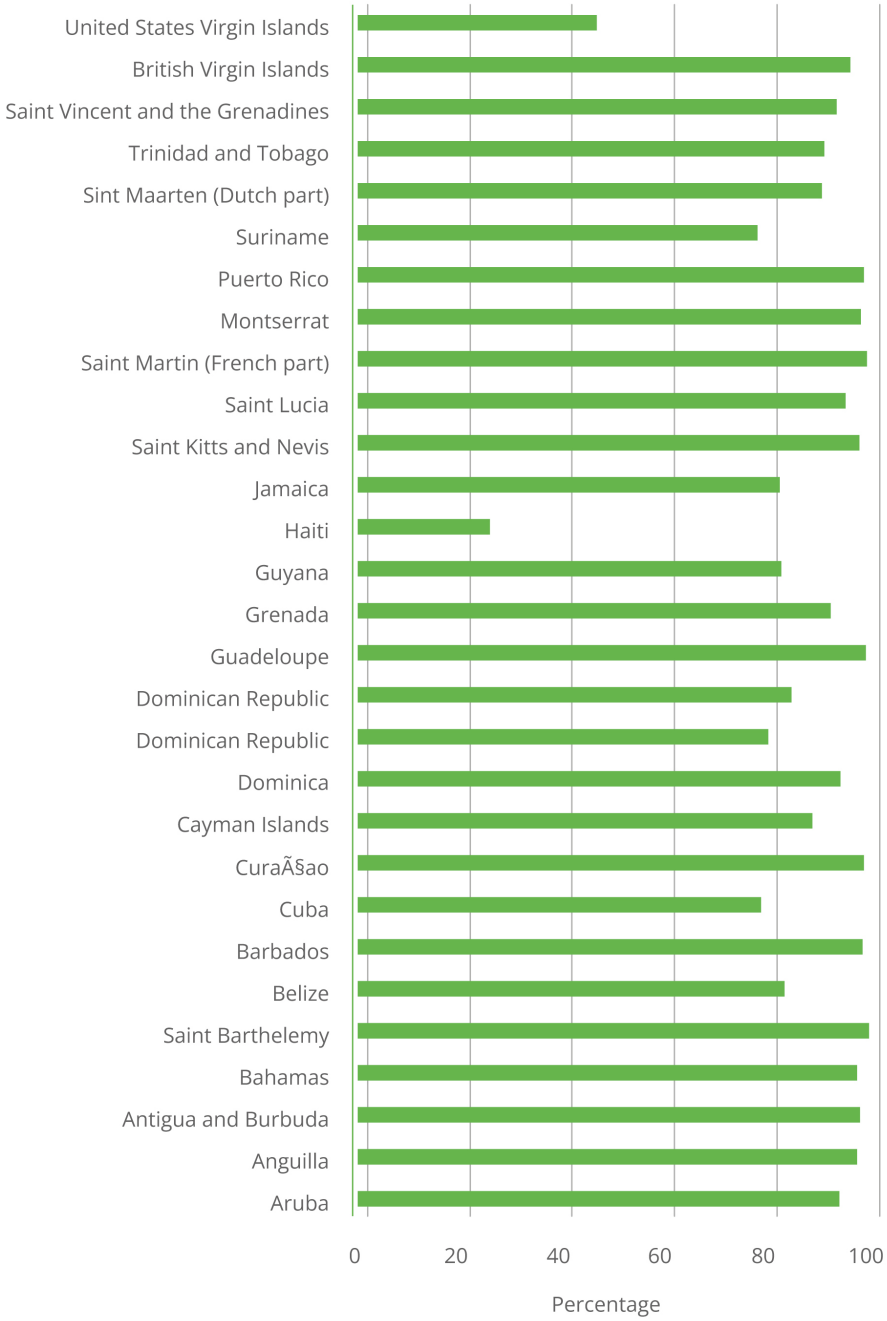


Figure 16: World Health Organization (WHO) & United Nations Children's Fund (UNICEF). (n.d.). *Access to piped water supply* [Dashboard]. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene. https://washdata.org/

HOUSEHOLD DATA - 2022 - SERVICE LEVELS

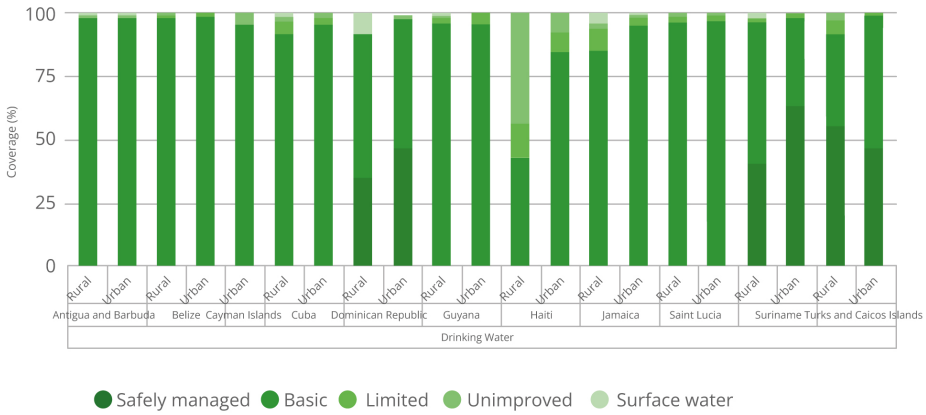


Figure 17: World Health Organization (WHO) & United Nations Children's Fund (UNICEF). (n.d.). *Access to drinking water supply by service level* [Dashboard]. WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene. *https://washdata.org/*

The Covid-19 pandemic had a significant impact on Caribbean economies, particularly those reliant on tourism. The virtual collapse of tourist arrivals reduced hotel water consumption and also resulted in other changes in consumption patterns. The effects of the pandemic on water consumption in Barbados and Trinidad was investigated (Roopnarine, et al., 2023), though assessing the impact on domestic consumption in Trinidad was problematic due to a lack of metering to measure consumption, In Barbados, where there is universal metering, there was nearly 10% increase in consumption accompanied by a 60% decrease in hotel consumption and a 20% decrease in commercial consumption. The available figures for Trinidad indicated a 10% decrease in residential consumption but this was put down to a) a lack of metering and b) the classification of schools in the residential category. Commercial consumption which included health facilities, increased by 10% probably reflecting increases due to health and hygiene requirements.

Limitations on supply and constrained demand has been an issue in the Region. Barbados is utilizing about 87.5% of its available water resources, Saint Lucia has a water supply deficit of approximately 35%, and Nevis of 40%, Trinidad has had a water supply deficit since 2000 (WASA, 2005), Jamaica is projected to experience deficits in supplies to areas of important economic activity (GoJ, 2011), Antigua and Barbuda are reliant on desalination to meet their demands for water; whilst in Dominica, Grenada and Saint Vincent and the Grenadines demand exceeds supply during the dry season due to reduction in stream flows (UWI/GoB, 2012). Ageing water infrastructure and low pipeline replacement rates are thought likely to contribute to challenges in meeting human demand for water in the future.

Concerns have been expressed regarding the impact that seasonal spikes in tourist arrival numbers can have on local water demand and consumption patterns and by extension on the

LA HAUT WATER STEWARDSHIP PROGRAM, SAINT LUCIA

The Saint Lucia Water Utility partnered with the Windward and Leeward Brewery Ltd. (Heineken) to develop a business case to address water security issues in Vieux Fort area. The need was to increase access to potable drinking water for the local community reduce the health risks associated with the consumption of inadequately treated water, reduce water supply interruptions and improve community resilience during extreme conditions. The development partnership was able to mobilise technical and financial resources to improve the local water security situation and in doing so create additional economic opportunities in the area.

Water Partnerships

ability of sources and infrastructure to meet them. In the case of Barbados there is a slight but weak correlation between tourist arrivals and hotel water demand, generally though this type of analysis has not been systematically carried out or reported on in or across territories. In Barbados in 2022, there were 540,000 stayover tourists with an average length of stay of about 10 days. For those that stay in hotels the average water consumption can be up to three times more than that of residents – not all tourist arrivals stay in hotels though, especially with the rise of Airbnb type accommodation. This is a significant additional water demand and as countries seek to grow their tourism industry to benefit their economies, questions are being raised regarding competition for water supply and increased demands on often limited water sources. It is not clear as to what is being done across the region to address potential issues and conflicts around access to water supplies, and infrastructure investments needed to maintain services and supplies.

Access to water is multi-dimensional (Cashman, 2014), and must take into account adequacy of the sources, accessibility, assurance of supply and affordability. For example, although water supply coverage in Trinidad is nearly 100%, many of those who are connected do not receive water 24/7/52. There appears to be a growing acceptance that providing a continuous water supply is likely to be increasingly challenging for water utilities and in response many are encouraging consumers to install personal water storage tanks[4]. Several countries are including personal tank programmes for consumers as part of their water supply strategies with the rational that this increases resilience during supply interruptions and in emergency situations (Cashman, 2023).

An area of potential concern for water supplies, but where little research has been carried out, is around contaminants of emerging concern (CEC) and microplastics. One reason for this is that little testing is done to identify them and concommitant with this are the resources to be able to do so. Carr, et al. (2023) investigated the presence of organic chemicals in sediments in Cienfuegos Bay, Cuba. They identified local sources as being nearby industrial sources, recycling plants, urban waste outfalls and a cement factory and highlighted the need for further research concerning the rapid influx of these emerging contaminants. Research into the potential of Saharan Dust to transport persistent organic pollutants, trace metals and viable microorganisms to the Caribbean demonstrated that these were detected in dust episodes from Trinidad north to the US Virgin Islands (Garrison, et al., 2006). Edwards et al. (2018) reported that there have been few reports in peer-reviewed literature on the levels of CECs in municipal wastewaters in the Caribbean

4 This matter was debated at the High Level Forum for Ministers with Responsibility for Water Meeting held in The Bahamas in October 2022.

after detecting a range of pharmaceutical products in high concentrations in wastewaters in Barbados. Almost no work has been carried on on the presence or otherwise of microplastics in water sources and drinking water supplies.

These recent studies indicate the importance of developing Water Safety Plans and tackling the increasing water quality monitoring challenges that the Caribbean faces. Interest in WSP has been increasing as several countries have developed them – Belize, Dominica, Guyana, Jamaica and more recently through the PAHO-CARPHA Climate-Resilient Water Safety and Food Safety Plans, Barbados and Trinidad and Tobago have also embarked on their development.

An area of increasing interest and prominence is Gender and Social Inclusion (GESI), particularly as International Funding Institutions such as the Green Climate Fund make developing GSI Action Plans a key criterion for approving funding applications. Equality gaps continue to exist particularly in the integration of planning and institutional processes that mainstream GESI within the water sector, often because of viewing water services as distinct from gender considerations. There is a growing realisation that water and gender are connected and that there are disparities in access to water services that perpetuate social inequalities (UNESCO, 2023). GESI encompasses not only accessing water services but also how those services are managed, by who and how. GESI issues around access to water services are a part of broader socio-economic disparities, which can serve to perpetuate inequalities. Recognising what the nature of the social inequalities are, different needs and how they can be addressed and having disaggregated quantitative and qualitative data are important steps. An example of steps being taken to surface GESI issues is the requirement built into the GCF grant to the Barbados Water Authority to have training for personnel that addresses the gender and water nexus and associated issues. GESI issues form part of the GCF funded Water Sector National Adaptation Plan for Belize. As more projects are funded through agencies such as the GCF, it will be the case that GESI will become mainstreamed into the management of water resources, the planning and provision of water services, and the management of water services. It might be anticipated that more attention will be given to GESI beyond the formal requirements that funding agencies attach to grants, loans and other forms of financial support.

3.1.4 FRESHWATER BIODIVERSITY AND ECOSYSTEMS

The unspoken attitude towards water is that it is a commodity for human use and which classical economics ignores the need to maintain the in-stream flows necessary for healthy ecosystems. This approach is implicit in many policies related to water where emphasis is placed on maintaining public supplies and the state of the aquatic environment is at best a secondary consideration. Environmental flow requirement (EFR) for water resources allocation requires that water be left in or released into an aquatic ecosystem to maintain it in a condition that will support its direct and indirect uses such as to maintain ecosystem health. Determining what the flow requirements are is challenging particularly if the information needed is not available on top of which there is no single best method of calculation. Jamaica's approach is to set reliable yield as the streamflow exceeded 90% of the record period and for environmental flows estimated as 60% of 7-day minimum flow recorded over 10-year return period.

In the case of those countries with substantial water endowments such as Belize, Guyana, and Suriname, environmental water flows are understandably of small concern. Among the countries of the insular Caribbean with surface water resources little attention has been paid to this topic. Abstractions through 'run-of-the-river' offtake schemes divert water for water supply and during the dry season sometimes result in little or no downstream flow.

A situation which it is expected that a changing climate will see more frequently. By contrast, the Water Resources Authority in Jamaica considers environmental flows when reviewing and allocating abstraction licenses. A certain portion of the water resources in each river basin is reserved to support the aquatic environment, in line with its water resources management policy of maintenance of ecosystem integrity and ensuring sustainable water use and ecosystem protection on a long-term basis. The determination of environmental flows may vary with downstream requirements but however determined, their application can only be successful if there is a strong, independent water resources management regime in place.

