



BASELINE ANALYSIS ON DOMESTIC WASTEWATER MANAGEMENT IN THE WIDER CARIBBEAN REGION



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**BASELINE ANALYSIS ON DOMESTIC WASTEWATER
MANAGEMENT IN THE WIDER
CARIBBEAN REGION**

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I. INTRODUCTION

In the Wider Caribbean Region (WCR), improperly treated domestic wastewater can be a significant source of marine pollution and represents a threat to human health, sustainable development and marine resources. However, a tendency to the stagnation in the sanitation services is observed among many municipalities in the region as population's size and the economy are increased. Also, natural resources vital to economic growth are wasted or lost through misdirected urban policies and practices, and population overspill into areas less suitable for urban development, thus creating further pressure on these resources as urban sprawl increases, turning the town concerned into one large drain ¹.

The environmental problems associated with uncontrolled urban development are particularly marked among the poorest urban sectors those with the worst housing and the most restricted access to public services. But the principal impact of unrestrained urban expansion is on the environment caused by pollution of inland and marine waters, exhaustion of water reserves, destruction of woodlands and fertile agricultural land, and encroachment on ecologically-productive territory (the ecological footprint). The severest effects are declining drinking water reserves and deteriorating housing quality, public health and sanitation services ².

In WCR countries, an important sector of the population lives in coastal areas where sewerage systems are deficient and even absent in some cases and have illegal connections to the storm drains. The limited access to a basic sanitation by means of the domiciliary connection to a sewer system, low-cost household systems made up of septic tanks, dry latrine and with discharge of water, and to the simple pit latrine; as well as the shortage of sewage treatment plants in countries that have sewer systems causing risks to public health and the environment ³.

The pattern of sanitation cover in the region is extremely patchy in terms of its extent and treatment capabilities, reflecting sharp differences between the various countries in terms of culture and tradition, as well as degrees of socio-economic development; factors that significantly influence the lives of their populations and the environmental quality.

The development of these services in the region over the last three decades compares quite favorably with other parts of the world. However, as regards to coverage, the absolute numbers are worrying, an estimated 100 million inhabitants (15% of those living in upstream coastal areas) have no access to sanitation services, while some 43% of the sewer system effluents receives some degree of treatment(pre-treatment, primary treatment, secondary treatment, tertiary treatment or sewage discharges by means of submarine outfalls) ⁴.

Consequently, the greatest challenge is associated with the expansion of sanitation coverage, and the efficiency of sewer systems and alternative improved on-site household systems; together with environmental awareness, the qualification and training of personnel for the sanitation sector, adequate environmental policies and the improvement of sewage management programs. Conditions of inadequate domestic-wastewater treatment facilities remain one of the most serious problems in most of WCR countries. The ratification and entering in force of the Protocol Concerning Pollution from Land-Based Sources and Activities (Protocol LBS) by the countries of the region will be juridical tool of an appreciate value to achieve the eradication of this problem, which affects the human health and the sustainable development of the marine resources

The work shows a preliminary baseline study on domestic wastewater management in hot spots among coastal marine pollutant ecosystems (hot spots) in Colombia (Cartagena Bay), Jamaica (Kingston Harbour), Nicaragua (Bluefields Bay), Trinidad & Tobago (Gulf of Paria), Venezuela (Gulf of Cariaco), Guyana (Georgetown) and Suriname (Paramaribo) and the management plan design for the environmental rehabilitation of the hot spots within the framework of the Global Environment Facility, Caribbean Regional Fund for Wastewater Management (GEF, CReW Project).

Hot spots are coastal marine polluted areas of considerable importance in WCR countries each concerned, in terms of the socio-economic value associated with their use fishing, marine-port, industrial, tourist-recreational and cultural (Figure 1).



Figure 1. Hot spots applicable to CReW Project

The CReW project objective is to improve the capacity of WCR countries for sewage management, to develop a Regional Fund prototype, to provide sustainable financing and to address capacity constraints in the countries within existing legal, institutional, educational and policy frameworks for sewage management in the WCR.

II. BASELINE ANALYSIS IN WCR COUNTRIES

II.1. Jamaica

Kingston Harbour lies off the south-eastern coast of Jamaica, overlooked by Kingston. Its drainage basin covers 365 square km and has a population of some 920,000.

Domestic wastewater is collected from homes, business and other entities via lateral drainage pipelines which connect to an underground public sewer or main pipeline, and is fed by gravity and/or pumping to the Sewage Treatment Plants (STPs). There are 14 STPs in the Kingston Bay drainage basin, which discharge effluent at various levels of treatment into the bay via watercourses, mostly the Sandy Gully canal, while two plants discharge directly into the Kingston Harbour. Jamaica's National Water Commission (NWC) operates 11 STPs; the remainder are run by private firms (Figure 2). There are other, industrial-sector treatment plants in the Kingston area.

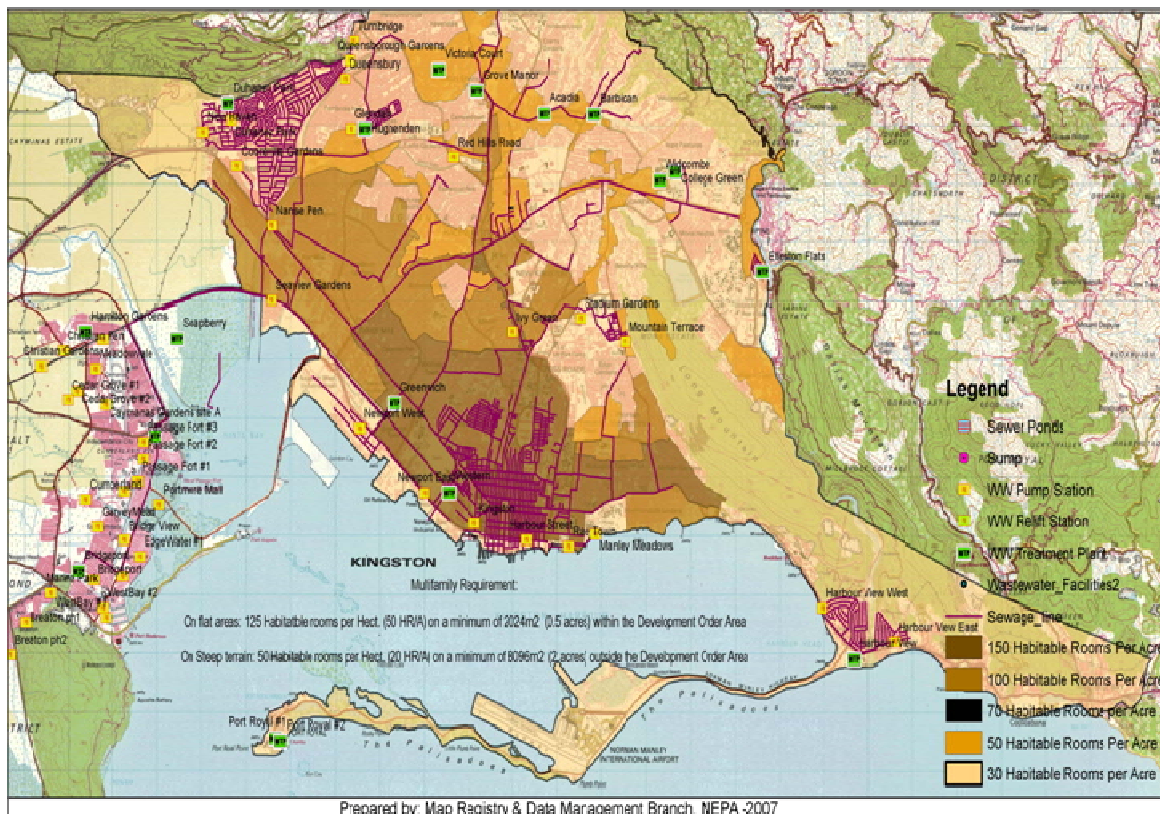


Figure 2. Wastewater treatment plants in Kingston and St. Andrew

In general, STPs use secondary biological processes based on activated sludge, although aerated ponds, extended aeration, contact stabilization, oxidation ditches and septic tanks are other treatment technologies employed.

Stabilization ponds are widely used by NWC, with the major one situated at Soapberry, Kingston. The widespread use of stabilization ponds reflects their simplicity, efficiency, reliability and low capital, maintenance and other operating costs in the major basin. NWC is the main provider of sanitation services in Jamaica and it is in charge of the wastewater treatment and disposition generated for more than 600,000 inhabitants. 47% of sanitation coverage is attributable to SPTs (47%), septic tanks (46%) and latrines (7%). The domestic wastewater flow discharged into the bay is some $0.84 \text{ m}^3 \cdot \text{sec}^{-1}$. Effluent leaving in STPs has average per-litre concentrations of 24.8 mg DBO_5 , 22.87 mg TSS, 6.9 mg $\text{NO}_3\text{-N}$ and 5.53 mg $\text{PO}_4\text{-P}$ which exceed the levels specified in the relevant Jamaican quality standards for discharge into the sea, implying eutrophication risks in areas of slowly circulating waters and a threat to public health. Fecal coliforms are also present in high concentrations of 843.37 /100 ml ⁵.

The Kingston drainage basin has the oldest sewerage system in WCR, it has been in use for over a century, and provides 30% sanitation coverage. Soapberry STP is the largest in Jamaica, with a capacity of 75,000 cubic meters and includes tertiary treatment (Figure 3).



Figure 3. Soapberry STP in the Kingston Metropolitan Area

The Soapberry STP was planned to focus on domestic wastewater treatment generated in the Kingston Metropolitan Area and south-east St. Catherine (Portmore). The Soapberry STP was commissioned into operation in 2008 and has to date replaced the Greenwich, Barbican Mews and Western STPs have already been closed and other plants as well, which were experiencing operational challenges and exceeded their useful economic life. Greenwich and Western STPs have been converted to pumping stations.

It is the purpose of the NWC to rationalise its sewerage systems within the Kingston drainage area by converting its package waste water treatment plants where technically feasible, to have their flow directed to the Soapberry central sewerage system. Some of these STP includes College Green, Widcombe/Ravina, and Grove Manor.

The main socio-economic concerns include the commercial and industrial sector, urban sector and tourism, port-maritime activity and protected areas. The urban runoff is one of the area's main environmental problems, involving polluted water and solid waste often dumped into the Sandy Gully Storm water drain.

The legislative framework for domestic wastewater management in Jamaica includes the following:

- Natural Resources Conservation Act, 1991
- Natural Resources Conservation Authority (NRCA) Permits and Licences Regulations, 1996
- Natural Resources Conservation Authority (NRCA) Wastewater and Sludge Regulations, draft.
- National Water Commission (NWC) Act.
- Sewage Connection Policy (NWC)
- Public Health Act.

