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Water Security and Services in The Caribbean

Adrian Cashman

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Acronyms

CCCCC	Caribbean Community Climate Change Centre
CIMH	Caribbean Institute for Meteorology and Hydrology
CReW	Caribbean Regional Fund for Wastewater Management
GDP	Gross Domestic Product
GEF	Global Environment Facility
IWCAM	Integrating Watershed and Coastal Area Management
IWRM	Integrated Water Resources Management
KSA	Kingston and St. Andrew (metropolitan area)
LBS	Land-based Sources of Marine Pollution
RCM	Regional Climate Model

Abstract

In October 2012, at the 8th High Level Ministerial Forum of Water Ministers in the Caribbean, the importance of ensuring long-term water security as a driver for economic and social development and the urgent need to address water scarcity in the Caribbean region were recognized.[1] Out of the meeting came a clear understanding that insufficient political attention was being paid to promoting measures to ensure water security. The prominence of the issue is an indication that there are growing concerns over the ability of governments to ensure the good management and provision of water without jeopardizing economic growth and the maintenance of social well-being. Of concern are the impacts of climate change, tariffs and the financial sustainability of service provision, the need to upgrade existing water infrastructure and improve resource use efficiency, the prevention of pollution of water sources, and the management of resources and services in the face of natural hazards.

Box 1. What is the Caribbean Region?

The term Caribbean Region provides a unifying idea, yet it has multiple uses and masks many differences among the sovereign states, overseas departments, and dependent territories in the region. Geographically the Caribbean is diverse, and given its different geologic histories it displays a marked variety of different landforms—small inhabited islands with a few thousand people, and large islands such as Cuba with populations in the millions. It ranges from flat low-lying islands to those with mountains of up to 3,000 meters and includes, according to some classifications, countries on the mainland of Central and South America. The various population mixes, languages, and cultures reflect the colonial and political histories of the various states and territories. In terms of political economy, regionalism and collective coalitions have provided a means for Caribbean states to play an important role in international politics that their individual small size might otherwise have prevented. This is facilitated through a number of institutions such as CARICOM, the Association of Caribbean States, the Organisation of Eastern Caribbean States, and others. Thus the term Caribbean Region can be interpreted in differing ways and as a result is deliberately used loosely throughout this paper.

[1] GWP-C 2012.

This paper provides an overview of the major factors influencing water security in the Caribbean Region. Given the diversity of the region, this will necessarily entail a "broad brush" approach; to balance this, case studies are used to illustrate some of the points being made. A broad outline of the state of water resources and service provision is given, along with discussions, grouped under four headings, of the factors affecting the supply and demand for the goods and services that water makes available. The potential impact of future changes, such as demographics, climate change, and economics, are also explored.

Figure 1. The Caribbean Region (source: Google Earth)

1. Water Security

Water scarcity can be a product of the conditions that determine demand and supply: social conditions influence demand (patterns of behavior, social norms and expectations) while the nature of the available resources, the provision of infrastructure, and the condition of ecosystem services can all determine the conditions of supply. At the Rio+20 Conference in 2012, the themes of water security and sustainable development were very much in evidence, even though there were "no agreements on any ambitious treaties or deadlines for dealing with pressing issues such as climate change, food and water scarcity."[2] Evidence of the growing importance attached to water security can be found in the call on the U.N. Security Council "to recognize water as one of the top security concerns facing the global community."[3] In other words, there are fears that growing water insecurity could lead to social unrest and conflict within and between states. Hence achieving a water-secure world is a necessary condition for the realization of social well-being and equitable economic development.

Water security is seen increasingly as an integral part of human security and central to the achievement of other rights such as the right to life, to education, to health, and to adequate housing.[4] Thus, access to enough safe water at an affordable price is necessary for a person to lead a healthy, dignified and productive life; at the same time, maintaining the health of ecosystems that provide water is essential for water security.[5]

Grey and Garrick[6] propose that "water security is defined as a tolerable level of water-related risk at any scale and for any actor" and that it includes "every interaction between society and water." They emphasize that water security operates across the dimensions of values, scale, and actors, suggesting that water insecurity impedes social and economic development and leads to environmental degradation. More straightforwardly, the Global Water Partnership has defined a water-secure world as one that "integrates a concern for the intrinsic value of water together with its full range of uses for human survival and well-being. . . .[It] harnesses water's productive power and minimizes its destructive force. It is a world where every person has enough safe, affordable water to lead a clean, healthy and productive

[2] EEA 2012.
[3] Bigas 2012.
[4] UNDP 2006.
[5] Ibid.
[6] Grey and Garrick 2012.

life. . . . where communities are protected from floods, droughts, landslides, erosion and water-borne diseases."[7]

2. Drivers of Insecurity

Considering the various definitions of water security, there are common elements that provide a characterization and framework within which to examine the Caribbean situation. The common elements identified are adequacy, accessibility, assurance, and affordability. Within each of these terms there are different drivers and pressures that affect water security.

- Adequacy addresses conditions governing water resource availability in time and space that satisfies often competing demands and the nature of the demands that drive exploitation.
- Adequacy is complemented by physical accessibility, ensuring that water is available when and where it is needed in such a way that is not an undue burden.
- Assurance concerns the ability to secure safe and sufficient resources to cope with potential system shocks such as extreme events, security threats, and contaminated resources.
- Affordability applies to providers of water services and those who have to obtain those services and is related to how water management and services are to be paid for as well as the financial position of state agencies and of businesses and citizens.

Table 1 provides a provisional listing of the various drivers and pressures associated with the different aspects of water security, though it does not capture the overlapping nature of some.

Table 1. Drivers of Water Security – The 4 As

WATER SECURITY			
Adequacy	**Accessibility**	**Assurance**	**Affordability**
Resource availability Demographics Economic development Water demands and use efficiency Ecosystem services	Human right to water Millennium Development Goals (MDGs) Water policies and legislation Service provision and coverage Service management	Hydrological variability Shocks Public health Water management	Financing Public policy Economic instruments Tariffs

[7] GWP 2012.

Adequacy

The Caribbean is a humid tropical region; the climate varies with both elevation and the size of the land mass. Temperatures are strongly elevation-dependent; in coastal areas they vary on average between a high of 32ºCelsius (C) and a low of 24º but with increasing elevation temperatures can drop to 10ºCelsius. There are two distinct seasons during the year: a dry and a wet summer hurricane season. Precipitation varies greatly, with windward sides of the islands receiving much more rain than the leeward sides, occurring in short and heavy downpours. Table 2 gives details of average rainfalls by country. Thus water resources are spatially varied and determined by the interaction of climate, geology, and topography. Temperatures tend to vary little throughout the year at sea level, so for a significant part of the year evapotranspiration rates exceed precipitation, affecting availability. Availability of freshwater has been of concern for at least the last 30 years.[8] Given increasing levels of demand and the expected changes in precipitation patterns brought on by climate change, even a slight reduction in rainfall would have serious consequences.[9]

Box 2. Responding to Drought
In 1994–1995, Barbados experienced a one-in-100-years drought event when over 3,000 households were regularly without water, including the island's main hospital. As a result, a desalination plant was built in anticipation of future drought events. It also prompted the Barbados Water Authority to embark on a program of universal metering and the gradual removal of public standpipes.

Table 2. Average Long-term Annual Rainfall by Country

Country	Average Annual Rainfall (millimeters)
Antigua & Barbuda	1030
Bahamas	1292
Barbados	1422
Belize	1705
Cuba	1335
Dominica	2083
Dominican Republic	1410
Grenada	2350
Guyana	2387
Haiti	1440
Jamaica	2051
Puerto Rico	2054

[8] CEHI 2002.
[9] UNEP 2003; IPCC 2007.