In Grenada, Lake Antoine used to be a source of water for the banana farmers, however agrochemical contamination from the agricultural practices in the surrounding areas has made it unfit as a source of supply (FAO, 2015). The Grenada National Ecosystems Assessment identified nutrient pollution, greywater and sewage pollution, sedimentation of waterways, and hazardous waste as contributing to species decline and change in distribution and structure of aquatic and other biota and biodiversity loss (Agard, St Louis, & Boodram, 2023). The effects of climate change and economic development pressures could significantly reduce the ecosystem services and biodiversity of Grenada's freshwater ecosystems and their ability to support water resources and availability (ibid).

Among the more innovative options to address the loss of biodiversity and reduction in the services provided by freshwater ecosystems would be the introduction of 'Payment for Ecosystem Services' schemes. Supported by The Nature Conservancy, such an approach has been explored in several Caribbean countries over the last decade: Bahamas, Grenada, Jamaica, Saint Lucia. To date no PES scheme as such has been implemented. Jamaica with support from the Inter-American Development has embarked on developing a scheme for the Hope and Yallahs River Watersheds but it is still in the development stage.

4. DISASTER RISK REDUCTION AND MANAGEMENT

KEY MESSAGES

- The Caribbean is one of the most natural disaster prone regions and Climate Change will exacerbate that situation.
- The Region has developed strong institutional coordination arrangements and a range of mechanisms to prepare for and respond to the regrettably frequent occurrence of natural disasters.
- Recognising the frequency of natural disasters the region is responding by investing in the development of climate services and products such as the CariCOF climate forecast, early warning systems and sector specific weather bulletins.
- The Caribbean Catastrophic Risk Insurance Facility offers low-cost parametric insurance addressing the impacts of natural disaster, it was the world's first such facility and has since diversified its insurance offerings and expanded to include cover for countries in Central America as well as the Caribbean.
- The impact of natural disasters is aggravated by poor physical planning and enforcement of controls. Building codes have struggled to keep pace and be translated into regulations.

4.1 PREVENTION AND MANAGEMENT OF HAZARDS

Natural hazards that exist in the Caribbean include earthquakes, landslides, volcanic eruptions, floods, droughts, hurricanes, tornadoes, tsunamis, cyclones, wildfires, and pandemics. The list of technological hazards is, perhaps, shorter and comprise mainly of fires, explosions, transport accident and spills. Disasters occur when an area or community exposed to a hazard, experiences a hazard event to which it is especially vulnerable i.e. the capacity of that area or community to recover on its own is exceeded. While it may be problematic to reduce or mitigate exposure, there is a lot that can be done to address vulnerability and much of the effort of disaster risk management and reduction focuses on reducing vulnerabilities, whether of infrastructure, communities or businesses.

The Caribbean Disaster Emergency Management Agency (CDEMA) is the regional inter-governmental agency for disaster management in the Caribbean Community established in 1991 and works through national disaster management offices. It covers 19 Caribbean countries and is headquartered in Barbados. Its primary responsibility is the coordination of emergency response and relief efforts to Participating States that require such assistance. Its work is guided by its Comprehensive Disaster Management Strategy, the current iteration of which runs until 2024. In the event of an emergency and at the request of governments, CDEMA can activate the Regional Response Mechanism. Through its Regional Training Centre, CDEMA offers training and capacity building to participating states. It also has a risk information database of disaster across the Region. Other projects it is actively engaged with include the Safe Schools programme and the development and use of early warning systems in collaboration with the UNDP, Red Cross and Red Crescent Societies and the European Union. As an organisation CDEMA also participates in research, partnering with local and regional organisations. At the national level, all countries have their own disaster management organisations, most of which liaise with CDEMA.

The Caribbean Institute for Meteorology and Hydrology (CIMH) has Memoranda of Understanding with CDEMA, CWWA, CARDI, CARPHA, CTO, and CHTA to provide and share information from CIMH's early warning network and promote the dissemination of climate information as well as other joint actions (CIMH, 2020). CIMH also produces long range climate forecasts and sector specific climate bulletins (CIMH, n.d.) and is active in the provision and development of climate services for the Caribbean.

The Regional Security System (RSS) was created out of a need for a collective response to security threats, which were impacting on the stability of the Region in the early 1970's and 1980's. The RSS currently has eight members and provides mutual assistance on request from a member state. The Humanitarian Assistance and Disaster Response (HADR) desk of the RSS takes responsibility for annual training of the Caribbean Disaster Relief Unit (CDRU) teams and coordinates the deployment of the CDRU on behalf of CDEMA. The RSS has supported the coordination of several HADR operations in the Region related to hurricanes and tropical storms, volcanic eruptions and earthquakes, among other things.

Given the vulnerability of the Region, there are quite a few past and present initiatives that focus on disaster risk reduction and management. Apart from some of the initiatives mentioned above, others include understanding and quantifying financial exposure and exploring various pathways for disaster risk financing, which in some ways overlaps with financing for climate mitigation and adaptation suggesting that a more comprehensive approach may result in greater impact at less cost. One of the mechanisms that the Caribbean has developed

to manage has been the Caribbean Catastrophic Risk Insurance Facility (CCRIF). This parametric insurance scheme is a multi-country multi-hazard risk pool facility that offers governments low-cost premiums to insure against specific natural disasters. Unlike other forms of insurance, payouts are automatically triggered when a natural disaster exceeds a predetermined trigger level. The facility provides governments with badly needed liquidity in the immediate aftermath of a disaster when funding is critical. Typically, payments are made within 10 days. During the 2023 Hurricane season three countries received payments amounting to nearly US$6 million. Between 2007-2023 62% of payouts went to immediate post-event activities, 14% to long-term infrastructure work, and 6% to risk mitigation activities.

The insurance model has been rolled out across other regions of the world and in the Caribbean has been expanded to take in some Central American countries. The CCRIF portfolio of insurance products has been extended to the water sector – as discussed in section 6.1. CCRIF offers tropical cyclone policies, excess rainfall policies as well as fisheries policies and coverage to electrical utilities. In addition to its insurance activities, it provides scholarships, small grants and training. It has been operating for 16 years.

The University of the West Indies has several undergraduate and postgraduate programmes that address disaster risk resilience. Further, Caribbean WaterNet has also run training programmes on drought and flood risk management.

FLOODING AND HURRICANE ERIKA 2015

Hurricane Erika which hit Dominica in 2015 was characterised by short and intense downburst of rainfall which caused excessive surface runoff. Approximately, twelve major rivers broke their banks and caused severe flooding taking out vital bridges, and disrupting water, electricity and telecommunications. This disaster resulted in thirty confirmed deaths and 271 homes damaged or destroyed.

Most of the country lacked access to water, DOWASCO stated that 100% of the national water system was affected by the disaster. 54 cases of gastroenteritis, 8 cases of acute respiratory illness, 11 cases of undifferentiated fever and 1 case of tetanus were reported. Residents in 3 communities were using unsafe streams as water supply, and water infrastructure and water quality remained a problem in 2 other communities for several months..

Flooding and Hurricane Erika

4.1.1 FLOODS AND DROUGHT

The nature of flood hazards varies across the Caribbean, influenced not only by climate but by topography, geology, and land use. The nature of flooding is therefore varied. In Guyana and Suriname, the flat coastal areas are prone to slower onset riverine flooding that can be widespread and last several weeks and affected nearly 300,000 people in the case of the 2005 floods. The larger islands of Cuba, Dominican Republic, Haiti, Jamaica and Trinidad and Tobago experience a mixture of flash flooding associated with tropical cyclones, and general and riverine flooding. In Trinidad in 2018,

flooding affected 150,000 people (Fontes de Meira & Phillips, 2019; Roopnarine, Ramlal, & Roopnarine, 2022), in Jamaica a flood in 2004 affected some 350,000 people (Fontes de Meira & Phillips, 2019). Those islands characterised by relatively small land areas and steep topography such as Dominica are more prone to flash flooding associated with heavy rainfall and tropic cyclone activity, though inundation times are relatively short. Belize though a larger country is also prone to flash flooding, more so in the south where the coastal plain narrows and river lengths are shorter. The central and northern watersheds are larger with longer river reaches and hence experience riverine flooding and longer periods of inundation. Anguilla, Antigua and Barbuda, Bahamas, Barbados, the Cayman Islands, and the Turks and Caicos Islands are all relatively flat islands and although they experience localised flooding, inundation periods tend to be short. The Bahamas are particularly prone to storm surges and coastal flooding associated with hurricane activity.

Between 2000 and 2023 there were 126 recorded flood events in the Caribbean in the International Disaster Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain (UCL), Belgium. Half of these are classified as riverine flooding with Cuba, Dominican Republic and Haiti accounting for two thirds. Floods (general) is the next most frequent category accounting for a further 25% of the events, again with Dominican Republic and Haiti accounting for two thirds of the entries, and similarly for flash flooding. Of course, the database does not capture all events, only those that are reported. For example, based on work by Burgess, et al. (2015), Jamaica suffered some 198 flooding events between 1978 and 2010 and has continued to experience flooding e.g. 2017 and 2022.

Across the Caribbean, flooding has been exacerbated by developmental change and urbanisation (Fontes de Meira & Phillips, 2019). Clearing of land for housing and urban development, whether controlled through physical planning regimes or as a result of the development of informal settlements, are among the key drivers as well as agricultural practices. For example, in Trinidad this includes cultivation on steep slopes at the head of catchments. The changes have contributed to soil erosion and increased sediment yields in rivers and drainage networks causing changes in the distribution of the runoff over peak flows and baseflows. In Port of Spain, Trinidad, urban spawl and upslope developments have contributed to an increase in the frequency and severity of flood events (Fontes de Meira & Phillips, 2019), a trend that is replicated across the Region and exacerbated by climate change. Looking to the future, the predictions are that the effects of climate change, changing precipitation patterns and intensities, will amplify trends and severity of flooding events (Hirabayashi, Roobavannan, Koirala, & Konoshima, 2013). However, as the accuracy and effectiveness of early warning systems improves it is hoped that fewer people will be affected. Gradually, improvements to infrastructure enabled by greater attention to both disaster mitigation and climate change adaptation should counter the negative impacts of all but the most extreme events. Interestingly, Fontes de Meira & Phillips (2019) in their study of the economic impacts of flooding in Jamaica and Trinidad and Tobago concluded that the low impact of flooding events on GDP may disguise the cumulative effects and non-monetary implications to local populations in such areas. This suggests that the financial, economic, and social impacts of flooding are not that well understood or evaluated in the Caribbean, for reasons that are open to speculation. Of concern is that for much of the Caribbean, critical infrastructure and centres of population are concentrated in often confined coastal areas. These are the very areas that are most vulnerable to coastal flooding associated with storm surges and flash flooding. Guyana and Suriname are special cases because their capital cities are not only located in coastal areas, but they are below sea level, presenting an additional risk of inundation.

In 2011 it was observed that in most Caribbean states rainfall intensity – duration – frequency (IDF) curves are not readily available and there were no countries with nationally consistent flood hazard maps (Lumbroso, et al., 2011). This has implications for the design of flood management and drainage infrastructure. Since then, the situation has improved considerably with respect to flood forecasting and the preparation of flood risk maps. An example of the advances is the Caribbean Handbook on Risk Information Management (CHARIM), so that although there is still much work to be done some parts of the Region are better placed than over a decade ago. Information gaps continue to exist, and existing flood maps are not as accurate as is needed. The Caribbean Development Bank is currently supporting a project with CIMH to update IDF curves for its Caribbean members.

Developments in technology and the use of AI look set to change the way predictions of river flooding are made, without the need for detailed models. Google in collaboration with the World Meteorological Organization has harnessed the power of AI for flood forecasting, this points to possibilities (Nearing, et al., 2024). It is also of interest to note that in Barbados' 2024 budget a 20% rebate is to be provided on the assessed land tax for residential properties that suffer from perennial flooding and associated damage, provided that there is valid home insurance with flood insurance coverage.

WATER INTAKES

The water intakes providing water to the Garifuna communities of Owia, Fancy, Sandy Bay and Perseverance in Saint Vincent were severely affected by high turbidity, sediment levels, and damage to intakes in linked to heavy ash falls from the Soufriere volcanic eruption. Access to the intakes was also compromised and so they had to be altered.

To increase resilience a groundwater intake has been developed, which will also enhance the water quality and quantity throughout the year. This will ensure that the vulnerable northern areas of the island receive consistently good water quality in an efficient and affordable manner. The project will encapsulate two storage tanks, water quality mechanisms, monitoring, and production wells.