Other legal obligations applicable in Jamaica include the Cartagena Convention and its Protocol Concerning the Pollution from Land-Based Sources and Activities, known as LBS Protocol, and regard the definition and application of standards and codes of practice. All the waters off Jamaica's shores are regarded as Class I under Annex III of the LBS Protocol hence licences to discharge effluent will need to meet tighter standards for effluent limits by 2015.

The National Programme of Action (NPA) for the Protection of the Coastal and Marine Environment from Land-Based Sources provides a framework for the period 2005-2010 for land-based sources management and identifies three priority areas:

1. Domestic wastewater treatment and disposal.
2. Improved farming practices for the soil conservation and fertilizers use and pesticides.
3. Solid wastes collection and disposal.

The key issues associated with wastewater management are:

- Disposal and reuse of treatment- plant sludge.
- Disposal and reuse of treated effluent.
- Inadequate preventive maintenance at the sewage treatment plants.
- Inadequate levy systems and penalties in the sanitation sector.

- Expansion of sewerage system coverage.
- Low operating efficiency at many of the sewage treatment plants, which also fail to meet targeted effluent limits.
- Tariff is not adequate to cover operational expenditure and capital investment in Wastewater Treatment Facilities.
- Collection and treatment of industrial waste (i.e. sludge management).

The following are the activities proposed for inclusion in a future CReW Project:

- i. Expansion of the sewerage network in the Kingston Metropolitan Area and domestic wastewater treatment in Soapberry STP.
- ii. Expansion of the sewerage network in Portmore, St. Catherine and domestic wastewater treatment in Soapberry STP.
- iii. Construction of a new domestic wastewater treatment plant in Harbour View, St. Andrew.
- iv. Construction of an industrial-effluent treatment plant.

II.2. Nicaragua

Nicaragua's three large natural regions, based on differences in climate, soil-type and topography, are Pacific, Central and Atlantic (or Caribbean). The Pacific region accounts for 19% of the country and is the most developed and densely populated. The Central region occupies 39% and is marked by its rugged terrain and cool climate. The Caribbean region covers 42% of the land surface and comprises an extensive plain vulnerable to flooding. Bluefields and its bay are in the Caribbean region. The city is an administrative centre on one side of the bay with a population of some 40,000. The coastal zone is varied, with features including wetlands, swamps, mangroves, coastal lagoons, estuaries, rivers, gallery forests and flooded woodland, beaches and sandbanks. Facing the north east corner of the Deer Island is El Bluff (population 2,000), whose port has an economic great importance for the territory.

Bluefields Bay (or Lagoon) covers 176 square km, is elongated in shape and runs north-south. It is 30 km in length, while the width varies between 3 and 8 km. It is an economic great importance for their fishing high activity, its estuarine character making it home to many marine species at different stages in their life cycles. It was designated a Ramsar Site in November 2001 and is listed as a wetland of international importance. This bay is the main route for domestic trade between Bluefields and the Rama Port, and international trade via the Bluff Port. The town's and the whole region's industry (medium-category industrial development) is closely bound up with its basic natural resources - fish, timber and agricultural land.

The main drainage basin is formed by the Río Escondido, which discharges 26×10^9 cubic meter of fresh water annually into Bluefields Bay, accompanied by 5×10^6 tons per year of material in

suspension. It has a surface area of 12,700 km² and 75 km in length. The Docuno, Torsuani and Kukra rivers feed the bay to the south; their banks are cultivated by few families of the Rama ethnic group.

Bluefields City settles in the Northwest side of the bay in the lower part of the Rio Escondido river basin, on four micro-basins that function as the town's natural drainage system; there is no Master Plan. The urban sector covers 496.55 hectares, while a total of around 144 hectares is not suitable for settlement. Population growth, uneven and badly planned, has accelerated in recent years, involving an influx from the countryside that is now affecting the urban environment and intensifies pressure on the public sanitation services.

There are 6,704 dwellings in Bluefields' downtown, most of which have no drinking-water supply or access to the municipal solid-waste collection services. It has no system of any kind for domestic wastewater collection and disposal, included the lack of a stormwater and sanitation sewerage system which originates the surface and underground waters pollution as well as the bay itself.

Hurricane Juan in October 1988 destroyed an estimated 250,000 hectares of mangroves; the impact on their ability to regenerate has contributed to erosion and the drift of sediments to the bay, where the wildlife habitat has undergone marked changes. Other factors contributing to the deterioration of the bay environment include the topography of the soil, scarcity of drinking water, industrial activity and the lack of environmental education programme. However, urban and industrial concentration is low, limiting the incidence of serious pollution, which is generally local and it are associated with cattle-raising and other agricultural activities and mining.

35.4% of the Bluefields population live in districts with ready access to water and 14.7% with intermediate access, while half the townspeople have serious problems of water supply in summer. A desalination plant was started up in 2008 supplying 5,000 cubic meter of drinking water per day, but does not operate properly and has not improved the town's water-supply situation, on top of which it generates some 5,000 cubic meter of brine residue, which is dumped straight back into the bay with no treatment whatever.

The town's lack of a domestic wastewater collection and disposal system is the primary cause of the pollution of the subsoil, of the streams that traverse the town and of the bay. The excreta of 54.4% of the population is eliminated via public cesspools that do not adequately prevent its penetration of the stormwater drainage system, while 45.5% use flushing lavatories with clandestine connections to the drainage flow into Bluefields Bay. The domestic wastewater flow discharged into the bay is some 0.38 m³.sec⁻¹.

Table 1 shows the estimated domestic-wastewater pollution load discharged in Bluefields Bay.

Table 1. Estimated domestic pollutant load discharged in Bluefields Bay

Indicator	Estimated load	
	kg per day	tons per year
Chemical Oxygen Demand (COD)	1,800	657
Biochemical Oxygen Demand (BOD ₅)	756	276
Total nitrogen (TN)	36	13
Total phosphorus (TP)	14	5
Total suspended solids (TSS)	1,260	460

Table 2 shows the main land-based sources and activities affecting the bay. The effluent is discharged untreated into the bay via the stormwater drainage system and surface watercourses. Some sites have septic tanks, but these do not work properly.

Table 2. Land-based sources into the Bluefields Bay

Economic activity	Inventoried sites
Farmhouse cheese-making	68
Human settlements	31
Hospitals, clinics etc.	17
Hotels	17
Cattle & pig slaughterhouses	13
Municipal garbage dumps	9
Municipal flea-markets	7
Seafood firms	3
Milk depots	3
Sawmills	2
Creamery	1
Oil palm firms	1

Wilhelm Gutierrez T. - National inventory of pollution loads. Technical Report. 2009

These sources discharge virtually untreated effluent into the runoff system that empties into the bay. Some sites have septic tanks but these are not emptied (sludge removal) regularly by the relevant specialized-vehicle services.

El Bluff is a Bluefields' urban district and home to the fuel and oil-derivative reservoirs. It is limited to port activities and fishing, and a shipyard. The domestic wastewaters are discharged into the sea and swamps, with minimal use of septic tanks and predominant use of latrines.

The environmental deterioration of Bluefield's ecosystem (town and bay) is seen as a limitation on sustainable development in the territory.

The Ministry of the Environment & Natural Resources (MARENA) drives Nicaragua's environmental policy. The Government of Reconciliation & National Unity's human development strategy aims at the alleviation of poverty and transformation of the country based on an alternative, fairer development model applied in a spirit of solidarity, involving a new citizen-power, direct democratic structure guaranteeing environmental rights (to live in a healthy environment and to make sustainable use of the natural resources).

The human development policy includes the following key principles:

- Water, land, woodland, bio-diversity, coastal-fishing, energy, mining and environmental resources can be used to provide livelihoods for the poor.
- Environmental improvements should not be postponed until economic growth has reduced poverty.

The government's environmental policies, based on the principles adopted in the human development strategy for 2007-2011, are as follows:

Policy 1: Restoration of the values of cultural identity with nature ... environmental education for all Nicaraguans of both sexes.

Policy 2: Safeguarding of our water sources. Rescue of the natural heritage ... water is life.

Policy 3: Rescue of our natural resources, woodlands, ecosystems, biodiversity and protected areas.

Policy 4: Systemization of environmental quality ... promotion of types of development that are free of environmental pollution.

Policy 5: Territorial environmental regulation.

Policy 6: Management of valleys reforested to reflect climate change.

The environmental educational programmes are informal and are implemented via MARENA and the Mayor's Office in the area of reforestation and environmental sanitation. There are no formal programmes associated with the latter activity recognized as such by the Ministry of Education.

The activities proposed for inclusion in a future CReW project are:

- i. Current sanitation infrastructure rehabilitation.
- ii. Sanitation coverage completion, using improved on-site local systems involving septic tanks and diffusing wells.
- iii. Master plan for wastewater management in Bluefields.

II.3. Trinidad & Tobago

Trinidad & Tobago lies at the southern end of the Lesser Antilles islands, at 10° - 11° 30' North and 60° - 62° 30' West. The combined surface area of the two islands is 5,123 square km; the coastlines are highly varied, with marshy areas and a great diversity of flora and fauna. Trinidad, whose western coastline borders the Gulf of Paria, covers 4,823 square km and has landscape marked by mountains, steep hills, and plains. Relative to the rest of the small islands of the Lesser Antilles, Trinidad & Tobago is industrialized. The economy is based on the oil industry and a small but fast-growing tourist trade.

The primary socio-economic concerns are port-maritime operations, oil refineries, iron and steel industries, fertilizers, industrial gases, food-processing plants, breweries, animal feedstuffs, cosmetics, paper and manufacturing industry, schools, urban and farming settlements and the medical industry. Fishing and marine transport are the main interests in the Gulf of Paria.

Trinidad's population is some 1'208,282, of whom some 1'055,307 (83%) live on the Gulf of Paria upstream coastal. The area draining into the Gulf of Paria covers 2,386 square km (47% of the combined area of Trinidad & Tobago). The domestic wastewater flow discharged is some 1.28 m³.sec⁻¹. Sanitation coverage involving connection to the municipal sewerage system amounts to 30%; the rest is represented by improved on-site local system based on septic tanks and diffusing wells (42%), and dry and flushing latrines that adequately segregate human excreta (28%). The proportion of sewage effluents subjected to some grade of treatment is some 30%.

There are 160 SPTs in Trinidad & Tobago (12 SPTs public and 148 private). There has been a focus in recent years on assessing and refurbishing these, some of which are idle or they are not working correctly. Figure 4 depicts the Malabar SPT in Trinidad.



Figure 4. Malabar SPT in Trinidad

The Beetham STP operates on domestic and industrial effluent via a pond system (Figure 5). The three stages of operation are:

- Preliminary treatment in sub-stages involving sieving and removal by helical conveyor.
- Secondary treatment with surface mechanical aerators.
- Tertiary treatment using ultra violet for effluent final disinfection.



Figure 5. Beetham STP in Trinidad

Table 3 summarizes Trinidad & Tobago's domestic-wastewater treatment facilities.