St. Kitts & Nevis	1427
St. Lucia	2301
St. Vincent & Grenadines	1583
Suriname	2331
Trinidad & Tobago	2200

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,[10] small islands are especially vulnerable to the effects of climate change and Caribbean islands are likely to experience increased water stress. The main pathways through which climate change affects water resources are sea level rise, temperature, and changes in precipitation patterns. Changes in hurricane activity will also have an effect, through impacts on infrastructure as well as on associated extreme rainfall events. Sea level in the Caribbean has been projected to rise at a rate of 5–10 millimeters a year. However, this effect is complicated by the occurrence of vertical crustal changes on some Caribbean islands as a result of tectonic processes.[11] Such changes are likely to affect coastal aquifers to a greater or lesser extent, depending on the rate of tectonic uplift.

Recent climate change projections for the Caribbean have indicated increases in temperature of between 0.7 ºC and 4.0 ºC, depending on the emission scenario used.[12] More recent climate modeling work[13] for the Caribbean, using the A1B emissions scenario, projects a 2.5–3 ºC rise in temperatures for the northern and southern Caribbean and 2–2.5 ºC for the eastern Caribbean for 2075–2099. This warming occurs alongside an increase in the number of days and nights where temperatures exceed 35 ºC during the day and 25 ºC at night. A greater warming is observed in the northwest Caribbean (Jamaica, Cuba, Hispaniola, and Belize) than in the eastern Caribbean island chain; and a greater warming is observed in the summer months than in the cooler and traditionally drier early months of the year. Such changes will have a significant impact on soil moisture and evapotranspiration rates.

With respect to rainfall patterns, previous work projected a general drying trend with decreases in precipitation of 25–50 percent by 2080.[14] However, in the very northern part of the Caribbean (The Bahamas and Cuba) as well as in southern parts (over Panama and Colombia), increases in precipitation were projected. Looking at the seasonal distribution of

[10] IPCC 2007.
[11] Farrell et al. 2007.
[12] Campbell et al. 2010.
[13] Hall et al. 2012.
[14] Campbell et al. 2010.

rainfall, the models indicate significant decreases in wet season precipitation across the Caribbean.[15] Extreme rainfall events are of particular interest, as water availability depends strongly on rainfall. The pattern from regional climate models (RCMs) of consecutive wet days and annual maximum consecutive five-day precipitation totals is mixed, though there are indications of an increase in drier conditions in isolated areas of the major Caribbean islands. The RCM suggests that while the northern Caribbean will experience more-intense rainfall and fewer rainy days, the southern part will experience the opposite: less-intense rainfall and more rainy days.[16]

More recent work by Hall et al.[17] generally supports the earlier conclusions, although it projects a decrease in annual precipitation of 10–30 percent, and during the wet season there is projected to be a 30 percent decrease for the northern and 20 percent for the eastern Caribbean. However, over Belize and Guyana there are projected to be increases of between 20–30 percent during the summer months of the wet season. Analysis of the mean daily precipitation during a particular period indicated a 10–15 percent decrease in higher-intensity rainfall for the northern and an increase in intensity of at least 15 percent for the southern Caribbean, with no change for the eastern area. Changes in precipitation intensity and the overall rainfall projections for 2075–2099 suggest a shift in rainfall distribution patterns across the region. The significant reduction in wet season rainfall across most of the insular Caribbean is particularly problematic for water resources, especially when coupled with projected higher temperatures. This suggests that there is the potential for a major reduction is water availability. Anecdotal evidence from Dominica appears to suggest that this may already have begun (Bernard Ettinoffe, Dominica Water and Sewage Corporation, personal communication), with decreases in stream flows being observed.

[15] ECLAC 2010a.
[16] Campbell et al. 2010.
[17] Hall et al. 2012.

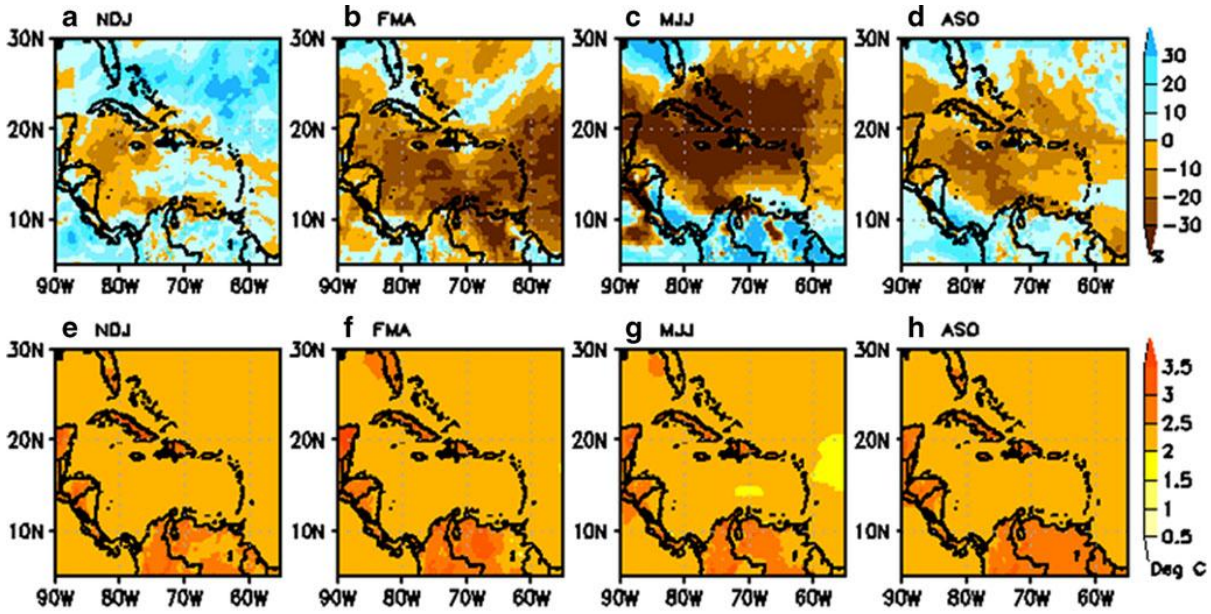

Figure 2. MRI AGCM simulated three monthly seasonal changes for the period 2075–2099 relative to 1979–2003. a–d Show rainfall, units in percent. e–h Show temperature, units degrees Centigrade. Source: Hall et al., 2012

The potential impacts of meteorological changes on water resources require much more investigation to quantify what these might be in terms of resource availability and adequacy. A simplistic interpretation of the reduction in wet season rainfall would suggest less available flows and potential changes in water quality. For groundwater, irrespective of any shifts in rainfall intensity and number of consecutive dry days and the impact on intra-annual flow variability, a reduction in rainfall means less water available for recharge.

