# WATER FORUM OF THE AMERICAS

# REPORT OF THE CARIBBEAN SUB-REGION

**Prepared for the**

**INTERAMAERICAN DEVELOPMENT BANK**

**By**

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**SEPTEMBER 2008**

# PREFACE

A critical part of the preparation for the 5th World Water Forum is the Regional Process in which each region of the world works together with its constituencies to present their unique perspectives and positions related to water resources management and services. In this context, the Americas Regional Consortium (ARC), comprising over 50 members, has been created in order to lead the regional process activities in the Americas and to reach this goal a “Water Forum of the Americas” has been scheduled.

In order to guide the discussions of the regional process, a document will be formulated for each of the sub-regions, and consequently a Regional Document of the Americas will be formulated with the inputs from each of the sub-regional documents, and the conclusions emanating from the Water Forum of the Americas. The Regional Document will outline the specific problems faced by each sub-region, including a section on the state of water resources, and will recommend institutional and policy directions and options for addressing those problems.

This Report documents the contribution from the Caribbean sub-region. Much of the information came from country-related strategies, programs and projects as well as secondary data sources. A major difficulty encountered in preparing the Report was (i) dearth of information, from the Caribbean, on the water resources sector in general; and (ii) the inconsistency in the types and volume of data available for each of the seventeen countries covered in this Report.

The Report is divided into three sections: The first section describes the characteristics of the sub-region and maps the main actors that should be considered for water policy and management in the sub-region. The second section provides an analysis of the key water challenges and priority areas in the sub-region; and an inventory of some of the progress achieved during the past 10 years to address water challenges .The concluding section, section three, identifies the policy options necessary for addressing the challenges that had been identified in the previous sections.

One constraint to writing this Report was the number of countries in the sub-region (17) and consequently the volume of data that had to be processed; and the relative size of the report (40 pages) that was requested in the terms of reference. This meant that much of the data had to be abbreviated and not all countries could have been analysed for each of the sections.

While the author takes sole responsibility for the content of the Report, much appreciation is given to those who reviewed each of the drafts of the Report and made valuable recommendations for improving its content.

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# ACRONYMS

| | |
|---|---|
| ODA | Overseas Development Assistance |
| FDI | Foreign Direct Investment |
| GNI | Gross National Income |
| MDGs | Millennium Development Goals |
| NWC | National Water Commission (Jamaica) |
| MGD | Million Gallons Per Day |
| RO | Reverse Osmosis |
| BWA | Barbados Water Authority |
| DOWASCO | Dominica Water and Sewerage Company |
| RAMSAR | The Convention on Wetlands of International Importance |
| VINLEC | St Vincent Electricity Services |
| IWCAM | Integrated Watershed and Coastal Area Management |
| GEF | Global Environmental Facility |
| CEHI | Caribbean Environmental Health Institute |
| IWRM | Integrated Water Resources Management |
| CARICOM | The Caribbean Community |
| CARDI | Caribbean Agricultural Research and Development Institute |
| CDERA | Caribbean Disaster Emergency Response Agency |
| CCCCC | Caribbean Community Climate Change Centre |
| CIMH | Caribbean institute for Meteorology and Hydrology |
| UWI | University of the West Indies |
| WUE | Water Use Efficiency |
| CDC | Centre for Disease Control |
| UNEP | United Nations Environmental Programme |
| CWWA | Caribbean Water and Wastewater Association |
| SIDS | Small Island Developing States |

# WATER RESOURCES MANAGEMENT IN THE ISLAND STATES OF THE CARIBBEAN

## PART I

## AN OVERVIEW

### 1.0 Characteristics of the Caribbean Region

#### 1.1 Location

The Caribbean Region generally refers to an area 10º to 23 º North Latitude and 60º to 80º degrees West Longitude. Countries within the Region border the Caribbean Sea (See Figure 1). The Caribbean archipelago is a serpentine chain of islands stretching nearly 4,800 kilometers south from The Bahamas and trending east through Cuba, Jamaica, Puerto Rico and the Virgin

**Figure 1: Map of the Caribbean**


Source: world atlas.com

Islands, then curving due south to Grenada and Trinidad and ending with a westward tail constituting the Dutch islands of Aruba, Bonaire, and Curacao. The islands fall roughly into three major geological and geographical groups: the Bahama Bank Assemblage, located east of the Florida peninsula; the partially elevated platform of the Greater Antilles, which supports a mature volcanic range

peaking in Haiti and the Dominican Republic and sloping west to Cuba and Jamaica and east to Puerto Rico; and, the Lesser Antilles located southeast of Puerto Rico. The scope of this report covers the independent nations of the region and the English-speaking Overseas Territories inclusive of: The Bahamas, Cuba, Cayman Islands, Jamaica, Turks and Caicos, The Republic of Haiti, Dominica Republic, The British Virgin Islands, Anguilla, Antigua and Barbuda, Montserrat, St Kitts and Nevis, The Commonwealth of Dominica, Barbados, Saint Lucia, St. Vincent and the Grenadines, Grenada, Trinidad and Tobago. Cuba, Hispaniola, Jamaica, and Puerto Rico are collectively known as the Greater Antilles, and the smaller islands in the eastern part of the chain are known as the Lesser Antilles.

The countries under review range significantly in size and physiography. Cuba has the largest area of 110,900 square kilometers, followed by Hispaniola[1] with an area of 76,480 km². Of the remaining islands, all of which are Anglophone, Jamaica is the largest with an area of 10,831km$^2$, while Grenada is the smallest island with an area of 344km$^2$. The majority of the Caribbean countries are single islands; others are archipelagos, constituting multiple islands[2].

### 1.2 Geology

The islands of the region have varying geological characteristics: Barbados and The Bahamas are predominantly coral limestone; Trinidad and Tobago consists of igneous, sedimentary and metamorphic rocks; Antigua and Barbuda, and some of the Virgin Islands are a mix of volcanic and limestone formations; and 70% of Cuba is made up of limestone.

[1] Made up of the Dominican Republic which has a total area of 48,700 square kilometers, and Haiti with an area of 27,800 square kilometers

[2] For example, Jamaica is a single island state; Trinidad & Tobago is a twin-island state; Grenada is a tri-state; The Republic of Haiti also includes five satellite islands; St. Vincent and the Grenadines is an archipelago as is The Commonwealth of the Bahamas, which consists of thirteen larger islands and seven hundred small islands.

The Islands of St. Kitts-Nevis, Antigua & Barbuda, Dominica, Saint Lucia, St. Vincent and the Grenadines, and Grenada form part of a volcanic arc resulting from the subduction of the North American Plate below the Caribbean Plate. These islands are dominated by igneous formations with Dominica for example, having igneous rocks such as basaltic lavas, andesitic tuffs, and dacitic andesitic lava.

Cuba, Hispaniola, Jamaica, and Puerto Rico are collectively known as the Greater Antilles. The Greater Antilles are made up of continental rock, as distinct from the Lesser Antilles[3], which are mostly young volcanic or coral islands.

The island in the region exhibit variable topography. In The Commonwealth of the Bahamas, the islands are flat and low-lying, with the maximum height above sea level not exceeding 10m. Barbados is also dominated by a gently undulating topography where the highest elevation is 336 metres. This is in sharp contrast to the steep rugged terrain that dominates the volcanic islands such as Dominica Saint. Lucia, St. Vincent and the Grenadines and Grenada, where the tallest peaks rise in excess of 900 m. The interior landscapes of Jamaica and Hispaniola are also very rugged with high mountain ranges of over 2,000 metres in elevation. The highest peak in the Caribbean, Pico Duarte at 3,087 meters, is located in the Dominica Republic. Trinidad's landscape features three separate mountain ranges, ranging in height from 300m to 900m with undulating plains and swamps in between.

### 1.3 Climate

The islands in the region generally have tropical marine climates, with more diurnal and local variations in temperature than seasonal ones, and with strong

[3] The islands are part of a long volcanic island arc, most of which wraps around the eastern end of the Caribbean Sea on the western boundary with the Atlantic Ocean, and some of which lies on the southern fringe of the sea just north of South America. The Lesser Antilles more or less coincide with the outer edge of the Caribbean Plate, and many of the islands were formed by subduction, as one or more other plates slipped under the Caribbean Plate.

seasonal variability in rainfall distribution. Individual climatic conditions are strongly dependent on elevation. At sea level, there is little variation in the temperature, regardless of the time of the day or the season of the year; temperatures range between 24°C and 32°C[4]. Cooler temperatures experienced between December and March (winter months).

Most islands have a have a dry season from December to May and a rainy season from June to November, which is the hurricane season. The islands' relief strongly influences rainfall distribution over the landscape. Total annual rainfall accumulation varies between the islands, with the smaller, lower elevated islands receiving comparatively less rainfall than the larger, more elevated ones. The Commonwealth of Dominica for instance, has a heavy annual rainfall of 1981.2mm while the annual rainfall in Antigua and Barbuda is somewhat lower (1016mm per year).

There is also rainfall variation within a country. The lush forested interior of Dominica enjoys an average annual rainfall in excess of 7620mm at the central peaks; this reduces to an average of about 1270mm per annum along the central portion of the west coast, which tends to be the driest section of the island[5]. In Haiti, the rainfall ranges from 400mm in the northwest to more than 3000mm in the mountains of the southwest[6]. Jamaica has an average annual rainfall, for the entire island, of 195.8cm; The Blue Mountains and the northeast coast, however, experience the highest annual rainfall, of over 3300mm; Kingston, on the other hand, receives less than 1270mm of rain annually.[7] Similarly, the mountainous areas in Cuba have an average precipitation of more than 1800mm;

[4] In Kingston, Jamaica, which is at sea level, the mean temperature is 26°C, whereas Mandeville, at a little over 600 meters high in the Carpenters Mountains of Manchester Parish, has recorded temperatures as low as 10°C. In the Dominican Republic, the average annual temperature is 25° C, ranging from 18° C at an altitude of over 1,200 meters to 28° C at an altitude of 10 meters. Highs of 40° C are common in protected valleys, as are lows of zero in mountainous areas.

[5] Drigo, Anthony. 2001. Integrating Management of Watersheds & Coastal Areas in Small Developing States of the Caribbean. Prepared for the Ministry of Agriculture and the Environment, Dominica; CEHI and UNEP.

[6] Ministere De L'environnement, Unite De Mise En Oeuvre Du Plan D'action Pour L'environnement ( Umo-Pae) 2001. Integrating The Management Of Watersheds And Costal Areas In Haiti" , Haiti National Report

[7] Natural Resource Conservation Authority. 2001. National Report. Integrating Management of Watersheds and Coastal Resources. Prepared for CEHI and UNEP.

most of the lowland area has from 900 to 1400 mm annually; and the area around Guantánamo Bay has less than 650 mm. In Tobago, in the Southern Caribbean, the average rainfall ranges from 3,800 mm in the Main Ridge to less than 1,250 mm in the south-western lowlands[8].