Securing water supplies

While floods are often fast onset event for which a start and end point can be identified, droughts are more difficult as they are slow onset events, the end of which may not be apparent. Droughts also tend to have a more regional character than flooding, affecting several territories. According to Climate Studies Group Mona (CSGM) (2020) the Caribbean has over the last few decades experienced several drought events, with many seemingly linked to years with El Niño events: 1957, 1968, 1976-77, 1986-1987, 1991, 1994, 1997-1998, 2009-2010, and again in 2013-2016. However, EMDAT only records 14 instances of drought. CSGM reported that since 1950, the Caribbean has experienced a drying trend though the northern Caribbean is least prone to drought. After 1983 the south Caribbean and Jamaica region experienced a shift to drier conditions followed by the Eastern Caribbean after 1990. The 2013-2016 drought was the most severe experienced by the Caribbean, as virtually the entire Region experienced a Pan-Caribbean drought (CSGM, 2020). Rainfall records show that for many areas in the Greater Antilles, even during the wet season, dry spells are frequent and therefore pose a high risk to agriculture and ecosystems. Conversely, other locations such as northern Guyana and Dominica

are relatively low risk areas for dry spells, even during the dry season (CSGM, 2020).

According to Trotman et al. (2021) drought early warning is one of the evolving climate risk management success stories in the Caribbean, particulary since the drought of 2010. Significant progress has been made in monitoring, forecasting, and mitigating the impacts of drought in the Region with investments in early warning systems, better analytical tools, strategic partnerships, and information dissemination. These have enabled and enhanced the provision of climate services products by CIMH such as the CariCOF Climate Outlooks, Drought and Precipitation Monitoring Fire Monitoring and Standard Precipitation Index Forecasts. Recognising the importance of planning for droughts, several countries have been considering their national response and some have started to develop drought management plans e.g. Belize and Grenada. The importance of this is illustrated by the following:

"The events ensuing from the drought and Hurricane Erika in 2015 are indicative of a climate in which multiple hazards may, whether or not catastrophically, impact Caribbean nations. The case thereby forms an example of enhanced vulnerability to compounded risk of climate hazards related to extremes that coincide or follow in rapid succession. If the Caribbean is to work towards climate resilience in the face of climate change, it will have to take this risk caused by an anticipated increase in extremes into close consideration." (CSMG, 2020).

In the case of Tropical Storm Tomás which hit Saint Lucia in 2010, the effects of the extreme rainfall were magnified by the preceding drought and dry catchment conditions which intensified runoff.

4.1.2 WATER INFRASTRUCTURE

Both Grenada and Saint Vincent and the Grenadines are working on upgrading their river intake systems as part of their climate resilient measures and to counter the effects of increased siltation from watersheds that they are experiencing. Saint Vincent, like Grenada and Saint Lucia experiences low flows in their surface water sources during the dry season. To counter this, CWSA has been partnering with the International Atomic Energy Agency's Isotope Hydrology Section to identify groundwater sources with the aim of developing these to use conjunctively with surface water sources. If successful, this approach has applications in many of the Eastern Caribbean islands. The Isotope Hydrology Section has been active in seeking to assist Barbados, Guyana, Jamaica, and Trinidad and Tobago are open to further collaboration.

Under Dominica's Climate Resilience and Recovery Plan 2020-2030 (GoD, 2020), post a disaster event, 60% of the population is to have access to water and sanitation within 7 days - a 2030 target. The intermediate target is 10 days. The Output milestones is for there to have been undertaken a full infrastructure assessment, digital elevation modelling, hydrological survey, flood risk mapping and landslide mapping. Unfortunately, due to Covid and other circumstances the Output Milestones were not achieved within the 2021/22 timeline.

DISASTER RISK MANAGEMENT – POINTS TO PONDER

The following were some of the points raised during a CWWA Pre-conference discussion session on Disaster Risk Management.

- The range of disaster risks is increasing as are conjunctive risks. This developing situation is creating additional challenges for countries in developing management strategies.
- The region has not properly documented

the challenges and lessons to be learnt from dealing with disasters and to properly share the experiences gained.

Disaster Risk Management
Points to Ponder

4.2 RISK MANAGEMENT

4.2.1 REDUCING VULNERABILITY, INCREASING RESILIENCE

Vulnerability is the inability to resist a hazard or to respond when a disaster has occurred. The key features are the type of hazard and the level of exposure to the hazard; it therefore takes in aspects of place and condition. Resilience is the capacity to withstand or to recover quickly from difficulties, it can be applied to infrastructure, institutions and individuals and is related to coping capacity. Coping capacity takes in aspects such as financial and economic assets, governance, infrastructure resilience, and the abilities of emergency services. Key to increasing resilience is financial and economic capacity, not just of governments but down to the level of individuals as well. As already described at the level of government and more recently for the water sector, there have been advances made in providing financial resources through risk pooling mechanisms such as CCRIF-SPC and the expansion of its portfolio to cover the water sector. Through CCRIF-SPC support has also been provided to support the installation of monitoring devices that feed into early warning systems.

Increasing resilience through governance means putting in place institutions, laws and regulations necessary to promote and support the implementation of measures that foster increasing resilience. These include measures such as how to prioritise infrastructure needs; infrastructure financing; regulation, codes and standards; capacity and resourcing: and data, information and technology. Strengthening governance systems – the mechanisms that ensure that infrastructure is of high quality and is sustainable over the long-term – can lead to substantial increases in the efficiency and productivity of infrastructure. In this respect, the work of national disaster management agencies and the support available through CDEMA have been key.

Most countries have passed laws related to the preparedness and management in the event of disasters, see Table 5. Some passed legislation over 25 years ago (Dominica, Grenada, Saint Kitts and Nevis) while in 2006 several countries enacted laws: Barbados, Bahamas, Saint Lucia and Saint Vincent and the Grenadines. In 2019 Guyana drafted a Disaster Risk Management Bill which is still under consideration. More recently the International Federation of the Red Cross and Red Crescent Societies has been engaging with governments to adopt the International Disaster Response Law. In other words, there is an extensive body of law across the Caribbean that addresses disaster risk management. How effective the laws are and whether they need revisiting is not clear.

Table 5: List of Disaster Management Acts by country (author's compilation)

Country	Year	Act
Antigua and Barbuda	2015	Disaster Risk Management Act
Barbados	2006	Disaster Management Act
Dominica	1987	Emergency Powers (Disasters) Act
Grenada	1984	National Disasters (Emergency Powers) Act
Haiti	2010	Loi sur l'Etat d'urgence
Saint Lucia	2006	Disaster Management Act
Belize	2000	Disaster Preparedness and Response Act
Saint Vincent and the Grenadines	2006	National Emergency and Disaster Management Act
The Bahamas	2006	Disaster Preparedness and Response Act
Jamaica	2015	Disaster Risk Management Act
Saint Kitts and Nevis	1998	National Disaster Management Act

Physical planning and zoning aim to balance demands for development with the need to protect the environment, another consideration in this balance is to ensure that developments do not take place where persons might be put at risk, for example, building houses in flood prone areas. All countries have some form of planning control regulations, and requirements for environmental impact assessments. However, how well they are regulated and enforced does vary between countries. The presence of informal housing in flood prone areas, on unstable hillsides or in water source protection areas are sources of vulnerability both to the environment and to people placing both at risk (UN HABITAT, 2020). Barbados is an example of a country that has robust planning controls which are enforced, whilst conditions are lax in others, in Trinidad especially around Port of Spain and in Haiti. An example of lack of enforcement of planning measures contributing to vulnerabilities is failure to maintain riparian forest buffer strips along rivers and watercourses in Belize.

Accompanying planning controls are building codes which are also intended to ensure the safety of occupants. Due to the Region's high exposure to climate events and historic disaster losses, many countries in the Region already do have building codes in place. In the 1990s, the Organisation for Eastern Caribbean States (OECS) Secretariat developed a model building code based upon Caribbean Uniform Building Code (CUBiC) to facilitate the introduction and adoption of building codes in Eastern Caribbean countries and these have been revised and kept up to date and tailored to specific country-level administrative and enforcement requirements. Other building codes adopted in the

YOUTH IN IWRM

Working with students at the University of Guyana an assessment was carried out to understand the awareness, knowledge and understanding of the threats to Guyana's water resources. As a result, materials were developed and distributed addressing water issues. Water sampling kits were purchased and members of the Ecotrust and Geographical Societies have conducted water sampling in several communities, shared the results and uploaded simple analyses to a Youth in Water Resources (YIWR) website.

Youth in IWRM

Region include the International Code Council's (ICC) International Building Code (IBC) and International Residential Code (IRC) (Benavidez, 2021). Regionally, CDEMA and the Caribbean Regional Organisation for Standards and Quality (CROSQ), developed a regional code of practice to inform the resilient construction of houses in 2005. In 2019, CROSQ released a set of new standards for energy efficient buildings for CARICOM Member States. The challenge is that no matter how strong and rigorous the requirements of the building code are, they need to be implemented, enforced and kept up to date to account for evolving climate related hazards. This is not being systematically done. Furthermore, building practice may ignore codes and builders and developers rely on their local knowledge of risk-prone areas (Benavidez, 2021).

Dominica's institutional response in the wake of Hurricane Marie in 2017, one of the worst ever disasters to hit the country, was to declare the intention to become the first Climate Resilient Country (World Bank, n.d.) and to develop its Disaster Resilient Strategy. This is both an example of the multi-spectrum approach to what needs to be done and a lesson in the difficulties in realising such a strategy (IMF, 2021), e.g. the negative effects of Covid-19.

Water utilities have procedures in place to prepare for and manage disasters. One of the measures is to ensure that there is sufficient reservoir storage in the event of supply interruptions. This has highlighted the need, in Barbados, Grenada, Saint Vincent and Dominica for example to increase storage capacity. Other measures have included installation of back-up generators and renewable energy systems for pumping. The availability of external support in the event of emergencies and disasters, including training in disaster responses, has increased since Erika and Emily impacted Dominica and its water systems, which were in many ways a trigger. Organisations such as Operators Without Borders were established to provide support.

In addition, the UNICEF WaSH LAC has increased its presence and support to CDEMA and water utilities in the Region particularly post the volcanic eruption in Saint Vincent. CWWA and CAWASA are the WaSH focal points for the CDEMA response mechanism and PAHO and UNICEF were Focal points for the UN Humanitarian Response. A WASH Rapid Assessment App was made available by the UNICEF which facilitated live feedback from the ground teams to the focal points which operated virtually.

Challenges in locating and accessing spare parts needed for repair as a result of disasters are also being addressed through the H2Bid (Data Sharing Platform) supported by the IDB.

While water utilities are now better prepared to handle disasters such as floods, droughts and tropical cyclones, the same cannot be said for their ability to cope with health pandemics, as revealed by the Covid-19 pandemic. Although some changes were made to the way utilities operate, few if any lessons have been learnt. For example, there has been no regional review of responses, identification of best practices or consideration to change standard operating procedures.

At the individual level, sensitising populations on the need for preparedness is an annual undertaking when the Hurricane Season is approaching. As described elsewhere in this report, many countries are promoting the adoption of rainwater harvesting systems as a resilience and security measure for emergencies. Work under the GEF-IWEco project that investigated Rainwater Harvesting in Grenada, Jamaica and Saint Lucia concluded the practice should be supported as a disaster resilience and climate change adaptation measure. But that there were financial issues to be addressed to achieve this, highlighting that resilience at the individual and household level is dependent on having access to financial resources and other assets, and that those individuals and households that have fewer assets are less resilient.

5. COOPERATION AND HYDRO-DIPLOMACY

KEY MESSAGES

- Cooperation mechanisms across the water sector rely on informal relationships between individuals.
- There are increasing efforts to develop and embed more formal collaboration mechanisms, particularly by institutionalising the IWRM approach. A challenge is that often water is not treated as a high priority sector.
- There are a limited number of shared or transboundary water resources, only five Caribbean countries have shared water resources. For two of these Belize and Guyana collaboration with their neighbours has been complicated by territorial disputes.
- Water service providers have developed outreach programmes and are becoming increasingly more sophisticated in their approaches.

5.1 GOVERNANCE FRAMEWORKS

Table 4 lists the countries which have established an agency that has responsibility for water resources management, noting that only seven countries have separate or independent dedicated agencies. Among these, capabilities vary, for example, Belize has only six persons employed in its National Hydrological Service, while Jamaica's Water Resources Authority employs over 40 people. The responsibilities of the agencies broadly encompass hydrologic data collection, compilation, and analysis; water resources investigation, assessment, and planning; water resources allocation and licensing; and environmental monitoring and impact assessment. As would be evident some agencies are more capable than others in fulfilling these functions.

Notably absent are formal institutional arrangements for cooperation and collaboration between agencies responsible for water management and those responsible for land management. Water resources cannot be properly managed without integration with land management, with agencies such as those responsible for physical planning, agriculture, fisheries, forestry and municipalities. Jamaica has instituted an Integrated Water Resources Management Council which is a multi-sectoral body that includes representation from land, environmental and business sectors (GoJ, 2021). The Government of Jamaica has plans to extend this concept by establishing Local Integrated Water Resources Management Committees for each of the country's 26 watersheds (GoJ, 2019). The National Integrated Water Resources Policy for Trinidad and Tobago (MPU, 2022) acknowledges the importance of Inter-Agency Cooperation but other than proposing the use of Memoranda of Understanding/Agreement does not propose putting any formal structures in place. The Grenada Integrated Water Resources Management Plan (GoG, 2019) does not include provision for a formal coordination mechanism with other agencies beyond water for the integrated management of natural resource such as land and water. A reading of the various proposals for IWRM across the Caribbean suggests that the approach set out in both Grenada and Trinidad and Tobago's water policy documents is the norm. The apparent approach to coordination and collaboration is one of informal arrangements.