Table 3. Domestic-wastewater treatment facilities and flow (m³.day⁻¹)

Site	Type of treatment	Design Flow	Current Flow
Beetham	Stabilization ponds	56,780	14,300
Arima	Biological trickle filter	6,520	5,000
San Fernando	Biological trickle filter	17,080	6,000
Chaguaramus	Imhoff tank & biological bed	-	354
WASA Head Office	Extended aeration	130	31
Trincity	Activated sludge	1,000	1,200
Santa Rosa Heights	Contact stabilization	1,560	1,560
Piarco	Extended aeration	176	162
Lange Park	Extended aeration	681	217
Penco Lands	Extended aeration	143	185
Techier Village	Contact stabilization	454	400

Low-cost alternative technologies under consideration include a composting lavatories project in the Rio Caura/Tacarigua valley for 2010. There are also programmes for monitoring rivers and other watercourses that affect the coastal zone, and a domestic wastewater monitoring programme under

the support of the Water and Sewerage Authority (WASA). With the approval of Environmental Management Authority (EMA) an individual monitoring scheme under an Environmental Sanitation Rule (CEC) certificate is underway.

The three main sewerage systems are:

- *Port of Spain (city)*: The system includes the western, northern and eastern suburbs, with two main pumping stations (Westmoorings and Beetham). Treatment is based on a system of (2) anaerobic and (4) aerobic ponds. Effluents are discharged in Caroni River (near its mouth) that drains in the Gulf of Paria. However, Ponds are virtually full of sludge and the pumping facility is corroded and damaged. Dredging and sludge removal operations are pending.
- *San Fernando (town)*: This system includes the northern and eastern suburbs. Treatment is by high-speed trickle filter. Effluents are discharged in Cipero River (near its mouth) that drains in the Gulf of Paria.
- *Arima (Borough)*: It is a small sewerage system. Treatment is by high-speed trickle filter. Effluents are discharged in Mausica River, a tributary of the Caroni River.

The key institutions concerned with the management of domestic wastewater are as follows:

- Water and Sewerage Authority (WASA); set up in 1965 (the country's principal sanitation agency).
- Environmental Management Authority (EMA); set up in 1965.
- Ministry of Public Services Companies; represents WASA in parliament and in the Government cabinet.
- Regulated Industries Commission (RIC); monitoring and enforces the conditions for Environmental Licences.
- Ministry of Health; responsible for coping with the effects of domestic wastewater and the contamination of surface and underground water.
- Other ministries:
 - ✓ Ministry of Planning, Housing & the Environment
 - ✓ Ministry of Works & Transport
 - ✓ Ministry of Education.
 - ✓ Ministry of Trade & Industry
 - ✓ Ministry of Local Government.
- Provincial planning authority.
- Land Settlement Agency.
- National territorial planning authority.

Problems associated with the domestic wastewater management include:

- An ageing sanitation infrastructure; the plant and equipment date back 30-45 years, the collection systems 100 years.
- Inadequate preventive maintenance.
- Illegal discharge of polluting effluent; inadequate systems of penalties.
- Insufficient training of treatment-plant operatives and workers engaged in maintenance, refurbishing and on pumping systems.
- Obsolete services technologies for access to improved sanitation.
- Lack of penalties for bad design or construction of STPs.
- Underfunding of the sanitation sector.

The activities proposed for inclusion in a future CReW Project are:

- i. Current sanitation infrastructure rehabilitation and assimilating (by means of processes investors) the domestic wastewater volume that currently exceed those collected and treated.
- ii. Reorganization and improvement of the sanitation sector in line with the development objectives.
- iii. Training in domestic wastewater treatment plant maintenance.

II.4. Colombia

Cartagena, the capital of Bolívar Department, lies on Colombia's Caribbean coast. It has some 950,000 inhabitants and is one of the country's main ports and tourist resorts. It is becoming one of the most dynamic cities in the Caribbean basin, based on its historical and cultural traditions, environmental and geo-morphological features, port activity and accelerating development (petrochemical and other industries, commerce and tourism). It has been listed as a UNESCO World Heritage site since 1984. The city's domestic wastewater is discharged in the Cartagena Bay and in the Ciénaga de la Virgen, coastal lagoon also known as Ciénaga de Tesca, which support various activities including swimming, fishing, port-maritime operations, as well as wastewater received from land-based sources and activities.

The sewerage and water-supply system in the Boca Grande area and the city centre is virtually complete. In the Ciénaga de la Virgen and Cerro de la Popa area, the housing infrastructure is dilapidated; although there is a sewerage system, domestic wastewater is discharged (untreated) directly into the lagoon or internal canals, reflecting the prevalence of low-income families in the area, inadequate environmental awareness and connection problems caused by difficult access to the sewer. Also, many dwellings lack wastewater plumbing. Socio-economic activities in Cartagena include the following:

- *Mamonal industrial area:* It is Cartagena oil refinery, one of the country's largest, and the associated petrochemical-industry activity, plus other lesser industrial installations. 70% of the region's petrochemical activity is concentrated here.
- *Cartagena Bay and the Dique Canal:* these two bodies of water facilitate substantial port traffic towards the interior for connection with the Rio Grande de la Magdalena River, and outwards via the Caribbean. The port area is also a focus for the tourist trade (cruises and tourist passenger services linking the Rosary Islands with Cartagena Bay).
- *Cartagena de Indias:* this is an important tourist resort based on its place in history and magnificent setting. The Boca Grande area has an extensive hotel and services infrastructure, although serious problems with stormwater runoff pose a constant flooding risk.

The environmental conditions of Cartagena Bay are not favourable, while those of the Cienaga de la Virgen are worse. The drainage basins of these two areas cover 650 and 3,340 hectares, respectively. The domestic wastewater flow discharged is some $1.04 \text{ m}^3.\text{sec}^{-1}$. Sanitation coverage by the sewerage system is 83.35%, whilst 8% is covered by septic tanks and 5% by latrines.

Cienaga de la Virgen has had a regulation and management scheme since 2005, due to an agreement between CARDIQUE and International Conservation to ensure its sustainable use. This coastal lagoon was deteriorated, reflecting its reception of 60% of Cartagena's domestic wastewater. It has recovered by over 80% however, as a result of the Stabilized Tidal Mouth project (Figure 6). This water regulation system, constructed by the Colombian and Netherlands governments in 2000, connects the lagoon to the sea, enabling constant renewal of its waters.



Figure 6. Stabilized Tidal Mouth

The general policy in Cartagena is for users to be connected to the sewerage system, which covers virtually the entire city. However, in the poor quarters -especially around the Cienaga de la Virgen- in the majority of cases this has not been possible, because of lack of funds, difficult access and lack

of environmental awareness; the wastewater is discharged directly into the canals and in the Ciénaga de la Virgen.

An undersea outlet discharges 40% of the domestic wastewater (some $30,000 \text{ m}^3 \cdot \text{day}^{-1}$), untreated, into Cartagena Bay, at a depth of 20 m and 800 m from the shore, to mitigate the impact on the marine environment. The remaining domestic wastewater is discharged at sea without appropriate treatment.

The city's Sewerage Master Plan does not envisage alternative systems using improved on-site household systems. It aims at 95% coverage city-wide, based on conventional sewerage and final disposal by means of submarine outfalls. A new long submarine outfall, scheduled for completion in 2010, will discharge the domestic wastewater currently dumped indiscriminately in Cartagena Bay and the Ciénaga de la Virgen.

Figure 7 depicts the new submarine outfall, which will feature pre-treatment with mili-sieves (Figure 8) prior to discharge at Punta Canoa, 3 km distant from the coast. It is hoped that the project will result in the elimination of the present practice of disposing of domestic wastewater in Cartagena Bay and the Ciénaga de la Virgen.



Figure 7. Planned submarine outfall in Cartagena



Figure 8. Mili-sieves for the pre-treatment

Nevertheless, it is feared that a volume (un-quantified) of domestic wastewater will continue to find its way into the Ciénaga de la Virgen from the poorer districts, where access to the sewer system is also sometimes a problem because of steep slopes and other topographical features.

The alternative is to use more suitable, low-cost technologies, whose viability has been demonstrated. However, even the use of septic tanks is too expensive for certain segments of the populace, a situation aggravated by inadequate environmental awareness among the inhabitants.

Aguas de Cartagena Company has plans for monitoring the Dique Canal -the city's main source of water- and the submarine outfalls discharges, but has not still been carried out.

Colombia has the institutional framework needed to ensure safeguarding of the environment nationwide. The agencies present in Cartagena include the following:

- *Ministry of the Environment, Housing & Territorial Development (MAVDT)*: defines and implements national policies for safeguarding the environment in the country's 33 regions, which have regional authorities for sustainable development (CARDSs) tasked with monitoring and managing these policies and defining specific regional policies for preserving their ecosystems.
- *Dique Canal Regional Authority (CARDIQUE)*; established by Law 99 of 1993, and belonging to the National Environmental System (SINA), adopts methods determined by the MAVDT, is an administratively and financially independent public corporation with its own assets and legal status. Its jurisdiction covers the Cartagena rural district (Cartagena Bay, Cienaga de la Virgen and the Inland Waterways System) plus 20 northern and central boroughs of Bolívar Department. Its mission is to promote sustainable development among the communities and economic sectors in its four eco-regions (Canal del Dique, Montes de Maria, Coastal Zone and Cienaga de La Virgen basin), involving environmental plans, programmes and projects, and to provide services based on its technical innovation capability, research facilities (environmental laboratory) and personnel, to various firms and institutions in Cartagena.
- *Public Environmental Agency (EPA)*; a district environmental authority created by law in 2002 and belonging to the Cartagena district local authority. It implements and monitors environmental policies in the urban sector and has a free hand in managing its budget. It addresses urban environmental management via a Sanitation & Effluent Discharge Control Plan (PSMV) approved by the environmental authorities. Like CARDIQUE, EPA has environmental development plans that identify the key environmental objectives within a four-year timeframe. These are backed by the District Development Plan (PDD) 2008-2010, two of whose six strategic objectives support environmental initiatives and investment designed to improve the life quality of Cartagena's inhabitants.
- *Aguas de Cartagena*: The only company in the Cartagena district supplying drinking water; it operates a domestic-wastewater sewerage system. It is a joint-venture company between the Cartagena local authority and Aguas de Barcelona (Spain). Its Environment & Quality Office is responsible for domestic-wastewater management and implementation of the city's Sewerage Master Plan. The Quality Laboratory monitors the public drinking-water supply and effluent discharged via submarine outfalls in the Manzanillo area of the bay. Its funding is limited, deriving from subsidies by the Cartagena local authority and levies charged to the users for the sewerage service.

