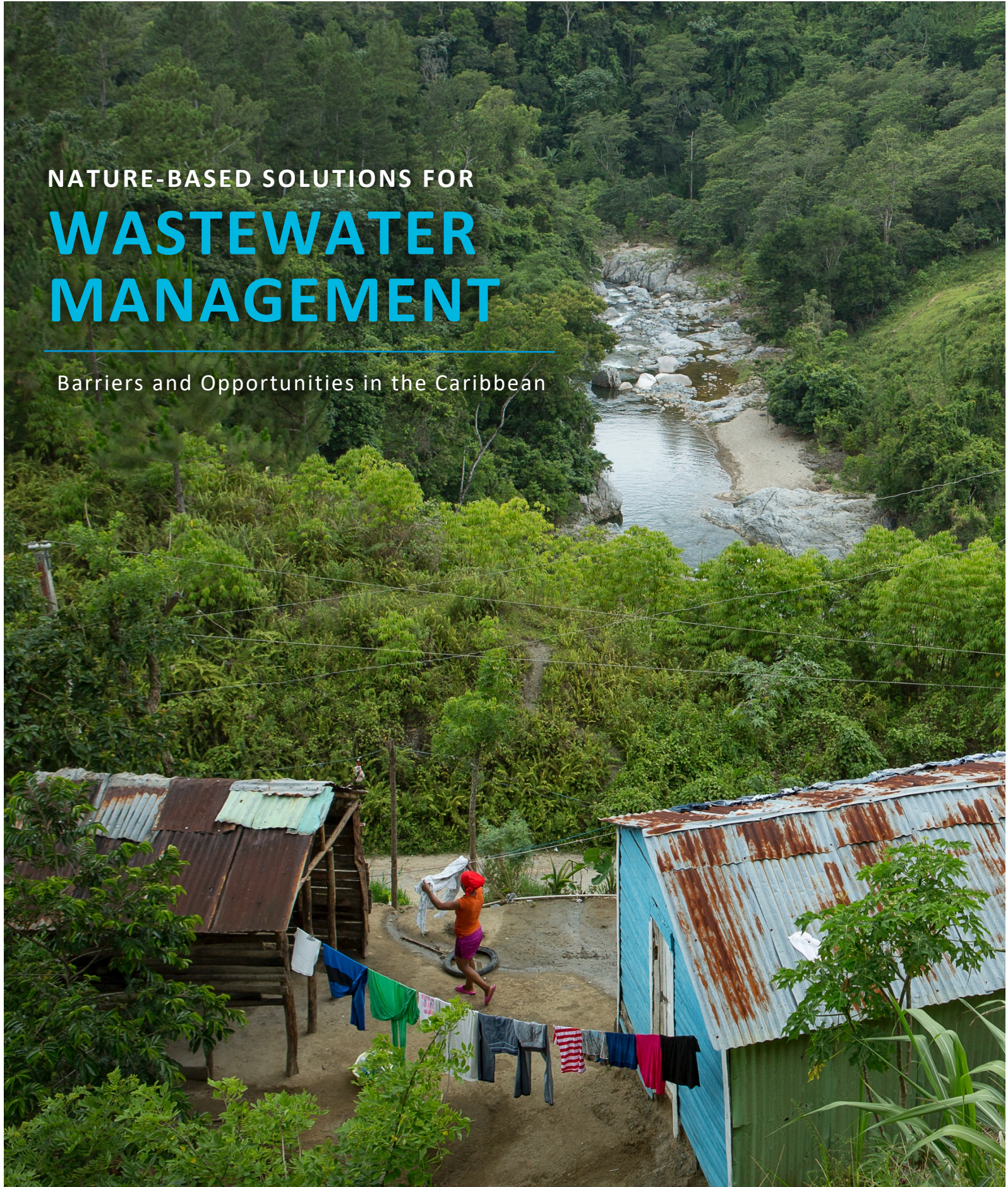


NATURE-BASED SOLUTIONS FOR WASTEWATER MANAGEMENT

Barriers and Opportunities in the Caribbean



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Front page photo credit: Tim Calver – *A view from Rafael A. Jeromo's plantation, near Santana, Dominican Republic*



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NATURE-BASED SOLUTIONS FOR WASTEWATER MANAGEMENT: BARRIERS AND OPPORTUNITIES IN THE CARIBBEAN

INTRODUCTION

Wastewater pollution is a serious problem in the Caribbean. The Nature Conservancy (TNC) is assessing wastewater management in four island nations—the Dominican Republic, Haiti, Jamaica, and Grenada—to understand the barriers and opportunities for addressing this issue. The assessment focuses on scientific/technological approaches; policy, legal, and institutional frameworks; and stakeholder engagement. This assessment will also determine the best role that TNC can play to support the prevention and reduction of pollution from untreated or inadequately treated wastewater discharges in order to sustain the region’s remarkable biodiversity and to ensure human well-being. The overall analysis will be completed by June 2021.

