Caribbean Regional Fund for Wastewater Management

# Baseline Assessment Study on Wastewater Management

# Belize

**December 2013**

Revised January 2015

# Baseline Assessment Study for the GEF CReW Project: Belize


**December 2013**
**Prepared by Dr. Homero Silva**

**Revised January 2015**

# CONTENTS

# LIST OF ACRONYMS

| | |
|---|---|
| 2NC | Second National Communication |
| AAS | Atomic Absorption Spectrophotometer |
| BAHA | Belize Agricultural Health Authority |
| BAL | Belize Aquaculture Ltd. |
| BCES | Belize Centre for Environmental Studies |
| BEST | Belize Enterprise for Sustainable Development |
| BHRHO | Belize Human Resources for Health Observatory |
| BNTF | Basic Needs Trust Fund |
| BOD | Biochemical Oxygen Demand |
| BSI | Belize Sugar Industry |
| BSIF | Belize Social Investment Fund |
| BWS | Belize Water Services Ltd. |
| BZ | Belize |
| CAR/RCU | Caribbean Regional Coordinating Unit |
| CAREC | Caribbean Epidemiology Centre |
| CBD | Convention on Biological Diversity |
| CBO | Community-Based Organisation |
| CCA | Chromated Cooper Arsenate |
| CCJ | Caribbean Court of Justice |
| CDC | Centers for Disease Control and Prevention |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| $CO_2$ | Carbon dioxide |
| COD | Chemical Oxygen Demand |
| CReW | Caribbean Regional Fund for Wastewater Management |
| CSME | Caribbean Community Single Market and Economy |
| CWIP | Coastal Water Quality Improvement Project |
| CZMA/I | Coastal Zone Management Authority/Institute |
| DALY | Disability Adjusted Lost Year |
| DO | Dissolved Oxygen |
| DOE | Department of the Environment |
| EIA | Environmental Impact Assessment |
| EM | Effective Microorganism |
| ENGO | Environmental Non-Governmental Organization |
| EU | European Union |
| EWB | Engineers without Borders |
| GDP | Gross Domestic Product |
| GE | Gastroenterology |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GOB | Government of Belize |
| GPS | Global Positioning System |

| | |
|---|---|
| HACCP | Hazard Analysis and Critical Control Points |
| HPLC | High Performance Liquid Chromatograph |
| ICCAT | International Commission for the Conservation of Atlantic Tunas |
| IDB | Inter-American Development Bank |
| IDCP | International Dolphin Conservation Program |
| IMF | International Monetary Fund |
| INFAL | Inter-American Network of Food Analysis Laboratories |
| IPCC | Inter-governmental Panel on Climate Change |
| IPTBH | Improved Productivity Through Better Health Project |
| IUCN | International Union for Conservation of Nature |
| JWP | Joint Monitoring Programme |
| LBS | Land-Based Sources |
| LULUCF | Land Use, Land Use Changes and Forestry |
| KAP | Knowledge, Attitudes and Practices |
| LIC | Land Information Centre |
| LOSC | United Nations Law of the Sea Convention |
| MACC | Mainstreaming Approach to Climate Change |
| masl | metres above sea level |
| MDG | Millennium Development Goal |
| MED | Ministry of Economic Development |
| MLLGRD | Ministry of Labour, Local Government and Rural Development |
| MNRE | Ministry of Natural Resources and the Environment |
| MOA | Ministry of Agriculture |
| MOH | Ministry of Health |
| NAVCO | National Association of Village Councils |
| NGO | Non-Governmental Organization |
| OLDEPESCA | Latin American Organization for Fisheries Development |
| PCSD | Placencia Citizens for Sustainable Development |
| PDC | Parish Development Committee |
| ppm | parts per million |
| PUC | Public Utilities Commission |
| RIA | Rapid Impact Assessment |
| RWS | Rural Water Supply |
| RWSSP | Rural Water Supply and Sanitation Programme |
| SIA | Social Impact Assessment |
| SIB | Statistical Institute of Belize |
| SIDS | Small Island Developing State(s) |
| SPAW | Specially Protected Areas and Wildlife |
| STP | Sewage Treatment Plant |
| SWMA | Solid Waste Management Authority |
| TIDE | Toledo Institute for Development and Education |
| TDS | Total Dissolved Solids |
| TSS | Total Suspended Solids |
| WHO | World Health Organization |

| | |
|---|---|
| UB | University of Belize |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNEP-CAR/RCU | United Nations Environment Programme-Caribbean Regional Coordinating Unit |
| UNICEF | United Nations Children's Fund |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNFPA | United Nations Population Fund |
| USAID | United States Agency for International Development |
| USDS | United States Department of State |
| VIP | Ventilated Improved Pit |
| WASA | Water and Sewerage Authority |
| WCR | Wider Caribbean Region |
| WECAFC | Western Central Atlantic Fisheries Commission |
| WWTP | Wastewater Treatment Plant |

# 1. INTRODUCTION

This National Baseline Assessment on Wastewater Management for Belize was prepared to provide information for a Regional Baseline Assessment Study on Wastewater Management for the Wider Caribbean Region. The regional assessment will assist these governments in meeting the requirements of the Protocol Concerning Pollution from Land-Based Sources and Activities (LBS Protocol), with particular emphasis on meeting the effluent standards specified in Annex III of the Protocol. The Regional Assessment will assist the United Nations Environment Programme-Caribbean Regional Coordinating Unit (UNEP-CAR/RCU) in the design and implementation of future capacity building activities. It will be the foundation of information for a broad group of stakeholders to understand the general and the specific needs that should be considered in the development of national domestic wastewater management plans.

The National Baseline Assessment is structured as follows:

- **National Context** – the social, environmental and economic characteristics of Belize
- **Methodology** – the assessment methodology
- **Mathematical Model** – the mathematical model used for analysis of the data
- **Overview of wastewater management** – Belize's wastewater management infrastructure, technologies and practices
- **Pollution problems and their cost –** the impacts of current wastewater management practices and their social, environmental and economic costs
- **National capacity –** the legislative, policy and institutional capacity for wastewater management
- **Surveillance and enforcement** – the capacity and systems for monitoring and enforcement to promote good wastewater practices
- **Manpower capacity** – the availability of staff and capacity needs for wastewater management
- **Financing** – existing and required financing for wastewater management
- **Knowledge, attitudes and practices** – current knowledge, attitudes, behaviours and practices regarding water and sanitation
- **Information** – systems and capacity for collecting, sharing and using data to facilitate improved wastewater management
- **Supporting organizations** – the presence and participation of non-governmental and community-based organizations in water and sanitation
- **Climate change impacts** – impacts of climate change on water and sanitation services

The assessment concludes with a **summary of main findings** and **recommendations for action**.

# 2. THE NATIONAL CONTEXT

# DESCRIPTION OF THE COUNTRY

## History

The history of Belize dates back thousands of years. The Maya civilization spread into the area of Belize between 1500 BC and AD 200 and flourished until about AD 1200. Several major archeological sites – notably Cahal Pech, Caracol, Lamanai, Lubaantun, Altun Ha and Xunantunich – reflect the advanced civilization and much denser population of that period. The first recorded European settlement was established by shipwrecked English seamen in 1638. Over the next 150 years, more English settlements were established. This period also was marked by piracy, indiscriminate logging and sporadic attacks by "pre-America natives" and neighbouring Spanish settlements (U.S. Department of State (USDS) 2008).

Great Britain first sent an official representative to the area in the late 18th century, but Belize was not formally termed the "Colony of British Honduras" until 1840. It became a crown colony in 1862. Subsequently, several constitutional changes were enacted to expand representative government. Full internal self-government under a ministerial system was granted in January 1964. The official name of the territory was changed from British Honduras to Belize in June 1973, and full independence was granted on September 21, 1981(USDS 2008).

## Growth Rates and Demographics

Belize has a total population of 323,226 persons: 161,648 females and 161,560 males. The intercensal growth rate was 39.3 per cent, the life expectancy is 76.8 years: 79.2 years for females and 74.3 for males. Total fertility rate is 2.6. Other information is presented in Table 1 (Ministry of Health (MOH) Belize 2011).

**Table 1: Demographic and social Indicators (2010)**

| | Total Population | Male Population | Female Population | Urban Population | Rural Population | Intercensal Growth Rate | Youth Population (15yrs - 24yrs) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | % | T | M | F |
| | 2010• | 2010 | 2010 | 2010 | 2010 | 2010 •• | 2010 ••• | | |
| COUNTRY | 323,226 | 161,560 | 161,648 | 146,509 | 176,717 | 39.3 | 65,462 | 32,454 | 33,008 |
| DISTRICTS Corozal | 41,177 | 20,569 | 20,608 | 10,306 | 30,871 | 27.8 | 8,420 | 4,121 | 4,301 |
| Orange Walk | 46,069 | 23,239 | 22,826 | 14,007 | 32,062 | 21.0 | 9,532 | 4,757 | 4,775 |
| Belize | 95,496 | 46,937 | 48,545 | 69,098 | 26,398 | 51.4 | 18,598 | 9,025 | 9,570 |
| Cayo | 75,122 | 37,508 | 37,614 | 38,074 | 37,048 | 46.7 | 15,622 | 7,763 | 7,859 |
| Stann Creek | 34,547 | 17,878 | 16,669 | 9,658 | 24,889 | 41.3 | 7,084 | 3,658 | 3,425 |
| Toledo | 30,815 | 15,429 | 15,386 | 5,366 | 25,449 | 33.3 | 6,206 | 3,130 | 3,078 |

* 18 sex not reported ** Based on 2010 Census. Growth Rate reflects 2000 and 2010 Censuses ***1 sex not reported

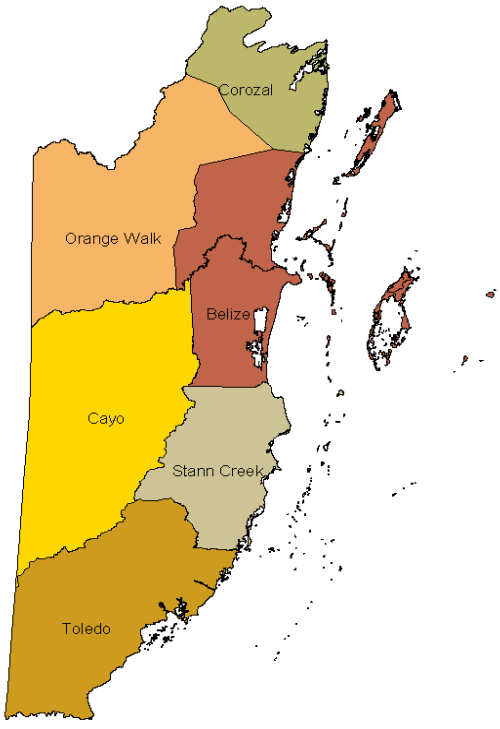
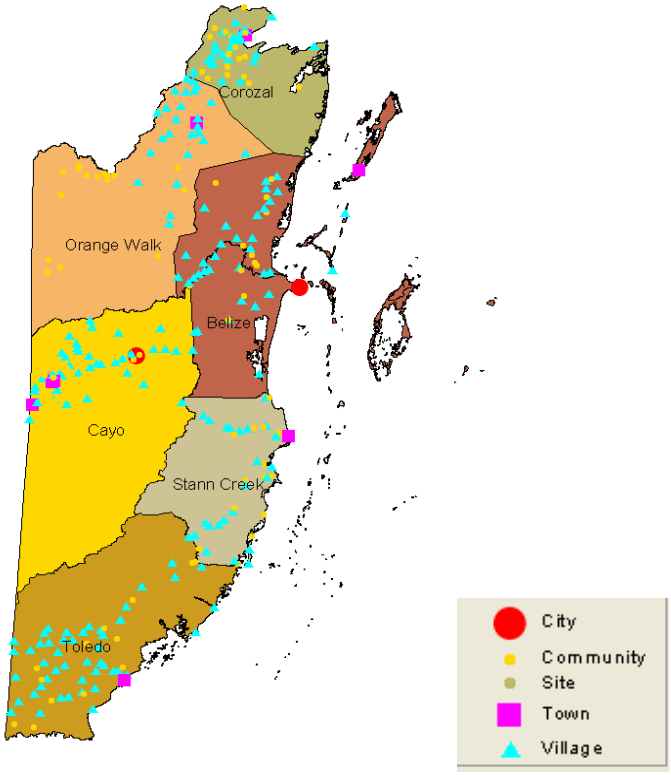
| | Population Density (pop. X mls.$^2$) | Dependency Ratio (x 100 pop.) | Crude Birth Rate (x1,000 pop.) | Crude Death Rate (x1,000 pop.) | Life Expectancy at Birth (years) | | | Total Fertility Rate | Adolescent Fertility Rate 15-19yrs |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Both | M | F | | |
| | 2010 | 2010 | 2010 | 2010 | 2010 | | | 2010 | 2010 |
| COUNTRY | 36.5 | 66.3 | 22.4 | 4.8 | 76.8 | 74.3 | 79.2 | 2.6 | 79.9 |
| DISTRICTS Corozal | 57.3 | 63.6 | 21.6 | 4.5 | | | | | |
| Orange Walk | 25.7 | 64.1 | 22.7 | 4.1 | | | | | |
| Belize | 57.4 | 56.9 | 21.0 | 6.3 | | | | | |
| Cayo | 37.4 | 72.2 | 23.4 | 3.6 | | | | | |
| Stann Creek | 35.0 | 70.6 | 26.1 | 5.8 | | | | | |
| Toledo | 18.1 | 88.1 | 20.3 | 3.4 | | | | | |

Source: Ministry of Health, Belize. "Health Situation in Belize: Belize Basic Indicators". Office of the Director of Health Services. The Epidemiology Unit. Volume No. 8, Year 2011.

## National Government and Local Government

Belize is a sovereign state governed under the principles of parliamentary democracy based on the Westminster model. The 1981 constitution provides for a Governor General who must be a citizen of Belize, but who is appointed by the Queen of England to be her representative. Joining the Governor General, the executive branch of the Government is formed by the Prime Minister and Cabinet, which is drawn from the National Assembly. The National Assembly forms a bicameral legislature comprising a 31-member elected House of Representatives and a 12-member appointed Senate. (Government of Belize (GOB) 2006) The judiciary is comprised of a Supreme Court and Court of Appeals, both located in Belize, and a Privy Council which consists of members of the British House of Lords. As a signatory to the Treaty of Chaguaramas, which established the Caribbean Community Single Market and Economy (CSME), Belize also recognizes the authority of the Caribbean Court of Justice to interpret and apply the treaty relevant to trade relations (Caribbean Court of Justice (CCJ) 2003).

There are six administrative districts (Corozal, Orange Walk, Belize, Cayo, Stann Creek and Toledo) (Figure 1) and a number of towns and villages (Figure 2). The administrative affairs of these communities are conducted by a combination of city, town and village councils. Belize City has a nine-member elected council, whereas Belmopan City and the town and village councils have seven-member elected councils.

| Figure 1: Belize Administrative Districts | Figure 2: Belize Settlements |
|---|---|
|  |  |



Source: Biodiversity and Environmental Resource Data System of Belize

### Health Indicators

The ten leading causes of death are: diabetes mellitus (9.5 per cent), ischaemic heart diseases (7.7 per cent), homicide and injury purposely inflicted (7.6 per cent), AIDS (6.7 per cent), cerebrovascular diseases (5.3 per cent), diseases of pulmonary circulation and other forms of heart disease (4.0 per cent), other chronic pulmonary diseases excluding external agents, residual respiratory infections (3.8 per cent), acute respiratory infections (3.7 per cent), hypertensive diseases (3.4 per cent) and transport accidents (3.1 per cent). The ten leading causes of hospitalization are presented in Table 2 (PAHO 2009).

**Table 2: Ten Leading Causes of Hospitalization for All Ages – Belize 2010**

| Causes | Rank | Total Causes | Percentage |
|---|---|---|---|
| Complications of pregnancy, childbirth and the puerperium | 1 | 8617 | 39.1% |
| Injury, poisoning and certain other consequence of external causes | 2 | 1425 | 6.5% |
| Acute respiratory infections | 3 | 1166 | 5.3% |
| Diseases of other parts of the digestive system | 4 | 834 | 3.8% |
| Appendicitis, hernia of abdominal cavity and intestinal obstruction | 5 | 649 | 2.9% |
| Diabetes mellitus | 6 | 638 | 2.9% |
| Diseases of urinary system | 7 | 637 | 2.9% |
| Intestinal infectious diseases | 8 | 557 | 2.5% |
| Other conditions originating in the perinatal period | 9 | 461 | 2.1% |
| Factors influencing health status and contact with health services | 10 | 420 | 1.9% |
| **Sub Total** | | **15404** | **69.9%** |
| Symptoms, signs and ill-defined conditions | | 627 | 2.8% |
| Residual | | 1436 | 6.5% |
| Total other causes | | 4555 | 20.7% |
| **Total all causes** | | **22022** | **100.0%** |

Source: Epidemiology Unit
Note: Excluding signs, symptom and ill-defined conditions and residuals

## GEOGRAPHIC CHARACTERISTICS

### Location

Belize is a small independent country on the Caribbean coast of Central America, bordered on the north by Mexico and on the west and south by Guatemala (15° 53′ to 18° 30′N Latitude; 87° 15′ to 89° 15′ W Longitude; Figure 1). It has a land area of 22,960 km$^2$ of which 95 per cent is located on the mainland and 5 per cent is distributed over more than 1,060 islands. Total national territory (including territorial sea) has an area of 46,620 km$^2$.

## Geology

The country is well known as the home of the longest barrier reef in the Western Hemisphere. This 220 km reef stretches along the entire coastline and is recognized by the United Nations as a World Heritage Site. The Government of Belize has also recognized the reef's uniqueness, protecting substantial portions in marine reserves.

Belize is physiographically very diverse because it lies at the boundary between two sharply contrasting geologies. Northern Belize is an extension of the Yucatan Platform, while southern Belize shares the mountainous geology of eastern Guatemala (Fairbridge, cited in UNDP 2011a). The Yucatan Platform consists of hard, dense limestone over red shale (Viniegra, cited in UNDP 2011a) that results in a topography consisting of low (approximately 250 metres above sea level (masl)), rolling limestone hills and escarpments. The escarpments are the result of north-northeast trending faults caused by the subsidence of the continental shelf toward the Yucatan Trough in the Caribbean Sea (Hartshorn et al., cited in UNDP 2011a). The dominant physiographic feature of the country is the Maya Mountains, which rise steeply from the coastal lowlands to a maximum elevation of 1124 masl. The Maya Mountains are a tectonically uplifted block of ancient meta-sedimentary, granite, and volcanic rocks (Bateson and Hall, cited in UNDP 2011a) that occupy the south-central portion of the country, stretching west into Guatemala's Petén district. Surrounding the mountains are low karstic limestone hills that grade into an abbreviated coastal plain that meets with the Caribbean Sea.

Over 1,060 mangrove cayes (small islands) and three atolls dot Belize's marine territory. Many of these are located along the barrier reef shelf, while the three atolls – the Turneffe Islands, Lighthouse Reef and Glover's Reef – rest beyond the protective shelter of the barrier reef. Many of the cayes are uninhabitable, but those that are habitable have often been settled or used by fishermen, or are developed for tourism. Many cayes and large sections of Belize's coastline stand at less than one metre above sea level, making these areas very vulnerable to storm surge from cyclones and rising sea levels (UNDP 2011a).

## Climate and Weather Conditions

Belize lies in the subtropical geographic belt and has a climate governed strongly by seasonal variations in rainfall. Mean monthly temperatures range from 16°-28° C in the winter months to 24°-33° C in the summer and humidity ranges between 40 per cent and 99 per cent throughout the year (mean = 80 per cent; King et al. 1986). Distinct wet (June – December) and dry (January – May) seasons exist throughout the country and are most pronounced in the north. More than 80 per cent of annual precipitation in southern Belize occurs during the wet season (Heyman and Kjerve, cited in UNDP 2011a), and a strong precipitation gradient exists from north to south (UNDP 2011a).

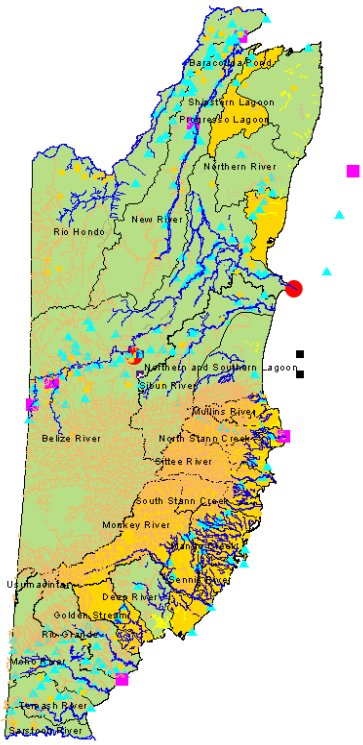
Annual precipitation ranges from approximately 1,100 mm in northern Belize to 4,000 mm in the deep south (Walker, cited in UNDP 2011a). During the winter months (November – February), cold wet air masses, locally called "northers", occasionally descend from the north to cause heavy rains and choppy seas.

Belize has a long history of devastating encounters with cyclones (tropical depressions, tropical storms or hurricanes), with major events recorded in 1931, 1955, 1961, 1971, 1974, 1978, 2000, 2001 and 2007. Historically, tropical storms and hurricanes have affected the country once every three years, and, according to hurricane tracks available from the US National Weather Service, are more likely to hit in the north than in the south (Lee et al., cited in UNDP 2011a). Belize City, the former capital, was destroyed twice by hurricanes in the 20th century prompting the relocation of the capital to Belmopan City.

## Hydrography

The abundance of rain in Belize and the low coastal topography has resulted in the formation of an important network of waterways and water bodies. These provide the population with drinking water, building aggregate, destinations for recreation and tourism, fish and wildlife, and a place for daily domestic activities. There are 16 major watersheds and numerous smaller ones that deliver freshwater, sediment and nutrients to the Caribbean Sea (Figure 3). Four of the 16 watersheds are shared with Guatemala, and one (Rio Hondo) has major portions draining both Guatemala and Mexico. Although the Rio Hondo watershed dwarfs the rest of Belize's watersheds in terms of catchment area (15,075.5 km$^2$), only 18 per cent of this occurs in Belize. The Belize River (total area 9,434 km$^2$; 69 per cent in Belize) occupies substantially more of Belize's land mass and dominates the central portion of the country.

**Figure 3: Major and minor watersheds and river system**




Source: Biodiversity and Environmental Resource Data System of Belize

Northern Belize is characterized by wetlands that tend to occur in crustal slumps within the north-northeast trending fault zones that occur there or within karstic depressions. Topography of the northern coastal plain is relatively flat and most of the freshwater wetlands occur at or below five metres above sea level. Most of these systems are spring-fed and many are perennially waterlogged, with water fluctuations of about 1 m in conjunction with the seasons. Many of the wetlands of northern Belize occur as expansive lagoon systems containing multiple habitat types (e.g., swamp forests, herbaceous marshes and open water areas). The most notable among these is Crooked Tree Lagoon, a 165 km$^2$ wetland complex connected to the Belize River via two streams. Other substantial wetlands include New River Lagoon, Progresso Lagoon, Cox Lagoon and Pulltrouser Swamp. Several freshwater wetlands also occur in southern Belize. There, recent tectonic movement along fault lines has back-tilted the continental crust to form a number of swamps – most notably the Sarstoon-Temash Delta and Aguacaliente Swamp, a 35 km$^2$ wetland surrounded by tropical wet broadleaf forest ecosystems and land cover (UNDP 2011a).

# ECONOMY BY SECTORS

Belize is a small economy in Central America. Tourism and exports of marine products, citrus, cane sugar, bananas and garments are the most important foreign trade earners. However, oil discoveries in 2006 are expected to be a major factor behind Belize's future growth.

From the early colonial history of Belize until the mid-20th century, the Belize economy was dominated by forestry activities. However depletion of mahogany stocks and diversification of economic development led to a shift toward export agriculture. Cane sugar has been a strong segment of the economy since the decline of the mahogany industry. Subsequent expansion of citrus and banana industries also took place. Today these crops remain a mainstay of the economy, but the service industry related to tourism has become one of the strongest sectors of the economy. Belize has slowly diversified its economy over time, with substantial aquaculture and manufacturing industries, and more recently, a small but lucrative petroleum industry (UNDP 2011a).

Belize's currency (Belize dollars, BZ$) has been pegged to the US dollar since 1976 at a ratio of 2-to-1 (BZ$-to-US$). As a result, Belize has achieved generally satisfactory macroeconomic outcomes. Inflation has been relatively low and stable, growth has been above the regional average and exports have performed well (Lee et al., cited in UNDP 2011a).

As of 2006, the GDP at current market prices was US$1,213.65 million (mn), with a per capita GDP of approximately US$3,896 (CBB 2006). GDP growth during the 1990s averaged 4.6 per cent and, notwithstanding three natural disasters and the 9/11 attack, growth between 2000 and 2006 averaged 6.5 per cent.

The service and wholesale/retail trade sectors contribute most significantly to GDP (20 per cent and 14.5 per cent respectively in 2006), followed by manufacturing (10.6 per cent), transport and communication (10.4 per cent), government services (9.8 per cent), and agriculture and forestry (9.1 per cent). Tourism is a large contributor to both the service and wholesale/retail trade sectors. In 2006, tourist arrivals totaled 903,000 and tourist receipts amounted to US$199 mn, or about 16 per cent of the GDP (Caribbean Planning for Adaptation to Climate Change Regional Project Implementation Unit (CPACC) 2002).

Belize imports one and a half times more goods than it exports. In 2006, goods valued at US$660 mn were imported, while goods worth US$427 mn were exported. The top imports were machine and transportation equipment (17 per cent), fuels and lubricants (16 per cent), manufactured goods (12 per cent) and food (9 per cent). The United States is the source of 39 per cent of goods entering the country and another 20 per cent come from Central America. Agricultural products comprise the majority of export earnings in Belize. Citrus concentrate was the most valuable export commodity for Belize in 2006 (US$54.5 mn), followed by cane sugar (US$50.5 mn), and bananas (US$25.3 mn). Petroleum (US$44.3 mn) and marine products (US$43.0 mn) also contributed substantially to export earnings. The United States was the main recipient of Belizean exports (42 per cent) in 2006, followed by the United Kingdom (17

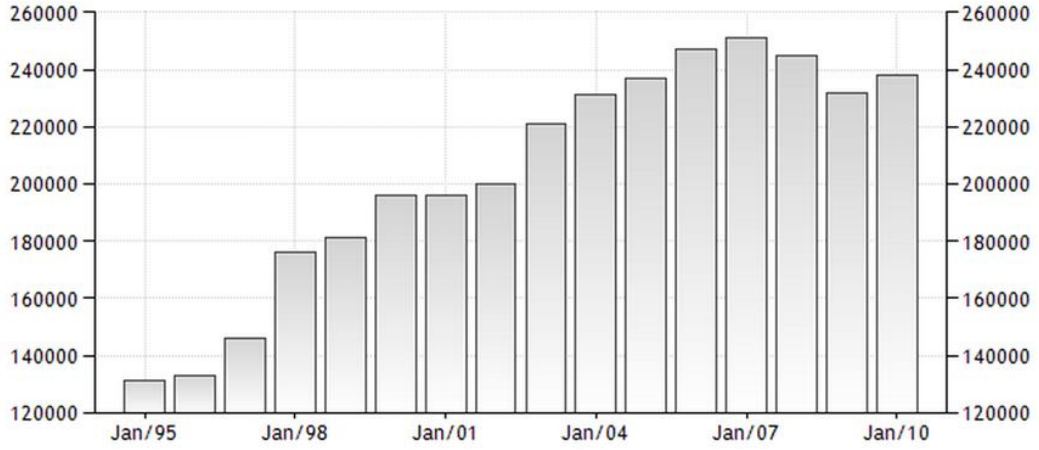
per cent). Between 2003 and 2006 the balance of trade deficit ranged from US$173 mn to US$231 mn with an average of US$199 mn (CPACC 2002).

Belize's sugar and banana industries have long benefited from preferential market access, but this access is being weakened by deepening global trade liberalization. Preferential access to the EU market has afforded Belize growers significantly higher export prices. However, ongoing reforms in the EU trade regimes for bananas and sugar are eroding these prices, thus having economic and social consequences for Belize. An International Monetary Fund (IMF) assessment of the economic implications of the expected decline in trade preferences predicted negative effects on the trade balance, economic growth and, to a lesser extent, the fiscal balance of Belize. Medium-term scenarios predicted that loss of preferential agreements will lead to a lower GDP growth of ¼ per cent through 2010 and moderate declines in export receipts for bananas and sugar (El-Masry, cited in UNDP 2011a).

In 1998, the then newly elected government enacted aggressive policies to stimulate economic activity, which led to large fiscal and current account deficits fueled by foreign borrowing. As debt service costs rose, access to voluntary financing fell and borrowing costs increased sharply. As a result, Belize's sovereign credit ratings, which help determine the country's access to international capital markets, dropped in the early years of the new millennium. At this time the IMF cautioned that the macroeconomic policies were overly expansionary and could threaten the country's currency. In response, the government began to implement a stabilization program in the 2005/06 budget by raising taxes, cutting expenditures, and tightening monetary conditions. These moves helped reduce the central government deficit from 8½ per cent of GDP in FY2004/05 to 3 percent in FY2005/06. In 2006, the government made a debt exchange offer to its creditors which would convert eligible debt instruments into new bonds that would start to amortize in 2019. A majority of Belize's creditors accepted the debt exchange in February 2007, which led to a decrease in the debt service burden and an upgrade of sovereign debt ratings (Caribbean Development Bank 2007).

The extraction of petroleum from an estimated 10 million barrel reserve in western Belize commenced in December 2005. In 2006, approximately 811,199 barrels of crude oil were extracted from this location, 80 per cent of which was exported to the US. The geology of Belize suggests a high probability of the existence of more oil deposits, which if located and exploited, could lead to a shift in the economic base of Belize over a relatively short time span. There are currently six companies with production sharing agreements with the Belize government exploring the country for oil (Ministry of Natural Resources and the Environment (MNRE) 2002a).

**Figure 4 Number of Arrivals (1995 – 2010)**




Source: http://www.tradingeconomics.com/belize/international-tourism-number-of-arrivals-wb-data.html

## Tourism

Belize's main economic growth continues to be in agriculture and tourism (UNDP 2011a). The number of arrivals (from international tourism) in Belize was last reported at 238,000 in 2010, according to a World Bank report released in 2011; 232,000 in 2009 and 245,000 in 2008 (Figure 4). International inbound tourists (overnight visitors) are the number of tourists who travel to a country other than that in which they have their usual residence, but outside their usual environment, for a period not exceeding 12 months and whose main purpose in visiting is other than an activity remunerated from within the country visited. When data on the number of tourists are not available, the number of visitors, which includes tourists, same-day visitors, cruise passengers and crew members, is shown instead. Sources and collection methods for arrivals differ across countries. In some cases data are from border statistics (for example, police and immigration) and supplemented by border surveys. In other cases data are from tourism accommodation establishments. For some countries, the number of arrivals is limited to arrivals by air and for others to arrivals staying in hotels. Some countries include arrivals of nationals residing abroad while others do not. Caution should thus be used in comparing arrivals across countries. The data on inbound tourists refer to the number of arrivals, not to the number of people traveling. Thus a person who makes several trips to a country during a given period is counted each time as a new arrival.

## Agriculture

Belize has a suitable climate for agriculture along with abundant water resources. Approximately, 800,000 hectares or about 38 per cent of Belize's total land area, is considered potentially suitable for farming and raising livestock. But currently, only 9.7 per cent of the land (about 78,000 hectares) is used for agricultural practices (Martin. D. & Manzano, O. 2010a). About half of this area is under pasture, with the remainder in a variety of permanent and annual crops. According to Martin and Manzano, (2010a), the traditional system of "milpa" (shifting cultivation) involves the annual clearing of new land for crop production. However,

increasing numbers of farmers are making permanent use of cleared land by mechanical means.

The main reasons for the low rate of utilization of arable land can be explained mostly by the rationale of the input cost to develop the land: providing potable water and electricity, constructing irrigation facilities and in some cases clearing the land, without touching protected areas. Lack of secure markets and profitable new farming options are also factors contributing to the apparent under-utilization of the land resource (Martin. D. and Manzano, O. 2010b).

The current structure of agriculture in Belize is characterized by three main sub-sectors: 1) a fairly well organized traditional export sector for sugar, banana, citrus and marine products which are the principal sources of agricultural employment and foreign exchange earnings 2) a small-scale farm sector, producing food mainly for local consumption, and 3) a well-integrated large-scale commercial sector (including participation by Mennonite communities). The Mennonites do not directly participate in the traditional export sector, but they do export food products. A recent census of farms in Belize shows that 74 per cent of farms in the country are below 50 acres; 24 per cent of farms are less than 5 acres and 33 per cent are between 5 and 20 acres (FAO, 2011).

The agriculture and fisheries sectors together employ approximately 26 per cent of the total work force in the country (MAF Report, 2008). In commercial terms the most important agricultural export crops are citrus, bananas and sugar; the principal cereal grains produced as annual crops are mainly rice, corn and sorghum. Vegetables, root crops and beans are important for the domestic market and to a much lesser extent, the export market. The smallest and poorest farms typically grow corn and beans in shifting cultivation practices (milpa). In addition to the traditional major crops, commercial farms grow a diversity of beans. A significant amount of hot pepper is grown in the region for processing into hot sauces for both the domestic and export markets. Tomatoes, onions, sweet peppers and other vegetables are important for the domestic market.

Use of farm livestock is a common practice in the pasture land. The principal types of livestock are beef cattle, dairy cattle, poultry and pigs, although there is growing interest in sheep rearing. There are very few fattening operations for beef cattle, with grass-fed beef being the main product. Livestock production is valued at about US$20 mn per year, predominantly from production of poultry/eggs, beef, and pork.

The agriculture sector is envisioned, by the Government of Belize as the base to support economic growth, development and poverty reduction. Belize's agriculture policy has emphasized market-led strategies, increasing diversification and achieving self-reliance for food products as the main goal. This has resulted in the development of new export commodities (for example, papayas, aquaculture and Habanero peppers) and an expansion of the food crop and livestock sub-sectors. However, the sugar, banana and citrus industries still remain the three most important agricultural export sub-sectors propelling growth.

## Banking and Finance

Belize is famous for being an offshore banking hot spot. For banking within the country, Belize has five commercial banks. Three are based in Belize and two are large multinational banks with branches in Belize. The local banks are small, about the size of a small-town local bank or savings and loan in the U.S. Belize also has several credit unions and small mortgage lending institutions (Ambergris Caye 2014).

## Fisheries

"In 2007, the value of the reef and mangrove related fisheries, tourism and shoreline protection services, was estimated around US$ 395 to US$ 559 million. Also, in terms of national employment, it is estimated that the reef-related tourism employs 20 per cent of the national workforce." (Wade cited in UNEP 2011). For many years commercial fishing has been the third largest revenue earner in the country, accounting for some BZ$25 million annually. Ninety percent of the industry is based in the barrier lagoon and atolls. Reef-associated demersal species such as lobster and conch account for 98 per cent of the export earnings in the industry. In 2006 spiny lobster and conch exports accounted for approximately BZ$22 million in earnings. The primary threats to the fishing industry are increased sea surface temperatures, changes in pH and loss of habitat.

Species such as the spiny lobster, shrimp and queen conch are in demand both on the local and foreign markets. These species are the main targeted species for local fishermen and is the main source of income. Although sold locally, they are primarily harvested for the export market. Export statistics are indicating that the spiny lobster, shrimp and queen conch are possibly being exploited beyond sustainable thresholds. Therefore, there is a need to amend existing legislation to properly address the issues of dwindling stocks and smaller sizes (UNEP 2011).

# THE ENVIRONMENT

### Solid Waste, Liquid Waste, Flora, Fauna, Biodiversity

Environmental degradation in Belize occurs due to the lack of proper legislation and enforcement of regulations, lack of infrastructure, outdated production approaches and the use of obsolete technologies. It is therefore, very crucial for the well-being of the country and its people that these sources of environmental degradation are identified and dealt with accordingly (Chicas 2008).

## Solid Waste

The Solid Waste Management Authority (SWMA) was established by the Solid Waste Management Authority Act of 1991. The SWMA is the organization responsible for waste collection and disposal services in Belize. The SWMA coordinator works closely with the Department of the Environment (DOE) – the agency responsible for prevention and control of pollution – by coordinating all activities related to the discharge of wastes into the environment.

In the most recent technical assessment of Belize's waste stream, it was estimated that Belize generated 112,000 tons of domestic solid waste, or about 1.32 kg/person/day. Approximately half of this is domestic waste from the major urban centers of the country (Table 3). About 60 per cent of this domestic waste consisted of organic material and the remaining 40 per cent comprised equal percentages of metals, glass, plastic, paper and other waste. The majority of Belizean households (51 per cent) dispose of their waste through municipal collection services which exist in all major urban centers in Belize. An additional 33 per cent of households burn their waste and the rest carry it themselves to a public dumping area (8 per cent), dump it in their own yard (4 per cent) or bury it (2 per cent). Burning of waste is a preferred disposal technique in rural areas (Stantec cited in UNDP 2011b).

**Table 3: Solid Waste Generated in Different Municipalities in 2000**

| Municipality | Tons per day | Tons per annum | Kg/capita/day |
|---|---|---|---|
| Corozal | 12.82 | 4,680 | 1.50 |
| Orange Walk | 17.44 | 6,365 | 1.27 |
| Belize City | 81.56 | 29,770 | 1.54 |
| San Ignacio | 19.46 | 7,104 | 1.32 |
| Benque Viejo | 5.70 | 2,080 | 1.13 |
| Belmopan City | 9.62 | 3,510 | 1.18 |
| Dangriga | 8.55 | 3,120 | 0.95 |
| Punta Gorda | 4.27 | 1,560 | 0.99 |
| San Pedro | 10.68 | 3,900 | 2.18 |
| Total | 170.11 | 62,089 | 1.32 |

Source: Stantec. 1999. Belize Solid Waste Management Project, Phase 2 Report and Plan Volume I. Consultants report to Government of Belize.

Solid wastes are disposed of in an unsanitary manner throughout Belize. The disposal locations, in a majority of instances, are not appropriate due to environmental concerns. Very little has been done to address this problem. These sites are hazards to the environment since they are literally "open dumps." They contaminate surface and underground waters. Wind, rain and running water convey litter from these disposal sites into water sources. What should be landfills in Belize can only be described as dumpsites as there is no treatment of collected wastes. Presently, there are seven municipal open dumps of which six, with the exception of the one in Belmopan City, operate without addition of cover material. There is no waste separation at any of the sites, though salvaging is permitted. Interviews with the Town Boards indicate that the standard operating practice in these dumps is to simply spread the waste and burn it to reduce the volume. According to a SWMA Manager, there are five garbage disposal sites considered a threat to human health and marine ecosystems, and they need immediate relocation. The disposal sites in Corozal Town, San Pedro, Caye Caulker, Belize City and Punta Gorda Town all require urgent relocation, as they are in extremely low-lying areas, causing seepage to both surface and sub-surface waters. Also, these sites are very close to human inhabited areas and are within half mile of the coast (DOE 2008).

The country's largest disposal site is located at the edge of Belize City in what is a low-lying mangrove area with a high water table. This site receives the majority of Belize City's solid waste stream, which equalled over 81 tons per day in 2000. Other, sometimes impromptu, waste disposal sites are dispersed throughout the mainland and on the offshore islands near population centres. Fires are common at most disposal sites and leachates are assumed to escape into the local water table (Statistical Institute of Belize (SIB). 2007b)

Belize developed a Solid Waste Management Plan in 2001. The plan proposes:

- Building a regional sanitary landfill in a central location with a 25-year capacity
- Creation of modified landfills at existing sites in Orange Walk and Corozal
- Creation of new modified landfills in Placencia, Dangriga and Punta Gorda
- Building transfer stations along the western corridor
- Closure of the landfills on Caye Caulker and San Pedro and movement of their waste to the central sanitary landfill
- Development of a collection system to provide service to small villages and rural residents along the three main highways corridors.

This plan remains in a pre-implementation state.

During the period 1995-2000, industrial waste generated was estimated to be between 400 and 650 thousand metric tons, primarily from agricultural activities. Solid waste from these industries is mostly organics (60 per cent) and consists of rejected fruits from the banana industry, citrus rinds from the production of juice concentrate, shrimp heads, and bagasse, the fibre left from sugar cane processing. Bananas are disposed of in approved sites near farms, citrus rinds are composted, shrimp heads are usually buried for decomposition and about half of all bagasse is burnt for the production of energy, a figure that has increased since 2009 when the new biomass-to-energy plant at the Tower Hill Sugar Factory began operation. This new plant burns 82 tons of bagasse (from the 275 tons of sugarcane) per hour, providing 13.5 MW of electricity to the grid, 8 MW of electricity and heat, required for the sugarcane processing (Jobling, 2011) and also reducing the volume of waste produced (Jobling 2011 cited in UNEP RISO 2013).

## Liquid Waste

Information on liquid waste and sludge is very limited. In terms of human liquid waste, about 15 per cent of all households are connected to a sewer system, and an additional 35 per cent use septic systems. The households connected to sewer systems are located in Belmopan, Belize City and San Pedro. The Belize Millennium Development Goal (MDG) reports (UNDP 2011b) that the population served by sewer systems is as follows:

- Belmopan (since 1970): approx. 7,900 consumers
- Belize City (1980): approx. 37,500 consumers
- San Pedro Ambergris Caye (1996): 3,400 consumers

Households that are not connected to sewer systems may have their own individual sanitation system such as a flush toilet or latrine with a septic tank, or collection of waste in buckets for later disposal in the sea or in overgrown bushes. The waste stream from a septic leach field

may enrich groundwater with nutrients. In densely settled areas on porous soil, this may cause groundwater contamination, but is as yet unmeasured in Belize (UNDP 2011b).

No detailed information is available on which households have an improved sanitation system and which do not. Only latrines with a concrete slab and a ventilation pipe are considered improved sanitation systems. There is no detailed data system based on cadastral maps which would give authorities insight into where action has to be taken to improve the level of sanitation coverage in the country.

In a report prepared by UNEP (2011) it is stated that "In 2002-2007, the sugar industry alone produced 5,074,261 to 5,950,123 gallons of liquid waste per year. The increased levels of BOD and nutrients are the parameters of main concern. The banana industry draws approximately 460 million gallons of water from South Stann Creek, Swasey, Trio and Bladden rivers each year with this supply being augmented by well water. Most of it is used for irrigation and fruit processing. Other uses include aerial spraying, airplane cleaning, and mixing herbicide. Wash waters and irrigation runoff ends up contaminating the watershed in the two southernmost districts, Stann Creek and Toledo. The banana and citrus industries use the highest estimated amounts of fertilizer per acre. The use of pesticides is also relatively high in the banana industry which compounds the concerns with surface runoff and chemical pollution of adjacent water bodies.

An inference that can be made from import statistics and practices is that the agricultural sector is one the largest, if not the largest, non-point sources of water and soil pollution associated with siltation from erosion and chemical run off from the use of fertilizers."

There have been instances of unsustainable agricultural practices which have been primarily responsible for riparian and steep slope deforestation and degradation (BET 2010). Almost a third of the roughly 1 million acres of agricultural land in Belize occurs on land classified as marginal or unsuitable for agricultural activity. More than a third of all agricultural land in Belize is on acidic soils particularly sensitive to land degradation. Table 4 presents information on estimated fertilizer use.

**Table 4: Estimated Fertilizer Use Intensity[1], pounds/acre**

| Agricultural Sector | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|
| Banana Industry | 4,042 | 4,720 | 3,427 | 1,992 | 2,398 |
| Citrus Industry | 297 | 232 | 393 | 664 | 744 |
| Rice, Corn, Beans, etc. | 213 | 219 | 220 | 258 | 236 |
| Sugar Industry | 91 | 85 | 114 | 97 | 123 |
| Others | 192 | 332 | 372 | 300 | 467 |
| Average | 289 | 296 | 332 | 338 | 391 |

[1]Estimated Fertilizer Use Intensity was derived using fertilizer sales and area under main crops.
Source: Land Information Center-MNRE 2006

## Flora

Belize has one of the world's richest habitats for flora and fauna. No fewer than 4,000 different species of native flowering plants are found within its borders, along with approximately 700 species of trees and several hundred species of other plants. Scientists are only now beginning to carry out an exhaustive inventory of Belize's plants. The task is daunting: over 70 per cent of the country is under some kind of forest cover and almost half of Belize's primary forest is still standing (Table 5).