To summarize, the main agencies involved in the treatment of domestic wastewater are CARDIQUE (a regional body) and EPA (a district authority). Aguas de Cartagena Company supplies drinking water and manages domestic-wastewater drainage via its sewerage system. The District Administration, District Council and District Comptroller's Office have important roles in managing and controlling investment in improvements to the sanitation infrastructure. Other entities that should be directly involved in the domestic wastewater management include the hotel-owners' or other tourist-industry trade association, universities, the NGOs with responsibilities under environmental programmes and the Community Associations. CARDIQUE is formulating a regulatory programme aimed at assessing conflicts of use in Cartagena Bay, based on six variables:

1. Susceptibility to regulation, policies and institutionalization.
2. Technological development.
3. Territorial regulation.
4. Institutional coordination.
5. Ecosystem quality and civic participation.
6. Environmental education and managerial management.

The industrial sector has all but doubled its output in the last 10 years, while the industrial pollution load in the bay has fallen by 68.3%, reflecting the environmental authority's success in securing systematic compliance by 90% of the companies with the regulations concerning treatment plants and cleaner production. CARDIQUE's and EPA's priorities include environmental education, with supporting initiatives in their development plans. They also target the new generations, working with children in the schools, and are implementing a programme of activities to promote public awareness, based on public-service broadcasts and TV programmes. Environmental management in Cartagena Bay and the Cienaga de la Virgen lagoon is a public asset of the citizenship, requiring awareness of the use and conservation needs of these natural resources, with the aim of ensuring the wellbeing of the territory, the competitiveness of its firms and the success of the ongoing development initiatives.

The activities proposed for inclusion in a future GEF CReW project are:

- i. Extension of sanitation coverage to the areas affected by access difficulties, based on improved on-site local system using septic tanks.
- ii. Extension of the sewerage system to the upstream coastal population in Cienaga de la Virgen, involving pipe-laying to the dwellings. Some dwellings currently have no connection to the sewerage system, reflecting the poverty of the families concerned.

II.5. Venezuela

Gulf of Cariaco is a marine coastal aquatic system on Venezuela's north-eastern coast in the Sucre state. It has an area of 645 square km, a volume of water some 31.5 cubic km, a length of 62 km (east-west), a width of 15 km and a narrow (5.5 km) entrance. The depth averages 50 m, reaching a maximum of 90 m. Its northern coastal strip forms the southern coast of the Araya peninsula,

creating a natural harbour. The eastern zone (fed by the Cariaco River at its eastern edge) is regarded as a wildlife sanctuary of great socio-economic and ecological importance.

The Gulf's fertile waters support a wide variety of fish, mollusc and crustacean species and aquatic vegetation, among other life-forms. It is an important centre of small fisheries and is the region's main fishing ground. It is one of Venezuela's most productive fishing areas; with an annual sardine catch (the main species) averaging 4,700 tons. The waters fertility enables marine cultivation (marine aquaculture), a contribution to food security in the territory.

Active boat-owning fishermen number some 2,000, supporting a permanent workforce of some 6,000 additional small fishermen, on the basis of the natural harvests of the local small fisheries. Then there is all the employment, also permanent, arising from the associated trading and distribution activities that start with the landing of the catch.

In the agriculture sector, important crops include taro, cassava, cocoa, coconuts, coffee, yams, bananas and sugarcane. Apart from fishing, the main industries around the Gulf of Cariaco are rum distilleries and production of chocolate, tobacco, leather, textiles and craft goods. The more common livestock farming activities are the raising and slaughter of cattle, pigs and poultry. Most of the industrial activity is takes place to the west, near Cumana city (Figure 9).

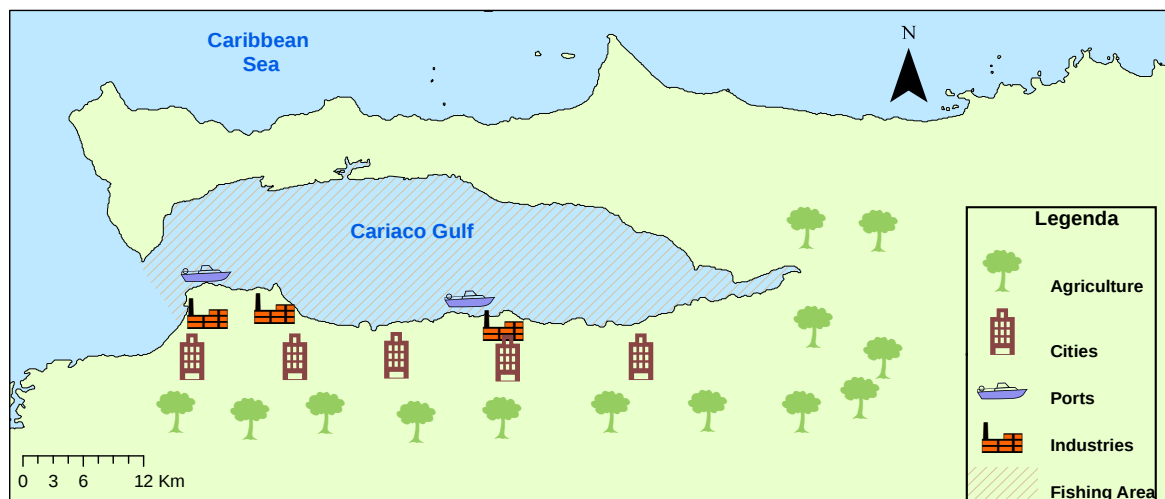


Figure 9. Social and economic activity in the Gulf of Cariaco

To summarize, the Gulf of Cariaco is a large, highly fertile, natural reserve and nursery and a recreation and tourism area with around 50 natural seaside resorts. It is an appropriate setting for promoting aquaculture at national level, having excellent cultivation potential; it is a major fishing ground supporting a traditional industry and is a mainstay of the populace; it is also a focus of natural biodiversity (especially pelagic and bottom-dwelling marine species and swampland species).

Upstream coastal population is some 930,000 and the domestic wastewater flow discharged in Gulf of Cariaco is some $1.01 \text{ m}^3 \cdot \text{sec}^{-1}$ combined with bilge-water and lubricants discharged from vessels, heavy-metal sediment, fats and greases and hydrocarbons, the result is a serious level of pollution in the Gulf of Cariaco.

79 watercourses (rivers, streams and intermittent rivulets) discharge into the gulf, 45 and 34 on the north and south coast's respectively. On the south coast, from east to west, are the mouths of the Potrero River, Manzanares River (an inflow of 600 million cubic meter p.a., having traversed the towns of Cumanacoa and Cumana to the west) and the minor rivers Tunantal, Guaracayal, Marigüitar, Tarabacoa, Cachamaure and Cariaco, which have contributed to the wide deltas scattered along the southern coast. To the north, particularly in the central-eastern zone, many of the watercourses are no more than 2 km in length, and there are no alluvial flats or deltas.

Figure 10 depicts the outflow from the Rio Manzanares into the gulf. The plume of spray practically crosses the mouth of the gulf entrance.



Figure 10. Outflow from the Manzanares River northwards from the southern coast in Gulf of Cariaco

Sanitation coverage amounts to 96% and is represented by septic tanks and diffusing wells (84%), and latrines (12%), although in practice there is constant discharge of insufficiently-treated domestic wastewater into the sea, along much of the gulf's coastline, reflecting the poor performance of these systems (Figure 11).



Figure 11. Uncontrolled dumping to Gulf of Cariaco

The legislative framework relating to sanitation is summarized in Table 4.

Table 4. Legislative framework relating to sanitation

CONSTITUTIONAL FRAMEWORK	
Instrument	Outline
Constitution of the Bolivarian Republic of Venezuela (Official Gazette No.5453, 24/03/00)	Environmental rights: The state will promote sustainable development protecting the environment, biodiversity, the ecosystems, natural resources and people. Everyone has a right to participate and to have an ecologically safe, healthy and balanced environment. All activities potentially damaging to the environment are subject to prior environmental-impact assessment.
Constitution of Sucre state (Legislative Assembly, State of Sucre, 29/01/64)	Provisions include "Promoting the opening of all kinds of roads and the construction of facilities of public interest in coordination with the roadbuilding and development plans and with the technical procedures for architectural engineering works undertaken by the relevant national agencies".
LEGAL FRAMEWORK	
Enactment	Outline
Organic Law of the Environment (Official Gazette No.31004, Congreso de la Republica, 16/06/76)	Provides as follows: "within the national comprehensive development policy, the guiding principles for the conservation, defence and improvement of the environment to the benefit of the quality of life".
Organic Law of the Central Administration (Official Gazette No.36850, Presidencia de la Republica, 14/12/ 99)	Establishes the structure and governs the working of the central administration and its agencies and systems, determines the number and designations of the Ministers, their powers and the bases of their organization.
Organic Law of Territorial Planning & Management (Official Gazette No.38.264 of 02/09/05)	Provides as follows: "the provisions that govern the general process for planning and managing the territory in ways consistent with the ecological situation and the principles and strategic objective criteria for sustainable development, including citizen participation, and which forms the basis of planning of the nation's endogenous, economic and social development".
Enactment	Outline

Organic Law of Public Health (Official Gazette No.5263, Congreso de la Republica, 17/09/98)	Sets the guidelines and bases for public health as a comprehensive process throughout the nation.
Organic Law of Administrative Procedures (Official Gazette No.2818, Congreso de la Republica, 1/07/81)	Governs the administrative activities, procedures, acts and sanctions of national, decentralized, state and municipal public administration, and of the Comptroller General's Office and the Attorney General's Office.
Organic Law of Decentralization, Delimitation & Devolution of Public Power and its Partial Regulation N° 1 (Congreso de la Republica, 20/12/89)	The aim is to "develop constitutional principles for promoting administrative decentralization and determine the division of powers between central government and the states".
Organic Law of Municipal Government (Official Gazette No. 38.204 of 08-06-05)	"Its purpose is to develop the constitutional principles relating to municipal government, its autonomy, organization, working, management, administration and control, for effective, proactive participation by the people in the affairs of their locality ..."
Organic Law of Waters & Islands (Official Gazette No.37290, Congreso de la Republica, 25/09/01)	Its purpose is "to regulate the sovereignty, jurisdiction and control of the Bolivarian Republic of Venezuela's waters and islands, in accordance with domestic and international law".
Law of Environmental Crime (Official Gazette No.4358, Congreso de la Republica, 3/01/92)	"The purpose of this law is to characterize as crimes acts that breach the provisions regarding the conservation, defence and improvement of the environment, and fix the corresponding penalties. Similarly, it defines the relevant precautionary measures and those of restitution and reparation".
Forestry Law of Soils & Waters (Official Gazette No.1004, Congreso de la República, 26/01/66) and its regulations (Official Gazette No.2022, Presidencia de la Republica, 28/04/77)	Governs "the conservation, promotion and use of the natural resources identified herein and the products deriving from these". Was amended via its regulations..
Wildlife Protection Law (Official Gazette No.29289, Congreso de la República, 11/08/70) and its regulations.(Official Gazette No.5302, Presidencia de la Republica, 29/01/99)	This law and its implementing regulations govern "the protection and rational use of wildlife and its products, and the practice of hunting".
Approbatory Law "Convention for the Protection of Flora, Fauna, and the Natural Treasures of American Countries" (Official Gazette No.20643, Congreso de los Estados Unidos de Venezuela, 13/11/41)	The aim is to establish a system in the American countries for protection and conservation of examples of all the species and genera of their indigenous flora and fauna, including migratory birds ... to avoid their extinction ... and protect and conserve the landscapes of incomparable beauty, the extraordinary geological formations, the regions and natural objects of aesthetic interest or historical or scientific interest.
Enactment	Outline
Approbatory Law of the Convention on Biological Diversity (Official Gazette No.4780, Congreso de la República, 12/09/94)	Provides for the maximum possible conservation of biodiversity for the evolution and maintenance of the biosphere or the planet's life, for the benefit of Earth's future generations.