Even during the rainy period, the precipitation range fluctuates greatly. Windward sides of islands with mountains receive much rain, whereas leeward sides can have very dry conditions. Recording stations in the Northern Range in Trinidad measure some 3020mm of rainfall per year, while at Piarco Airport on the Caroni Plains the measurement is only 1400mm. Flat islands receive slightly less rainfall, but its pattern is more consistent.

Most of the rainfall occurs during short heavy outbursts during daylight hours. In Jamaica, about 80 percent of the rainfall occurs during the day. The period of heaviest rainfall usually occurs after the sun has passed directly overhead, which in the Caribbean islands would be sometime around the middle of May and again in early August. The rainy season also coincides with the disastrous summer hurricane season, although Barbados, too far east, and Trinidad and Tobago, too far south, seldom experience hurricanes.

The vulnerability of the region to climate events is demonstrated by the impact of hurricanes on the region. Hurricanes are a constant feature of most of the Caribbean, with a "season" of their own lasting from June to November, with cyclonic activity reaching its peak between August and October

Hurricane activity in the region in 2004 was particularly devastating: Hurricanes and tropical storms caused approximately US$$6,059 million in economic damages to The Bahamas[9], The Cayman Islands[10], Dominican Republic[11],

[8] Water Resources Agency. 2001. National report. Integrating Management of Watersheds and Coastal Resources. Prepared for the Ministry of the Environment, Trinidad and Tobago.
[9] See, Economic Commission for Latin America and the Caribbean, InterAmerican Development Bank (2004) *Hurricanes Frances and Jeanne, Their Impact in the Commonwealth of the Bahamas*
[10] See Economic Commission for Latin America and the Caribbean, United Nations Development Programme, Cayman Islands Government (2004) *The Impact of Hurricane Ivan in the Caymans*

Grenada[12], Haiti[13], and Jamaica[14] . In 2007, Hurricane Dean caused extensive flooding in Saint Lucia, Dominica, Jamaica, Haiti, and the Dominican Republic. At the time of writing this report, hurricane Gustave had stormed through Jamaica, the Cayman Islands, The Bahamas and the Turks and Caicos Islands in August. This was followed by Hurricane Ike in September. Ike left 4 persons dead and estimated damages between US$3 and $4 billion in Cuba; and 80% of homes in Turks and Caicos were damaged. Hurricanes Fay, Gustave, Hanna and Ike, all within a three week period, have caused more than 350 deaths in Haiti[15].

### 1.4 Socio-Economic Trends

Caribbean economies share many of the characteristics of small states, with open and vulnerable economies, limited diversity in production, exports concentrated on a few products, thin markets, and high transportation costs. Despite their best efforts, Caribbean Governments face considerable challenges in seeking to generate sustained economic growth rates that exceed the rate of unemployment and poverty. These challenges are exacerbated by a series of external shocks, including energy price shocks, fluctuating commodity prices, the rising cost of external credit, the dismantling of preferential market arrangements for traditional agricultural commodities and the introduction of stringent market entry conditions including sanitary and phyto-sanitary (SPS) restrictions. The region's vulnerability to external price shocks is further exacerbated by the rising cost of imported food items. In 2006, the region's food import bill was

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[11] See Economic Commission for Latin America and the Caribbean, United Nations Development Programme (2004) *Los Efectos Socioeconómicos del Huracán Jeanne en la República Dominicana*

[12] See Organization of the Eastern Caribbean States (2004), *Grenada: Macro Socio-economic Assessment of the Damages Caused by Hurricane Ivan*

[13] See, Economic Commission for Latin America and the Caribbean, United Nations Development Programme (2004). *Le Cyclone Jeanne en Haïti: degats et effets sur les departements du nord-ouest et de l'artibonite : approfondissement de la vulnerabilite*

[14] Economic Commission for Latin America and the Caribbean, United Nations Development Programme, Planning Institute of Jamaica, *Assessment of the socioeconomic and environmental impact of Hurricane Ivan on Jamaica*

[15] http://new.unep.org/pdf/FastFacts-Hurricane-Ike.pdf

approximately US$3 billion[16]. This figure is expected to rise dramatically in line with the steep rise in the cost of fuel.

The growing debt burden of many Caribbean countries is generating considerable concern. Seven Caribbean countries are included among the ten most indebted countries in the world.[17] The net result of this increasing debt burden has been a deepening of the economic vulnerability of the region and the erosion of the impressive social development gains that were achieved from the 1970s through to the mid 1990s.

Over the past decade, several Caribbean countries have sought to transform their economies away from agriculture and manufacturing to tourism and financial services. The contribution of Travel & Tourism to Gross Domestic Product is expected to rise from US$39.9 bn in 2008 to US$69.9 bn by 2018. It is also the major foreign exchange earner in the region, accounting for 20 per cent of foreign exchange earnings, and about 12 per cent of total employment[18]. However, as the fall-out from the events of 9/11 has shown, tourism is no less vulnerable than agriculture to external shocks. Heightening this vulnerability is the threat posed by climate change and associated sea level rise, compounded by increased hurricane occurrence and damaging storm surges. This issue is of great concern given the fact that the industry's infrastructure is concentrated almost exclusively along the narrow costal zone in all the islands..

Caribbean countries must also contend with declining foreign direct investment (FDI) and overseas development assistance (ODA). In 2006, the Caribbean region's share of global FDI inflows declined, as flows increased more rapidly in other parts of the world. Also of concern to the region is the global decline in

16 CARICOM Secretariat, "CARICOM AGRICULTURE MINISTERS MEET IN GEORGETOWN FOR SPECIAL COTED," News release 16/2006, (20 January 2006); "http://www.caricom.org/jsp/pressreleases/pres16_06.jsp

17 Sahay R, (2005). *Stabilization, Debt and Fiscal Policy in the Caribbean*. IMF Working Paper WP/05/26

18 World Travel and Tourism Council. 2007

Overseas Development Assistance, which dropped from US$106.8 billion in 2005, to about US$103.9 billion in 2006.[19] However, the impact of this decline has been offset somewhat by the steady growth in remittances, which moved from 5.2%of Gross National Income (GNI) in 2000 to 7.0% in 2004[20].

Selected socio-economic indicators for each of the islands represented in this report are provided in Table 1, Annex 1. While virtually all Caribbean countries have achieved many of the Millennium Development Goals (MDGs) and while poverty levels in the Caribbean have declined, poverty remains high in many countries. Poverty rates in the Caribbean are higher in rural areas than in urban areas. In Barbados, however, the available data indicate that poverty rates are higher in urban areas than they are in rural areas[21].

The economic growth prospects of the region are also constrained by a variety of natural factors, including adverse physiographic conditions in many countries. These conditions are primarily related to limited land space (on account of mountainous terrain) where flat arable lands and lands for other development purpose are confined to the relatively narrow coastal zone which is vulnerable to storm surges and salt water intrusion.

Caribbean Governments are faced with a dilemma: that is how to pursue sustainable human development with a context of poor resource endowment; harsh internalities and externalities; low rates of economic growth; weak institutional capacity and rising expectations of a burgeoning population. It is against this background that the sustainable use and management of water resources becomes critical.

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[19] Global Development Finance 2007, *The Globalization of Corporate Finance in Developing Countries,* http://siteresources.worldbank.org/INTGDF2007/Resources/3763069-1179948748801/GDF07_Overview.pdf

[20] Briguglio et al, 2006*Toward an Outward-Oriented Development Strategy for Small States*, Small States Forum 2006

[21] Ministry of Social Transformation, Barbados. 2003. Poverty Reduction Strategies Pursued During The Last Decade. High Level Meeting On Poverty, Equity And Social Inclusion. Isla Margarita, Venezuela

## 2.0 Key National, Regional and International Stakeholders

### 2.1 National Stakeholders

The management of water resources in all territories of the Caribbean lies under the jurisdiction of a number of agencies and as such, management responsibilities are dispersed. On average across the region, at least four entities are involved in the joint management of water resources. Table 2 in the Annex provides a matrix of all the stakeholders involved in water resources management in the countries covered in this report. The following therefore is a more detailed description of the institutional framework for water resources management in selected countries. It highlights the multiplicity of organisations and responsibilities that have hindered the integrated and holistic approach to water resources management in the Caribbean.

In **Antigua and Barbuda** the Antigua Public Utilities and Authority, the Central Board of Health, the Ministry of Finance and the Ministry of Planning are all involved in aspects of water management. Similarly, in **The Bahamas**, the Office of the Prime Minister, the Ministry of Health, the Water and Sewerage Corporation, the Ministry of Finance and Planning, the BEST Commission, the Ministry of Public Works, and the Public Utilities Commission are similarly involved.

In the case of **Barbados**, the Barbados Water Authority has the major responsibilities for water resource management in areas that include policy formulation, research, treatment, distribution (production), wastewater, source protection, and resource assessment. However, four other agencies also have major roles that can impact on groundwater use, monitoring, and control: Generally, development of irrigation rests with the Land and Water Use Unit of the Ministry of Agriculture and the Irrigation Unit of the Barbados Agricultural Development and Management Corporation, which operates and maintains the two public irrigation schemes. They have no regulatory mandates. The Soil Conservation Unit of the Ministry of Agriculture must be consulted on all

development in the Scotland District. Water quality and environmental pollution matters fall within the mandate of the Environmental Engineering Division while public health water-related matters fall to the Public Health Inspectorate. Both are sections within the Ministry of Health.

Potable water supplies in **Jamaica** are the responsibility of the National Water Commission (NWC)[22], the Urban Development Corporation and the Parish Councils. The National Irrigation Commission, on the other hand, is responsible for the harnessing and distribution of groundwater and surface water for allocation to farmers and also non-agricultural users. The Water Resources Authority (WRA) which was established by statute, regulates the island's water resources There are presently four different government agencies with legal responsibility for water quality monitoring; Water Resources Authority, Natural Resources Conservation Authority (NRCA/NEPA), Ministry of Health (Environmental Health Unit) and Office of Disaster Preparedness and Emergency Management (ODPEM). Though the objective of water quality monitoring are different for some of these agencies, for others the differences are not clear and have resulted in duplication of efforts[23]

Policy and regulatory functions in the water and sanitation sector in the **Dominican Republic** are also highly fragmented: The Secretariado Técnico de la Presidencia is in charge of setting policies; drinking water quality regulation is the responsibility of the Secretaria de Salud Publica through its State Secretariat of Public Health and Social Security (SESPAS). Environmental regulation is shared between the Secretaria de Estado de Medio Ambiente y Recursos Naturales, and the National Institute of Hydraulic Resources (INDRHI), which regulates concessions for all use and preservation of water. The General Directorate of Norms and Systems Quality (DIGENOR) approves quality standards in the sector.

[22] the major supplier
[23] Natural Resources Conservation Authority, 2001. The National Report On Integrating the Management Of Watersheds and Coastal Areas In Jamaica.