These projections are particularly troubling given that there are already serious gaps between available supply and demand in many Caribbean countries; Barbados is using close to 100 percent of its available water resources, St. Lucia has a water

Box 3. Some Impacts of the 2009–2010 Drought

Antigua and Barbuda, The Bahamas, and the Cayman Islands obtain a significant portion of their potable water supplies from desalination plants and are thus buffered from the effects of drought on water resources. On some of the smaller islands, such as the Grenadines and in rural communities, rainwater harvesting is used to meet domestic demand. The timing and extent of a drought determines the impact on surface and groundwater resources, with surface water resources, as they are fed by rainfall and runoff, being affected sooner than groundwater. During 2009 and the first quarter of 2010, countries such as Jamaica, Trinidad, Dominica, and St. Lucia reported significantly lower than normal flows. In Antigua, the main supply reservoir that meets 22 percent of water demand was empty by March 2010. In Barbados, water levels in aquifers and production boreholes reached extremely low levels, leading to the implementation of Stage 1 of the national Drought Management Plan. The island of Carriacou, part of Grenada, which relies exclusively on rainwater for its water needs, had to have water tinkered to the island from the mainland, even though water production in Grenada was reduced by 30 percent.

supply deficit of approximately 35 percent, Nevis is at 40 percent, Trinidad has had a deficit since 2000,[18] Jamaica is projected to experience deficits in areas of important economic activity by 2015,[19] Antigua and Barbuda rely on desalination to meet demands for water, and in Dominica, Grenada, and St. Vincent and the Grenadines demand can exceed supply during the dry season due to reduction in stream flows.[20] Belize and Guyana face a different set of problems to those of the insular Caribbean. Water resources are more than adequate, but they are more prone to the effects of drought and flooding, and in the case of Belize the effects of hurricane activity. The situation across the region is compounded by high levels of unaccounted-for water (e.g., 67 percent in Jamaica, 40 percent in Trinidad, and 50 percent in Barbados). The paradox is that many of these countries have sufficient water resources to meet demand but not the infrastructure or institutional frameworks to close the supply-demand gap. It is only in some of the drier islands, such as Antigua and Barbuda, Barbados, and The Bahamas, that water resources can be considered scarce, and it could be argued that the level of peak renewable water has been reached there.[21]

However, some care needs to be exercised, as situations are more complex at subnational levels since there are disparities between available surface and groundwater resources, their spatial distribution, and the centers of demand. This can give rise to situations where, as will be shown in the case of Jamaica, some of the water resources are exploited at levels beyond their renewable levels. This is particularly the case for nonrenewable sources such as groundwater. Thus any changes in recharge rates due to climate change are likely to have severe supply implications. The impact of climate change on the infrastructure can be twofold. First, existing infrastructure may be ill equipped to cope with changes in the hydrological regime and water quality; more treatment may be required to deal with changes in water quality, pumping arrangements may need to be reconfigured, and more storage distribution storage provided. Second, it is anticipated that there will be an increase in category 4 and 5 hurricanes.[22] Existing hurricane activity already affects water infrastructure through landslides that compromise dam reservoir integrity and damage pipelines, damage to intake works and boreholes through sediment and debris, damage to pump stations either directly due to floods or loss of power, and damage to wastewater treatment facilities—

[18] WASA 2005.
[19] GoJ 2011.
[20] USACE 2004.
[21] Gleick and Palaniappan 2010.
[22] Holland 2012.

leading to heightened threats to public health. An increase in more-severe hurricanes could well have serious detrimental effects.

The region has recognized its vulnerability and has, through the Caribbean Community Climate Change Centre (CCCCC), developed a regional Climate Change Strategy and Implementation Plan. The plan identifies key adaptation and mitigation measures for water to address the impacts of climate change. Key to this is the recognized need for a major improvement in data availability through better data gathering and monitoring platforms and through a sharing of water information.

Box 4. Saline Intrusion in The Bahamas and Jamaica

The Bahamas consists of an archipelago of some 700 islands, only a few of which are inhabited. The islands are low-lying and made up predominantly of coral and oolitic limestones, reaching a maximum height of 63 meters, making them prone to flooding from tropical storms and hurricanes. Freshwater is available from groundwater, recharged by rainfall, which exists as lenses that "float" on top of the heavier and more saline seawater. Abstraction of groundwater takes place from shallow wells or trenches. The threats to groundwater arise either from overabstraction, causing saline intrusion by an upwelling of the underlying saline waters to replace the abstracted freshwater, or from saline contamination due to storm surges that inundate low-lying areas.

In 2004, Hurricane Francis affected the whole of The Bahamas, the first hurricane to do so since 1864, and it destroyed almost the entire Bahamian agricultural economy. On North Andros, the associated storm surge increased chloride levels from 400 to 13,000 milligrams per liter (mg/L) in some of the well fields. The surge gave rise to elevated chloride levels in the upper parts of the freshwater lens, but at depths over 3 meters it did not appear to have adversely affected the aquifer. This was ascribed to the presence of a network of trenches and pits used for abstracting water. The storm surge, though not directly observed, was thought to have flooded the trenches and contaminated the aquifer through infiltration, and in doing so it affected half the supply to New Providence.

The lesson to be learned from this example is that inappropriate infrastructure, in this case open trenches, can increase the vulnerability and compromise the safety of water resources. It points to the need for proper vulnerability mapping to identify areas at risk from storm surges and flooding and it highlights the fact that climate change will in all probability increase the existing vulnerabilities.

Unplanned and uncontrolled abstraction of the Lower Rio Cobre aquifer in Jamaica starting in 1935 resulted in the overexploitation of the aquifer and a landward movement of saline groundwater in the main limestone aquifer. The limestone aquifer is recharged via outcrops and through seasonal rainfall. Due to the karstic nature of the limestone, most recharge is believed to be due to conduit flow. Pumping from production wells at levels of up to 8 meters below sea level resulted, between 1930 and 1973, in the fresh/saltwater interface advancing up to 8 kilometers inland in some places and in chloride levels increasing to 200 mg/l.

Surface Water

Many of the islands—Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, St. Lucia, Dominica, and others—predominantly use surface water for their water supplies. Though the variation between wet and dry season flows can be ameliorated through water storage reservoirs, there appears to be little attempt to use this strategy. The volume of surface water storage, per person, in St. Lucia is 16 cubic meters (m^3), in St. Vincent 45 m^3, and in Trinidad approximately 8 m^3 per person. In contrast, the figures are 274 m^3 for the Dominican Republic, 1,161 m^3 for Honduras, and 1,568 m^3 for Mexico. Though a crude measure, this highlights that the insular Caribbean is vulnerable to climatic variations in precipitation and stream flows.

An increasing threat that is affecting streamflows is the conversion of catchments either through development or for agriculture. The urbanization of the upper watershed areas around Port of Spain in Trinidad and Castries in St. Lucia has resulted in higher peak flows, downstream flooding, an overall reduction in base streamflows,[2324] and higher sediment loads. The devastating effects of catchment conversion can be most clearly seen in Haiti, where denuding of hillsides has resulted in slope instability, mud flows, and catastrophic flooding, as happened in Gonaives in 2008.[25]

The decrease in surface resources during the dry season often leads to significant reduction in water production (in Dominica, this can amount to a 50 percent decrease; Bernard Ettinoffe Dominica Water and Sewage Corporation, personal communication), as noted above. Many catchments and watersheds used for water supply are essentially ungauged and rainfall measurements are sparse. Thus for many of the smaller islands, making estimations of safe yield and environmental flows is problematic while for the larger islands there are better hydrological networks so that they are better able to understand their catchment hydrology and to estimate safe yields.

Box 5. Predicting the 2009–2010 Drought

The Caribbean Region has experienced a number of (meteorological) droughts since 1990: in 1994–1995, 1997–1998, 2002–2003, 2004–2005, and most recently 2009–2010. These events are correlated with the El Niño Southern Oscillation and result in below-average rainfall and above-average temperatures. The onset of the 2009-2010 drought event first became apparent during the 2009 wet season, particularly from October in the southeast Caribbean and then spreading northwards. The drier-than-normal conditions led the Caribbean Institute for Meteorology and Hydrology (CIMH) to issue Drought Alerts for Barbados and Grenada and in January 2010 to inform Antigua and Barbuda, Trinidad and Tobago, Jamaica, and Dominica of the situation.