Through support from the United Nations Environment Programme Cartagena Convention Secretariat, TNC has taken on separate, but complementary, research on how nature-based solutions (NBS) can be used to treat wastewater in the region. As a point of reference, the Land-Based Sources of Marine Pollution and Specially Protected Areas and Wildlife (LBS and SPAW) Protocols of the Cartagena Convention provide a regional legal framework for addressing the issue of wastewater management in an integrated manner including through the use of NBS. The research in this report complements the LBS and SPAW protocols by focusing on the aforementioned countries and includes an analysis of existing research and interviews with subject-matter experts in the region.

Our research found that the use of NBS to treat wastewater is limited in the region, but there are indications that the opportunity for increasing use of wastewater-focused NBS projects could be significant. For example, in the Dominican Republic, the use of constructed wetlands are a key tool for watershed management and wastewater management in and around the city of Santiago. And in Jamaica, reed beds, another type of constructed wetland for treating wastewater, are being used more widely.

The need for wastewater treatment is profound in the region, but there are common threads that hinder both traditional built infrastructure solutions and NBS from being implemented successfully to address wastewater treatment needs. Without the proper planning and design, stakeholder involvement, government policies and regulatory structures, operations and maintenance, and adequate public financing, the biodiversity and human health of the region will remain at risk no matter what types of wastewater solutions are promoted.

This analysis attempts to focus on findings specific to NBS as a wastewater treatment approach from more engineered or “grey” solutions. It is difficult, however, to separate these projects

from the overarching geopolitical and socioeconomic barriers to improving wastewater management in the region. The analysis also includes an overview of the perceived and actual barriers to wastewater management improvements, for both NBS and grey infrastructure development. Overall, a comprehensive systems-thinking approach to wastewater management in the Caribbean is needed in order to realize the full potential of NBS to address wastewater management.

Across the Caribbean, from island nations to those along the Latin American mainland, nature-based solutions are increasingly part of the toolkit for addressing a range of important challenges, including pollution, conserving biodiversity, safeguarding human health, and reducing vulnerability to climate change impacts. Projects that enhance coastal storm protection, improve water quality, and treat wastewater are growing in popularity.

The Global Environment Facility-funded CReW+ project is implementing small scale solutions for the improved management of water and wastewater that can be upscaled and replicated. The project plans to significantly reduce the negative impact of untreated wastewater on the environment and people of the wider Caribbean region. Participating countries will receive support to implement practical solutions to the problems of improper wastewater management and poor sanitation at the local community levels including through the use of NBS. Furthermore, TNC is deeply involved in expanding the awareness of and application of NBS in the Caribbean, and we currently are designing projects to improve wastewater treatment either directly due to NBS or as a co-benefit of NBS installations.

NBS solutions to wastewater management represent an opportunity to take a holistic “Source to Sea” approach to conservation programs. The way water is managed and used on the land, and especially as it is intercepted and used in cities and towns, affects the health of rivers, estuaries, bays, reefs, and fisheries. Thus it is critically important to manage against changes in both quantity and, especially, the quality of water that flows through the landscape to protect both biodiversity and human health.

DOMINICAN REPUBLIC

Ecological and Social Context

The island of Hispaniola (also called Quisqueya) is the second largest island in the Caribbean and encompasses both the Republic of Haiti and the Dominican Republic. The latter, with a population of roughly 10.62 million,¹ has most of its critical infrastructure located close to the coast. Major economic activities include tourism, mining, construction, manufacturing and agriculture. The Dominican Republic has a wide variety of ecosystems (from high-mountains to

¹ National Statistic Office (ONE) Population Projection data 2000-2030, <https://www.one.gob.do/demograficas/proyecciones-de-poblacion>

semi-arid) including the whole range of coastal and marine ecosystems (mangrove forests, coral reefs, beaches, seagrass beds, etc.) and finally, lakes and lagoons.