The situation in **Cuba** differs from that of the rest of the Caribbean. The National Water Resources Institute (Instituto Nacional de Recursos Hidraulicos, INRH) is in charge of "directing, executing and controlling the application" of the government's water resources activities. The INRH is made up of a number of parastatals, including 19 water and sanitation companies. Service provision is the responsibility of the country's 14 provinces and 140 municipalities through their respective water and sanitation directorates, except in the case of 12 municipalities in Havana. A mixed public-private company with partial foreign ownership provides water and sanitation services to 12 of the 15 municipalities in Havana.

The types of institutional arrangements described above are typical for the entire region. The multiplicity of institutions and jurisdictions that deal with the various aspects of water resources management, often develop and implement policies and programmes in isolation from each other. Consequently, the approach to the development of the water sector has not been holistic and has not involved all stakeholders and disciplines in the planning and management of the resource[31].

### 2.2 Regional and International Stakeholders

There are also a number of regional and international agencies that are involved in supporting water resources management in the Caribbean. These agencies are primarily involved in resource mobilisation, advocacy, policy formulation, training and capacity building, networking, and data collection and dissemination. A sample of the agencies and their mandates for water resources management is provided in Table 3, in the Annex.

[31] Integrating Watershed and Coastal Area Management in Small Island Developing States of the Caribbean Synthesis Report.

# PART II

# CHALLENGES AND PROGRESS MADE IN WATER RESOURCES MANAGEMENT IN THE CARIBBEAN

## 1.0 Key Characteristics of Water Resources in the Sub-Region

The Caribbean islands are highly dependent on rainfall to feed surface intakes and replenish groundwater. In general the water supply is primarily via surface sources (rivers, springs, ponds) as well as groundwater sources. There are, however, variations from island to island regarding groundwater and surface water abstraction and utilisation. In addition, rain water harvesting is practiced in some of the smaller islands and in islands where topographic constraints limit access to the public distribution system in some locations. Desalination technologies are seeing increased application in the more water-stressed countries Caribbean where the demand for fresh water substantially surpasses the supply from natural sources.

The water profiles of a few countries are provided below to highlight specific characteristics of the water resources in the region..

In the case of **Antigua and Barbuda**, the water supply comes from a combination of surface water, ground water and desalination plants. Domestic and commercial water demands in Antigua are met by one desalination plant, three surface dams, multiple small ponds, and five well fields[24]. The desalination plant supplies approximately 60% to 75% of Antigua's drinking water. Ground water resources are limited and threatened by excessive use, saltwater intrusion, and pollution by chemicals and sewage[25]. The wells are gravel packed and are

[24] http://www.rlc.fao.org/paises/h2o/antigua.htm. Accessed on September 12 2008
[25] Food and Agriculture Organization of the United Nations, "Overview of Priority Areas," Internet, http://www.fao.org/docrep/X5681E/x5681e04.htm, Accessed on September 112008

usually 60 ft deep in the coastal areas, and about 180 ft deep in the interior areas; some wells have been capped due to saltwater intrusion.

The total water supply produced from all three sources is about 4.1 to 4.5 mgd[26] . Water supply from each source varies, depending upon the season. The water from all three sources is blended for quality purposes. Water withdrawal per capita is about 80 $m^3$. Annual withdrawals of ground water and surface water are 48% of total available water[27]. Low average rainfall and erratic distribution cause water supply shortages[28].

In Barbuda, ground water is used for domestic purposes by the residents while each hotel has its own desalination plant to provide water for the tourists..

To address water resource constraints in Antigua and Barbuda, the Town and Country Planning Act requires that all dwellings must be built with facilities to store at least 3 to 4 days water requirements based on the house size; this approximates 18 $m^3$ (4,000 gallons) storage for every bedroom.

**The Bahamas** obtains its water supply from ground water and RO and distillation. Much must be barged from one island to another. New Providence barges over 50% of its water supply from Andros. The only source of freshwater in the country is rainfall. The rainfall form freshwater lenses in the ground as well as wetlands, small pools at the surface, and seasonal ponds. Freshwater wetlands tend to be small, seasonal, and widely scattered. The total freshwater reserve is estimated at 7.7 x $10^9 m^3$ throughout the country in localized lenses of various sizes and quality. Exploitable freshwater is a small amount of the total reserves because the bulk of the reserves is used as a container which maintains

[26] US Army Corps of Engineers, 2004. Water Resources Assessment of Dominica, Antigua, Barbuda, St, Kitts and Nevis
[27] United Nations, http://www.un.org/esa/agenda21/natlinfo/countr/antigua/natur.htm. Accessed on August 9th 2008
[28] Cooper, Brian and Vincent Bowen, 2001. IWCAM National Report for Antigua and Barbuda. Environment Division, Ministry of Tourism and Environment

the geometry of the freshwater body. The freshwater lens aquifers throughout most of the country are vulnerable to storm surges, causing saltwater inundation of the aquifers in many cases[29].

The primary source of drinking water is fresh ground water. Reverse Osmosis is increasing in usage, and will most likely continue to increase, as fresh (ground) water availability continues to decline, and water demands grow. Rainwater catchment is rarely used, supplying possibly 3% or less of the water consumed[3031]. A huge bottled water industry has developed due to water quality issues and brackish water.

In **Barbados**, the main water supply is from groundwater aquifer reserves (79% of the total fresh water resources), and 2005 estimates of production stood at 159,909 $m^3$/day (35 MGD)[32]. Other abstractions include that from privately owned and operated wells for industrial and irrigation uses. The amount licensed for private abstractions was approximately 36,364 $m^3$/day (8MGD)[33]. There are presently two desalination plants in operation; one, a seawater reverse osmosis desalination plant, is privately owned and used for irrigation of a golf course. The second one is a brackish water reverse osmosis plant contracted to supply up to 40,000 $m^3$/day (6 MGD) to the Barbados Water Authority (BWA) under a 15-year Build Own Operate (BOO) arrangement. Desalinated water is supplied to sections of the west and southern coasts. .

Rainwater harvesting was traditionally practiced on Barbados but has been on the decline. Nonetheless, the amendment to the Town and Country Planning Development (Amendment) (No. 2, Order of 1995) requires all new residences in Barbados to make provision for rainwater storage.

[29] US Army Corps of Engineers, 2004. Water Resources Assessment of the Bahamas.
[30] PAHO, 1998. "Health in the Americas; the Bahamas." 1998. http://www.paho.org/ENGLISH/HIA1998/Bahamas.pdf, accessed on September 15 2008
[31] http://www.wsc.com.bs/rev_osm.ht, accessed on September 15 2008
[32] CEHI. *Ibid*
[33] Brewster, Leo and John B. Mwansa, 2001. IWCAM Barbados National Report. Prepared for the Caribbean Environmental Health Institute and UNEP.

Presently, eight desalination plants serve the **British Virgin Island**'s (BVI) public water supply system. These plants supply approximately 11,365 $m^3$ (2.5 million imperial gallons) of desalinated water per day for distribution. This accounts for approximately 60 % of the demand. The remaining 40% comes from groundwater, private cisterns and catchments, and private desalination plants (owned by hotels).

In order to satisfy the demand for water in the **Commonwealth of Dominica**, the Dominica Water and Sewerage Company (DOWASCO) currently abstracts water from about 47 independent river intakes, providing a total capacity of over 10mgd[34]. The largest of the water systems, which services the capital Roseau and its environs[35], has a supply capacity of over 4.3mgd. DOWASCO provides service for over 90 % of the total population; it is not responsible for providing water for agricultural purposes. Small communities not serviced by DOWASCO receive their water from small systems built by non-government organizations. The main uses of water in Dominica are domestic supply, hydropower and export. As a result, the entities requiring the most water include DOWASCO for domestic use and export, and the Dominica Electricity Services for hydropower generation.

Mainland **Grenada**'s water supply is drawn almost exclusively from surface stream sources located at relatively high elevations; the distribution network is therefore primarily gravity-fed. The estimated water production ranges between 27,300 $m^3$/day (6 MGD) and 31,800 $m^3$/day (7 MGD) during the dry and wet seasons respectively. The National Water and Sewerage Corporation (NAWASA) claims up to 90% coverage of their distribution network with reliability in service provision that ranges between 85 and 90%. Communities in the

[34] Dominica National Report

[35] This system serves a population of about 25 thousand people. Two other systems have a supply capacity of about 1.4mgd, whilst the other systems are much smaller serving communities with populations usually less than 1000. In addition to these domestic supply systems, a system has been built particularly for bulk water export, which is capable of delivering 6mgd at a special docking facility situated in Newtown just north of the city center.

extreme south and north of the island tend to be more water-stressed given their relative location at the distal ends of the distribution networks, a problem that can be particularly acute during the dry season. In 1998, the Government of Grenada procured a 1,818 $m^3$/day desalination plant to assist in augmentation of water supply to the southern communities; however, inadequate supply from production wells delayed the completion of project.

On the sister islands of **Carriacou** and **Petit Martinique** water is drawn almost exclusively from individual or communal rain water harvesting systems as these islands are very arid and have virtually no perennial streams. There is 1 borehole from which ground water is abstracted to serve the small downtown core of Hillsborough in Carriacou. Rainwater also finds uses in other sectors such as agriculture, construction, and tourism. In 1998 the Government of Grenada invested in desalination plants for both Carriacou (100,000 US GPD output capacity) and Petit Martinique (30,000 GPD output capacity). The former is plagued with regular mechanical failures, while the latter, since the passage of hurricane Ivan, has been non-functional. A few hotels and resorts have small desalination plants to augment their water supplies[36].

**Jamaica** exploits over 400 ground and surface water sources where the estimated annual production is about 4,083 MCM[37]. Of this amount, 16% is from surface water while the remaining 84% of from ground water[38]. The public water supply system operated by the National Water Commission presently services 72% of the population. While Jamaica has sufficient water to meet all demands[39], the resources are unevenly distributed in both time and location. The present shortfall is approximately 400 MCM/yr.

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[36] CEHI, *ibid*

[37] Jamaica Water Sector Policy Paper

[38] Water Resources Authority. http://www.wra.gov.jm/. Accessed on September 16 2008

[39] It is estimated that more than 100,000 Jamaicans depend on rainwater harvesting as the primary source of water[39]. In some of the new housing areas established on reclaimed lands from abandoned bauxite operations rainwater, harvesting systems are the primary sources of potable water.

The available surface water in **Trinidad** is estimated to be 3,600 MCM per year, which is more than ten times the water demand. For **Tobago** the available surface water is estimated to be 140 MCM per year and the demand is estimated to be about 7% of the supply. The water availability per capita for Trinidad and Tobago[40] is approximately 2,500 $m^3$/year, which exceeds the international standard of less than 1,000 $m^3$/year per person for water scarcity. However, surface water availability which is the major source of water is strongly influenced by seasonal and spatial variations.

### 1.1 Demands on Fresh Water Systems in the Caribbean

The region is well endowed with fresh water (which accounts for almost two thirds of total resources and ecosystems. It is basically a humid region. However, there are extreme variations in time and geographical availability within and between countries, as well as in the availability of surface and groundwater.