**Table 5: Broad Ecosystem Classes for Terrestrial and Marine Habitat Types**

| Ecosystem Class | % Land Area | Area ($km^2$) |
|---|---|---|
| **Terrestrial** | | |
| Lowland broadleaf forest and shrub land | 51.4 | 11,803 |
| Agriculture, all subclasses | 16.7 | 3,835 |
| Sub-montane and montane broadleaf forest | 10.0 | 2,296 |
| **Terrestrial** | | |
| Lowland savanna including pine savanna | 8.8 | 2,021 |
| Mangrove and littoral forest | 4.2 | 964 |
| Sub-montane pine forest | 2.1 | 482 |
| Water | 2.1 | 482 |
| Wetland | 1.9 | 436 |
| Lowland pine forest | 1.4 | 321 |
| Coastal savanna (marine salt marsh) | 1.1 | 253 |
| Urban | 0.5 | 115 |
| **Marine** | | |
| Sea grass habitats | 44.2 | 4,152 |
| Deep water | 35.1 | 3,294 |
| Sand/silt with sparse algae | 11.8 | 1,105 |
| Coral reefs and associated habitats | 6.2 | 586 |
| Unclassified | 2.4 | 227 |
| Shallow gorgonian beds | 0.4 | 33 |
| Note that the marine figures do not take into account deep water pelagic figures beyond the Mesoamerican Barrier Reef. | | |

**Trees** Belizean forests support over 700 tree species including a large variety of economically and historically important trees. Economically valuable trees have played a vital role in the history of the country. Indeed, the history and the very existence of Belize as a colony is inseparable from the logging industry. Among the most important historical tree crops are logwood, mahogany and chicle. The national tree of Belize is the Mahogany tree (*Swietenia macrophilla*).

**Fruits and Nuts** Common fruit trees and plants of Belize include cashew, coconut, custard apple, guava, mango, papaya, banana, pineapple and mammee.

**Orchids** The national flower of Belize is the Black Orchid (*Encyclia cocheeata*). There are approximately 250 species of orchids in Belize.

**Medicinal Plants** At Ix Chel Farm, the Panti Medicinal Trail winds through a living display of arboreal and herbal remedies in the second-growth forest. The trees seem overwhelming as one strolls along the path, along which signs describe one plant after another, many bearing unusually descriptive names. By cooperating with the wise elders of a community, ethnobotanists have been able to collect samples of many unusual plant specimens, and new kinds of non-traditional medicine are now being used to treat the sick and injured.

**Other Plant Life** Belize is estimated to have roughly 4,000 species of native flowering plants (angiosperms) of which 2,500 are dicots (Dwyer and Spellman 1981) and 1,500 are monocots (Spellman et al. 1975). The latter include approximately 250 species of orchids (B. Adams, pers. comm.). Approximately 700 species of native trees are reported in Belize, representing 331 genera in 87 plant families (Ministry of Natural Resources, Environment, and Industry 2002b).

## Fauna

**Cats** There are five cat species in Belize. The largest, the jaguar, was among the most revered animal of the ancient Maya and even today, commands great respect among Belizeans. Alan Rabinowitz[1], during an intensive field study, brought the jaguar into the international spotlight as a means to protect the Cockscomb Basin Wildlife Sanctuary, the only designated jaguar preserve in the world. The other four native cats of Belize are the puma, ocelot, margay and the jaguarundi.

**Monkeys** The Community Baboon Sanctuary was established in 1985 to protect one of the few healthy black howler monkey populations in Central America.

**Tapirs** Called a "mountain cow" by locals, this nocturnal species is the national animal of Belize. Still fairly plentiful here, the Baird's Tapir has almost disappeared from the rest of its native Central America and Mexico, earning it a place on the endangered species list.

**Manatees** Belize is said to have the largest population of manatees of any country, with the possible exception of the United States. They have been protected in Belize for many years.

Other mammals include the river otter, Brainville's spotted dolphin, rough-toothed dolphin, Atlantic bottle-nosed dolphin, peccary, hickatee and deer among others.

**Turtles** Three of the world's eight species of sea turtle are known to nest in Belize: the Green, Loggerhead and Hawksbill. All three species have been declared endangered.

[1] Alan Rabinowitz is the CEO of Panthera, a nonprofit conservation organization devoted to protecting the world's 37 wild cat species

**Snakes** Variously known as the yellow-jaw tommygoff, barba amarilla and tres minutos, the fer-de-lance is a nocturnal pit viper related to the water moccasin and tropical rattlesnake. The fer-de-lance is at home in any part of Belize, including cities and can be vicious if it does decide to attack.

**Lizards** Two iguanid species live in Belize: the Green Iguana or "bush-chicken" and the Black or Land Iguana, locally called a "wish-willy". Basilisks, locally labeled "the Jesus Christ lizard", are also found in Belize.

**Crocodiles** There are two crocodile species in Belize, the American Crocodile which occurs mainly in coastal areas, and Morelet's Crocodile which is found in areas in the Community Baboon Sanctuary. The creole name for both is "alligator".

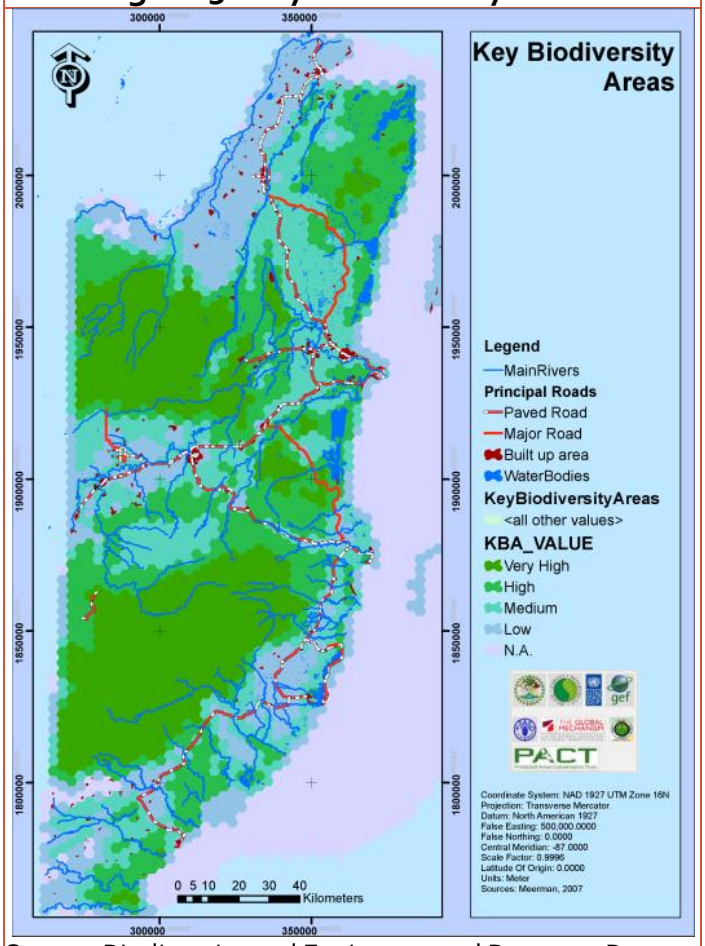
**Birds** The pamphlet entitled "Checklist of the Birds of Belize" (Carnegie Museum of Natural History) lists over 530 species that have been sighted in Belize, including more than 200 migratory birds from North America which winter in the tropics. In many parts of the inland forest, it is not unusual to see as many as 120 birds over a period of as little as four or five days. At the request of the Belize Audubon Society, seven small mangrove cayes were declared bird sanctuaries. These cayes are nesting rookeries for Wood Storks, Great and Cattle Egrets, Boat-billed and Tricoloured Herons, Reddish Egrets and White Ibis, as well as Magnificent Frigatebirds, Anhingas and other birds.

## Biodiversity

Belize occurs in the Mesoamerican biodiversity hotspot, a region characterized by exceptional levels of endemism and high levels of habitat loss. A great variety of terrestrial, marine and freshwater ecosystems are represented in Belize (Figure 5; Table 5).

Eighty-five terrestrial ecosystems, 15 marine ecosystems and 43 different riverine ecosystems have been classified in the country. Lakes and lagoons are as yet unclassified. When the most recent nationwide ecosystem classification was done (2004), approximately 15,867 km$^2$

**Figure 5: Key Biodiversity Areas**




Source: Biodiversity and Environmental Resource Data System of Belize

or 69 per cent of Belize's land area was under some form of forest cover, though this number is certainly lower today. In the coastal zone, sea grass habitats are the most prevalent ecosystem, followed by deep water systems, sand- and silt-bottom habitats and coral reefs. Despite the fact that coral reefs and their associated habitats only comprise about 6 per cent of the coastal zone, they are disproportionately important for their high levels of biodiversity and the tourism and fisheries economies that they support (UNDP 2011a).

Coral reef systems are highly vulnerable to the consequences of global climate change – from increased temperatures, damage from severe storm events and ocean acidification from increased levels of dissolved carbon dioxide ($CO_2$). Several severe coral bleaching events have been documented in Belize waters in the past decade as a result of temperature stresses to these ecosystems (UNDP 2011a).

## LAND USE, LAND USE CHANGES AND FORESTRY (LULUCF)

### Land Use

Over the last few decades Belize has experienced considerable demographic, social and economic change and this has provoked calls for greater access to the land's natural resources for a range of uses, including agriculture, aquaculture, housing, tourism and conservation (Figure 6). This increasing demand has been accompanied by increasing popular pressure for augmented resource management, largely through efficiency, effectiveness and accountability.

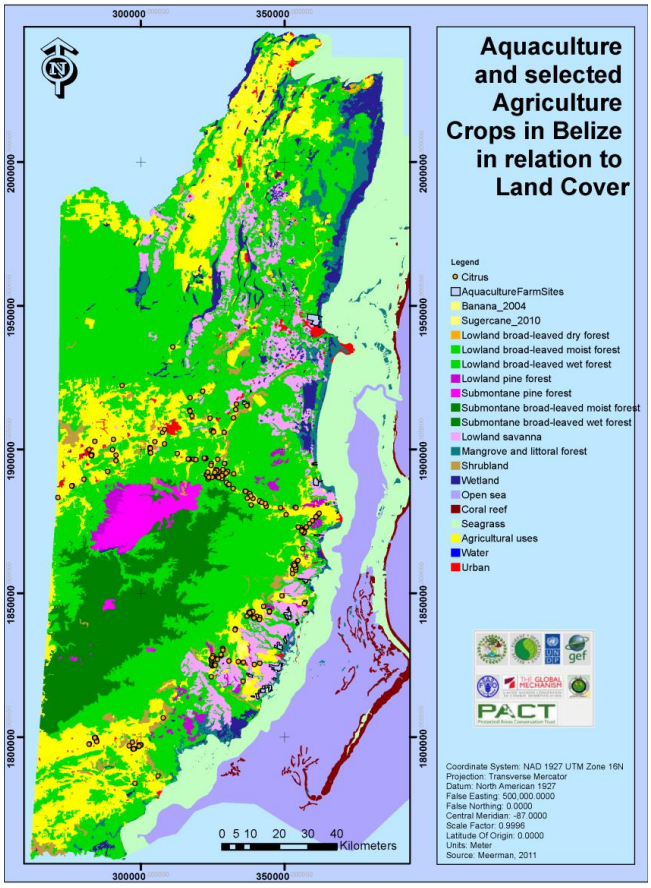
These factors can be seen to have impacted every part of the land and society of Belize. Moreover, this change in demand and expectation has come at a time of mounting economic and environmental anxiety, which has affected public and private investment and the sustainability of the very resources upon which, economic and social well-being is founded.

The Government of Belize has recognized these concerns and has resolved, through the auspices of the United Nations Development Programme (UNDP), to address them through the preparation of a comprehensive Land Use Policy and National Integrated Planning Framework to guide and implement the development of land resources. The primary outcomes are three products: a National Land Use Policy, a National Integrated Planning Framework for Land Resource Development and a Land Suitability Mapping System for Belize. Accordingly, the activity plan has been organized into broad activity areas addressing project initiation and then each of the three major deliverables. The methodology for achieving the required outcomes is described below.

The first of the required deliverables is the Policy which sets out the principles on which land development should be undertaken. These are value-based statements that will be clearly measurable, implementable and assessable through popularly conceived indicators.

The Land Suitability Mapping System is a dynamic Geographic Information System (GIS) toolkit that contains information gathered through the Resource Assessment. Belize is fortunate to have several GIS centres up and running, such as the Land Information Centre (LIC) in the Lands and Surveys Department. Reflecting the provisions of the National Land Use Policy, the Consultant Team has assessed the existing GIS network and drafted a structure that brings full mapping capability into a central and accessible position. Technical inputs were solicited from the Government Task Force when the GIS was being established to ensure that all relevant data layers were included. The system can be used to inform the preparation and updating of the national development plan and other district and community level plans.

**Figure 6: Aquaculture and Selected Agriculture Crops in Belize in Relation to Land Cover**




**Forested Area and Production Forestry**

The colony British Honduras was founded on forestry – logwood, mahogany, cedar and chicle (a natural chewing gum base) – but the sector declined by the mid-1900s because of unsustainable stock management and because a synthetic gum base replaced chicle. While a small industry around timber still exists, it contributes very little to GDP (Table 6) (UNDP 2011a).

**Table 6: Volume (in cubic feet) of Timber Harvest of the Four Most Popular Species 1999 to 2009**

| Species | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|
| Pine | 833.0 | 710.2 | 1,404.4 | 1,410.6 | 21.9 | 1,689.6 |
| Mahogany | 140.3 | 81.3 | 126.8 | 134.2 | 137.8 | 868.1 |
| Santa Maria | 160.2 | 86.8 | 218.6 | 93.4 | 133.1 | 904.9 |
| Yemeri | 191.6 | 109.7 | 110.3 | 142.8 | 20.5 | 418.3 |

The Forest Department within the Ministry of Natural Resources and Environment is the agency responsible for management of all forest reserves and most terrestrial protected areas (except archeological reserves), with more limited authority over private forested lands.

At the time of the last inventory, total forest area in Belize was 15,867 $km^2$, which is equivalent to 69 per cent of the country, though it is likely that the current percentage of forested land is closer to 61 per cent. Forest cover is changing due to extensive export agriculture development as well as small areas of slash and burn agriculture (Percival Cho cited in UNDP 2011a).

While 1990-2000 deforestation rates for Central America were 1.2 per cent per year, the deforestation rate in Belize during this period (2.3 per cent per year) exhibited much higher rates of forest loss. Approximately 80 per cent of the lost area was broadleaf forest (620 $km^2$). The remaining 20 per cent was secondary forest (100 $km^2$), coniferous forest (34 $km^2$), riverine vegetation and bamboo (16 $km^2$) and mangroves (11 $km^2$). Deforestation is very common along river courses where agricultural conditions (soils and access to water in the dry season) are best. DiFiore (2001) recorded a 22 per cent (72 $km^2$) loss of forest cover from 1989 to 2001 in the riparian corridor along the Belize River – a forest conversion rate of 2 per cent per year. This trend is likely to hold for other floodplain forests in Belize. (UNDP 2011a)

A number of mills currently operate throughout the country, mostly focusing on production of pine lumber and secondary hardwood lumber (Table 6). The Forest Department grants logging concessions within Forest Reserves to local and international logging companies. Recently, in an effort to promote sustainable management of timber resources, the Forest Department began granting long-term (40-year) management concessions. These concessions are managed by stricter standards that regulate rotation periods, utilize area control and use of improved harvesting practices.

Teak and mahogany are the significant tree species in Belize. It is estimated that there are over 5,000 acres of teak plantations in Belize, in small scattered plots of a few acres to a couple of hundred acres. No known mahogany plantations exist, but mahogany line planting for forest enrichment has occurred in several places around the country, though in quantities far less than teak (Percival Cho, Forest Officer, personal communication).

Approximately 80 $km^2$ of Belize's economically important Caribbean pine (*Pinus caribaea*) forests were decimated by an infestation of the southern pine bark beetle (*Dendroctonus frontalis*) between 1999 and 2001. Only 4 $km^2$ of Caribbean pine have been replanted since that time as part of restoration efforts.

Recalculation of the results for 1994 showed that the total emission of $CO_2$ from the LULUCF sector of 7,483 Gigagrams (Gg) was mainly from deforestation and soil carbon from agriculturally impacted soils. Carbon sequestration from forest growth following logging and the regrowth of abandoned lands reduced this quantity by 2,891 Gg to a net emission value of 4,592 Gg (UNDP 2011a).

Belize is not unique in that within our region one of the major sources of greenhouse gas emissions is deforestation. The continued reduction in forest areas that are being logged and/or actively managed will also diminish our capacity to offset emissions from deforestation.

Increases in land degradation and increased utilization of land with less productive potential coupled with the present rate of population increase may very well contribute to greater forest conversion.

Therefore the continuous monitoring of deforestation incorporating existing data gathering mechanisms and institutions is important to provide baseline information for developing strategies to ameliorate the impacts of these development activities on the climate change process and to create adequate adaptation mechanisms. It is also very clear that the compilation of data and its retrieval in an efficiently utilizable format is a major weakness in many, if not most of the public (and to a lesser extent private) institutions that are mandated to maintain a database of information relevant to the particular sector they are charged to administer or manage. It also becomes evident that there is wide overlap in the type of data that these institutions should be compiling and maintaining and the data necessary to carry out a greenhouse gas (GHG) inventory for the LULUCF sector. A strategy therefore needs to be developed where the importance of GHG inventories and other climate change related activities can serve to assist these institutions in leveraging the attention and resources sorely

**Figure 7: River Flooding and/or Rain Inundation**


needed to fulfill their sectoral data management responsibilities. At the same time this would provide timely and consistent data required to fulfill our national climate change related responsibilities, hopefully at an acceptable economic cost. The Forest Department plays and will continue to play a key role in providing data related to changes in forest biomass stocks.

## DISASTERS

Belize is highly susceptible to natural disasters, such as hurricanes, tropical storms, flooding and drought, which affect the country on a regular basis. In recent years, Belize has paid a high price for atmospheric disasters as the country is located within the path of Atlantic Tropical Cyclones. Table 7 displays a list of the most significant storms that have severely impacted the country. Among those are the hurricane of 1931 which claimed 1,500 lives and Hurricane Hattie which killed 275 people and caused damages in excess of $1 billion in U.S. normalized dollars (1998) (Fernandez, Klein et al. 2003).

Belize has a long, low-lying coastline, which lies within the trajectories of late season hurricanes and also accommodates 45 per cent of the country's population, ports and industries. The effects of these hazards have resulted in loss of lives and destruction of property which were worsened by poverty, environmental degradation, poor housing and the location of communities in "disaster prone" areas (National Policy Development Committee, 2003) (Figure 7).

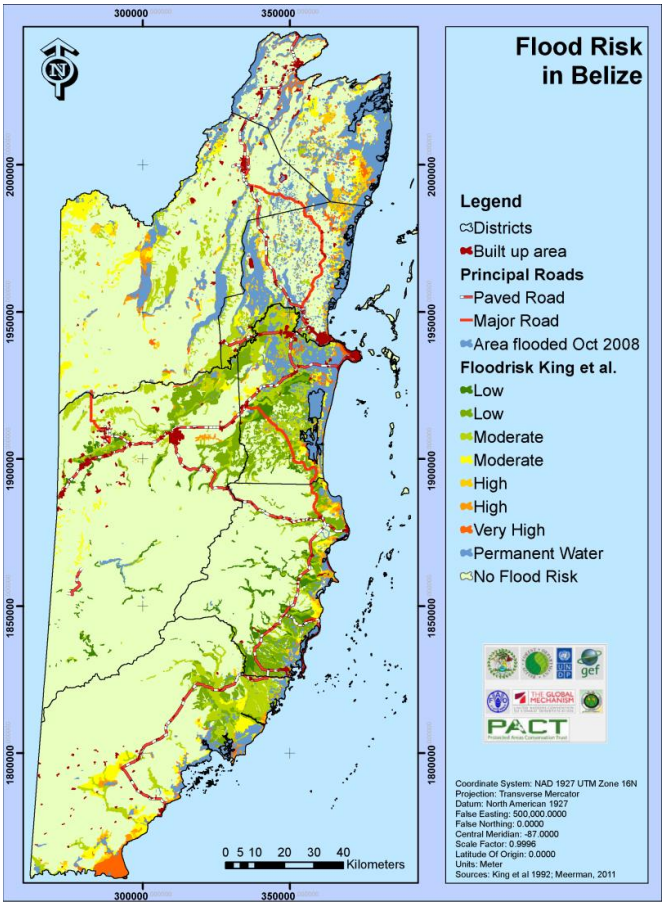
Infrastructure and economic losses especially in the agricultural sector are high during the hurricane season: from June to November. Hurricane Mitch (1998), Tropical Storm Chantal (2001), Hurricane Dean (2007), Tropical Storm Arthur (2008), Tropical Depression # 16 (2008) and Hurricane Richard (2010) all resulted in extensive flooding and damages to the banana, sugarcane, papaya, rice, corn and vegetable industries across the country.

Belize is less susceptible to landslides and earthquakes than other Caribbean territories. The country north of Belmopan, the nation's capital, is mostly level land interrupted only by the Manatee Hills. To the south the land rises sharply toward a mountainous interior from a flat and swampy coastline heavily indented by many lagoons. The Maya and the Cockscomb mountains (which reach a high point of 1,122 m (3,681 ft.) at Victoria Peak, in the Cockscombs) form the backbone of the country, which is drained by 17 rivers (Figure 8 (Usher 2007)).

**Table 7: History of Hurricanes**

| Year | Storms |
|---|---|
| 1931 | Hurricane of 1931 |
| 1954 | Hurricane Gilda |
| 1960 | Hurricane Abby |
| 1961 | Hurricanes Anna & Hattie |
| 1978 | Hurricane Greta |
| 1980 | Hurricane Hermine |
| 1993 | Hurricane Gert |
| 1998 | Hurricane Mitch |
| 2000 | Hurricane Keith |
| 2001 | Hurricane Iris |
| 2007 | Hurricane Dean |
| 2010 | Hurricane Richard |

**Figure 8: Flood Risk**



According to the US Geological Survey, the entire nation of Belize falls within the 0.2 to 2.4 m/s² range of peak ground acceleration. This is quite low in the regional context. Both Mexico and Guatemala experience shocks in excess of 4.0 m/s². The Pacific Coast of Central America is far more susceptible to earthquakes than the Caribbean Coast.

There are no known volcanoes in Belize, but the territory is exposed to ash falls from neighbouring volcanoes. In 1982, for instance, the eruption of the Chichón volcano, in the Chiapas region of Mexico, covered much of the country with ash. And although landslides are rare, flooding in the western and southern regions is frequent. The west and south may experience an average of between 183 and 200 rainy days per year, pouring in excess of 160 inches of rain in a year. These torrents routinely cause flash floods and rivers to breech their banks.

## CLIMATE CHANGE IMPACTS

Climate change impacts include higher temperatures; higher relative humidity; rising seas; increased risk of drought, fire and floods; stronger storms and increased storm damage; changing landscapes; economic losses; and increased wildlife at risk.

Belize, like many other non-Annex I Parties to the United Nations Framework Convention on Climate Change (UNFCCC) has prepared its Second National Communication (2NC), submitted in 2011, in partial fulfillment of its obligation to implement the Convention as stipulated in Articles 4.1 and 12 of the Convention (United Nations, 1992).

Within the health sector, the global circulating models for climate change projects that in tropical low latitude areas such as Belize, a warmer climate system resulting from a doubling in carbon dioxide concentration in the atmosphere will lead to increased frequency of warm spells/heat waves, intense droughts, and heavy rainfall events. It is projected that these conditions will exacerbate those that increase the risk and incidence of vector-borne diseases and illnesses (Vanzie 2008).

The first assessment of Belize's vulnerability to climate change study, conducted to determine the vulnerability of the coastline to sea level rise, was conducted by the Belize Centre for Environmental Studies (BCES) in 1994. The coastal area had been prioritized because of its low-lying state, the concentrations of populations in this zone, the level of infrastructure development and the range of economic activities occurring there. Preliminary vulnerability assessments were conducted also in the agriculture sector and reported in the First National Communication to the UNFCCC.

For the preparation of the Second National Communication, it was decided that vulnerability assessments would be conducted in different but very relevant and important sectors in Belizean development (UNDP 2011a). These included:

1. *Vulnerability and Adaptation Assessments in the Agriculture Sector.* Belize's economic growth and food security is highly dependent on agricultural activity. There is moderate diversification of crops, and both food security and economic growth are at risk from the impending impacts of climate change. The initial assessment of this sector focused on the

staple crops grown in Belize, rice, beans and corn. The 2NC study expanded the range of crops, but concentrated on two of the major trade commodities, sugar cane and citrus.

2. *Vulnerability and Adaptation Assessment of the Coastal Zone.* An initial vulnerability assessment was conducted on the coastal zone of mainland Belize using the Inter-governmental Panel on Climate Change's (IPCC's) Aerial Videotape Assisted Vulnerability Analysis methodology to determine those areas of the coast most likely to be affected by sea level rise. The process conducted for the 2NC was a more comprehensive assessment taking into consideration the social, economic, and environmental impacts resulting from sea level rise and other phenomena related to climate change.
3. *Vulnerability and Adaptation Assessment of the Fisheries and Aquaculture Industries.* This sector of agriculture is very important for food security and revenue generation. A significant proportion of the population is employed in this industry. The assessment focused on both capture fisheries and the aquaculture industry.
4. *Vulnerability and Adaptation Assessment of the Health Sector.* The risks to human life and well-being resulting from climate change were identified as another area of study. In collaboration with the Ministry of Health, this initial study focused on dengue and dengue haemorrhagic fever and the conditions that would favour outbreaks or increases in incidence.
5. *Vulnerability and Adaptation Assessment of the Tourism Sector.* The tourism industry has become the largest revenue generator for Belize, directly and indirectly involving the greatest proportion of the labour force, and affecting all other sectors.
6. *Vulnerability and Adaptation Assessment of Water Resources.* The vulnerability of coastal water resources to changes in the hydrological cycle and rising sea levels was conducted under the Mainstreaming Approach to Climate Change (MACC) Project with the intent of reporting in the 2NC. The drought experienced in 2007/2008 revealed instances where coastal wells were showing signs of salt water intrusion. The national measurements also indicated an advancing of the salt water wedge up certain river systems, reaching the point of extraction for Belize's largest urban area. Sites representing coastal aquifers and inland catchment areas were evaluated using scenarios selected to determine the potential future of the surface and sub-surface water characteristics. The study was supervised by the National Pro-Tem Water Commission and the Hydrological Section of the National Meteorological Service.

## RELEVANT NATIONAL, REGIONAL AND INTERNATIONAL CONVENTIONS AND AGREEMENTS

Belize is signatory or party to many international conventions and agreements, and is a member of many regional organizations involved in the management and protection of biological resources. Those that impact on biodiversity are listed below[2].

[2] Sources:
http://www.doe.gov.bz/documents/EIA/Green%20Tropics%20EIA/3.0%20Policy,%20legal%20&%20Admin%20framework.pdf; http://www.iacseaturtle.org/eng-docs/International-Instruments-of-Contracting-Parties.pdf; http://www.noubelize.gov.bz/sites/nou-belize/default.asp?site=nou-belize&page_id=00B8845F-BDA4-4E82-9003-6CF44A5F0F2D, https://www.iattc.org/IDCPENG.htm; http://belizesharks.org/research/fisheries/

- United Nations Law of the Sea Convention (LOSC) (ratified 1983)
- World Heritage Convention (ratified 1990)
- Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) (ratified 1976)
- Convention on Biological Diversity (CBD) (ratified 1993)
- Convention for the Conservation of Biodiversity and the Protection of Priority Areas in Central America (entered into force 1994)
- Agreement on Cooperation between Belize and Mexico for the Protection and the Improvement of the Environment and the Conservation of Natural Resources in the Border Zone (signed 1991)
- Protocol on Specially Protected Wildlife (SPAW Protocol) (ratified 2008)
- Protocol Concerning Pollution from Land-Based Sources of Pollution and Activities (LBS Protocol) (ratified 2008)
- United Nations Framework Convention on Climate Change (ratified 1994)
- Convention for the Prevention of Pollution from Ships (MARPOL 73/78) (ratified 1995)
- International Convention for the Regulation of Whaling (signed 1982)
- Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (signed 1995)
- Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) Toxins and their Destruction (signed 1980)
- Western Central Atlantic Fisheries Commission (WECAFC) (1985)
- Latin American Organization for Fisheries Development (OLDEPESCA) (1997)
- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (The Cartagena Convention) (2004)
- The Convention on Wetlands of International Importance Especially as Waterfowl Habitats (Ramsar Convention) (signed 1971)
- Inter-American Convention for the Conservation and Protection of Marine Turtles (ratified 2003)
- International Dolphin Conservation Program (IDCP) (ratified)
- International Commission for the Conservation of Atlantic Tunas (ICCAT) (signed)

Belize's compliance with its commitments under the above mentioned conventions has been minimal due to the lack of appropriate enforcement mechanisms.

## WATER AND SANITATION COVERAGE

### National, Urban, Rural Water

The percentage of the population with access to potable water is 93.0 per cent at the national level, with 97.5 per cent in urban areas and 89.3 per cent in rural areas (GOB 2006). There is a sharp division between urban and rural homes in their drinking water source and sanitation facilities. In urban areas, 38 per cent of homes receive their water from a public source piped into their dwelling and an additional 28 per cent use purified (bottled) water. This contrasts with rural areas where most drinking water (37 per cent) comes from a private rainwater

catchment vat or a well. Five per cent, or about 1,300 rural households still rely on rivers, streams, ponds or springs for their drinking water. These statistics suggest that a large number of Belizean rural households that depend on rainwater or runoff may be vulnerable to drought and changes in the quality of surface and ground waters, which would reduce water security (SIB 2007b). Table 8 shows the drinking water coverage for 2010 reported by the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation (WHO / UNICEF 2012).

**Table 8: JMP Estimated Trends**

| | Drinking water coverage estimates | | | | | |
|---|---|---|---|---|---|---|
| | Urban (%) | | Rural (%) | | Total (%) | |
| | 1990 | 2010 | 1990 | 2010 | 1990 | 2010 |
| Piped onto premises | 75 | 87 | 21 | 68 | 47 | 78 |
| Other improved source | 14 | 11 | 40 | 31 | 27 | 20 |
| Other unimproved | 11 | 2 | 27 | 1 | 20 | 2 |
| Surface water | 0 | 0 | 12 | 0 | 6 | 0 |
| Source: WHO/UNICEF, JMP 2012 | | | | | | |

## Sanitation

Precise information on sanitation coverage is difficult to obtain, but JMP reports that 90 per cent of Belizeans have an improved sanitation facility (Table 9). According to the Belize Basic Indicators 2010, the population with access to a sewer system at the national level is 60.4 per cent, with 85 per cent access in urban areas and 40.1 per cent in rural areas.

**Table 9: JMP Estimated Trends**

| | Sanitation coverage estimates | | | | | |
|---|---|---|---|---|---|---|
| | Urban (%) | | Rural (%) | | Total (%) | |
| | 1990 | 2010 | 1990 | 2010 | 1990 | 2010 |
| Improved facilities | 77 | 93 | 77 | 87 | 77 | 90 |
| Shared facilities | 6 | 7 | 6 | 7 | 6 | 7 |
| Other unimproved | 13 | 0 | 7 | 3 | 10 | 2 |
| Open defecation | 4 | 0 | 10 | 3 | 7 | 1 |
| Source: WHO/UNICEF, JMP 2012 | | | | | | |

In other reports, it is estimated that approximately 28 per cent of the population is connected to sewerage systems. JMP (WHO / UNICEF 2012b) reports 81.3 per cent of the population is connected to either a sewerage system or a septic tank. The results of the Labour Force Survey, September 2009, indicate that 14.7 per cent of the population is connected to a piped sewer system and 51 per cent to a septic tank. For the purpose of this report it will be assumed that 28 per cent of the population is served by a sewerage system.

The differences in toilet facilities perhaps reveal the strongest difference between houses in rural and urban areas. In urban areas, most households (47 per cent) have toilets that run to a septic tank in their yard and many households (30 per cent) are also connected to a sewer system. By contrast, in rural areas, about 70 per cent of households use some type of latrine, 22 per cent have septic systems and 6 per cent have no toilet facilities at all. Table 10 shows the sanitation coverage for 2010, as reported by the JMP in 2012.

**Table 10: Sanitation Coverage by Type of Technology**

| | Urban | Rural | National |
|---|---|---|---|
| Population | 158,000 | 147,000 | 305,000 |
| | **Urban %** | **Rural %** | **National %** |
| Water closet linked to sewer system/septic tank | 81.3 | 42.4 | 62.6 |
| Pit latrine | 15.8 | 52.8 | 33.6 |
| None | 1.7 | 3.8 | 2.7 |
| Other | 1.2 | 0.7 | 1.0 |
| | 100 | 99.7 | 99.9 |
| Source: JMP 2012 | | | |

### Coverage by type of technology: latrine, septic tanks (onsite treatment), sewerage

Presently, only three municipalities (Belize City, San Pedro Town and Belmopan City) or about 28 per cent of the population are connected to sewerage systems. All other areas are serviced with septic tanks (34.6 per cent) and pit latrines (33.6 per cent). JMP reports that for 2010, 81.3 per cent of the urban population was connected to a either a sewer system or a septic tank, while in rural areas 42.4 per cent had that service. In regard to the use of latrines 15.8 per cent used latrines in urban areas and 52.8 per cent in rural areas (Table 10).

### Coverage by sewerage clustering: (1) Onsite individual household systems (2) Community-based Systems or (3) Centralized Municipal Systems

Belize Water Services currently operates and maintains sewerage systems in Belmopan, Belize City and San Pedro Town. None of the municipalities served by these sewerage systems enjoy 100 per cent coverage (Belize Water Services (BWS) 2012). The existing sewerage system in each municipality consists of conventional gravity sewers in zones (Belmopan - 2, Belize - 15 and San Pedro - 6), complete with concrete manholes and submersible fiberglass reinforced plastic pumping stations. In each zone, sewage is collected by gravity at each a pumping station and pumped to a neighboring zone towards the treatment works. Pump operations in each station are automatic and controlled by float switches. In Belmopan the sewage stations are of the wet-dry well type and made of concrete. It is estimated that 68.2 per cent of the population uses onsite individual household systems. No community-based systems are reported, except for commercial institutions such as hotels; 28 per cent of the population is connected to a centralized system.

# 3. METHODOLOGY

The methodology for this National Baseline Assessment consisted of a literature review, interviews with key experts and data analysis of a questionnaire using a mathematical model (described in the next section).

## LITERATURE REVIEW

Several documents produced to support the CReW project were reviewed to find the relevant information that could be used to conduct the Regional Baseline Assessment. The following reports were collected and studied:

1. Assessment of Wastewater Management Technologies in the Wider Caribbean Region
2. Gap Analysis and Regional Best Practices in Wastewater Management
3. Wastewater Management in the Wider Caribbean Region: Knowledge, Attitudes and Practice (KAP) Study
4. International Best Practices
5. Situational Analysis, Regional Sectoral Overview of Wastewater Management in the Wider Caribbean Region
6. Testing a Prototype Caribbean Regional Fund for Wastewater Management (CreW)

The analysis of each document helped to identify key areas and issues that need to be included in the assessment. The areas identified to be evaluated are as follows:

1. Wastewater treatment management
2. Pollution problems and their cost
3. National capacity (policy framework, legislative and institutional framework)
4. Surveillance and enforcement capacity
5. Manpower capacity
6. Financing
7. Best practices and innovative technological treatment solutions.
8. Current knowledge, attitudes, behaviours and practices
9. Information collection and sharing
10. Water and sanitation diaspora organizations
11. Climate change impacts

These documents were supplemented by an internet search for other studies and research on the wastewater sector (provided in the References section).

## INTERVIEWS WITH KEY EXPERTS

Communication by email was conducted with the CreW Focal Point, Martin Alegria and the CreW Alternate Focal Point, Yvette Alvarez to discuss the proposed questionnaire and the proposed strategy to collect the required information for the baseline assessment.

# 4. MATHEMATICAL MODEL USED

# RATIONALE FOR THE MODEL

The study and analysis of documents mentioned in Section 3 helped to identify key areas that needed to be included in the assessment. Based on the identified areas a list of issues was identified. Each issue contains a list of attributes to be identified to assist in measuring the adequacy of the issue. The list of issues is as follows:

1. Sanitation coverage
2. Disposal of treated/untreated wastewater
3. Wastewater reuse
4. Type of reuse
5. Quality of effluent
6. Industrial waste management
7. Tourism/ hotel wastewater management
8. Institutional effluent discharges
9. Amount of water discharged
10. Quality of discharge
11. Septage/biosolids management
12. Infrastructure condition
13. Pollution problems and their cost
14. Policy framework
15. Legislative framework
16. Institutional framework
17. Surveillance and enforcement capacity
18. Availability of staff for wastewater management
19. National/regional training needs for wastewater management
20. National/regional training opportunities for wastewater management
21. National/regional training areas for wastewater
22. Financial issues
23. Best practices and innovative technological treatment solutions
24. Current knowledge, attitudes, behaviors and practices
25. Information collection and sharing
26. Organizations support for wastewater management
27. Climate change impact

A questionnaire was created based on these 27 issue areas, using the associated attributes. The questionnaire comprised a total of 284 questions. The questions can be seen in Annexes 2 and 3 which present the raw data from the questionnaire and the results of the analysis using the mathematical model, respectively.

The instrument was prepared in such way that the evaluation could be quantitative if information was available or qualitative if it was not. Each question was divided into five columns. The first column indicates presence or absence and the second, third and fourth columns measure the adequacy of the attribute evaluated.

The methodology can be applied at the national level, parish level or basin level. Due to time and economic constraints, this evaluation was conducted at the national level. The grading of each answer took into consideration: 1) presence or absence (Yes/No), 2) degree of adequacy (score from 1 to 3), and 3) significance for meeting the LBS Protocol.

The assessment used the scaling of the Rapid Impact Assessment (RIA) Tool. This methodology is designed to help parish councils and other organizations by providing a preliminary assessment and screening of potential environmental impacts of a project or proposal before a final decision on a proposed activity is taken.

To enhance visual representation the scale was colour coded as follows:

Scale Score 1-3 (RED): Negative Environmental Impact
Scale Score 4-7 (AMBER): Neutral Environmental Impact
Scale Score 8-10 (GREEN): Positive Environmental Impact

In this case each factor is scored on a scale of 0 to 100 where a score of:

0 to 10 = significant adverse adequacy impact
20 or 30 = negative adverse adequacy impact
40 to 70 = neutral adequacy
80 = good positive adequacy impact
90 = very good positive adequacy impact
100 = excellent positive adequacy impact

| 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| Significant | Negative | | Neutral | | | | Good | Very good | Excellent |

A mathematical model was developed to grade each question and to be able to present the information at the national level. Examination of the results of the evaluation will allow for the identification of priorities at the national and regional levels. Also it will allow countries to measure the level of compliance with Annex III of the LBS.

## CONSTRAINTS/LIMITATIONS OF THE MODEL

The process of modeling might be defined in the following way:

- Identify the problem to be investigated.
- Determine the important factors.
- Represent those factors and their interplay in a mathematical way and analyze the mathematical relationships.
- Interpret the mathematical results in the context of the real-world phenomenon.
- Evaluate how applicable the results are to the real-world situation.
- If necessary, re-examine the factors that were considered and structure of the initial model.

Any mathematical model has its weaknesses and strengths.

## Weaknesses

Potential weaknesses of the model that was developed for this study include the following:

- The answers should represent the whole country; therefore it is very difficult to grade the adequacy of a question using a small amount of data. Review of a large amount of information is necessary to provide a valid response.
- Answers to the questions involve a group of experts that agree to the answer to be included.
- Information required is not available in one institution and in one report and is not available in the form that the assessment requires it;
- Information applicable to some questions is not available
- It is difficult to build a complete model of real processes due to lack of available data.
- Computational complexity is a possible limitation - a model sufficiently accurate may require enormous computer power.

## Strengths

Strengths of mathematical models include the following:

- A mathematical model is systematic, results can be repeated, and the model can be refined. This would be in contrast to prediction systems based on emotion or "soft" events such as observation of human behaviour.
- There are several situations in which mathematical models can be used very effectively as an introductory evaluation.
- Mathematical models can help many stakeholders understand and explore the meaning of equations or functional relationships.
- Mathematical modelling software such as Excel programmes make it relatively easy to create a learning environment in which introductory stakeholders can be interactively engaged in guided inquiry and heads-on and hands-on activities.
- After developing a conceptual model of a physical system it is natural to develop a mathematical model that will allow one to estimate the quantitative behavior of the system.
- Quantitative results from mathematical models can easily be compared with observational data to identify a model's strengths and weaknesses.
- Mathematical models are an important component of the final "complete model" of a system which is actually a collection of conceptual, physical, mathematical, visualization, and possibly statistical sub-models.
- A mathematical model helps to establish relationships among a multiple amount of factors that in the past were not included.
- The model used in this study helps to present in a pictorial way the complexities of wastewater management.

# 5. OVERVIEW OF WASTEWATER TREATMENT AND MANAGEMENT

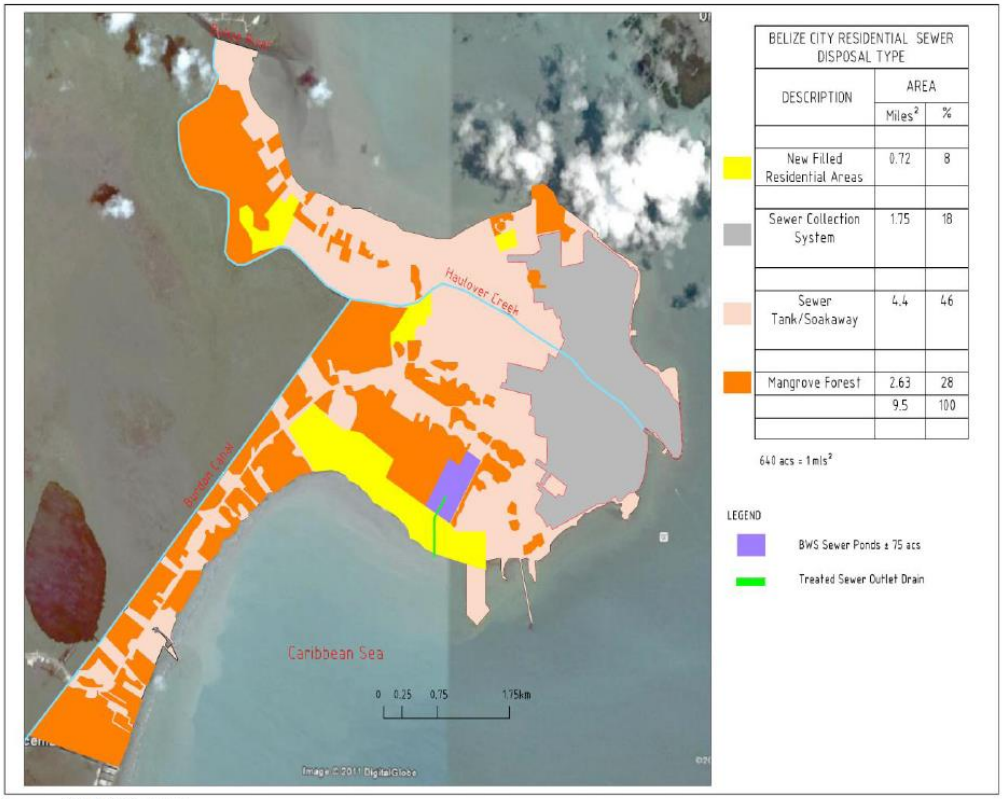
## DOMESTIC WASTEWATER TREATMENT SYSTEMS

Presently the treatment of wastewater can be divided into two distinct forms but with the same environmental end result. The first involves the use of septic tank systems connected to a soak away or leach field. This is a common practice for residents and commercial establishments, especially in the new Belize City, and consists of discharging raw sewage into septic tank systems with the sludge accumulating and the clarified liquid flowing into the soak away or leach field for disposal (PADECO 2011).