The purpose of the GEF-IWEco project is to promote the integration of water, land and ecosystems management. Component 3 specifically addresses the strengthening of policy, legislative and institutional reforms and capacity building for integrated natural resources including Integrated Water

Resources Management among the 11 participating countries. Under Component 3 the project an Action Framework for IWRM for the CARICOM Region has been developed. It builds on multiple efforts towards a coordinated approach to IWRM in the Region. These include a CARICOM resolution in 2008 to initiate the Consortium of CARICOM Institutions on Water to develop a Common Water Framework for the Community. The Global Environment Facility's (GEF) Caribbean-wide Integrating Watershed and Coastal Area Management (IWCAM) project, (2006 to 2011), which supported the development of national IWRM plans and reviewed the policy, legislation, and institutional structures in IWEco participating states. The Action Framework is being revised in 2024 to ensure the needs and priorities of all countries within the CARICOM Region are incorporated. The revised Framework is then expected to be presented to the Council for Trade and Economic Development- Environment (COTED-Environment) for formal endorsement by CARICOM. The document sets out six strategic goals and a list of actions under each goal intended to achieve the goals.

The Framework was developed through consultation with stakeholders in IWEco participating states and given that it is intended to support the CARICOM region, this document serves as a first draft. The next step includes the revision of the Framework to ensure the needs and priorities of all countries within the CARICOM Region are incorporated. The revised Framework is then expected to be presented to the Council for Trade and Economic Development- Environment (COTED-Environment) for formal endorsement.

5.2 HYDRO-DIPLOMACY

According to a 2021 Report by the Inter-American Development Bank (Castillo, et al., 2021), none of the countries of Latin America and the Caribbean have ratified global conventions providing the basis of framework for transboundary water cooperation, and only 11 of the 67 basins have any operational arrangement for water cooperation. Common problems include water pollution, land use changes, erosion and sedimentation, loss of biodiversity, alteration of hydraulic regimes, climate change and increasing hydro-climatic events, and lack of effective governance frameworks. There are though a few bi-lateral agreements that Caribbean countries have with respect to the limited number of transboundary water resources. A list of transboundary water river basins and aquifers is given in Table 6.

Table 6: List of Caribbean Transboundary River Basins and Aquifers
(Author's compilation from numerous sources)

Basin	Countries
River Basins	
Artibonite	Dominican Republic, Haiti
Dajabon-Massacre	Dominican Republic, Haiti
La Hoya del Lago Herniquillo	Dominican Republic, Haiti
Pedernales	Dominican Republic, Haiti
Amazon	Brazil, Columbia, Ecuador, Peru, Venezuela, Guyana, Suriname, French Guiana, Bolivia
Barima	Guyana, Suriname
Corantijn/Courantyne	Guyana, Suriname, Venezuela

Cuenca	Países
Essequibo	Suriname, Guyana, Brazil
Maroni	Suriname, Guyana, Brazil
Oyupock	Venezuela, Brazil, Columbia, Guyana
Orinoco	Belize, Guatemala
Mopan-Belize	Belize, Mexico, Guatemala
Hondo	Belize, Guatemala
Moho	Belice, Guatemala
Sarstoon-Temash	
Aquifer Basins	
Grupo Roraima	Brazil, Guyana, Venezuela
Boavista-Serra do Tucano-North Savannah	Brazil, Guyana
Coesewijne	Guyana, Suriname
Sand A/Sand B	Guyana, Suriname
Zanderij	Guyana, Suriname
Yucatan-Candeleria-Hondo	Belize, Guatemala, Mexico
Mopan-Belize	Belize, Guatemala
Moho	Belize, Guatemala
Sartoon-Temash	Belize, Guatemala
Artibonite	Dominican Republic, Haiti
Masacre	Dominican Republic, Haiti
Pedernales	Dominican Republic, Haiti
Los Lago	Dominican Republic, Haiti

Guyana has shared river basins with Brazil, Suriname and Venezuela and shared aquifers with Suriname; Suriname has shared aquifers with Guyana and river basins. Dominican Republic and Haiti share both river basins and aquifers and Belize has shared river basins and aquifers with Guatemala and Mexico. The state of hydro-diplomacy in many ways reflects the state of relationships between states, in some cases cordial and in others far less so.

In Guyana, groundwater from the coastal aquifer system provides about 90% of the domestic water for the country with this and two other aquifers shared with Suriname. At present there are no legal agreements between the two states governing the management of shared aquifers but there are informal levels of cooperation. With respect to their shared river basins, there has been a history of disagreement particularly over boundaries but more recently the countries have agreed to cooperate on shared water resources though details are difficult to determine as there are no published reports. Both Guyana and Suriname are signatories to the Amazon Cooperation Treaty signed in 1978 by all eight basin-states. In 2002, the Amazon Cooperation Treaty Organization was created to help implement the 1978 Treaty (UN Water, 2021; UNEP, 2007). The Essequibo River Basin which encompasses Guyana and Venezuela is the fourth largest in South America. There is no formal cooperation or treaty governing the shared basin, exacerbated recently

by the breakdown in relationships between the two countries due to the planned annexation of the Essequibo Region of Guyana by Venezuela.

Suriname is a partner in the BIO-PLATEAUX initiative to strengthen transboundary cooperation for water resources and aquatic biodiversity management in the Guiana shield, led by French Guiana and co-financed by the European Union. In 2022 the implementing partners agreed to work towards the creation of a Transboundary Observatory, develop proposals for participative governance, and eventually work towards joint river basin planning and management (Bio-plateaux, 2024).

With respect to Belize, there is the Mexico-Belize International Borders and Waters Commission the purpose of which is to develop, enforce and monitor international border- and water treaties. At present on the Belizean side, there is a hold up due to not having appointed a Water Commissioner. That said there is cooperation, as far as capacity allows, between the two countries over the Peninsula de Yucatán-Candeleria-Hondo Aquifer and the Rio Hondo River-which forms part of the border between the two countries. Examples include cooperation on water management through the Regional Committee for Hydraulic Resources and annual meetings of the Mesoamerican Basins Group, which analyses management issues and best practices. Because of the ongoing dispute over sovereignty, there is no cooperation with Guatemala. All contacts are through international bodies.

On the island of Hispaniola, Haiti and the Dominican Republic share both groundwater (4 aquifers) and surface water resources. Article 10 of the Peace, Perpetual Friendship and Arbitration Treaty signed with Haiti in 1992, bans any works affecting the flows or the existing waterway of the Transboundary Rivers. The prohibition does not apply to equitable irrigation or industry use of water by either State in its own territory. Prompted by international organizations, there are bi-national projects expected to have institutional impacts. The shared resources do enjoy a degree of protection as parts of them are in protected areas, ranging from 82% of the area to 22% (UNEP, 2007). However, according to Castillo, et al., (2021) water quality and tensions over the use of the resource pose increasing threats to the shared resources.

With the exceptions of the Amazon Treaty and Dominican Republic and Haiti there are no formal or legal instruments in place governing the management and cooperation of transboundary resources in the Caribbean. The main reason given for this is a lack of capacity and resources within the Region together with the perception that there is little need and therefore this enjoys a low priority when compared with other water related issues to be addressed in the three main countries with significant transboundary water resources.

5.3 CROSS-SECTORAL

All Caribbean water utilities have their own websites and some form of media outreach. These include Facebook, Instagram, X (formerly Twitter), newsletters, news announcements on government information channels, and YouTube. Blogs tend not to be used by utilities but are used by projects, such as IWEco. The forms of outreach are the backbone of engagement with the public. The extent to which they are used depends very much on the resources that the utility can make available, the larger and better off the utility, the greater the diversity and regularity of content. Some utilities have developed reporting and payment Apps for customers e.g. NAWASA in Grenada and BWA in Barbados. The COVID pandemic had a catalysing effect which encouraged utilities to look for new ways to engage with their customers and the public, the development of Apps being an example of this. Some utilities for example in Antigua and Barbuda have developed outreach programmes addressing issues such as water

conservation through engagement with schools or posting information on their websites. From time to time, water utilities will sponsor competitions on a particular water topic, usually in conjunction with an event such as World Water Day.

The above are routine activities and beyond these some utilities have established a relationship with local radio and TV stations, taking part in phone-in programmes or even generating their own content such as BWA's weekly Water Wednesday videos which are broadcast on local media. NAWASA in Grenada has previously done something similar. However, as indicated the extent to which these activities are undertaken are determined by the human resources available within the organisation. A common feature is that these are limited, and the structure of the marketing and communications departments is often not structured to promote and sustain such activities.

Since 2012, the Water Resources Agency (part of WASA) in Trinidad and Tobago has developed the 'Adopt a River' programme (AdoptaRiver, n.d.) after accessing funding from the country's Green Fund. The programme aims to bring awareness of local watershed issues and to facilitate the participation of public and private sector entities in sustainable and holistic projects to improve the status of rivers and watersheds in Trinidad and Tobago. Supported by WASA the project has its own Implementation Unit, is supported by volunteers and partners with private organisations. It is perhaps one of the most successful of the outreach programmes in the Region.

Other forms of outreach are associated with project development, where there is a requirement for engagement with the public either over the implementation of projects or policies. These take the form of 'Town Hall' meetings with the public. Town Hall meetings are also used to engage with the public if there are matters of local or national concern where people feel strongly and wish to make their feelings know.

The Royal Bank of Canada (RBC) has been running its Blue Water Project since 2017, from which the Caribbean has benefited through support to charitable organisations engaged in water management such the Caribbean Natural Resources Institute, The Bahamas National Trust and others across the Region.

The IWEco, CReW+ and many of the Green Climate Fund supported projects have associated with them training, capacity building and outreach components. For example, there is the GEF CReW+ Academy which has developed and provides training courses around water and wastewater management bringing together all the training initiatives within the GEF CReW+ project in a single point (GEF CReW+, 2022). The Green Climate Fund supported Water Sector Resilience Nexus for Sustainability in Barbados project has developed as part of its capacity building and outreach component its Aquasure programme which aims to educate and raise awareness of water conservation. In Grenada under the G-CREWS project there is a substantial communication and awareness component which aims to communicate about the project, about the upcoming regulation changes but also to raise awareness on water consumption and the need to conserve water. The project, under another component, has a regional replication target and a community of practice has been created to support replication of such projects in water.

6. WATER FINANCE

KEY MESSAGES

- Levels of debt to GDP ratios are high with on average 33% of government budgets being spent on debt servicing.
- Tariff levels are still determined by Ministers, even where there are formal economic regulators.
- Independent financial and economic regulation is the exception. As a result tariffs are kept low and hamper the ability of water utilities to properly fund their operations.
- The costs of upgrading and expanding water infrastructure and particularly the development of wastewater systems, are high, limiting the ability of governments and water utilities to scale-up their investment programmes.
- The Regional Strategic Action Plan has captured that there is an increase in the diversity of sources of funding coming into the Caribbean, and it has recoded investments in excess of US$400 million over the last 5 years.
- The Caribbean has been at the forefront of exploring new, innovative funding mechanisms, including:
    - Disaster pause clauses
    - The Bridgetown Initiative
    - Carbon credits associated with non-revenue water loss reductions
    - Wastewater management revolving funds
    - Parametric based disaster insurance for water utilities
- The Region has lagged behind in accessing climate-related financing and needs to address the organisational barriers and improve the generation and use of water data to support proposals.

6.1 FINANCIAL RESOURCES

Broadly speaking, the ability to adequately fund the provision of water and sanitation services in a country is contingent on prevailing economic conditions. The Covid-19 pandemic led to a sharp increase in debt-to-GDP ratios in the Region though these are now starting to decline. As the IDB noted, there are examples of large reductions in public debt-to-GDP ratios via a combination of institutional reforms and sustained primary fiscal surpluses (Jamaica) or more recent explosive economic growth (Guyana). Debt restructuring has also played an important role in reducing debt ratios in several countries (Belize) (IDB, 2023). Recent research also indicates that half of Caribbean countries' public debt-to-GDP levels are above the maximum "safe" debt limits: prudent levels are between 46%-55% of GDP. An overview of debt levels, inflation and economic growth gives an indication of the fiscal challenges facing countries in the Region (ECLAC, 2023; Powell & Valencia, 2023).

The Caribbean's average debt service ratio is around 33% of government revenue. The levels of debt are exacerbated by small, open economies often dominated by a single economic sector activity and with limited diversification opportunities. The almost annual impact of hydrometeorological disasters on countries in the Region results not only in economic losses but also the diversion of funds that would otherwise be invested in development, for recovery. Economies can take up to 15 years of more to recover, assuming that they are not impacted again.

A mix of fiscal policy decisions, economic drivers, and external factors drive debt dynamics, including weather events that can affect GDP and other factors. These affect how governments can finance the provision of infrastructure, including water infrastructure. Actual expenditure on water and sanitation in middle income countries has been reported to vary between 0.54% and 2.59% of GDP (Cashman & Ashley, 2008); for low income countries this increases to over 6% of GDP. For countries like China, India and Brazil it was estimated that they should be spending between 1.9% and 2.5% of GDP on water and sanitation (Cashman & Ashley, 2008). However, these levels of expenditure are seldom achieved given the debt servicing levels and other demands, and the smaller the economy of a country the greater the relative investment needed.