Approbatory Law of the "Convention on International Trade in Endangered Species of Wild Fauna and Flora." (Official Gazette No.2053, Congreso de la República de Venezuela, 29/06/77)	The aim is to establish a system in the American countries for protection and conservation of "examples of all the species and genera of their wild flora and fauna, including migratory birds ... to avoid their extinction through international trade".
Law of Biological Diversity (Official Gazette No.5468, Congreso de la Republica, 24/05/00)	Defines the principles governing the conservation of biological diversity and its genetic resources (in situ and otherwise) as legal assets of the nation's environmental heritage and fundamental to life.
Law of Hazardous Substances, Materials & Wastes (Official Gazette No.5554 Ext., Asamblea Nacional, 13/11/01)	"The purpose of this law is to regulate the generation, use, collection, storage, transport, treatment and final disposal of hazardous substances, materials and wastes, and any operation involving these, with the aim of protecting health and the environment".
Law of Partial Reform of the Law of the National Parks Institute (Official Gazette No.2290 Ext., Congreso de la República, 21/07/78)	"This law governs all matters relating to the planning, construction, expansion, organization, equipping, conservation and administration of the national parks and recreational and other open spaces subject to intensive use". Excludes the parks whose administration is governed by specific by-laws or other special legislation.
Law of Expropriation on grounds of Public Utility (25/04/58)	Defines the requirements for expropriation of property for works of public utility undertaken with state funds for the general good. Similarly, these must be carried out with state funding. It provides that "the Government is empowered to decree as of public utility, ownership by the state of land and buildings it considers essential to the security or defence of the nation".
Stamp Duty Law (Official Gazette No.37625, 05/02/03)	Its purpose is to specify taxes and similar dues on the issue of documents and performance of official tasks of public administrative and associated with activities of interest for a particular sector, whether public or private..

The institutional framework associated with sanitation activities is set out in Table 5.

Table 5. Institutional framework associated with sanitation activities.

INSTITUTIONAL FRAMEWORK	
Institutions	Brief description
Ministry of the Environment & Natural Resources (MARN)	Administer natural resources for conserving, defending and improving the environment to the benefit of the quality of life. Creation of the Coastal Zones Technical Unit as coordinator of the Coasts Consultancy & Participation Committee of the National Commission for Aquatic Resources.
State of Sucre Administration	Responsible for the administration of its resources, co-management of the process of designing & implementing the Comprehensive Coastal Management Scheme (GIZC). Its executive agencies and foundations include the Tourism Authority, FONMITUR, Fundambiente.
National Institute of Fishing & Aquaculture	Administers the marine resources and promotes their exploitation.
Institutions of Higher	Tasked with optimizing human resources through formal education those

Education (UDO-Venezuelan Oceanographic Institute)	results in a productive individual to the benefit of the nation. Promotes research at various levels, with power to extend research projects and authority to access whatever resources are needed in this respect.
National Institute for Agricultural Research	Determines the lines of research required to improve the production processes adopted in the region..
National Parks Institute	Administers and "establishes the structure and regulates the working of the Central Administration, its agencies and systems, fixes the number and denominations of the ministries, their powers and the bases of their organization."
Ministry of Education, Culture & Sport	Regulation, formulation and monitoring of policies, planning and implementation of activities in matters of education, through guidance, control and assessment of the education programme.
Ministry of Health & Social Development	Sets and coordinates the guidelines and bases for public health as a comprehensive process, throughout the entire nation.
Ministry of Infrastructure	Planning and implementation of the policies of the National Executive regarding the road system, circulation, traffic and transport on land, water and by air; the operation of ports, docks and similar installations.
National Institute of Aquatic Resources (Harbourmaster's Office, Sucre ports)	Responsible for developing the aquatic sector in line with current policies, and regulating and improving the control of the services provided, generally improving port services and rescuing our shipping industry, with the aim of making these competitive and of high quality.
Ministry of Defence (National Guard, Armed)	Regulation, formulation and monitoring of policies, planning and government action in matters of land-, sea- and air-defence and of cooperation.
Ministry of Justice & Home Affairs	Regulation, formulation and monitoring of policies, planning and government action in matters of home affairs, including the political relations between central government and the other agencies of public administration.
Federation of Small Fishermen and NGOs	Promotion of citizen participation.

There are gaps in the coverage of the territory's environmental education programme; a "Programme for promoting awareness of the need for restoring the waters quality in the Gulf of Cariaco" is planned, with the aim of motivating the resident and transient population to cooperate in activities aimed at progressive environmental restoration and sustainable use of a gulf damaged by the discharge of domestic and industrial wastewater, and reducing the exhaustion of the fish stocks.

The justification for the programme rests on the results of studies by various institutions showing that the waters are being increasingly affected by the various forms of domestic and industrial wastewater they receive without adequate -or in some cases any- treatment. The spread of population along the coastline has provoked further deterioration, with knock-on effects on fish stocks which, according to the local fishing communities themselves, have declined in recent years.

Gulf of Cariaco is a primary focus of various species that contribute to the state of Sucre's main source of income -fishing in general and sardines in particular-, while at the same time another

potential source is being eroded, that based on recreational and tourist activity in the area, threatened by the gradual loss of beaches and seaside resorts.

The project's planned activities include:

- Staging workshops and meetings with those involved, to coordinate, define responsibilities and determine the priority tasks for restoring the quality of the gulf's waters.
- Designing an action plan for restoring the quality of the gulf's waters.
- Entering into a formal agreement with the parties involved, for implementation of the restoration plan.
- Designing strategies for wide-ranging communication at company, institution and community level, aimed at securing commitment by the parties to implementation of the project, such that they identify fully with its aims and scope and adopt proactive roles.
- Holding inter-institutional environmental-awareness workshops in the fishing communities, aimed at ensuring the effectiveness of the proposed sector solutions to the problems identified. Sustainable use will be a theme of these workshops.
- Staging environmental-awareness workshops for entrepreneurs (including small businessmen) in the fishing and tourism sectors, to promote sustainable use of resources along the coastal strip of the gulf.
- Monitoring and progressing implementation of the project, to measure the degree of acceptance and assimilation of the programme at the various levels.

The beneficiaries of the education programme include all the communities on the gulf's southern coastal strip. The institutions involved are the Ministry of the Environment & Natural Resources (Sucre State); Mayors' offices; Governance (Fundambiente); INIA; the Harbourmaster's Office; INAPESCA; Ministry of Education, Culture & Sport and Venezuela's East University-Oceanography Institute.

The activities proposed for inclusion in a future GEF CReW project are:

- i. Current sanitation infrastructure rehabilitation.
- ii. Completion of the sanitation coverage, based on septic tanks.
- iii. Monitoring in the drainage basin and the Gulf of Cariaco.
- iv. Programmes to promote public awareness.

II.6. Guyana

Guyana has a population of some 746,000, of which over 50% (some 400,000 inhabitants) live in the Demerara river basin, which flows into the Caribbean. About one-third live in Georgetown (population 250,000), which is the country's commercial capital, home to most of the retail banks, insurance companies, headquarters offices, government agencies and the retail trade, as well as the

university, schools, hospitals and other healthcare establishments. Linden (population 35,000) is the country's second most populous town.

90% of Guyana's industry is based in the Demerara basin. Sectors include food, beverages, tobacco, paint, footwear, clothing, furniture and pharmaceuticals. The tourist trade is largely concentrated here too, in the country's main resorts (Arrowpoint, Timberhead, Splashmins, Emerald Tower and Takama), as well as guest houses and smaller vacation spots mostly associated with eco-tourism.

Some 80% of the visitors stay in the river basin area, mostly in establishments with an average of some 80 rooms, while the larger hotels have 150-200 rooms. Guyana Power & Light (GPL) has generating facilities with a capacity of around 73,000 MW, at power stations in Garden of Eden (East Bank Demerara), Versailles (West Bank Demerara) and Kingston, Georgetown. The hospital sector is, also, an important employment source in the area. Guyana's main ports and moorings are on the banks of the Demerara River or in areas adjacent to the river in Georgetown, where most of the country's maritime traffic is concentrated and it is the preferred location for the urban and industrial growing development.

In 2006, the government hired SENES Consultants Limited to design and implement a public awareness programme and to compile a report on the state of the environment (SOE). A key task was to launch a programme for monitoring the water quality in the Demerara River: 15 indicators were measured over 20 days along the river from Yaraibo, upstream (fresh water) in Linden, to the dikes on the estuarine part of the Demerara River.

The results included very low (average 4.5) freshwater pH levels, while those in the brackish waters averaged 6.2, reflecting admixture with more neutral (8 units) oceanic waters. The results from various indicators also enabled identification of the point, downstream from Gales, where the saline environment begins.

The level of dissolved oxygen, along the length of the river, averaged 5 mg per litre. Temperature readings included 26 °C in Yaraibo (upstream) and a maximum of 30 °C in the vicinity of Harbour Bridge (downstream), reflecting the higher, slightly cooler area where the river rises, than in the lower, warmer land downstream.

Relatively high concentrations (0.2 mg per litre) of nitrites were found in the fresh water. Also, rather high for aquatic life were the concentrations of ammonia: averages of 0.4 and 0.2 mg per litre in fresh and brackish water respectively, and higher values in areas affected by the Omai bauxite mine, the region between Clemwood and Dora downstream and the stations near livestock, pig and poultry farms, caused by runoff (mining, farm and urban-industrial).

The domestic wastewater flow discharged is some 0.48 cubic meter per second. Sanitation coverage through sewer system amounts to 5.7%, 34.4% by septic tanks and 57.9% by latrines. Some 16% of

domestic wastewater receives some treatment degree by way of a small submarine outfalls installed in 1985 which discharges at the Demerara River mouth (Figure 12).



Figure 12. Submarine outfalls at Demerara River mouth

Recommendations arising from the programme include: monitoring every five years in both the wet and less-rainy seasons; inclusion of the sediment matrix (more conserving) and the bottom-dwelling fauna and flora; stepping up logistic and financial support for the detection of heavy metals, inorganic material and faecal coliform content; taking account of tide levels when obtaining samples; reducing the stations number and adding new stations upriver near Yraribo's old bauxite mines; applying the monitoring to other rivers with similar characteristics; and extending monitoring to land-based sources and activities, for the purposes of assessing urban/industrial effluent and the spill impact (using physical, chemical and biological indicators).