Much of the existing septic systems are not functioning properly, mostly due to the designs which are not to standard and as such only partially treat the raw sewage and grey water. Recent enforcement has steered towards constructing functional treatment systems. Likewise, there is the lack of proper maintenance and desludging of septic tanks. This results in direct environmental impacts that can immediately contaminate any nearby water body such as creeks, rivers, sea and underground water. There have been recorded instances that there are no soakaway or leach fields and sewage is simply discharged into wetlands or water bodies. The second form of wastewater treatment presently being used is a sewer collection system.

As noted above, Belize Water Services currently operates and maintains sewerage systems in Belmopan, Belize City (Figure 9) and San Pedro Town.

**Figure 9: Sewage Disposal Type**




Source: PADECO, 2011

It is estimated that 16 per cent of Belize's population (48,800/305,000) is connected to a sewage treatment plant. Sewage treatment and disposal of effluent varies in each municipality as described below.

**Figure 10: Condition of Belize City Wastewater Treatment Plant**

**Belize City** Treatment is provided by a two-cell facultative lagoon system and the treated effluent is discharged into the Caribbean Sea via canals cut through a mangrove wetland. The lagoon cells operate in series (Figure 10) and are designed to provide 10 days of hydraulic retention time in each. The system presently serves some 37,500 consumers and treats about 1,500,000 gallons of sewage per day. Figure 10 shows an aerial view of the city's treatment facility.

The sewer ponds are divided into three zones with the outfall being discharged via two pipes and into an excavated drain that connects to the sea. The collection systems are interconnected with Zone 1 flowing into Zone 2 and Zone 2 into Zone 3 and so forth. On occasions, one of these zones fails and the wastewater is directly discharged into the sea, river or canal via a series of outfalls designed as a failsafe mechanism to deal with overflows, malfunction and power outages.

The operation of the sewage collection system only serves a portion of the residents. Though a step in the right direction, the maintenance programmes of the sewage treatment plants are not up to date and as such the plants resort to emergency discharges into the sea, canals, creeks and other water bodies. The function of the sewage ponds is to treat the incoming wastewater effluent and it is unknown if the ponds are operating effectively and efficiently in treating the wastewater.

**San Pedro Town** Two facultative lagoons operating in series followed by one maturation pond with impermeable layers at their bottoms are used to treat the collected sewage in San Pedro Town. The treated effluent from the maturation pond is discharged to the surrounding mangrove wetland, via a dispersion pipe, for polishing before final disposal into the natural lagoon environ (the Caribbean Sea). The cells are each designed to provide a hydraulic retention time of 10 days. The sewerage system currently serves approximately 3,400 consumers and treats about 160,000 gallons of sewage per day.

**Belmopan** The sewage system in Belmopan comprises sewage draining into two pumping stations, and then pumped into a treatment plant (Country Environmental Profile 2006). A primary treatment plant made up of a settling tank and four sludge drying beds together with 1½ miles of 18" diameter disposal pipe makes up the facility for treatment of sewage in

Belmopan. The treated effluent (clarified waste water) empties into the Belize River via the disposal pipe and the sludge is deposited onto the drying beds and later made available for agricultural uses. Approximately 7,900 consumers are served by the sewerage system. It is estimated that the flow to the sewage treatment plant is 200,000 gallons per day. This system is not functional, resulting in direct release of raw sewage into the Belize River, which serves various social and ecological functions, including the water source for Belize City.

**Dangriga Town** The municipality of Dangriga Town, with 10,800 residents, has no sewage treatment facility. The number of households is estimated at 3,000 with 40 per cent having septic tank sewage treatment. The remaining 60 per cent of households use pit latrines and/or dispose of sewage directly into the waterways or sea. In addition to the 60 per cent of the households that use pit latrines, the shrimp, citrus, banana and other industries attract many from Belize's labour force who remain working in the area for extended periods. Furthermore, the soil type increases the risk of sewage pollution to the marine environment in this area. The general area is made up of highly porous course sand, which can lead to leaching.

**Corozal Town** The Corozal Bay is the eastern boundary for Corozal Town, a municipality of 8,800 residents with no sewage treatment plant. All sewage from the estimated 1,100 households is treated in pit latrines, septic tanks and soakaways. The underlying limestone geology allows the sewage to leach into the Corozal Bay.

The Belize Water Services, despite results from sampling conducted that shows otherwise, contends that outfall from the city's sewage treatment facility is within the accepted standard. This issue has been exacerbated by the planned construction of the Carnival Cruise Terminal and Free Zone in the area between the lagoons and the sea, where once there was a healthy stand of mangroves that polished the effluent from these sewage treatment ponds. Today, this outfall empties directly into the sea.

Other towns without sewerage are Orange Walk, San Ignacio, Benque Viejo del Carmen and Punta Gorda.

## WASTEWATER REUSE

There are several examples of wastewater reuse mainly for irrigation purposes. At least two facilities are reusing treated wastewater for irrigation purposes and some other projects are in the pipeline with the same aim. The identified projects are described below.

**Kanatik Reef and Jungle Resort** The Kanatik Reef and Jungle Resort Resort installed two "wastewater gardens" – one of area 200 $m^2$ and the other 120 $m^2$ – to treat wastewater from their restaurant, laundry and guest rooms, to handle a total of 90-100 guests and staff. The wastewater garden system arose from the experience with water treatment and reuse in Biosphere 2, a closed ecological system facility supporting eight people, their technical/research laboratories, habitat and agricultural/food production and a variety of natural ecosystems in a virtually air-tight "mini-world". That initial constructed wetland, for over two years successfully treated and recycled the wastewater from humans, domestic

animals and laboratory/workshops and sent its remaining nutrients and freshwater back in to supply water for the system's intensive agriculture irrigation system. Thus all nutrients and water were continually recycled in agricultural soils which produced food for humans and domestic animals. Vegetation from the constructed wetland increased plant biodiversity, providing additional habitat space and beauty (Nelson 2006).

The plants of the constructed wetland were pruned to supply animal fodder for the domestic animals – whose solid waste was composted and whose wastewater returned to the constructed wetland. In such a small system, an approach to completely closing the loop between food production and sewage was possible. This mirrors the spread of more natural approaches to sewage treatment and water recycling/reuse which reflects growing concern about human health and environmental degradation caused by sewage pollution, and the recognition of the limited amount of clean, potable water the Earth has.

**Hunting Caye** Another interesting experience is the Alternating Intermittent Recirculating Reactor system which is an innovative alternative for a conventional drain field. It is designed to treat effluent in areas where percolation is limited or non-existent so the land can still be used for homes or businesses. This system uses different types of bacteria to remove pathogens and to clean effluent water, which is then reused in above ground irrigation discharges into waterways or to drain underground. This system is presently being used in Hunting Caye (Mendoza 1998); the largest of the six cayes of the Sapodilla Cayes located in the south and has approximate area of six hectares. This system is also recommended for other islands especially those with high tourism potential.

## INDUSTRIAL EFFLUENT DISCHARGES

The industrial sector is limited to light manufacturing industries which are mostly concentrated in Belize City such as battery manufacturing, welding shops, and mechanic shops beer and others like rum production and feed processing. Raw materials are all imported and assembled locally (Fernandez 2002).

Large industries include:

- Processing of sugarcane into sugar at the Tower Hill factory in Orange Walk
- Processing of citrus into concentrate at Del Oro's Alta Vista and Pomona Processing Facility in the Stann Creek District. These plants make the largest contribution of organic load to the North Stann Creek River.
- Packaging of bananas in the Stann Creek District. The banana industry draws approximately 460 million gallons of water from South Stann Creek, Swasey, Trio and Bladden rivers each year with this supply being augmented by well water.
- The Belize Brewing Company located in Ladyville. Apart from the production of beer, soft drinks are also produced by a sister company Bowen & Bowen Ltd. PEBCO also has its factory in Ladyville.

- Belize Travelers, which has its formulating plant on the Northern Highway along with Belize Mills which processes wheat into flour. Other manufacturing industries include manufacture of boats, and clothing.
- The Commercial Free Zone, at the Santa Elena Border in the Corozal District. It is the largest source of industrial pollution in that district. While there are few manufacturing activities in the Zone, there are over 200 stores and al least three gas stations. The Free Zone is built alongside the Rio Hondo.
- The Tower Hill Sugar Processing Plant in the Orange Walk District. Situated on the banks of the New River, it is the largest polluter of that river.
- The Cuello's Distillery as well as the L&R Distillery in Orange Walk District.
- New River Enterprise, which is a sawmill operation operating on the banks of the New River.
- Shrimp Farms in the Stann District. Waste from these farms can be a significant source of pollution.

Small industries include:

- Running W Farms and B&H Meats, which are involved in the processing of cattle and pigs; Quality Chicken and Homestead Acres, which are involved in the processing of chicken; and Big H Juices and Western Dairies that produce milk, ice cream and juices. These are all in the Cayo District.
- The Traveller's Distillery, located in Belmopan.

Table 11 presents a list of main industries in Belize.

**Table 11: Industries in Belize**

| Company | Activity | Location | Company | Activity | Location |
|---|---|---|---|---|---|
| National Sand and gravel quarry | Mining | Belize | Running W Meats | Meat Processing | Cayo |
| Belize Electricity Limited | Power Generation | Belize | Homestead acres | Meat Processing | Cayo |
| Texaco Belize Ltd. | Fuel Storage/Distribution | Belize | Quality chicken | Meat Processing | Cayo |
| Esso Standard Oil | Fuel Storage/Distribution | Belize | Reimers Feed Mill | Feed Processing | Cayo |
| Shell Belize Ltd | Fuel Storage/Distribution | Belize | Farmer Feed Supply | Feed Processing | Cayo |
| Belize Gases Ltd. | Liquid Gas Production | Belize | Western Dairy | Milk Processing | Cayo |
| Messer Gas Co | Liquid Gas Production | Belize | Macal Dairy | Milk Processing | Cayo |
| Prosser Fertilizer and | Fertilizer/Pesticide Formulation | Belize | Cayo tropical Fruits | Fruit Processing | Cayo |

| Table 11: Industries in Belize | | | | | |
|---|---|---|---|---|---|
| **Company** | **Activity** | **Location** | **Company** | **Activity** | **Location** |
| Agrotec Co. Ltd. | | | processing | | |
| Belize Mills Ltd | Food Processing | Belize | Shrimp farms | Effluent Discharge Food Processing | Countrywide |
| National Fishermen Cooperative Society Ltd. | Seafood processing | Belize | L&R Distillery | Distillery | Orange Walk |
| Northern Fishermen Cooperative Society Ltd. | Seafood Processing | Belize | Travellers Rum | Distillery | Orange Walk |
| Williamson Industries | Apparel manufacture | Belize | Cuellos Distillery Ltd | Distillery | Orange Walk |
| PEBCO | Soft drink production | Belize | Tower Hill Factory | Cane processing | Orange Walk |
| Bowen and Bowen Ltd | Soft drink production | Belize | Marie Sharps Habanero | Food Processing | Stann Creek |
| Belize Brewing Co. Ltd. | Beer production | Belize | Del-Oro factory, Pomona | Citrus processing | Stann Creek |
| Renco Battery | Battery manufacture | Belize | Del-Oro Factory, Alta Vista | Citrus processing | Stann Creek |
| B&H Meats | Meat Processing | Cayo | Belize Minerals Ltd. | Mining | Toledo |
| - | - | - | Printing Press | - | - |

Effluent regulations have been established for different industries by Chief Parliamentary Counsel (2009) (Table 12). There is an additional set of regulation based on effluent concentration, wastewater volume and wastewater performance (Table 13). In theory the effluent regulations are able to control any kind of industrial pollution if they are fully applied and monitored. However, a constant monitoring plan or sewage discharge/disposal facilities are not in place to safeguard discharge of effluents.

| Table 12: Effluent Regulations for Different Industries | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Industry** | **Temp (°C)** | **pH** | **$BOD_5$ (mg/l)** | **TSS (mg/l)** | **COD (mg/l)** | **$NO_3$ (mg/l)** | **$PO_4$ (mg/l)** |
| Plastic and Synthetics | | | 10 | 30 | 40 | | |
| Food Processing | | | 15 | 15 | | | |
| Service Industries | | | 15 | | 40 | | |
| Garment Industry | 40 | 6 -9 | 50 | 100 | 100 | 10 | 5 |
| Citrus Industry | 40 | 6 -9 | 50 | 50 | 100 | 10 | 5 |
| Battery Manufacturing | 40 | 7.6 - 10 | 30 | 30 | 100 | 10 | 5 |
| Fish Processing | 40 | 6 -9 | 100 | 100 | 100 | 10 | 30 |
| Poultry Industry | 40 | 6 -9 | 50 | 50 | 100 | 10 | 5 |
| Dairy Industry | 40 | 6 -9 | 50 | | 100 | 30 | 5 |
| Rum Refinery Industry | 40 | 6 -9 | 50 | 60 | 200 | 10 | 1 |
| Brewery Industry | 40 | 6 -9 | 35 | 50 | 200 | 10 | 5 |
| Sugar processing | 40 | 6 -9 | 50 | 50 | 200 | 10 | 5 |
| Shrimp Processing | 40 | 6 -9 | 30 | | 200 | 10 | 1 |
| Other Industries | 33 | 6 -9 | 50 | 50 | 100 | | |

| Table 13: Effluent Regulation Limits for Different Industries Based on Quantity and Quality of Effluents and Wastewater Plant Performance | | | | | | |
|---|---|---|---|---|---|---|
| **Industry** | **WW Vol. (mgd)** | **WW Load (lb. BOD/day)** | **BOD Reduction** | **TSS Reduction** | **Temp (°C)** | **pH** |
| Garment Industry | 0.035 | 39 | 303:1 | | 40 | 6 -9 |
| Citrus Industry | 0.04 | 26.7 | 2300:1 | 1176:1 | 40 | 6 -9 |
| Battery Manufacturing | | | | | 40 | 7.6 - 10 |
| Fish Processing | | | | | 40 | 6 -9 |
| Poultry Industry | 0.4 | 18.75 | 2000:1 | 1500:1 | 40 | 6 -9 |
| Dairy Industry | 0.0005 | 1.3 | 500:1 | | 40 | 6 -9 |
| Rum Refinery Industry | 0.03 | | | | 40 | 6 -9 |
| Brewery Industry | 0.015 | 35 | 175:1 | | 40 | 6 -9 |
| Sugar Processing | 25.97 | 7840 | 1000:1 | 1500:1 | 40 | 6 -9 |
| Shrimp Processing | | | | | 40 | 6 -9 |
| Other Industries | | | | | 33 | 6 -9 |

Currently, wetland wastewater treatment systems are being utilized in Belize for a variety of domestic, commercial and industrial effluent treatment. With the enactment of the Environmental Protection Act and its subsequent regulations - the Effluent Limitation Regulations and the Environmental Impact Assessment (EIA) Regulations all new and existing

industries must employ environmentally sound systems to treat their wastewater in order to protect the public's health and to ensure a safer, cleaner and healthier environment.

**The Belize Sugar Industry (BSI)** Chicas (2008) in his research indicates that BSI has a crushing capacity of 6,000 tons of cane per day and an operating season from the end of November to late June. In 2002-2007, the sugar industry alone produced 5,074,261 to 5,950,123 gallons of liquid waste per year (Table 14). The increased levels of biochemical oxygen demand (BOD) and nutrients are the parameters of main concern. A study was conducted on the factory's wastewater treatment plant. The data revealed that the chemical oxygen demand (COD) removal efficiency of ponds #1 and #3 need improvement.

**Table 14: Pollutant loading in wastewater streams from Belize Sugar Factory**

| Stream | Volume | | COD mg/L | pH | Temp °C |
|---|---|---|---|---|---|
| | m³/tc* | m³/day | | | |
| Cooling water | 0.003 | 22 | 1,342,000 | 7,6 | 30 |
| Washing | 0.09 | 681 | 4,086,000,000 | 4.65 | 33 |
| Excess condensate | 0.11 | 814 | | 7.0 | 85 |
| Boiler blow down | 0.008 | 50.38 | 9,773,720 | 9.68 | 95 |
| Total | 0.13 | 1567.38 | 4,097,115,720 | | |

Source: BSI

* tc = tonne of cane

The Belize Sugar Industry wastewater treatment plant, that treats the wastewater discharged by BSI's sugar manufacturing process, is consists of seven wastewater treatment ponds. Ponds 1 to 5 are used to treat the wastewater from the production process, laboratory and sanitary facilities. Ponds No. 6 and 7 (ash pond and ash pond #2) are used specifically for the treatment of boiler ash wash water. The COD of the effluent is 7,393 mg/l and is discharged to a swamp for further treatment and then flows into the New River. The quality at the exit of the swamp is 32 mg/l of COD. In 2008 a new treatment method was introduced which increased the removal efficiency of the wastewater plants.

Pesticides in Belize are registered by formulation. There are a number of pesticides, especially fungicides which may contain a heavy metal in their composition. This is usually copper in the form of copper sulphate or copper oxide. Fungicides are used extensively in the banana industry, rice industry and among small farmers. The only inorganic pesticide is Chromated Cooper Arsenate (CCA) which is a wood preservative used exclusively for the treatment of lumber. The restrictive license allows only two manufacturers to use the product (Fernandez 2002).

Three main companies carry out poultry production in Belize, Quality Poultry Product and Fiesta Chicken in Spanish Lookout and Caribbean Chicken in Blue Creek, Orange Walk.

Interviews with these companies' personnel indicate that together 465,000 gallons of water flow through these facilities per week. Quality Poultry used 5 treatment ponds to treat and store 240,000 gallons of water while Caribbean Chicken disposes of 225,000 gallons into their field behind the facility. In terms of solid waste, averages of 50 – 55 gallon drums full of waste are generated per week by these facilities. This waste is burnt and the remains then taken to respective community dumpsites (DOE 2008).

Belize has an agrarian-based economy with tourism also making a significant contribution to the national economy. Agriculture, including aquaculture, accounts for 89.9 per cent of total exports. As noted previously, the major agricultural products are sugarcane in the Corozal and Orange Walk District, citrus in the Stann Creek and Cayo District, and bananas in the Stann Creek and Toledo Districts. Other products include red kidney beans, papayas, rice, peanuts, cocoa, mangoes, blackeye beans and habanero peppers. There are over 15,000 small farmers who plant such produce as tomatoes, cabbage, peppers, potato, celery and other vegetables. They are concentrated mainly in the Cayo, Orange Walk and Corozal Districts. Farmers in Toledo practice the slash and burn milpa system where they plant rice, corn and beans (Fernandez 2002).

There is much agricultural activity occurring in the Belize River Valley and the Stann Creek Valley. The two northern districts and Stann Creek and Toledo also have significant agricultural activity. In Stann Creek and Toledo agricultural activity is along the coast as further inland the unsuitability of the mountain pine ridge makes it impossible to engage in agriculture. The Cayo District also has a large area that is a forest reserve prohibiting agriculture in that area.

Pesticide and fertilizers are used widely throughout the country but especially in the sugarcane, banana, citrus, and papaya plantations. The sugarcane and citrus industry use a large amount of herbicides, while the banana industry also uses nematicides, fungicides and insecticides. The small vegetable farmers use a variety of pesticides and often use them more frequently. Various reports show that small farmers use greater amounts of pesticides than they require.

Pesticide imports for the last three years are given in Table 15. Imports have remained relatively constant over the last couple of years. The top 20 pesticides imported in 2001 by chemical family are given in Table 16. These are the total amount of formulated product. The actual amount of active ingredient is actually much lower (Fernandez 2002). Exact quantities are not readily available. Pyrethroids make up the largest group imported. These include insecticides, miticides, aerosols and veterinary use products. The organophosphates are the next largest group. These are mostly insecticides. Inorganic arsenicals, which is CCA is used solely for wood treatment. Its use is tightly controlled. The other two in the top five are Bipyridylium (such as paraquat) and carbamates (such as Temik used in the banana industry as a nematicide) (Fernandez 2002).

| Table 15: Pesticide Imports for the period 1999-2001 | | | |
|---|---|---|---|
| | Quantity (lbs) | | |
| **Pesticide** | **1999** | **2000** | **2001** |
| Insecticide | 1,385,865 | | 700,451 |
| Herbicide | 859,176 | | 804,740 |
| Fungicide | 353,863 | | 341,052 |
| Nematicide/Ins.* | | | 192,939 |
| Others** | 401,233 | | 1,748,385 |
| **Total** | **3,000,137** | **2,854,765** | **3,787,570** |

| Table 16: 2001 Pesticide Import by Chemical Family | |
|---|---|
| **Chemical Family** | **Quantity (lbs)** |
| Synthetic pyrethroid | 499967 |
| Organophosphate | 280963 |
| Inorganic Arsenicals | 263971 |
| Bipyridylium | 244579 |
| Carbamate | 231967 |
| Ethylene Bisdithiocarbamate | 209412 |
| Phosphoric Acid | 171799 |
| Glyphosphate | 55912 |
| Substituted Urea | 36436 |
| Chlorinated Phenoxy | 30852 |
| Triazine | 25173 |
| Thiourea | 22702 |
| Phenoxy propionate | 20326 |
| Triazole | 18242 |
| Amide | 12100 |
| Oximinoacetate | 11870 |
| Dinitroaniline | 9302 |
| Phenol | 8192 |
| Biological | 7177 |
| Benzimidazole | 5140 |

Ariola (2003) gave the following description of the shrimp farm operations near the Placencia Lagoon. Considerable attention was given to the impacts of shrimp mariculture operations in the margin of the Placencia Lagoon. At the time of this study, the upper portion of the lagoon was not affected by aquaculture effluent. On the other hand, Belize Aquaculture Ltd. is a fully functional super intensive, closed system operation with a zero effluent discharge (Boyd et al., 2002). Royal Mayan, Tex Mar and Crustaceans Ltd. are three operations that are in close

proximity to each other. Each of these operations meet the settling pond requirements (10 per cent of the production area) stipulated by the Department of the Environment. Effluents discharged from these operations are subjected to mangrove wetlands for nutrient and sediment reduction prior to entry into the lower portions of the Placencia Lagoon. The fact that the lower portion of the lagoon has a much higher water exchange rate with the sea (as opposed to the upper portion) is the reason why there is no significant impact on the ecological and environmental conditions of the lagoon. Aqua Mar is located at the southern boundary of the lagoon and its effluents are released into wetlands in the northeastern tip of the Sennis River Catchment. Taking into account the predominant southerly coastal currents, the impacts of this operation on the Placencia Lagoon are questionable.

## TOURISM /HOTEL SECTOR WASTEWATER MANAGEMENT

Smaller resorts and hotels have septic systems, but the larger developments are required by the Department of Environment (DOE) to install package plants. A certain effort is made by DoE to monitor the effluent discharge by these package plants. Eighty per cent (80 per cent) of Belize's hotels, condominiums and guest houses are located along the coast. In Placencia Peninsula an EIA found that of the average monthly use of 8,000,000 gallons in 2007/2008, 80 per cent of this volume (6,400,000 gallons/month) will be disposed of through sanitation systems, and ultimately be returned to the environment. The 2006 Engineers without Borders (EWB) study calculated an average monthly wastewater flow of 240,000 gallons per day which is 7,200,000 gallons of wastewater per month (Meerman 2010).

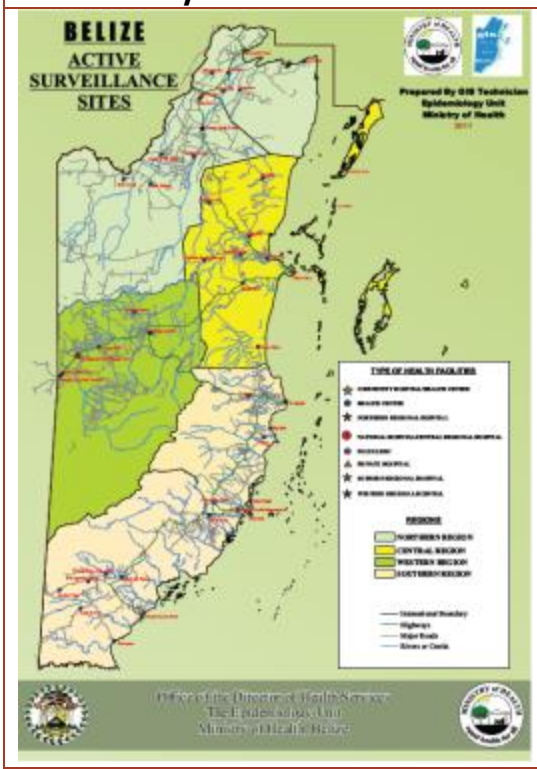
## COMMERCIAL AND OTHER INSTITUTIONS NOT CONNECTED TO SEWERAGE SYSTEMS

There are a number of commercial and other institutions such as hospitals and schools, which are not connected to sewerage systems. It is important for hospitals, regardless of their sewerage connection situation, to provide a level of treatment to their wastewater, because of the highly infectious liquid wastes they discharge. There are many public health threats imposed by improperly treated hospital wastewaters. Waterborne diseases that can be acquired from contact with hospital waste polluted waters are described below.

**Viral** – Hepatitis A, rotavirus, enterovirus, adenovirus y Coxsackie A y B, all of which cause diarrhoeas and vomit.
**Bacteria** – Salmonella sp, Shigella sp, *Vibrio cholerae*, *Escherichia coli*, among others
**Protozoa** – They are microscopic organisms. *Entamoeba histolytic*, *Giardia lamblia*, Cryptosporidium.
**Helminthes** – better known as worms. They get into the human body when people ingest polluted water or soil polluted with eggs.
**Respiratory** – Legionella pneumophila: pneumonia known as "trench diseases". (This has low water transmission.)

The health sector has different facilities around the country (Figure 11) (MOH 2011). There are 7 public hospitals, 32 health centres and 38 health posts and policlinics. In the private sector there are 6 hospitals and more than 32 private clinics. Table 17 presents the distribution of the health care facilities in Belize.

**Figure 11: Active Surveillance Sites, Health Services**




The majority of the wastewater generated in hospitals is not treated and is disposed directly underground. However, some positive steps have been taken.

- **The Punta Gorda Hospital wastewater management project**. For many years, the hospital in discharged poorly treated wastewater into the Gulf of Honduras. A Rotary International matching grant, with partner clubs from Idaho and Wisconsin, USA, corrected this problem. The total project funding was US$37,550 to build a new septic tank, a new collection system around the hospital campus and subsurface constructed wetlands (a wastewater garden) for high quality final treatment.
- The **Northern Regional Hospital**. The hospital had its septic systems renovated and a small treatment tank installed. Although some Belize national regulations do not allow the discharge of certain liquid wastes into the sewerage system and water bodies, the expired drug wastes from this hospital are diluted and finally disposed in the sink.

**Table 17: Health Care Network**

| Health Region | Pop Served | Hospitals | Hospital Names | Health Centres | Health Posts | Bed Capacity |
|---|---|---|---|---|---|---|
| Northern | 77,964 | 2 | Northern Regional Hospital<br>Corozal Community Hospital | 11 | 16 | 57 and 30 |
| Central | 93200 | 1 | Karl Heusner Memorial Hospital | 3 | 10 | |
| Western | 61000 | 2 | Western Regional Hospital - Belmopan<br>San Ignacio Hospital - San Ignacio | 4 | 0 | 50 and 16 |
| Southern | 61000 | 2 | Southern Regional Hospital<br>Punta Gorda Hospital/ Community Hospital | 14 | 12 | 52 and 30 |
| **Total** | **323,226** | **7** | | **32** | **38** | |

In regard to sanitation in schools, Chatterley (2011) found that:

- Only 21 per cent of schools have adequate sanitation, defined as access to improved toilets where the number of students per facility meets international standards for schools in low-cost settings: 25 girls per toilet and 50 boys per toilet and urinal (Adams cited in Chatterley 2011) (Table 18).

**Table 18 Structural Condition of Student Toilets (% of schools)**

| Component | Good | Fair | Poor | Very Poor |
|---|---|---|---|---|
| Internal door | 53 | 33 | 10 | 4 |
| External doors | 53 | 34 | 8 | 5 |
| Toilet seats | 56 | 29 | 10 | 5 |
| Toilet bowls | 51 | 29 | 15 | 5 |
| Toilet floor | 66 | 23 | 9 | 3 |
| Septic tank | 62 | 21 | 9 | 8 |
| Urinals | 47 | 38 | 9 | 7 |
| All toilet components are in good condition: boys 33%<br>girls 33%<br>teachers 42% | | | | |

- Flush toilets are the most common sanitation technology found in Belizean schools and constitute 77 per cent of school bathrooms nationwide: 96 per cent in the urban areas and 69 per cent in the rural areas. Twenty per cent (20 per cent) of schools have some other type of improved sanitation technology, including pit latrines (12 per cent), ventilated improved pit (VIP) latrines (7 per cent), and composting toilets (1 per cent). Three per cent (3 per cent) have unimproved sanitation such as pit latrines without a slab – all in rural areas.
- Age of toilets: 39 per cent of school toilets have been constructed within the past five years, while 11 per cent of toilets were constructed over twenty years ago.
- Toilet quantities: 30 per cent of schools nationwide meet the standard for girls' toilets and 33 per cent meet the standard for boys' toilets and urinals (individually, 60 per cent and 46 per cent meet the standard for boys' toilets and urinals, respectively). The urban areas struggle the most to provide sufficient quantities for their typically larger student population and smaller land area.
- Gender separated facilities: The majority of schools (94 per cent) provide separate toilets for girls and boys. There is no significant difference in the existence of gender separated facilities between the urban and rural areas.
- Toilet location: 36 per cent and 38 per cent of schools have boys' and girls' toilets located within the school building, respectively. Urban schools are more likely than rural schools to have toilets within the school building.
- In regard to treatment and disposal of wastewater in schools it has been found that 62 per cent of septic tanks are in good condition, 21 per cent in fair condition, 9 per cent in poor condition and 8 per cent in very poor condition.

## SEWAGE DISCHARGED INTO WATER BODIES

Forty-five per cent (45 per cent) of Belize's population of 310,000 (CSO, 2007) lives in the coastal zone. Presently, about 28 per cent of the population (living in Belize City, San Pedro Town and Belmopan City) are connected to sewerage systems (WHO / UNICEF 2012b). All other areas are serviced with septic tanks and pit latrines. The 227.9 million litres of sewage (including wastewater) from the Belmopan sewerage system is disposed of directly into the Belize River; 248.6 million litres of sewage from San Pedro flows into a shallow pond and into the sea; and 3,039.3 million litres of sewage from Belize City is disposed of directly into the sea as the mangrove swamp once used as a natural filtration system has been cleared for tourism development. Phosphorus from sewage is believed to be a major point source of pollution to the marine environment (DOE 2008). The total amount of water discharged is 3,515.98 million litres per year and 2,521.28 million litres (71.1 per cent) are treated (Table 19).

**Table 19: Amount of Wastewater Produced and Discharged, Treated and Capacity Installed by Wastewater Plants**

| City | Population Total | Households connected | Waste water Generated Million litres/year | Disposal Site | Capacity of Plants Million litres/year | Actual Treatment Million litres/year |
|---|---|---|---|---|---|---|
| Belize City | 53,532 | 6,665 | 3,039.360 | Sea | 2,072.2875 | 2,072.2875 |
| San Pedro Town | 11,510 | 307 | 248.674 | Mangrove/Sea | 221.0440 | 221.0440 |
| Belmopan | 13,654 | 879 | 227.951 | River | 276.3050 | 227.9510 |
| **Total** | | | **3,515.980** | | **2,569.6365** | **2,521.2825** |

Marine-based tourism is one of the main types of tourism promoted in the country. Phosphates and nitrates from sewage and bilge (ballast water) are discharged directly into the marine environment from live-aboard vessels. Cruise ships and other marine vessels' effluents are a major threat to the health of Belize's marine environment. This is especially alarming as a constant monitoring plan or sewage discharge/disposal facilities are not in place to safeguard discharge of effluents from these vessels (DOE 2008).

## SEPTAGE/BIOSOLIDS MANAGEMENT

The Ministry of Works operates a septic tank emptying service for a fee (PAHO 2000). Septic tanks are emptied by sanitary service personnel and the sludge disposed of at landfills. In the case of Placencia, two villages on the peninsula, each household and business is responsible for its wastewater. Systems most used are septic systems with a form of soak-away (soak away field, leach pit) and vaulted pit latrines, vaulted septic systems whereby the vault does not have a sealed bottom. Sanitary waste is collected and dumped on the beach or in the sea/lagoon (Meerman 2010). It is assumed that the same procedure is used in other towns.

No information was found on the management of biosolids, but it is suspected that they are disposed in the same manner as septic tank sludge is disposed of.

## CONDITION OF WASTEWATER TREATMENT INFRASTRUCTURE

Belize Water Services currently operates and maintains sewerage systems in Belmopan, Belize City and San Pedro Town. None of the municipalities served by these sewerage systems enjoy 100 per cent coverage. The systems came into operation in 1970, 1980 and 1996 respectively (BWS 2012), meaning that all three systems are more than 15 years old. The condition of the infrastructure is found to be in a fragile state.

Pit latrines and septic tanks are the most common forms of sanitation infrastructure in rural areas. Most systems are constructed by home owners, starting with a pit latrine and later investing in a septic system when they can afford it. It is common for homeowners to gradually expand their houses, at the same time improving the standard of housing with bathrooms and toilet facilities. The knowledge of how to build a septic system and a soakaway is often gleaned from neighbours or family members and copied without knowing the reason for the construction specifications (UNDP 2011b).

# 6. POLLUTION PROBLEMS AND THEIR COST

## POLLUTION IN RIVERS, LAKES, MANGROVES AND COASTAL AREAS (THERMAL POLLUTION AND NUTRIENT POLLUTION)

According to a study conducted by IDB (2011), the lack of proper environmental planning and infrastructure development has set back Belize City in providing its residents and visitors with a safe and environmentally approved manner of disposing its wastewater. Historically, waste management was by pit latrines and bucket parades to nearest creek, river or 'bush'. Grey or residual water was simply funneled to a nearby drain, soak away or water body. It was a 'out of sight, out of mind' mentality that the early inhabitants practiced. Presently, not much has changed and the same traditional methods are used today, mostly, though by the poor population with no basic sanitary infrastructure.

There are a myriad of direct environmental impacts associated with both practices. These impacts include increased nutrients to the water bodies and the proliferation of pathogenic diseases through direct contact with fecal matter. These pollutants lead to disease of the nervous, gastrointestinal and reproductive systems. Diseases associated with contaminated water include cholera, typhoid bacillary dysentery, and infectious hepatitis. The polluted water causes various skin infections in children and adults who take bath in the polluted streams.

The effects of pollutants on aquatic systems are primarily a function of the amount and nature of the contaminants introduced (Corbitt, 2005). The situation of increased nutrients in the water bodies is generally referred to as eutrophication. This relates to the macro-nutrients, which are 'phosphates' and 'nitrates'. These are generally derived from gray water effluents, as well as sewage effluents from the flushing of toilets and human sanitizing.

A major source of macro-nutrients in gray water effluents is from detergents and is primarily generated by the residential and industrial/tourism component. Another potential source of macro-nutrients is from the general decomposition of the organic substances within the sewage and grey water. The magnitude and scope of this potential sources and its impact has been assessed as 'moderate to high' without proper mitigation measures. Secondary impacts of these macro-nutrients and pathogen contamination include loss in recreational activity and loss of aquatic biodiversity and productivity.

The Belize National Program Report (DOE 2008) reported that the nutrient load from sewage is believed to be increasing with the steady growth in population living in the low-lying coastal areas like Placencia, Ambergris Caye, and other small cayes. In addition, tourism (mainly marine-based) is increasing in Belize; cruise tourism is the fastest growing sector and has increased seventeen-fold between 2001 and 2005 from 48,116 to 800,331 tourist arrivals. Overnight tourist arrivals have also increased. This is an immense concern, particularly as most of the coastal zone is vulnerable to flooding and currently has inadequate sewage treatment facilities.

Increased supply of nutrients to the marine environment is a major threat to the health and sustainability of the sensitive marine ecosystems including coral reefs, and sea grass beds. The

impacts of increasing nutrient supply vary depending on the level of eutrophication. The effects of moderate eutrophication include increased growth of phytoplankton, benthos and fish to changes in species composition. Severe eutrophication effects include algal blooms that may be toxic to growth of certain species and death of others. Several examples are presented below:

- Algal blooms and "fish kills" have been reported occasionally in the country in rivers such as the New River in the Orange Walk District and have been attributed to nutrient rich effluents entering catchments from point and non-point sources.
- Some other incidents of elevated nitrate levels have been recorded in Belize City, Port Honduras Marine Reserve in Toledo, Dangriga and Cayo; however, these may be due to natural nitrogen dissolved in rain or due to soil mineralization releasing nutrients naturally in the rivers of watersheds.
- Low dissolved oxygen was noted at Haulover Creek, Belize District, near the sugar storage facility. Phosphate levels recorded have generally been within acceptable limits.
- Sulphate levels of the effluents from aquaculture farms are generally above the normal recommended value of 200 ppm (Effluent standards, DOE).
- Hydrocarbon residues have been observed in the marine environment although there has been no major oil spills in the country. Hydrocarbons (primarily diesel from pleasure crafts and crude oil from oil tankers) are a major threat to Belize's marine environment. Oil residues and slick can result in death to many marine species such as corals and wildlife and destroy inter-tidal habitats of endangered species such as birds and marine turtles.
- Aqua Mar is located at the southern boundary of the lagoon and its effluents are released into wetlands in the northeastern tip of the Sennis River Catchment. Taking into account the predominant southerly coastal currents, the impacts of this operation on the Placencia Lagoon are questionable.
- According to the Placencia Citizens for Sustainable Development (PCSD), shrimp farms in the past had impacted the flora and fauna of the lagoon by discharging untreated waste water that resulted in the decline of the sea grass beds which are particular important to dolphins and manatees. During the last years, most of the shrimp farms on the Placencia Lagoon have significantly reduced their run-off and effluent load through voluntary efforts. To maintain a healthy lagoon, the existence of the marsh lands and the mangroves are needed.

While several observations have been made and documented of nutrient pollution in isolated areas of the country, there has been no study done to quantify the impacts of nutrient pollution. Neither have there been any sustained monitoring programmes to determine the nutrient load within waterways leading to the marine environment.

The country can be divided into five major regions (Fernandez 2002) based on its agricultural activity and system of rivers, as follows:

1. The Rio Hondo and New River generally empty into the Chetumal Bay/Corozal Bay Region.

These rivers carry waste from the sugarcane industry including agricultural runoff from the sugarcane fields and waste from the Tower Hill factory.

2. The Belize River empties into the Belize City area. This river forms from a confluence of the Macal and Mopan River and later the Roaring Creek. Pollution from this source is mainly agricultural and residential from the towns (Benque Viejo, San Ignacio, and Belmopan) and villages along its path.
3. The North Stann Creek empties into the Dangriga Area. Agricultural runoff from the Stann Creek Valley as well as effluent from the two citrus processing plants empty into this river. Additionally, both the Sittee and South Stann Creek River have banana plantations along its banks.
4. The Monkey River, Sennis River and August Creek empty into the Placencia Lagoon region. The predominant agricultural activity is banana production and shrimp farming. Most of the country's shrimp farms are in this area.
5. The Sarstoon and Temash Rivers empty into the Gulf of Honduras region. This region consists of mostly small vegetable farmers involved primarily in the planting of rice, beans and corn. There are also some citrus orchards.

Typically, the northern part of the country is generally flat and the rivers are slow moving. The slow moving nature of the New River is manifested in its low dissolved oxygen (DO) content. In the south, the terrain is hillier and as a result the rivers are faster flowing. The flood plains of the north help in dispersing some of the sediments and detritus from these rivers. The mangroves in these plains help to hold back a large amount of the waste being transported by the rivers during flooding. This effect is not as pronounced in the south.

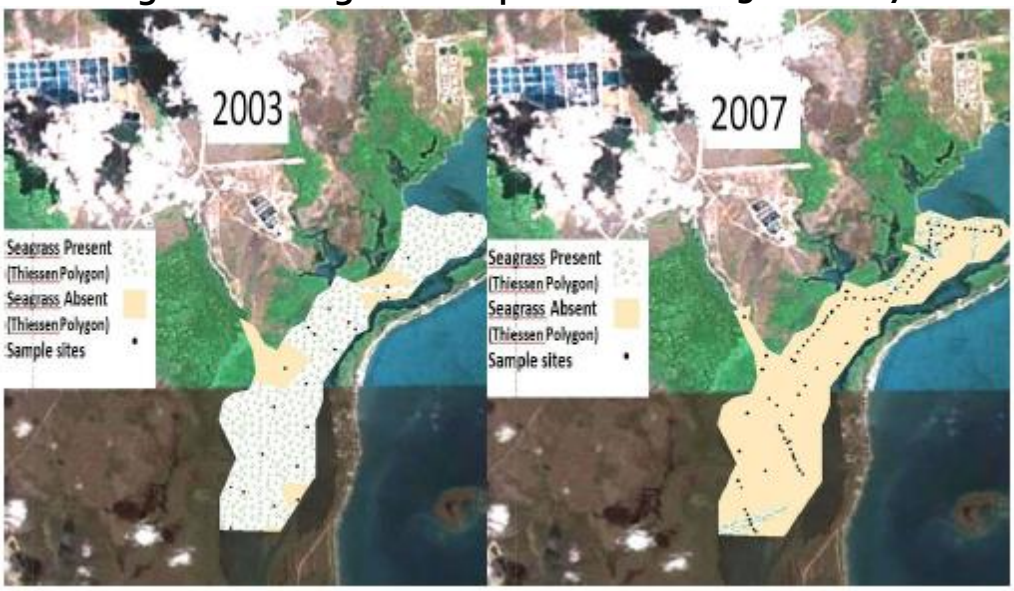
## ENVIRONMENTAL DETERIORATION SUCH AS TOXIC ALGAE BLOOM AND DESTRUCTION OF CORAL REEFS

As previously mentioned, algal blooms and "fish kills" have been reported occasionally in rivers such as the New River in the Orange Walk District and have been attributed to nutrient rich effluents entering catchments from point and non-point sources (DOE 2008).

A study assessed the ecological impacts of the Belize Aquaculture Ltd. (BAL) and Aquamar shrimp farms in southern Belize (Ledwin 2010). Water and *in situ* periphyton samples (measuring nitrogen content, $\delta^{15}N$, carbon/nitrogen ratios, and growth) indicated that shrimp farm effluent was influencing receiving waterways. At BAL, periphyton sampling showed significant elevation of nitrogen content, $\delta^{15}N$, and growth within the group of sites below the effluent release creeks. Compared to other BAL sampling sites, nitrate, phosphate and total suspended solids (TSS) were the highest and DO the lowest at sample sites in Santa Maria Creek, the major effluent release point at BAL. Seagrass distribution decreased significantly in the middle portion of Placencia Lagoon between 2003 (Garcia) and 2007, coinciding with increased nutrient loading from BAL and adjacent development in the area (Figure 12). The map in Figure 12 represents results of the Theissen polygon nearest neighbour analysis using presence or absence data. At Aquamar, sampling showed significantly higher $\delta^{15}N$ and

significantly lower carbon/nitrogen ratios within the group of sites closest to the effluent source (<2500 m). Compared to other Aquamar sampling sites, nitrate and TSS were highest and DO lowest in Plantation Creek, the major effluent release point at Aquamar. The suite of parameters used in this study helped elucidate the magnitude and extent of the influence of shrimp farm effluent on the two receiving waterways.

**Figure 12: Seagrass Sample Sites in 2003 and 2007**




Map from Google Earth. Imagery Date 28 November, 2004 (Mountain View, California, Google Corporation).