In most Caribbean countries, tariff levels are low, at best covering operation and maintenance costs (see section 2.3.3). For a variety of reasons, there is a reluctance to raise tariffs. If tariffs are not sufficient to meet financing needs, then the alternatives are that it must come from taxes and transfers (grants and loans) (Andres, et al., 2021). The result is that capital expenditures on infrastructure replacement, upgrading and expansion are either financed through general taxation or transfers through loans, repayable through central government or grants. Because governments take on the debt it is difficult to ascertain the level of capital expenditure on water infrastructure as well as the repayment conditions. In an economic environment where debt levels are already high, there can be little appetite for taking on further debt and restrict the ability to secure funding to invest in new and more resilient infrastructure. There are though exceptions, where income from tariffs is sufficient to fund capital works, the Cayman and Turks and Caicos being examples of this.

6.1.1 MANAGEMENT

How much to charge for water services must take into account a range of factors, some of which may conflict with each other. On the one hand, revenues should be sufficient to cover Opex costs, the costs of operating and maintaining the service at a given standard. On the other hand, tariffs may be designed to be affordable to low-income consumers as well as encouraging water conservation (Andres, et al., 2021). Tariffs across the Caribbean do not consider other potential objectives such as environmental sustainability, promotion of access, or quality of service. Jamaica has introduced into their water tariffs what are referred to as K and X factors: the K-factor is an approved yearly percentage applied to each customer's monthly charges that goes towards capital works, the X-factor is a deduction for efficiency improvements. Most countries have adopted an Increasing Block Tariff (IBT) structure with the aim of ensuring affordability for those on low incomes and to encourage water use efficiency among customers with higher water consumption. However, the validity of this argument has been questioned (Young & Whittington, 2016; Dahan & Nisan, 2007). Because of the low penetration of metering in Trinidad and Tobago, unlike most of the Caribbean countries, it has a tariff for residential customers based on property tax. In Trinidad and Tobago there is also a Utilities Assistance Programme (UAP) which is a social intervention strategy that provides financial assistance to ensure continued access to basic utilities such as water and electricity. In other jurisdictions assistance is usually through the welfare system and requires separate application.

In most countries, customers must connect to the public water supply system. Where water is produced under contract by desalination through a private company, the general requirement is that it cannot be sold or supplied directly to consumers but through the water utility. An exception to this model is what might be called an inset arrangement[5] in The

5 An Inset is where a company provides a water service within an area which was previously provided by the incumbent provider.

Bahamas, where there are two private concession areas which are responsible for water supply within their respective areas. In addition, some hotels, for example in Antigua, have their own water supply systems, utilising seawater desalination. This relieves the pressure on the public water supply system. A further development is the financing of solar powered desalination plants, in some cases supported by private or bi-lateral financial arrangements. The United Arab Emirates has indicated that it is supporting the Government of the Federation of Saint Kitts and Nevis with financing for the installation of two solar desalination plants. This type of plant is being increasingly rolled out in the smaller and drier islands where rainwater harvesting is the main source of water due to the absence of other sources of water. This development which is being accelerated by climate change can be seen particularly among the Grenadine islands of Grenada and Saint Vincent and the Grenadines.

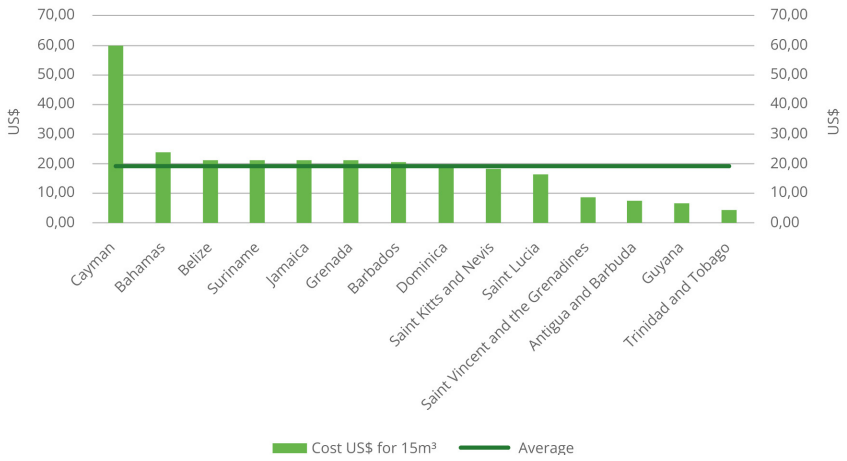
The cost of 15m3 of water per month for a residential consumer is shown in Figure 18 (Jansen, Burkhard, & Jones, 2021), apart from Trinidad the countries have a minimum fixed charge.

DOMINICA'S WATER SECTOR DEVELOPMENT PLAN

Following the impacts of Tropical Storm Erika in 2015 and Hurricane Maria in 2017 the Government of Dominica and DOWASCO embarked on a programme of resilient building in the Water and Wastewater sector. The WSSDP involved the vulnerability mapping of the water systems, corrective or strengthening mechanism necessary and the ranking of prioritized projects based on the Infrastructure Prioritization Framework methodology of the World Bank. This forms the basis for guiding investment in Dominica's water and wastewater sector.

Guiding water sector investments

Figure 18: Jansen, A., Burkhard, B., & Jones, C. (2021). *Comparison of cost of residential water* [Report].



Countries make a distinction between residential customers and others, charging higher rates for non-residential customers, except where agricultural water is recognised as a separate category of consumption. Each country has its own customer classification, reflecting differences across countries. For example, in Trinidad and Tobago there is a Cottage category while in Barbados Hotels are a separate category of consumer.

With the exceptions of Cuba, Martinique and Puerto Rico, see section 3.1.1 and Figure 15, centralised sewer systems are the exception rather than the norm. The cost and ability to finance wastewater systems are among the reasons for this situation. For example, a feasibility study to sewer the west coast of Barbados, which would serve some 50,000-70,000 people estimated the capital cost to be approximately US$300 million at 2008 prices. The current upgrading of the Bridgetown Wastewater Treatment Plant is estimated to cost US$50 million, though this is being financed through a grant from the Green Climate Fund. There are further amounts of approximately US$100 million needed for upgrading of the South Coast system to Tertiary treatment. In other words, the capital cost of introducing centralised sewer systems is a financial challenge that, under present circumstances, few countries could afford. Then there is the challenge of cost recovery.

Where there are sewer connections, sewerage charges are levied through a variety of means. These include a flat rate (e.g. Dominica), a charge based on a percentage of the water supply volume (e.g. Saint Lucia) or determined by the number of water fixtures on a property (e.g. The Bahamas). In each of these cases it is the beneficiary that pays. Barbados has taken a different tack, for all domestic customers it introduced a daily charge but for all non-domestic customers the sewer charge is set at 25% of the value of water consumption. These charges are irrespective of whether there is a sewer connection or not. In the case of Barbados, this has allowed the water utility to cover the sewer system operation and maintenance costs.

REGIONAL STRATEGIC ACTION PLAN FOR WATER

The Regional Strategic Action Plan for the Water Sector in the Caribbean (RSAP) was developed by Regional Stakeholders for the 8th World Water Forum, held in Brazil, 18 – 23 March 2018. A revised and updated document was presented to the 14th High Level Forum for Ministers with Responsibility for Water (HLF), held in Montego Bay Jamaica, 9–10 October 2018. Recognising that the RSAP is a response to the myriad of common challenges facing the Caribbean Water Sector it proposed a framework of action, at the national and regional levels to respond to the challenges. At the heart of the document is the acknowledgement of commonalities and of differences in circumstances and challenges but that by working together Caribbean countries will be better able to respond.

The RSAP

6.1.2 INCREASE AND DIVERSITY

A wide range of institutions provide various forms of financial services and support to governments in the Region, in addition to the expenditures by national governments and regional projects. In addition to support to national governments there are regional projects. Starting in 2021, the Caribbean has instituted an informal coordinating mechanism through the CWWA, the Regional Strategic Action

Plan for Water–Implementation Monitoring Committee (RSAP-IMC). The committee has broad representation from various agencies supporting and working with the water sector and seeks to track implementation progress, improve coordination, and identify synergies and support. Representation includes persons from the IDB, CDB, EIB, World Bank, OAS, OECS, CWWA, CAWASA, GWP-C, UNEP, UN-HABITAT, GIZ, and CCCCC.

At present the RSAP lists investments in water related projects across the Region of nearly US$400 million plus a further US$458 million for the Climate Infrastructure Fund through the CDB. These amounts do not include country level funding. Major funding has been provided through the Global Environmental Facility to three regional projects, investment in monitoring and early warning networks through the European Union and USAID, the EU provides support for a spectrum of projects from multilateral agreements, climate services through to resilient water systems, and UKAID indirectly through the CDB. At present there are no UN Adaptation Fund projects for water a sanitation though there is a building climate resilience to climate change project in Trinidad and Tobago that covers water resources issues, mainly flooding. The Green Climate Fund is supporting 7 countries either with funding for projects or for project preparation. Other sources of funding include the EIB and CAF (Development Bank of Latin America). Although China has been a significant investor in the Caribbean, from the information available none of this has been in the water and sanitation sector (Global Policy Development Center, 2024).

6.1.3 SCALING UP AND INNOVATIVE FINANCING MECHANISMS

Given the scale of the investment challenges and the weak financial and economic position of many Caribbean countries new approaches to water financing are needed. In this respect the Caribbean has been something of a leader in exploring alternatives. As a Region the Caribbean has been at the forefront of pushing for greater support to counter the existential threat of the effects of climate change. Whilst the various mechanisms are not specific to the water and sanitation sector, they are supportive of efforts by the sector to address its infrastructure and investment challenges. However, the mechanisms are necessary but by themselves are not sufficient to address the underlying biophysical and socio-economic vulnerabilities. The following are some of the initiatives that the Caribbean has either promoted and/or can benefit from.

Disaster pause clauses, also known as Climate Resilient Debt Clauses (Landers & Aboneaaj, 2023). These transform a bond or a loan into state-contingent debt instruments and set out pre-defined triggers that would lead to a borrower deferring repayments of interest, premium or both. The uptake of these clauses is currently limited to Grenada, Barbados and The Bahamas though in 2023 the World Bank indicated it would include pause on repayments and embedding catastrophe insurance into new loans, joining the IDB. The idea of pause clauses has been part of Barbados' Prime Minister Mottley's Bridgetown Initiative.

The **Bridgetown Initiative** was first put forward in 2022 and proposed increases in emergency liquidity, an additional $1 trillion in multilateral lending, private investment in climate resilience backed by Special Drawing Rights, the suspension of interest surcharges, and the operationalisation of the IMF's Resilience and Sustainability Trust. The original proposals have been somewhat scaled back and include more emphasis of the role of the private sector in supporting "green transformation." A further development aligned with the Initiative is Barbados' proposal to the Green Climate Fund to establish a Blue-Green Investment Corporation (BGIC) as the first green bank in the Caribbean. The GCF press release said:

"BGIC is a public-private sector initiative that aims to overcome the financing challenges and constraints of climate change adaptation and mitigation in the Caribbean region. Initially focused on Barbados, BGIC will finance several private and public initiatives for green, affordable, gender-inclusive housing, energy generation, water conservation, food security and low carbon transport. The financing vehicle will be able to target high impact sectors through the financing of green bonds and other capital market instruments. BGIC will strengthen financing capacity and infrastructure to draw in other financial players like banks, credit unions, pension funds, and insurance companies." (GCF November 2022).

Although not in the water sector, one of the most significant recent Debts Swaps involved Belize and illustrates the potential impact that such deals can have. Belize signed a debt-for-nature swap with The Nature Conservancy (TNC), which reduced the country's external debt by 10% of GDP. Belize though has pioneered other debt for nature swaps in the past, setting up the Rio Bravo Reserve in the early 2000s with the additional benefit of being able to sell carbon credits to finance the operation. More recently, the adjacent Selva Maya area has been established also allowing the Maya Forest Trust to sell carbon credits. Carbon sequestration and the sale of carbon credits will play an important role in ensuring the Greater Belize Maya Forest's sustainability. Notable too is that one of the local private sector partners (Belize Brewing Company) invested in the Trust to ensure the preservation of the forest and its role in maintaining water yields.

In a manner of speaking the use of debt swaps and carbon credits from forest conservation and management could be seen as a form of payment for environmental services (PES). More traditional forms of PES to protect watersheds and forests have been explored in the Caribbean, specifically in Saint Lucia and Grenada. The conclusion reached was that there was not a conducive legal environment as well as capacity issues.

The concept of using Carbon Credits to fund conservation has been taken to a new level. CWWA's Vice-President has put forward a discussion paper proposing that reducing Non-Revenue Water Losses can be seen as a way of mitigating climate change by reducing the carbon emissions associated with excess energy needed for additional pumping and emissions associated reactive repairs of bursts and leaks. The initiative has gained a degree of support but is contingent on scaling up active water loss reduction programmes.