The current legal framework provides no clear guidance on the improvements needed in the sanitation sector. The main items of environmental legislation are public-health law and the Water and Sewerage Act. Other laws and regulations significantly affecting the sanitation and hygiene sector include:

- Town & Country Planning (ref. Cap. 20:01).
- Code of practice for the design and construction of septic tanks and associated secondary treatment and disposal systems.
- Water-quality regulations as part of environmental protection (2000).
- Standards for industrial effluent discharge.
- The public health legislation.
- Environmental Protection Act (1996).
- Municipal & District Councils legislation (ref. Cap. 28:01).
- Municipal authority by-laws.
- Act No. 11 of 1984, Guyana National Bureau of Standards

Sanitation services are regulated by the Water and Sewerage Act (2002). All activities relating to sewerage and sewage, including collection and treatment, are the responsibility of Guyana Water Inc. (GWI), which was set up to provide the public water supply at national level, although its scope for sewerage-system operating and maintenance is restricted to Georgetown (which is the only major system of the kind in the country).

GWI's Operator's Licence gives it the exclusive right to sewage collect and treat in Georgetown and service profit, although other operators are allowed to provide septic-tank services (sludge removal, treatment and final disposal). The licence does not cover GWI sanitation services elsewhere in Guyana.

The national plan for the sanitation sector identifies an urgent need for clear division of responsibilities among various institutions involved in sanitation and cleansing services. Their organizations are fragmented and their directives in the sanitation sector are ineffective. Also, the lack of a chief to manage the sector makes securing funds for its improvement and sustainability difficult. The results of this policy are:

- A national strategy lacking coherence as regards the most appropriate sanitation types and technologies for the sector.
- Lack of accountability for failures in the sanitation sector.
- Erroneous distribution of funding for the various activities.
- Neglect of the environmental and hygiene programmes and education.

Problems associated with the domestic wastewater management include:

- Insufficient funding for maintaining and expanding the current sewerage system.
- Insufficient sanitation coverage for upstream coastal population.
- Lack of funds on the part of residents to pay for sanitation services and the septic tanks installation.
- Limited preventive maintenance on the sanitation networks and installations.
- Poor training of personnel and an exodus of sector professionals.
- An antiquated system of sanitation-sector tariffs and penalties.
- Cultural barriers to the preferential use of sanitation systems between sewerage, cesspits, diffusing wells and septic tanks.
- Lack of cooperation and coordination between the various agencies and ministries in dealing with environmental issues.
- Inadequate environmental awareness at all levels, impeding the effective use of the current environmental powers under the policy, plans and programmes.

The activities proposed for inclusion in a future GEF CReW project are:

- i. Development of a sanitation master plan for Georgetown, to include management of effluent and sludge and rehabilitation of the canals.
- ii. Complete rehabilitation of the existing sanitation infrastructure.
- iii. Completion of sanitation coverage with the installation of septic tanks.
- iv. Sanitation sector training programmes.
- v. Civil awareness programmes.
- vi. Classification of the coastal waters (Class I or Class II), according to the LBS Protocol.

II.7. Suriname

Suriname is a very small country. 80% Suriname' territory is covered by the Amazon Rain Forest, hence its nickname "the green country" or the greenest country in the world. Its small population (some 500,000) is concentrated along a 30-km coastal strip, confined by the dense forest spreading from the inland.

Paramaribo on the banks of the Surinam River is the capital and the country's largest town (Figure 13). It is the main seaport and industrial and commercial centre, the focus of distribution of bauxite, aluminium, timber, rice, sugarcane, citrus fruit and processed food. It covers a total area of 183 square km and has a population of 242,946. The old town is listed as a UNESCO World Heritage site. Small-scale agriculture, livestock farming and fishing are carried on to the north.



Figure 13. Surinam River mouth, near Paramaribo City

Paramaribo has serious problems as regards natural drainage, resulting from the town's expansion. Watercourses have been diverted to reclaim land for construction projects and road-building. Farmland has been converted to residential use. Canals have been dredged and replaced by pipelines with lesser throughput capacity.

The town's domestic wastewater is discharged with minimal treatment into the Surinam River and the Saramacca Canal, by means of floodgates and pumping stations. A pumping station sends the

effluent from part of northern Paramaribo directly into the sea. Residents often dump solid waste into the drainage channels, severely obstructing the system and giving rise to local bacterial concentration, bad odours and alterations to flow in the channels, and eutrophication, creating an anti-hygienic situation (that is aggravated by rainfall).

The domestic wastewater flow discharged in the coastal area is some 0.7 cubic meter per second. Sanitation coverage based on septic tanks covers 86% of the population, while 8% is by latrines whose effluents pass into the sewerage networks or open ditches that drain into the Surinam River. The sewerage networks do not function as an integral system, due to:

- There is no public domestic-wastewater collection system serving the homes and offices etc, in the urban sector. Effluent from dwellings makes its way to the lower areas where it flows into the central branch of the sewerage system or open ditches.
- Its construction is defective, it follows the wrong path, the elevations are incorrect; liquid cannot flow properly.
- It is too small and antiquated to carry or discharge the domestic wastewater; many areas get flooded in the rainy season.
- Obstruction results from the discarding of plastic cups and other refuse and loss of the covers of the channels.
- Hydrocarbons and other substances are poured into the sewers.
- They are not taken into account in the partitioning of land.

The septic tank is emptied (sludge removal) by municipal sewage tankers, which dump their loads in the Surinam River at Ornamibo, a site designated by the government. Occasionally, when the road to the site is in a bad state, the sludge is dumped into ditches in the vicinity, creating a deplorable situation for people and for the environment.

There is an oxidation pond at the Santo Boma prison in Wanica for disposal domestic wastewater and treatment, with a retention period of 90 days. Following chlorination, the effluent is discharged into open water. Lack of planned maintenance affects the pond operation.

There are five ministries involved in the sanitation sector:

- *Ministry of Public Works:* Responsible for sewerage and collection sewage and disposal at national level. Responsibility for sewerage management and effluent disposal is shared between the ministry's Drainage & Sewers Division and the public health authority's Environmental Control Division. Also, included is responsibility for national hydrological matters, including the water cycle and water quality measurement (carried out by the Water Research Division). Supervises the sewerage system maintenance and drainage channels, including the pumping stations and floodgates.

- *Ministry of Public Health*; Responsible for environmental health matters and public health in the widest sense, plus supervision. Addresses promotion of public health in particular, including extending healthy life, and education.
- *Ministry of Agriculture, Stockbreeding & Fishing*: Tasked with conservation of water resources in farming areas (irrigation channels).
- *Ministry of Employment, Technology, Development & the Environment*: Responsible for protecting the marine waters from land-based sources of pollution and polluting activities.
- *Ministry of Regional Development*.

The legal and institutional framework is not structured effectively, at either local or national level, for dealing with the most urgent problems in the sanitation sector. The only legislation in force is out of date and in most cases inapplicable to rural areas, having been framed for the urban sector. It suffers from the following limitations:

- Domestic wastewater management is not a political priority.
- Penalties are very low, while wastewater management is never taken into account in considering permit applications by companies.
- Sanitation-sector offences and penalties are not properly spelled out in the legislation.
- The legislation does not properly address illegal practices in the sanitation sector.
- Lack of rules and methodologies for wastewater management.

The following legislation is in place, however:

- Penal law
- Criminal law
- Construction law
- Refuse disposal law
- Law on ankylostomiasis; disease caused by an intestinal parasite (an *Ankylostomum* nematode) marked by gastrointestinal disturbances and anaemia.

There are grey areas concerning the disposal of excreta, regulations for private individuals, dumping, applications and quality requirements for construction projects. The legislative framework for the health sector needs bringing up to date. Water-supply and sanitation planning may be improved when there is intelligent planning of land use. The key requirements for the management of domestic wastewater are:

- *Greater technical capacity*; the personnel involved are not sufficiently motivated -too poorly paid- to train properly in effluent management and sanitation.

- *Public awareness/information*; there is too little awareness among the Paramaribo townspeople of environmental pollution and its effects on public health, caused by inadequate wastewater management and inappropriate sanitation sector operations.
- *Funding*; the institutions associated with the sector lack the funds needed to acquire equipment and supplies required to ensure the system's sustainability.
- *Legislation*; there is a lack of clear legislation, with a regulatory approach, to cover the activities. Without appropriate legislation, there are no mechanisms for regulating the sanitation sector. Lack of company registration results in difficulties over enforcing fines and other penalties in the sector.
- *Ageing and inadequate sanitation infrastructure*: the current sanitation infrastructure does not support effective domestic wastewater management.

The activities proposed for inclusion in a future GEF CReW project are:

- i. Rehabilitation of the urban sewers and their connection to dwellings and public- and private-sector establishments.
- ii. Construction of a pluvial water drainage system.
- iii. Compilation of a sanitation master plan for Greater Paramaribo and creation of a Drainage Authority.
- iv. Development of alternative treatment local systems for tourist areas of Paramaribo and in the sewage-collection areas, to prevent pollution of waters used for recreation and of underground water.
- v. Development of an effluent-management plan for hospitals, hotels and other tourist installations.
- vi. Design and construction of stabilization ponds for treated sludge from the septic tanks and latrines.
- vii. Improvement in sanitation services in the coastal towns of Nieuw Amsterdam, Meerzorg, Groningen and Domburg.

III. BASIS FOR PLANNING & DESIGN IN DOMESTIC WASTEWATER MANAGEMENT IN WCR

Starting from the collection, interpretation and validation of the countries information the sewage discharge into hot spots were evaluated. These results are associated to the upstream coastal population's size and the sanitation coverage, as well as to the levels and specificity of the domestic wastewater treatment.

The sewage inflow discharges into the sea was evaluated starting contribution per capita of drinkable water in each country and the upstream coastal population's size. It was considered a return coefficient to the sewer system of 0.8 and the sewerage coverage percentage in each watersheds inflow; the population remainder without sewerage coverage and with/without solutions

improved in situ it was considered a 0.5 return coefficient lower. The sum of both flows is the sewage inflow into the sea.

A plan for domestic wastewater management in the watersheds inflows to hot spots encloses the following aspects:

- The upstream coastal population's size and the sewage inflow discharged in the hot spots.
- The type, percent and specificity of the current sanitation coverage and treatment.
- The legal and institutional framework, coupled with the relevant environmental-education programmes.
- The desired level of sanitation coverage following rehabilitation of the current sanitation infrastructure and completion of sanitation coverage with improved on-site household systems that have proved effective in WCR.

In sanitation coverage in WCR, several critical elements which have not been resolved have been identified, in particular ⁶:

- The economic development in WCR countries.
- The lack of government support for the sanitation sector.
- Inadequate knowledge of sanitation among the population.
- The need to change existing methods and funding criteria for treatment plants.
- Inadequate environmental policies in the sector.
- Institutional weaknesses.
- The need to formulate technological and engineering standards appropriate for domestic wastewater treatment in developing countries.