## HUMAN SHELLFISH AND REEF FISH POISONING

The presence of CFP dinoflagellates and cases of human poisoning are described below.

A study conducted by Maria A. Faust (2009) reported that harmful and potentially toxin-producing and CFP dinoflagellates in the genera *Gambierdiscus, Ostreopsis, Coolia* and *Prorocentrum* seem to be commonly found in coral reef mangrove marine environments in Belize. Dinoflagellates were present on macrophytes, sand, floating detritus, and during blooms. Marine embayments that are protected from wind have low water turbulence and restricted water exchange from the lagoon and high nutrients would favor dinoflagellates suggesting that increased nutrient inputs in the oligotrophic Belizean central lagoon will favor a shift toward CFP-dinoflagellate species. This species shift may have consequences for food web dynamics and the prevalence of toxin-producing dinoflagellate population in the food chain.

In 2009 a case of ciguatera poisoning occurred in Ambergris Caye (Ambergris Caye Forum 2009) in a 16-year-old boy, who ate mostly mackerel caught near the caye. Ciguatera is a food borne illness in humans caused by eating marine species whose flesh is contaminated with a toxin known as ciguatoxin, which is present in many micro-organisms living in tropical waters.

Fish such as barracudas, snapper, moray eels, parrot fishes, groupers, trigger fishes and amberjacks, are most likely to cause ciguatera poisoning, although many other species (including lobster) have been found to cause occasional outbreaks of toxicity. Ciguatoxin is very heat-resistant, so ciguatoxin-laden fish cannot be detoxified by conventional cooking. Cases of ciguatera poisoning have been few in Belize in the past, but with the increase in development more fish species will likely be affected in the future. The Ministry of Health reports that the number of cases of ciguatera fish poisoning are so low they do not even appear in the annual stats. However, it is a problem in other Caribbean countries. In a study done by the Caribbean Epidemiology Centre (CAREC) (2008) over a twenty-five year review period, there has been an increasing trend over the past three decades with a peak of 736 cases reported in 2001. The majority of ciguatera poisoning cases in the Caribbean were reported by Antigua and Barbuda and The Bahamas.

## WATER- AND FOOD-RELATED ILLNESSES CAUSED BY BAD SANITATION

Diarrhoea outbreaks and burden of environmental diseases are discussed below. They are closely related to water and sanitation conditions.

- Intestinal infectious diseases rank 8$^{th}$ (557 cases) among the ten leading causes of hospitalization for all ages - Belize 2010 (MOH 2010). In March 2010 an outbreak of gastroenteritis occurred in Belize (Channel 5 Belize 2010). In the tourism industry, several hotels and food handling facilities were blamed by customers for contracting gastroenteritis from their facilities.
- WHO has estimated the environmental burden of disease for Belize to be 810 DALYs (Disability Adjusted Lost Years), which is low compared with other Latin American and Caribbean countries (Table 20).

## Table 20: Belize Profile of Environmental Burden of Disease

# Belize

| | |
|---|---|
| Population | 270 000 |
| GNI/capita | 6 200 US$ |
| % urbanization | 48% |
| % people living in cities greater than 100 000 inhabitants | 25% |
| Population below the poverty line (national) | NA |
| Population below the poverty line (international, <$1/day) | NA |
| Under age 5 mortality rate | 16/1000 live births (2006) |
| Life expectancy | 69 years (2006) |

**Environmental burden of disease for selected risk factors, per year**
Estimates based on national exposure and WHO country health statistics 2004

| Risk factor | Exposure | | Deaths /year | DALYs/ 1000 cap /year |
|---|---|---|---|---|
| Water, sanitation and hygiene (diarrhoea only) | Improved water: 91%<br>Improved sanitation: 47% | | - | 2.5 |
| Indoor air | SFU% households: | 43% | - | 1.9 |
| Outdoor air | Mean urban PM10: 12 ug/m3 | | - | - |
| Main malaria vectors | *A. albimanus; A. darlingi; A. vestitipennis; A. pseudopunctipennis* | | | |
| Main other vectors | *Culex quinquefasciatus, Anopheles darlingi, Lutzomyia cruciata, Triatoma dimidiate,* | | | |

**Environmental burden of disease (preliminary), per year**
Estimates based on Comparative Risk Assessment, evidence synthesis and expert evaluation for regional exposure and WHO country health statistics 2004

| | | |
|---|---|---|
| DALYs/1000 cap | (World - lowest: 13, highest: 289) | **37** |
| Deaths | | **330** |
| % of total burden | | **18%** |

Environmental burden by disease category [DALYs/1000 capita], per year

| Disease group | World's lowest country rate | Country rate | World's highest country rate |
|---|---|---|---|
| Diarrhoea | 0.2 | **2.7** | 107 |
| Respiratory infections | 0.1 | **2.2** | 71 |
| Malaria | 0.0 | **0.1** | 34 |
| Other vector-borne diseases | 0.0 | **0.2** | 4.9 |
| Lung cancer | 0.0 | **0.2** | 2.6 |
| Other cancers | 0.3 | **1.2** | 4.1 |
| Neuropsychiatric disorders | 1.4 | **2.5** | 3.0 |
| Cardiovascular disease | 1.4 | **2.9** | 14 |
| COPD | 0.0 | **0.5** | 4.6 |
| Asthma | 0.3 | **1.6** | 2.8 |
| Musculoskeletal diseases | 0.5 | **0.6** | 1.5 |
| Road traffic injuries | 0.3 | **5.0** | 15 |
| Other unintentional injuries | 0.6 | **7.7** | 30 |
| Intentional injuries | 0.0 | **2.3** | 7.5 |

**Other indicators**

| | | |
|---|---|---|
| Use of leaded gasoline | No | (2008) |
| Overcrowding | NA | |
| Malnutrition (% stunting) | 22% | (2006) |

World Health Organization

Public Health and the Environment
Geneva 2009

## VECTOR-BORNE DISEASES (DENGUE, MALARIA, YELLOW FEVER, ETC.)

A review of data (Vanzie 2008) related to the occurrence of dengue in the period 1995-2007 reveal that low levels of dengue transmission have been consistently occurring in all districts during this period (Table 21).

**Table 21. Dengue Cases for Years - Recorded with Complete Data**

| Districts | 1995 | 2002 | 2005 | 2007 |
|---|---|---|---|---|
| Corozal | 1 | 9 | 8 | 72 |
| O. Walk | 21 | 7 | 3 | 17 |
| Belize | 46 | 22 | 19 | 159 |
| Cayo | 15 | 3 | 614 | 18 |
| S.Creek | 7 | 0 | 5 | 39 |
| Toledo | 10 | 0 | 1 | 3 |
| Unknown | | | 2 | 23 |
| **Totals** | **100** | **41** | **652** | **331** |

The trend is toward an increased incidence of dengue and all virus serotypes have been isolated. The risk to the population as determined by the 2007 incidence was 0.00106 with the Corozal District exhibiting the highest risk. Data from different years consistently show June to November as the period of highest occurrence. There is a strong correlation (Pearson Product Moment "r" of 0.758) between dengue seasonal variation and monthly average rainfall.

An entomological cross-sectional survey conducted during the month of August 2008 revealed the presence of the virus in all districts. The vector density as determined using the Breteau and other entomological indices is high, requiring urgent attention. Seventeen (17) per cent of surveyed communities had a Breteau Index below 2 per cent (Table 22). This is the threshold (even though disputed) below which dengue transmission is unlikely. Thirty-nine (39) per cent had Breteau Indexes between 2 and 5 per cent; this level of larvae infestation supports the maintenance of endemic dengue and low-level outbreaks. Eight communities (44 per cent) had larvae infestation as determined by a Breteau Index value of between 6 and 24 per cent; the probability of dengue outbreak is very high in these communities.

**Table 22: Entomological Indices by District and Village- Belize 2008**

| District | Village | House Index | Cont. Index | Breteau Index |
|---|---|---|---|---|
| **Corozal** | Ranchito | 4% | 2% | 4% |
| | Paraiso | 3% | 2% | 3% |
| | Little Belize | 9% | 2% | 9% |
| **Orange Walk** | Douglas | 2% | 1.4% | 0.2% |
| | Fire Burn | 0% | 0% | 0% |
| | Trial Farm | 3.8% | 1.3% | 4.7% |
| **Belize** | Double Head | 3.9% | 1.1% | 3.9% |

| Table 22: Entomological Indices by District and Village- Belize 2008 | | | | |
|---|---|---|---|---|
| **District** | **Village** | **House Index** | **Cont. Index** | **Breteau Index** |
| | Cabbage | | | |
| | Barrel Boom | 4.2% | 3.1% | 4.2% |
| | Crooked Tree | 7% | 2.4% | 9% |
| **Cayo** | Santa Familia | 9% | 6.32% | 16% |
| | Ontario | 16% | 7.28% | 22% |
| | Cristo Rey | 9% | 5.21% | 17.14% |
| **Stann Creek** | Valley Community | 0% | 0% | 0% |
| | South Stann Creek | 14% | 13.6% | 24% |
| | Hope Creek | 7% | 3.8% | 9% |
| **Toledo** | Blue Creek | 4.9% | 2% | 4.9% |
| | Forest Home | 4% | 9% | 4% |
| | San Antonio | 8.7% | 3% | 12% |
| Source: Entomological Survey. Vanzie et al, 2008. | | | | |

Dengue transmission is related to sanitation, including septic tanks and sewer lines (Barrera 2008). It is important to mention this, because in the past, dengue-carrying mosquitos' natural habitat was related to only clean and stagnant water. But studies made in Puerto Rico and Peru by the US Centers for Disease Control and Prevention (CDC) have reported the discovery of dengue-carrying mosquitos that can actually harbour the dengue virus underground, in septic tank and sewer systems. In the case of Belize, there is likely to be a sudden increase in dengue cases if the disease-carrying *Aedes aegypti* mosquito adapts to dirty environments in the country.

It must be noted that the *Aedes aegypti* mosquito also transmits the chikungunya virus which spread rapidly across many Caribbean countries in 2014. While only a few cases were recorded in Belize (Manzanero 2014), this additional illness creates additional incentive to take precautions to minimize the *Aedes aegypti* mosquito population.

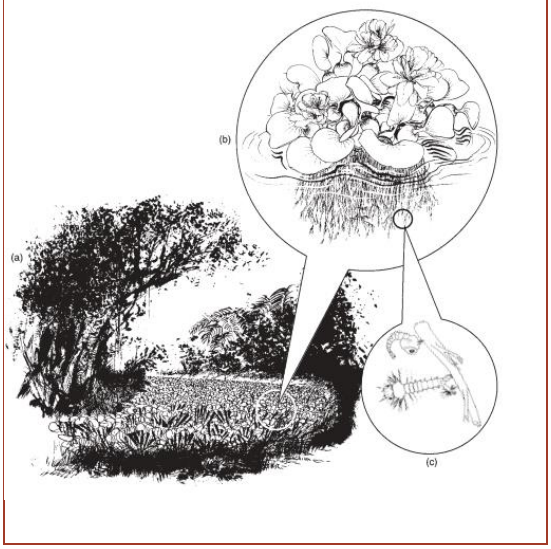
The malaria incidence rate is 0.5/1,000 at the national level, being the highest (2.8/1,000) at Stann Creek (MOH 2011). It has been mentioned previously that processing of citrus into concentrate made the largest contribution of organic load to the North Stann Creek River. The organic contributions of carbon, nitrogen and phosphorous create the optimum conditions for eutrophication and hence mosquito breeding sites. Eutrophication may occur in slow movement waters and water hyacinths may grow.

The correlation of breeding of mosquitos to hyacinth growths has long been an established and recognized fact. It has been found that these plants harbour mosquito larvae and otherwise protect them from fish and other beneficial forms of life which feed on the larvae. In

areas where malaria is a hazard, the removal of water hyacinth plants was one of the accepted control measures for controlling the breeding of anopheline mosquitos (Tabita 1962).

Moreover, in treating bodies of water where mosquito breeding is associated with hyacinth growths, a larger amount of the larvicide is required and the result of the treatment is not as effective. Thus the cost factor is increased by hyacinth growths not only because of the material cost of the larvicide, but also because of the labour time element and the frequent periodic treatment necessary for adequate control. Water hyacinths are the host of Mansonia and culex mosquito species, the larvae of which obtain their oxygen beneath the water surface through the roots of these plants (Figure 13). Mansonia mosquitos are mostly found in marshy areas in tropical countries (WHO 1997). According to Belding (1970), this species is known to be a vector of filariasis.

**Figure 13:** A canal in which the water surface is covered with floating mats of water hyacinth (*Eichhornia)* (a) On the right (b), the water hyacinth in more detail. *Mansonia* larvae and pupae are attached to the roots, from which they take oxygen for breathing (c).




## DETERIORATION OF BATHING AND RECREATIONAL AREAS

The recent accelerated growth in the tourism and aquaculture industries has resulted in significant impacts on the country's natural resources (Cooper, E.,L. Burke and N. Bood 2009). Concerns have been raised about the level of coastal development and the ability of the ecosystem to cope with modification or loss of habitat as a result of land clearing, land reclamation, dredging, increased effluent loads and increased human activities.

Lead agencies in the tourism, fisheries and aquaculture sectors have been promoting the use of best practices for operators in these industries. The current 'green' revolution is providing incentives for operators to develop eco-friendly ways of doing business.

A review of EIAs for Blackadore Caye, Stake Bank and Ara Macao indicated the presence of *Escherichia coli* (*E. coli)* in recreational water. The EIA results indicated that all samples were above the allowed levels for drinking water and the area of southern Belize around Placencia was the only site that was above the standard for recreational purposes. A report from the Public Health Department indicated that the department has had to declare Belize Beach a no swimming area as there have been cases of skin problems by people swimming in these waters (DOE 2008).

Currently, there is no monitoring programme for sewage in the marine ecosystem. However, there is investigative evidence that *E. coli,* which is in indicator that sewage is present, has

been detected within the Bahia de Chetumal, in Corozal Bay, near Blackadore Caye in the lagoon system, north of Belize City, and on the beaches of Dangriga Town and Placencia. Such water-borne and beach evidence was found in these areas but its eastward extent is not known. These levels of *E. coli* can lead to temporary eutrophication of the water, reducing the transparency of the water. This reduction in transparency can lead to reduction of available sunlight for coral reef and reduce reef growth (DOE 2008).

In addition to the health risk and ecological damage that can result from sewage, this pollution is a substantial threat to Belize's tourism industry. The health of Belize's marine ecosystem's flora and fauna are integral to the tourist industry on San Pedro Ambergris Caye, Caye Caulker, Belize City, Dangriga, Placencia and Punta Gorda Town (DOE 2008).

## SOCIAL IMPACT DUE TO DETERIORATION OF THE ENVIRONMENT

Social impacts can be defined as the consequences to people of any proposed action that changes the way they live, work, relate to one another, organize themselves and function as individuals and members of society. This definition includes social-psychological changes, for example to people's values, attitudes and perceptions of themselves and their community and environment. Indeed, some Social Impact Assessment (SIA) practitioners consider social impacts to be only 'as experienced' (e.g. stress, disruption, hunger) and differentiate these from the causal processes (e.g. over-crowding, infrastructure pressure, poverty).

The key characteristics and variables that are often correlated with adverse social impacts of development include:

- demographic change, e.g. size and composition of resident population, influx of temporary work force or new recreational users (disrupts the cohesion of a small, stable community)
- economic change, e.g. new patterns of employment/ income, real estate speculation (marginalizes long term, older residents)
- environmental change, e.g. alterations to land use, natural habitat and hydrological regime (loss of subsistence or livelihood in resource dependent community)
- institutional change, e.g. in the structure of local government or traditional leadership, zoning by-laws or land tenure (reduced access or loss of control leads to disempowerment or impoverishment of the established population)

The main types of social impact that occur as a result of bad sanitation practices and environmental degradation can be grouped into five overlapping categories:

- *lifestyle impacts* – on the way people behave and relate to family, friends and cohorts on a day-to-day basis
- *cultural impacts* – on shared customs, obligations, values, language, religious belief and other elements which make a social or ethnic group distinct

- *community impacts* – on infrastructure, services, voluntary organizations, activity networks and cohesion
- *amenity/quality of life impacts* – on sense of place, aesthetics and heritage, perception of belonging, security and livability, and aspirations for the future
- *health impacts* – on mental, physical and social well-being, although these aspects are also the subject of health impact assessment (see Topic 6 – *Impact analysis*).

As an example we refer to a questionnaire survey of 100 randomly selected individuals living in Orange Walk Town and Palmar Village, who are affected by the water pollution caused by the discharge of the Belize Sugar Company (Chicas 2008).

The data collected from the questionnaire showed that among the 95 respondents:

- 35 per cent strongly agreed that New River in their community was polluted; 45 per cent agreed and the other 20 per cent was distributed between neutral, disagree, and strongly disagree
- 73 per cent stated that the New River had bad odour
- 85 per cent stated that the New River had unusual dark coloration
- 62 per cent have been witnesses of fish kills in the river as a result of pollution
- 66 per cent considered the New River to be an important recreational area
- 59 per cent answered that at some point in time they had had displeasure as a result of living too close to the river
- 67 per cent knew someone that had become ill as a result of swimming in the New River
- 17 per cent stated that they had suffered illness and thought it was because of the current situation with the New River

## ECONOMIC IMPACT DUE TO DETERIORATION OF THE ENVIRONMENT

Total tourist spending associated with coral reefs and mangroves in Belize was estimated in 2009 at approximately US$150 - US$196 million per year (Table 23). In addition to direct economic impacts in the tourism sector, there are additional impacts on the economy from spending by reef- and mangrove-associated visitors. These "indirect" impacts are not included in an economic valuation, but would be included in an economic impact assessment.

**Table 23: Economic Contribution of Reef- and Mangrove-associated Tourism**

| Tourist Expenditure Categories | Gross Revenues ($US million/year) |
|---|---|
| Reef/Mangrove-associated Accommodation | $56.3 – 75.4 |
| Reef/Mangrove Recreation | |
| Diving | $20.1 – 25.1 |
| Snorkeling | $10.1 – 12.6 |

| Table 23: Economic Contribution of Reef- and Mangrove-associated Tourism | |
|---|---|
| **Tourist Expenditure Categories** | **Gross Revenues ($US million/year)** |
| Sport Fishing | $7.2 – 8.5 |
| Other | $0.2 – 0.3 |
| Other Visitor Expenses | $31.8 – 44.7 |
| Cruise Tourism | $4.6 – 5.7 |
| Taxes and Fees | $19.6 – 23.4 |
| **Total Direct Impact** | **$149.9 - 195.7** |
| Source: Cooper 2009 | |

The valuation findings underline the extent to which coastal and marine ecosystems provide vitally important goods and services to Belize's economy. The protection they furnish from erosion and wave damage from coastal storms, valued at US$231 – US$347 million in avoided damages per year, is especially notable, and highlights the importance of protecting coral reefs and mangroves for their less visible services as well as for the more obvious benefits of fisheries and marine tourism. As these resources become increasingly threatened, it is critical to recognize the value they provide, and to incorporate them into decision making

The foreseen economic impact from deterioration of the environment as a consequence of a deficient waste management can be grouped on the areas of health, tourism and food safety.

As mentioned previously, bad sanitation can increase the cases of diarrhoea, dengue and malaria and this has an impact on human capital development. What people can achieve contributes to human capital development. In this regard, Theodore Schultz formulated his theory about development – where to achieve it, human as well as fixed capital should be considered. The possibility, the capability of human beings to produce and contribute is called human capital. The two most important ingredients to achieve this are health and education. Schultz produced his ideas of human capital in the 1960s to explain the advantage of investing in health and education in order to improve agricultural production. He demonstrated that human capital production in the US economy was higher than that based on physical capital (i.e., a new plant or machine).

For Schultz, the concept of human capital implies investing in people. He argues that education, training and health investments open opportunities and options that would normally not be available to many individuals. He compares the acquisition, knowledge and skills to the "acquisition of production means". Workers should not be at mercy of others. To the contrary, they can control the increase of their own productivity and income. He defends that income difference among persons is related to differences in education and health.

In the past, the belief was that fixed capital investment was the most important contributor for the future growth of a country. But, Schultz has demonstrated this is wrong – investment in

human capital contributes up to 65 per cent to the economic growth of a country. When we talk about poverty, or how to improve the situation of a country, we should never forget human capital, because it contributes to the growth of wealth in that country.

Health status can influence poverty itself but, contrarily, health can contribute to the productivity or wealth of a country. It is obvious that ill persons cannot contribute to their own development or to their country; their productivity is relatively low. Health is an element that impacts on well-being and contributes to economic growth in four ways. It reduces production losses by workers infirmity; allows the use of natural resources that, due to diseases, were totally or practically inaccessible; increases school enrollment of children and allows them to learn better; and liberates, for other uses, resources needed to treat infirmity in other ways.

For example, in some classical studies in Central America in populations dedicated to agriculture, correction of anaemia has shown that productivity increases greatly. Iron deficiency and anaemia reduce the capacity of individuals and of the entire population causing serious economic consequences and obstacles for national development. Inversely, anemic treatment can increase national productivity by 20 per cent. Overall, the poorest and the least educated are more vulnerable and disproportionately affected by iron deficiency. These vulnerable groups benefit most from anaemia treatment.

Recent studies show that improvements in workers' health are associated with productivity improvements, particularly in workers whose income is low. There are many reasons why the relationship between productivity and health in developing countries is of special interest.

Ill health has an impact on the tourism industry. Some examples from other countries are provided below.

- In Mexico, the number of foreign visitors declined by 11.4 per cent in 2009 due to an AH1N1 (commonly known as swine flu) epidemic.
- In Rio de Janeiro, Brazil, cancellation of 45 per cent of room reservations occurred after a dengue outbreak was announced in the media.
- In French Reunion, a severe outbreak of chikungunya led to a decline in international tourist arrivals of up to 40 per cent.
- In southern Mozambique, there was a 44 per cent cancellation of rooms after a malaria outbreak was announced.
- Cook Islands lost tourism estimated US$ 3 million due to a dengue epidemic.
- In Malaysia and Thailand it has been estimated that a dengue outbreak would result in a 4 per cent decline in tourists from non-endemic countries.

Regarding the impact on tourism, a deteriorated environment will not be attractive to tourists who will look for other destinations. Beaches provide not only an important escape but also a crucial source of tourism revenue for beach communities. The paradox that beautiful locations attract tourists, who subsequently degrade the location leading to its abandonment as a desirable location has been widely noted.

Dyson (2010) has prepared an extensive discussion on the links between beach pollution and tourism. The following information is extracted from her paper. Many studies have found that clean beaches are one of, if not the, most important factor to tourist beach selection and enjoyment. Tourists associate the presence of wastes along the coasts with polluted beaches and poor water quality, and hence littered beaches are a major deterrent to tourism. In Wales, for 19 beaches studied, 'clean litter-free sand' and 'clean water' were the first and second most important factors in beach selection (Tudor, 2006). These results have been mirrored for beaches with a wide variety of characteristics in England (Tunstall and Penning-Roswell, 1998), South Africa (Balance *et al*., 2000) and Brazil (Santos et al., 2005), among others.

In South Africa, 85 per cent of out-of-town tourists and local tourists would avoid visiting beaches with more than 2 items of litter per square metre, and 97 per cent of visitors would avoid visiting if the beach had more than 10 large items per square metre (Balance *et al*., 2000). As a result, areas that are dependent on tourism can face serious hardship due to beach litter pollution. It should also be noted that local tourists, even more so than out-of-town tourists, are very sensitive to information about beach degradation (Tunstall and Penning-Roswell, 1998).

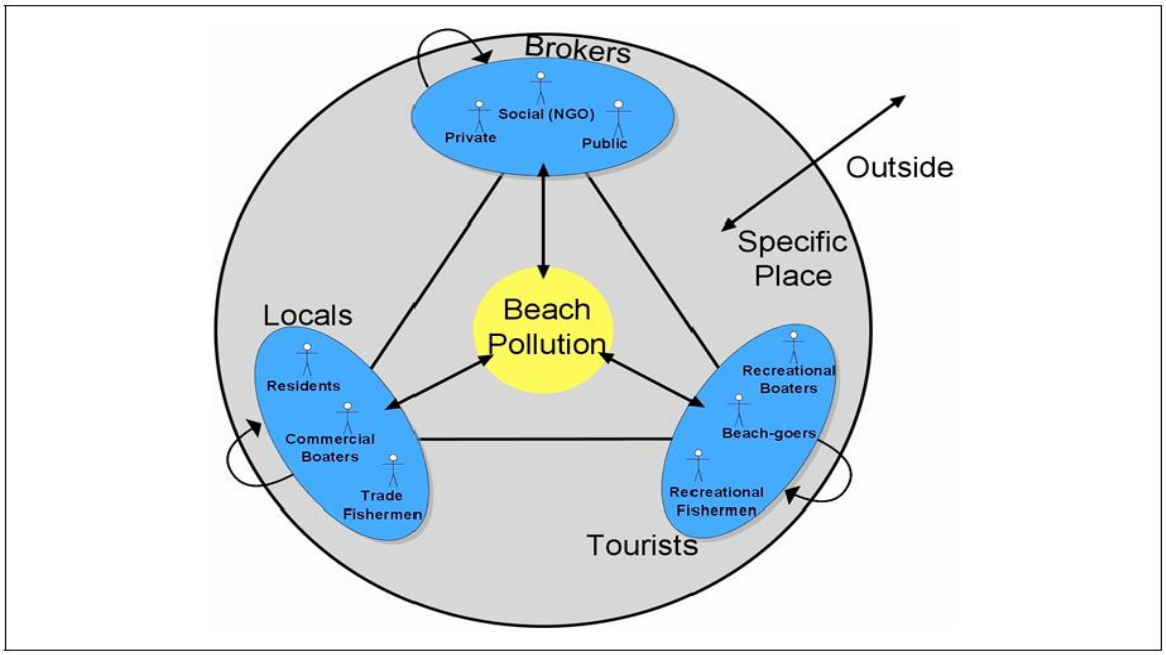
The effects of these aesthetic preferences include "a loss of tourist days producing damage to the leisure and tourism infrastructure; damage to commercial activities, *e.g*. fisheries, dependent on tourism; and damage to the resort image" (Tudor and Williams, 2006). Furthermore, if the media reports on a marine debris wash-up event, beaches that are not affected by the event will also see reduced visitation numbers and lost revenue (Ofiara and Brown, 1999).

The Broker-Local-Tourist (BLT) model is used as a basic framework in an attempt to explore the interactions between tourism and beach pollution. Miller and Auyong's BLT model (Figure 14) classifies the components of a tourism system into three groups. *Brokers* are those who are professionally involved in the tourism industry, and consist of *private sector brokers*, those who belong to the tourism industry, *public sector brokers* who regulate, legislate, and plan for tourism, and *social movement brokers* (or NGO brokers), who address tourism issues from outside the government and industry. Brokers are neither uniformly for or against tourism, and broker-broker conflicts are very common (Miller *et al*., 1999).

Public and private brokers, such as managers of municipal beaches or beach resorts, are often required to remove beach litter frequently to continue attracting tourists. This results in much higher maintenance costs, as beach cleaning is quite expensive. In South Africa, cleaning costs for the Cape Metropolitan Area for 1994-5 was R3.5 million, which is very expensive when compared to the value of these beaches (Ballance *et al*., 2000).

Clean-up efforts have since increased in scope and cost (Ballance *et al*., 2000). Publicly owned community beaches and local and national parks – the responsibility of public brokers – are also subject to increased maintenance costs for which the community must pay.

## Figure 14: The Place-Based Tourism Model




**Notes**: The place-based tourism model, which depicts the interactions between brokers, locals, tourists and the central element, here beach pollution, in the context of a specific place, in this case a beach.

When marine debris and beach litter cause tourists to avoid private brokers, as mentioned above, it negatively impacts the economy of tourism dependent communities. As a result, local businesses are often harmed, even if they are not directly involved in the tourism industry (Ofiara and Brown, 1999). This phenomenon is known as the 'multiplier effect' (Ofiara and Brown, 1999).

Local fishermen who rely on populations of near-shore fish for their livelihood are very vulnerable to events which harm fish stocks (Gregory, 1999, Ofiara and Brown, 1999; Ivar do Sul and Costa, 2007). Fisheries can be harmed through "outright mortality, loss of fish habitat and spawning grounds, and decreases in recruitment and gain in weight" (Ofiara and Brown, 1999). Ghost fishing caused by local fishermen's discarded nets can also cause high mortality of commercially valuable species. In Korea, 200 kg of king crab was found in derelict nets in one harbour (Cho, 2005). Harmed fish stocks will result in fishermen catching fewer fish, resulting in decreased incomes and possibly economic hardship.

Shellfish fisheries may need to be completely shut down if a health hazard is suspected. Furthermore, locals who own boats, even if they are not fishermen, are subject to the hazards of marine debris as described in the brokers section (Gregory, 1999). Similarly, locals who enjoy dining on locally caught fish, especially shellfish, are faced with safety issues if, sewage contaminates local waters or the marine debris contains medical waste (Ofiara and Brown,

1999). This can in turn reduce the prices that locals are willing to pay for local seafood, further depressing local economies (Ofiara and Brown, 1999).

It is also possible that locals and tourists will find that the devaluation of the beach goes beyond any lost community income or reduced enjoyment of beach facilities. The existence value – the pleasure derived from knowing something exists – along with the other intangible benefits of a clean beach is something that no study has yet examined. When marine debris and beach litter make beaches unpalatable, tourists are harmed because their beach experiences are less enjoyable. This is especially true when beach litter is sewage derived, or is perceived to be sewage derived even if it is not (Tunstall, 1998). Even at urban beaches, the illusion of being in and interacting with a 'natural' litter free environment is very important (Tunstall, 1998). The reactions people have to high levels of beach litter can be very strong.

This loss of enjoyment derived from the beach experience can be approximated using willingness to pay studies. These studies determine the amount a consumer, or in this case a tourist, would be willing to spend to increase the quality of the beach they are visiting. Estimates of this willingness to pay range quite a bit, and are often tied to tourists' incomes and other factors, but one estimate put the value of a linear foot of clean beach at US$14/year (Cho, 2005).

The impacts on beachgoers can also be more physical – 30 per cent of beach users surveyed had suffered problems caused by beach litter, mostly from cutting themselves on glass and other sharp materials (Santos *et al.*, 2005). The incidence of human diseases, along with general public health, has also been tied to beach litter and marine debris. These matters affect both tourists and locals. As mentioned previously, *E. coli* has been found in recreational waters around Blackadore Caye, Stake Bank and Ara Macao with the area of southern Belize around Placencia being the only site in that area that was above the standard for recreational purposes.

Recreational fishers, like local fishermen, are affected when fish stocks suffer due to marine debris (Ofiara and Brown, 1999). Fewer fish in the water means fewer fish caught per hour or per trip, greatly reducing the pleasure of fishing (Ofiara and Brown, 1999). Faced with this situation, some recreational fishermen either reduce the number of trips they take, or stop fishing in the affected location (Ofiara and Brown, 1999). If they choose to fish in alternate locations, they may face increased travel costs (Ofiara and Brown, 1999). Recreational fishermen will also reduce the number of fishing trips they take if the quality of fish is negatively impacted (Ofiara and Brown, 1999).

## LOST OPPORTUNITIES DUE TO DETERIORATION OF THE ENVIRONMENT

Lost opportunities have been covered in the preceding section.

# 7. NATIONAL CAPACITY

# EXISTING LEGISLATIVE FRAMEWORK

Sanitation regulations exist under different laws, and their enforcement therefore falls under different ministries and agencies. Legislation and enforcement should be revised and harmonized into one instrument, with one lead ministry spearheading all matters related to sanitation (UNDP 2011b).

The Environmental Protection Act (1992, revised 2000) regulates the use of natural resources and is administered by the Department of the Environment. The Act requires certain development projects to conduct environmental impact assessments prior to project implementation, regulates the prevention and control of environmental pollution, establishes prohibitions on dumping, and outlines the investigation, procedures and general penalties for offences. It also established the Department of the Environment to carry out the Act and conduct a broad range of related activities. Subsidiary legislation passed under this Act are:

- Environmental Impact Assessment Regulations, 1995
- Effluent Limitation Regulations, 1996,
- Pollution Regulations, 1996
- Environmental Impact Assessment (Amendment) Regulations, 2007

Chapter 329 of the Coastal Zone Management Act (1998, revised 2000) establishes the Coastal Zone Management Authority, an autonomous institution with the power to acquire, hold and dispose of property and do all things necessary for the fulfilment of its objectives. The Authority may exercise any of the functions entrusted to it by or in accordance with the provisions of this Act or any regulations made there under and may exercise any other duties incidental or ancillary to, or consequential upon, the performance of its functions. The functions of the Authority shall be to advise the Minister of Agriculture and Fisheries in relation to the development and utilization of the resources of the coastal zone in an orderly and sustainable fashion.

The Water Industry Act (revised 2000, 2003) covers national water services and is the responsibility of the Public Utilities Commission and Belize Water Services Limited. The Act addresses the regulation and provision of water and sewerage services, water abstraction and use, licenses, water pollution control, permits for discharge, and offenses and penalties.

The Land Utilization Act (revised 2000 and 2003) is the primary legislative instrument for land registration, subdivision and utilization. The Act establishes the Land Utilization Authority, which controls the sub-division of any public or private land in Belize. It establishes the Land Utilization Authority which makes recommendations on subdivision applications. It also establishes Special Development Areas which limit the types of development permissible within these zones. The Act is administered by Ministry of Natural Resources, through the Land Utilization Authority.

Belize has relatively good effluent regulations categorized by type of industry. The effluent licence system requires monthly reporting on effluent quality. The effluent limitation regulations were recently amended based on the LBS Protocol to address domestic sewage.

## EXISTING POLICY FRAMEWORK

There is no specific policy for wastewater management. However, a draft policy for water and sanitation coverage and maintenance has been formulated through the MDG Acceleration Framework (MAF) process. The MAF initiative supports developing countries to intensify efforts in meeting the MDG targets. The draft Water and Sanitation Policy aims to enhance access to improved water sources and sanitation and to guide institutional, economic, social and legal reforms that will lead to improved governance of the water and sanitation sector at the national and local level (UNDP 2011b).

The Rural Water Supply and Sanitation Programme (RWSSP), initially established within the Ministry of Health, was transferred to the Ministry of Natural Resources in 1987. The mandate of the programme is to provide potable water and sanitation services to all rural communities in Belize. In some communities, potable water is provided through strategically located hand pumps, while in others, rudimentary water systems are used to deliver water to the households. Until 2001, the Water and Sewerage Authority (WASA) provided significant technical support to the RWSSP. The programme provided piped water to communities with populations of more than 250 people. As a result, new rudimentary water systems were continually being established under WASA's supervision (PAHO 2000b).

The Government recently instituted a policy that requires coastal and island developments to use package treatment plants for sewage treatment (UNEP-CEP, 2009).

## EXISTING INSTITUTIONAL FRAMEWORK

There is no lead agency addressing sanitation issues and lack of cooperation and coordination among responsible entities is an issue (UNDP 2011b).

Responsibility for natural resources and freshwater and coastal resources in Belize is primarily concentrated at the national level. The Department of the Environment, under the Ministry of Natural Resources and the Environment is responsible for inter-ministerial cooperation and coordination on the use and management of Belize's natural resources and control of pollution of the natural environment.

The Department of the Environment was created in 1989 and legally established by the Environmental Protection Act of 1992. It is headed by a chief environmental officer and is responsible for monitoring the implementation of the Environmental Protection Act and the regulations made under it, and for taking necessary action to enforce its provisions. The Act provides for the appointment by the Public Service Commission of environment officers, inspectors, and other staff necessary to carry out the provisions of the act and any regulations made under it. The Act specifies 27 areas of responsibility under the heading of powers, duties, and functions of the department. Those related to various aspects of water resources

management are: assessment of natural resources; development control; land use planning; control of waste discharges; pollution control; pollution monitoring; enforcement; use of natural resources; policy formulation; cooperation; and public education.

The Forest Department, under the Ministry of Natural Resources and Environment, administers the Forest Act, National Parks Systems Act and Wildlife Protection Act. The Lands & Survey Department is responsible for land use planning and allocation through implementation of the National Lands Act and Lands Utilization Act (UNEP 2010).

Other government institutions that have some responsibility for natural resources primarily in the area of monitoring and permit granting for land and resource use are the Lands & Survey Department and the Department of Geology and Petroleum (under the Ministry of Natural Resources and the Environment), the Fisheries Department and Pesticide Control Board (under the Ministry of Agriculture and Fisheries). The Ministry of Health's Environmental Health Programme conducts some water quality monitoring related to public health, and the National Service of Meteorology (under the Ministry of Natural Resources and the Environment) is responsible for monitoring water level, and quantity of surface water, brackish water and freshwater in Belize.

The Ministry of Energy, Science, Technology, and Transport also has responsibility for management and provision of water and sanitation services. In addition, the Ministry of Agriculture and Fisheries, the Ministry of Works, and the Ministry of Housing are indirectly involved.

Before January 1995, the Ministry of Natural Resources was responsible for the activities of one quasi-governmental institution and two departments directly involved in the management and supply of water. These are the Water and Sewerage Authority (WASA) and the Rural Water Supply and Sanitation Programme. The Water and Sewerage Authority, a quasi-governmental institution, was established by the Water and Sewerage Ordinance, Chap. 185 of 1971. Under the Water and Sewerage Act, water supply and sewerage services are regulated by WASA.

As part of a privatization initiative of the Government, WASA was privatized in 2001. Belize Water Services Limited was formed in January 2001 and vested with the assets and liabilities of WASA in March 2001. Some 83% of the shares of BWS were acquired by Cascal, a joint British-Dutch company, via an investment agreement with the GOB. In October 2005, GOB repurchased the majority shares from Cascal, thereby ensuring Belizean ownership (BWS 2012).

BWS is responsible for urban and adjacent areas in Belize, accounting for in excess of 50% of the country's population. The Water Law of 1970 gave WASA the right to manage all water services in Belize. In 1995, WASA handed over its involvement in rural areas to the Ministry of Rural Development. Water in the island of San Pedro is provided through a desalination system provided by Consolidated Water. BWS remains actively involved in these areas in a support capacity (Pinsent Masons 2011).

In the three urban areas of Belmopan, Belize City and San Pedro Town, BWS is responsible for maintaining and developing the existing sewerage system and related property, for constructing and developing such other sewerage works as it considers necessary or expedient, for administering the sewerage system so established, and for providing sewerage services. It is assumed that the sewerage system and sewerage works is also taken to include any works for the treatment and disposal of sewage.

The Ministry of Health is undergoing significant reform which will result in significant change in the management approach of the Ministry of Health. The Health Sector Reform Project, a multi-year activity funded by the Inter-American Development Bank was implemented. The National Health Plan 1996 – 2000 (supported by PAHO/WHO) was developed in 1995 and its implementation began shortly thereafter. The current plan developed by the Ministry of Health, the Health Agenda 2007-2011 renews the commitment to the primary health care strategy established in the earlier plan as the means to the attainment of equal health for all. Presently, the Public Health Bureau and the Health Education and Community Participation Bureau are the departments within the Ministry of Health that are directly involved in the water and sanitation sector.

The Public Health Ordinance, Chapter 31, and its amendment of 1985 give the Ministry of Health, through the Public Health Bureau, the regulatory powers for various health related concerns. These include: monitoring water quality; investigation of public health and related complaints; monitoring of sewage, solid waste, and liquid waste management; pollution prevention; monitoring the use of chemicals, pesticides, herbicides, insecticides, and industrial waste; and prosecution of public health offenders.

The Health Education and Community Participation Bureau was set up to support social mobilization, health education, and community participation activities. As part of the community-based strategy, the Bureau intends to reorient its health education strategy to incorporate the behavioural approach accepted internationally as standard within hygiene education for water and sanitation projects. Using this framework, the Bureau is developing district and community capacities to identify those health practices of villages which put them at risk for contracting diseases and to develop and effectively communicate relevant hygiene messages aimed at changing risk behaviours and practices. Within the Ministry of Health, health education is also provided by the Office for Primary Health Care.

The Fisheries Department of the Ministry of Agriculture and Fisheries was established on January 1, 1965, and is concerned with the conservation and protection of both inland and marine fisheries, and in ensuring that fishing is conducted in a sustainable manner. In March 1990, the Coastal Zone Management Unit was set up with the particular responsibility of coastal zone planning and the protection of coastal ecosystems.

The Ministry of Works is entrusted with bridge construction and maintenance, land reclamation and drainage, and road construction and maintenance. The ministry also has

budgetary allocations for activities related to the drains of Belize City and other main towns and villages, drainage of several roads, and river bank maintenance. In addition, the ministry is involved in the maintenance, improvement, and cleaning of navigable waterways and canals and the construction of piers and jetties. The ministry operates a septic tank emptying service for a fee.

The Hydrology Department is responsible for implementing the stated policy relating to collection and analysis of data on quantity, quality, and variability of water resources; hydrological investigations for engineering and water resources projects; and publication and dissemination of information. The department works closely with the National Meteorology Service and advises the government on watershed and environmental management, and natural disasters such as droughts, floods, and water pollution.

The Ministry of Economic Development (MED) is responsible for the efficient allocation of resources for economic and social development. This responsibility is expressed through the coordination of national development planning, management of external cooperation activities and technical assistance, management of the Public Sector Investment Programme, the promotion and monitoring of selected private sector investments for both export and domestic production, and the preparation of annual analyses of the country's economic and social performances. As stated earlier, there is a relation between the water supply and sanitation sector and other sectors such as health, tourism, mining, environment, and housing. The laws that regulate such sectors also regulate their use of water resources. As a result, there is an overlap in competence and functions among different institutions, creating conflicts that foster fragmentation of the water resource sector with a corresponding lack of coordination. This has resulted in some activities being performed by more than one agency and others that are not carried out by any. Nonetheless, there are inter-sectoral coordination efforts that merit mention.

Since 1993, the Ministry of Health and the Ministry of Natural Resources have participated in an inter-sectoral "Community-Based Environmental Health Programme" to coordinate the delivery of community-based services. Introduced under the auspices of the AID-funded Improved Productivity Through Better Health Project (IPTBH), this strategy calls for coordinated planning with the Ministry of Health through the development of inter-sectoral community-based environmental teams to address environmental problems common to both ministries. A major accomplishment of this programme has been the formation of institutional linkages between the Ministry of Health and the Ministry of Natural Resources, using primary health care as a vehicle for this effort.

The functional organizational structure for these linkages consist of inter-sectoral teams at different ministerial levels: a Senior Inter-sectoral Executive Committee (senior decision makers including the chief executive officer of BWS[3]), a Central Management Team (technical

[3] The CEO of WASA was designated to be part of this committee; presumably this responsibility has gone to the BWS CEO.

staff), and at the district level, an Environmental Health Subcommittee of the District Health Team. The lines of communication between these teams are both vertical and horizontal in nature. This approach has proved effective in coordinating service delivery at the community level resulting in a more effective utilization of scarce resources within both ministries. It has also provided a means for decentralizing services.

The Land Utilization Authority is provided for in the Land Utilization Act of 1993. It repeals the former act of 1981. The authority comprises the Commissioner of Lands and Survey as Chair, the Chief Engineer of the Ministry of Works, the Chief Agricultural Officer, the Chief Environmental Officer, a representative of the Ministry of Economic Development, the Director of Social Development, the Physical Planner, a representative of the Ministry of Natural Resources, the Senior Planning Officer of the Department of Housing and Planning, and two persons from the private sector. The authority considers all applications for the subdivision of land, and may require that the applicant submit verification that the application conforms to the standards established by WASA regarding waterworks, the Director General of Electricity Supply, and the Principal Public Health Inspector. An Environmental Impact Assessment approved by the Department of the Environment may be required and the Authority may consult the local authorities concerned and any statutory planning authority. A prescribed fee is required with each application. The authority will also demarcate specific areas as Special Development Areas for which development plans shall be prepared.

There is very little authority for resource management at a municipal or village level. In 2000, legal recognition was given to village water boards for management of community rudimentary water systems, but decision making and enforcement power still lies with the central government.