Water utilities are large energy consumers, using power from the national grids. Power that is predominately generated through the burning of fossil fuels. As a way of reducing energy costs, many water utilities are considering installing photo-voltaic renewable energy systems. Barbados, Dominica, Jamaica, Saint Kitts and Nevis, are examples of countries where this is being implemented. However, Barbados has gone a step further, and rather than saving on its energy bill, the savings are being put to other uses: funding mains replacements and contributing to revolving funds for installing water savings devices.

The CReW+ project has been exploring the use of Revolving Funds to fund the provision of wastewater infrastructure. Pilot schemes have been set up in Belize, Guyana and Trinidad and Tobago. In Jamaica a Credit Enhancement Facility provided support for a local commercial bank together with surcharges from the water utility to a special account to finance wastewater projects. CReW provided funding into a Reserve Account to support US$12 million of investments. If the issue of wastewater management and the need to provide decentralised infrastructure becomes a policy objective, then creative financing solutions are going to be needed. One way is

to harness the technical and financial expertise of the private sector. Most of the desalination infrastructure through the Region is provided on the basis of public-private partnerships that leverages that technical and financial expertise, so there could be a similar approach for wastewater. Jamaica, as noted in a previous section, has shown the way in this regard with the Soapberry Treatment Works serving Kingston.

Natural disasters can have a ruinous impact on water infrastructure and services in the immediate aftermath of an event in the time it takes to recover, and refinance affected plant and operations. Not least among the challenges is being able to finance the recovery and given the tight financial environment utilities operate under, this circumscribes their ability to recover. The Caribbean Water Utilities Insurance Collective (CWUIC) has been developed by the IDB, CDB and with financial assistance from the UK Government to capitalise the facility. CWUIC is a parametric insurance facility which offers fast disbursement after a trigger event, emergency response assistance, resilience building through access to financing at preferential rates. Approximately 35 water utilities in 29 territories in the Caribbean have been identified as potential clients for CWUIC, which intends to insure against drought, volcanic eruptions, landslide/mudslides, flood (runoff), windstorms, and tsunamis. Because this is a not-for-profit facility and the risk is spread across Caribbean Utilities, it will be possible to keep insurance premiums affordable. Assistance in the form of premium subsidies will be available to water utilities in six official development assistance eligible Caribbean countries. CWUIC is another parametric based insurance product being offered by CCRIF-SP.

Loss and Damage was first referred to in a formally negotiated UN text in the 2007 Bali Action Plan, which called for "Disaster reduction strategies and means to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change". It has taken 15 years to get to the point where proposals to set up a mechanism for addressing Loss and Damage has been accepted. Loss is taken to refer to things that are lost permanently to the climate crisis such as human and animal lives, species, territories, water sources, ecosystems, livelihoods, heritage sites and languages. Damage refers to things that have been affected but can be restored, such as impacts to physical and mental health, soils, roads, schools, homes, health centres, and businesses. While Damage can to a certain extent be addressed through investment in mitigation and adaptation measures, Loss cannot.

At the COP27 climate summit, all countries agreed to set up a fund to pay for loss and damage, and that a “transitional committee” should be established, dedicated to coming up with a plan for how the fund would work in practice. At the COP28 climate summit, countries agreed to set up the new fund, initially housed at the World Bank. However, there are still many details to be addressed before the Loss and Damage Fund would be open to business, who would pay, where the money would come from, who would benefit, and how.

Quite what this might mean and how it would work for Caribbean SIDS and for financing of the water sector remains to be seen. The fact that there are multiple funding mechanisms associated with responding to climate change would indicate that the global community is still unsure or reticent in how to respond to the threat of climate change. The potential of Loss and Damage mechanisms will take many years to get off the ground. Some have seen this as being complementary to the Bridgetown Initiative while others believe that the Bridgetown Initiative complicates responses to climate change.

6.2 ENABLING ENVIRONMENT

6.2.1 GOVERNANCE

In an IMF Blog, Guerson, et. al. (2023) stated that the Caribbean Region's access to climate financing has been low because of the difficulties in developing bankable projects. They gave limited capacity and expertise for project preparation, qualification requirements to access climate funds often being beyond the administrative capacity of the countries, and the fixed costs of project evaluation and appraisal. The challenges are even greater when it comes to private financing. The multifaceted nature of climate finance operations, which include finance, legal, environmental and budget aspects, requires the involvement of several departments across the public administration leading to costly and lengthy preparation periods. Data gaps undermine project appraisal and monitoring, limiting risk pricing and impact evaluation. Private financing usually requires information about collateral and creditworthiness, which is often not readily available.

A recent IDB initiative highlights some of the governance challenges (IDB, 2023). The preparation of a portfolio of projects and an investment strategy in some Caribbean Countries was put forward as a way of bridging an identified funding gap. The proposition was that by engaging with governments, they would have the opportunity to prioritise projects and identify financing mechanisms, whether public or private. Spanning infrastructure sectors; transport, solid waste, water and sanitation, and energy, that brings the opportunity to integrate and accelerate the agenda of development and climate in infrastructure projects and guide the discussion toward more effective participation of private financings in infrastructure. That at least was the intention.

The starting point to all this is having an idea of what the proposed infrastructure projects are and their state of progress and development. There were several practical road humps encountered. The first concerns the fact that by its nature IDB liaises with national ministries of finance and that liaison is through the IDB Country Offices. Ministries of Finance very often do not know what the infrastructure ministries and agencies are planning or have details of how far potential projects have progressed. Few countries have in place a mechanism whereby all infrastructure projects are required to go through a central, national approval process – Jamaica has such a system in place. Therefore, Ministries of Finance would either have to contact the line ministries for details or liaise with the line ministries to request their cooperation and coordinate with the IDB team.

A further 'hump' is that for water and sanitation there are several different line ministries and agencies, each of which may have their own plans and capital financing needs. In addition, there are some projects which are cross-cutting and could therefore result in double accounting. For example, several water utilities are considering installing solar power generation plant to reduce their operational costs – are these water projects or energy projects?

The provision of water and sanitation services is often a politicised business. Service providers can be pressured to undertake projects which they would not otherwise have prioritised. In this they are also often hampered by an absence of medium to long term infrastructure planning. This is more prevalent where there is an absence of independent financial and economic oversight, see section 6.2.2. Whilst political direction is crucial in a democracy to ensure that policy goals are set, political interference is not beneficial. The result is confusion as to priorities.

Independent economic regulation of water utilities usually requires the utility to prepare business plans which set out the operational and investment goals over the period under review and how these are to

be financed. In other words, it provides a degree of certainty and risk management. Countries such as Belize and Jamaica have such requirements in place. Where this is not the case, line ministries and agencies must submit their Estimates through a parliamentary process on an annual basis, creating a degree of uncertainty over financing, particularly of capital projects. Further, where grants and loans are involved for capital works, these have to go through and be scrutinised by ministries of finance as they are added to the country's balance sheet.

Then there is the implementation of large projects. Anecdotal evidence suggests that even after a loan can be accessed, the drawing down on the loan can be protracted. The main reason given for this is a lack of capacity to manage and implement projects on the part of the water utility. Sufficient resources are not available in-house and so contract staff must be hired. This takes time and delays start-up and implementation, all of which speaks to a wider governance issue.

6.2.2 REGULATION

There has been a gradual uptake in the establishment of economic regulators across the Caribbean. Prior to this the financial and economic regulation and oversight of water utilities was kept within government ministries. The current situation with respect to financial and economic regulation is set out in Table 7. The situation in overseas territories which are effectively part of the home country is such that they are subject to external governance arrangements.

Table 7: Financial and Economic Regulation Arrangements (Author's compilation)

Country	Financial and Economic Regulation
Anguilla	Under the Water Corporation of Anguilla Act of 2008, the Corporation, with the approval of the minister can set water charges. There is not independent economic regulation. Further WCA has exclusive rights to provide water services.
Antigua and Barbuda	The tariffs charged by the APUA are determined by it and with the approval of the Minister. No independent oversight.
Aruba	No information
The Bahamas	Utilities Regulation and Competition Authority Act came into force in 2009 as an independent regulatory authority. The functions and powers include the regulation, investigation and direction on economic, standards of service, and technical matters of Utilities. However, this does not cover the water sector which is still covered by the Public Utilities Commission although this body has been superseded by URCA so there is no capacity to regulate the water sector and further its remit only covered the WSC and not private water utilities.
Barbados	Fair Trading Commission. Established by Act of Parliament 2001. Limited regulation of BWA, does not determine water rates but does set and monitor standards of service. Determination of water rates are made by the minister on application of the BWA Board.
Belize	Public Utilities Commission. Established by Act of Parliament in 2001. Issues licenses and only regulates Belize Water Services Ltd. Monitors performance, reviews tariffs and ensure water utilities deliver affordable services while earning a reasonable return on their investments. PUC approves three codes: "the Customer Code", the "Disconnection Code" and the "Leakage Code". Condition 2 of the License allows for "quality of services standards" to be set out in the Codes of Practice. Minister makes the final determination on water charges on advice from PUC.
Bonaire	Regulating authority is Netherlands Authority for Consumers and Markets, which takes into account customer protection, return on investment and promotion of productive efficiency in setting water charges.
British Virgin Islands	No independent economic regulation.

Country	Financial and Economic Regulation
Cayman Islands	Utility Regulation and Competition Office established by Act 2017. Issues licenses for water services, reviews and sets water charges, sets standards of service, oversees investment plans and promotes actions and activities in the public interest.
Cuba	No clear information found
Curaçao	No economic regulatory framework, water charges are set by government.
Dominica	No independent financial and economic regulatory oversight. Water charges are set by the minister on application from DOWASCO.
Dominican Republic	"At present, the institutional framework of the sector is dispersed, being made up of different institutions with the same roles and functions (differentiating only their spatial location), without a defined governing body that outlines the guidelines to follow and unifies the criteria in terms of models of management, nor a regulatory body for quality in the management of services." (World Bank, 2023)
Grenada	Public Utilities Regulatory Commission established by Act of Parliament in 2016 but only regulates the electricity industry. NAWASA applies to the minister to revise water charges.
Guadeloupe	No information found
Guyana	Public Utilities Commission. Established by Act of Parliament 2016. Remit covers issuing of licences, economic research, adequacy of service provided, expansion plans, quality and standards of service, reviews and sets water rates.
Haiti	Ministry of Public Work's DINEPA, including the authority to set policy, create pricing schemes, establish water quality standards, issuing permits, enforcing violations, and mediating disputes. (Stoa, 2017)
Jamaica	Office of Utility Regulation. Established by Act of Parliament in 1995. Provides oversight of all utilities including the National Irrigation Commission. Determines the rates that are to be charged and service level standards applicable to service providers. The minister has the final decision on rates.
Martinique	No information found
Montserrat	No independent regulation. Water charges are set by government.
Puerto Rico	Financial Oversight and Management Board for Puerto Rico was created under the Puerto Rico Oversight, Management and Economic Stability Act of 2016. Oversees the public utility Puerto Rico Aqueduct and Sewer Authority
Saba	Regulating authority is Netherlands Authority for Consumers and Markets, which takes into account customer protection, return on investment and promotion of productive efficiency in setting water charges.
Saint Barthélemy	Governed by the franchise agreement between the water service provider and the government.
Saint Martin/Sint Maarten	Netherlands Authority for Consumers and Markets for Sint Maarten. No information for Saint Martin but would be subject to national arrangements within France.
Saint Kitts and Nevis	No independent regulation. Water charges are set by government.
Saint Lucia	National Regulated Industries Commission. Established by Act of Parliament 2016. Issues licenses and regulates water supply and sewerage services, establishes, approves and reviews tariffs, monitors compliance with service conditions, protects customer interests, and promotes competition.
Saint Vincent and the Grenadines	There is no independent regulation of CWSA. CWSA applies to the minister for changes to water rates which are then approved by the Minister.
Sint Eustatius	Regulating authority is Netherlands Authority for Consumers and Markets, which takes into account customer protection, return on investment and promotion of productive efficiency in setting water charges.
Suriname	No provision for the regulation of water and wastewater services.

Country	Financial and Economic Regulation
Trinidad and Tobago	Regulated Industries Commission. Established by Act of Parliament 1998. Regulates WASA. Sets and monitors standards of service to ensure compliance, provide an avenue for redress for dissatisfied customers of the service provider and approve rate reviews for service providers. Sets framework for price reviews. However, only limited price reviews have been implemented, mainly for commercial customers but not for residential consumers. Although the regulator makes the final decision on rates, the determination has to be Gazetted and so requires Cabinet to agree to the rates.
Turks and Caicos	Establishment of a Water and Sewage Board in 2009. Issues licenses for abstraction and water supply. A service provider sets water charges which are approved by the minister after consultation with the Board.
US Virgin Islands	Economic regulation undertaken by the Virgin Islands Public Services Commission which oversees water charges.

6.2.3 TRANSPARENCY

Camacho (2021) provides an overview of corruption risks in the water sector, pointing out the different levels. For example, at the level of service delivery, there is a high risk of petty corruption where low-level and mid-level officials abuse their power, whereas grand corruption usually involves politicians, senior officials and higher-level engineering staff. By its nature, corrupt practices are hard to quantify and cite examples without extensive investigation. Anecdotal evidence of petty corrupt practices includes turning a blind eye to illegal connections and altering meter readings, while more serious practices include the suggestion that large contracts have been awarded just before a government demits office.