The use of water and the manner in which it is used varies by country and by water subsector. The principal water resources subsectors (i.e., those areas of the water resources sector that relate individually to specific economic, social or environmental activities that depend in whole or in part on water to fulfill their aims and goals) in the region as a whole are irrigation and drainage, water supply and sanitation including water transport of wastes, and hydropower.

As is expected, the primary demand is for domestic use, which is given priority by most countries. Be that as it may, the strong contribution of tourism and agriculture to some economies has resulted in significant competition for

[40] Trinidad and Tobago exploits surface and groundwater at the rate of 65 % and 25% of total volume respectively. Ten percent of the water produced is from desalination. In Tobago water production stands at approximately 40,000 $m^3$/day (9 MGD) to be soon increased to 545,000 $m^3$/day (12 MGD) by the drilling of new water wells. In the late 1990's the Government of Trinidad and Tobago through WASA established a contract for the supply of desalinated water from DESALCOTT. This involved the construction of 100,000 $m^3$/day (24 MGD) capacity desalination plant to service the Point Lisas Industrial Estate on the west coast of Trinidad which houses the heavy petrochemical plants. Water from this plant accounts for 10% of the total water production in the country.

allocation of scarce water supplies. In the majority of the cases however, where agriculture is dominant, it is often rain fed agriculture. In recent times, with international pressures for improving quality and local pressures to increase the yield, there has been a move, by many of the countries, towards irrigation. This has significantly increased the demand for freshwater resources.

### 1.1.1 Water and Health

The major health concerns related to water resources management are the control of activities that may impact on water quality. Poor water quality can contaminate humans when they consume water containing high levels of toxic chemicals, heavy metals or bacteria and viruses from sewage. Contaminated water poses the indirect threat of harbouring many water-borne, water-washed, water-based, and water-related diseases. Some of the more common diseases in the Caribbean are presented here:

- Water-borne diseases: They are contracted when drinking water is contaminated with human or animal faeces. Such diseases caused are enteric fever, diarrhoea, poliomyelitis, and Ascariasis.
- Water-washed diseases: The unavailability of water causes an inability to keep things clean and causes diseases such as Tracoma and Leishmaniasis.
- Water-based diseases: Water provides a home for host organisms in which certain parasites spend part of their life cycle; when this host organism is ingested by a fish or freshwater organism it can be passed up through the food chain on to humans. Such diseases are Schistomiasis and Dracunculiasis
- Water-related disease: Some disease-carrying insects rely on water as a habitat. In this case disease contraction in humans occurs through indirect contact with the same insects. They cause diseases such as African trypanosomiasis, elephantiasis, yellow fever, dengue fever and malaria.
- Water-dispersed infections: Infectious agents, which thrive in water, are inhaled into the respiratory tract of humans with minute water droplets causing diseases such as Legionella.

To ensure that water quality does not pose a major health hazard, many countries have a national water quality-monitoring programme in place to monitor the bacteriological and chemical quality of the water on a monthly basis. In most of the Anglophone countries, water utility companies monitor the quality of both ambient waters (at the abstraction zones) and the finished water to consumers, the latter falling with a more routine scrutiny. The ministries of health will support these efforts by undertaking spot observations to validate the findings of the utility companies and ensure compliance with public health regulations.

A review is presented below of some selected countries and their response to water related health concerns.

In 2000 about 91% of **Cuba**ns had access to an improved source of water (95% of the urban population, but only 78% of the rural population)[41]. Unusually, access to adequate sanitation is higher than access to an improved source of water at a rate of 98% (99% of the urban population and 95% of the rural population). There is however, no systematic information on the quality of water services in Cuba. In some parts of the countries, such as in Santiago de Cuba, residents at times go without water for as much as 20 days. Water is not reliably chlorinated, partly due to the unavailability of chlorine. As a result, residents receive water that is not safe to drink and have to store it in their homes. Some households have resorted to sand filters to treat water in their homes[42].

In the **Dominican Republic**, 92% of urban households have connections while in the rural areas only 62% have connections[43]. However, only 10.5% of the population connected to water systems receives water on a continuous basis. Furthermore, only 87.3% of the urban population and 57.4% of the rural

[41] WHO/UNICEF, *ibid*
[42] The International Development Research Centre. ND. Coping with Water Crisis in Cuba.
[43] WHO/UNICEF Monitoring Programme, 2006. Water and Sanitation based on Dominican Republic Demographic and health Survey(2002)

population has access to treated water. In addition, according to 2002 figures only 73.6% of drinking water quality samples showed satisfactory drinking water quality (as measured by the absence of total coliforms), while the international norm is 95%[44].

Various factors affect the water quality in the Dominican Republic, including: poor condition of purification systems, minimal operational controls, low level of maintenance of treatment plants, and mostly intermittent systems. It is estimated that about 40% of water systems have no chlorination system installed. These are mostly smaller systems in rural areas. Furthermore, according to 2002 figures, only 73.6% of drinking water quality samples showed satisfactory drinking water quality (as measured by the absence of total coliforms), while the international norm is 95%.[45]

In **Jamaica**, 98% of the urban and 88% of the rural population have access to water supply. Unfortunately, many homes receive water only at low pressure while a number of rural communities receive water that is not or only irregularly chlorinated[46]. In addition, most of the country's over 595 unplanned squatter settlements containing approximately 10% of the population are located within unhealthy and unsanitary environments without piped water or sanitation facilities where there is a high risk of waterborne disease incidence. The country's vulnerability to natural disasters is an ever present threat to the fragile and sometimes over-burdened water distribution and sanitation systems. Following hurricanes, there is often a heightened risk of contamination of these systems due to service interruption, with the increased probability of water-borne disease outbreak[47].

[44] http://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_the_Dominican_Republic
[45] Rosa Urania Abreu. October 2005. Republica Dominicana: Situacion actual del sector APS y sus principales necesicades
[46] WHO/UNICEF. 2006 Joint Monitoring Programme for Water Supply and Sanitation.
[47] Smith, Ianthe. 2005. National Sanitation Policy for Jamaica (draft).

To date Jamaica has experienced disease outbreaks which have been related to unsanitary conditions resulting from inadequate water supply for hygiene purposes. The link has been based on the timing of outbreaks i.e. occurrences of illness usually coincide with periods of low rainfall/dry season. The most vulnerable group to these illnesses are generally population groups with weaker immune systems such as young children (five years and under) and the elderly. These outbreaks are often localized and brought under control with the help of specifically designed public education programmes of the Ministry of Health and trucking of water to the areas most affected[48].

Coverage figures in **Haiti** do not give an indication of service quality, which is generally quite poor. In rural areas, systems have often fallen into disrepair. They either do not provide any water service at all or provide service only to those close to the source, with those at the end of the system ("tail-enders") remaining without water. In almost all urban areas water supply is intermittent[49].

The lack of access to a safe water supply contributes to poor health and hygiene in Haiti. Infectious and parasitic diseases, often spread through unsafe water, are the leading causes of morbidity and mortality. Of the three agencies responsible for water supply only one has a laboratory and routinely monitors water quality. In the arid northwest, the lack of safe water causes people to consume brackish water, often resulting in dire health effects.

Surface Water contamination from domestic and industrial sources occurs throughout the country, especially near heavily populated areas. Specific information on water quality is not available, but many sources indicate that surface water contamination has increased significantly in recent years. Domestic wastewater and agricultural runoff cause biological contamination of the surface water near and downriver of populated places. Biological

[48] Jamaica National Report
[49] http://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Haiti

contamination from untreated domestic wastewater is a serious problem. Chemical contamination may be a problem near major cities and industrial sites[50].

In the smaller islands in the **Eastern Caribbean**, more than 90% of the urban population and 60 to 85% of the rural population have access to pipe borne water. Similarly, access to sanitation facilities is fairly universal accept in poverty stricken areas which also tend to be areas of unregulated settlements. In these settlements, sanitation facilities tend to be communal or to be pit latrine systems.

Frequent problems associated with the water supply in the smaller islands in the Eastern Caribbean are water shortages and low pressure, even in the rainy season. Water supply to rural areas tends to undergo only primary treatment and turbidity is a water quality problem particularly in areas where water is sourced from areas that are also under cultivation. This gives rise to concerns about possible contamination of the water sources, through chemical wash or percolation. In Antigua and Barbuda, for instance, there has been at least one incidence of a fish kill at Potworks Reservoir, the cause of which was not confirmed, but agro-chemical poisoning was strongly suspected[51].

### 1.1.2 Water and Ecosystems

Freshwater ecosystems (wetlands, lakes and rivers) are critical habitats in the Caribbean . They harbor extraordinarily rich and unique biodiversity; they also prevent and regulate floods, prevent saline water intrusion, ameliorate erosion impacts by retaining sediments, provide nutrient retention and toxicant removal, offer micro-climate stabilization, act as a global carbon sink.

[50] Us Army Corps of Engineers, 1999. Water Resources Assessment of Haiti
[51] Antigua and Barbuda National Report

The Caribbean boasts of a number of wetlands which are RAMSAR sites[52]. These include, to mention a few: The Codrington Lagoon in Antigua and Barbuda; the Inagua National Park in The Bahamas; The Graeme Hall Swamp in Barbados, the Buenavista in Cuba; the Lago Enriquillo in the Dominican Republic; the Black River Lower Morass in Jamaica; and the Caroni Swamp in Trinidad and Tobago. Being listed as RAMSAR sites, these wetlands are recognized by the international community as being of significant value not only for the country, in which they are located, but for humanity as a whole.

The region's rivers directly support life (phytoplankton, fish, crabs, crayfish, etc.) and other useful plants (used in local craft industry) which rural peoples depend on for local consumption and/or export trade. The rivers are also popular tourism and recreational sites, especially those such as the Caroni and Nariva in Trinidad and Tobago which support abundant avifauna, especially waterfowl) and other wild life. These systems provide water for game animals and non-game animals small rodents, bats and insects. There is also large-scale agriculture on the alluvial flood plains.

Information on the biodiversity of fresh water systems in the Caribbean is inadequate. Collected research tends to focus only on major rivers or select hotspots, leaving out many other freshwater systems. Many native freshwater species are not currently utilized commercially and their status is not well documented. Furthermore, information is not easy to access and search. As a result, it has been difficult to gain a truly comprehensive understanding of patterns of freshwater biodiversity across the Caribbean. Nevertheless, according to a news release issued by the World Wildlife Fund in 2008, Cuba and Hispaniola have been determined to have large numbers of endemic fresh water species. The region's fresh water ecosystems are, however, under severe threats from wide spread damming and extraction of water, overfishing,

[52] The List of Wetlands of International Importance. 2008

contamination, and the proliferation of exotic species that may displace native species, to mention a few.

As with information on the biodiversity of the region's freshwater resources, water quality information for fresh water ecosystems is also scarce. Water quality data of this type is collected regularly only at intakes for public water supply systems. Be that as it may, general trends in land use and sanitation indicate that elevated levels of organic matter, fecal coliform bacteria, nutrients, and in some cases salinity, pesticides, and other contaminants are likely in many surface waters passing through agricultural and urban areas.