From December 2009 to February 2010 rainfall monitoring stations in Trinidad, Grenada, St. Vincent, Barbados, St. Lucia, Dominica, Dominican Republic, and Jamaica all recorded their lowest three-month totals in recorded history, followed by below-normal rainfalls in March. Many stations also recorded their lowest six-month totals (October 2009–March 2010), including stations in Tobago, Grenada, Barbados, St. Vincent, St. Lucia, and Guyana.

Outputs from CIMH's Precipitation Outlook and Caribbean Drought and Precipitation Monitoring Network, operational since January 2009, had consistently forecast below average rainfalls for the region over the four to six months prior to January 2010. The January–March 2010 Outlook indicated a continuation of below-average rainfall, while the March 2010 Outlook (March–May, part of the dry season) suggested a gradual return to near-normal conditions, and a period of above-average rainfall followed during the wet season. A worrying concern was that in spite of the issuing of the Precipitation Outlooks to national meteorological services, it appeared that few took sufficient notice of them, and many agencies across the region were

Groundwater

With respect to groundwater resources, which the islands of Barbados (90 percent of supplies), The Bahamas, Antigua, and Jamaica (84 percent of supplies) make use of for public water supply, the nature of the resource and recharge mechanisms attenuate intraseasonal rainfall and recharge variability. For example, in Barbados and Puerto Rico recharge occurs

[23] Edwards 2011.
[24] Williams 2010.
[25] Smith and Hersey 2008.

during the peak wet season months[26] and is significant when monthly rainfall is above a threshold of 195 millimeters. Threats to aquifer yields include prolonged periods of low rainfall and prolonged abstraction levels that exceed the sustainable long-term aquifer recharge.[27] This is especially the case for coastal aquifers, where abstractions have resulted in "up coning" and increased levels of salinity as the fresh-saline water interface has migrated inland. In some cases, such as abstraction from the Liguanea aquifer in the Kingston St. Andrews area of Jamaica, high concentrations of nitrates have been attributed to inappropriate sewage disposal in urban areas.[28] Such contamination of groundwater makes it unusable unless expensive treatment is provided. Overexploitation of aquifers above safe yield, saline intrusion, and pollution pose major threats to groundwater resources, turning them into nonrenewable sources. A major challenge facing water resources managers as well as service providers is the difficulties associated with being able to determine the safe yields of aquifers and to undertake regular forward assessments of the yield-demand balance. Often the required hydrogeological data, the models, and the skilled personnel are all in short supply.

Demographics

Population dynamics and rising incomes have been identified as two of the underlying drivers of the demand for water.[29] Arguably, population growth is not as important as trends in age distribution and urbanization. Most Caribbean countries have population growth rates of 1 percent per year or less, and they are experiencing net outward migration rates of between 2 and 10 persons per thousand. In addition, levels of urbanization are increasing: 65 percent of the population live in conurbations. A feature of most Caribbean countries, especially the islands of the Lesser Antilles, is that most of the urbanization has taken place around the coastal fringes; up to 70 percent of the population live in coastal cities, towns, and villages, and 40 percent live within 2 kilometers of a coast.[30] There are few available data on the percentage of the urban population considered to be living in slums; Jamaica has a reported figure of 61 percent, Guyana 34 percent, and St. Lucia 12 percent.[31]

The impact of these demographic changes in the Caribbean with respect to demand and consumption patterns has not been studied, but urbanized populations consume more water per capita than rural populations do. Rural poverty is much higher than in urban areas,

[26] Jones and Banner 2003.
[27] Box 4 from White 1980.
[28] Mandal and Haiduk 2011.
[29] WWAP 2009, p. 14.
[30] Bueno et al. 2008; UNEP 2008.
[31] UNFPA 2007.

and estimates suggest a relatively high level of income inequality as well.[32] An increasingly urbanized population along with improvements in standards of living are likely to drive further increases in both total and per capita levels of water consumption.

In 2011 some 17.6 million tourists went to the Caribbean on holiday, with an average stay of 7–10 days. Tourism and tourist facilities are large consumers of water, with visitors often consume at least three times as much as the local population.[33] As a mainstay of many Caribbean economies, governments across the region remain keen to encourage growth in tourist numbers. While in some instances hotels are responsible for their own supplies, many are supplied from municipal distribution systems, and they can account for between 10–15 percent of all water supplied. Although there are some incentives to encourage the efficient use of water, such as through tax incentives and certification schemes, for the majority of hotels this is not a prime consideration.

Ecosystem Services

The Millennium Ecosystem Assessment[34] defined ecosystem services as benefits people obtain from ecosystems, and it recognized four categories of services: supporting (which are the basis of the other three), provisioning, regulating, and cultural services. The ecosystem services provided by watersheds are among the most important; they capture, filter, and store rainwater, they give protection against erosion, landslides, and flooding, and they provide habitat for plant and animal species. As watersheds deteriorate, however, poor water supply, quality, and reliability increasingly affect consumers and threaten key economic sectors. At the same time, water abstraction can also have an adverse impact on habitats. This is especially important as the Caribbean has high levels of species endemism (plants 50 percent, mammals 46 percent, birds 27 percent, reptiles 93 percent, amphibians 100 percent, and freshwater fish 40 percent). And it ranks third among the world's 34 biodiversity hotspots[35] at the genus level. The large islands of the Greater Antilles and island chains have some of the highest degrees of diversity, in keeping with the principles of island biogeography. Among the main threats to terrestrial biodiversity in the insular Caribbean are severe weather events, climate change, and the exploitation of natural resources, including water.

Tropical streams are increasingly being recognized as vital to the conservation of the ecosystem services furnished by watersheds. They not only provide habitat but also are a

[32] Downes 2010; Schmid 2007.
[33] Charara et al. 2011.
[34] Millennium Ecosystem Assessment 2005.
[35] Anadon-Irizarry et al. 2012.

marine–terrestrial ecotone and corridor for the exchange between different ecosystems[36] and are key to the dispersal patterns at various stages of species life histories.[37] Many of the migratory species play important roles in shaping community composition and ecosystem properties in watersheds, as well as being important to coastal fisheries. However, little is known of how biota respond to changes in the hydrology of tropical systems, and this is seldom considered when water resources are being developed. Water resources development that adversely affects fauna and flora can cause shifts in assemblage structure and can result in increases in sedimentation. This highlights the need to better understand the environmental requirements not just of watershed ecosystems but particularly of aquatic ecosystems, especially to provide estimates of instream ecological water flows[38]—in particular where structures such as dams have been introduced.

An approach that has been suggested as a better way to manage the ecosystem services provided by watersheds has been payment for environmental services (PES). There is little to no experience of this in the Caribbean, though its potential contribution to watershed management has been investigated in Trinidad and Tobago, Jamaica, Grenada, St. Lucia, and St. Vincent and the Grenadines.[39] The study identified a number of constraints and concluded that it was not practical to introduce PES schemes, especially as the sectors that had the greatest potential to be buyers—water utilities, tourism, and agriculture—considered themselves to be overtaxed already.

Accessibility

The drivers for greater accessibility originate from both the supranational and the national level. There can be little doubt that the Millennium Development Goals have played a pivotal role in driving the provision of water and wastewater services globally. The more recent debates around water as a human right have the potential to influence policies and actions at the national level.