The Curbing Corruption website identifies three groupings related to water and sanitation, improper use of Data, corruption in Operations, and corruption in Governance (CurbingCorruption, n.d.). According to Transparency International (Jenkins & Allakulov, 2017) the incentives for corruption in the water sector are high:

"water sector institutions are natural monopolies responsible for projects with high initial capital and maintenance costs, and which are managed by officials with large amounts of discretionary power. At the national level, water management may be the responsibility of more than one agency or ministry, is therefore challenging to design comprehensive anti-corruption strategies for the sector. In highly corrupt environments, regulatory bodies are likely to face conflicts of interest, especially when a government department assumes the dual role of water service provider and regulator."

On the Corruption Perception Index (2023), which looks at corruption in general terms and is assumed to be a proxy for corruption in the water sector in line with the paragraph above, Barbados, The Bahamas, Saint Vincent and the Grenadines, and Dominica were ranked in the top 40 out of 180 countries as being perceived to be the among the least corrupt. Manifestations of public sector corruption include bribery, diversion of public funds, use of official office for private gain, lack of disclosure of finances by public officials, and others.

A study "Beyond Leakage: Quantifying the Effects of Corruption on the Water and Sanitation Sector in Latin America and the Caribbean" (Adam, et al., 2020) included Jamaica as the only Caribbean country. The findings give Jamaica's CRI score in Water and Sanitation as 0.4, where 1 = high CRI and 0 = low CRI. This may be taken as indicating a somewhat below average level of corruption associated with the water sector.

Camacho (2021) suggests that water utilities should seek transparency in three key dimensions: outreach and openness; dialogue with users and participation of relevant stakeholders; and controls for integrity. A way that this can be achieved would be to implement the use of The Integrity Management Toolbox (WIN, 2018).

7. KNOWLEDGE AND INNOVATION

KEY MESSAGES

- The absence of research and development units in water service providers hampers the identification, development and uptake of new technology.
- The lack of a 'critical mass' of research capability within universities and utilities creates a reliance on advances developed outside of the Region which may not fully address regional needs.
- The pace of adoption of new technology is low and water service providers often lack the experience to make informed choices and implement them.
- There has been limited engagement around Local and Indigenous Knowledge, one reason being that their numbers are low and often there are not mechanisms that allow a voice.
- The Region continues to develop innovative science-policy interface opportunities. An example of this is the annual High-Level Forum for Ministers with Responsibility for Water.
- The Region hosts several tertiary level educational establishments, including the only Regional University – The University of the West Indies. However, UWI and others are primarily teaching and not research-led institutions. There are an increasing number of water sector-related courses but for the more technical and advanced training, persons have to study outside of the Region.
- Interest in Water Information Management Systems has been increasing and systems are now beginning to be implemented, which should start to address some of the data gathering and monitoring challenges already highlighted.

7.1 KNOWLEDGE AND INNOVATION

7.1.1 SCIENTIFIC

No water utility has a Research and Development (R&D) or Innovations arm or programme to promote and collaborate with partners to support innovation and implementation. Collaborations with academia are very limited, on both sides. There are few incentives, regulatory or otherwise. Universities are not geared to handle scientific research. Research funding opportunities are very limited. Absence of data information systems and sharing limits what can be done. Employment opportunities in the Region are limited and there is a brain drain.

The lack of water utilities in the Caribbean having an R&D arm can be seen as a legacy from the days when the utilities were focused on supplying water. There are few incentives for water utilities to delve into R&D by themselves, meaning that they are innovation takers rather than setters. The economic and standard of service regulators, where they are present, are concerned with tariffs and, at present, offer few inducements or requirements that would incentivise water utilities to engage in R&D. While this approach does serve to minimise operational costs, the downside is that the innovations that are offered originate outside of the Region and may not respond to the needs of the Region or utilities.

From time-to-time water utilities may partner with academia and this would be facilitated where there is an academic institution present in the same territory. Many of the universities in the Region find it challenging to undertake research that would support the water sector. One reason is that water utilities do not have a culture of working with academia or recognise that there are benefits in doing so. Most often it is academia going to the utilities and others in the water sector to try to initiate partnerships, rather than the other way around. Then there is the lack of funding for research in the

Region and most funding is from sources outside of the Region. The consequence of this is that the focus of research projects tends to be on challenges facing the funding countries, offering few opportunities for Caribbean researchers to bring local research needs to the fore. In other words, they are more often junior partners in research consortia. In fairness, this is not always the case, but the opportunities are limited and tend to be around topical issues such as climate change. A further challenge is that university administrations are seldom set up in such a way as to facilitate and support the servicing of research projects. As a result, much of the research that takes place is not carried out by groups of researchers but by individuals. The notable exception to the absence of vibrant research teams is the University of the West Indies Mona Climate Modelling Group which has established a world class reputation for climate research. A further challenge is that it can be difficult to transition research into development and the rolling out/commercialisation of an innovation. Again, universities in the Region have very little experience of this and do not have the resources or infrastructure in place to nurture and support new start-ups.

Individual researchers who do try to engage with the challenges facing the water sector face a further challenge, the availability, reliability and consistency of data. Accessing data, even for research purposes, can be a frustrating process. Often, data is only collected and generated as part of consultancy projects and hence longitudinal data is scarce. In part, it could be argued that this is a consequence of limited planning capacity within utilities.

APPLICATION OF EMERGING TECHNOLOGIES

The Valle Nuevo National Park in Dominican Republic is of vital importance for water, energy and food security of the country. Over the years, the Park has suffered from the impact of human activities, such as: deforestation, agriculture, and abstraction of groundwater and surface water. To address the situation a project was developed to integrate emerging technologies for supporting hydro-morphological assessment and revitalisation of its streams and rivers. Five technologies were used in the project:

- Geographic information systems (GIS) for mapping stream and reaches.
- ODK system for data collection with mobile phones.
- Unmanned aerial vehicles for remote areas data collection.
- Salinity sensor for water discharge measurements.
- Thermal cameras for mapping intermittent streams.

The use of these technologies has allowed the restoration of streams and rivers in the Park.

Application of Technologies to Catchment Management

7.1.2 TECHNOLOGICAL

The adoption of new technology in the water sector of the Caribbean has been somewhat slow. Many water utilities have implemented Supervisory Control and Data Acquisition (SCADA) systems to control and monitor devices and the state of their systems and have incorporated GIS technology. However, very few have installed smart meters to provide automated readings that are transmitted to utility companies for

billing, leak detection, water conservation initiatives, and analysis for operational optimisation purposes. The case of the introduction of smart water meters in Barbados is illustrative of the difficulties that can be encountered. In 2015 BWA commenced on a water meter replacement programme, swopping mechanical with smart water meters. This would have allowed their automatic reading, improved accuracy of readings and the ability to analyse water consumption in fine geographic and temporal detail. But the programme hit a snag with a dispute around payment for the access code, something that despite assurance in 2021, has still not been resolved in 2024 and may well end up in litigation. Meanwhile the meters continue to be read manually. More generally, there are questions around whether water utilities are ready to be able to utilise the new capabilities of smart meters. The limited uptake and practical difficulties around implementation mean that the opportunities to utilise advances in artificial intelligence (AI) and underlying techniques such as Machine Learning to inform better water resource and operational management are being delayed.

Opportunities in the market for improving water use efficiency have been recognised by some entrepreneurs, highlighted by the GWP-C's Young Caribbean Water Entrepreneurs Shark Tank Competition (GWP-C, 2024). Examples include:

- In Guyana, the development of remote monitoring of water quality in water systems in Hinterland to detect contamination.
- From Saint Kitts and Nevis, equipping systems with sensors to measure the amount of water in a storage tank and monitoring usage.
- In Jamaica, offering a smart phone-based service for businesses to monitor and control water usage, and identify opportunities to improve water use.
- From Trinidad a portal car washing system which uses 2 litres of water and is creating jobs through franchising.

7.1.3 TRADITIONAL/INDIGENOUS KNOWLEDGE

In March 2023, UNESCO and its partners organised a side even at the United Nations' 2023 Water Conference on indigenous knowledge of water governance and management. The side event noted that Indigenous Peoples have been managing and governing water since time immemorial and that their knowledge has contributed to the development of water management practices that are sustainable and based on the principles of stewardship, conservation and equity (UNESCO, n.d.). Despite this, much of the traditional and contemporary indigenous ways of living with water remain undocumented or little-known to decision-makers and scientists.

Local and Indigenous Knowledge (LINK) is derived from the close relationship with nature, a relationship based on understanding the local environment and oral traditions that preserve detailed and rigorous knowledge of local water bodies sometimes dating back centuries (GWP, n.d.). The challenging and problematic colonial history of Caribbean countries has adversely affected indigenous communities such that those that remain are found in few countries. There are indigenous communities in Belize, Dominica, Guyana, Saint Vincent and Suriname some of whom still maintain traditional practices, reliant on their knowledge of the environment. The need for labour on plantations led to the subsequent trafficking of people into the Region. The association with the land and the natural environment nurtured the development of local traditional knowledge. This is particularly so amongst those who make their living from the land.

The number of indigenous and other groups as a percentage of the overall population varies between countries, with indigenous groups forming a small percentage of the populations, Table 8.

Many of the indigenous groups live in what is referred to in Guyana as the Hinterland, away

from the main population areas. This is true also of Belize. As such there is a reliance on the land for their livelihoods and sustenance. In Belize the Maya practice milpa agriculture a traditional agricultural system in which maize is intercropped with other species, such as common beans, faba beans, squashes or potatoes. This is practised on small plots of land spread across the landscape, cleared by slash and burn and cultivate for a few years before moving on. In Guyana and Suriname similar rotational farming, along with hunting, fishing and foraging are practised. Forest resources/timber on Indigenous lands are fully under the managerial authority of the Amerindian title holders, while minerals under the same lands remain under ultimate national government authority. A range of water sources are used, depending on the season in Belize, Guyana and Suriname: springs, rivers and streams, wells, and rainwater harvesting.

Table 8: Indigenous and other Groups (% of population) (Compiled from Countries' latest National Population Census)

	Belize	Guyana	Suriname
Amerindio Maya	9.90%	10.50%	3.80%
Maroon Garifuna	4.60%		21.70%
Creole	22.20%	29.30%	15.70%
East Indian	2.30%	39.80%	39.80%

During interviews with Maya communities in southern Belize, the effects of climate change on water sources was highlighted. During the dry season village handpumps often did not provide sufficient water and wells were running dry during use, which is a new occurrence. Many creeks were drying up and so traditional uses such as for bathing, hygiene and laundry, activities with high social interaction are being affected. Rains are arriving late, up to six weeks later than normal and when the rain arrives the soil is hot and 'cooks' the seedlings, and yields are reduced significantly. When asked what adaptations they were making they said that their way of life does not require major changes, that their milpa farming is a traditional way of spreading risk. However, community elders are passing new rules on how the villages will interact with land and water uses; cattle cannot drink from, nor wade into, creek and waterbodies were given as examples. In other communities it was said the community elders were reluctant to change the traditional ways but that younger community members were making a change and accessing technology tools to adapt their farming practices. As the interviews highlight, much of the concern around water is associated with the impacts on traditional livelihoods Figure 16 such as subsistence farming and increasingly the effects of climate change on their way of life.

Figure 19: Pictures of Maya practices: land clearing, water collection and clothes washing (Author's own)

7.1.4 SCIENCE TO POLICY INTERFACE

The Caribbean has been fortunate to have developed over the years two formal opportunities for the promotion of the science policy interface. The two are the Caribbean Water and Wastewater Associations (CWWA) Annual Conference and associated High Level Forum for Ministers with Responsibility for Water and the more recent Global Water Partnership-Caribbean's (GWP-C) biennial Water Science Symposium.

The first CWWA Annual Conference was held in 1991 the same year the association was formed by Act of Parliament in Trinidad and Tobago. The aim of the Conference is to bring together the Region's water and sanitation professionals to share their experience in support of sustainable development and public health in the Region. However, it became apparent that there was a need to expand the dialogue beyond water professionals talking to each other and engage with policy makers and decision makers. As a response to this need, in 2005 the first High Level Forum for Ministers with Responsibility for Water was held to promote discussion on water matters affecting the Region. The HLF, as it is known, was jointly organised by the CWWA in partnership with the GWP-C. Over two days, the HLF allows presentations to be made by water professionals on topics of interest, for ministers to be updated on the latest national and regional developments and to invite them to share their thoughts and development directions in their respective countries. It is a unique opportunity to share experiences and ideas for addressing water issues affecting the Region and individual countries.

A more recent initiative, by GWP-C is the Caribbean Science Symposium. Unlike the HLF which is held in person, this is a virtual Symposium, being a mix of paper presentation, opportunities for youth and water entrepreneurs to share and showcase their ideas and concerns, and for open discussion with water professionals, policy advisors and politicians.

FRESHWATER AVAILABILITY IN SAINT KITTS – A COLLEGE PROJECT

The Clarence Fitzroy College introduced a programme to stimulate interest in maths and science in high school students and train technical personnel on how to optimise the management of water catchments and aquifers. The programme involves fieldwork, data collection and analysis. The results are presented by the project teams and students to stakeholders with the aim of sensitising policymakers and consumers.