### 1.1.3 Water and Food

Water is clearly a constraint to agricultural and economic development in most of the Caribbean. Water availability per capita has been decreasing gradually not only due to growing populations, but also due to rapid increases in demand for additional services related to the tourism sector. Most island states have very limited internal renewable water resources but still would like to expand irrigated agriculture. The rapidly increasing food prices rapid population growth, and lack of export markets have led to an increasing diversification into high value production for domestic consumption, including the tourism sector. However, these crops need timely and reliable water supplies in the form of irrigation water.

Supply of irrigation water is often a principal controlling factor restricting agricultural expansion within the small island states of the Caribbean. In **Barbados**, irrigation is the second highest water consumer, after domestic use, amounting to 16.2 million $m^3$ a year[53]. Similarly in **Jamaica**, it was estimated that in 1985, 75% of the nation's total water demand went to agriculture although in 1997, it was estimated that the demand of the agricultural sector was 60%

[53] This amount has been forecast to increase by 15-20% over the next 10-15 years if export markets can be gained and less than half of that, if only local markets are supplied, resulting in an average increase rate of 1% annually.

(645MCM/yr) of the total water demand. [54]. A 2001 Report estimates that irrigated agriculture was responsible for more then 85% of national water use in the **Dominican Republic**[55]. In **Cuba** about 70% of the water resources were used, in 2000, for irrigating rice, sugar cane, fresh vegetables citrus and root crops[56].

The demand water for irrigation has, however, raised significant issues and challenges associated with the allocation and management of the resource[57]. In **Saint Lucia** for example one is only allowed to abstract water from a river at a point downstream of the potable water supply intake. In recent times this practice has been under significant scrutiny by the local Water and Sewage Commission, resulting in the intention to impose licensing agreements on such users. Water for potable use i.e. residential, commercial and tourism is still given priority.

With growing demands for water and increasing costs of water supply, a number of Caribbean countries have ventured into nontraditional water sources for both irrigation. Rainwater harvesting in the form of rooftop or communal catchments is undertaken in several countries in the region. Furthermore, treated wastewater is used in resort hotels in the Caribbean islands to irrigate golf courses.

### 1.1.4 Water and Industry

There is significant water utilization for industrial processes in the larger countries such as **Trinidad and Tobago** and **Jamaica**. The heavy demands for water at the Point Lisas Industrial Estate in Trinidad coupled with the unreliability of the

[54] Government of Jamaica, 1990. Water Resources Development Master Plan, Water Resources Authority.
[55] International Resources Group Limited, 2001. Dominican Republic Environmental Assessment. USAID/Santo Domingo
[56] http://www.idrc.ca/en/ev-51486-201-1-DO_TOPIC.html Accessed September 16 2008
[57] Irrigation in Jamaica is characterized by low efficiencies and significant wastage of water. Conveyance of water from source to farmland is hindered by the poor condition of many of the existing waterworks. An estimated 20 percent of water is lost in irrigation water supply systems. Further losses occur due to the 'continuous flow' method of delivering water to farmland. Farmers experience a lack of control in the application of irrigation water, and runoff losses from farmland are consequently large.

public supply system necessitated the installation of a desalination plant, illustrating the challenges in meeting all the competing demands for potable water for all sectors. In Jamaica, in 1985 approximately 7% of the total water consumed was used by the industrial sector. This figure rose to 23% in 2000 and is expected to remain at that level into 2015[58].

There is industrial activity in the smaller islands but on a smaller scale. These light industries include beverage manufacturing and agro-processing (including livestock such as poultry processing). While these industries are very small scale they are however water-dependent.

Pollution of surface and ground waters from industrial effluents poorly treated or untreated domestic and industrial sewage, runoff of agricultural chemicals, and mining wastes is a growing problem in the Caribbean. The main contaminants found in water include detergents, pesticides, petroleum and other derivatives, ,toxic metals (for example, lead and mercury), fertilizers and other plant nutrients, and oxygen-depleting compounds

### 1.1.5 Water and Tourism

Countries with well-developed tourism sectors place heavy demands on water resources to sustain tourism-based activities. In the main, tourists consume more water than residents on a per-capita basis. In **The Bahamas**, for instance, the average daily consumption of water by tourists is estimated at 400 to 1,000 liters per head; this is in contrast to residential consumption of 150 to 200 liters per head. In **St. Vincent and the Grenadines**, the per capita demand for fresh water by the tourism sector is estimated at approximately four times that of domestic households. In **Saint Lucia**, hotels consume 15% of the total volume

[58] National Resources Conservation Authority. 2001. The National Report On Integrating the Management Of Watersheds and Coastal Areas In Jamaica. Prepared for the Caribbean Environmental Health Institute and UNEP.

of pipe-borne water supplied by the Water and Sewage Company, with an additional 5% being consumed by the cruise ships[59].

In the case of **Barbados** for example, the total groundwater used for golf course irrigation presently amounts to 2,400 $m^3$/day. Given current development plans, the demand for irrigation water for golf courses is estimated to increase to a total of 11930$m^3$/day.[60] These golf course developments also impact on groundwater recharge and quality due to chemical applications, and inadequate liquid and solid waste disposal.

### 1.1.6 Water and Energy

A number of the Caribbean countries generate hydroelectricity. For many years, the **St. Vincent** Electricity Services (VINLEC) has maintained a hydroelectric plant at South Rivers. With the growing cost of fossil fuel however, the company saw prudence in the installation of a second plant on the Cumberland River. To meet the water needs of the plant, water was diverted from a river on the Richmond side. Consequently, the river on the Richmond side remains dry for most of the year negating any water related activity in that area.

In **Dominica**, the Dominica Electricity Services (DOMLEC) uses well over 6mgd on average in the hydropower generation system for its four (4) hydro-electricity plants, accounting for 48% of the generation capacity to the national output. The water catchments in the vicinity of the Fresh Water Lake, Laudat and Trafalgar, are used to generate electricity/ There is no competition with the potable water supply since that water is obtained from different water supply sources.

Hydroelectricity is second only to biofuel options in **Cuba**'s renewable energy portfolio. While Cuba has few large rivers, it has many small ones, which are well suited for microhydro generators. Microhydro generators already provide

[59] Saint Lucia National Report.
[60] Barbados National Report.

electricity to some rural villages in Cuba's mountainous regions. The hydroelectric potential in Cuba is estimated at 650 MW, with an annual generation of 1300 GWh. The microhydro potential in Cuba is estimated at 25 MW, spread out over more than 400 sites.

**Haiti** generates about 39.7% of total its installed capacity, from hydroelectric generation. Haiti has seven hydropower projects, of which the Peligre project with an installed capacity of more than 47 megawatts is by far the largest. The most serious problem facing the Peligre project is deforestation which causes erosion and sedimentation that is filling the reservoir[61].

J**amaica**, lacks the potential for large-scale hydroelectricity generation. Only some 23.8 MW of power is presently installed with potential for about another 100 MW.

### 1.1.7 Water and Climate Change and Natural Disasters

The Caribbean is dependant on rainfall to feed surface intakes and replenish groundwater resources. Therefore any change in rainfall pattern is liable to result in more severe and longer drought, reduced stream flow and reservoir storage. At the same time, watershed areas that have been denuded could produce flooding in coastal areas and extensive deposition of silt in the coastal marine environment.

Availability of water resources is a limiting factor for economic and social development in the Caribbean. The situation is critical in the low limestone islands of where seasonality of rainfall (a marked dry and wet season regime) is pronounced. On islands such as **Anguilla, Antigua and Barbuda, Grenada, and Barbados,** more than 65% of total annual rainfall may be recorded in the wet season, which spans the 6-month period of June to December. Moreover, most of the rainfall is strongly associated with the genesis and passage of

[61] US Army Corps of Engineers, *ibid*

easterly waves, tropical depressions, and storms[62,63]. Thus, changes in the occurrence of these heavy rainfall events will certainly impact the water supply of many Caribbean islands. The situation is further exacerbated in Barbados, where recent research has shown that groundwater recharge is restricted to the three wettest months of the year, and only 15-30 % of annual rainfall reaches the aquifer[64].

Reduced availability of adequate water supply in a changing climate also poses a potential threat. Within the past few decades in **Dominica**, for instance, an apparent tendency toward more extended periods of drought is well correlated with reduced flows in the Castle Comfort, Roseau, Layou, and Geneva Rivers[65]. Because rivers are the main source of potable and irrigation water on the island and are also harnessed for power generation, declining flows have become a matter of serious national concern.

Climate change can present additional water management challenges. Such challenges may arise from a variety of factors, including increased flood risks and impeded drainage and the presence of elevated water tables which may pose special engineering problems. It is projected that on Andros island, in The Bahamas, where the water table presently is only 30 cm below the surface, high evaporation rates and increasing brackishness will eventuate with continued sea-

[62] Gray, C.R., 1993: Regional meteorology and hurricanes. In: Climatic Change in the Intra-Americas Sea [Maul, G.A. (ed.)]. Edward Arnold, London, United Kingdom, pp. 87-99.

[63] Nurse, L.A., R.F. McLean, and A.G. Suarez, 1998: Small island states. In: The Regional Impacts of Climate Change: An Assessment of Vulnerability. A Special Report of IPCC Working Group II [Watson, R.T., M.C. Zinyowera, and R.H. Moss (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 331-354.

[64] Jones, I.C., J.L. Banner, and B.J. Mwansa, 1998: Geochemical constraints on recharge and groundwater evolution: the Pleistocene Aquifer of Barbados. In: Proceedings of the Third Annual Symposium, American Water Resources Association, and Fifth Caribbean Islands Water Resources Congress, San Juan, Puerto Rico, July 12-16, 1998. 6 pp.

[65] Government of Commonwealth of Dominica, 2000: The Commonwealth of Dominica's First National Report on the Implementation of the United Nations Convention to Combat Desertification (UNCCD). Environmental Coordinating Unit, Ministry of Agriculture, Planning and Environment, Roseau, Commonwealth of Dominica, 20 pp.

level rise[66]. Similar projections also have been made for **Cuba**, where underground water supplies already are stressed[67]. For many small island States in the Caribbean that are reliant on ground water, the prospect of saline intrusion into the freshwater lens is of great concern. In many of these islands where salinisation from overpumping of aquifers is already occurring (e.g., **The Bahamas and Barbados**), sea-level rise would compound the risk. Singh[68,69] has reported a recent increase in salinity levels for several coastal aquifers in **Trinidad and Tobago** in the southern Caribbean, attributable mainly to rapid drawdown exacerbated by sea-level rise.

Natural hazards are a major issue for the Caribbean region. There is a long and well-documented history of episodes involving hurricanes and other tropical weather systems. Although large volumes of rainfall normally accompany severe tropical weather systems, the usual resultant effects are heavy microbial contamination and siltation of ground and surface water sources. These weather events also cause damage to the water distribution infrastructure. Earthquakes and volcanic eruptions, though not as frequent, also have the potential to disrupt water distribution systems and contaminate water sources.