Village councils are legally charged with sanitation responsibilities in villages, but only in a few communities are they likely to take on the leadership role to ensure proper monitoring of sanitation.

There are a number of international and indigenous non-governmental organizations (NGOs) working in Belize on matters related to the environment and public health. The local NGOs are important in facilitating the expression of community views and promoting grassroots participation. The more prominent national NGOs concerned with water-related issues are the Belize Centre for Environmental Studies, the Belize Audubon Society, and the Belize Enterprise for Sustainable Technology.

The NGOs also play a large role in the management of natural resources through the administration of specific protected areas and community coordination. While responsibility for protected areas falls under the mandate of the Forest Department, other departments (i.e., the Fisheries Department and Archaeology Department) and NGOs do manage a large number of them. Examples of these organizations include the Belize Audubon Society (management of some protected areas both inland and on the Halfmoon Atoll), Programme for Belize (management of the Rio Bravo Conservation Area along the New River), SATIIM (management

and monitoring of the Temash-Sarstoon National Park), and the Belize River Keeper (previously worked on the Belize River, especially near the Guatemalan border).

# 8. SURVEILLANCE AND ENFORCEMENT CAPACITY

The adequacy of Belize's surveillance capacity to support wastewater effluent and ambient environmental quality monitoring to assess compliance with LBS Protocol Annex III parameters is described below.

Fernandez (2002) reported that while legislation is in place to address the management of marine pollution there is a lack of other services such as a proper laboratory or an environmental health monitoring system. Most laboratories in the country are limited in their analytical capacity. The water laboratory of the Ministry of Health can carry out only minimal testing of physical and chemical parameters of liquids such as pH, dissolved oxygen and elemental analysis.

A national laboratory system does not exist. However with the establishment of the Belize Agricultural Health Authority (BAHA) there has been an attempt to group a number of laboratories together. The lack of a proper laboratory was for a long time one of the problems affecting Belizean exports. Previously, the BAHA laboratory was only capable of conducting qualitative analysis using the CHARM System for organophosphates and carbamates. However, BAHA has accelerated the upgrading of the Central Investigation Laboratory (CIL) of its Food Safety Department by purchasing state-of-the-art equipment. The CIL was completely refurbished in 2002 and equipped with state-of-the art testing and support equipment under the Government of Belize Modernization of Agricultural Health Services project funded by the Inter-American Development Bank (IDB). Importantly, the laboratory is providing high-quality training for the staff to enable them to use this equipment competently, professionally and with optimum efficiency. It is enrolled in several proficiency testing and quality assurance programs such as the Inter-American Network of Food Analysis Laboratories (INFAL) to ensure testing excellence and gain industry and consumer confidence as well as to keep abreast of international developments in the field. (BAHA ND).

There are limited laboratory services available in the Ministries of Agriculture, Health, and National Security, as well as in the Coastal Zone Management Authority/Institute (CZMA/I) and Department of the Environment. These laboratory services are tailored to the specific needs of the particular ministry. The CZMA/I is in a position to take on the task of conducting testing excluding pesticide residue analysis. Given its knowledge of the area it should play a key role in the implementation of the monitoring programme.

A description of the capabilities of each lab is presented below.

**Ministry of Agriculture** The Belize Agricultural Health Authority of the Ministry of Agriculture offers laboratory services such as microbiology and diagnosis testing. BAHA has three microbiologists, two pesticide residue testing technicians and a Lab Director at its Belize City Laboratory. BAHA has recently begun testing for pesticide residue at the Veterinary Laboratory in Belize City. This is a qualitative test using the CHARM assay kit which is specific for organophosphates and carbamates. Various pieces of equipment, including two gas chromatography systems, a high performance liquid chromatograph (HPLC) system and an

Atomic Absorption (AA) spectrophotometer were purchased personnel trained to do residue testing. This is the only laboratory to have the capacity to conduct water testing for physical, chemical and residue analysis.

**Ministry of Health** The Ministry of Health has a water laboratory, which carries out routine testing of water samples from municipal water supply as well as from rural and rudimentary water supply sources. The laboratory has a spectrophotometer along with other equipment to test for physical parameters such as dissolved oxygen (DO), chemical oxygen demand (COD), total suspended solids (TSS), pH, salinity, and conductivity. It has the capability to test for chemical species such as phosphates, nitrates and iron, and for biological contaminants such as total and faecal coliform bacteria. The laboratory is limited to water testing only and its capability is restricted by the irregular supply of reagents. Samples are collected by the Public Health Inspectors in the districts and sent to the laboratory for analysis.

**Coastal Zone Management Authority/Institute** The CZMA/I has been conducting monitoring studies of the Belize marine environment since 1997. The CZMA/I possesses a water laboratory, which is used to obtain its data. Physical parameters are measured in-situ while chemical species are analyzed in the laboratory. A total of 75 water quality stations are strategically designated in the coastal zone, including at the Gales Point lagoon, Faber's Lagoon, San Pedro and Port Honduras Area. The stations are monitored once per month for basic physical and physicochemical parameters. The CZMA/I owns its own boat so that it is capable of going out to do sampling on a regular basis.

**Department of the Environment** The Department of the Environment (DOE) has field testing capability consisting of a DREL 2000 water lab which includes a spectrophotomer, pH meter, TSS/conductivity meter, DO meter and salinity meter. The absence of trained personnel and lack of reagents have restricted the use of this equipment. The Department routinely collects samples (water, sediment) which are then sent to the Bowen & Bowen Laboratory for analysis. The condition of the DOE equipment is unknown but a number of the sensing units would need to be replaced.

**Ministry of National Security** The Forensic Laboratory of the Ministry of National Security is used solely for the analysis of forensic samples such as confiscated drugs. This laboratory would not normally be available to carry out analysis for other institutions given the nature and sensitivity of the analysis being conducted.

**Private Laboratories** There are a number of private laboratories mainly in the large industries. The citrus and sugarcane processing plants have laboratories for both qualitative testing and environmental monitoring. The shrimp farms also have their own laboratory as do the brewery and distilleries. These industries have to send quarterly effluent reports to the DOE. Bowen & Bowen Ltd. and Tower Hill Factory both have a good laboratory and analysis is done on a daily basis.

The only non-governmental organization that is involved in water monitoring is the Toledo Institute for Development and Education (TIDE). TIDE conducts freshwater and marine water quality research at 48 sites within Port Honduras Marine Reserve, Monkey River and Rio Grande. TIDE possesses field testing equipment as well as a boat (TIDE website).

Public Health Officers are legally mandated to inspect building plans to ensure they include properly designed septic systems. However, there is little control of the design and quality of septic tanks due to inadequate monitoring (UNDP 2011b).

# 9. MANPOWER CAPACITY

## AVAILABILITY OF STAFF FOR WASTEWATER MANAGEMENT

According to the Belize Water & Sanitation Sector Analysis within the Regional Plan for Investment in Environment and Health conducted by PAHO (PAHO 2000b), the distribution of human resources working in this sector is fragmented. Even though nine departments currently participate in the utilization and management of water resources, many of them do so as one of many other important activities. Only two departments are directly involved in the management of water resources. The Hydrology Department collects data and conducts some analysis to support planning. The Department of the Environment establishes standards and regulates the sector as a part of its mandate for overall management of the natural resources of Belize. Tables 24 – 26 and the accompanying discussion refer to WASA as the main provider of water and sanitation services. As previously noted, Belize Water Services assumed the major role for provision of water and wastewater services from WASA in 2001. Much of the information related to WASA is likely to be similar for BWS in the following discussion.

**Table 24: Employees dedicated to the Water and Sanitation Sector**

| Institution | Employees (Aug 95) | | Additional Requirements |
|---|---|---|---|
| | Number | Percentage | |
| MNR | … | … | … |
| RWSSP | 56 | 17.5 | 2 |
| WASA | 241 | 75.3 | … |
| MOH | … | … | … |
| PHB | 17 | 5.3 | 9 |
| MTE | … | … | … |
| DOE | 3 | 0.9 | 5 |
| MESTT | … | … | … |
| HYDRO | 3 | 0.9 | 5 |
| **Total** | **320** | **100.0** | **21** |
| Source: PAHO 2000b | | | |

**Table 25: Classification of Sector Personnel by Category**

| Institution | Manager | Admin. Support | Engineer | Technical | Lab. Tech. | Operator | Foreman and Crew | Total |
|---|---|---|---|---|---|---|---|---|
| MNR | … | … | … | … | … | … | … | … |
| RWSSP | 1 | 10 | … | 29 | … | … | 16 | 56 |
| WASA | 1 | 87 | 3 | 33 | 2 | 29 | 86 | 241 |
| MOH | … | … | … | … | … | … | … | … |
| PHB | … | … | 1 | 14 | 2 | … | … | 17 |
| MTE | … | … | … | … | … | … | … | … |
| DOE | … | … | … | 3 | … | … | … | 3 |
| MESTT | … | … | … | … | … | … | … | … |
| HYDRO | … | … | 1 | 2 | … | … | … | 3 |

| Table 25: Classification of Sector Personnel by Category | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Institution** | **Manager** | **Admin. Support** | **Engineer** | **Technical** | **Lab. Tech.** | **Operator** | **Foreman and Crew** | **Total** |
| **Total** | **2** | **97** | **5** | **81** | **4** | **29** | **102** | **320** |
| **%** | **0.62** | **30.31** | **1.56** | **25.31** | **1.25** | **9.06** | **31.87** | **100** |
| Source: PAHO 2000b | | | | | | | | |

WASA was empowered to develop regulations for the water supply and sanitation subsector but it is unlikely that BWS has this mandate. As a private company, BWS may hire the human resources required to execute the delivery of water supply, limited exclusively by financial constraints. WASA was the single biggest employer in the sector (see Table 24) with attractive salary and benefits packages.

| Table 26: Classification of Sector Personnel by Region | | | | | | |
|---|---|---|---|---|---|---|
| **Institution** | **Level** | | | | **Region** | |
| | **National** | **District** | **Town** | **Total** | **Urban** | **Rural** |
| MNR | … | … | … | … | … | … |
| RWSSP | 13 | 43 | … | 56 | … | 56 |
| WASA | 58 | 115 | 68 | 241 | 232 | 9 |
| MOH | … | … | … | … | … | … |
| PHB | 17 | … | … | 17 | 11 | 6 |
| MTE | … | … | … | … | … | … |
| DOE | 3 | … | … | 3 | 3 | … |
| MESTT | … | … | … | … | … | … |
| HYDRO | 3 | … | … | 3 | 3 | … |
| **Total** | **94** | **158** | **68** | **320** | **249** | **71** |
| **%** | **29.37** | **49.37** | **21.25** | **100** | **77.81** | **22.18** |

Faced with financial constraints, there have been few requests for an increase in human resources by the various ministries involved in the sector. Tables 24 and 26 show the following: Of the sector's human resources, 78 per cent services the urban area's (48 per cent of the total population) and 22 per cent services rural areas (52 per cent of the total population). The area least serviced by the sector's personnel on a per capita basis are the rural zones of the country. As can be appreciated, there is an uneven distribution and assignment of resources to address the needs of the rural area. Issues related to the water resource sector at the national level are addressed by 29 per cent of human resources. There are five engineers servicing the sector and constitute 1.56 per cent of the total numbers of people working in the sector. Technical personnel, including lab technicians and operators, comprise 66 per cent of the existing human resources.

The Belize Enterprise for Sustainable Development (BEST) (2009) reports that "The National Meteorological Service and other technical agencies supporting water administration and management are operating with human resource levels below the required capacity for normal

operations. The technical expertise and level of staffing of these institutions and organizations need upgrading and expansion. As a consequence, the state of meteorological and hydrological information could be described as fragmented and discontinuous. Information on basin characteristics is not current and in some cases, is unavailable. Very little water quality information is available and the reliability of the various laboratories that provide data is questionable with regards to quality assurance and thus results."

BEST has instituted a capacity strengthening programme, which includes the training of three hydrologists, two at the Bachelor's level and one at the Master's level. The programme also includes in-country short-term training for all staff in areas such as administration, project management and integrated water resource management.

## NATIONAL/REGIONAL TRAINING NEEDS FOR WASTEWATER MANAGEMENT

A large deficit of specialized professionals exists. To develop the present programmes, hydraulic engineers, sanitation engineers, chemical engineers, lab technicians, biologists, geologists, and mechanics are required (PAHO 2000b). BEST (2009) reports that the following areas require strengthening to meet strategic imperatives:

- monitoring networks need to be expanded
- water inventory and standards of quality established
- a National Water Plan should be prepared and implemented
- laboratory resources need to be brought together to create a national water quality laboratory.

## NATIONAL/REGIONAL TRAINING OPPORTUNITIES FOR WASTEWATER MANAGEMENT

PAHO (2000b) reported that "since higher education institutions in Belize do not offer degrees in engineering, human resources training requires costly investments. WASA is the only institution that has ongoing training programs for its human resources within its structure. Other institutions require overseas training. Most receive their training in the United States, England, and the English-speaking Caribbean. Bilingual personnel are able to go to educational institutions in Central America. Generally, institutions do not have sufficient funds to undertake a sustainable human resources development program".

Through staff training and development, BWS continues to build an efficient and versatile workforce (BWS 2009). Employees have benefitted from technical onsite operational training, as well as new technological advances introduced and adapted for greater efficiency. Training has covered areas of professional and technical skills and knowledge, health and safety and information technology. Also, BWS has initiated an internship programme for undergraduate and post-graduate students interested in careers in the water and wastewater industry (BWS website).

PAHO (2000b) reported that "the RWSSP has a limited number of specialized personnel and it does not have the financial resources to execute a training program that would allow it to carry out its functions." The previous working relationship between WASA and RWSSP allowed the former to provide significant technical support to the latter. BWS does provide technical assistance for the provision of rural services. PAHO reported that qualified personnel that receive training overseas often decide to work outside the country.

Human resources development and training in public health has been ongoing and conducted in collaboration with the University of Belize (UB). Public Health inspectors/environmental health officers, public health and rural health nurses, pharmacists, medical laboratory technologists continue to be educated at UB. In 2006, the Ministry of Health, in response to the 2005 Toronto call to action for a decade in Human Resources for Health in the Americas, set up the Belize Human Resources for Health Observatory. The Observatory is a multi-stakeholder group drawn up from various ministries, educational institutions, professional associations, private sector and non-governmental organizations. The mandate of the Observatory is to guide policy decisions to ensure that Belize has adequate number of qualified and motivated health workforce, distributed according to the healthcare needs of the country (BHRHO ND).

The University of Belize, through its Faculty of Nursing, Allied Health and Social Work, offers programmes in professional nursing, midwifery, practical nursing, rural health nursing, public health nursing, pharmacy, medical laboratory technology, public health inspectors, and social work. UB graduates between 60 and 90 non-physician health care professionals annually. The curricula for undergraduate programmes are under review by the faculty. The limited pool of qualified health professionals to teach certain specialized subjects poses a challenge for UB.

PAHO (2009a) reported that "continuing education opportunities in a wide range of medical topics and health knowledge and skills areas are provided to health professionals in Belize based on supply from local and international trainers, and through professional associations. However, these are not part of a structured programme for the management, development and continuing education of human resources in health. Targeted but temporary ad hoc training initiatives in relevant skill areas are provided to semi-professionalized health care providers such as community health workers and traditional birth attendants. Certification mechanisms for health workers exist but are in need of revision. The establishment of a Human Resources Development and Management Unit in the MoH will address staff development issues."

The Natural Resource Management Programme offers a course on waste management (Table 27) (University of Belize 2012).

| Table 27: University of Belize Natural Resource Management Programme NRMP 207 Waste Management |
| --- |
| Describe the scope, history and general present day waste problems. |
| Expose students to current issues and philosophy of waste generation and waste management. |
| Introduce ecological, economic and political concepts that provide a knowledge base for responsible decision making in waste management issues |
| Examine global and regional conservation issues and sustainable development approaches involving recreational management |
| Discuss many of the environmental and economic issues and challenges facing the growing industry of Belize today and in the future |
| Describe the scope, history and general present day waste problems. |
| Expose students to current issues and philosophy of waste generation and waste management. |
| Introduce ecological, economic and political concepts that provide a knowledge base for responsible decision making in waste management issues |

# 10. FINANCING

This section describes the level of financing on wastewater management to assess compliance with LBS Protocol Annex III.

Water from both Belize Water Services Ltd. and Belize Social Investment Fund (BSIF) systems are financed either through grants or loans undertaken by the Government of Belize (UNDP 2011b). Loans are repaid from public finances, which mean that the general public is effectively subsidizing water systems. The sustainability of both types of systems ultimately depends on a cost recovery structure that guarantees income for operation and maintenance, and for financing repairs and replacement of basic infrastructure. Currently there is no transparent tariff structure governing what a consumer has to pay for water usage in rural areas. All use of water should be recorded on a metered system, and user rates determined by appropriate authorities after a thorough analysis of the costs to that particular system. Though the Public Utilities Commission (PUC) currently controls the rate structure of BWS, the fee for the metered rural water supply (RWS) is determined on a case-by-case basis and so uniformity in the fee structure is absent.

The UNDP (2011b) also reports that "All water provided by BWS is chlorinated and connections are metered. The fee structure for the BWS is a progressive one which encourages the user to save water as much as possible. BWS maintains a 'social fee' of BZ$7.69 for monthly usage of less than 1,001 gallons. This 'social fee' is higher in areas with sewerage services (BZ$9.23) and considerably higher in San Pedro (BZ$22.55), an offshore island."

In Belize City, Belmopan City and San Pedro, BWS also operates sewerage systems which service parts of all three municipalities. Households that are connected to the sewerage system pay a higher rate per gallon of water that they consume.

Programming and funding support for sanitation has come primarily from BSIF, NGOs and UN agencies, specifically United Nations Children's Fund (UNICEF) and Pan-American Health Organization (PAHO)/WHO. Humana Belize, an NGO focusing on humanitarian assistance, has made an effort to improve the sanitation facilities in several communities in the country. Humana provides the necessary materials and, with the help of villagers, completes, the construction of each facility. Humana hopes that by partnering with the communities, people will learn how to properly build a latrine; and that, in the future, other families will develop the capacity to build and maintain their own.

The national focus on sanitation services has been less urgent than the supply of water systems. Belize has made enormous efforts in supplying rural communities with RWS, but not as much with sanitation facilities, and open defecation still continues in some areas of the country, mostly in the south. Analyzing the projects executed by the BSIF under the fifth cycle of the Basic Needs Trust Fund (BNTF) reveals that 19 rural water supply systems were constructed (some projects are still ongoing) but not a single sanitation project was included in the menu of project interventions. Indeed, only a few sanitation projects have been executed by BSIF, for example the building of latrines in Hopkins Village and in the South-side of Belize City.

Consequently, there appears to be a need for technical (and financial) support at the community level for those households adopting pit latrines as an improved sanitation facility. More broadly, there is a need to create awareness in the general population of the importance of proper sanitation, especially taking into account the health hazards and economic costs that result from an unimproved and unmaintained sanitation system.

Vanzie (2008) indicates the following: "The Ministry of Health's portion of the GOB's budget has had a marked upward trend in the years 2004 to 2007 (Table 28). During this time period it increased by $32,863,313 or 41 per cent to account for 10.9 per cent of the Government of Belize Budget for the year 2007. It has also had a minimal but steady rise in its portion of the GDP, increasing from 2.2 per cent in 2004, to 3.1 per cent in 2007. To place these figures in context, worldwide statistics indicate that a global average of 5.5 per cent of GDP is spent on health, with 3.2 per cent being the norm for Latin America and 5.8 per cent for the United States. The highest published figures emanate from the wealthiest European nations at 6.6 per cent".

**Table 28: MOH Budget, Belize 2001 - 2007**

| Year | Revised MOH Budget | % of GOB Budget | % of GDP |
|---|---|---|---|
| **2004** | BZ$ 46,619,809 | 8.6% | 2.2% |
| **2005** | BZ$ 53,222,465 | 8.4% | 2.4% |
| **2006** | BZ$ 64,241,066 | 9.2% | 2.7% |
| **2007** | BZ$ 79,483,122 | 10.9% | 3.1% |

Source: Estimates of Revenue and Expenditure for Fiscal Year 2005 - 2008

# 11. BEST PRACTICES AND INNOVATIVE TECHNOLOGICAL TREATMENT SOLUTIONS

This section identifies existing and potentially viable approaches to addressing domestic wastewater system needs and evaluates and presents recommendations based on criteria such as local conditions, effectiveness, availability, cost-effectiveness, and stakeholder acceptability.

Not many best practices and innovative technological treatment solutions were found in Belize with regard to the policy, legislative or institutional framework or for surveillance capacity, manpower, financing and sanitation projects as a community source of revenue.

In the area of wastewater treatment technology, use of the effective microorganism (EM) technology in the wastewater treatment ponds of Belize Sugar Industries Ltd. is proving to be a cost-saving mechanism for the factory (Usher 2009). Within four and a half months of management with the EM system, cost saving were in the range of 37 per cent. Equally important was the reduction of COD levels from an average influent level at 13,579 mg/l to an average effluent level of 2,036 mg/l. This reduction represented an 85 per cent purification level compared to previous years where purification levels were of an average 75 per cent using an oxygen injected system.

Belize has dedicated funds for wastewater, which has an effluent license fee of BZ$ 300 per annum for industries. While such a fee is a best practice, the amount of the fee is inadequate.

# 12. CURRENT KNOWLEDGE, ATTITUDES, BEHAVIOURS AND PRACTICES

A Knowledge, Attitudes and Practices (KAP) survey is a representative study of a specific population to collect information on what is known, believed and done in relation to a particular topic – in this case, wastewater management in the Wider Caribbean.

Poor sanitation is often not seen as a problem; most people are satisfied as long as a facility does not smell, even if it is not ultimately hygienic. The main (most pressing) wastewater management issues and problems could be categorized as follows:

1. Poor attitudes and low levels of awareness of wastewater management issues
2. Poor practices
3. Low levels of enforcement
4. Need for improvements in legislative and policy frameworks
5. Low levels of capacity
6. Old/inadequate infrastructure and technologies

The Wastewater Management in the Wider Caribbean Region: Knowledge, Attitudes and Practice (KAP) Study (Emanuel E. 2010) provided the information in Table 29 for Belize.

**Table 29: Knowledge, Attitudes and Practices related to Wastewater Management in Belize**

| KAP Issue | Current Situation |
|---|---|
| Do decision makers develop needs-based wastewater projects, which are on par with other infrastructure priorities? | Neutral |
| Has the country highlighted domestic wastewater/ sewage as a priority pollutant in national objectives/ sustainable development planning? | Positive attitude |
| Are (government) wastewater and sanitation policies, laws, regulations, guidelines adequate? Does the country have a national programme/ plan of action for Wastewater Management? | Standard Practice<br>Belize is being proactive - effluent regulations are being modified to include domestic sewage |
| Is sanitation infrastructure considered adequate? | Poor practice |
| Are there adequate resources for proper construction, operation, and maintenance of sewage collection systems? | Poor practice |
| To what extent are people aware of the impact of current methods of disposal on health and environment? | Moderate level of knowledge |
| Are people aware of the link between sewage, poor sanitation and health problems such as diarrheal diseases etc.? | Moderate level of knowledge |
| Do officials in government/decision makers have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio-economic development? | Low level of knowledge |
| Are wastewater operators aware of proper operations and maintenance techniques? | Moderate level of knowledge |

| Table 29: Knowledge, Attitudes and Practices related to Wastewater Management in Belize | |
|---|---|
| **KAP Issue** | **Current Situation** |
| Do national, local and sectoral education and public awareness programmes and campaigns exist for wastewater management or for environmental management (which includes wastewater management)? | Standard practice |
| Is there periodic assessment of short-term and long-term data-collection and research needs for wastewater management? | Poor practice |
| Source: Wastewater Management in the Wider Caribbean Region: Knowledge, Attitudes and Practice (KAP) Study | |

# 13. INFORMATION COLLECTION AND SHARING

This section discusses Belize's capacity to collect and share information related to wastewater management and the avenues used for communicating this information within the sector and with the general public.

No detailed information is available on which households have an improved sanitation system and which do not. There is no detailed data system based on cadastral maps which would give authorities insight into where action has to be taken to improve the level of sanitation coverage in the country. Information gathering and management for water and sanitation development requires input from different agencies such as the Ministry of Health, the Ministry of Labour, Local Government and Rural Development (MLLGRD), the Sugar Industry Board, National Association of Village Councils (NAVCO), Central Medical Laboratory and the Department of the Environment. All pertinent data dealing with the villages should be centrally stored and available for community workers and representatives of relevant agencies to use for planning purposes. In the absence of such a database, acquiring necessary information becomes slow and tedious and negatively impacts the speed with which local decisions can be made. The existence of a functional and updated database system for water and sanitation can facilitate joint collection, dissemination and use of data (UNDP 2011b).

# 14. PRESENCE AND PARTICIPATION LEVEL OF WATER AND SANITATION ORGANIZATIONS

There are different organizations that support environmental protection and sanitation programmes. They invest a large amount of funds in technical cooperation and financing of infrastructure, as well as in raising awareness.

There are a number of international and indigenous non-governmental organizations working in Belize on matters related to the environment and public health. The local NGOs are important in facilitating the expression of community views and promoting grassroots participation. The more prominent national NGOs concerned with water-related issues are the Belize Centre for Environmental Studies, the Belize Audubon Society and the Belize Enterprise for Sustainable Technology. The NGOs also play a large role in the management of natural resources through the administration of specific protected areas and community coordination. While responsibility for protected areas falls under the mandate of the Forest Department, other departments (i.e., the Fisheries Department and Archaeology Department) and NGOs do manage a large number of them. Examples of these organizations include the Belize Audubon Society (management of some protected areas both inland and on the Halfmoon Atoll), Programme for Belize (management of the Rio Bravo Conservation Area along the New River), Sarstoon Temash Institute for Indigenous Management (management and monitoring of the Temash-Sarstoon National Park), and the Belize River Keeper (previously worked on the Belize River, especially near the Guatemalan border) (UNEP 2010).

# 15. CLIMATE CHANGE IMPACTS

The objective of this section is to determine if there is an impact on the sanitation infrastructure by the effects of climate change and if available funds will be diverted to prioritize the work emergency response in the field of sanitation or if they will be diverted to serve other areas outside the sector.

Based on the Second National Communication to the UNFCCC (UNDP 2011a) and National Adaptation Strategy to Address Climate Change in the Water Sector in Belize: Strategy and Action Plan (BEST 2009), the following comments can be made.

A warmer climate system resulting from a doubling in carbon dioxide concentration in the atmosphere will lead to increased frequency of warm spells/heat waves, intense droughts, more frequent and intense rainfall events, higher relative humidity, rising seas, more fire and floods, stronger storms and increased storm damage, changing landscapes, economic losses, and increased risk to wildlife.

Also, there will be an increase in the consumption of water with a rise in temperature, since the number of showers per person per day is likely to increase in many places and consequently the amount of water for laundry. This would bring an increase in the amount of greywater generated in each household.

The coastal area has been prioritized because of its low-lying state, the concentrations of populations in this zone, the level of infrastructural development, and the range of economic activities occurring there. Therefore it is expected that sanitation infrastructure will be affected (sewer lines, latrines and septic tanks) increasing the amount of wastewater and excreta in contact with groundwater (BEST 2009).

# 16. SUMMARY OF MAJOR FINDINGS

# MAIN FINDINGS FROM LITERATURE REVIEW

## Access to Water and Wastewater Services

- Belize has a high level of access to drinking water, but low use of piped water. Five per cent (5 per cent) of the population uses raw water sources. Many people are vulnerable to drought (37 per cent depend on rainwater or wells).

- Twenty eight percent (28 per cent) of the population is connected to sewers and 57.1 per cent of wastewater receives treatment before discharge.

## Legislative, Policy and Institutional Frameworks

- No established wastewater surveillance programme for discharges is in place.

- Environmental degradation in Belize occurs due to the lack of proper legislation, insufficient enforcement of regulations, lack of proper infrastructure, outdated production approaches and use of obsolete technologies.

- Surveillance and information collection and sharing are weak.

- There is no specific policy for wastewater management but a draft water and sanitation policy has been prepared. The Government recently instituted a policy that requires coastal and island developments to use package treatment plants for sewage treatment.

- There is no intersectoral approach to wastewater management. There is no lead agency addressing sanitation issues and there is a lack of cooperation and coordination among responsible entities.

- Sanitation regulations exist under different laws, and their enforcement therefore falls under different ministries and agencies. Legislation and enforcement should be revised and harmonized into one instrument, with one lead ministry spearheading all matters related to sanitation.

- No plans exist for the financing of wastewater management. The national focus on sanitation services has been less urgent than the supply of water systems. Belize has made enormous efforts in supplying rural communities with rural water services, but has not been as successful at providing sanitation facilities, and open defecation still continues in some areas of the country, mostly in the south.

- Manpower capacity for wastewater management is an issue. Educational opportunities in all aspects of wastewater management are limited.

- Belize has harmonized domestic effluent discharge limits with Annex III of the LBS Protocol.

- Belize has prepared regulations for priority industries identified in the LBS Protocol.

## Wastewater Management Infrastructure, Technology, and Practices

- Flatness of terrain leads to the use of lift stations to raise the wastewater to the level of the sewage treatment plants (STP). Many STP maintenance programmes are not up to date and as such the plants often resort to emergency discharges into streets, the sea, canals, creeks and other water bodies.

- The main technology used in large towns is pond systems (which provide secondary treatment). Oxidation ponds not well operated. Industries and hotels use package plants, septic tanks and lagoons.

- Two WWTPs (Belize and Belmopan) are more than 30 years old. In-situ systems have been upgraded from latrines to septic tanks. There is frequent gradual expansion of homes, but they maintain the same septic tank, many of which are not constructed properly.

- In some towns, Government operates a septage service where the septage is taken to dumpsites. In other towns, service is private and the septage is disposed of in lagoons or the sea. No information on disposal of biosolids is available, but it is likely that biosolid disposal uses the same procedure as septage disposal.

- Eighty-three per cent (83 per cent) of wastewater is discharged into sea or mangroves and 16 per cent into rivers.

- The potential for direct pollution (caused by discharge of raw wastewater and open defecation) is about 13 per cent of the population or about 40,000 persons.

- In general, in-situ systems are always considered to cause less pollution than raw wastewater from sewerage systems. However, many of the existing septic systems are not functioning properly, mostly due to their designs which are not to standard and as such only partially treat the raw sewage and grey water. Recent enforcement has moved towards constructing functional treatment systems. Likewise, there is a lack of proper maintenance and desludging of septic tanks.

- Improper sewage treatment results in direct environmental impacts that can immediately contaminate any nearby water body such as creeks, rivers, sea and underground water. There have been recorded instances of no soakaway or leach fields, where sewage is simply discharged into wetlands and water bodies.

- In coastal areas there are sandy porous soils with high permeability, where the use of septic tanks imposes a pollution potential to coastal water.

- In Corozal, 1,100 households' wastewater is treated in pit-latrines, septic tanks and soakaways. The underlying limestone geology allows the sewage to leach into the Corozal Bay.

- Industrial activity is related to agro-industries, rum, sugar and shrimp production. Industrial discharge regulations have been established. Treatment of waste is varied; there is no recycling and serous agro-industrial discharge impacts have been observed on coastal lagoons.

- Hotels mainly located along the coast have a significant contribution to wastewater loads; wastewater is treated with package plants. Cruise ships and other marine vessels' effluents are a major threat to the health of Belize's marine environment.

- The majority of the wastewater generated in hospitals is not treated and is disposed directly underground. However, some positive steps are being taken. In regard to treatment and disposal of wastewater in schools it has been found that 62 per cent of septic tanks are in fair condition, 21 per cent in fair condition, 9 per cent in poor condition and 8 per cent in very poor condition.

- In hotels and other institutions, secondary treated sewage from septic tanks reaches the groundwater as well as the coast and mangroves. Primary treated sewage is discharged into rivers.

- Industrial wastewater is treated on occasion. The effluent from shrimp farms is causing environmental problems in the Placencia Lagoon.

- Wastewater reuse is practiced at a small scale and the quality of reused water is good.

- Impacts of climate change on wastewater management have not been addressed.

## ANALYSIS USING MATHEMATICAL MODEL

An analysis of the responses to the questionnaire using the mathematical model is summarized below and grouped according to 22 focus areas derived from the 27 issues identified in Section 2. Annex 1 describes these focus areas. Annex 2 presents the actual data used for the evaluation. Annex 3 presents the actual results from the mathematical model. Annex 4 provides a graphical representation of the results, showing which areas have a negative (red), neutral (amber) and positive environmental impact (green). Annex 5 explains the significance values used in the mathematical model.

**Sanitation Coverage**

- Belize's sanitation service (infrastructure) has a grade of 61.4%; a low percentage of the population is without sanitation service. Wastewater from sewerage systems receives primary or secondary treatment and those not connected have in-situ systems in form of septic tanks or latrines.

**Disposal of Treated/Untreated Wastewater**

- The effluent discharge point has a grade of 6.3%; it is graded as having a negative adverse adequacy impact. Effluents are directly discharged either into the sea and mangroves or into groundwater. Primary treated wastewater from Belmopan is discharged into rivers.

**Wastewater Reuse/Type of Reuse/Quality of Effluent**

- Wastewater treatment and reuse has a grade of 0%; it is graded as significant adverse adequacy impact. Reuse practices has a grade of 33.3%; reuse is limited to some hotels. The quality of effluent has a grade of 66.7%; the quality of reused water is high.

**Industrial Wastewater Management**

- Treatment of industrial wastewater has a grade of 14.8%; it is graded as negative adverse adequacy impact because industrial wastewater is treated on occasion.

**Tourism/ Hotel Wastewater Management**

- Effluent from the tourism sector has a grade of 44.4%; it is graded as neutral adequacy. Some hotels treat their wastewater with package plants and others use septic tanks. Cruise ships and other marine vessels' effluents are a major threat to the health of Belize's marine environment.

**Institutional Wastewater Management**

- Institutional effluent has a grade of 57.9%; it is graded as neutral adequacy. A large number of hospitals, schools and other institutions have taken steps to manage wastewater appropriately.

**Volume of Wastewater Discharged/Quality of Discharge**

- The amount of effluent has a grade of 36.3%. The amount of wastewater discharged into mangroves, rivers and sea is high. The quality of effluent receives a grade of 40.9%. Quality needs to be improved.

**Septage/Biosolids Management**

- Septage/Biosolids has a grade of 34.6%. Government operates septage service in some towns and private services are used in other towns. The disposal of biosolids is likely to be similar.

**Infrastructure Condition**

- Infrastructure conditions have a grade of 52.8%. Two WWTPs are more than 30 years old. In-situ systems have been upgraded from latrines to septic tanks. However,many septic tanks are inadequate and not properly constructed.

**Pollution Problems and their Cost**

- Pollution problems are graded as neutral adequacy with a grade of 60.6%. Pollution problems are evident in some areas, but their impact on health is not reflected, except for diarrhoea cases.

**National Capacity (Policy, Legislative and Institutional Frameworks)**

- The level of adequacy of national capacity is graded to be 33.4%. The policy framework has a level of adequacy of 52.4%, the legislative framework 23.6% and the institutional framework 24.2%. Wastewater management policies are not enough. Regulations for better waste management are lacking and there is a need to increase the enforcement and the institutional coordination. No leading agency for wastewater management exists.

**Surveillance and Enforcement Capacity**

- Surveillance and enforcement capacity is low; the level of adequacy is 16.0%. The national laboratory should be certified and its budget increased for acquisition of equipment and hiring staff.

**Manpower Capability**

- Manpower capability adequacy is 36.9%. Adequacy of availability of staff is average (64.4%); the meeting of training needs is also average (50%). Training opportunities adequacy is low (22.2%) and regional training opportunities is very low (11.1%).

**Financing**

- Financing has a level of adequacy of 33.3%. A budget for sanitation should be dedicated to wastewater treatment management, measures to ensure that smaller communities obtain affordable financing for improving wastewater infrastructure and making affordable financing available for investments in wastewater management. Cost estimates for wastewater transport and treatment technologies should be prepared and private investments should be allowed.

**Best Practices and Innovative Technological Treatment Solutions**

- There is a very poor level of application of best practices and technologies (7.4%). Attention should be directed to the policy, legislative and institutional frameworks, surveillance capacity, manpower strengthening, financing and sanitation projects as community sources of revenue.

**Current Knowledge, Attitudes, Behaviours and Practices**

- The level of adequacy of current knowledge, attitudes, behaviours and practices is regular (52.8%). Priority should be given to increase: the level of awareness about wastewater management concepts, issues and technologies; level of focus on wastewater compared with water; responsiveness of wastewater operators for proper operations and maintenance techniques; and use of appropriate operations and maintenance techniques.

**Information Collection and Sharing**

- The adequacy of information collection and sharing is very poor (4.2%). Steps should be taken for: establishment of facilities for data collection where analysis, revision and expansion of information is conducted; the standardization of terminology; conducting periodic assessment of short-term and long-term data collection and research needs for wastewater management; increasing access by government officials to information related to wastewater management issues for decision making; public access to information related to wastewater management issues for decision making; establishment of a standardized data collection system, in order to gather comprehensive and comparable information; and establishment of a national knowledge and information system/ clearing house mechanism of tools and approaches for wastewater management that are effective and appropriate to the expectations and context of the beneficiaries in the Wider Caribbean.

**Organizations' Support for Wastewater Management**

- The presence and participation of water and sanitation organizations is regular (27.8 %) and the level of support of international UN and cooperation agencies is high. Steps should be taken to improve the participation of: financial agencies (IDB, World Bank, Central American Development Bank); professional organizations; media organizations; "Healthy Schools" programmes; eco clubs; theatre groups and community organizations.

**Climate Change Impacts**

- The impact level of climate change on wastewater management is expected to be high (6.7%). The impacts that are expected to have a medium level of impact are higher humidity and increased risk of fire. Belize should increase resilience in wastewater management for: higher temperatures; rising seas; high water tables; increased risk of drought; increased risk of flood; stronger storms and increased storm damage and increased risk of hurricanes.

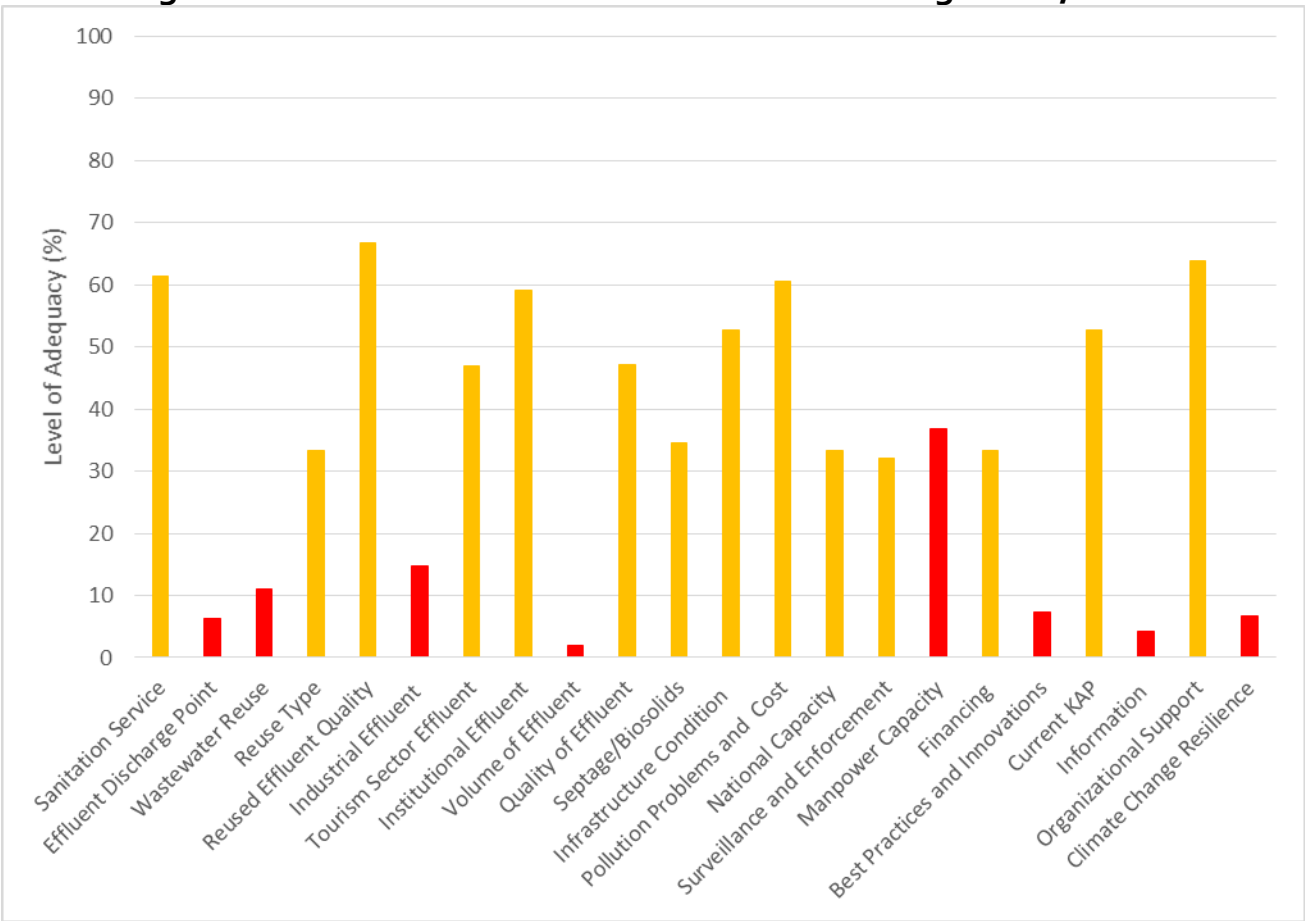
Table 30 presents a summary of the grades assigned to the issue areas from the analysis of the questionnaires. These grades can be seen as the level of adequacy of the particular wastewater issue. Figure 15 shows a graph of these results illustrating the level of adequacy using the following scale:

0 to 30 = negative adequacy impact (red)
31 to 70 = neutral adequacy (amber)

**71 to 100 = positive adequacy impact (green)**

| Table 30 Level of Adequacy of Wastewater Issues | | | |
|---|---|---|---|
| **Issue Area** | **Level of Adequacy** | **Issue Area** | **Level of Adequacy** |
| Sanitation Service | 61.4 | Infrastructure Condition | 52.8 |
| Effluent Discharge Point | 6.3 | Pollution Problems and Cost | 60.6 |
| Wastewater Reuse | 11.1 | National Capacity | 33.4 |
| Reuse Type | 33.3 | Surveillance and Enforcement | 32.0 |
| Reused Effluent Quality | 66.7 | Manpower Capacity | 36.9 |
| Industrial Effluent | 14.8 | Financing | 33.3 |
| Tourism Sector Effluent | 46.9 | Best Practices and Innovations | 7.4 |
| Institutional Effluent | 59.1 | Current KAP | 52.8 |
| Volume of Effluent | 2.0 | Information | 4.2 |
| Quality of Effluent | 47.1 | Organizational Support | 63.9 |
| Septage/Biosolids | 34.6 | Climate Change Resilience | 6.7 |

**Figure 16: Baseline Assessment Wastewater Management, Belize**



# 17. RECOMMENDATIONS FOR ACTION

The main recommendations are presented below. These are based on the literature review and the results of the mathematical model.

## Legislative, Policy and Institutional Frameworks

1. Consolidate all sanitation legislation into one comprehensive act that will address all aspects of sanitation services consistent with the LBS Protocol.

2. Consolidate regulations governing the sanitation sector. Sanitation regulations exist under different laws, and their enforcement therefore falls under different ministries and agencies. Legislation and enforcement should be revised and harmonized into one instrument, with one lead ministry spearheading all matters related to sanitation. Build capacity of the lead sanitation agency – once identified – to implement sanitation policy and enforce the sanitation act. This lead agency should have the resources and the capacity to take up this role.

3. Clarify which entity should lead in the execution of sanitation-related responsibilities since there is an overlap in responsibilities.

4. Review and approve the draft policy for water and sanitation coverage and maintenance that has been formulated through the MAF process.