In the Dominican Republic, most of potable water supply and sewer collection and disposal services (26 provinces out of 32) fall under the responsibility of the National Institute of Potable Water Supply and Sewerage Service (INAPA) while in the larger cities, it is managed by autonomous parastatal corporations known as *Corporaciones de Acueducto y Alcantarillado* (CORAAAs). However, these institutions focus more on the supply than to sewage and sanitation to the point that only 53 percent of the water treatment plants and 26 percent of the wastewater plants are operating adequately² and only two water utilities (CAASD and CORAASAN, from Santo Domingo and Santiago, respectively) have plans to enhance and increase their wastewater treatment capacity.

The Dominican Republic has developed NBS wastewater projects in the course of establishing formal water funds³ in the city of Santiago. In contrast, the approach in areas surrounding Santo Domingo, the capital city, is more focused on agroforestry and riparian restoration. These inland and rural projects are usually associated with biodiversity conservation, climate change adaptation and mitigation strategies, and the sustainable use of natural resources. However, all projects have wastewater implications and co-benefits since they help to restore the functionality of watersheds, thus diminishing the amount of pollution flowing into coastal ecosystems.

Since 2014, TNC has been implementing replenishment projects in key watersheds of the country by applying NBS approaches such as promoting agroforestry, reforesting riparian forests, and conserving remaining forest to reduce superficial runoff. These efforts have helped prevent soil erosion and reduced the amount of nutrients washing into waterways.

The use of NBS for wastewater treatment was seldom considered until constructed wetlands arose as a feasible and cost-effective way to provide sanitation services to small communities in rural and suburban areas that were not connected to a sanitary sewer system. Today, these constructed wetlands represent the main technique used in the Dominican Republic for wastewater treatment.

In 2015, the U.S.-based Charles River Watershed Association (CRWA) requested TNC's assistance locating a community to set up the Twinning River partnership program that provides peer-to-peer knowledge exchange and capacity building for sustainable river management. As part of this endeavor, CRWA hired the company Tetra Tech to provide technical capacity development to community partners that were working to improve water

² World Bank (2020) Realizing SDGs for Water and Sanitation in Dominican Republic, <https://www.worldbank.org/en/results/2020/05/06/realizing-sustainable-development-goals-for-water-and-sanitation-in-the-dominican-republic>

³ Water funds are organizations that protect the quality and amount of water by using funds from downstream users to pay for investments that protect water quality upstream.

quality in Jarabacoa, a small municipality in the upper watershed of the Yaque del Norte River that serves the city of Santiago.

Tetra Tech recommended a series of approaches tailored to the watershed's local context. Among them were:

- *Gravity-flow constructed wetland systems.* These systems consist of a pond covered by an impermeable membrane and filled with gravel containing aquatic macrophyte plants. They reproduce the natural method of water purification by eliminating pollutants through physicochemical and bacteriological processes such as sedimentation, microbial degradation, absorption, and volatilization. Because the systems use gravity, they can only be sited in areas where houses are located at a higher elevation than the treatment site.
- *Riparian wetland side-stream systems.* These systems shunt water from a natural stream into a wetland created in the riparian zone, where the water undergoes enhanced treatment before reconnecting with the stream. These systems are designed to treat baseflows and the most polluted first-flush stormwater flows.
- *Vegetated sand filter wastewater treatment systems.* These are highly effective single-pass sand or gravel filters planted with functional and/or aesthetic vegetation. They consist of a gravity collection sewer to convey sewage from houses that would otherwise directly discharge into the river by using a septic tank, pumping system, and vegetated filters. The wastewater travels through these filters, then infiltrates into the natural soil and is discharged back into the river.
- *In-stream boulder filter systems.* These adaptable systems can be easily implemented in existing flowing conveyances, particularly those with armored banks. They primarily treat baseflows, which likely include a significant amount of wastewater.
- *In-stream mycofiltration systems.* These very adaptable systems use mushroom mycelium mats as biological filters. They are more appropriate for a conveyance with intermittent flow and are targeted for constructed drainage channels within the planning area.

Of these practices, gravity-flow constructed wetlands are most commonly used in the Dominican Republic because they are very scalable and provide effective treatment with practically no maintenance. Sand filters are commonly used in some rural aqueducts as part of the water intake treatment.