## 2.0 Challenges to Water Resources Management

Caribbean states will continue to face the tremendous pressures exerted by population growth and development, with attendant intense competition for land

[66] Martin, H. and J.P. Bruce, 1999: Effects of Climate Change: Hydrometeorological and Land-Based Effects in The Bahamas. Global Change Strategies International Inc., Ottawa, ON, Canada, 34 pp

[67] Planos, E.O. and O. Barros, 1999: Impacto del cambio climatico y medidas de adaptacion en Cuba: sector recursos hidricos. In: Impactos del Cambio Climatico y Medidas de Adaptacion en Cuba [Gutierrez, T., A. Centella, M. Limia, and M. Lopez (eds.)]. Proyecto No. FP/CP/2200-97-12, United Nations Environment Programme/Institute of Meteorology, La Habana, Cuba, pp. 28-54.

[68] Singh, B., 1997a: Climate-related global changes in the southern Caribbean: Trinidad and Tobago. Global and Planetary Change, **15**, 93-111.

[69] Singh, B., 1997b: Climate changes in the greater and southern Caribbean. International Journal of Climatology, **17**, 1093-1114.

and water resources, along with pollution of the environment. These factors threaten both quantity and quality of available water resources in the medium to long-term. Changing climate and the threats posed to water security on account of sea-level rise and saline intrusion of coastal aquifers, rainfall variability and potential reduced catchment recharge, coupled with increased frequency of natural disasters such as hurricanes and drought will present challenges to the management of water resources on Caribbean islands due to the complex interactions between the various threats. Other challenges to sustainable and efficient water resources management in the Caribbean include, *inter alia*:

- Lack of national "apex" agencies with core mandate for comprehensive management of water resources;
- Multiplicity of agencies involved in water resources management in a single jurisdiction;
- Legislation governing water resources management is deficient and is fragmented through the multiple agencies involved in water resources management;
- Data to make informed decisions is often inadequate ;
- Rapid growth in urbananisation, and in tourism and commercial activities, all of which increase demand beyond system capacities and stresses the current water supply and sanitation services and resources;
- Poor and aging water distribution and sanitary system networks.

## 3.0 Progress Made to Meet the Challenges

The development of national water policies are ongoing activities in several of the Caribbean countries. Some countries like **Grenada**[70], **Jamaica and Barbados** have relatively well-developed, defined and operational policies on water whereas, countries such as Saint Lucia, are in the process of developing comprehensive water management policies that take account of coastal areas

[70] Government of Grenada. 2007 Draft National Water Policy

management issues[71]. In **Anguilla**, freshwater management issues have gone largely unaddressed, as the Government has not established regulatory measures, incentives or related decision making tools. However, they have promoted the use of desalination and rainwater collection systems[72].

Commendable strides have been made to establish policy and institutional frameworks to manage water resources by countries such as **Barbados, Jamaica, Antigua and Barbuda and Trinidad and Tobago**. In Jamaica, Integrated Water Resources Management is being promoted with the enactment of the Watershed Act and the implementation of its National Water Policy and Strategy; in Trinidad and Tobago, through the development of the Water Resources Management Policy and Strategy; in **Haiti**, through the Ministry of Environment sectoral policies and the National Environmental Action Plan (NEAP); and in **Saint Lucia**, with the establishment of the Water Resources Management Unit, the Water and Sewage Commission and the development of a Water Sector Policy.

A model policy for the water sector of the Caribbean is currently being developed by the Caribbean Environmental Health Institute with support from the OAS[73]. This model policy[74] is being developed on the basis of the comprehensive studies undertaken in thirteen Caribbean countries through the IWCAM (GEF) Project and the Jamaica model water policy.

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[71] Model Water Sector Policy for the Caribbean (Draft Report)

[72] Anguilla Country Profile. Framework for Action: National Implementation of SIDS. ECLACC/CDCC. 1997

[73] Sweeney, Vincent and Jan Vermerien. 2008 Caribbean Water Vision Synthesis and Strategy. Prepared by the Caribbean Environmental health institute in Collaboration with the Organisation of American States.

[74] The draft model policy addresses the key areas of:

- Efficiency in provision of use
- Creating an enabling environment
- Financing and cost recovery for the water sector
- Ownership and private participation issues
- Management of water for irrigation
- Social issues related to water management

The Caribbean Environmental Health Institute (CEHI) in conjunction with the Water and Sewerage Commission of **Saint Lucia** developed and presented a draft model Water Sector Policy which could be adapted and adopted by regional governments. This policy introduced the concept of “Social Water”.

The Crayfish River Water Project in the Carib Reservation in **Dominica** provides an example of the community’s participation in the water resources management process to protect their health, social and economic well-being. This project consisted of public awareness programs relating to watershed management as well as support for farmers to improve their agricultural practices and be more involved in the management of the resource.

One example of the use of appropriate/innovative technology is the “novel groundwater development technology and contract structure” to solve long standing water shortage problems on the island of **Tobago**. This approach incorporated satellite imagery and a novel public-private sector partnership contract used for discovering and developing enormous quantities of high quality groundwater for Tobago. This is the first application of these technologies and type of partnership in the Caribbean region. It involved a “shared-risk” between the client and the contractor, combined with the application of the novel “mega watersheds” paradigm and an advanced state-of-the-art exploration programme, which resulted in the identification of 66 million MCM/year of previously undetected, renewable groundwater resource in the prevailing crystalline bedrock of the island.

The **Barbados** Five Zones planning system is a good example of the use of land-use planning for protecting the water resources. In this case the country is divided into zones and specific land use activities are allowed according to the zone. The zoning is based on the location of ground water in the vicinity. Zone 1 is closest to the production wells or areas earmarked for such and have the most stringent restrictions on development activities. Zone 5 has the least restriction.

The boundaries for the zones are based on travel times of pollutants. Enforcement is through the Town and Country Development Planning Office, Ministry of Health and the Barbados Water Authority.

The Inter-American Development Bank is financing a $15 million soft loan for a program to expand drinking water and sanitation services to rural communities in **Haiti** where average consumption of water is around seven litres per person a day, nearly one-third of the basic minimum recommended by the World Health Organization. Communities will decide through a participatory process whether they want to take part in the program, choose the systems best suited to their needs and capacity to operate and maintain them, and establish local water user committees to run the services. To ensure the sustainability of the systems, communities will establish cost recovery mechanisms to cover operation and maintenance expenses.

Other notable progress in the region includes:

- The recognition by CARICOM's Council for Trade and Development[75] of the ongoing efforts towards the development and/or strengthening of the national water policies, Integrated Water Resource Management (IWRM) Plans and Water Use Efficiency (WUE) Plans in the various Member States. The Council also endorsed the formation of a consortium of CARICOM Institutions that include, i*nter alia*, the CARICOM Secretariat, CARDI, CDERA, CEHI, CCCCC, CIMH and UWI, to assist Member States in coordinated consultation with national, regional and international partners in the formulation of IWRM and WUE.

- The initiation of Integrated Water Resources Management activities with support provided by the GEF financed Integrated Watershed and Coastal Area Management Project and supported by GWP-Caribbean. Start-up activities have began in Grenada, Dominica, Saint Lucia Antigua and Barbuda, and Union Island in St. Vincent and the Grenadines. The project has also sponsored community-based water resource assessment training as a means of promoting the linkages between community action and IWRM at the local level.

[75] Communiqué Issued At The Conclusion Of The Twenty-Fifth Special Meeting Of The Council For Trade And Economic Development [Environment] (COTED), 17-18 April 2008, Georgetown, Guyana

- The development of Water Safety Planning approaches by water utility companies. This initiative is being facilitated by the CDC in partnership with CEHI. Pilot activities have occurred in Jamaica in the Spanish Town supply system. Saint Lucia will be the focus for another pilot project.

- Ratification by Saint Lucia and Trinidad and Tobago of the LBS Protocol under the Cartagena Convention.

- The promotion of Rainwater Harvesting in the Caribbean. CEHI, supported by UNEP has developed a national RWH promotional programme for the pilot island of Grenada and a regional programme for the wider Caribbean.

- GWP-Caribbean has established national chapters in various countries, including Anguilla, Barbados, The Bahamas, British Virgin Island, Dominica, Dominica Republic, Grenada, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, and Trinidad & Tobago.

- Caribbean WaterNet is an EU-funded programme that is seeking to build capacity among water resource managers and other stakeholder in the Caribbean. A few training workshops have been convened.

- The Caribbean Basin Water Management Programme has offered training to utility companies.

- Caribbean Water and Waste Water Association (CWWA) has an annual conference which provides a major opportunity for water professionals to network and to make technical presentations.

- CEHI's Caribbean Environment Forum is a biennial forum with water as a major pillar. It provides opportunities for scientific exchange and networking.

## PART III POLICY OPTIONS FOR WATER RESOURCES MANAGEMENT IN THE SUB-REGION

Some of the major problems and the challenges which need to be addressed for the sustainable management of fresh water resources in the island States of the Caribbean are summarised in Table 4 below. Meeting these challenges in light of the limited resource-base of many Caribbean countries will require concerted government, private sector and civil society response.

At the national level, clearly there is no single prescription for achieving efficient water management, as approaches will of necessity vary from country to country and must be appropriate to local circumstances. However, there is an emerging consensus from the Caribbean region that there are certain critical policy elements that ought to be considered in the design of an effective IWRM strategy. The genesis of these policy elements is rooted in the special physiographic and socio-economic features that characterize Small Island Developing States (SIDS). These countries are (i) small in size with limited land space, (ii) typified by highly sensitive environments/ecosystems that have relatively high endemism and provide the flow ecosystem services (water, food, environmental quality, etc.) to the population, (iii) have open, fragile economies that are highly vulnerable to shocks in the global market place and (iv) are predisposed to frequent extreme events (hurricanes, drought) where in terms of smallness the scale of impact is at the national level.