5. Conduct proper planning to guarantee the timely delivery of interventions in this sector, especially to identify and share responsibilities among stakeholders, reduce costs and make the best use of available materials and human resources. Strategic planning is necessary to guarantee sustainability and prevent any deterioration in access to sanitation for the most vulnerable populations.

6. Prepare a 20-year sanitation development plan to determine the minimum needs for sewage treatment and secure land for expansion.

7. Secure funding and identify new revenue / funding sources for sewerage expansion efforts. Improve income generation capacity of the sanitation sector.

8. Strengthen the human resources capabilities both in terms of number and qualifications of the Ministry of Labour, Local Government and Rural Development. To implement the proposed interventions and solutions, the capacity of this ministry will need to be strengthened with a focus on building technical capacity, acquiring key equipment and developing an operational budget sufficient to properly carry out water and sanitation responsibilities in the rural areas.

9. Heighten the regulatory roles of the other ministries in this sector such as the Ministry of Health and the Ministry of Natural Resources and the Environment, and make available the necessary resources that they need to carry out their responsibilities. At the same time, communities need to hold service providers to account.

10. The first responsible partners are the ministries involved in the water and sanitation sector including the MLLGRD, MED, MOH and MNRE. Increase coordination between these ministries and review and revise the associated, scattered legislation.

11. Establish and harmonize minimum standards for individual sanitation systems.

12. Build capacity and provide resources to develop land use policy.

13. Tighten control of construction activities in urban areas, densely populated villages, coastal regions and cayes.

14. Build leadership capacity at the community level to integrate and implement improvement of sanitation in villages.

## Sanitation Coverage

15. Provide more attention to sanitation. Sanitation continues to remain a neglected portfolio; water and sanitation receive very limited attention to build and improve technical capacity both at the institutional and community levels. Progress in sanitation should be accelerated and will require a concerted effort at the national and local levels to accelerate the progress. Sanitation has remained slow, moving coverage from 41 per cent in 1995 to 73.5 per cent in 2009, with success impeded by the absence of a primary agency, limited coordinated communication and awareness, cultural practices and poverty. Approximately 26.4 per cent of Belize's population is affected by un-improved sanitation, mostly in rural areas.

16. Sanitation is achievable if supported by the right set of policies, targeted technical assistance, institutional capacity, adequate funding, and strong political commitment and community engagement.

17. Provide attention to improve the inadequate treatment and disposal of municipal wastewater (Belize City and San Pedro Ambergris Caye). The Belmopan wastewater plant is being rehabilitated. Belize City is 40 per cent sewered but is discharging its outfall directly to the sea. Wastewater analyses have verified pollution in the surroundings of the outfall, however BWSL denies these findings. A study should be initiated to assess the functioning of the sewage ponds in Belize City and San Pedro Ambergris Caye since it is unknown if the ponds are operating effectively and efficiently in treating the wastewater.

18. Expand piped sewerage systems in urban centers (Belize City, Belmopan and San Pedro Ambergris Caye and others) to those households that presently use septic tanks. Use of small diameter sewerage systems should be considered, taking advantage of the septic tanks. A cost benefit analysis of this intervention will be needed to justify the upfront investment. Today, whereas much of the city is now connected to the central system, a

large portion of the city still relies on septic tanks and soakaways for sewage disposal. In some areas, disposal is still directly into open canals, though this practice is now very limited. In much of the country outside Belize City, there is no central sewage disposal system, and disposal is overwhelmingly by septic tanks in conjunction with soakaways, and occasionally in conjunction with leach fields. There is high risk of pollution from septic tanks located above limestone in Corozal and sandy soils in Dangriga Town. Sand does not have a large absorption complex like clay, and excess amounts of nutrients will pass through and end up in the shallow fresh water layer under the peninsula and ultimately flushed out towards the sea and the lagoon on either side of the peninsula. Filtration time is short and pathogens are not sufficiently killed off, which is confirmed in a recent study that showed the presence of streptococci in the lagoon water (J. Franco, 2010, unpublished data). Households that are not connected to sewer systems may have their own individual sanitation system including a flush toilet with a septic tank or latrine, or collect waste in buckets for later disposal in the sea or in overgrown bushes. Facilitate household upgrade to connections to BWSL sewer system.

19. Provide amenities to prevent open defecation, which still continues in some areas of the country, mostly in the south.

20. Take steps to eliminate the 'honey pot' method. This method is nothing more than collecting the waste and disposing of it on the beach or in the sea or lagoon. Provide other sanitation facilities comprised of pit latrines (improved and non-improved) for households who cannot invest in the construction of a flush toilet and septic system.

21. Provide lift stations in the Belize City sewerage system with automatic dry priming backup systems to increase system reliability and enable scheduled preventative maintenance and repair. This is to prevent direct discharge of wastewater into the sea, river or canal via a series of outfalls designed as a failsafe mechanism to deal with overflows, malfunction and power outages.

22. Explore, identify and adapt relevant technology for disposal and treatment of sewage. The present strategy regarding wastewater management (package plants, biogas toilets, alternating intermittent recirculating reactors, and wetland wastewater treatment) should be continued and extended both in new housing schemes and in the booming tourism industry where more resorts are being built in coastal and off-shore sites.

23. Increase tertiary wastewater treatment. Package plants are adequate solutions for the handling of waste water to a certain extent, but the discharged effluents still contain a high level of nutrients, and if these effluents do not receive a form of tertiary treatment, the nutrients can still be detrimental to the environment of the lagoon and the sea where the nutrients ultimately will end up.

24. Facilitate the construction of basic improved sanitation facilities for the poorest households, based on joint efforts with the community.

25. Conduct a needs assessment review of the sanitation sector for new and/or expansion of sewerage systems and investigate alternative sanitation facilities.

### Industrial Effluents

26. Provide attention to solve the incomplete treatment of industrial effluent due to technology and capacity shortfalls by implementing and enforcing the effluent regulations, especially including the penalties for violations, to prevent contamination of water bodies from industrial effluents. With the enactment of the Environmental Protection Act and its subsequent regulations – the Effluent Limitation Regulations and the EIA Regulations – all new and existing industries must employ environmentally sound systems to treat their wastewater in order to protect the public's health and to ensure a safer, cleaner and healthier environment.

### School Sanitation

27. Improve sanitation in schools to meet international recommended standards of 25 girls per toilet in 70 per cent of schools and 50 boys per toilet or urinal in 67 per cent of schools. This should include sufficient toilets and urinals accessible to students with physical disabilities. Many physically disabled students have to rely on their peers to assist them when they need to use the toilet. This can lead to embarrassment, students not using the facilities when they need to and compromises their independence.

28. Initiate a hygiene management programme to promote hygiene practices such as handwashing with soap and ensure the provision of soap. Conduct efforts to improve the sanitary condition / cleanliness of school toilet facilities.

### Sanitation Information System

29. Develop a database system to facilitate evidence-based planning and interventions for sanitation services and programmes. The database should be built on the resources available among agencies that support sanitation projects.

30. Make available detailed information on the households which have an improved sanitation system and those which do not. This information should include a detailed data system based on cadastral maps which would give authorities insight into where action has to be taken to improve the level of sanitation coverage in the country. It also should include all information pertinent to the sanitation sector such as overview of ongoing sanitation projects and villages / households in need of technical or financial assistance. The system should be developed and installed in MLLGRD.

### Surveillance and Enforcement

31. The MOH, through its Central Laboratory, and the Department of the Environment should implement joint efforts to improve surveillance of wastewater discharges and

water bodies. DOE on a regular basis samples the discharged effluents from sewerage systems. Although there is limited evaluation and monitoring system, it is estimated that a large part of the superficial water in urban areas is contaminated because of the inadequate disposal of household, agricultural and industrial liquid and solid wastes. There is no proactive monitoring of the status of household sanitation facilities and is absent at the rural level.

32. Identify, delineate and preserve catchment areas for the major water sources.

33. Prohibit any activity that compromises the quality and quantity of water bodies.

34. Introduce safeguards where water sources are used for irrigation purposes to prevent any contamination as a result of agro-chemical application.

35. Improve Public Health Bureau and Department of the Environment laboratory capabilities to enable water quality monitoring of mercury and other chemicals relevant to Belize's water quality.

36. Public Health Officers, who are legally mandated to inspect the building plans to ensure they include properly designed septic systems, shall supervise that every construction activity in urban and rural areas have a building permit from the Central or Local Building Authorities. In practice, this only happens during the construction of larger buildings and only in urban areas.

37. Implement more control on the design and quality of septic tanks through adequate monitoring. Officers shall also be required to monitor the status of improved pit latrines in urban areas, although these are likely to be replaced by flush toilets when the households can afford it.

38. Improve enforcement to ensure constructing functional treatment systems, proper maintenance and desludging of septic tanks. Much of the existing septic systems are not functioning properly and are mostly due to the designs which are not to standard and as such only partially treat the raw sewage and grey water. The lack of proper maintenance and desludging of septic tanks results in direct environmental impacts that can immediately contaminate any nearby water body such as creeks, rivers, sea and underground water. There have been recorded instances also that there are no soakaway or leach field and simply discharge these into the wetland or water bodies.

39. Enforce changes in traditional methods of waste management used today. The country's poor population with no basic sanitary infrastructure use pit latrines and bucket parades to the nearest creek, river or 'bush'. Grey or residual water is simply funneled to a nearby drain, soak away or water body. It is a 'out of sight, out of mind' mentality that still is practiced.

## Technical Assistance

40. Decentralize improved sanitation coverage to make it available to anyone anywhere in the country because it is a service that most households should be provided with. The challenge will be to mobilize the population of Belize in such a way that those who can afford to improve the standard of their sanitation system do so independently. At the same time, a concerted push should be made to target that section of the population who does not have the technical and/ or financial means to improve their own sanitation facilities of which a large majority is located in rural communities.

41. Build community capacity and skills to maintain or improve the standards of sanitation facilities for each household. Village councils are legally charged with sanitation responsibilities in villages, but only in a few communities are they likely to take on the leadership role to ensure proper monitoring of sanitation. Capacity building of the village councils in the field of sanitation monitoring and regulation may be very useful in guiding and controlling the different efforts to establish sanitation facilities in rural areas. Capacity building should also be extended to the wider community so that they can demand better monitoring of sanitation coverage in their community.

42. Provide technical and financial support at the community level for those households adopting pit latrines as an improved sanitation facility, taking into consideration local conditions (for example, sandy soil and a high water table).

43. Disseminate amongst the general public technical assistance and information on how to determine the size of the leach pit. Partnering with the communities, people will learn how to properly build a latrine and, in the future, other families will develop the capacity to build and maintain their own.

44. Reactivate the inter-sectoral "Community-Based Environmental Health Programme" to coordinate the delivery of community-based services. Introduced under the auspices of the USAID-funded Improved Productivity Through Better Health Project (IPTBH), this strategy calls for coordinated planning with the Ministry of Health and the Ministry of Natural Resources through the development of inter-sectoral community-based environmental teams to address environmental problems common to both ministries. A major accomplishment of this programme has been the formation of institutional linkages between the two ministries, using primary health care as a vehicle for this effort.

## Public Awareness

45. Conduct public awareness campaigns about good sanitation practices. A sanitation education campaign should be strengthened to change the low priority perception of improved sanitation by households. The public awareness campaign and training should be innovative and appealing to the public. It should promote awareness of the need for proper sanitation and explain the associated health and financial benefits.

The campaign should also be addressed to the different stakeholders to raise support to wastewater management issues. It should disseminate information on the standards of sanitation and good sanitation practices to the general public, professionals, teachers, and health workers. It should target and train the community (leaders, heads of households, women, youth, etc.). To achieve this, there is a need to mobilize and coordinate rural community development officers and MLLGRD, BSIF, etc. to inform and train all community stakeholders in sanitation and hygiene.

## Innovative Approaches

46. Explore, identify and adapt relevant technology for disposal and treatment of sewage.

47. Conduct a review of sanitation facilities and investigate use of alternative, cost-effective systems.

## Research

48. Conduct studies related to the impact on health and environment of bad wastewater management.

49. Conduct an evaluation on how climate change will impact on wastewater management. The information available does not fully address this problem.

# REFERENCES

1. Ariola, E., 2003. Characterization of a tropical estuarine system: The Placencia Lagoon. Report by the Belize Coastal Zone Management Authority.
2. Barrera 2008. Barrera R, Amador M, Diaz A, Smith J, Munoz-Jordan JL, Rosario Y. *"Unusual productivity of Aedes aegypti in septic tanks and its implications for dengue control."* Dengue Branch, Division of Vector-borne Infectious Diseases, Centres for Disease Control and Prevention, San Juan, Puerto Rico. Med Vet Entomol. 2008 Mar; 22(1):62-9.
3. Belding 1970. The culicidae of Jamaica, (Mosquito Studies. XXI). Contrib. Amer. Ent. Inst., vol. 6, no. 1, 1970. http://www.mosquitocatalog.org/files/pdfs/008800-0.pdf
4. Belize Agricultural Health Authority (BAHA) ND. Central Investigation Laboratory Food and Environmental Testing Service. Available at: http://www.baha.bz/About%20CIL%20brochure.pdf
5. Belize Audubon Society 2008. An Environmental Agenda for Belize 2008–2013: FULL REPORT.
6. Belize Human Resources for Health Observatory (BHRHO) ND. Belize Human Resources in Health Steering Committee Meeting. Available at: http://www.observatoriorh.org/belice/?q=node/4
7. Belize Water Service (BWS) 2009. Annual Report 2008-2009. Accessed in July 12th 2012 http://www.bws.bz/static/uploads/2008_2009%20Annual%20Report.pdf
8. Belize Water Services (BWS) 2012. Home page accessed in September 2011. http://www.bws.bz/waste-water/
9. Belize Enterprise for Sustainable Development (BEST) 2009. National adaptation strategy to address climate change in the water sector in Belize: Strategy and action plan. Prepared for the Caribbean Community Climate Change Centre.
10. Caribbean Court of Justice (CCJ). 2003. Caribbean Court of Justice. www.caribbeancourtofjustice.org.
11. Caribbean Development Bank (CDB). 2007. Annual Economic Review: Belize 2006. Caribbean Development Bank, Barbados, West Indies.
12. Caribbean Epidemiology Centre (CAREC/PAHO/WHO) 2008.
13. Caribbean Planning for Adaptation to Climate Change Regional Project Implementation Unit (CPACC). 2002. Final Report of the Caribbean Planning for Adaptation to Climate Change (CPACC) Project. Produced jointly by the Unit for Sustainable Development of the Organization of American States and the CPACC Regional Project Implementation Unit. Washington, D.C.
14. Channel 5 Belize 2010. Gastroenteritis on the rise in Belize. March 23, 2010. Seen October 12, 2012. http://edition.channel5belize.com/archives/29984
15. Chatterley Christie. *"National Assessment of WASH in Schools – Belize: Analysis of 2009 survey data to assess water, sanitation and hygiene in Belizean schools".* Prepared for the Ministry of Education and UNICEF, Belize May 2011. http://dbzchild.org/uploads/docs/final_wash_assessment.pdf
16. Chicas 2008. Study on Cleaner Production Opportunities for the Sugar Industry in Belize. International Master's Program in Environmentally Sustainable. National Central University, Taiwan ROC.

17. Chief Parliamentary Counsel 2009. Cap. 328, Environmental Protection Act - subsidiary law. Ministry of Natural Resources and the Environment. Environmental protection. No 102.
18. Ciguatera – Food Poisoning. AmbergrisCaye.com. http://ambergriscaye.com/index.php
19. Cooper, E, Burke L. and Bood N. 2009."Coastal Capital: Belize. The economic contribution of Belize's coral reefs and mangroves ". WRI Working Paper. World Resources Institute. Washington DC. 53 pp. Available on line at http://www.wri.org/ppublications
20. Department of Environment 2008. *Draft* National Plan of Action for the Control of Land-Based Sources of Marine Pollution in Belize. Ministry of Natural Resources and the Environment.
21. Dyson K. 2010. Pollution in paradise: A conceptual model of beach pollution and tourism-Links between beach pollution and tourism-. KMI International Journal of Maritime Affairs and Fisheries.
22. Emanuel E. 2010a. Wastewater Management in the Wider Caribbean Region: Knowledge, Attitudes and Practice (KAP) Study. Prepared for Caribbean Regional Fund for Wastewater Management (CReW). CEP Technical Report 64
23. Emanuel E. 2010b. Gap Analysis and Regional Best Practices in Wastewater Management. Prepared for Caribbean Regional Fund for Wastewater Management (CReW). CEP Technical Report 64
24. Faust Maria A. *"Ciguatera-Causing Dinoflagellates In a coral-reef mangrove ecosystem, Belize"*. Atoll Research Bulletin No. 569. National Museum Of Natural History Smithsonian Institution Washington, D.C., U.S.A. July 2009
25. Fernandez 2002. Development of a marine pollution monitoring project for the Meso American barrier reef systems project (MBRS): Belize country report. Prepared for the Meso American Biological Reef System Project.
26. Food and Agriculture Organization (FAO). 2011. *Country Programming Framework for Belize: 2011-2015*, Belmopan City, Belize.
27. Garcia, L., 2003. Placencia Lagoon Seagrass Report for Friends of Nature Belize. Final Report. Placencia, Belize.
28. Government of Belize (GoB) 2006. Government of Belize Website. http://www.governmentofbelize.gov.bz/index.php.
29. PADECO 2011. Annex 04 – Existing Issues of Water Supply and Sewerage in Belize City, Prepared for the Inter American Development Bank.
30. Kareem M. Usher 2007 « Natural Hazard Mitigation Strategies in the Continental Caribbean: The Case of Belize », *Études carib éennes* [En ligne], 7 | Août 2007, mis en ligne le 04 février 2008, consulté le 04 février 2013. URL : http://etudescaribeennes.revues.org/324 ; DOI :10.4000/etudescaribeennes.324
31. Ledwin Sean. *"Assessment of the Ecological Impacts of Two Shrimp Farms in Southern Belize"*. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Natural Resources and Environment of the University of Michigan April 2010.
32. Manzanero, Marvin in *Belize records first case of Chikungunya virus.* November 22, 2014.The Daily Observer. Accessed January 6 2015 at: http://antiguaobserver.com/belize-health-belize-records-first-case-of-chikungunya-virus/

33. Martin. D. & Manzano**, O.** 2010a. *Towards a Sustainable and Efficient State: The Development Agenda of Belize*, Inter-American Development Bank, Washington, D.C.
34. Martin, D. & Manzano, O. 2010b. Brief profile of the agriculture sector. Prepared for Bureau of Western Hemisphere Affairs 2010b
35. Meerman J. C. & Boomsma T. *Environmental and Social Analysis of the Construction and Operation of a Wastewater Collection, Treatment, and Disposal System for the Placencia Peninsula*. Sep 2010. http://www.doe.gov.bz/documents/Placencia%20Wastewater%20System%20ESA.pdf
36. Mendoza 1998. COUNTRY REPORTS: Domestic & Industrial Wastewater Treatment in Belize. Proceedings of the Workshop on Adopting, Applying and Operating Environmentally Sound Technologies for Domestic and Industrial Wastewater Treatment for the Wider Caribbean Region. CEP Technical Report #43. UNEP
37. Ministry of Health, Belize. "Health Situation in Belize: Belize basic Indicators". Office of the Director of Health Services. The Epidemiology Unit. Volume No. 8, Year 2011.
38. Ministry of Natural Resources and the Environment (MNRE) 2002a. Frequently Asked Questions. http://www.mnrei.gov.bz/faq.asp
39. Ministry of Natural Resources, Environment, and Industry 2002b. Belize National Report to the World Summit on Sustainable Development.
40. Nelson, et al 2006. Worldwide Applications of Wastewater Gardens and Ecoscaping: Decentralized Systems which Transform Sewage from Problem to Productive, Sustainable Resource. Paper for International Conference on Decentralized Water and Wastewater Systems, Environmental Technology Centre, Murdoch University, Fremantle, W.A. 10-12 July 2006
41. Pan American Health Organization (PAHO) 2009a. "Health Systems Profile Belize: Monitoring and Analyzing Health Systems Change/ Reform". Washington, D.C. OPS, 2009. ISBN: 978-92-75-13040-7 (Electronic)
42. PAHO 2000b. Belize Water & Sanitation Sector Analysis. Draft final report. Plan Regional de Inversiones en Ambiente y Salud. Serie Análisis No. 1
43. Pinsent Masons 2011. Water Yearbook 2010-2011 Available at: http://www.sanpedrosun.com/old/01-132.html
44. Stantec. 1999. Belize Solid Waste Management Project, Phase 2 Report and Plan Volume I. Consultants report to Government of Belize.
45. Statistical Insitute of Belize (SIB). 2007b. Belize: Total Population Estimates and Projections (1980-2050). Statistical Institute of Belize, Belmopan.
46. Tabita 1962. History of Hyacinth Control in Florida. http://www.apms.org/japm/vol01/v1p19.pdf
**47.** United Nations Development Programme 2011a. Second National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change.
**48.** UNDP 2011b. *Belize MDG acceleration framework: water and sanitation*. UNDP**.**
49. UNEP-CEP. 2009. *Report of the 18th Caribbean Water and Wastewater Association Conference.* Prepared by Sustainability Managers.

50. UNEP 2010. Profiles of Wastewater Management in WCR Countries. Technical Report 54. Viewed 07 July 2012 from http://www.cep.unep.org/publications-and-resources/technical-reports/Annex%20A%20Country%20profiles%20-%20May%207-%202010.pdf
51. UNEP 2011. National Environmental Summary Belize.
52. U.S. Department of State. "Background Note: Belize". (August 2008).
53. University of Belize 2012. Viewed 08 July 2012 from http://www.ub.edu.bz/nrm/degrees_offered.php
54. Usher William (2009). The use of effective microorganism technology™ (EM) in the waste water treatment ponds of the Belize Sugar Industries Ltd. Belize Agro-Enterprise Limited, BAEL. Viewed 08 July 2012 from http://www.emturkey.com.tr/TR/dosya/1-264/h/05-belize-empresentationsummarybsiwastewatertreatment.pdf
55. Vanzie Errol 2008. A*ssessment of the impact of climate change on Belize's health sector: dengue and dengue hemorrhagic fever*. Belize second national communication (SNC) project.
**56.** WHO 1997. Vector Control**:** Methods for Use by Individuals and Communities. Prepared by Jan A. Rozendaal.
57. WHO / UNICEF 2012. Joint Monitoring Programme for Water Supply and Sanitation Estimates for the use of Improved Drinking-Water Sources: Belize. wssinfo.org
58. WHO / UNICEF 2012b. Joint Monitoring Programme for Water Supply and Sanitation Estimates for the use of Improved Sanitation Facilities. wssinfo.org
59. World Bank 2011. International tourism, number of arrivals. http://data.worldbank.org/indicator/ST.INT.ARVL

# ANNEX 1 DEFINITION OF OBJECTIVES FOR AREAS OF FOCUS

**1. Sanitation Coverage**

The objective is to present information regarding the type of sanitation used for carrying, treating and disposing the excreta and wastewater generated. This includes:

- the type and coverage of excreta disposal systems used
- the total population served with Wastewater Treatment Plants
- the percentage of population receiving primary, secondary and tertiary treatment
- the percentage of WWTPs meeting discharge limits

**2. Disposal of Treated/Untreated Wastewater**

The objective is to find out where wastewater is disposed and the perceived level of environmental impact. This includes determining the impact of wastewater reuse. It is believed that wastewater discharges into the sea or mangroves have the greatest impact on the LBS Protocol. Reuse of wastewater has the least impact, because in the case of irrigation, wastewater receives additional treatment.

**3. Wastewater Reuse**

The objective is to find out the degree of treatment before reuse and the level of reuse in each case. In many countries wastewater is reused unintentionally.

**4. Type of Reuse**

The objective is to find out where water is reused and the level of reuse. Effluent from septic tanks disposed of into the ground by the use of trenches or percolation pits, are ways of unintentional artificial recharge.

**5. Quality of Effluent**

The objective is to find out the quality of the effluent for each type of reuse.

**6. Industrial Effluent Discharge**

The objective is to determine existing industries in the country that are considered a priority in the LBS Protocol, the industrial wastewater management practices and level of discharges. This also seeks to determine the level of effluent compliance and if there is surveillance and enforcement.

**7. Tourism/Hotel Sector Wastewater Management**

Tourism plays an important role in the economy of Caribbean countries. If wastewater produced by the tourism industry is not managed properly, tourism will become environmentally unsustainable and tourists will migrate to cleaner locations. The objective is to find out hotel wastewater management practices and level of discharges as well as the level of effluent compliance and how proper surveillance and enforcement is conducted.

**8. Institutional Effluent Discharges**

Hospitals and schools can be important sources of infectious and other liquid wastes. Commercial centres and other types of institutions, many of which manage their own wastewater management systems, are also important sources of pollution. Thus, the objective is to determine institutional wastewater management practices and level of discharges as well as the level of effluent compliance and how proper surveillance and enforcement is conducted.

**9. Amount of Water Discharged**

The objective is to estimate the pollution load in different water bodies. Therefore information on the amount of wastewater discharged in different water bodies is needed. In case that information is not available, then a qualitative answer is obtained, i.e. level of discharge.

**10. Quality of discharge**

This question is the complement of focus area #9. Here the objective is to find out the level of treatment before discharge. Water bodies receive different quality levels (raw, primary, secondary and tertiary).

**11. Septage/Biosolids Management**

Sludge from septic tanks (septage) and sludge produced in WWTPs (raw and digested) are important sources of pollution that is frequently ignored. The objective is to assess the level of adequacy of septage and biosolids management, in terms of treatment, place of disposal and amounts generated.

**12. Condition of wastewater treatment infrastructure**

The objective is to get information on the physical condition, age and obsolescence of wastewater sewerage and WWTPs.

**13. Pollution Problems and their Cost**

The objective is to assess the types of problems and the costs associated with not addressing them, such as poor health and disease, loss of business, resources, recreational, and other pertinent areas.

**14. National Capacity**

The objective is to identify national planning issues pertaining to policy, legal and regulatory frameworks, government institutions, information management systems, and education to enable national compliance with Annex III of the LBS Protocol of the Cartagena Convention as well as political will.

**15. Surveillance and Enforcement Capacity**

It is impossible to know how good or bad a wastewater management programme is without a diagnostic. Adequate laboratory capacity along with adequate of surveillance capacity is of utmost importance to support wastewater effluent and ambient environmental quality monitoring to assess compliance with LBS Protocol Annex III parameters. To close the cycle, another important element is enforcement. The objective is to assess these issues.

**16. Manpower Capacity**
The objective of this is to acquire information on training requirements and actual training offered at the national and regional levels.

**17. Financing**
The objective is to determine the level of financing of wastewater management to assess compliance with LBS Protocol Annex III.

**18. Best Practices and Innovative Technological Treatment Solutions**
The objective is to identify existing and potentially viable approaches to addressing domestic wastewater system needs and evaluate and develop recommendations based on criteria such as local conditions, effectiveness, availability, cost-effectiveness, and stakeholder acceptability.

**19. Current Knowledge, Attitudes, Behaviours and Practices**
A KAP survey is a representative study of a specific population to collect information on what is known, believed and done in relation to a particular topic. The objective is to conduct a brief KAP survey related to wastewater management in the Wider Caribbean.

**20. Information Collection and Sharing**
The objective is to examine the capacity of countries in the region to collect and share information related to wastewater management and the avenues used for communicating this information within the sector and with the general public.

**21. Water and Sanitation Diaspora Organizations**
There are different organizations that support environmental protection and sanitation programmes. These organizations invest a good amount of funds both in technical cooperation and financing of infrastructure, as wells as in the creation of awareness. The objective is to determine the various organizations involved and their degree of support wastewater management.

**22. Climate Change Impacts**
With global warming, human well-being will be affected by droughts and higher temperatures either directly or indirectly. Pathogen loading of streams and poor sanitation could possibly result from lack of potable water. Storage of water during droughts in drums provides suitable habitats for mosquitos and so augments the transmission of vector-borne diseases such as dengue fever and malaria, which are likely to increase with predicted higher temperatures. Increased pesticide use for vector control will also have an impact on water bodies and the food chain.

Increased temperatures are also associated with increased episodes of diarrhoeal diseases, sea food poisoning and increases in dangerous pollutants. Threats from higher temperatures may cause greater contact between food and pest species. Warmer seas contribute to toxic algae

bloom and increased cases of human shell-fish and reef-fish poisoning. Incidents of high temperature morbidity and mortality are projected to increase and so the use of pharmaceuticals which will end up in water bodies.

Thus, the objective is to assess the level of discussion about of how climate change is going to affect compliance with the LBS Protocol.

## Mathematical Model Belize

## 2. Overview of Wastewater Treatment Management

| 2a. Domestic Wastewater Treatment Systems | | | | | |
|---|---|---|---|---|---|
| **1** | Level Sanitation service | | Adequacy of service/treatment | | |
| | | % | Poor | Medium | High |
| **1A** | Sewerage System | **28** | | X | |
| **1B** | Septic Tank (on-site treatment) | **34.6** | X | | |
| **1C** | Latrine | **33.6** | | | X |
| **1D** | Open defecation | **2.7** | X | | |
| **1E** | % Population connected to a WWTP | **16** | | X | |
| **1F** | % Population Primary Treatment | **1.7** | X | | |
| **1G** | % Population Secondary Treatment | **14.3** | | X | |
| **1H** | % Population Tertiary Treatment | **0.01** | X | | |
| **1I** | % Meeting Discharge Standards | **14.3** | X | | |
| **2** | Disposal of treated/untreated wastewater | | **Impact** | | |
| | | % | Low | Medium | High |
| **2A** | River | **2.6** | | X | |
| **2B** | Lake | **1.1** | | X | |
| **2C** | Sea | **12.3** | | | X |
| **2D** | Underground | **69.2** | | X | |
| **2E** | Reused | **0.1** | X | | |
| **2F** | Other (specify): | | | | |

| 2b. Wastewater Reuse | | | | | |
|---|---|---|---|---|---|
| **3** | **Wastewater Reuse** | | **Level of reuse** | | |
| | | Yes = 1 | Low | Medium | High |
| **3A** | Treatment and Reuse | **1** | X | | |
| **3B** | Treatment and No Reuse | **1** | | | X |
| **3C** | No Treatment and Reuse | **1** | X | | |
| **4** | **Type of Reuse** | | **Level of Reuse** | | |
| | | Yes = 1<br>No = 0 | Low | Medium | High |
| **4A** | Irrigation Unrestricted<br>Root and Leaf Crops, high and low growing crops | 1 | X | | |
| **4B** | Irrigation Restricted<br>Labour Intensive and highly mechanized | 0 | | | |
| **4C** | Lawns/Parks | 1 | X | | |

| | | | | | |
|---|---|---|---|---|---|
| **4D** | Golf Courses | 0 | | | |
| **4E** | Cricket Grounds/Football Fields | 0 | | | |
| **4F** | Industrial | 0 | | | |
| **4G** | Aquaculture | 0 | | | |
| **4H** | Artificial Recharge (Septic Tank effluents) | 1 | X | | |
| **4I** | Surface reservoirs | 0 | | | |
| **4J** | Other (specify) | | | | |
| **5** | **Quality of Effluent** | | Level Quality of Effluent | | |
| | | | Low | Medium | High |
| **5A** | Unrestricted<br>Root and Leaf Crops, high and low growing crops | 1 | | | X |
| **5B** | Restricted<br>Labour Intensive and highly mechanized | 0 | | | |
| **5C** | Lawns/Parks | 1 | | | X |
| **5D** | Cricket Grounds/Football Fields | 0 | | | |
| **5E** | Cricket Grounds | 0 | | | |
| **5F** | Industrial | 0 | | | |
| **5G** | Aquaculture | 0 | | | |
| **5H** | Artificial Recharge | 1 | X | | |
| **5I** | Surface reservoirs | 0 | | | |
| **5J** | Other (specify) | 0 | | | |

| **2c. Industrial Effluent Discharges** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Type of Industries | Priority Industries* | | | | | | | | |
| | | a | b | c | d | e | f | g | h | i |
| | Presence of priority industry | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| **6A** | % of untreated wastewater sent to a WWTP | low | low | low | low | low | | | high | low |
| **6B** | % untreated wastewater discharged directly into water bodies | high | high | high | high | high | | | low | high |
| **6C** | % treated before discharged into water bodies | low | low | low | low | low | | | high | low |
| **6D** | % untreated before discharged into municipal sewers | low | low | low | low | low | | | low | low |
| **6E** | % of industrial wastewater that is treated together with municipal wastewater | low | low | low | low | low | | | low | low |
| **6F** | Level of effluent compliance | low | low | low | low | low | | | high | low |
| **6G** | Are there sampling and reporting requirements. | low | low | low | low | low | | | low | low |
| **6H** | Is there enforcement? Level of enforcement. | low | low | low | low | low | | | low | low |

*a = Agricultural; b= Chemical; c= Extractive Industries and Mining; d = Food Processing Operations; e = Manufacture of Liquor and Soft Drinks; f = Oil Refineries; g = Pulp and Paper Factories; h = Sugar Factories and Distilleries; i = Intensive Animal Rearing Operations

| **2d. Tourism /Hotel Sector Wastewater Management** | | | | | | |
|---|---|---|---|---|---|---|
| **7** | Tourism /Hotel Sector Wastewater Management | Existence | | Presence Level of Discharges | | |
| | | Yes = 1 | % | Low | Average | High |

| | | | | | | |
|---|---|---|---|---|---|---|
| **7A** | Are tourism and hotel facilities connected to a central sewerage system? (% connected) | 1 | | | X | |
| **7B** | Is the wastewater in the central sewerage system treated before it is discharged? (% treated) | 1 | | | x | |
| **7C** | Do tourism and hotel facilities not connected to a central sewerage system treat their wastewater before discharge? (% of facilities that treat) | 1 | | | | X |
| **7D** | Is treated wastewater in tourism and hotel facilities reused? (% reused) | 1 | | X | | |
| **7E** | Do tourism and hotel facilities discharge treated wastewater into water bodies? (% that discharge into water bodies) | 1 | | | x | |
| **7F** | Do tourism and hotel facilities discharge untreated wastewater into water bodies? (% that discharge into water bodies) | 1 | | X | | |
| **7G** | Level of effluent compliance | 1 | | | X | |
| **7H** | Is there sampling and reporting? | 1 | | X | | |
| **7I** | Is there enforcement? (Level of enforcement) | 1 | | X | | |
| | | | 0 | | | |

| **2e. Commercial and institutions not connected to sewerage situation** | | | | | | |
|---|---|---|---|---|---|---|
| **8** | Institutional Effluent Discharges | Existence | | Connection Level/Adequacy | | |
| | | Yes = 1 | % | Low | Average | High |
| **8A** | Hospitals (% connected to sewerage) | 1 | | | | X |
| **8B** | Schools (% connected to sewerage) | 1 | | | X | |
| **8C** | Camps (% connected to sewerage) | 1 | | X | | |
| **8D** | Other (specify): (% connected to sewerage) | 1 | | X | | |
| **8E** | Do institutions discharge treated wastewater into water bodies? Level of discharge? | 1 | | | X | |
| **8F** | Do institutional WWTPs exist in commercial and other institutions? Presence level? | 1 | | | X | |
| **8G** | Is treated wastewater in institutions reused? (% reused) | 0 | | | | |
| **8H** | Level of effluent compliance | 1 | | | X | |
| **8I** | Is there sampling and reporting requirement? | 1 | | X | | X |
| **8J** | Is there enforcement? (Level of enforcement) | 1 | | X | | |

0

| **2f. Pollution Load of sewage discharged into water bodies (Quantity and Quality)** | | | | | |
|---|---|---|---|---|---|
| **9** | **Amount of water Discharged** | **Yes= 1** | **Low** | **Medium** | **High** |
| | | **No = 0** | | | |
| **9A** | Do you know the total amount of sewage discharged into water bodies? | 1 | | | |
| **9B** | How much in MGD? | 1.82 | | | |
| | | How Much | Level of discharge | | |
| | Is water being discharged to: | | Low | Medium | High |

| | | | | | |
|---|---|---|---|---|---|
| **9C** | Creeks | 0 | | | |
| **9D** | Rivers, | 0.17 | | X | |
| **9E** | Natural or constructed reservoirs | 0 | | | |
| **9F** | Mangroves | 0.16 | | X | |
| **9G** | Coastal waters | 1.5 | | | X |
| **9H** | Outfalls | 0 | X | | |
| **9I** | Underground Injection (**Septic Tanks)** | 5.5 | | | X |
| **10** | Quality of discharge | Yes = 1 | **Level of Treatment** | | |
| | Is water being discharged to: | No = 0 | **Prim** | **Secon** | **Tert** |
| **10A** | Creeks | **0** | | | |
| **10B** | Rivers, | **0.17** | X | | |
| **10C** | Natural or constructed reservoirs | **0** | | | |
| **10D** | Mangroves | **0.16** | | X | |
| **10E** | Coastal waters | **1.5** | | X | |
| **10F** | Outfalls | **0** | | | |
| **10G** | Underground | **5.5** | X | | |

| **2g. Septage/Biosolids Management** | | | | | |
|---|---|---|---|---|---|
| **11** | Septage/Biosolids Management | | Adequacy of Treatment/Disposal | | |
| | | Yes = 1 | Low | Medium | High |
| **11A** | Does septage receive treatment? | 0 | X | | |
| **11B** | Adequacy of septage disposal? | 1 | X | | |
| | Where is disposed? | | | | |
| **11C** | Treatment plants? Quantity? | 0 | | | |
| **11D** | Landfills/dumpsites? Quantity? | 1 | | | X |
| **11E** | Land? Quantity? | 1 | | X | |
| **11F** | Water Body? Quantity? | 1 | | X | |
| **11G** | Do biosolids receive treatment? | 0 | | | |
| **11H** | Adequacy of biosolids disposal? | 1 | X | | |
| | Where are disposed of? | | | | |
| **11I** | Landfills/dumpsites? Quantity? | 1 | X | | |
| **11J** | Reused? Quantity? | 0 | | | |
| **11K** | Land? Quantity? | 1 | X | | |
| **11L** | Water body? Quantity? | 1 | X | | |
| **11M** | Amount of Septage produced (m3/year) | 1 | | | X |
| **11N** | Amount of Biosolids produced (m3/year) | 1 | X | | |

| **2h. Condition of wastewater management infrastructure** | | | | |
|---|---|---|---|---|
| **12** | Infrastructure Condition | Low | Medium | High |
| **12A** | How adequate is your sanitation WWTP infrastructure? | X | | |

| | | | | |
|---|---|---|---|---|
| **12B** | How adequate is your sanitation pipe network infrastructure? | X | | |
| | **Age of Infrastructure (YEARS)** | <10 | 10 - 20 | >20 |
| **12C** | Age of sewerage systems. What percentage of your total sewerage systems are | | 34 | 66 |
| **12D** | Age of WWTPs. What percentage of your WWTPs are | | 34 | 66 |
| | **Deterioration of Infrastructure** | | | |
| **12E** | Degree of deterioration of sewer lines | X | | |
| **12F** | Degree of deterioration of WWTPs | X | | |
| **12G** | Are technologies used old or obsolete? | | X | |
| | | | | |

| **3. Pollution Problems and Their Cost** | | | | |
|---|---|---|---|---|
| 13 | **Pollution Problems and Their Cost** | Very Little | Some | A Great Deal |
| **13A** | Level of pollution in rivers, lakes, mangroves and coastal areas (increase in thermal pollution in addition to nutrient pollution) | | | X |
| **13B** | Level of environmental deterioration such as toxic algae bloom and destruction of coral reefs | | | X |
| **13C** | Level of deterioration and impact in residential areas | | X | |
| **13D** | Level of deterioration and impact in commercial areas | | X | |
| **13E** | Level of deterioration of bathing and recreational areas | | | X |
| **13F** | Level of Social impact due to deterioration of the environment | | X | |
| **13G** | Level of Economic impact due to deterioration of the environment | | X | |
| **13H** | Number of cases of human shellfish and reef fish poisoning during last year. | X | | |
| **13I** | Number of outbreaks (water and food) related to bad sanitation during the last year. | | X | |
| **13J** | Number of vector borne diseases (Dengue, malaria, yellow fever, etc.) in the last year. | | X | |
| **13K** | Lost Opportunities due to deterioration of the environment | | X | |

| **4. National Capacity** | | | | | |
|---|---|---|---|---|---|
| **14** | **Policy framework** | | Level of Adequacy | | |
| | | Yes = 1<br>No = 0 | Low | Moderate | High |

| | | | | | |
|---|---|---|---|---|---|
| **14A** | Has the country highlighted domestic wastewater/ sewage as a priority pollutant in national objectives/ sustainable development planning? | 1 | | | X |
| **14B** | Are there strategies associated with the development of this sector? | 1 | | X | |
| **14C** | Are there performance indicators associated with the development of this sector? | 1 | | X | |
| **14D** | Are there targets associated with the development of this sector? | 1 | | X | |
| **14E** | Are there national policies in wastewater management, including a National Plan of Action? | 1 | | X | |
| **14F** | Do main cities have a Plan for wastewater management? | 0 | | | |
| **14G** | Do national policies allow for private sector participation in sewerage services in the absence of adequate public facilities island-wide? | 0 | | | |
| **15** | **Legislative framework** | | Level of Adequacy | | |
| | Which of the following Laws and Regulations exist in the country? | Yes = 1<br>No = 0 | Low | Moderate | High |
| **15A** | Environmental Act | 1 | | | X |
| **15B** | Public Health Act | 1 | | | X |
| **15C** | Environmental health Act | 1 | | | X |
| **15D** | Environmental Impact Assessment | 1 | | | X |
| **15E** | Marine protected areas | 1 | | X | |
| **15F** | Ambient Water Standards | 0 | | | |
| **15G** | Discharge Limits | 1 | | | X |
| **15H** | Marine Pollution Control Act | 0 | | | |
| **15I** | Design Standards for Wastewater Plants | 0 | | | |
| **15J** | Design for On-site Treatment Systems | 0 | | | |
| **15K** | Regulations on biosolids Management | 0 | | | |
| **15L** | Storm water runoff | 0 | | | |
| **15M** | Irrigation Standards | 0 | | | |
| **15N** | Urban Wastewater management | 0 | | | |
| **15O** | Agricultural pollutants standards | 0 | | | |
| **15P** | Pesticides environmental management | 0 | | | |
| **15Q** | Regulation of industry types | 0 | | | |
| **15R** | National Zoning Policy | 0 | | | |
| **15S** | Building Code | 1 | | X | |
| **15T** | Public Information e.g. boil water advisories | 0 | | | |
| **15U** | National Wastewater Management Strategy | 0 | | | |
| **15V** | Are legislative instruments adequate for wastewater pollution control? Level of Fusion? | 0 | | | |

| | | | | | |
|---|---|---|---|---|---|
| **15W** | Do legislative instruments for wastewater pollution overlap? Level of overlap? | 1 | | | X |
| **15X** | Level of enforcement of existing laws and regulations? | 1 | X | | |
| **16** | **Institutional framework** | | Level of Adequacy | | |
| | | Yes = 1 | Low | Moderate | High |
| **16A** | Is there a designated/ lead national authority for wastewater management? | 0 | | | |
| **16B** | Is there a water resource management authority? | 1 | | X | |
| **16C** | Is there a public service regulatory commission? | 1 | X | | |
| **16D** | Is there an intersectorial approach for wastewater management? | 0 | | | |
| **16E** | Is there an interdisciplinary approach? | 0 | | | |
| | Level of communication and collaboration between various sectors and agencies: | | | | |
| **16F** | Water | 1 | | | X |
| **16G** | Sanitation | 1 | | | X |
| **16H** | Health | 1 | | | X |
| **16I** | Environment | 1 | | | X |
| **16J** | Tourism | 0 | | | |
| **16K** | Industry | 0 | | | |
| **16L** | Agriculture and Livestock | 0 | | | |
| **16M** | Social development | 0 | | | |
| **16N** | Planning | 0 | | | |
| **16O** | Finance | 0 | | | |
| **16P** | Labour | 0 | | | |
| **16Q** | Food | 0 | | | |
| **16R** | Developers | 1 | | X | |
| **16S** | How adequate are the current institutional arrangements for wastewater management at the community, local and national levels? | 1 | X | | |
| **16T** | Is there a Regional Intersectorial/interdisciplinary approach? | 1 | | X | |
| **16U** | Do responsibilities overlap among various agencies with respect to wastewater management? Level of overlap? | 1 | | X | |
| **16V** | Is there a fragmented approach in the institutional framework with respect to wastewater management? Level of fragmentation? | 1 | | X | |
| **16W** | Is your Water Authority:<br>1: a government department,<br>2: a statutory authority, or<br>3: a public company? | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **5. Surveillance and Enforcement Capacity** | | | | | |
| 17 | Surveillance and Enforcement Capacity | | Level of Adequacy | | |

| | | Yes = 1 | Low | Average | High |
|---|---|---|---|---|---|
| **17A** | Is there a wastewater discharge surveillance programme? How adequate is coverage and frequency of monitoring? | 1 | X | | |
| **17B** | Is there a natural water surveillance programme? How adequate is coverage and frequency of monitoring? | 1 | X | | |
| **17C** | Are there qualified personnel for surveillance? Is the quantity of personnel adequate? | 1 | | X | |
| **17D** | Is enforcement of regulations applied? How adequate is the level of enforcement? | 1 | X | | |
| **17E** | Is there equipment and supplies for wastewater and natural water sampling? Is it sufficient? | 1 | X | | |
| **17F** | Are there standardized methods for wastewater and natural water sampling? Are they adequate? | 1 | | | X |
| **17G** | Are there laboratory facilities available? Is their capacity adequate? | 1 | | X | |
| **17H** | Are the Laboratories certified? | 0 | | | |
| **17I** | Can Chemical and biological supplies be acquired locally? Is their availability adequate? | 0 | | | |
| **17J** | Can laboratory equipment be repaired and maintained locally? Is availability of these services adequate? | 0 | | | |
| **17K** | Are there standard Methods for reporting? | 0 | | X | |
| **17L** | How adequate is the budget for surveillance and enforcement? | | X | | |
| **17M** | Are Operational Parameters measured in WWTP? How adequately are they measured? | 0 | | | |
| | Laboratory Parameters and Capability Parameters | Yes = 1<br>No = 0 | # Samples Required | # Samples Analyzed | |
| **17N** | Total Suspended Solids | 1 | | | Low |
| **17O** | Biochemical Oxygen Demand ($BOD_5$) | 1 | | | Low |
| **17P** | Chemical oxygen Demand | 1 | | | Low |
| **17Q** | pH | 1 | | | Low |
| **17R** | Fats, Oil and Grease | 1 | | | Low |
| **17S** | Total Nitrogen | 1 | | | Low |
| **17T** | Total Phosphorous | 1 | | | Low |
| **17U** | Faecal Coliform | 1 | | | Low |
| **17V** | *E. coli* (freshwater) and | 1 | | | Low |
| **17W** | Enterococci (saline water) | 1 | | | Low |
| **17X** | Heavy metals | 1 | | | Low |
| **17Y** | Pesticides | 1 | | | Low |

| **6. Manpower Capacity** | | | | | |
|---|---|---|---|---|---|
| 18 | **Availability of Staff for Wastewater Management** | | | | |
| | | | Adequacy Level | | |
| | | Yes=1 | Low | Medium | High |

| | | | | | |
|---|---|---|---|---|---|
| | | No = 0 | | | |
| **18A** | Planning Capacity for WWTP | | | | |
| **18B** | Managerial capacity | **2** | X | | |
| **18C** | Developing project proposals | **4** | | X | |
| **18D** | Design and Construction capacity | **4** | | X | |
| **18E** | Operation and maintenance Capacity | **76** | | X | |
| **18F** | Surveillance Capacity | **4** | X | | |
| **18G** | Sampling and reporting capacity | | | | |
| 19 | ***Are there national/regional training needs for existing or new staff in the following areas of wastewater management?*** | | | | |
| | | Yes=1 | Urgency Level | | |
| | | No = 0 | Low | Medium | High |
| **19A** | Planning Capacity for WWTP | 1 | | | X |
| **19B** | Managerial capacity | 1 | | | X |
| **19C** | Developing project proposals | 1 | | X | |
| **19D** | Design and Construction capacity | 1 | | X | |
| **19E** | Operation and maintenance Capacity | 1 | | X | |
| **19F** | Surveillance Capacity | 1 | | | X |
| 20 | ***Are the following types of national/regional training available in the area of wastewater management?*** | | | | |
| | | Yes=1 | Level of Adequacy | | |
| | | No = 0 | Low | Medium | High |
| **20A** | Basic operator certification | 0 | | | |
| **20B** | Technical | 0 | | | |
| **20C** | BSc | 1 | | X | |
| **20D** | Specialization | 1 | | X | |
| **20E** | MSc | 0 | | | |
| **20F** | PhD | 0 | | | |
| 21 | ***Is national/regional training available for the following areas concerning wastewater?*** | | | | |
| | | Yes=1 | Level of Adequacy | | |
| | | No = 0 | Low | Medium | High |
| **21A** | Management, | 0 | | | |
| **21B** | Administration, | 0 | | | |
| **21C** | Accounting | 0 | | | |
| **21D** | Engineering | 1 | | X | |
| **21E** | Technician | 0 | | | |
| **21F** | Operators | 0 | | | |
| **21G** | Human Resources | 0 | | | |