Capacity Building in Saint Kitts

7.1.5 EDUCATION AND TRAINING

There are nearly 100 institutions of higher learning across the English, Spanish, French and Dutch speaking Caribbean, public and private. So, accessing a place at a university to study for an undergraduate degree is usually not an issue. However, the number offering postgraduate degrees in water, wastewater or related subjects is limited, though The University of the West Indies has been increasing its offerings in the fields of water, environment and disaster management. A fortunate few students opt to study outside of the Region, for example attending IHE Delft Institute for Water Education. The cost of taking a postgraduate degree and the prospect of having to live away from a home country poses a significant barrier and only a few lucky prospective students can access scholarships. Increasingly, prospective students are turning to on-line, distance education offerings.

One of the challenges though is that with a limited number of employment opportunities available in the sector, persons are either compelled to leave the Region or go into jobs with little connection to the studies. Those who attend institutions outside of the Region may well choose not to return contributing a 'brain drain' from the Region.

For those who can pursue a career in the water sector the opportunities for continuing their professional training and development are limited. One of the reasons for this is that apart from professional registration there are few requirements for continuing education and training[6]. Compounding this is that there are few regional accredited programme offerings that could contribute to further education and training opportunities, other than some which may offer certificates of attendance. These tend to be offered on an ad hoc basis rather than as a part of a structured programme. Funding for programmes is an issue. To date, universities and places of higher education have mainly focused on undergraduate programmes and have not ventured into the field of offering professional development programmes. An issue which has been raised but not fully engaged with is the need for transferable skills to enable movement of labour (trade) and emergency support. Furthermore, with emerging technological changes, for example, Information and Communication Technologies and Artificial Intelligence, there is a debate to be had as to how to meet the future needs of the water sector in this emerging area.

The situation is appreciated and over the last few years efforts are being made to try to address the situation. This has been particularly the case through some of the Global Environmental Facility funded programmes and Green Climate Fund funded projects. This is a response to the somewhat ad hoc approach to training and capacity building exercised in the past, whereby the offering and attendance at seminars has been used as a proxy for capacity building (often with little or no evaluation attached), and which ceases once a project has been completed. The emerging best practice is that large, multi-country projects or projects that have significant funding allocated include a structured approach to capacity building and one in which sustainability beyond the duration of the project is built in. An example of this is the GEF-CReW+ Academy. Here, training material has been developed and courses offered through the project, open to water professionals in the Region. And the intention is that the materials developed will then be available beyond the duration of the project, through partnerships with established regional bodies such as GWP-C and CWWA.

The Caribbean WaterNet has been running training courses for water professionals for over a decade. A recent development of both CWWA and GWP-C has been their efforts to venture into offering training and capacity building. For GWP-C this has resulted in the formation of the Water Academy for

6 There exists an anomaly whereby the Terms of Reference for consultancies put out by Development agencies usually require a certain level of academic achievement for key personnel e.g. a master's degree. But there is seldom requirement to demonstrate that persons have kept up date or considering professional experience.

Youth (GWP-C WAY) which offers a 3-month training programme for young Caribbean persons between the ages of 20 – 35 with a keen interest in water resources management. GWP-C also runs its annual Shark Tank competition for young entrepreneurs, in which the finalists receive mentorship and business training. For CWWA, the approach is two pronged. The first is collaboration with the CReW+ Academy to provide a 'home' for the training material after the end of the project. The second is through their Water Loss Specialist Group which has been active, together with the IDB and the IWA in offering capacity building. In addition, CWWA collaborates with the Caribbean Water & Sewerage Association Inc (CAWASA).

CAWASA is a regional training organization serving its member water utilities. It offers accredited, certificate training and development programmes for managers and operators as well as providing institutional support to its members. Through its collaboration with Water Professionals International and the Associated Boards of Certification, members have access to a range of materials. Operators Without Borders' (OWP) is a not-for-profit organisation which is supported by volunteers from water utilities and water professionals. The main focus of OWP's activities is in providing assistance to water utilities in responding to natural disasters, it offers disaster management training as well as operator certification training or specific training on aspects of utility operations, assessment of facilities and their operation as well as mentoring.

The Caribbean Institute for Meteorology and Hydrology is a regional training and research organisation that offers technician training in meteorology and hydrology, and through The University of the West Indies offers undergraduate courses in meteorology. The technician programmes are designed to upgrade the skills of personnel working in the field of water resources at the operational level. From time-to-time CIMH also offers short, specialised courses and workshops aimed at upgrading the skills and expertise of experienced meteorologists and hydrologists.

Vocational qualifications are offered through the Caribbean Examinations Council Caribbean Vocational Qualification (CVQ) or through National Vocational Qualifications. Both are based on a competency-based approach to training, assessment and certification. Candidates are expected to demonstrate competence in attaining occupational standards developed by practitioners, industry experts and employers. The CVQ allows for those who have qualified to move easily and take up employment across CARICOM. The Caribbean Examination Council (CEC) has 16 member states including the Netherland Antilles and Suriname. At present CEC offers Level 1 courses for Directly Supervised/Entry –Level Workers in wastewater process plant operations and water process plant operations. Eventually, there will be five levels of training offered up to Managerial and/ or Professional Worker.

While there are many education and training opportunities, these are mainly focused on providing the basic foundation needs of the water sector. Moving beyond that level and providing training and capacity development opportunities for improving skills sets and a higher level of technical professional and managerial training is less well developed.

7.1.6 WATER INFORMATION SYSTEMS

Water information systems gather and organise data that can be used for addressing environmental, physical, social, political, economic, and ecological issues of water supply, consumption, availability, and accessibility. The data can be used for a variety purposes, the range of which depends on the extent and completeness of the data being gathered but ultimately it is about efficient planning and decision making. A water information management system

can be thought of as having three parts: the data gathering network, data storage and management, and data analysis and information generation. Dissemination of the information is usually a separate issue. Typical questions that have to be addressed are: what data is to be gathered and by who, what organisation will be responsible for hosting and maintaining the data storage and management platform, and who will have access to the data either for analysis or dissemination.

The range of data gathered will be determined by the circumstances of each country, the nature of its water endowments and the challenges facing the country in managing its water. For example, there is little point in Barbados or The Bahamas monitoring surface water resources as there are effectively none, whereas for Guyana and Suriname surface water resources are a significant resource.

The status of water information systems in the English-speaking Caribbean is indicated in Table 9.

Table 9: Water Information Systems in the Caribbean (Author's compilation)

Country	Comment
Barbados	The Barbados Water Authority did have a WIS – though it is not clear what BWA information was incorporated but it is reported to have included water quality data including from the Environmental Protection Department. However, when BWA moved building the system was discontinued on grounds of cybersecurity (pers com – Mr A Ifill).
Belize	The National Hydrological Service has started to set up a WIS using proprietary software called WISKI which provides solutions for monitoring network management, data acquisition, monitoring and evaluation tasks in hydrology, meteorology, groundwater monitoring, flood forecasting and alerting, water quality control, urban water systems and dam operations. NHS is in the process of getting other agencies in Belize to share their information on the platform (pers comm - Mrs T Hendry).
Grenada	Grenada developed a WIS through McGill University with support from the Canadian Government in 2009. It is hosted and operated by the Ministry of Agriculture. It includes hydrologic, climate, land, watershed, infrastructure and water-related data (CIMH, 2024). Under the GEF-CReW+ project the country has indicated that it wishes to update the Grenada National Water Information System and include data on wastewater management.
Jamaica	The WIS is hosted by the Water Resources Authority and has been in operation since 2007 and is accessible on the internet. It receives and hosts water information from National Water Commission, Forestry Division, National Land Agency, Land Information Council of Jamaica, National Environment and Planning Agency and the Environmental Health Unit of the Ministry of Health. Some data records go back to the 1950's (Fletcher-Paul, Madramootoo, & Thomas, n.d.). Under the GEF-CReW+ project the country is updating its existing water information system.
Saint Kitts and Nevis	Consultants have developed specifications for a water information system for SKN. The next stage is to move to implementation.
Saint Lucia	Saint Lucia developed its Water Resources Information System in 2005, with assistance from the Food and Agriculture Organization. Although it was populated with data it did not become operational for reasons that are vague. It is now under the auspices of the Water Resources Management Agency, under the Ministry of Agriculture. With support from the World Bank the WRMA has instituted a Hydromet Portal which uses the DEWETRA platform, an open-source web-based system for real-time monitoring and forecasting of natural hazards (CIMA Foundation, 2023). With the assistance of the GEF-CReW+ project the WRMA is ensuring coordination between departments for data exchange and data sharing agreements and is working on data capture and integration.
Saint Vincent and the Grenadines	SVG was to be supported through the GEF-CReW+ project in the upgrading of the CWSA's in-house information system. No progress has been reported.

Country	Comment
Trinidad and Tobago	The Water Resources Agency, part of the Water and Sewage Authority, collects data produced by the Meteorological Office, the Drainage Division and from its own instrumentation network. With respect to primary data collection, many of the stream flow gauges have been destroyed or vandalized and are therefore, non-functional and some of the equipment is also obsolete. Financial restrictions and onerous bureaucratic procedures make it difficult to access funds to replace and upgrade the equipment. The WRA has moved at least three times since its inception. With each move, data files have been lost since the system is not fully computerized and most of the information is stored on hard copy (Fletcher-Paul, Madramootoo, & Thomas, n.d.). Through the GEF-CReW+ project the design and development of a WIMS is being implemented. The work remaining includes deployment and data upload by partners.

EIn the GEF-IWEco project's Action Framework for Integrated Water Resources Management for the CARICOM Region, the fifth strategic area was identified as Research and Information Sharing. The document proposed the development or strengthening of an independent, overarching water resources entity to govern inter-agency coordination and oversight at the national level, and cooperation at the regional level (GWP-C, 2022a). To achieve this would require technical support for the development of standards for data management and the development and/or upgrading of a water information management system to facilitate access to water sector data by institutions and civil society. It also called for the standardisation of water data and information at the national level and improved access to water sector data and information (GWP-C, 2022 b).

Under a further GEF-IWEco work component, "Strengthening of the Policy, legislative and institutional reforms and capacity building for SLM, IWRM/WUE and ecosystem services management taking into consideration climate-change-resilience building", OECS countries were asked to identify projects. Barbados and Saint Kitts and Nevis indicated that their priority was the development of Water Information Systems: terms of reference for consultancy to develop WIS for these countries were developed. Saint Kitts and Nevis have moved ahead with the design of a WIS. As part of the GEF-CReW+ funding is being made available for Water Information Management Systems for Grenada, Jamaica, Saint Lucia, Saint Vincent and the Grenadines and Trinidad and Tobago. The work will entail upgrading the existing systems.

Progress has been made in establishing water information systems but, not all countries have or plan to have water information systems. Furthermore, the range of information included in the systems is variable across countries, with the primary focus on water resources information. Climate information systems appear to be operated separately and independently. Few countries have considered including water demand data in their WIS and furthermore, water quality monitoring data is sparce. This reflects the difficulties in collecting and collating water demand and water quality data, and data sharing between agencies. When it comes to sharing information with the public, there is a reluctance to do so, though some countries are better than others in this regard. This contrasts with the situation in the Dominican Republic, Puerto Rico and the US Virgin Islands where information is to be publicly shared. The latter two countries benefit by being part of the USA and thus share access to national water information systems. Dominican Republic though does not have a National Water Information System but plans over the next 3-5 years to implement one with support from the National Statistics Office (GWP Central America, 2021).

Although not a water information system, Regional Environmental Monitoring Data Portal (REMDAP)

was launched in 2024. It hosts and makes available environmental spatial data and information, includes metrics, indicators and variables for monitoring and decision-making purposes. It is designed to improve data availability and to serve as a clearinghouse mechanism to strengthen the process of regional environmental monitoring and assessment. The portal has been developed and implemented in 8 participating countries, including 5 OECS Member States: Antigua and Barbuda, Grenada, Saint. Kitts and Nevis, Saint Lucia and Saint. Vincent and the Grenadines. The remaining 4 OECS Member States of Dominica, Montserrat, Anguilla and the Virgin Islands with support from the Biodiversity Support Programme in ACP Costal Environments (BioSPACE) project are to be added later in 2024.

In respect to public access to information only 11 countries in the Caribbean have ratified the Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean: the Escazú Agreement. Its objective is to guarantee the rights of access to environmental information, public participation in the environmental decision-making process and access to justice in environmental matters. So, there is still much to be done to promote the Agreement, the following are key points coming out of the report "Access to Environmental Information in Latin America and the Caribbean" (Celis, Botero, Lamarche, & de Miguel, 2024):

- Courts and oversight bodies have consistently upheld the rights of requestors seeking environmental information, emphasizing the importance of exceptions to access rights that adhere to legal standards.
- There is a need to strengthen and expand the collection of environmental information and explore and encourage the proactive disclosure of environmental information, especially considering environmental crises like climate change, biodiversity loss, and pollution, which require timely and reliable data for informed decision-making.
- Progress is needed in implementing or strengthening legislative frameworks that support access to environmental information, alongside promoting equal access to new technologies such as open data. Additionally, efforts should focus on ensuring effective implementation of existing frameworks and facilitating access for vulnerable individuals and groups.

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