The intensification of the sectoral demand for water has also accentuated the recognition that water resources should be best analysed and dealt with in an “integrated” manner. An integrated and comprehensive approach towards water management is the correct way to face the challenges of managing a multiple-use resource, such as water. To conduct and implement the changes needed to

**Table 4: Summary of Problems in Water Resources Management in the Caribbean Sub-Region**[76]

| Root Cause | Immediate Causes | Consequences |
|---|---|---|
| Water needs an Integrated Approach | Lack of Integrated Approaches | Multiplicity of institutions and jurisdictions that deal with various aspects of water resource management, often developing and implementing policies and programmes in isolation of one another. |
| | Fragmented and sectoral approach to water resources management | Multiplicity of laws, each dealing separately with various aspects of water resource management, thus encouraging a compartmentalised approach to management of the sector. |
| | | Poor stakeholder participation / low awareness among public and decision makers. |
| Water is also an economic good | Deficient economic valuation of water resources | Water mainly considered a social and public good. |
| | Economic<br>Poor feasibility assessment of water projects | Inadequate pollution control and regulation is threatening the development of the tourism industry |
| | Social<br>Access and affordability<br>Lack of appropriate / direct /transparent targeting and subsidy policies | Inadequate access to safe water can impact on socioeconomic development |
| | Environmental<br>Deficient urban & rural land<br>use planning. | Deforestation, soil erosion, water resource degradation. |

[76] Adapted from Orlando San Martin, 2002. Water Resources in Latin America and the Caribbean: Issues and Options. Inter-American Development Bank Sustainable Development Department Environment Division

| Root Cause | Immediate Causes | Consequences |
|---|---|---|
| Heterogeneity of water quantity, quality and availability | Insufficient information to support decision making | Inadequate data collection and information management |
| | Deficient capacity to deal with natural hazards | |
| Public awareness and political commitment | Multiple water legislation, regulatory and monitoring frameworks, and institutions | Each institution/agency has its "own" piece of legislation and mandate, limiting the scope for action and coordinated efforts. |
| | | Water pollution from untreated municipal and industrial discharges |
| | | Weak technical capacities among water sector personnel. |
| | | Lack of resources for research and technology |
| | Water policies<br>Inadequate policies on integrated water resources management<br>Unclear responsibilities of the range of stakeholders in the water sector | Lack of consistency on policies to promote contribution of water resources to national economies. |
| | | Policy on future consumption patterns related to population growth, increased tourism, agricultural and industrial developments are poorly articulated |

facilitate this shift in the approach, new/amended laws, regulations and institutions are needed. At the core of this approach is the adoption of a comprehensive policy and legal framework and the treatment of water as an economic good, combined with decentralized management and delivery structures, greater reliance on pricing, and fuller participation by stakeholders.

In this context, Integrated Water Resources Management (IWRM) policy elements for Caribbean SIDS should be directed towards the following areas that fall within the three pillars of IWRM (1) the Enabling Environment, (2) Institutional Roles and (3) Management Instruments.

1. **The Enabling Environment**
    a. Commitment by Governments to initiate, where not yet commenced, IWRM policy and plan formulation (in accordance with the Johannesburg Declaration, 2002 and MDGs). IWRM must be 'mainstreamed' into national development planning processes.
    b. Formulation and implementation of integrated watershed best management practices to rationalize land resource use, and reduce land-based pollution of water sources (both surface and groundwater).
    c. Implementation of National Land Use Plans and Policies that clearly articulate the nexus between good land use and water resource management, and effect positive change.
    d. Advancement of gender-balanced approaches and promotion of the role of the youth in the context of driving societal attitudinal changes toward improved water resources management.
    e. Rationalization and enhancement of water resources legislation, paying attention to effective enforcement.
    f. Promotion of more nuanced approaches to inform water pricing and economic policies through the application of appropriate economic

instruments that are sensitive to the socio-economic conditions of the users.

**2. Institutional Roles**

a. Establishment of politically independent national bodies to formulate policy and regulation related to the sustainable management of water resources (inclusive of management of waste water).
b. Enhancement and strengthening of institutional capacities in water management organizations.
c. Enhancement of operating efficiencies by water utilities in the area of fuel consumption in powering water distribution and waste treatment systems; reduction in their carbon footprint.
d. Investment in research and development not only with respect to augmentation and 'new' technologies, but also with a view to optimizing the distribution system, and reducing operational costs without compromising quality of service.

**3. Management Instruments**

a. Promotion of demand-side management, which may include incentives (and sanctions, where appropriate) for water conservation, use efficiency and optimization, and waste treatment
b. Strengthening of capacities to sustain comprehensive assessments of existing and future demands, by sector for decision-making.
c. Enhancement of capacities for forecasting occurrence and risk assessment of *extreme events*, i.e. droughts and floods, and formulation of appropriate mitigative measures.
d. Investment in equipment for data collection and monitoring.
e. Resolution of allocation issues such as trade-offs, use rights and user-conflict, e.g. potable use vs. irrigation needs; domestic supply vs. sale of water to cruise ships, etc.

f. Integration of databases that support water resources and environmental management.
g. Institution of self-sustaining and cost-effective mechanisms in support of assessment, repair and replacement of aging infrastructure.
h. Strengthening of monitoring for quality assurance and control.
i. Investment in appropriate technologies in water augmentation. The practice of rainwater harvesting must be afforded more attention in national water development strategies, particularly in the context of changing rainfall patterns associated with climate change and its impact on water security; and the use of water for agriculture.

No policy, however well-intentioned and conceived, will achieve the desired outcome if stakeholder education is not an institutionalized element of the implementation process. This may require strategies aimed at effecting behavioural and attitudinal change, dispelling false notions (e.g. that the resource is '*limitless*') and enhancing public awareness and understanding of the 'true' cost of providing water, arguably one of the most undervalued natural resources.

Finally, a collective regional approach is one through which all of the Caribbean SIDS can benefit. A regional-level advocacy, research, development, implementation-support and training node specializing in various aspects of IWRM (e.g., resource exploration, characterization, development, protection, and valuation) should be supported.

# ANNEXES

**Table 1: Selected Socio-Economic Indicators: 2005**[77]

| Country | Area ($Km^2$) | Population ('000) 2005 | HDI[78] (2005) | GDP per capita at current prices (US$) 2005 |
|---|---|---|---|---|
| Anguilla | 91 | 13.6 | n/a | 12,314 |
| Antigua and Barbuda | 442 | 82.8 | 0.815 | 10,513 |
| Bahamas | 13,939 | 320.7 | 0.845 | 18,990 |
| Barbados | 431 | 273.0 | 0.892 | 11,212 |
| British Virgin Islands | 151 | 25.8 | n/a | 37,656 |
| Cayman Islands | 264 | 48.4 | n/a | 47,336 |
| Commonwealth of Dominica | 750 | 70.6 | 0.798 | 4,251 |
| Cuba | 110,900 | 11,260 | 0.838 | 4,500 *(2007 est.)* |
| Dominican Republic | 48,381 | 9,470 | 0.779 | 9,200 *(2007 est.)* |
| Grenada | 345 | 105.9 | 0.777 | 4,758 |

[77] Sourced from databases from the Caribbean Development Bank the World Bank and the United Nations Development Programme.

[78] Human Development Index (HDI) is a comparative measure of life expectancy, literacy, education, and standards of living for countries worldwide. It is a standard means of measuring well-being, especially child welfare. It is used to distinguish whether the country is a developed, a developing, or an under-developed country, and also to measure the impact of economic policies on quality of life. The HDI for developing countries in the medium range was estimated at 0.691, while the low range was estimated at 0.488.

| Country | Area ($Km^2$) | Population ('000) 2005 | HDI[78] (2005) | GDP per capita at current prices (US$) 2005 |
|---|---|---|---|---|
| Haiti | 27,800 | 9,300 | 0.529 | 1,900 *(2007 est.)* |
| Jamaica | 10,991 | 2,660.7 | 0.736 | 3,633 |
| Montserrat | 1.03 | 4.8 | n/a | 9,189 |
| St. Christopher and Nevis | 269 | 49.3 | 0.821 | 8,695 |
| Saint Lucia | 616 | 164.2 | 0.795 | 5,374 |
| St. Vincent and the Grenadines | 388 | 104.9 | 0.761 | 4,101 |
| Trinidad and Tobago | 5,128 | 1,294.5 | 0.814 | 11,092 |
| Turks and Caicos | 417 | 30.6 | n/a | 18,636 |

**Table 2: National Stakeholders Involved in Water Resources Management in the Caribbean[79]**

| Country | Main Stakeholders | Basin/Watershed Organisations | | |
|---|---|---|---|---|
| | | Public | Private | NGO/CBO Partnerships |
| Anguilla | Anguilla Water Department<br>Water Laboratory | | Hotels with private desalination plants | Anguilla National Trust |
| Antigua and Barbuda | Antigua Public Utilities Authority (Water Division)<br>Ministry of Lands, Agriculture and Fisheries<br>The Development Control Authority<br>Ministry of Tourism and Environment<br>Ministry of Public Utilities (Water Division)<br>Ministry of Public Works and Communications<br>Ministry of Health and Social Improvement<br>Private Hotels in Barbuda (desalination plants) | Hotels with private desalination plants | Veolia water Company (Desalination Plant)<br>Soft Drink Manufacturers | Environmental Awareness Group<br>The Gilbert Agricultural and Rural Development centre |
| Bahamas | The Water and Sewerage Corporation (Ministry of Consumer Affairs)<br>Department of Physical Planning<br>Ministry of Works and Utilities<br>Ministry of Health<br>Ministry of Agriculture, Fisheries and local Government<br>Public Utilities Commission<br>Joint Water Quality and Pollution Control Unit<br>Paradise Utilities<br>Grand Bahamas Utilities Company<br>New Providence Development Company<br>District Councils and Town Committees | Bahamas Environment Science and Technology Commission | Soft Drink Manufacturers<br>Bottled Water Companies | The Bahamas National Trust |
| Barbados | Barbados Water Authority in the Ministry of Public Works and Transport<br>Drainage Unit of the Ministry of Public Works and Transport<br>Town and Country Development Planning Office of the Economic Affairs Division of the Ministry of | Land Degradation Committee<br>Planning and Priorities Committee (Cabinet)<br>National Commission on Sustainable Development | Soft Drink Manufacturers<br>Distilleries<br>Brewery | The Barbados National Trust,<br>The Barbados Environmental Society and<br>The Barbados Environmental Youth |

[79] The information has been derived from multiple sources. The information provided is not uniform or complete for all countries because similar data sets are not available for all countries. The accuracy of the information has also not been validated.