## 7. Financing

| 22 | Financial Issues | | | | |
|---|---|---|---|---|---|
| **22A** | What are the Primary Source of Funding for Water and Wastewater Projects | | | | |
| | | | Level of Adequacy | | |
| | | Yes = 1<br>No = 0 | Low | Medium | High |
| **22B** | Is the polluter pays principle applied | 1 | | X | |
| | Indicate which of the following sources fund wastewater management. | | | | |
| **22C** | User fees | 1 | X | | |
| **22D** | Taxes | 1 | X | | |
| **22E** | Grants | 1 | | X | |
| **22F** | Loans | 1 | | | X |
| **22G** | Private investments (e.g. Hotels, developers) | 0 | | | |
| **22H** | Is there a budget in sanitation dedicated to wastewater treatment management for capital improvements? (adequacy of budget) | 0 | | | |
| **22I** | Is there a budget in sanitation dedicated to wastewater treatment management for operations and maintenance? (adequacy of budget) | 0 | | | |
| **22J** | Do smaller communities have access to affordable financing for improving wastewater infrastructure? (adequacy of access) | 0 | | | |
| **22K** | Is financing available for investments in wastewater management affordable? | 0 | | | |
| **22L** | What is the per capita investment into wastewater management projects?<br>< $60 = not very adequate;<br>$60-$120 = Somewhat adequate;<br>> $120 = Very adequate | | X | | |
| **22M** | How adequate is spending on the wastewater sector compared with other sectors? (E.g. water, health) | | X | | |
| **22N** | Is there a sewer tariff for cost recovery? (adequacy of the tariff) | 1 | X | | |
| **22O** | How adequate are the funds from all available sources for the operations or service delivery cost of the utilities? | | X | | |
| **22P** | To what extent are public authorities assisted by other stakeholders (community groups, private development companies etc.) in wastewater management**?** | | | X | |
| **22Q** | How adequate are the rates for biosolids disposal? | 1 | | X | |
| **22R** | Are there standard cost estimates in your country for estimating wastewater network, treatment plant capital improvements and reviewing new technologies? | 0 | | | |

| 8. Best practices and Innovative technological treatment solutions | | | | | |
|---|---|---|---|---|---|
| 23 | **Best Practices and Innovative technological Treatment solutions** | Existence | Level of Application | | |
| | | Yes=1 | | | |
| | | No = 0 | Low | Medium | High |
| **23A** | Policy framework | **0** | | | |
| **23B** | Legislative framework | **0** | | | |
| **23C** | Institutional framework | **0** | | | |
| **23D** | Surveillance capacity | **0** | | | |
| **23E** | Manpower | **0** | | | |
| **23F** | Financing | **0** | | | |
| **23G** | Wastewater treatment technology* | **1** | | X | |
| **23H** | Sanitation projects as Community source of revenue | **0** | | | |
| **23I** | Other (Specify)water conservation | **0** | | | |

| 9. Current knowledge, attitudes, behaviors and practices | | | | |
|---|---|---|---|---|
| 24 | Current knowledge, attitudes, behaviors and practices | Level of Adequacy | | |
| | | Low | Medium | High |
| **24A** | How is the Level of awareness about wastewater management concepts, issues and technologies in the general public? | X | | |
| **24B** | How is the Level of awareness about wastewater management concepts, issues and technologies in government/Boards of Trustees etc.? | X | | |
| **24C** | How are the Attitudes towards implementing proper wastewater practices? | | **X** | |
| **24D** | Level of focus of wastewater compared with water | **X** | | |
| **24E** | How likely is it that decentralized natural treatment systems (e.g. ecological sanitation, constructed wetlands, sand filters) would be accepted as options for domestic wastewater treatment? | | **X** | |
| **24F** | How likely are people to be aware of the impact of current methods of disposal on health and environment? | | **X** | |
| **24G** | How likely are people to be aware of the link between sewage, poor sanitation and health problems such as diarrheal diseases, malnutrition, vector diseases, human capital, etc.? | | **X** | |
| **24H** | How likely is it that senior management officials in government/decision makers have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio-economic development? | | **X** | |

| | | | | |
|---|---|---|---|---|
| **24I** | How likely is it that officials and politicians have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio- economic development? | | **X** | |
| **24J** | How likely it is that wastewater managers are aware of proper operations and maintenance techniques? | **X** | | |
| **24K** | How likely it is that wastewater operators are aware of proper operations and maintenance techniques? | **X** | | |
| **24L** | How likely is it that national, local and sectoral education and public awareness programmes and campaigns exist for wastewater management or for environmental management (which includes wastewater management) | | **X** | |
| | | | | |

| 10. Information Collection and Sharing | | | | | |
|---|---|---|---|---|---|
| 25 | Information Collection and Sharing | Yes = 1 | Level of Adequacy | | |
| | | No = 0 | Low | Medium | High |
| 25A | Do you have facilities for data collection where analysis, revision and expansion of information are conducted? | **0** | | | |
| 25B | How is the quality of data analysis? | **1** | **X** | | |
| 25C | Are there periodic assessments of short-term and long-term data- collection and research needs for wastewater management? | **0** | | | |
| 25D | Is there access to information related to wastewater management issues for decision making to Government Officials? | **0** | | | |
| 25E | Is there public access to information related to wastewater management issues for decision making? | **0** | | | |
| 25F | Is there an Standardize Data Collection, in order to gather comprehensive and comparable information, | **0** | | | |
| 25G | Is the terminology standardized? | **0** | | | |
| 25H | Existence of national knowledge and information system/ clearing house mechanism of tools and approaches for wastewater management that are effective and appropriate to the expectations and context of the beneficiaries in the Wider Caribbean. | **0** | | | |

| 11. Presence and Participation Level of Water and Sanitation Organizations | | | | | |
|---|---|---|---|---|---|
| 26 | Organizations that provide support for wastewater management | Yes=1 | Level of Support | | |
| | | No=0 | Low | Medium | High |

| | | | | | |
|---|---|---|---|---|---|
| **26A** | UN | **3** | | | **X** |
| **26B** | NGOs | **3** | | **X** | |
| **26C** | International Cooperation Agencies | **2** | | | **X** |
| **26D** | IDB | **1** | | X | |
| **26E** | World Bank | | | | |
| **26F** | Sub regional banks | | | | |
| **26G** | Professional Organizations | | | | |
| **26H** | Media organization | | | | |
| **26I** | Healthy Schools | | | | |
| **26J** | Eco clubs | | | | |
| **26K** | Theatre groups | | | | |
| **26L** | Community organizations | | | | |
| | | | | | |

| 12. Climate change impacts | | | | | |
|---|---|---|---|---|---|
| 27 | Climate Change Impact | | Level of Impact Expected | | |
| | | Yes = 1 No=0 | Low | Medium | High |
| **27A** | Higher temperatures | 1 | | | X |
| **27B** | Higher Humidity | 1 | | X | |
| **27C** | Rising seas | 1 | | | X |
| **27D** | High Water Tables | 1 | | | X |
| **27E** | Increased risk of drought | 1 | | | X |
| **27F** | Increased risk of fire | 1 | | X | |
| **27G** | Increased risk of flood | 1 | | | X |
| **27H** | Stronger storms and increased storm damage | 1 | | | X |
| **27I** | Increased Risk of Hurricanes | 1 | | | X |
| **27J** | Higher infrastructure flows | 1 | | | X |

# ANNEX 3 RESULTS OBTAINED FROM MATHEMATICAL MODEL

| 2a. Domestic Wastewater Treatment Systems | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Level Sanitation service | Grade | Weight | | | | | | |
| **1A** | Sewerage System | 2 | 1 | 28.0 | 0.086 | 66.7 | 5.7 | 5.7 | |
| **1B** | Septic Tank (on-site treatment) | 1 | 2 | 69.2 | 0.213 | 33.3 | 7.1 | 7.1 | |
| **1C** | Latrine | 3 | 3 | 100.8 | 0.310 | 100.0 | 31.0 | 31.0 | |
| **1D** | Open defecation | 1 | -3 | -8.1 | -0.025 | 33.3 | -0.8 | -0.8 | |
| **1E** | % Population connected to a WWTP | 2 | 2 | 32.0 | 0.098 | 66.7 | 6.6 | 6.6 | |
| **1F** | % Population Primary Treatment | 1 | 1 | 1.7 | 0.005 | 33.3 | 0.2 | 0.2 | |
| **1G** | % Population Secondary Treatment | 2 | 2 | 28.6 | 0.088 | 66.7 | 5.9 | 5.9 | |
| **1H** | % Population Tertiary Treatment | 1 | 3 | 0.0 | 0.000 | 33.3 | 0.0 | 0.0 | |
| **1I** | % Meeting Discharge Standards | 1 | 4 | 57.2 | 0.176 | 33.3 | 5.9 | 5.9 | |
| | | | | 325.6 | | | | 61.4 | 61.4 |
| **2** | Disposal of treated/untreated wastewater | Grade | Weight | | | | | | |
| **2A** | River | 2 | -1 | -2.6 | -0.02 | 66.7 | -1.6 | -1.6 | |
| **2B** | Lake (Mangrove) | 2 | -1 | -1.1 | -0.01 | 66.7 | -0.7 | -0.7 | |
| **2C** | Sea | 3 | -3 | -36.9 | -0.33 | 100.0 | -33.5 | -33.5 | |
| **2D** | Underground | 2 | 1 | 69.2 | 0.63 | 66.7 | 41.9 | 41.9 | |
| **2E** | Reused | 1 | 3 | 0.3 | 0.00 | 33.3 | 0.1 | 0.1 | |
| **2F** | Other (specify): | 0 | 0 | 0.0 | 0.00 | No Data | 0.0 | 0.0 | 6.3 |
| | | | | 110.1 | | | | 6.3 | |

| 2b. Wastewater Reuse | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | **Wastewater Reuse** | Grade | Weight | | | | | | |
| **3A** | Treatment and Reuse | 1 | 3 | 3.0 | 0.50 | 33.3 | 16.7 | 16.7 | |
| **3B** | Treatment and No Reuse | 3 | -1 | -1.0 | -0.17 | 100.0 | -16.7 | -16.7 | |
| **3C** | No Treatment and Reuse | 1 | -2 | -2.0 | -0.33 | 33.3 | -11.1 | -11.1 | |
| | | | 0 | 6 | | | | -11.1 | 11.1 |

| 4 | **Type of Reuse** | Grade | Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **4A** | Irrigation Unrestricted<br>Root and Leaf Crops, high and low growing crops | 1 | 1 | 1.0 | 0.3 | 33.3 | 11.1 | 11.1 | |
| **4B** | Irrigation Restricted<br>Labour Intensive and highly mechanized | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **4C** | Lawns/Parks | 1 | 1 | 1.0 | 0.3 | 33.3 | 11.1 | 11.1 | |
| **4D** | Golf Courses | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **4E** | Cricket Grounds/Football Fields | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **4F** | Industrial | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **4G** | Aquaculture | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **4H** | Artificial Recharge (Septic Tank effluents) | 1 | 1 | 1.0 | 0.3 | 33.3 | 11.1 | 11.1 | |
| **4I** | Surface reservoirs | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **4J** | Other (specify) | 0 | 1 | 0.0 | 0.0 | No Data | 0.0 | 0.0 | |
| | | | | 3 | | | | 33.3 | 33.3 |

| 5 | **Quality of Effluent** | Grade | Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **5A** | Unrestricted<br>Root and Leaf Crops, high and low growing crops | 3 | 1 | 1.0 | 0.3 | 100.0 | 25.0 | 25.0 | |
| **5B** | Restricted<br>Labour Intensive and highly mechanized | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **5C** | Lawns/Parks | 3 | 1 | 1.0 | 0.3 | 100.0 | 25.0 | 25.0 | |
| **5D** | Cricket Grounds/Football Fields | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **5E** | Cricket Grounds | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **5F** | Industrial | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **5G** | Aquaculture | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **5H** | Artificial Recharge | 1 | 2 | 2.0 | 0.5 | 33.3 | 16.7 | 16.7 | |
| **5I** | Surface reservoirs | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| **5J** | Other (specify) | 0 | 1 | 0.0 | 0.0 | Not Applicable | 0.0 | 0.0 | |
| | | | | 4 | | | | 66.7 | 66.7 |

| 2c. Industrial Effluent Discharges | | | | | | |
|---|---|---|---|---|---|---|
| 6 | Type of Industries | | | | | |
| | Presence of priority industry | Grade | Weight | | | |
| **6A** | % of untreated wastewater sent to a WWTP | 1.3 | 1 | 0.05 | 42.9 | 2.1 |
| **6B** | % untreated wastewater discharged directly into water bodies | 2.7 | -3 | -0.15 | 90.5 | -13.6 |
| **6C** | % treated before discharged into water bodies | 1.3 | 3 | 0.15 | 42.9 | 6.4 |
| **6D** | % untreated before discharged into municipal sewers | 1.0 | -1 | -0.05 | 33.3 | -1.7 |
| **6E** | % of industrial wastewater that is treated together with municipal wastewater | 1.0 | 3 | 0.15 | 33.3 | 5.0 |
| **6F** | Level of effluent compliance | 1.3 | 3 | 0.15 | 42.9 | 6.4 |
| **6G** | Are there sampling and reporting requirements. | 1.0 | 3 | 0.15 | 33.3 | 5.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **6H** | Is there enforcement? Level of enforcement. | 1.0 | 3 | 0.15 | 33.3 | 5.0 | | |
| a = Agricultural; b= Chemical; c= Extractive Industries and Mining;<br>d = Food Processing Operations; e = Manufacture of Liquor and Soft Drinks; f = Oil Refineries; g = Pulp and Paper Factories; h = Sugar Factories and Distilleries; i = Intensive Animal Rearing Operations | | | 20.0 | | | 14.8 | | |
| | | | | 14.8 | | | | |

| 2d. Tourism /Hotel Sector Wastewater Management | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | Tourism /Hotel Sector Wastewater Management | Grade | Weight | | | | | |
| **7A** | Are tourism and hotel facilities connected to a central sewerage system? (% connected) | 2 | 2 | 2 | 0.07 | 66.7 | 4.9 | 4.9 |
| **7B** | Is the wastewater in the central sewerage system treated before it is discharged? (% treated) | 2 | 3 | 3 | 0.11 | 66.7 | 7.4 | 7.4 |
| **7C** | Do tourism and hotel facilities not connected to a central sewerage system treat their wastewater before discharge? (% of facilities that treat) | 3 | 3 | 3 | 0.11 | 100.0 | 11.1 | 11.1 |
| **7D** | Is treated wastewater in tourism and hotel facilities reused? (% reused) | 1 | 4 | 4 | 0.15 | 33.3 | 4.9 | 4.9 |
| **7E** | Do tourism and hotel facilities discharge treated wastewater into water bodies? (% that discharge into water bodies) | 2 | 3 | 3 | 0.11 | 66.7 | 7.4 | 7.4 |
| **7F** | Do tourism and hotel facilities discharge untreated wastewater into water bodies? (% that discharge into water bodies) | 1 | -3 | -3 | -0.11 | 33.3 | -3.7 | -3.7 |
| **7G** | Level of effluent compliance | 2 | 3 | 3 | 0.11 | 66.7 | 7.4 | 7.4 |
| **7H** | Is there sampling and reporting? | 1 | 3 | 3 | 0.11 | 33.3 | 3.7 | 3.7 |
| **7I** | Is there enforcement? (Level of enforcement) | 1 | 3 | 3 | 0.11 | 33.3 | 3.7 | 3.7 |
| | | | | 27 | | | 46.9 | 46.9 |

| 2e. Commercial and institutions not connected to sewerage situation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8 | Institutional Effluent Discharges | Grade | Weight | | | | | | |
| **8A** | Hospitals (% connected to sewerage) | 3 | 3 | 3 | 0.136 | 100.0 | 13.6 | 13.6 | |
| **8B** | Schools (% connected to sewerage) | 2 | 2 | 2 | 0.091 | 66.7 | 6.1 | 6.1 | |
| **8C** | Camps (% connected to sewerage) | 1 | 1 | 1 | 0.045 | 33.3 | 1.5 | 1.5 | |
| **8D** | Other (specify): (% connected to sewerage) | 1 | 1 | 1 | 0.045 | 33.3 | 1.5 | 1.5 | |
| **8E** | Do institutions discharge treated wastewater into water bodies? Level of discharge? | 2 | 3 | 3 | 0.136 | 66.7 | 9.1 | 9.1 | |
| **8F** | Do institutional WWTPs exist in commercial and other institutions? Presence level? | 2 | 3 | 3 | 0.136 | 66.7 | 9.1 | 9.1 | |
| **8G** | Is treated wastewater in institutions reused? (% reused) | 0 | 3 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **8H** | Level of effluent compliance | 2 | 3 | 3 | 0.136 | 66.7 | 9.1 | 9.1 | |
| **8I** | Is there sampling and reporting requirement? | 1 | 3 | 3 | 0.136 | 33.3 | 4.5 | 4.5 | |
| **8J** | Is there enforcement? (Level of enforcement) | 1 | 3 | 3 | 0.136 | 33.3 | 4.5 | 4.5 | |
| | | | | 22 | | | | 59.1 | 59.1 |

| 2f. Pollution Load of sewage discharged into water bodies (Quantity and Quality) |
|---|

| 9 | **Amount of water Discharged** | **Grade** | Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **9A** | Do you know the total amount of sewage discharged into water bodies? | | | | | | | | |
| **9B** | What is the total population of your country? | | | | | | | | |
| | Is water being discharged to: | | | | | | | | |
| **9C** | Creeks | 0 | 3 | 0.0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **9D** | Rivers, | 2 | 3 | 0.5 | 0.026 | 66.7 | 1.7 | 1.7 | |
| **9E** | Natural or constructed reservoirs | 0 | 4 | 0.0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **9F** | Mangroves | 2 | 4 | 0.6 | 0.033 | 66.7 | 2.2 | 2.2 | |
| **9G** | Coastal waters | 3 | 5 | 7.5 | 0.382 | 100.0 | 38.2 | 38.2 | |
| **9H** | Outfalls | 1 | 5 | 0.0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **9I** | Underground Injection (**Septic Tanks)** | 3 | 2 | 11.0 | 0.560 | 100.0 | 56.0 | 56.0 | |
| | | | | 19.7 | | | | 2.0 | 2.0 |
| | | | | | | | | | |

| 10 | Quality of discharge | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Is water being discharged to: | Grade | Weight | | | | | | |
| **10A** | Creeks | 0 | 3 | 0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **10B** | Rivers, | 1 | 3 | 0.51 | 0.026 | 33.3 | 0.9 | 0.9 | |
| **10C** | Natural or constructed reservoirs | 0 | 4 | 0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **10D** | Mangroves | 2 | 4 | 0.64 | 0.033 | 66.7 | 2.2 | 2.2 | |
| **10E** | Coastal waters | 2 | 5 | 7.5 | 0.382 | 66.7 | 25.4 | 25.4 | |
| **10F** | Outfalls | 0 | 5 | 0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **10G** | Underground | 1 | 2 | 11 | 0.560 | 33.3 | 18.7 | 18.7 | |
| | | | | 19.65 | 1.0 | | | 47.1 | 47.1 |

| 2g. Septage/Biosolids Management | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 11 | Septage/Biosolids Management | | | | | | | | |
| | | Grade | Weight | | | | | | |
| **11A** | Does septage receive treatment? | 1 | 3 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **11B** | Adequacy of septage disposal? | 1 | 4 | 4 | 0.15 | 33 | 4.9 | 4.9 | |
| | Where is disposed? | | | | | | | 0.0 | |
| **11C** | Treatment plants? Quantity? | 0 | 4 | 0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **11D** | Landfills/dumpsites? Quantity? | 3 | 3 | 3 | 0.111 | 100.0 | 11.1 | 11.1 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **11E** | Land? Quantity? | 2 | 2 | 2 | 0.074 | 66.7 | 4.9 | 4.9 | |
| **11F** | Water Body? Quantity? | 2 | -3 | -3 | -0.111 | 66.7 | -7.4 | -7.4 | |
| **11G** | Do biosolids receive treatment? | 0 | 3 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **11H** | Adequacy of biosolids disposal? | 1 | 4 | 4 | 0.15 | 33.3 | 4.9 | 4.9 | |
| | Where are disposed of? | | | | | | | 0.0 | |
| **11I** | Landfills/dumpsites? Quantity? | 1 | 4 | 4 | 0.148 | 33.3 | 4.9 | 4.9 | |
| **11J** | Reused? Quantity? | 0 | 3 | 0 | 0.000 | Not Applicable | 0.0 | 0.0 | |
| **11K** | Land? Quantity? | 1 | 2 | 2 | 0.074 | 33.3 | 2.5 | 2.5 | |
| **11L** | Water body? Quantity? | 1 | -3 | -3 | -0.111 | 33.3 | -3.7 | -3.7 | |
| **11M** | Amount of Septage produced (m3/year) | 3 | -1 | -1 | -0.037 | 100.0 | -3.7 | -3.7 | |
| **11N** | Amount of Biosolids produced (m3/year) | 1 | -1 | -1 | -0.037 | 33.3 | -1.2 | -1.2 | |
| | | | | 27 | | | | 34.6 | 34.6 |

2h. Condition of wastewater management infrastructure

| 12 | Infrastructure Condition | Grade | Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **12A** | How adequate is your sanitation WWTP infrastructure? | 1 | 2 | 2 | 0.250 | 33.3 | 8.3 | 8.3 | |
| **12B** | How adequate is your sanitation pipe network infrastructure? | 1 | 2 | 2 | 0.250 | 33.3 | 8.3 | 8.3 | |
| | **Age of Infrastructure (YEARS)** | | | | | | | | |
| **12C** | Age of sewerage systems. What percentage of your total sewerage systems are | 44.7 | 1 | 1 | 0.125 | 44.7 | 5.6 | 5.6 | |
| **12D** | Age of WWTPs. What percentage of your WWTPs are | 44.7 | 1 | 1 | 0.125 | 44.7 | 5.6 | 5.6 | |
| | **Deterioration of Infrastructure** | | | | | | | | |
| 12E | Degree of deterioration of sewer lines | 3 | 1 | 1 | 0.125 | 100.0 | 12.5 | 12.5 | |
| **12F** | Degree of deterioration of WWTPs | 3 | 1 | 1 | 0.125 | 100.0 | 12.5 | 12.5 | |
| **12G** | Are technologies used old or obsolete? | 0 | 1 | 0 | 0.000 | No Data | 0.0 | 0.0 | |
| | | | | 8 | 1.000 | | | 52.8 | 52.8 |

3. Pollution Problems and Their Cost

| 13 | **Pollution Problems and Their Cost** | Grade | Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **13A** | Level of pollution in rivers, lakes, mangroves and coastal areas (increase in thermal pollution in addition to nutrient pollution) | 1 | 1 | 1 | 0.1 | 33.3 | 3.0 | 3.0 | |
| **13B** | Level of environmental deterioration such as toxic algae bloom and destruction of coral reefs | 1 | 1 | 1 | 0.1 | 33.3 | 3.0 | 3.0 | |
| **13C** | Level of deterioration and impact in residential areas | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |
| **13D** | Level of deterioration and impact in commercial areas | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |
| **13E** | Level of deterioration of bathing and recreational areas | 1 | 1 | 1 | 0.1 | 33.3 | 3.0 | 3.0 | |
| **13F** | Level of Social impact due to deterioration of the environment | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **13G** | Level of Economic impact due to deterioration of the environment | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |
| **13H** | Number of cases of human shellfish and reef fish poisoning during last year. | 3 | 1 | 1 | 0.1 | 100.0 | 9.1 | 9.1 | |
| **13I** | Number of outbreaks (water and food) related to bad sanitation during the last year. | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |
| **13J** | Number of vector borne diseases (Dengue, malaria, yellow fever, etc.) in the last year. | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |
| **13K** | Lost Opportunities due to deterioration of the environment | 2 | 1 | 1 | 0.1 | 66.7 | 6.1 | 6.1 | |
| | | | 11 | 11 | | | | 60.6 | 60.6 |

| 4. National Capacity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 14 | **Policy framework** | | | | | | | | |
| | | Grade | Weight | | | | | | |
| **14A** | Has the country highlighted domestic wastewater/ sewage as a priority pollutant in national objectives/ sustainable development planning? | 3 | 1 | 1 | 0.14 | 100.0 | 14.3 | 14.3 | |
| **14B** | Are there strategies associated with the development of this sector? | 2 | 1 | 1 | 0.14 | 66.7 | 9.5 | 9.5 | |
| **14C** | Are there performance indicators associated with the development of this sector? | 2 | 1 | 1 | 0.14 | 66.7 | 9.5 | 9.5 | |
| **14D** | Are there targets associated with the development of this sector? | 2 | 1 | 1 | 0.14 | 66.7 | 9.5 | 9.5 | |
| **14E** | Are there national policies in wastewater management, including a National Plan of Action? | 2 | 1 | 1 | 0.14 | 66.7 | 9.5 | 9.5 | |
| **14F** | Do main cities have a Plan for wastewater management? | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **14G** | Do national policies allow for private sector participation in sewerage services in the absence of adequate public facilities island-wide? | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| | | | 7 | 5 | 0.7 | | | 52.4 | |
| 15 | **Legislative framework** | | | | | | | | |
| | Which of the following Laws and Regulations exist in the country? | Grade | Weight | | | | | | |
| **15A** | Environmental Act | 3 | 1 | 1 | 0.04 | 100.0 | 4.2 | 4.2 | |
| **15B** | Public Health Act | 3 | 1 | 1 | 0.04 | 100.0 | 4.2 | 4.2 | |
| **15C** | Environmental health Act | 3 | 1 | 1 | 0.04 | 100.0 | 4.2 | 4.2 | |
| **15D** | Environmental Impact Assessment | 3 | 1 | 1 | 0.04 | 100.0 | 4.2 | 4.2 | |
| **15E** | Marine protected areas | 2 | 1 | 1 | 0.04 | 66.7 | 2.8 | 2.8 | |
| **15F** | Ambient Water Standards | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15G** | Discharge Limits | 3 | 1 | 1 | 0.04 | 100.0 | 4.2 | 4.2 | |
| **15H** | Marine Pollution Control Act | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15I** | Design Standards for Wastewater Plants | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15J** | Design for On-site Treatment Systems | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **15K** | Regulations on biosolids Management | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15L** | Storm water runoff | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15M** | Irrigation Standards | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15N** | Urban Wastewater management | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15O** | Agricultural pollutants standards | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15P** | Pesticides environmental management | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15Q** | Regulation of industry types | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15R** | National Zoning Policy | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15S** | Building Code | 2 | 1 | 1 | 0.04 | 66.7 | 2.8 | 2.8 | |
| **15T** | Public Information e.g. boil water advisories | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15U** | National Wastewater Management Strategy | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15V** | Are legislative instruments adequate for wastewater pollution control? | 0 | 1 | 0 | 0.00 | Absent | 0.0 | 0.0 | |
| **15W** | Do legislative instruments for wastewater pollution overlap? Level of overlap? | 3 | -1 | -1 | -0.04 | 100.0 | -4.2 | -4.2 | |
| **15X** | Level of enforcement of existing laws and regulations? | 1 | 1 | 1 | 0.04 | 33 | 1.4 | 1.4 | |
| | | 23 | 24 | 7 | 0.29 | | | 23.6 | |
| 16 | **Institutional framework** | Grade | Weight | | | | | | |
| **16A** | Is there a designated/ lead national authority for wastewater management? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16B** | Is there a water resource management authority? | 2 | 1 | 1 | 0.045 | 66.7 | 3.0 | 3.0 | |
| **16C** | Is there a public service regulatory commission? | 1 | 1 | 1 | 0.045 | 33.3 | 1.5 | 1.5 | |
| **16D** | Is there an intersectorial approach for wastewater management? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16E** | Is there an interdisciplinary approach? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| | Level of communication and collaboration between various sectors and agencies: | | | | | | | | |
| **16F** | Water | 3 | 1 | 1 | 0.045 | 100.0 | 4.5 | 4.5 | |
| **16G** | Sanitation | 3 | 1 | 1 | 0.045 | 100.0 | 4.5 | 4.5 | |
| **16H** | Health | 3 | 1 | 1 | 0.045 | 100.0 | 4.5 | 4.5 | |
| **16I** | Environment | 3 | 1 | 1 | 0.045 | 100.0 | 4.5 | 4.5 | |
| **16J** | Tourism | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16K** | Industry | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16L** | Agriculture and Livestock | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16M** | Social development | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16N** | Planning | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16O** | Finance | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16P** | Labour | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16Q** | Food | 0 | 1 | 0 | 0.000 | Absent | 0.0 | 0.0 | |
| **16R** | Developers | 2 | 1 | 1 | 0.045 | 66.7 | 3.0 | 3.0 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **16S** | How adequate are the current institutional arrangements for wastewater management at the community, local and national levels? | 1 | 1 | 1 | 0.045 | 33.3 | 1.5 | 1.5 | |
| **16T** | Is there a Regional Intersectorial/interdisciplinary approach? | 2 | 1 | 1 | 0.045 | 66.7 | 3.0 | 3.0 | |
| **16U** | Do responsibilities overlap among various agencies with respect to wastewater management? Level of overlap? | 2 | -1 | -1 | -0.045 | 66.7 | -3.0 | -3.0 | |
| **16V** | Is there a fragmented approach in the institutional framework with respect to wastewater management? Level of fragmentation? | 2 | -1 | -1 | -0.045 | 66.7 | -3.0 | -3.0 | |
| **16W** | Is your Water Authority:<br>1: a government department,<br>2: a statutory authority, or<br>3: a public company? | 0 | | 0 | 0.000 | Null | 0.0 | 0.0 | |
| | | 24 | 22 | | 0.318 | | | 24.2 | 33.4 |

| 5. Surveillance and Enforcement Capacity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 17 | Surveillance and Enforcement Capacity | | Grade | Weight | | | | | |
| **17A** | Is there a wastewater discharge surveillance programme? How adequate is coverage and frequency of monitoring? | | 1 | 1 | 1 | 0.040 | 33.3 | 1.3 | |
| **17B** | Is there a natural water surveillance programme? How adequate is coverage and frequency of monitoring? | | 1 | 1 | 1 | 0.040 | 33.3 | 1.3 | |
| **17C** | Are there qualified personnel for surveillance? Is the quantity of personnel adequate? | | 2 | 1 | 1 | 0.040 | 66.7 | 2.7 | |
| **17D** | Is enforcement of regulations applied? How adequate is the level of enforcement? | | 1 | 1 | 1 | 0.040 | 33.3 | 1.3 | |
| **17E** | Is there equipment and supplies for wastewater and natural water sampling? Is it sufficient? | | 1 | 1 | 1 | 0.040 | 33.3 | 1.3 | |
| **17F** | Are there standardized methods for wastewater and natural water sampling? Are they adequate? | | 3 | 1 | 1 | 0.040 | 100.0 | 4.0 | |
| **17G** | Are there laboratory facilities available? Is their capacity adequate? | | 2 | 1 | 1 | 0.040 | 66.7 | 2.7 | |
| **17H** | Are the Laboratories certified? | | 0 | 1 | 0 | 0.000 | Absent | 0.0 | |
| **17I** | Can Chemical and biological supplies be acquired locally? Is their availability adequate? | | 0 | 1 | 0 | 0.000 | Absent | 0.0 | |
| **17J** | Can laboratory equipment be repaired and maintained locally? Is availability of these services adequate? | | 0 | 1 | 0 | 0.000 | Absent | 0.0 | |
| **17K** | Are there standard Methods for reporting? | | 2 | 1 | 0 | 0.000 | Absent | 0.0 | |
| **17L** | How adequate is the budget for surveillance and enforcement? | | 1 | 1 | 1 | 0.040 | 33 | 1.3 | |
| **17M** | Are Operational Parameters measured in WWTP? How adequately are they measured? | | 0 | 1 | 0 | 0.000 | Absent | 0.0 | |
| | Laboratory Parameters and Capability Parameters | % Analyzed | Grade | | | | | | |
| **17N** | Total Suspended Solids | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17O** | Biochemical Oxygen Demand ($BOD_5$) | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17P** | Chemical oxygen Demand | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **17Q** | pH | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17R** | Fats, Oil and Grease | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17S** | Total Nitrogen | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17T** | Total Phosphorous | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17U** | Faecal Coliform | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17V** | *E. coli* (freshwater) and | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17W** | Enterococci (saline water) | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17X** | Heavy metals | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| **17Y** | Pesticides | 1.00 | | 1 | 1 | 0.040 | 33.3 | 1.333 | |
| | | | | 25 | 20 | 0.800 | | 32.0 | |

| 6. Manpower Capacity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 18 | **Availability of Staff for Wastewater Management** | Grade | Weight | | | | | | |
| **18A** | Planning Capacity for WWTP | 0 | 1 | 0 | 0.000 | No Data | 0.0 | | |
| **18B** | Managerial capacity | 1 | 1 | 2 | 0.022 | 33.3 | 0.7 | | |
| **18C** | Developing project proposals | 2 | 1 | 4 | 0.044 | 66.7 | 3.0 | | |
| **18D** | Design and Construction capacity | 2 | 1 | 4 | 0.044 | 66.7 | 3.0 | | |
| **18E** | Operation and maintenance Capacity | 2 | 1 | 76 | 0.844 | 66.7 | 56.3 | | |
| **18F** | Surveillance Capacity | 1 | 1 | 4 | 0.044 | 33.3 | 1.5 | | |
| **18G** | Sampling and reporting capacity | 0 | 1 | 0 | 0.000 | No Data | 0.0 | | |
| | | 8 | 7 | 90 | 1.0 | | 64.4 | | |
| 19 | ***Are there national/regional training needs for existing or new staff in the following areas of wastewater management?*** | | | | | | | | |
| | | Grade | Weight | | | | | | |
| **19A** | Planning Capacity for WWTP | 1 | 1 | 1 | 0.167 | 33.3 | 5.6 | | |
| **19B** | Managerial capacity | 1 | 1 | 1 | 0.167 | 33.3 | 5.6 | | |
| **19C** | Developing project proposals | 2 | 1 | 1 | 0.167 | 66.7 | 11.1 | | |
| **19D** | Design and Construction capacity | 2 | 1 | 1 | 0.167 | 66.7 | 11.1 | | |
| **19E** | Operation and maintenance Capacity | 2 | 1 | 1 | 0.167 | 66.7 | 11.1 | | |
| **19F** | Surveillance Capacity | 1 | 1 | 1 | 0.167 | 33.3 | 5.6 | | |
| | | 9 | 6 | 6 | | | 50.0 | | |
| 20 | ***Are the following types of national/regional training available in the area of wastewater management?*** | | | | | | | | |
| | | Grade | Weight | | | | | | |
| **20A** | Basic operator certification | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **20B** | Technical | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **20C** | BSc | 2 | 1 | 1 | 0.167 | 66.7 | 11.1 | | |
| **20D** | Specialization | 2 | 1 | 1 | 0.167 | 66.7 | 11.1 | | |
| **20E** | MSc | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **20F** | PhD | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 6 | | | | 22.2 | | |
| 21 | ***Is national/regional training available for the following areas concerning wastewater?*** | | | | | | | | |
| | | | | | | | | | |
| | | Grade | Weight | | | | | | |
| **21A** | Management, | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **21B** | Administration, | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **21C** | Accounting | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **21D** | Engineering | 2 | 1 | 1 | 0.167 | 66.7 | 11.1 | | |
| **21E** | Technician | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **21F** | Operators | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **21G** | Human Resources | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | 36.9 |
| | | 2 | 6 | | | | 11.1 | | |
| 7. Financing | | | | | | | | | |
| 22 | Financial Issues | | | | | | | | |
| **22A** | What are the Primary Source of Funding for Water and Wastewater Projects | | | | | | | | |
| | | Grade | Weight | | | | | | |
| **22B** | Is the polluter pays principle applied | 2 | 1 | 1 | 0.059 | 66.7 | 3.9 | | |
| | Indicate which of the following sources fund wastewater management. | | | | | | | | |
| **22C** | User fees | 1 | 1 | 1 | 0.059 | 33.3 | 2.0 | | |
| **22D** | Taxes | 1 | 1 | 1 | 0.059 | 33.3 | 2.0 | | |
| **22E** | Grants | 2 | 1 | 1 | 0.059 | 66.7 | 3.9 | | |
| **22F** | Loans | 3 | 1 | 1 | 0.059 | 100.0 | 5.9 | | |
| **22G** | Private investments (e.g. Hotels, developers) | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **22H** | Is there a budget in sanitation dedicated to wastewater treatment management for capital improvements? (adequacy of budget) | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **22I** | Is there a budget in sanitation dedicated to wastewater treatment management for operations and maintenance? (adequacy of budget) | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **22J** | Do smaller communities have access to affordable financing for improving wastewater infrastructure? (adequacy of access) | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **22K** | Is financing available for investments in wastewater management affordable? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| **22L** | What is the per capita investment into wastewater management projects?<br>< $60 = not very adequate;<br>$60-$120 = Somewhat adequate;<br>> $120 = Very adequate | 1 | 1 | 1 | 0.059 | 33 | 2.0 | | |
| **22M** | How adequate is spending on the wastewater sector compared with other sectors? (E.g. water, health) | 1 | 1 | 1 | 0.059 | 33 | 2.0 | | |
| **22N** | Is there a sewer tariff for cost recovery? (adequacy of the tariff) | 1 | 1 | 1 | 0.059 | 33.3 | 2.0 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **22O** | How adequate are the funds from all available sources for the operations or service delivery cost of the utilities? | 1 | 1 | 1 | 0.059 | 33 | 2.0 | | |
| **22P** | To what extent are public authorities assisted by other stakeholders (community groups, private development companies etc.) in wastewater management? | 2 | 1 | 1 | 0.059 | 67 | 3.9 | | |
| **22Q** | How adequate are the rates for biosolids disposal? | 2 | 1 | 1 | 0.059 | 67 | 3.9 | | |
| **22R** | Are there standard cost estimates in your country for estimating wastewater network, treatment plant capital improvements and reviewing new technologies? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| | | 17 | 17 | | 0.6 | | 33.3 | | 33.3 |

| 8. Best practices and Innovative technological treatment solutions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 23 | **Best Practices and Innovative technological Treatment solutions** | Grade | Weight | | | | | | |
| **23A** | Policy framework | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23B** | Legislative framework | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23C** | Institutional framework | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23D** | Surveillance capacity | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23E** | Manpower | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23F** | Financing | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23G** | Wastewater treatment technology* | 2 | 1 | 1 | 0.11 | 66.7 | 7.4 | | |
| **23H** | Sanitation projects as Community source of revenue | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| **23I** | Other (Specify)water conservation | 0 | 1 | 0 | 0.00 | Absent | 0.0 | | |
| | | 2 | 9 | | | | 7.4 | | 7.4 |

| 9. Current knowledge, attitudes, behaviors and practices | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 24 | Current knowledge, attitudes, behaviors and practices | Grade | Weight | | | | | | |
| **24A** | How is the Level of awareness about wastewater management concepts, issues and technologies in the general public? | 1 | 1 | 1 | 0.083 | 33 | 2.8 | | |
| **24B** | How is the Level of awareness about wastewater management concepts, issues and technologies in government/Boards of Trustees etc.? | 1 | 1 | 1 | 0.083 | 33 | 2.8 | | |
| **24C** | How are the Attitudes towards implementing proper wastewater practices? | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |
| **24D** | Level of focus of wastewater compared with water | 1 | 1 | 1 | 0.083 | 33 | 2.8 | | |
| **24E** | How likely is it that decentralized natural treatment systems (e.g. ecological sanitation, constructed wetlands, sand filters) would be accepted as options for domestic wastewater treatment? | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |
| **24F** | How likely are people to be aware of the impact of current methods of disposal on health and environment? | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **24G** | How likely are people to be aware of the link between sewage, poor sanitation and health problems such as diarrheal diseases, malnutrition, vector diseases, human capital, etc.? | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |
| **24H** | How likely is it that senior management officials in government/decision makers have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio-economic development? | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |
| **24I** | How likely is it that officials and politicians have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio- economic development? | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |
| **24J** | How likely it is that wastewater managers are aware of proper operations and maintenance techniques? | 1 | 1 | 1 | 0.083 | 33 | 2.8 | | |
| **24K** | How likely it is that wastewater operators are aware of proper operations and maintenance techniques? | 1 | 1 | 1 | 0.083 | 33 | 2.8 | | |
| **24L** | How likely is it that national, local and sectoral education and public awareness programmes and campaigns exist for wastewater management or for environmental management (which includes wastewater management) | 2 | 1 | 1 | 0.083 | 67 | 5.6 | | |
| | | 18 | 12 | 12 | 1.0 | | 52.8 | | 52.8 |

| 10. Information Collection and Sharing | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 25 | Information Collection and Sharing | Grade | Weight | | | | | | |
| 25A | Do you have facilities for data collection where analysis, revision and expansion of information are conducted? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| 25B | How is the quality of data analysis? | 1 | 1 | 1 | 0.125 | 33.3 | 4.2 | | |
| 25C | Are there periodic assessments of short-term and long-term data- collection and research needs for wastewater management? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| 25D | Is there access to information related to wastewater management issues for decision making to Government Officials? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| 25E | Is there public access to information related to wastewater management issues for decision making? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| 25F | Is there an Standardize Data Collection, in order to gather comprehensive and comparable information, | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| 25G | Is the terminology standardized? | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| 25H | Existence of national knowledge and information system/ clearing house mechanism of tools and approaches for wastewater management that are effective and appropriate to the expectations and context of the beneficiaries in the Wider Caribbean. | 0 | 1 | 0 | 0.000 | Absent | 0.0 | | |
| | | 1 | 8 | | | | 4.2 | | 4.2 |

| 11. Presence and Participation Level of Water and Sanitation Organizations |
|---|

| 26 | Organizations that provide support for wastewater management | Grade | Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **26A** | UN | 3 | 1 | 3 | 0.3 | 100.0 | 25.0 | | |
| **26B** | NGOs | 2 | 1 | 3 | 0.3 | 66.7 | 16.7 | | |
| **26C** | International Cooperation Agencies | 3 | 1 | 2 | 0.2 | 100.0 | 16.7 | | |
| **26D** | IDB | 2 | 1 | 1 | 0.1 | 66.7 | 5.6 | | |
| **26E** | World Bank | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26F** | Sub regional banks | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26G** | Professional Organizations | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26H** | Media organization | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26I** | Healthy Schools | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26J** | Eco clubs | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26K** | Theatre groups | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| **26L** | Community organizations | 0 | 1 | 0 | 0.0 | No Data | 0.0 | | |
| | | 10 | 12 | 9 | 0.8 | | 63.9 | | 63.9 |

| 12. Climate change impacts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 27 | Climate Change Impact | Grade | Weight | | | | | | |
| **27A** | Higher temperatures | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27B** | Higher Humidity | 2 | 1 | 1 | 0.1 | 66.7 | 6.7 | | |
| **27C** | Rising seas | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27D** | High Water Tables | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27E** | Increased risk of drought | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27F** | Increased risk of fire | 2 | 1 | 1 | 0.1 | 66.7 | 6.7 | | |
| **27G** | Increased risk of flood | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27H** | Stronger storms and increased storm damage | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27I** | Increased Risk of Hurricanes | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | |
| **27J** | Higher infrastructure flows | 3 | 1 | 1 | 0.1 | 100.0 | 10.0 | | 6.7 |