Professional capacity limitations and the limited availability of specialized academic training in the Dominican Republic hinders the development and uptake of water quality and sanitation projects. Universities within the Dominican Republic offer degrees in civil engineering, chemical engineering, bioanalysis, microbiology, chemistry, and food technology, all of which have relevance and application engage with water quality management and sanitation. However, not all universities offer graduate level and post-graduate training in fields such as environmental

engineering and integrated water management, and the programs of study that do exist are relatively recent additions to academic curricula.

There is little information about the costs of various NBS versus grey wastewater systems. Nevertheless, the initial investment in NBS is generally lower and they tend to be more cost-effective in the long-term compared with conventional grey infrastructure, which often requires electricity, continuous maintenance, and chemical supplies in order to function properly.

Case Study

Santiago is home to half of the population of Yaque del Norte River⁴ basin. Although the city has the country’s most efficient sanitation system, it can only treat 20 percent of its wastewater. Therefore, the Yaque del Norte Water Fund (YNWF) was created to address water sanitation and started a campaign to promote the construction of artificial wetlands as a tangible solution to reduce the load of pollutants from the river flowing through the city.

The Fund and its partners identified places where wetlands could be a feasible solution and raised money to tackle the issue. By December 2020, YNWF had built 16 wetlands that treat 250,000 m³/year, and another five are in the pipeline.

The YNWF is funded by its members and other stakeholders. One of the members, Plan Yaque, a local NGO beneficiary of the Twinning River Restoration partnership program, received training to design and build wetlands, following a philosophy of “learning by doing.” It is now the implementing partner of the YNWF for all issues related to wastewater management. Local support is usually required to connect the houses to the system.

A recent national law for public–private partnerships provides a legal framework that supports the institutional arrangements and synergies with initiatives such as the YNWF.

Compromiso Santiago (a network that gathers the main development entities and business associations of Santiago), signed a management agreement with the Presidency of the Republic for the coordination of public investments aimed at valorizing the historic center of Santiago and the sanitation of the urban stretch of the Yaque del Norte River.

NBS SNAPSHOT

Location: Yaque del Norte River basin of the City of Santiago

Type of NBS: Constructed wetlands that treat 250,000 m³/year

Costs: Average cost per unit area is USD \$150/m²

Driving Factors for NBS: As only 20 percent of the wastewater of Santiago is handled by the city’s sanitation system, the Yaque del Norte Water Fund was established with water sanitation as a strategic objective, particularly through the construction of artificial wetlands.

⁴ The Yaque del Norte is the most important river in the Dominican Republic. It is 296 kilometers long and its basin covers 7,044 square kilometers (approx. 15% of the country). It has an impact on nearly two million people in seven provinces and 37 municipalities. It also irrigates 70,000 hectares of crops (mainly rice and bananas) and feeds a system of dams that stores 820.7 million cubic meters of water with the potential to generate 488 gigawatts per year.



Figure 1: Constructed wetland in the Dominican Republic. Photo Credit: Tim Calver