| Country | Main Stakeholders | Basin/Watershed Organisations | | |
|---|---|---|---|---|
| | | Public | Private | NGO/CBO Partnerships |
| | Finance and Economic Affairs<br>Economic Planning Unit (EPU) of the Economic Affairs Division of the Ministry of Finance and Economic Affairs<br>Soil Conservation Unit (SCU) of the Ministry of Agriculture and Rural Development<br>Ministry of Environment, Energy and Natural Resources<br>Ministry of Health | University of the West Indies<br>Coastal Zone Management Unit | | Network<br>National Conservation Commission |
| British Virgin Islands | Ministry of Natural Resources and Labour<br>Ministry of Communications and Works<br>Town and Country Planning Department<br>Development Control Authority | Project review and Advisory Committee | | National Parks Trust |
| Cayman Islands | Water Authority<br>Individual properties and developments (desalination plants) | | | |
| Commonwealth of Dominica | Dominica Water and Sewerage Company<br>Ministry of Communications and Works<br>Forestry and Wildlife Division of the Ministry of Agriculture and Environment<br>Ministry of Health | Development and Planning Corporation<br>Pesticide Control Board<br>Physical Planning Division<br>Department of Land and Surveys<br>Local Government and Community Development Division<br>Dominica Port Authority | Bottled Water Companies<br>Soft Drink Manufacturers<br>Dominica Electricity Services (Hydroelectricity) | Save the Children's Fund<br>Small Projects Assistance Team |
| Cuba | Instituto Nacional de Recursos Hidraulicos, INRH<br>Instituto de Suelos<br>Aguas de la Habana<br>Red de Observación Sistemática de los Niveles de las Aguas Subterráneas<br>Red de Observaciones de la Composición Hidroquímica y Bacteriológica),<br>Red Básica Nacional Hidrogeológica). | Instituto de Riego y Drenaje<br>Instituto de Investigaciones Forestal Instituto de Agraria de la Habana<br>CENICA<br>La Agencia del Medio Ambiente<br>Instituto de Meteorología | Breweries<br>Bottled Water Companies<br>Soft Drink Manufacturers<br>Distilleries | |

| Country | Main Stakeholders | Basin/Watershed Organisations | | |
|---|---|---|---|---|
| | | Public | Private | NGO/CBO Partnerships |
| | Ministry of Economy and Planning<br>Ministry of Health | National Institute of Hydrological Resources<br>Councils of Hydrographic Basin | | |
| Dominican Republic | Santo Domingo Water and Sewerage Corporation (CAASD<br>Santiago Water and Sewerage Company (CORAASAN)<br>Puerto Plata Water and Sewerage Company (CORAAPPLATA)<br>Moca Water and Sewerage Company (CORAMOCA)<br>Romana Water and Sewerage Company (CORAAROM)<br>Dirección General de Acueductos<br>Secretaría de Fomento, Obras Públicas y Riego<br>The Secretariado Técnico de la Presidencia<br>Secretaria de Salud Publica through its State Secretariat of Public Health and Social Security (SESPAS).<br>Secretaria de Estado de Medio Ambiente y Recursos Naturales,<br>The General Directorate of Norms and Systems Quality (DIGENOR) | National Institute of Hydraulic Resources (INDRHI) | Breweries<br>Soft drink manufacturers<br>Bottles Water Companies<br>Distilleries | |
| Grenada | National Water and Sewerage Authority in the Ministry of Works<br>Ministry of Health<br>Ministry of Agriculture (Land Use Division<br>Department of Forestry and National Parks; Department of Fisheries Agricultural Extension Division)<br>Land Development Control Authority in the | National Science and technology Council<br>Bureau of Standards<br>Meteorological Office in the Ministry of Tourism | Bottled Water Companies<br>Brewery<br>Soft Drink Manufacturers<br>Distillery | Agency for Rural Transformation<br>GRENCODA<br>Grenada Sustainable Development Council |

| Country | Main Stakeholders | Basin/Watershed Organisations | | |
|---|---|---|---|---|
| | | Public | Private | NGO/CBO Partnerships |
| | Ministry of Finance | | | |
| Haiti | National Water Commission<br>Ministry of Environment<br>Ministry of Agriculture<br>Ministry of Public Works<br>Ministry of Planning<br>Ministry of Health<br>Centrale Autonome Métropolitaine d'Eau Potable<br>Service National d'Eau Potable | POCHEP (a small unit under the Ministry of Health)<br>Water Reform Unit in the Ministry of Public Works<br>FAES (fund for Social and Economic Assistance) | Brewery<br>Soft Drink Manufacturers<br>Distilleries | *Comités d'Aprovisionnement en Eau Potable*<br>Concern Wordlwide<br>CARE<br>World Vision<br>Partners in Health and Kokapop<br>African Methodist-Episcopal Church |
| Jamaica | Water Resources Authority<br>National Water Commission<br>Ministry of Health<br>Forestry Department<br>New Environment and Planning Agency<br>Town Planning Department<br>Natural Resources Conservation Authority Land Development Utilization Commission<br>Office of Disaster Preparedness and Emergency Management<br>Parish Councils<br>Parish Health Departments | National Meteorological Service<br>Rural Agricultural Development Agency<br>Ministry of Transport and Works<br>Planning Institute of Jamaica | Brewery<br>Soft Drink Manufacturers<br>Bottled Water Companies<br>Distilleries | Jamaica Conservation Development Trust<br>National Environmental Societies Trust<br>Negirl Area Environmental Protection Trust |
| Montserrat | Montserrat Water Authority<br>Ministry of Agriculture, land, Housing and the Environment<br>Physical Planning Unit | | | |
| St. Kitts and Nevis | Water Department<br>Public Health Department<br>Physical Planning Unit<br>Department of the Environment | | Brewery<br>Soft Drink Manufacturers | |
| Saint Lucia | Water and Sewerage Company<br>Ministry of Agriculture, Lands, Forestry and Fisheries | National Conservation Authority | Bottled Water Companies<br>Brewery<br>Soft Drink manufacturers | Water Catchments Groups |

| Country | Main Stakeholders | Basin/Watershed Organisations | | |
|---|---|---|---|---|
| | | Public | Private | NGO/CBO Partnerships |
| | Development Control Authority<br>Ministry of Health | | Distillery | |
| St. Vincent and the Grenadines | Central Water and Sewerage Authority<br>Ministry of Health and the Environment<br>Ministry of Agriculture, Forestry and Fisheries<br>Ministry of Finance and Economic Planning | St. Vincent Electricity Services (hydroelectricity)<br>National Environmental Advisory Board<br>National Parks, Rivers and Beaches<br>Ministry of Community Development<br>Union Island Tourist Board | Soft Drink Manufacturer<br>Brewery<br>Distillery<br>East Caribbean Group of Companies | Donaldson Community Rain Water Harvest Catchment Group<br>Ashton Community Rain Water Harvest Catchment Group<br>Clifton Health Centre Rain Water Harvest Catchment Group<br>JEMS<br>Union Island Environmental Attackers |
| Trinidad and Tobago | Water and Sewerage Authority<br>Drainage Division, Ministry of Works and Transportation<br>Land and Water Division, Ministry of Agriculture, Land, and Marine Resources<br>Forestry Division, Ministry of Agriculture, Land and Marine Resources<br>Extension Division, Ministry of Agriculture, Land and Marine Resources<br>Town and Country Planning Division, Ministry of Housing and Settlement<br>Environmental Management Authority<br>Regulated Industries Commission<br>Point Lisas Desalination plant<br>Tobago House of Assembly | Institute of Marine Affairs<br>Central Statistical Office<br>University of The West Indies<br>Meteorological Services<br>Tourism and Industrial Development Corporation<br>National Emergency Management Agency | | |
| Turks and Caicos | Water and Sewerage Board<br>Provo Water Company Ltd.<br>Public Works Department | | | |

**Table 3: Regional and International organisations Involved in Water Resources Management in the Caribbean**

| Regional Agency | International Agency | Mandate |
|---|---|---|
| Caribbean Basin Water Management Inc. | | Provision of training on a regional basis for the employees of the participating water utilities with emphasis on a self-sustaining training delivery system and the development of a local "in-house" training capability within the utilities themselves. |
| Caribbean Environmental Health Institute (CEHI) | | The Climate and Water Dialogue provides a platform through which policymakers and water resources managers have better access to climate related information generated by climatologists and meteorologists. The Dialogue seeks to improve the capacity in water resources management to cope with the impacts of increasing variability of the world's climate |
| Caribbean Institute of Meteorology and Hydrology (CIMH) | | Collects analyses and archives meteorological and hydrological data from member States. |
| Caribbean Land and Water Resources Network (CLAWRENET) | | Develop Science and Technology in Land and Water Resources among public, private agricultural entities and NGOs to support agriculturally based industries in attaining international competitiveness and the sustainable development of the Caribbean region. |
| Caribbean Water and Wastewater Association (CWWA) | | To advance the science and practice of water supply, wastewater disposal and solid waste management, and promote the efficient management of utilities for the sustainable development of Caribbean people. |
| | Food and Agricultural organisation (FAO) | The Water Resources, Development and Management Service is concerned with sustainable use and conservation of water in agriculture. The four programmes focus on water for food security; special action programme for water and sustainable agricultural development; technical assistance and capacity building. |
| Global Water Partnership-Caribbean | Global Water Partnership | Establishment of strategic alliances and implementation of appropriate actions in water resources management. |
| | Inter American Water Resources Network (IRWIN) | A forum for bringing together key actors in the water sector to facilitate sustainable development and integrated water resources management world-wide. The objectives of the IWRN included building shared understanding of issues; clarifying water resources needs and priorities; increasing access to skills, knowledge and strategies; building a network of networks; and creating |

| | | |
|---|---|---|
| | | collaborative partnerships. |
| | Inter-American Development Bank (IADB) | Support and help the countries of the region to meet the Millennium Development Goals (MDGs) through the organization of a series of seminars that will provide an adequate framework for discussion with key stakeholders on mechanisms, options and factors that would increase investments and coverage (in accordance with the MDGs) in the water and sanitation sector in Latin America and the Caribbean. |
| Caribbean Development Bank | | Provides loans for the development of the water sector in its Borrower Member Countries. |
| | IW:Learn | A programme that promotes experience sharing and learning among GEF International Waters projects and the country officials, agencies, and partners working on them. The website serves as the Knowledge Base for GEF IW:LEARN and contains an extensive collection of resources, experiences, and materials for the portfolio. |
| | Small Island Water Information Network (SIWIN) of the Commonwealth Science Council | A network to address water resource information in small islands, arid and semi-arid states. |
| | UNEP | Develop policy-relevant assessments of the state of freshwater and marine resources; develop tools and guidelines for sustainable management and use of freshwater and coastal resources; and promote international cooperation in the management of river-basins and coastal waters and on the special needs of Small Island Developing States (SIDS). |
| | UNESCO | The UNESCO Regional offices are responsible for the implementation of the International Hydrological programme. IHP is UNESCO's international scientific cooperative programme in water research, water resources management, education and capacity-building, and the only broadly-based science programme of the UN system in this area. |
| | Virtual Water Learning Centre | A CDROM- and Internet-based Water Virtual Learning Centre that provides distance learning opportunities and information on best water management practices for developing countries |
| | WHO | WHO works on aspects of water, sanitation and hygiene where the health burden is high, where interventions could make a major difference and where the present state of knowledge is poor. The programme areas focus on policy, research, capacity building, partnerships, norms and standards, and testing of |

| | | |
|---|---|---|
| | | new technologies. |
| | World Bank | The World Bank's water strategy seeks to provide effective, tailored assistance to client countries to improve water resources management and enhance water services, in order to enhance growth and reduce poverty. The strategy is anchored in the premise that most developing countries need to be active in both management and development of water resources infrastructure. |
| | World Meteorological Organisation (WMO) | Facilitate international cooperation in the establishment of networks of stations for making meteorological, hydrological and other observations; and to promote the rapid exchange of meteorological information, the standardization of meteorological observations and the uniform publication of observations and statistics. |
| Inter-American institute for cooperation in Agriculture (IICA) | | Document, disseminate and promote best practices at the farm level and provide training to build human resources capacity. |
| Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC – Spanish Acronym) | | Establishment of regional networks that study regional hydrological processes and transfer of knowledge. Its principal objective is to transfer information, knowledge and new technologies among scientists and decision makers throughout the LAC region. |