As regards to sewerage systems, extending sanitation coverage in sewerage systems includes expanding the infrastructure, networks and treatment facilities, because in many cities in the region, gradual population growth leads to obsolete sewerage systems which are unable to handle the growing volume of domestic wastewaters. However, work on the expansion and rehabilitation of the sewerage systems in developing countries is subject to the availability of financial resources and of operational capacity for its planning and execution, not to mention environmental awareness, while the region's countries still suffer serious deficiencies in their capacity to operate and maintain the plant and equipment comprising their sewerage systems, resulting in blockages, overflowing and pumping-station breakdowns. Also, a large number of effluent treatment plants are either idle or working below capacity.

III.1. Sanitation coverage

In September, 2000, 191 nations approved the UN Millennium Declaration, which has defined the issues linked with peace, security and development, including areas like the environment, human

rights and government's form central concerns for the human development. As consequence, the Millennium Development Goals Declaration was established to express humanity's priorities around the imperious necessity of joining efforts to assist these topics.

Inside the objective of "Ensure Environmental Sustainability", they have incorporated the goals of reducing in 50% between 1990 and 2015 of the number of people that don't have access to drinkable sure water and the reduction of 50% between 1990 and 2015 of the number of people that don't have access to sanitation services. Also, as a result of the option of incorporating objectives that can be pertinent for the region and to incorporate the goal of having achieved for the year 2020 a considerable improvement in the lives of, at least, 100 million inhabitants of marginal neighborhoods it is incorporated like complementary goal for the year 2015, the reduction to 50% of the inhabitants that don't have access to treatment systems or final disposition of wastewater ⁶.

Figure 14 depicts the upstream coastal population of hot spots in the countries included in the study. The larger population are in the Gulf of Paria (Trinidad & Tobago), Cartagena Bay (Colombia), Gulf of Cariaco (Venezuela) and Kingston Harbour (Jamaica), with some 1 million inhabitants. The smallest is Bluefields Bay (Nicaragua) with some 42,000 inhabitants. Total upstream coastal population is some 4'335,000.

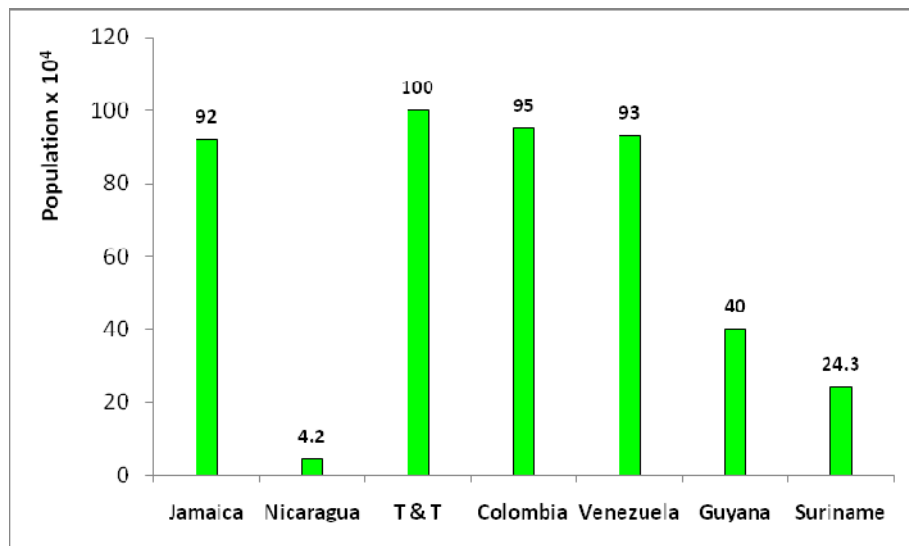


Figure 14. Upstream coastal population into WCR hot spots

Figure 15 depicts the domestic wastewater flow discharged into the sea. Gulf of Paria, Cartagena Bay, Gulf of Cariaco and Kingston Harbour show the larger domestic wastewater flows, according to their larger populations, with some 1 m³.sec⁻¹. Lesser rates are observed in Bluefields Bay (0.38 m³.sec⁻¹) and the upstream coastal population of Georgetown (0.48 m³.sec⁻¹). The total flow discharged into WCR is some 5.73 m³.sec⁻¹.

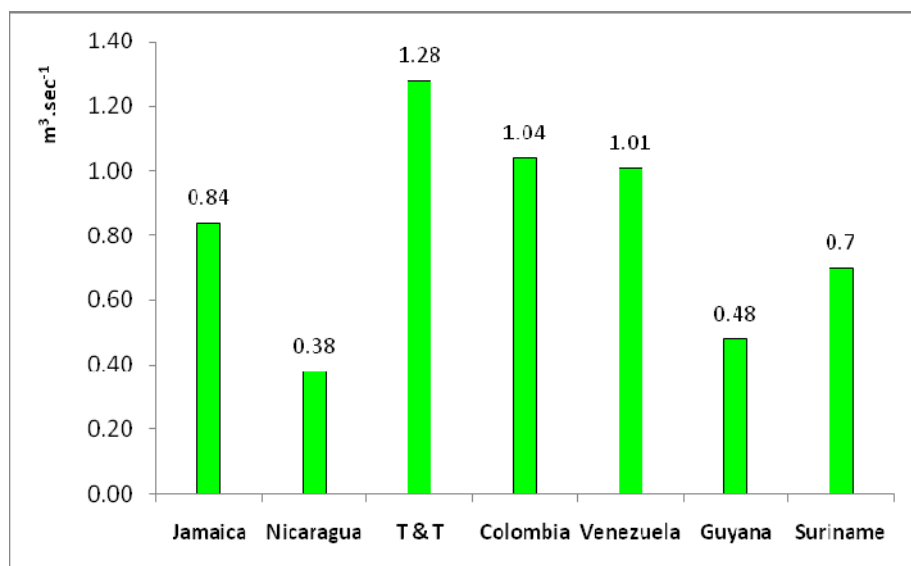


Figure 15. Domestic wastewater flow discharges into WCR hot spots

Figure 16 shows the sanitation coverage in the watersheds inflows. The predominance of septic tanks is apparent, followed by latrines those adequately separate human excrete, and the sewerage system. Jamaica and Trinidad & Tobago show the highest sanitation coverage (some 100%) whilst the lowest (54.5%) applies in Nicaragua, reflecting the large number of public latrines that do not adequately separate human excreta.

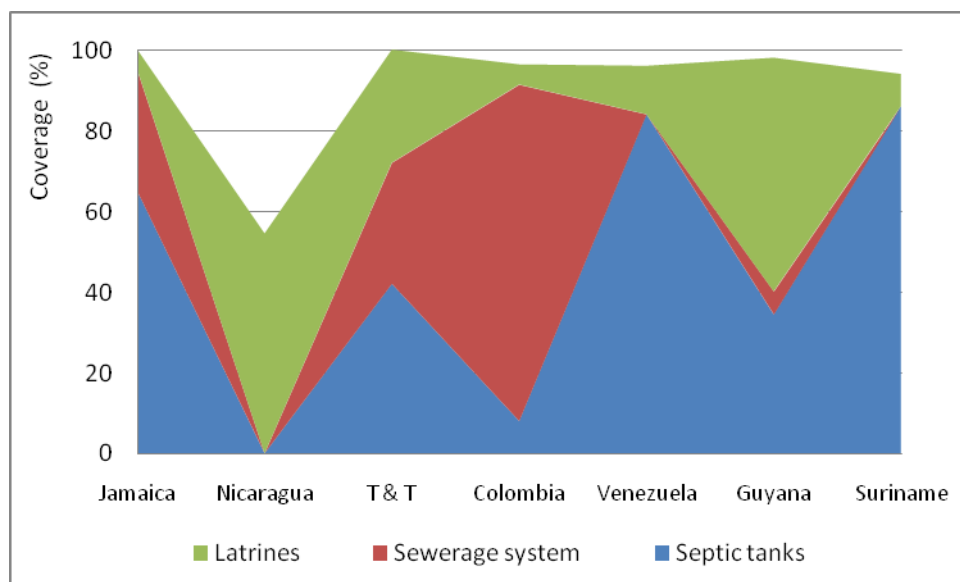


Figure 16. Sanitation coverage in watersheds inflows into WCR hot spots

Figure 17 shows the percentage of sewer system effluents with some treatment degree.

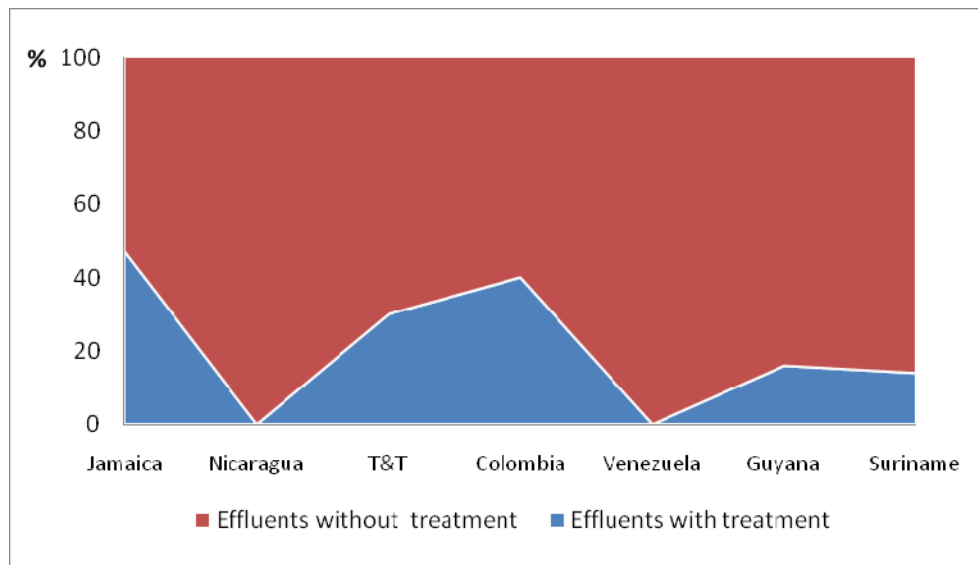


Figure 17. Percentage of sewage subjected to some treatment degree

In general, this is very low, with the exception of Jamaica (47%, based on treatment plants), Colombia (40%, taking account of sewage discharges by means of submarine outfalls), and Trinidad & Tobago (30% based on treatment plants). Hot spots belonging to Nicaragua and Venezuela are those marked by the lowest percentages.

Many countries in WCR are making efforts to apply the least complex and most cost effective technologies for the sewage treatment such as stabilization ponds, up-flow anaerobic reactors and submarine outfalls, as well as appropriate low-cost technologies. Nonetheless, it is a common practice in the region's coastal towns to discharge domestic wastewater (treated or otherwise) into the nearest or most convenient body of water, largely because of lack of funds, but in some cases through indifference to the damage this causes to the environment and to public health.