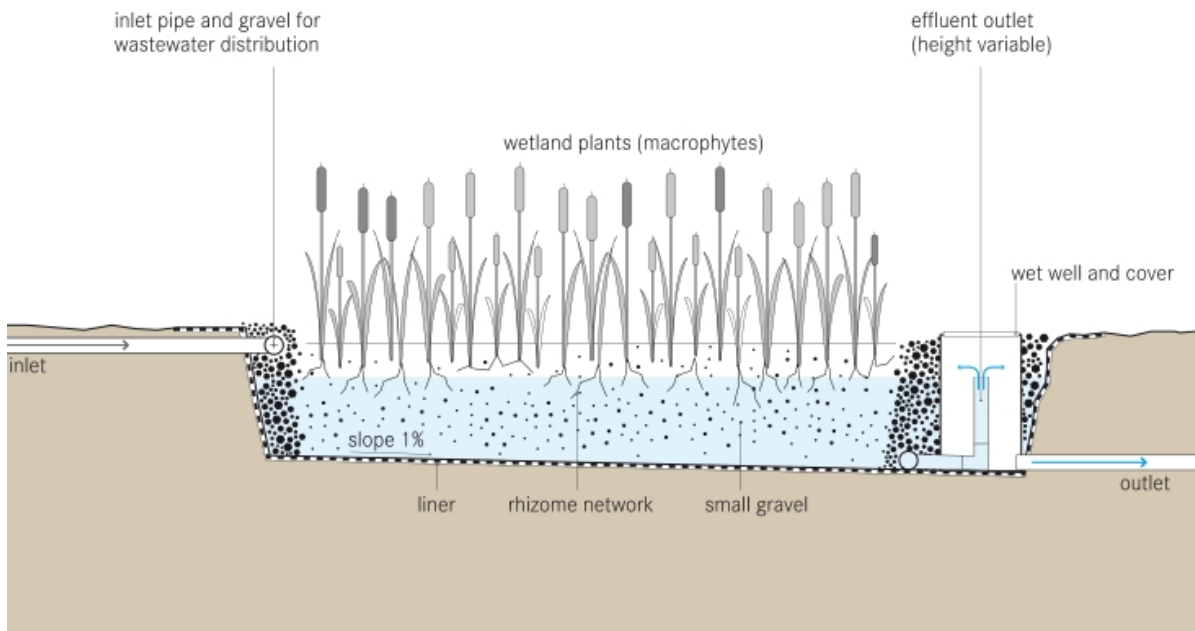


Figure 2: Schematic of type of constructed wetland used in some Caribbean island nations.⁵

⁵ Tilley, et al. 2014. Compendium of Sanitation Systems and Technologies.

Now that there is an established commitment to sanitation that is seeing positive results, Compromiso Santiago has formally invited YNWF to become a member of the commission that will advise them on where NBS are required and what kinds of interventions should be prioritized. The YNWF is now in a better position to influence decision makers, and more artificial wetlands will likely be built in the peri-urban zones of Santiago.

Some artificial wetlands, such as the one constructed at the facilities of the Environmental School of the Ministry of Environment in the Yaque del Norte River basin, have had a more significant effect than others. After proving the effectiveness of these interventions, the Ministry made two special requests to build wetlands beyond the basin, including one near Valle Nuevo National Park in the mountains, and more recently another one near the coast at the Estero Hondo Marine Mammal Sanctuary. The Deputy Minister of Coastal and Marine Resources contacted TNC requesting support for the construction of this latter wetland as a complementary facility to prevent the mangrove forest at the sanctuary's visitor center from becoming contaminated.

The constructed wetlands have been overwhelmingly successful. According to data from regular monitoring,⁶ artificial wetlands reduce organic pollutants, on average, by 85–90 percent. These data come from the laboratory of the water utility in Santiago, which is a partner of the YNWF.

Moving Forward

The topic of constructed wetlands is slowly gaining traction in the Dominican Republic. Tetra Tech prepared their report in 2015. A year later, the paper “Wastewater treatment through artificial wetland systems at Café de Herrera”⁷ was presented as a final project by undergraduate students in civil engineering at the Universidad Nacional Pedro Henríquez Ureña in Santo Domingo.

The university Instituto Tecnológico de Santo Domingo released another research paper in 2020, titled “Evaluation of the efficiency of the operation of the El Dorado wetland.”⁸ This research was assisted by technicians from the Ministry of Environment, Plan Yaque, and the University of Havana.

Fundación RedDom, another local NGO, systematized their own experience and published the results on their website.⁹

⁶ <https://fondoaguayaque.org/programas/gestion-sostenible-del-agua/monitoreo-agua/>

⁷ <https://repositorio.unphu.edu.do/bitstream/handle/123456789/888/Tratamiento%20de%20aguas%20residuales%20por%20medio%20de%20sistemas%20de%20humedales%20artificiales%20en%20el%20Caf%C3%A9%20de%20Herrera.pdf?sequence=1&isAlloved=y>

⁸ http://procedia-esem.eu/pdf/issues/2021/no2/8_40_Vargas_21.pdf

⁹ <http://fundacionreddom.org/humedales-artificiales-como-soluciones-ante-problemas-de-aguas-residuales/>

HAITI

Ecological and Social Context

Haiti shares the island of Hispaniola with the Dominican Republic (western one-third is Haiti, eastern two-thirds is the Dominican Republic). Haiti is the most mountainous nation in the Caribbean. Numerous smaller islands and inland lakes make up part of the country's total territory bordered by 1,771 km of coastline along the Caribbean Sea and 360 km along the Dominican Republic. Due to its dramatic landscape marked by many rugged mountains, the largest concentration of Haiti's 11 million population are in the low-lying areas near the coast. Major economic sectors include agriculture and manufacturing. Haiti is home to a diverse ecosystem including high and low altitude forests, rivers and lakes, wetlands, mangrove forests, beaches, coral seagrass beds, and coral reefs.