Water Supply Services

For many Caribbean countries, improved water supplies and sanitation exceeds 90 percent coverage. (See Table 3.) The problems are not so much associated with the universal provision and access to water services, though in some cases this does remain an issue;[40] rather they are related to the quality of service and the maintenance and operation of the

[36] Holmquist et al. 1998.
[37] Smith et al. 2003.
[38] Scatena 2004.
[39] MacIntosh and Leotaud 2007.
[40] Schneiderman and Reddock 2004.

existing infrastructure. The challenges include inappropriate governance arrangements, deficient legislation and regulation, aging infrastructure, high levels of unaccounted-for water, concerns over potable water quality, and poor infrastructure management.[41]

Table 3. Use of Sanitation and Drinking Water Facilities (percent of the population)

Country	percent Urban Population	Sanitation				Water Supply			
		Urban		Rural		Urban		Rural	
		Unimproved	Improved	Unimproved	Improved	Unimproved	Improved	Unimproved	Improved
Anguilla	100	6	94	n/a		40	60		
Antigua &	89	2	98	n/a		5	95	11	89
Barbuda	47	n/a	n/a	n/a			100		100
Aruba	84		100		100	2	98	14	86
The Bahamas	44		100		100		100		100
Barbados	65		100	n/a		n/a	n/a		n/a
Bermuda	52	7	93	13	87	2	98	1	99
Belize	41		100		100	2	98	2	98
British Virgin	75	6	94	19	81	4	96	11	89
Islands	100	4	96	n/a		4	96		n/a
Cuba	67	10	80	16	84	4	96	4	96
Cayman	69	13	87	25	75	4	96	16	84
Islands	39	4	96	3	97	2	98	7	93
Dominica	98	5	95	n/a	n/a	13	87		n/a
Dominican	29	12	88	18	82	2	98	7	93
Republic	52	76	24	90	10	15	85	49	51
Grenada	52	22	78	18	82	2	98	12	88
Guadalupe	89	5	95	n/a			100		n/a
Guyana	14	4	96	4	96	n/a	100		n/a
Haiti	93	n/a	n/a	n/a		n/a	n/a		n/a
Jamaica	99	n/a	n/a	n/a			n/a		n/a
Martinique	32	4	96	4	96	1	99	1	99
Montserrat	28	29	71	37	63	2	98	5	95
Netherlands	49	n/a	n/a	4	96	n/a	n/a	7	93
Antilles	69	10	90	34	66	3	97	19	81
Puerto Rico	14	8	92	8	92	2	98	7	93
St Kitts & Nevis									
St Lucia									
St Vincent & Grenadines									
Suriname									
Trinidad and									

[41] Cashman 2012.

Tobago									

Source: UNICEF/WHO, *Progress on Drinking Water and Sanitation 2012 Update*.
N/A not available

High levels of unaccounted-for water have been noted, and contributing to this are under-reading by domestic meters and bulk production meters (50 and 15 percent respectively in Barbados) and bursts and leakage (40 percent in Barbados).[42] Real losses are a function of the water network as well as its operation and maintenance. Many Caribbean countries have aging water infrastructure and focus on the maintenance of supply to customers. Investment in mains replacement as well as leakage management has not received the attention it deserves. This is partly due to water resource scarcity being something of a ghost issue (meaning that people hear about the issue but don't believe that it exists), with management efforts being focused on ensuring new developments are serviced, siphoning off investment in water loss, and prevention measures.

However, this situation is gradually changing due to practical and policy reasons. There is a growing need to supply new developments. On the policy front, there is increasing interest in transitioning to a green economy, with its emphasis on resource use efficiency and the sustainable use of natural resources such as water.[43]

Hurricane Tomás, which affected the Caribbean in 2010, highlighted the impact of extreme events on maintaining accessibility under emergency situations. In St. Lucia, the principal storage reservoir was damaged by a landslide, which led to damage to the electricity supply and pumping facilities. Some 80 percent of the population had to cope with limited water supply. Siltation blocked the lower intake, significantly reducing the available storage supply volume. Hurricane Tomás highlighted the multiple facets to maintaining accessibility; water systems cannot operate without electricity, and water becomes non-potable if it cannot be properly treated. This suggests that greater attention needs to be paid to scenarios where risk and uncertainty analysis are factored in (this approach is being incorporated into research being carried out by the University of the West Indies).

[42] Halcrow 2010.
[43] UNEP 2012.

Box 6. Drought Impact on Water Supply to Kingston and St Andrew, Jamaica

Between January 2009 and May 2010, Jamaica's rainfall was well below the 30-year average, and this was particularly the case for watersheds that supply the Kingston and St. Andrew (KSA) metropolitan area, Jamaica's capital, where calculations showed that the drought was severe to extreme. Daily streamflows into the two reservoirs supplying the KSA area were 50–75 percent less than normal daily flows. The drought situation affected nearly 600,000 people living and working in the KSA area, and water production at the height of the drought had to be reduced by some 40 percent. In some instances daily outputs from some water production facilities were reduced by as much as 90 percent. The economic impact of the drought on the operations of the National Water Commission, the body responsible for supplying the KSA area, was on the one hand around 36 percent less revenue and on the other hand increased operating costs associated with extra trucking costs and the labor costs associated with extra work. There was no appreciable drop in electricity consumption, as plants still had to be kept running.

Information on the cost to the local economy is not available, but the observed impacts included the additional cost of purchasing water supplies from private truckers; reduction of working hours, resulting in loss of output; and loss of productivity as workers arrived late for work. At the same time, the drought conditions did give rise to some entrepreneurial opportunities; individuals with private wells were able to supply water truckers, some of whom also started collecting water from untreated sources, posing a public health threat. Indeed, the impact on public health was marked. The number of reported oral rehydration/diarrheal cases of children under 5 years old requiring treatment increased by some 20 percent for January to March 2010, the height of the drought, compared with the previous corresponding period. The observed social impacts included:

- Increased mental stress resulting in anxiety, depression, and domestic violence
- Learning problems among schoolchildren due to closures
- Reduced nutrition due to increased cost of food
- Risks to public safety due to increased incidents of fires.

In response, mitigation measures were put in place to try to ensure that some level of supply was maintained while at the same time reducing overall demand. The measures included reducing the number of hours of supply, rotational cuts to distribution areas, reduced water pressure, increased trucking of water (especially to areas at higher elevation), and reactivation of unused wells to augment supplies. In the longer term, priority has been given to the implementation of a number of capital works projects that aim to increase the available supply by developing new surface and groundwater sources. These include: constructing new water treatment facilities and rehabilitating and upgrading old ones; undertaking mains replacement to improve the condition of the distribution system and reduce leakage; and a comprehensive customer meter installation programme. The importance of good catchment management was also recognized, and some efforts are being made to collaborate with the Forestry Department to undertake tree planting in one of the supply catchment areas.

Some of the lessons learned from the 2009–2010 drought that affected the KSA area included an increased awareness of the need to assess risks and vulnerabilities and to incorporate this into the development of planning and drought management strategies on an on-going basis, not as a one-off exercise; the development of Water Safety Plans; consideration of the conjunctive use of surface and groundwater resources; better coordination between urban and water planning; implementation of a leakage management strategy; and consideration of how wastewater could be transitioned from a problem to a resource.

Summarized from Barnett 2011.

Water is intrinsically heavy and requires energy to be transported through transmission and distribution systems. As a result, many water utilities are big consumers of electricity and in some states are the largest electricity customers. Electricity generation in the Caribbean relies heavily on the importation and use of fossil fuels, and as this has to be paid for in hard currency it represents a burden on many countries' balance of payments. As such,

energy costs in the Caribbean are among some of the highest in the western hemisphere. Realizing that increasing energy use by water companies represents a potential threat to water security, there are some initiatives, supported by international financing institutions, aimed at improving energy use and efficiency. It has been estimated that savings of 30–40 percent could be made by installing energy-efficient devices and optimizing pumping equipment.[44] Little use is made of renewable energy sources other than of hydropower, however, and this is an area that should receive more attention.