Submarine outfall may be an appropriate technology and relatively economical with very low operation and maintenance costs, and can be used for final disposal of sewage, when the dynamic characteristics of the receiving waters facilitate the dilution process and when they are combined with mili-screens. Submarine outfall effluents can reach dilutions immediate initials of the order from 100 at 1 in consistent form during the first minutes of discharge, what reduces the concentration of organic matter and other nutrients at levels that they would not have ecological adverse effects in the open sea.

Should wastewater re-use not be possible, the option of the submarine outfall is a disposal method more attractive than conventional urban treatment plants which discharge to the nearby coast in terms of reliability, efficiency, cost and low operational and maintenance requirements⁷.

Nevertheless, sewage discharges by means of submarine outfalls close to human contact recreational use areas or natural and sensitive biological communities such as coral reefs, marine feeding grounds, fishing areas, and shellfish populations should be avoided. Then, they need a permanent monitoring to determine any potential impacts from continued nutrient enrichment through submarine outfalls. On the contrary, its discharge to the sea usually faulty in nutrients could probably be beneficial in many areas of WCR. Also, submarine outfalls reduce the space competition because of the continuous expansion of the urban radio.

In addition to consideration of Class I and Class II waters under the LBS Protocol, the submarine outfall option must be assessed in terms of local needs and potential environmental impacts in the area of study.

The appropriate low-cost technologies that can be used for WCR, according to the characteristics of the place, are associated to the wastewater collection and transfer. The recommended technologies are ⁸:

- *Conventional sewerage*; where sewage is collected by an underground pipe system to treatment facilities.
- *Small bore (settled) sewerage*; in principle, the design of the settled system is the same as conventional system. However, before the sewage enters a septic tank where most settleable solid are removed, thus only the liquid effluent is reticulated.
- *Cluster system*; is a common collection and disposal system grouping several houses or trade. It is used to collected sewage from areas with significantly varying housing densities.
- *Cistern-flush toilet*; use large amounts of water. The toilet bowl consists of a siphon which provides a water seal against bad odors from the effluent. Provide the highest level of convenience and have a very clean and hygienic appearance.
- *Pit latrine*; it is design for the on-site disposal of human excreta. It consists of a concrete squatting plate or riser, which is placed over an earthen pit. It can be used with good results in rural areas.
- *VIP latrine*; the ventilated improved pit (VIT) is design for the on-site disposal of human excreta. VIP latrines do not need water for flushing. They rely on soil absorption and they are simple to construct.
- *Septic tank*; it is design for the on-site treatment of sewage. The tank is usually located underground and consists of two compartments allowing for one to three days of hydraulic retention. Septic tanks must be connected to a flush toilet therefore they are not suitable where water supply is scarce or unreliable.
- *Biogas-Bio fertilizer plant*; it is a concrete plant used for the anaerobic degradation of organic waste and agro-industrial waste and wastewater to produce biogas and biofertilizer. However, it does not work well with human excreta alone.

- *Sanitary bio-latrine unit (SBU)*; they are installed where the bio digester plants have been built to collect the waste from a VIP latrine. Effluents require tertiary treatment.
- *Portable chemical toilets*; it is a small toilet room built over a watertight waste holding tank. They are often used at many events where large numbers of people congregate and difficult access places or far-away for collection systems and sewage transfer.
- *Wetland filtration wastewater disposal systems*; they can be used in rural areas and small communities for the sewage treatment. Wetland gives sub-products and aggregate values by means of effluent re-use that can minimize the installation costs. Likewise, they reduce the biochemical oxygen demand, suspended solids, nitrogen and phosphorus at so low levels that they don't cause eutrophication process in the coastal waters and they can be considered as a tertiary treatment.

For the majority of the countries in the region, the basic problem as regards sanitation has been lack of cost recovery and shortage of funds for capital investment and, principally, to meet the operating costs. But, improvements in sanitation services cannot await better economic times for the territory; the situation demands progressive amelioration, in stages, in ways that safeguard the health of the population and the environment.

Another factor is the selection of technologies whose application is feasible in WCR. If attempts are made from the outset to employ everywhere the criteria and technologies of the industrialized world, the universal coverage needed (and set as a UN Millennium Development Goals) will not be achieved as quickly as the circumstances demand ⁹. In WCR, serious domestic-wastewater disposal problem can only be solved by means of appropriate low-cost technologies.

III.2. Legal and institutional framework

The countries studied need a legal and institutional framework that ensures maximum efficiency and effectiveness among their sanitation services, including regulations for effluent discharge consistent with Annex III of the Protocol Concerning to the Pollution from Land-Based Sources and Activities, known as LBS Protocol of the Cartagena Convention ¹⁰ and the legal politics on wastewater management, with special attention to the regulations concerning the environmental management of sustainable population growth in urban and coastal areas. Other requirements include prior experience in the field of information technology applied to promoting public awareness, such as environmental information systems, public information campaigns and urban culture.

Baseline analysis relating to the legal and institutional framework in the hot spots in the countries involved reveals an insufficient structure of institutions and legislation addressing marine/coastal planning and management, including the roles and responsibilities of the agencies responsible for promoting efficient, sustainable sanitation services.

The most urgently-required measures relate to the developing capacities for coordination, management, planning and implementation among the relevant institutions; making the various sectors and parties involved in environmental management work together effectively, including development of participative methodologies aimed at a design which the social agencies and community groups. Other measures take in the improving communication and coordination between the various local and national agencies, introducing an environmental information system that covers hot spots and the watersheds inflow and facilitates updating of information needed for decision-making, and staging public wellbeing or citizen-awareness campaigns targeting the sectors and parties involved, especially at community level.

The basic method to be employed is that of “focus groups”, combined with other modelling techniques together with a participative design, this is the preferred approach for developing a comprehensive inter-institutional management plan for the hot spots and their watersheds inflow. The plan should be based on key criteria for coastal and urban-development planning, updating and completion of the relevant legislation, strengthening of the local institutions concerned, among other sector-specific, environmental, territorial and participative aspects of management at local level, aimed at progressive improvement of environmental quality and the life quality of the population.

III.3. Environmental education

According to Agenda 21, education is vital in promoting sustainable development and increasing the capacity of communities to deal with environmental and development issues. It is a constant process in which individuals and communities are sensitized to their environment and acquire the skills, knowledge, values, experience and determination to act individually and collectively in resolving present and future environmental problems ¹¹.

Environmental education targets the community and the interest of the individual in an active process designed to solve problems that arise in the context of specific situations, encouraging initiative, responsibility and hope for a better tomorrow.

It should also address the problem of sanitation services from a comprehensive viewpoint that recognizes the needs of the settlements affected, and integration and interaction with their environment. This will facilitate finding solutions for the main problems in the hot-spot drainage basins and focus the attention of communities on the continuous improvement of basic sanitation services and on capacity-building within the community based on specific measures in the field of environmental education, and highlight the importance of safeguarding natural resources.

In general, public awareness of environmental matters is insufficient in the coastal drainage basins of the countries involved, and is accompanied by a lack of environmental education programmes. The measures needed should cover environmental problems diagnosis, participative methods involving all the main parties, strengthening of the traditional and cultural values of the ecosystem

from the environmental viewpoint, and assessment of the influence of social, political, cultural and economic factors on the environmental conditions in the hot spots and the watersheds inflow.

The system is based on an environmental education strategy for the coastal communities involving actions that are ordered, planned, carried out and controlled with a view to improving the performance of the parties involved, to be implemented in five stages whose final goal is a community environmental education plan.

The stages of the environmental education strategy include sensitization of the community and the main parties, diagnosis of the environmental problems, planning of the tasks, performance of these, and verification and assessment of the results (Figure 18).

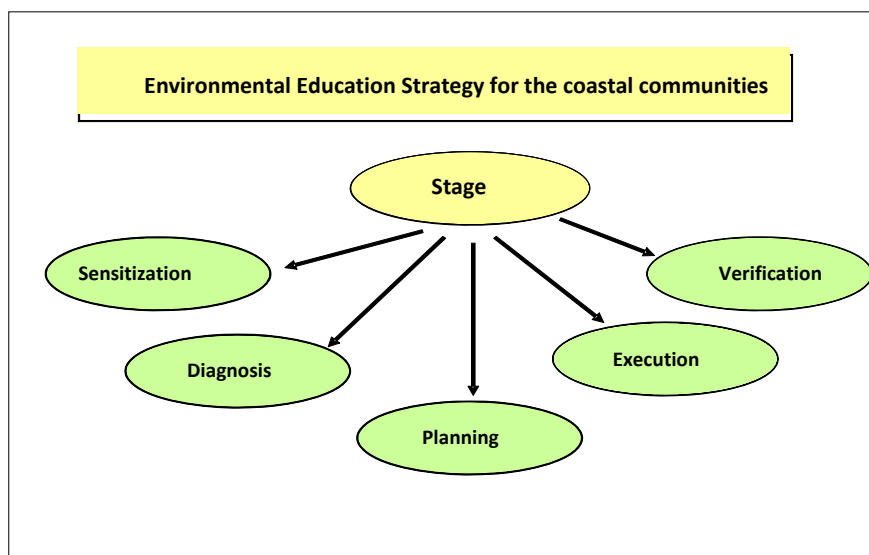


Figure 18. Environmental education strategy for coastal communities

CONCLUSIONS

- The hot spots studied are of considerable socio-economic importance to the countries concerned, and can be considered suitable subjects for the application of a GEF CReW project addressing domestic-wastewater management.
- Baseline analysis for the wastewater management in WCR shows current insufficient policy and laws for the sanitation sector and its limited execution, insufficient collaboration and communication among the involved agencies, limited awareness, knowledge and understanding of the appropriate treatment alternatives and limited technical capacities for its management.

- In the ecosystems studied, septic tanks were the most common feature, followed by latrines and conventional sewerage. Sanitation coverage is generally over 50% of upstream coastal population, while less than 50% of sewage is subjected to some treatment degree.
- Combined with environmental education programs, the establishment and operation of a legal and institutional framework for the sanitation sector is vital to promoting sustainable development and to increasing the capacity of the upstream coastal populations to approach the environmental problems and development appropriately.

RECOMMENDATIONS

- Sanitation infrastructure rehabilitation is recommended in the involved countries, to promote the use of appropriate low cost technologies, to promote the qualification and the consultancies, and the sanitation coverage completion, with home-made local systems improved in those places with difficult access to sewerage.
- To develop a legal and institutional appropriate mark for the domestic wastewater management and
- To develop environmental education programs as a critical factor to promote the sustainable development and to increase the capacity of the inflow coastal populations to approach environmental questions and of development.
- To promote the ratification of LBS Protocol by the countries forming parties of the Cartagena Convention, due to the importance of this juridical instrument for working in the decrease of polluting loads that inputs to the WCR, coming from activities and land-based sources of marine pollution.

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