Until recently, Haiti was one of the few countries in the world without a central sewage system in any of its larger cities. A new central system that collects and treats sludge and wastewater near the capital city of Port-au-Prince has just been launched. Except for a few systems in select towns or communities that were installed by the government or NGOs, there are no sewers connecting sinks, showers, and toilets to large wastewater treatment plants.

Most of Haitians use outhouses, and much of that waste ends up in canals, ditches, and other unsanitary dumping grounds, where it can contaminate drinking water and spread disease. During heavy rains, this wastewater carries household wastes and sewage from pit latrines, and is a major polluter of the country's natural waters, such as the Bay of Port-au-Prince.¹⁰ The impact of urban wastewater on aquatic ecosystems is not widely reported in the literature yet, but we know that it is a real threat, especially around large cities like Port-au-Prince or Cap-Haitien.

One key study carried out in 2009 by Quisqueya University¹¹ focused on urban effluent in the Bay of Port-au-Prince. The purpose of the study was to: (i) implement an environmental hazard assessment framework for untreated urban wastewater; and (ii) apply the framework on urban wastewater coming from an open channel of the combined sewer system of Port-au-Prince. The study characterized the environmental hazards of wastewater on the Port-au-Prince bay ecosystem by comparing the results with threshold values on effluent discharge. Key findings included:

- Untreated wastewater from rain, residential areas, industries, and manufacturing plants flows directly into the Bay of Port-au-Prince;

¹⁰ Emmanuel, E., Perrodin, Y., Théléys, K., Mompoin, M., and Blanchard, J.M.B. 2004. Environmental hazard assessment of untreated urban wastewater on the ecosystem of Port-au-Prince Bay.

¹¹ Emmanuel, E., Lacou, J., Balthazard-Accon, K., and Joseph, O. 2009. Ecological hazard assessment of the effects of heavy metals and nutrients contained in urban effluents on the bay ecosystems of Port-au-Prince, Haiti. *Revista Aqua-LAC* 1(1).

- The presence of contaminants in untreated urban wastewater significantly threatens the biological equilibrium of the bay ecosystem and its aquatic organisms; and
- The maximum concentration of dissolved oxygen (CDO: 4.54 mg/L) was lower than the concentration required (5 mg/L) to protect aquatic organisms against the wastewater effects.

The practice of discharging waste in Haiti’s waterways poses a significant concern to water quality and to the health of aquatic organisms. Not only are there various types of pollutants that impact these systems, but there are many ways pollutants can harm aquatic organisms.¹²

Pollution in Haiti has increased gradually during the past decade, due to a significant increase in the number of poorly maintained used cars that leak enormous amount of oil all around the cities, uncontrolled urbanization, and other factors. The mismanagement of wastewater in Haiti has a profound negative impact on the quality of life, for people and ecosystems both inland and in the ocean.

Haiti’s investment in NBS for multiple outcomes, including for wastewater management, is growing. Yet with limited wastewater infrastructure overall, NBS gains are modest compared with the overall need.

Case Study

This NBS project was launched in 2012. The 243-hectare Parc Industriel de Caracol (PIC) was constructed near the small fishing community of Caracol with support from USAID and IDB. The PIC’s footprint straddles the Rivière Trou du Nord approximately 3 km from where it empties into Caracol Bay. A diesel-powered electricity plant provides 10 megawatts (MW) of electricity to the PIC and surrounding communities. The IDB and USAID recently committed additional financial resources to construct two solar power plants inside the PIC, an 8-MW plant and a 4-MW plant. This industrial development has stimulated employment in this marginalized region in northeast Haiti and the local population generally approves of it.

NBS SNAPSHOT

Location: 243-hectare Parc Industriel de Caracol, along the Rivière Trou du Nord, just above Caracol Bay

Type of NBS: Constructed wetland ponds

Costs: Not available

Driving Factors for NBS: Avoiding soil and water contamination from dyes used in treating clothes at garment factory

The PIC features a wastewater treatment facility with solid removal and a cascading system of engineered wetland ponds to filter water to potable standards. Communities that are capable of housing several hundred persons were also constructed in the neighboring commune of Terrier-Rouge. The PIC has commenced operations with over 9,000 employees and plans to

¹² Adams, S.M. and M.S. Greeley. 2000. Ecotoxicological indicators of water quality: Using multi-response indicators to assess the health of aquatic ecosystems. *Journal of Water, Air, and Soil Pollution* 123:103-115.

eventually expand operations up to 20,000 workers. It has greatly increased employment, thereby attracting more people to the region.