Desalination as a source of supply is widespread throughout the Caribbean and is used on 14 islands. In some cases, such as the Cayman Islands and Aruba, there is very little other choice other than desalination. In other instances, desalination plants have been built either in order to supplement existing resources or as a drought proofing measure, such as in Barbados. There has been a growing tendency to push desalination as a solution for water supply difficulties without too much regard for other alternatives. The attraction is that such plants can be built relatively quickly and are often outsourced to the private sector under long-term Build and Operate contracts. But they are of course large consumers of energy. While desalination plants do provide a secure source of water, the continued affordability of such supplies when reliant on fossil fuels is open to question. What is more, given that they are often reliant on fossil fuels, any expansion of desalination needs to be balanced against commitments to reduce greenhouse gas emissions. Hence there is growing interest in smaller-scale desalination plants that use renewable energy, such as the one installed on Bequia. More needs to be done to improve the efficient use of energy in the water and wastewater sector and to make greater use of renewable sources and the opportunities for resource and energy recovery, especially in the wastewater sector.

Wastewater Services

The provision of infrastructure for wastewater services lags behind drinking water services. It has been estimated that 85 percent of wastewater entering the Caribbean Sea remains untreated. Poorly functioning sewage systems and the lack of or improper disposal of sewage are causing serious pollution of surface and groundwaters. Increasing levels of contaminants above World Health Organization guidelines are being recorded, which are posing a threat to public and environmental health throughout the Caribbean. Studies undertaken by the Pan American Health Organization in 2001 found that 51.5 percent of households lack any kind of sewer connections and only 17 percent are connected to adequate collection and treatment

[44] ECLAC 2010b.

systems.[45] This is indicative of the difficulties in developing strategies for wastewater management and investment in sewerage infrastructure.[46] In addition to the financial constraints,[47] other barriers include inadequate legal and regulatory frameworks; fragmented approaches to and responsibility for wastewater management; limited technical and operational capacity, knowledge, and awareness of low-cost treatment technologies.

In Trinidad, untreated organic matter from domestic sewage contaminates many water bodies and adds to the cost of water supply.[48] In other instances, contaminated water bodies, including the marine environment, cause health problems that give rise to the need for medical interventions and loss of productivity.[49] Sewage discharges into the marine environment are considered to be one of the main causes of degradation of coral reefs, eutrophication, and harmful algal blooms. A cost-benefit analysis of Barbados' proposed West Coast Sewerage Scheme[50] demonstrated that although the public health benefits were relatively minor, those arising from the avoided costs associated with deterioration of the marine environment were on the order of US$260 million and yielded benefit-cost ratios of between 1.3 and 1.6. Moreover, advanced wastewater treatment would allow augmentation of scarce water resources and increase availability for agriculture and industry. Under climate change this option is going to become more attractive.

Box 7. Drought Impacts on Agriculture
Agriculture in the Caribbean is predominantly rainfed and hence particularly prone to variations and extremes in rainfall and rainfall patterns. The drought had significant impacts on agriculture. For example, Dominica's banana industry production was reduced by 43 percent, in St. Vincent and the Grenadines agricultural production declined by 20 percent, and in Antigua and Barbuda vegetable crop losses of up to 30 percent were reported. Losses in local production, especially of vegetables, resulted in a marked increase in local food prices during the early part of 2010. The incidence of bush fires increased markedly due to the increased drying out of the landscape. In Trinidad, bush fires destroyed large areas of citrus farms, which resulted in greater imports. And when the rains did come, the denuded hill slopes were at greater risk from landslides and contributed to increased flooding, as happened in Dominica.

The coming into force of the Cartagena Convention's Protocol on Land-based Sources of Marine Pollution (LBS) has had a positive impact as it has allowed the development of innovative approaches to funding the expansion of wastewater services through the Caribbean Regional Fund for Wastewater Management (CReW). The objective of the CReW is to mobilize additional funding for wastewater treatment investments at an affordable cost of capital by leveraging co-financing arrangements. The fund is intended to support the improvement of existing institutional, policy, legal, and regulatory frameworks for wastewater management as well as to obtain training and capacity building for the

[45] PAHO 2001.
[46] UNEP-CEP 2010.
[47] Ibid.
[48] WRA 2001.
[49] GESAMP 2001.
[50] BWA 2008.

identification, evaluation, and maintenance of appropriate wastewater management technologies. A number of financing models are being considered, but the challenge will be to find innovative and cost-effective ways to address the current 48.5 percent of households that do not have a sewer connection. Barbados' Green Economy Scoping Study[51] suggests that addressing this backlog represents an opportunity for the private sector, given the right mix of incentives and regulations.

Assurance

Water resources are variable in both time and space. The challenge is to put in place infrastructure that is capable of meeting present and future needs while at the same time coping with the variability of the water resources. The fact that water infrastructure, especially in urban settings, is expensive to construct and maintain and is composed of assets that are long-lived compounds the challenge of assuring adequacy and accessibility.

Variability

There is some evidence that climate-related events have become more frequent and more extreme, resulting in an intensification of the hydrological cycle.[52] The greater variability within the hydrological cycle has important implications with respect to the adequacy of existing water infrastructure and future planning and design. It suggests a need to re-evaluate assumptions regarding stream flows, aquifer recharge rates, and sustainable levels of abstraction and assured yields from surface and groundwater resources. The problems during the 2009–2010 drought demonstrated the difficulties associated with assuring supply. Recent work has indicated that both surface and groundwater resources are likely to be adversely affected by climate change and variability,[53] with significant decreases in sustainable yields due to decreases in recharge rates. Thus the ability to assure the security of supply needs to be reassessed, though it has to be acknowledged that the availability, completeness, and reliability of data for such assessments presents a major challenge in the Caribbean. It does not help that the available information on water resources from which to calculate yields and assess the impact of climate change is sparse and often incomplete. Thus, ensuring water security across the Caribbean is challenging, as many states have no idea what their resources are, how they vary, and what controls need to be implemented to ensure reliable long-term yields.

[51] UNEP 2012.
[52] WWAP 2009.
[53] WRA 2008; BEST 2009; Edwards 2011.

Shocks

The ability to withstand shocks (droughts, floods, hurricanes, etc.) to water services infrastructure (i.e., robustness and resilience) has received little attention in the region. More attention has been paid to the formulation of drought management measures and sector responses to hurricanes than to disaster and emergency response planning across affected sectors (John Mwansa, Barbados Water Authority, personal communication). This is changing as greater attention is paid by water managers to the development of Water Safety Plans,[54] and more recently by industry in developing Source Vulnerability Assessments (Tricia Bartlett, Barbados Bottling Company, personal communication). This entails a systematic identification and assessment of risks and hazards in the production and supply chain from source to point of consumption and the development of monitoring and management plans. The necessity for preparing strategies to deal with a range of possible threats may be ascribed to a combination of factors:

- The realization that sector-based emergency response planning is not an adequate response
- The increasing globalization of what is considered to be operational norms
- Lessons learned from regional disaster and emergency events: droughts, for example, which affect security of water supply to agriculture, towns, and cities; Hurricane Tomás's impact on St. Lucia's water and wastewater infrastructure; and the cholera epidemic in Haiti
- Corporate reputational and customer confidence concerns.

It would appear from the regional 2009–2010 drought, where in many instances warnings were not heeded, and from the experience of Guyana with earlier droughts that a great deal more needs to be done to internalize the lessons and act accordingly.[55] And this has to be done with limited and overstretched resources, under difficult economic circumstances that limit the capacity of responsible organizations and stakeholders to respond. At the heart of it, the ability to cope with shocks is as much a governance issue as it is an infrastructure issue.