# ANNEX 4 SUMMARY OF GRADING OF ANSWERS (DNA OF WASTEWATER MANAGEMENT)

| | | | | | |
|---|---|---|---|---|---|
| 1A | Sewerage System | 66.7 | 10C | Natural or constructed reservoirs | Not Applicable |
| 1B | Septic Tank (on-site treatment) | 33.3 | 10D | Mangroves | 66.7 |
| 1C | Latrine | 100.0 | 10E | Coastal waters | 66.7 |
| 1D | Other (specify): | -33.3 | 10F | Outfalls | Not Applicable |
| 1E | % Population connected to a WWTP | 66.7 | 10G | Underground | 33.3 |
| 1F | % Population Primary Treatment | 33.3 | 11A | Does septage receive treatment? | Absent |
| 1G | % Population Secondary Treatment | 66.7 | 11B | Adequacy of septage disposal? | 33.3 |
| 1H | % Population Tertiary Treatment | 33.3 | 11C | Treatment plants? Quantity? | Not Applicable |
| 1I | % Meeting Discharge Standards | 33.3 | 11D | Landfills/dumpsites? Quantity? | 100.0 |
| 2A | River | 66.7 | 11E | Land? Quantity? | 66.7 |
| 2B | Lake | 66.7 | 11F | Water Body? Quantity? | -66.7 |
| 2C | Sea | 100.0 | 11G | Do biosolids receive treatment? | Absent |
| 2D | Underground | 66.7 | 11H | Adequacy of biosolids disposal? | 33.3 |
| 2E | Reused | 33.3 | 11I | Landfills/dumpsites? Quantity? | 33.3 |
| 3A | Treatment and Reuse | 33.3 | 11J | Reused? Quantity? | Not Applicable |
| 3B | Treatment and No Reuse | -100.0 | 11K | Land? Quantity? | 33.3 |
| 3C | No Treatment and Reuse | -33.3 | 11L | Water Bodies? Quantity? | -33.3 |
| 4A | Irrigation Unrestricted Root and Leaf Crops | 33.3 | 11M | Amount of Septage produced (m3/year) | -100.0 |
| 4B | Irrig Restric Labour Intensive and highly mechanized | Not Applicable | 11N | Amount of Biosolids produced (m3/year) | -33.3 |
| 4C | Lawns/Parks | 33.3 | 12A | How adequate is your sanitation WWTP infrastructure? | 33.3 |
| 4D | Golf Courses | Not Applicable | 12B | Adequate sewerage infrastructure | 33.3 |
| 4E | Cricket Grounds/Football Fields | Not Applicable | 12C | Age of sewerage systems | 44.7 |
| 4F | Industrial | Not Applicable | 12D | Age of WWTPs | 44.7 |
| 4G | Aquaculture | Not Applicable | 12E | Degree of deterioration of sewer lines | 100.0 |
| 4H | Artificial Recharge (Septic Tank effluents) | 33.3 | 12F | Degree of deterioration of WWTPs | 100.0 |
| 4I | Surface reservoirs | Not Applicable | 12G | Are technologies used old or obsolete? | No Data |
| 4J | Other (specify) | No Data | 13A | Level of pollution in rivers, lakes, etc | 33.3 |
| 5A | Unrestricted Root and Leaf Crops | 100.0 | 13B | Level of environmental deterioration | 33.3 |
| 5B | Restricted Labour Intensive and highly mechanized | Not Applicable | 13C | Level of deterioration and impact in residential areas | 66.7 |
| 5C | Lawns/Parks | 100.0 | 13D | Level of deterioration and impact in commercial areas | 66.7 |
| 5D | Cricket Grounds/Football Fields | Not Applicable | 13E | Level of deterioration of bathing and recreational areas | 33.3 |
| 5E | Cricket Grounds | Not Applicable | 13F | Level of Social impact | 66.7 |
| 5F | Industrial | Not Applicable | 13G | Level of Economic impact due to deterioration env | 66.7 |
| 5G | Aquaculture | Not Applicable | 13H | # cases human shellfish and reef fish poisoning | 100.0 |
| 5H | Artificial Recharge | 33.3 | 13I | # outbreaks (water and food) related to bad sanitation | 66.7 |
| 5I | Surface reservoirs | Not Applicable | 13J | # vector borne diseases (Dengue, malaria, etc.) | 66.7 |
| 5J | Other (specify) | Not Applicable | 13K | Lost Opportunities due to deterioration of the envir | 66.7 |
| 6A | % of untreated wastewater sent to a WWTP | 42.9 | 14A | WW highlighted priority pollutant national objectives | 100.0 |
| 6B | % untreated WW discharged directly into water bodies | -90.5 | 14B | Existence strategies associated w dev of this sector | 66.7 |
| 6C | % treated WW before discharged into water bodies | 42.9 | 14C | Existence performance indicators | 66.7 |
| 6D | % untreated before discharged into municipal sewers | -33.3 | 14D | Existence targets associated with the dev sector | 66.7 |
| 6E | % of industrial WW treated with municipal wastewater | 33.3 | 14E | Existence national policies in WW mngmnt/Nat Plan | 66.7 |
| 6F | Level of effluent compliance | 42.9 | 14F | Existence WW mngmnt Plan main cities | Absent |
| 6G | Are there sampling and reporting requirements. | 33.3 | 14G | Private sector participation National Policies | Absent |
| 6H | Is there enforcement? Level of enforcement. | 33.3 | 15A | Environmental Act | 100.0 |
| 7A | Hotel connection to central sewerage | 66.7 | 15B | Public Health Act | 100.0 |
| 7B | Treatment of WW central sewerage before discharge | 66.7 | 15C | Environmental health Act | 100.0 |
| 7C | Treatment of Hotel WW not connected to sewerage | 100.0 | 15D | Environmental Impact Assessment | 100.0 |
| 7D | Reuse treated wastewater in tourism and hotel | 33.3 | 15E | Marine protected areas | 67 |
| 7E | Hotel treated wastewater discharge into water bodies | 66.7 | 15F | Ambient Water Standards | Absent |
| 7F | Hotel raw wastewater discharge into water bodies | -33.3 | 15G | Discharge Limits | 100 |
| 7G | Level of effluent compliance | 66.7 | 15H | Marine Pollution Control Act | Absent |
| 7H | Is there sampling and reporting? | 33.3 | 15I | Design Standards for Wastewater Plants | Absent |
| 7I | Is there enforcement? (Level of enforcement) | 33.3 | 15J | Design for On-site Treatment Systems | Absent |
| 8A | Hospitals (% connected to sewerage) | 100.0 | 15K | Regulations on biosolids Management | Absent |
| 8B | Schools (% connected to sewerage) | 66.7 | 15L | Storm water runoff | Absent |
| 8C | Camps (% connected to sewerage) | 33.3 | 15M | Irrigation Standards | Absent |
| 8D | Other (specify): (% connected to sewerage) | 33.3 | 15N | Urban Wastewater management | Absent |
| 8E | Institutions treated wastewater discharge into water bodies | 66.7 | 15O | Agricultural pollutants stnadrds | Absent |
| 8F | Existence institutional WWTPs commercial and other institutions | 66.7 | 15P | Pesticides environmental management | Absent |
| 8G | Is treated wastewater in institutions reused? (% reused) | Absent | 15Q | Regulation of industry types | Absent |
| 8H | Level of effluent compliance | 66.7 | 15R | National Zoning Policy | Absent |
| 8I | Is there sampling and reporting requirement? | 33.3 | 15S | Building Code | 67 |
| 8J | Is there enforcement? (Level of enforcement) | 33.3 | 15T | Public Information e.g. boil water advisories | Absent |
| 9C | Creeks | Not Applicable | 15U | National Wastewater Management Strategy | Absent |
| 9D | Rivers, | -66.7 | 15V | Legislative instruments wastewater pollution control | Absent |
| 9E | Natural or constructed reservoirs | Not Applicable | 15W | Overlapping legislative instruments for WW | -100.0 |
| 9F | Mangroves | -66.7 | 15X | Level enforcement of existing laws and reg? | 33.3 |
| 9G | Coastal waters | -100.0 | 16A | Existence lead national authority for WW | Absent |
| 9H | Outfalls | Not Applicable | 16B | Is there a water resource mngment authority? | 66.7 |
| 9I | Underground Injection (Septic Tanks) | 100.0 | 16C | Is there pub service regulatory commission? | 33.3 |
| 10A | Creeks | Not Applicable | | | |
| 10B | Rivers, | 33.3 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Not Applicable | 16D | Intersectorial approach for WW management | Absent | 22B | Is the polluter pays principle applied | 66.7 |
| 66.7 | 16E | Is there an interdisciplinary approach? | Absent | 22C | User fees | 33.3 |
| 66.7 | 16F | Water | 100.0 | 22D | Taxes | 33.3 |
| Not Applicable | 16G | Sanitation | 100.0 | 22E | Grants | 66.7 |
| 33.3 | 16H | Health | 100.0 | 22F | Loans | 100.0 |
| Absent | 16I | Environment | 100.0 | 22G | Private investments (e.g. Hotels, developers) | Absent |
| 33.3 | 16J | Tourism | Absent | 22H | Budget in sanitation for capital improvements | Absent |
| Not Applicable | 16K | Industry | Absent | 22I | Budget in sanitation for WW treatment O&M | Absent |
| 100.0 | 16L | Agriculture and Livestock | Absent | 22J | Access to financing smaller communities | Absent |
| 66.7 | 16M | Social development | Absent | 22K | Affordability of financing available WW | Absent |
| -66.7 | 16N | Planning | Absent | 22L | Per capita investment wastewater projects | 33.3 |
| Absent | 16O | Finance | Absent | 22M | Spending compared with other sectors | 33.3 |
| 33.3 | 16P | Labour | Absent | 22N | Adequacy sewer tariff for cost recovery | 33.3 |
| 33.3 | 16Q | Food | Absent | 22O | Funds for the operations or service delivery | 33.3 |
| Not Applicable | 16R | Developers | 66.7 | 22P | Extent of assistance by stakeholders | 66.7 |
| 33.3 | 16S | Institutional arrangements for WW mngmnt | 33.3 | 22Q | How are the rates for biosolids disposal? | 66.7 |
| -33.3 | 16T | Regional Intersecto/interdisciplina approach | 66.7 | 22R | Existence cost estimates for WW technol | Absent |
| -100.0 | 16U | Responsibil overlap among various agencies | -66.7 | 23A | Policy framework | Absent |
| -33.3 | 16V | Level fragmented approach for WW mngmnt | -66.7 | 23B | Legislative framework | Absent |
| 33.3 | 16W | Water Authority a government department | Null | 23C | Institutional framework | Absent |
| 33.3 | 17A | Wastewater discharge surveillance programme | 33.3 | 23D | Surveillance capacity | Absent |
| 44.7 | 17B | Natural water surveillance programme | 33.3 | 23E | Manpower | Absent |
| 44.7 | 17C | Qualified personnel for surveillance | 66.7 | 23F | Financing | Absent |
| 100.0 | 17D | Application enforcement regulations | 33.3 | 23G | Wastewater treatment technology* | 66.7 |
| 100.0 | 17E | Equipment and supplies for surveillance | 33.3 | 23H | Sanitation proj as Community source revenue | Absent |
| No Data | 17F | Standardized methods | 100.0 | 23I | Other (Specify)water conservation | Absent |
| 33.3 | 17G | Availability laboratory facilities | 66.7 | 24A | Level awareness wastewater general public | 33.3 |
| 33.3 | 17H | Are the Laboratories certified? | Absent | 24B | Level awareness WW government/Boards | 33.3 |
| 66.7 | 17I | Availability Chemical and biological supplies locally | Absent | 24C | Attitudes towards proper WW practices | 66.7 |
| 66.7 | 17J | Llaboratory equipment repaired and maintained locally | Absent | 24D | Level of focus of WW compared with water | 33.3 |
| 33.3 | 17K | Are there standard Methods for reporting? | Absent | 24E | Likely decentrlzd nat treat syst be accepted | 66.7 |
| 66.7 | 17L | Adequacy budget for surveillance and enforcement? | 33.3 | 24F | Awareness impact disp on health and env | 66.7 |
| 66.7 | 17M | Are Operational Parameters measured in WWTP | Absent | 24G | Awareness link between sewage and health | 66.7 |
| 100.0 | 17N | Total Suspended Solids | 33.3 | 24H | Sr Officials Knowledge link WW mngmnt & SE Dev. | 66.7 |
| 66.7 | 17O | Biochemical Oxygen Demand ($BOD_5$) | 33.3 | 24I | Politicians knowledge link WW mngmnt & SE Dev. | 66.7 |
| 66.7 | 17P | Chemical oxygen Demand | 33.3 | 24J | Awareness WW managers proper O&M | 33.3 |
| 66.7 | 17Q | pH | 33.3 | 24I | Awareness WW operators proper O&M | 33.3 |
| 100.0 | 17R | Fats, Oil and Grease | 33.3 | 24K | Existence educ and public awareness programmes | 66.7 |
| 66.7 | 17S | Total Nitrogen | 33.3 | 25A | Facilities data collection and analysis | Absent |
| 66.7 | 17T | Total Phosporous | 33.3 | 25B | How is the quality of data analysis? | 33.3 |
| 66.7 | 17U | Faecal Coliform | 33.3 | 25C | Existence periodic assess of data- collection and res | Absent |
| 66.7 | 17V | *E. coli* (freshwater) and | 33.3 | 25D | Access to information to Government Officials | Absent |
| Absent | 17W | Enterococci (saline water) | 33.3 | 25E | Public access to information | Absent |
| Absent | 17X | Heavy metals | 33.3 | 25F | Standardize Data Collection | Absent |
| 100.0 | 17Y | Pesticides | 33.3 | 25G | Standardized terminology | Absent |
| 100.0 | 18A | Planning Capacity for WWTP | No Data | 25H | Existence clearing house mechanism | Absent |
| 100.0 | 18B | Managerial capacity | 33.3 | 26A | UN | 100.0 |
| 100.0 | 18C | Developing project proposals | 66.7 | 26B | NGOs | 66.7 |
| 67 | 18D | Design and Construction capacity | 66.7 | 26C | International Cooperation Agencies | 100.0 |
| Absent | 18E | Operation and maintenance Capacity | 66.7 | 26D | IDB | ***66.7*** |
| 100 | 18F | Surveillance Capacity | 33.3 | 26E | World Bank | No Data |
| Absent | 18G | Sampling and reporting capacity | No Data | 26F | Sub regional banks | No Data |
| Absent | 19A | Planning Capacity for WWTP | 33.3 | 26G | Professional Organizations | No Data |
| Absent | 19B | Managerial capacity | 33.3 | 26H | Media organization | No Data |
| Absent | 19C | Developing project proposals | 66.7 | 26I | Healthy Schools | No Data |
| Absent | 19D | Design and Construction capacity | 66.7 | 26J | Eco clubs | No Data |
| Absent | 19E | Operation and maintenance Capacity | 66.7 | 26K | Theatre groups | No Data |
| Absent | 19F | Surveillance Capacity | 33.3 | 26L | Community organizations | No Data |
| Absent | 20A | Basic operator certification | Absent | 27A | Higher temperatures | 0.0 |
| Absent | 20B | Technical | Absent | 27B | Higher Humidity | 33.3 |
| Absent | 20C | BSc | 66.7 | 27C | Rising seas | 0.0 |
| Absent | 20D | Specialization | 66.7 | 27D | High Water Tables | 0.0 |
| 67 | 20E | MSc | Absent | 27E | Increased risk of drought | 0.0 |
| Absent | 20F | PhD | Absent | 27F | Increased risk of fire | 33.3 |
| Absent | 21A | Management, | Absent | 27G | Increased risk of flood | 0.0 |
| Absent | 21B | Administration, | Absent | 27H | Stronger storms and increased storm damage | 0.0 |
| -100.0 | 21C | Accounting | Absent | 27I | Increased Risk of Hurricanes | 0.0 |
| 33.3 | 21D | Engineering | 66.7 | 27J | Higher infrastructure flows | 0.0 |
| Absent | 21E | Technician | Absent | | | |
| 66.7 | 21F | Operators | Absent | | | |
| 33.3 | 21G | Human Resources | Absent | | | |

| Summary of Answers | | |
|---|---|---|
| **Type of Answer** | **Number** | **%** |
| **Responded** | 186 | 65.5 |
| **Absent** | 67 | 23.6 |
| **No Data** | 12 | 4.2 |
| **Not Applicable** | 18 | 6.3 |
| **No Grading** | 0 | 0.0 |
| **Null** | 1 | 0.4 |
| **Total Questions** | 284 | |

# ANNEX 5 EXPLANATION OF SIGNIFICANCE VALUES USED IN MATHEMATICAL MODEL

The following tables present an explanation of each one of the significance values that were used in the Mathematical Model to assess each feature.

| 1 | **Sanitation Coverage** | | |
|---|---|---|---|
| | Level Sanitation service | Value | Description |
| 1A | Sewerage | 1 | The values assigned to the level of adequacy are related to the potential of wastewater reaching a surface water body. Open defecation is considered the worst form of sanitation and was given a value of -3, sewerage a value of 1, septic tank effluents a value of 2, because it is discharged underground and soil serves as treatment process. Latrines were given a value of 3, because the liquid waste is minimal. |
| 1B | Septic Tank (on-site treatment) | 2 | |
| 1C | Latrine | 3 | |
| 1D | None | -3 | |
| 1E | % Population connected to a WWTP | 2 | 1E is rewarded with a 2 |
| 1F | % Population Primary Treatment | 1 | For 1F,1G and 1H, the values assigned represent the level of adequacy of treatment, being tertiary treatment with the highest level of significance |
| 1G | % Population Secondary Treatment | 2 | |
| 1H | % Population Tertiary Treatment | 3 | |
| 1I | % Meeting Discharge Standards | 4 | 1I is rewarded with a 4 value |
| | 2. Overview of Wastewater Treatment Management | | |
| 2 | **Disposal of treated/untreated wastewater** | Value | Description |
| **2A** | River treated | -1 | Values assigned represent the level of impact to water bodies and to the LBS Protocol. Discharging to the sea has the highest negative value (-3), and reuse has the highest positive value (3). |
| **2B** | River untreated | -1 | |
| **2C** | Lake treated | 2 | |
| **2D** | Lake untreated | -1 | |
| **2E** | Sea treated | 3 | |
| **2F** | Sea untreated | -3 | |
| **2G** | Underground treated | 3 | |
| **2H** | Reused treated | 3 | |
| **2I** | Underground untreated | -1 | |
| **2J** | Other (specify): | 0 | |
| 3 | **Wastewater Reuse** | Value | Description |
| 3A | Treatment and Reuse | 3 | Values assigned represent the degree of suitability for protecting the environment and health. Reuse in occasions can be seen as a tertiary level or quaternary treatment. |
| 3B | Treatment and No Reuse | -1 | |
| 3C | No Treatment and Reuse | -2 | |

| 4 | **Type of Reuse** | Value | Description |
|---|---|---|---|
| 4A | Irrigation Unrestricted<br>Root and Leaf Crops, high and low growing crops | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 4B | Irrigation Restricted<br>Labour Intensive and highly mechanized | 1 | |
| 4C | Lawns/Parks | 1 | |
| 4D | Golf Courses | 1 | |
| 4E | Cricket Grounds | 1 | |
| 4F | Industrial | 1 | |
| 4G | Aquaculture | 1 | |
| 4H | Artificial Recharge (Septic Tank effluents) | 1 | |
| 4I | Surface reservoirs | 1 | |
| 5 | **Quality of Effluent** | Value | Description |
| 5A | Unrestricted<br>Root and Leaf Crops, high and low growing crops | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 5B | Restricted<br>Labour Intensive and highly mechanized | 1 | |
| 5C | Lawns/Parks | 1 | |
| 5D | Golf Courses | 1 | |
| 5E | Cricket Grounds | 1 | |
| 5F | Industrial | 1 | |
| 5G | Aquaculture | 1 | |
| 5H | Artificial Recharge | 2 | |
| 5I | Surface reservoirs | 1 | |
| 6 | Industrial Effluent Discharges | Value | Description |
| 6A | Agricultural Non-Point Sources | -1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 6B | Chemical Industries | -1 | |
| 6C | Extractive Industries and Mining | -1 | |
| 6D | Food Processing Operations | -1 | |
| 6E | Manufacture of Liquor and Soft Drinks | -1 | |
| 6F | Oil Refineries | -1 | |
| 6G | Pulp and Paper Factories | -1 | |
| 6H | Sugar Factories and Distilleries | -1 | |
| **6I** | Intensive Animal Rearing Operations **(shrimp and fish farms)** | -1 | |
| 6J | Do industries discharge raw wastewater directly into water bodies? | -3 | Values are assigned according to the potential level of pollution. Raw industrial discharges into water bodies are assigned a value of -3. Treated industrial discharges or industrial discharges mixed with municipal wastewater and treated, receive a value of 3 (very adequate). Pretreatment of industrial discharges into sewerage receive a value of 2. |
| 6K | Do industries treat effluents before discharge into water bodies? | 3 | |
| 6L | Do industries pretreat effluents before discharge into municipal sewers? | 2 | |
| 6M | Do industrial wastewaters are treated together with municipal wastewater? | 3 | |
| 6N | Level of effluent compliance (%) | 3 | A significance value of 3 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 6O | Is there surveillance? Level of surveillance? | 3 | |
| 6P | Is there enforcement? Level of enforcement? | 3 | |

| 7 | Tourism /Hotel Sector Wastewater Management | Value | Description |
|---|---|---|---|
| 7A | Are tourism and hotel facilities connected to a central sewerage system? | 2 | Values are assigned according to the potential level of pollution. 7A is assigned a value of 2, because being connected to a sewerage system does not ensure that the wastewater will be treated before discharge. 7B through 7D are assigned a value of 3 (adequate). Treated hotel wastewater but not reused is penalized with a -3 value. There is no reason for a hotel not to reuse its wastewater. |
| 7B | Is the wastewater in the central sewerage system treated before its discharge? | 3 | |
| 7C | Do tourism and hotel facilities not connected to a central sewerage system treat their wastewater before discharge? | 3 | |
| 7D | Is treated wastewater in tourism and hotel facilities reused? | 3 | |
| 7E | Do tourism and hotel facilities discharge into water bodies? | -3 | |
| 7F | Level of effluent compliance (%) | 3 | A significance value of 3 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 7G | Is there surveillance? Level of surveillance? | 3 | |
| 7H | Is there enforcement? Level of enforcement? | 3 | |
| 8 | Commercial and Institutional Effluent Discharges | Value | Description |
| 8A | Hospital | -3 | Values are assigned according to the potential level of pollution. Hospitals are considered as high polluters where infectious, chemical, heavy metals and radioactive material can be present, and that can be a public health and environmental problem. Hence a value of -3 is given to 8A. 8b, 8c and 8D are given a value of -1. |
| 8B | Schools | -1 | |
| 8C | Camps | -1 | |
| 8D | Other | -1 | |
| 8E | Do institutions discharge raw wastewater into water bodies? Level of discharge? | -3 | Values are assigned according to the potential level of pollution. 8E is given a value of -3, because its pollution potential. 8D and 8e are given a value of 3 (adequate) |
| 8F | Existence of institutional WWTPs in commercial and other institutions? Presence level? | 3 | |
| 8G | Is treated wastewater in institutions reused? | 3 | |
| 8H | Level of effluent compliance (%) | 3 | A significance value of 3 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 8I | Is there surveillance? Level of surveillance? | 3 | |
| 8J | Is there enforcement? Level of enforcement? | 3 | |
| | | | |
| 9 | Amount of water Discharged | Value | Description |
| 9A | Do you know the amount of sewage discharged into water bodies? | | |
| 9B | How much in MGD? | 3 | A value of 3 is given (as a bonus) for knowing the load of pollution. |
| | Is water being discharged to: | | |
| 9C | Creeks | -1 | Values assigned represent the level of impact to water bodies and to the LBS Protocol. Discharging to the sea has the highest negative value (-3). |
| 9D | Rivers, | -1 | |
| 9E | Natural or constructed reservoirs | -2 | |
| 9F | Mangroves | -2 | |
| 9G | Coastal waters | -3 | |
| 9H | Outfalls | -3 | |
| 9I | Underground Injection (**Septic Tanks)** | 2 | |

| 10 | Quality of discharge | Value | Description |
|---|---|---|---|
| | Is water being discharged to: | | |

| | | | |
|---|---|---|---|
| 10A | Creeks | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 10B | Rivers, | 1 | |
| 10C | Natural or constructed reservoirs | 1 | |
| 10D | Mangroves | 1 | |
| 10E | Coastal waters | 1 | |
| 10F | Outfalls | 1 | |
| 10G | Underground | 1 | |
| 11 | Septage/Biosolids Management | Value | Description |
| 11A | Does septage receive treatment? Adequacy? | 3 | A significance value of 3 is assigned for treatment and a value of 4 for safe disposal |
| 11B | Adequacy of septage disposal? | 4 | |
| | Where is disposed? | | |
| 11C | Treatment plants? Quantity? | 4 | A value of 4 is given for disposing of septage in a treatment plant and a value of -3 if it is discharged into a waterbody. |
| 11D | Landfills/dumpsites? Quantity? | 3 | |
| 11E | Land? Quantity? | 2 | |
| 11F | Water Body? Quantity? | -3 | |
| 11G | Do biosolids receive treatment? Adequacy? | 3 | A significance value of 3 is assigned for treatment and a value of 4 for safe disposal |
| 11H | Adequacy of biosolids disposal? | 4 | |
| | Where are disposed of? | | |
| 11I | Landfills/dumpsites? Quantity? | 4 | A value of 4 is given for disposing of septage in a treatment plant and a value of -3 if it is discharged into a waterbody. |
| 11J | Reused? Quantity? | 3 | |
| 11K | Land? Quantity? | 2 | |
| 11L | Water Body? Quantity? | -3 | |
| 11M | Amount of Septage produced (m3/year) | -1 | The amount of septage and biosolids is penalized by a value of -1 |
| 11N | Amount of Biosolids produced (m3/year) | -1 | |
| 12 | Infrastructure Condition | Value | Description |
| 12A | Is sanitation infrastructure adequate? | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 12B | How old are the sewerage systems?<br>0-10yrs= High; 10-20=Medium; >20 = Low | -1 | |
| 12C | How old are the WWTP?<br>0-10yrs= High; 10-20=Medium; >20 = Low | -1 | |
| 12D | Degree of deterioration of sewer lines<br>(leakage, tears, insufficient capacity of collectors, obstructions, illegal interconnections, storm water runoff, operational problems of pumping stations among others) | -1 | |
| 12E | Degree of deterioration of WWTPs<br>(leakage, tears, insufficient capacity of collectors, obstructions, illegal interconnections, storm water runoff, operational problems of pumping stations among others) | -1 | |
| 12F | Are technologies used old/obsolete? | -1 | |

| | 3. Pollution Problems and Their Cost | | |
|---|---|---|---|
| 13 | **Pollution Problems and Their Cost** | Value | Description |
| 13A | Level of pollution in rivers, lakes, mangroves and coastal areas (increase in thermal pollution in addition to nutrient pollution) | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 13B | Level of environmental deterioration such as toxic algae bloom and destruction of coral reefs | 1 | |
| 13C | Level of cases of human shellfish and reef fish poisoning | 1 | |
| 13D | Number of outbreaks (water and food) related to bad sanitation during the last year | 1 | |
| 13E | Level of vector borne diseases (Dengue, malaria, yellow fever, etc.) | 1 | |
| 13F | Level of deterioration of bathing and recreational areas | 1 | |
| 13G | Level of Social impact due to deterioration of the environment | 1 | |
| 13H | Level of Economic impact due to deterioration of the environment | 1 | |
| 13I | Lost Opportunities due to deterioration of the environment | 1 | |
| 4. National Capacity | | | |
| 14 | **Policy framework** | Value | Description |
| 14A | Has the country highlighted domestic wastewater/ sewage as a priority pollutant in national objectives/ sustainable development planning? | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 14B | Are there strategies, indicators and targets associated with the development of this sector? | 1 | |
| 14C | Are there national policies in wastewater management, including a National Plan of Action? | 1 | |
| 14D | Do main cities have a Plan for wastewater management? | 1 | |
| 14E | Do national policies allow for private sector participation in sewerage services in the absence of adequate public facilities island-wide? What is the extent? | 1 | |

| 15 | **Legislative framework** | Value | Description |
|---|---|---|---|
| 15A | Environmental Act | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 15B | Public Health Act | 1 | |
| 15C | Environmental health Act | 1 | |
| 15D | Environmental Impact Assessment | 1 | |
| 15E | Marine protected areas | 1 | |
| 15F | Ambient Water Standards | 1 | |
| 15G | Discharge Limits | 1 | |
| 15H | Marine Pollution Control Act | 1 | |
| 15I | Design Standards for Wastewater Plants | 1 | |
| 15J | Design for On-site Treatment Systems | 1 | |
| 15K | Regulations on Septage/biosolids Management | 1 | |
| 15L | Storm water runoff | 1 | |
| 15M | Irrigation Standards | 1 | |
| 15N | Urban Wastewater management | 1 | |
| 15O | Agricultural pollutants | 1 | |
| 15P | Pesticides environmental management | 1 | |
| 15Q | Regulation of industry types | 1 | |
| 15R | National Zoning Policy | 1 | |
| 15S | Building Code | 1 | |
| 15T | Public Information | 1 | |
| 15U | Are legislative instruments for water pollution control fusion? Level of fusion? | 1 | |
| 15V | Do legislative instruments for water pollution overlap? Level of overlap? | 1 | |
| 15W | Level of enforcement of existing laws and regulations? | 1 | |
| 16 | **Institutional framework** | Value | Description |
| **16A** | Is there a designated/ lead national authority for wastewater management? | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| **16B** | Is there a water resource management authority? | 1 | |
| **16C** | Is there a public service regulatory commission? | 1 | |
| 16D | Is there an intersectorial approach for wastewater management? | 1 | |
| 16E | Is there an interdisciplinary approach? | 1 | |
| 16F | Level of communication and collaboration between various sectors and agencies: | 1 | |
| | | 1 | |
| 16G | Water | 1 | |
| 16H | Sanitation | 1 | |
| 16I | Health | 1 | |
| 16J | Environment | 1 | |
| 16K | Tourism | 1 | |
| 16L | Industry | 1 | |
| 16M | Agriculture and Livestock | 1 | |

| | | | |
|---|---|---|---|
| 16N | Social development | 1 | |
| 16O | Planning | 1 | |
| 16P | Finance | 1 | |
| **16Q** | Labour | 1 | |
| 16R | Food | 1 | |
| 16S | How adequate are the current institutional arrangements for wastewater management at the community, local and national levels? | 1 | |
| 16T | Do responsibilities overlap among various agencies with respect to wastewater management? Level of overlap? | 1 | |
| 16U | Is there a fragmented approach in the institutional framework with respect to wastewater management? Level of fragmentation? | 1 | |
| 16V | Is there a Regional Intersectorial/interdisciplinary approach? | 1 | |

## 5. Surveillance and Enforcement Capacity

| 17 | Surveillance and Enforcement Capacity | Value | Description |
|---|---|---|---|
| 17A | Is there a wastewater discharge surveillance programme? How is Coverage and frequency of monitoring? | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 17B | Is there a natural water surveillance programme? How is Coverage and frequency of monitoring? | 1 | |
| 17C | Is there qualified personnel for surveillance? Is the quantity of qualified personnel adequate? | 1 | |
| 17D | Is enforcement of regulations applied? What is the level of enforcement? | 1 | |
| 17E | Is there equipment and supplies for wastewater and natural water sampling? Is it sufficient? | 1 | |
| 17F | Are there standardized methods for wastewater and natural water sampling | 1 | |
| 17G | Are there laboratory facilities available? Are there enough? | 1 | |
| 17H | Are the Laboratories certified? | 1 | |
| 17I | Can Chemical and biological supplies be acquired locally? | 1 | |
| 17J | Can laboratory equipment be repaired and maintained locally? | 1 | |
| 17K | Are there standard Methods for reporting? | 1 | |
| 17L | Budget Adequacy | 1 | |
| 17M | Are Operational Parameters measured in WWTP? Adequacy? | 1 | |
| | Laboratory Parameters Capability Parameters analyzed | | |
| 17N | Total Suspended Solids | 1 | |
| 17O | Biochemical Oxygen Demand ($BOD_5$) | 1 | |
| 17P | Chemical oxygen Demand | 1 | |
| 17Q | pH | 1 | |
| 17R | Fats, Oil and Grease | 1 | |
| 17S | Total Nitrogen | 1 | |
| 17T | Total Phosphorous | 1 | |
| 17U | Faecal Coliform | 1 | |
| 17V | *E. coli* (freshwater) and | 1 | |

| | | | |
|---|---|---|---|
| 17X | Enterococci (saline water) | 1 | |
| 17Y | Heavy metals | 1 | |
| 17Z | Pesticides | 1 | |

## 6. Manpower Capacity

| | Availability of Staff for Wastewater Management | Weight | Description |
|---|---|---|---|
| 18A | Planning Capacity for WWTP | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 18B | Managerial capacity | 1 | |
| 18C | Developing project proposals | 1 | |
| 18D | Design and Construction capacity | 1 | |
| 18E | Operation and maintenance Capacity | 1 | |
| 18F | Surveillance Capacity | 1 | |
| 19 | **National/Regional Training Needs for Wastewater Management** | Weight | Description |
| 19A | Planning Capacity for WWTP | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 19B | Managerial capacity | 1 | |
| 19C | Developing project proposals | 1 | |
| 19D | Design and Construction capacity | 1 | |
| 19E | Operation and maintenance Capacity | 1 | |
| 19F | Surveillance Capacity | 1 | |
| 20 | **National/Regional Training Opportunities for Wastewater Management** | Weight | Description |
| 20A | Basic operator certification | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 20B | Technical | 1 | |
| 20C | BSc | 1 | |
| 20D | Specialization | 1 | |
| 20E | MSc | 1 | |
| 20F | PhD | 1 | |
| 21 | **National/Regional Training Areas for Wastewater** | Weight | Description |
| 21A | Management, | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 21B | Administration, | 1 | |
| 21C | Accounting | 1 | |
| 21D | Engineering | 1 | |
| 21E | Technician | 1 | |
| 21F | Operators | 1 | |

## 7. Financing

| 22 | Financial Issues | Value | Description |
|---|---|---|---|
| 22A | What are the Primary Source of Funding for Water and Wastewater Projects | | |
| 22B | Is the polluter pays principle applied | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| | What economic Instruments are applied? | 1 | |
| **22C** | User fees | 1 | |
| 22D | Taxes | 1 | |
| 22E | Grants | 1 | |
| 22F | Loans | 1 | |
| 22G | Private investments | 1 | |
| 22H | Is there a budget in sanitation dedicated to wastewater treatment management? | 1 | |
| 22I | Do smaller communities obtain affordable financing for improving wastewater infrastructure? | 1 | |
| 22J | Is financing available for investments in wastewater management affordable? | 1 | |
| 22K | Investment per capita into wastewater management projects < $60 = Low; $60-$120 = Medium; > $120 = High | 1 | |
| 22L | How is spending on the wastewater sector, compared with other sectors? | 1 | |
| 22M | Is there a sewer tariff for cost recovery? Adequacy? | 1 | |
| **22N** | What is the adequacy of funds generated from central government, donors, bank loans or grants and revenue from tariffs, for the operations or service delivery cost of the utilities? | 1 | |
| 22O | To what extents are public authorities assisted by other stakeholders including community groups, private development companies etc. in wastewater management**?** | 1 | |
| 22P | Are Rates for septage disposal adequate? | 1 | |
| 22Q | Are there Cost Estimates for wastewater carrying and treatment technologies? | 1 | |

## 8. Best practices and Innovative technological treatment solutions

| 23 | **Best Practices and Innovative technological Treatment solutions** | Value | Description |
|---|---|---|---|
| 23A | Policy framework | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 23B | Legislative framework | 1 | |
| 23C | Institutional framework | 1 | |
| 23D | Surveillance capacity | 1 | |
| 23E | Manpower | 1 | |
| 23F | Financing | 1 | |
| 23G | Wastewater treatment technology* | 1 | |
| 23H | Sanitation projects as Community source of revenue | 1 | |
| 23I | Other (Specify)water conservation | 1 | |

## 9. Current knowledge, attitudes, behaviors and practices

| 24 | Current knowledge, attitudes, behaviors and practices | Value | Description |
|---|---|---|---|
| 24A | How is the Level of awareness about wastewater management concepts, issues and technologies? | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 24B | How are the Attitudes towards implementing proper wastewater practices? | 1 | |
| 24C | Level of focus of wastewater compared with water | 1 | |
| 24D | How likely is it that decentralized natural treatment systems (e.g. ecological sanitation, constructed wetlands, sand filters) would be accepted as options for domestic wastewater treatment? | 1 | |
| 24E | To what extent are people aware of the impact of current methods of disposal on health and environment? | 1 | |
| 24F | Are people aware of the link between sewage, poor sanitation and health problems such as diarrheal diseases, malnutrition, vector diseases, human capital, etc.? | 1 | |
| 24G | Do senior management officials in government/decision makers have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio-economic development? | 1 | |
| 24H | Do officials in politicians have a comprehensive knowledge of wastewater management issues and can link these with other areas of socio-economic development? | 1 | |
| 24I | Are wastewater operators aware of proper operations and maintenance techniques? | 1 | |
| 24J | Do national, local and sectoral education and public awareness programmes and campaigns exist for wastewater management or for environmental management (which includes wastewater management)? | 1 | |

## 10. Information Collection and Sharing

| 25 | Information Collection and Sharing | Value | Description |
|---|---|---|---|
| 25A | Do you have facilities for data collection where analysis, revision and expansion of information are conducted? | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 25B | How is the quality of data analysis? | 1 | |
| 25C | Existence of periodic assessment of short-term and long-term data-collection and research needs for wastewater management. | 1 | |
| 25D | Is there access to information related to wastewater management issues for decision making to Government Officials? | 1 | |
| 25E | Is there public access to information related to wastewater management issues for decision making? | 1 | |
| 25F | Is there an Standardize Data Collection, in order to gather comprehensive and comparable information, | 1 | |
| 25G | Is the terminology standardized? | 1 | |
| 25H | Existence of national knowledge and information system/ clearing house mechanism of tools and approaches for wastewater management that are effective and appropriate to the expectations and context of the beneficiaries in the Wider Caribbean. | 1 | |

## 11. Presence and Participation Level of Water and Sanitation Organizations

| 26 | Organizations support for wastewater management | Value | Description |
|---|---|---|---|
| 26A | UN | 1 | A significance value of 1 is |

| | | | |
|---|---|---|---|
| 26B | NGOs | 1 | assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 26C | International Cooperation Agencies | 1 | |
| 26D | IDB | 1 | |
| 26E | World Bank | 1 | |
| 26F | Sub regional banks | 1 | |
| 26G | Professional Organizations | 1 | |
| 26H | Media organization | 1 | |
| 26I | Healthy Schools | 1 | |
| 26J | Eco clubs | 1 | |
| 26K | Theatre groups | 1 | |
| 26L | Community organizations | 1 | |

## 12. Climate change impacts

| 27 | Climate Change Impact | Value | Description |
|---|---|---|---|
| 27A | Higher temperatures | 1 | A significance value of 1 is assigned to all. However you can assign a different value. This will automatically be updated in the model. |
| 27B | Higher Humidity | 1 | |
| 27C | Rising seas | 1 | |
| 27D | High Water Tables | 1 | |
| 27E | Increased risk of drought | 1 | |
| 27F | Increased risk of fire | 1 | |
| 27G | Increased risk of flood | 1 | |
| 27H | Stronger storms and increased storm damage | 1 | |
| 27I | Increased Risk of Hurricanes | 1 | |