Management

Poor operation and management of water systems will compromise the ability to maintain the integrity of resources and supplies and meet demands. Numerous reports from across the

[54] PAHO/EPA/CDC 2008; CEHI 2009.
[55] Farrell et al. 2010.

region on the state of water management[56] suggest that water management practices are sub-optimal. A World Bank report noted:

> *Institutional arrangements for policy making, planning, and regulation are confusing and weak, and often lead to overlapping and redundant responsibility. For instance, it is often unclear which agency is ultimately responsible for setting water service standards, and how they are enforced. The process for approving government contributions to capital investments is characterized by a game of political forces instead of economic criteria. Arguing that water and sanitation are essential social services, it is common for politicians and politically influenced regulators to keep tariffs below cost. The fact that many Caribbean water utilities are demonstrably inefficient helps rationalize this decision.*[57]

Water management and service tend to be "bottom heavy," employing large numbers of semiskilled staff and relatively fewer at the professional level. The relative scarcity of appropriate human resources and lack of capacity is matched by a lack of investment and use of information and communication technologies. Thus little use can be made of the data generated for evaluating performance or future planning. One senior engineering manager in a utility has said that they are "so busy putting out fires that they have no time to do anything else" (John Mwansa, Barbados Water Authority, personal communication). The effect of this has been to hamper future water management planning, and thus proposed investments are made on the basis of incomplete information and on a project-by-project basis. The result is that development has been hampered in many Caribbean states.

Poor management, lack of investment, and inadequate water services have led some states to address the problems through forms of franchise or private sector involvement (Guyana, Trinidad and Tobago, St. Lucia, and Belize). For a variety of reasons these initiatives have not been successful and have been opposed by trade unions and citizen groups. An emerging alternative has been to encourage cooperation between service providers in the region as well as with providers outside of the region and to benchmark the performance of water service providers. However, the lack of agreed standards of performance, confused and ineffective regulation of utilities,[58] and an absence of water

[56] The Global Environmental Facility Integrating Watershed and Coastal Area Management project prepared integrated water resources management plans for Grenada, Barbados, Union Island in St. Vincent and the Grenadines, St. Lucia, Dominica, St. Kitts and Nevis, and Anguilla and Barbuda. Each report evaluates water management and the challenges facing the countries and suggests how these might be responded to.
[57] World Bank 2005.
[58] Ibid.

policies[59] have allowed poor performance to continue to place security of supply and effective water management at risk.

Affordability

There are two sides to affordability: affordability of water management and services to the consumer/customer/citizen, which revolves around willingness and ability to pay for services, and affordability of the costs associated with the services for the provider. While there are many instances of affordability being largely determined by political considerations, within the Caribbean probably only Jamaica has an independent and functional regulatory regime[60] through which such matters can be resolved.

Consumer/Customer/Citizen Affordability

Of most concern is the ability of low-income people to be able to afford access to sufficient water to meet their needs so they are not spending a disproportionate amount of their income on water. Affordability issues have been addressed through charging a fix amount for a volume of water sufficient to meet water requirements, typically taken as between 10 and 15 cubic meters per month. After this, levels of consumption are charged at progressively higher unit rates in order to discourage excessive usage. While this may address questions of social equity, the basis for the tariffs is unclear. Anecdotal evidence from Barbados arising out of the 60 percent tariff increase in 2009 suggests that it was made to improve cost recovery but that the calculations were not particularly robust. The absence of robust economic regulation provides opportunities for less rigorous approaches to tariff setting. The suggested lack of affordability, combined with water being a basic need, provides powerful arguments to the political classes to keep water tariffs low.

In a survey of customer satisfaction two years after the 60 percent tariff increase, the Barbados Water Authority was rated the most satisfactory, including on price.[61] In Dominica, the 15 percent tariff increase in 2011 was judged to be reasonable by members of the public. However, affordability is clearly an issue in some cases. High level of outstanding accounts and a lack of effective measures to penalize non-payment are perhaps indicative of this. A further problem has been the ad hoc nature of tariff adjustments in many but not all cases. However, the mounting pressures on public finances may be having an effect, as several countries across the region have revised their tariffs over the last four years (e.g. Barbados, Jamaica, Dominica, Grenada, and St. Vincent and the Grenadines).

[59] Cashman 2012.
[60] World Bank 2005.
[61] NISE 2012.

Service Provider Affordability

The provision of water services requires financing in order to cover costs, and service providers have to generate sufficient income to cover these costs; if they do not, services have to be curtailed. The prescriptions for ensuring that service providers can afford to provide the services they offer have been set out by various authors and bodies with a reasonable degree of agreement.[62] These include finding a balance between not having too heavy an impact on household incomes through tariffs, the need to reduce dependence on public budgets (subsidies), and the need to encourage utilities to adopt a long-term approach to setting revenue requirements by considering not just operational needs but also asset management plans. It also includes being in a position to attract investment based on the organization's creditworthiness.

The predominate financing model in the Caribbean appears to be one whereby operation and maintenance costs are covered by revenue from tariffs but capital works are funded through loans and transfers and are guaranteed by governments. This "cash needs" approach[63] does not take into account implicit costs such as exchange and inflation risks, environmental costs, bad debts, and costs of forgone operation and maintenance. If tariffs are not regularly reviewed and adjusted there will be increasing reliance on taxation transfers. This appears to be the case in Barbados, Dominica, St. Lucia, and Trinidad and Tobago, and probably in other Caribbean countries as well, where increasing levels of utility indebtedness have been reported. (This can be difficult to determine if Annual Accounts of the service providers are not published.) A compounding factor is the lack of a clear institutional framework of policies, legislation, and regulations that set out duties and responsibilities, such as cost recovery policies.[64]

A development that appears to be emerging as a result of the current economic challenges is that of off-balance-sheet financing mechanisms such as public-private partnerships. To date such arrangements have been used in the provision of desalination plants, but there is no reason why the approach cannot be extended to other aspects of service provision and management.

[62] Massarutto 2007.
[63] Baietti and Curiel 2005.
[64] Cashman 2012.

3. Outlook

Since the mid-twentieth century the Caribbean region has undergone a remarkable transformation away from a predominantly rural, agriculture-based economy to a situation where the majority of the population is urbanized. There are, however, likely to be challenges for Caribbean states in holding on to the gains that have been made while at the same time moving toward sustainable water resources management. The Caribbean is one of the most vulnerable regions in the world with respect to exposure to the effects of climate change and also natural hazards, given that climate change and with it greater climate variability is likely affect the severity of natural hazards such as hurricanes, extreme rainfall events, drought conditions, and extreme temperatures.

The Good News

There is some good news about water security and services in the Caribbean:

- **Increased investment**. There is ongoing investment in infrastructure such as production wells, water treatment works, pumping installations, leakage reduction initiatives, and mains replacement programs. Water utilities in Dominica, Barbados, Grenada and others are investing, sometimes out of their own resources and sometimes with the help of international financing institutions, in works that extend existing supplies or make them more robust. Jamaica is to invest US$44 million in rural water supply upgrading, benefiting 250,000 people over three years, in addition to obtaining an IDB grant to carry out a rural water master plan and review of its water sector policy. In Haiti, with the investments being made by the IDB and other funding agencies, there is the prospect that the next few years will see considerable improvements in water supply and sanitation. Indeed, some of the successful models of service delivery involving private sector provision from Jamaica and Haiti may well find application within the wider Caribbean.
- **Climate change adaptation and regional coordination**. The Implementation Plan for Regional Framework for Achieving Development Resilient to Climate Change provides a sound, well-formulated plan of action that addresses water-related needs and forms the basis for attracting funding and investment for the region. It is the result of cooperation across the region coordinated through an apex body and provides a template for addressing water security challenges. Regional cooperation in water is strengthened at the formal level through the formation of a CARICOM Consortium of Water Institutions and the implementation of a common water framework in 2008. At the informal level the

contacts between water professionals across the region are facilitated by several mechanisms, including the sector-sponsored High Level Ministerial Forum, which provides a platform for improved coordination of water management initiatives in the Caribbean. This will be further strengthened by the Water and Climate Change Development Programme for the Caribbean that started in 2012.

- **Successful interventions**. The Global Environment Facility's project on Integrating Watershed and Coastal Area Management (IWCAM) in the Small Island Development States of the Caribbean raised the profile of integrated water resources management (IWRM) throughout the region through demonstration projects and specific interventions, such as the preparation of IWRM Roadmaps, IWRM Indicators Assessment, and engagement with national and regional stakeholders. As a result, some countries are moving toward revising their water policies and legislation, and the Organisation of Eastern Caribbean States is developing model water legislation based on IWRM principles and good practice. Support and engagement through IWCAM was credited with facilitating the entering into force of the LBS Protocol (Chris Cox, UNEP, personal communication), thus clearing the way for getting the Caribbean Regional Fund for Wastewater Management off the ground. The successor project IW-Eco promises to leverage cofinancing for the water sector of US$118 million.
- **Data gathering**. The development and improvement of the Caribbean Drought Monitoring and Precipitation Network continues to make a positive contribution to forecasting and preparedness in the region. Barbados, Guyana, Grenada, St. Lucia, and Jamaica have or are about to implement national water information systems, many of which have been made possible by external funding. Such systems are fundamental to better water management and to the ability to plan and adapt to increasing climate variability associated with climate change.

The Challenges

Many of the challenges arise from the macro-economic conditions that prevail in the Caribbean. Countries are heavily indebted, with debt-to-GDP ratios unsustainably high.[65] Unemployment, especially of young people and women, has been growing, and the high levels of poverty throughout the region pose particular challenges to governments to fund programs and initiatives and to maintain levels of services to communities.

[65] ECLAC 2009.

Adequacy

- **Agriculture**. The spikes in global food prices and high food import bills have prompted the region to seriously consider food security issues and a renewed interest in agriculture. The Jagdeo Initiative was designed to transform agriculture to ensure a food-secure region and a competitive agricultural sector. Since it was proposed in 2004, progress has been slow. But in 2012 Trinidad and Tobago announced its intention to establish of a food security facility with Guyana to expand agricultural production in Guyana. Key to realization of the initiative is the role of the private sector, and for some countries—such as Guyana, Belize, and the Dominican Republic—this represents an opportunity for growth and development. This is likely to result in a greater use of irrigation and an increase in demand for water for agricultural purposes. It would affect resource availability and requires serious thought as to how resources are allocated. The institutional and policy framework would have to adapt by moving toward the implementation of IWRM. Potentially the competition for resources could drive improvements in resource use efficiency and wastewater reuse.
- **Wastewater reuse and artificial recharge**. Given the potentially growing scarcity of water, the appropriate treatment and use of wastewater could provide a significant source of water either through direct reuse or artificial recharge. However, cost constraints and public health concerns are acute. The CReW project offers a potential means to address some of the problems by providing regional guidance and the development of standards, guidelines, and regulations.

Accessibility

- **Service provision**. Weak economic growth will be reflected in slower growth in demand for water, but this is offset by lifestyle changes. Metering and low water tariffs are not disincentives, and aging infrastructure will continue to cause management and service problems in meeting demands of different sectors. So access in terms of reliability and continuity of supply may actually deteriorate. At the same time, climate change will impose additional design and operational conditions that will have to be factored in when extending and upgrading infrastructure and this will have to be a key element in ensuring accessibility.
- **Service management**. Service providers are going to be challenged to balance the need to maintain and upgrade existing infrastructure against demands to provide new infrastructure. More will need to be done to improve the managerial capabilities of

service providers; at the same time there is a need for greater accountability, incentives, and oversight to improve performance.

Assurance

- **Extreme events and variability.** It is likely that there will be more-frequent extreme climatic events, which will affect national economies and water management and service provision. In some cases it would appear that lessons have not been institutionalized or reflected in operational procedures. The existing water infrastructure was not designed to accommodate the changes in baseline conditions that are likely, and therefore planning and upgrading needs to take this into consideration. For water resource managers, the availability of data is going to present challenges for them to develop adaptation plans and strategies. The region already experiences climatic variability that has an impact on water resources (e.g., droughts and floods). In order to respond to increased variability, basic information and models to inform management decisions will be the key when trying to account of climate change and a greater degree of uncertainty. Climate change is likely to exacerbate current water problems rather than be a problem itself, and thus it will have a negative impact on the assurance of service provision.
- **Institutional arrangements.** IWRM, despite some good work (e.g., the GEF-IWCAM project) has made little progress toward providing a basis for institutional reform. No country as yet has implemented any significant IWRM proposals, other than a few catchment-scale demonstration projects. Nor have the key linkages between land and water management been incorporated into policies and planning. This is probably the second biggest challenge, after economic development, facing the region.

Affordability

- **Customer affordability**. The affordability of water management and water services is reliant on the state of an economy. Governments can decide how these services are to be paid for and the relative burden between customer and taxpayer, but they are themselves constrained by their macro-economic circumstances. Affordability is a sensitive issue and it is likely that it will be used to keep tariffs low. This situation is problematic for the effective and efficient management of water services.
- **Service affordability**. The ability to invest in water infrastructure, services, and improved water management in the face of financial constraints when balanced against other priorities will require creative solutions and probably involve the private sector, at a high cost. While sustainable financing should be the goal, the region has a long way to go

in developing and implementing the economic instruments to achieve this. Adapting to climate change through more robust and resilient infrastructure will also come at a price, which will have to be accounted for.

- **Private sector involvement**. Private sector involvement in the water sector in the Caribbean has had a checkered track record. There are potential gains as well as dangers, so whether the greater use of public-private partnerships is a viable approach is an open question. (This appears to be an approach that the Barbados government is exploring.) Given the difficulties experienced in funding water management and services, it has its attractions to governments, but it will come at a cost. Perceptions of the private sector need to change, and at the same time policies and legislation have to let the private sector participate in service provision.

The key challenges and vulnerabilities may be summarized as follows. Data gathering and information availability and management are major challenges. The lack of data, compounded by barriers to making available what information there is, hampers the understanding current water vulnerabilities and the ability to plan ahead and to identify appropriate adaptation strategies. Forward planning has been largely neglected and is symptomatic of a lack of appreciation of the need for national water policies. In this respect, Jamaica's development of a national master water plan serves as an example. In finding innovative ways to improve the maintenance of water and sanitation infrastructure, introducing demand management, and extending wastewater services, the reluctance to involve the private sector needs to be addressed while a conducive environment is established to facilitate involvement. Last, the perception has to be addressed that welfare and water are synonymous. Water service providers have to be efficient, well managed, and allowed to do their job. This means that they have to be on a sound financial footing. The challenge is to find the balance between appropriate political and regulatory oversight and the autonomy of water managers and service providers.

Compared with 50 years ago, water security in the Caribbean has improved enormously, and the achievements are all the more impressive given where the region has come from socially, politically, and economically. There are still many challenges to be faced, and these often become acutely apparent through the impact of natural hazards. But climate change, on its own, is not the most pressing problem—it is the macro-economic conditions that are the main concern. These determine the creation and availability of resources—natural, human, intellectual, and financial—needed for a water-secure Caribbean.

Water security is realized through sustainable economic development as much as sustainable economic development depends on the achievement of water security.

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