However, the PIC may pose potential new threats to the already overexploited ecosystem. Located about 3 km from Caracol Bay near the center of the Three Bays National Park (3BNP), the PIC was designed to discharge its treated wastewater into the Trou du Nord River—the second largest freshwater source entering the Park. Some fishermen have expressed concerns about the potential threats to the fisheries on which they rely from the chemicals and dyes used in treating cloth.

In addition to the potential increase in pollution, the PIC also poses a risk to the environment due to an increase in the human population near the Three Bays National Park. More people will generate greater volumes of solid waste and sewage that eventually flow into the groundwater and surface waters. However, potential impacts to the area from the PIC can be mitigated with proper regulation, management, and monitoring. A good way to mitigate the risks may be scaling or replicating the constructed-wetland initiative across northern Haiti.

Moving Forward

Recent discussions with key government stakeholders in Haiti noted that the Haitian government is aiming to implement more than 20 wastewater treatment sites in future. One interviewee also confirmed that so far one wastewater treatment site has been completed near Port-au-Prince, a second one is expected to be completed in the city of Les Cayes in March 2021, and a third one will be completed in Cap Haitien in 2022. However, several challenges remain, including: (i) a lack of financial resources, as there are so many competing priorities at the government level; (ii) a lack of qualified human resources, as the country has experienced a “brain drain” for the past several years; and (iii) the need to reinforce governance at local and national levels in order to address land tenure and zoning-related issues.

While there is reason to be optimistic about the future of wastewater management in Haiti, support from NGOs, donors, and the education sector, alongside strengthened public sector programs, will be key to its success. In addition, there is a learning curve associated with implementing NBS. External partners and other countries that have developed their own “lessons learned” can assist this process. Most importantly, most government stakeholders recently interviewed by TNC believe that additional pilot projects are the best way to develop sound NBS projects for wastewater management in Haiti. Once a pilot has been successfully implemented in a select community, it may be used to educate and convince other stakeholders on both its feasibility and practicality.

JAMAICA

Ecological and Social Context

Jamaica is the third largest island in the Caribbean Sea. Most of its approximately 2.7 million people¹³ and critical infrastructure are located relatively close to the coast, as is the case for other Caribbean countries. Major economic sectors include mining and quarrying, tourism, agriculture, and manufacturing. Jamaica has a diverse range of ecosystems, including coastal and inland wetlands, mangrove forests and inland forests, coral reefs, beaches, seagrass beds, ponds, and rivers.

Wastewater management in Jamaica is the responsibility of several government ministries and agencies, with accompanying legal instruments used to govern and define roles and responsibilities. Jamaica's existing legislation is considered fragmented,¹⁴ as government agencies appear to lack an integrated approach to wastewater management issues. Wastewater management is primarily governed by four instruments: the National Resources Conservation Authority (NRCA) Act, the Public Health Act, the National Water Commission Act, and the Water Resource Act. The NRCA (Permits and Licenses) Regulations implements a system of permits for waste disposal. The Public Health Act sets national standards for the collection and disposal of waste material and assigns the responsibility for monitoring and enforcing these standards to the Ministry of Health and Wellness. In addition, the Office of Utilities Regulation sets and enforces quality of service standards for sewerage networks. The National Environment & Planning Agency monitors the health of the environment.

Effluent from sewage treatment plants, other types of sanitation facilities, and industrial discharge are known to pollute the environment and endanger ecosystem and human health. In Jamaica, 75 percent of sewage waste disposal systems are soak-away systems, which collect wastewater in underground chambers and disperse the water slowly through surrounding soils. These have been shown to contaminate groundwater sources, particularly in densely populated areas (e.g., Liguanea Plains).¹⁵ While the construction of new soak-away systems is no longer permitted, these systems are still prevalent in older construction.

About 83 percent of all Jamaicans have access to improved sanitation facilities¹⁶ (meaning flush or pour-flush to a piped sewer system, septic tank, or pit latrine; ventilated improved pit latrine; pit latrine with slab; or a composting toilet).¹⁷ Sewage volume reaching various sewage treatment plants commonly exceeds the plant's design capacity, and the noncompliance rate for sewage effluent quality standards is known to be high.

¹³ STATIN (2019) Population Data, https://statinja.gov.jm/Demo_SocialStats/PopulationStats.aspx

¹⁴ GEF CReW (2010) Situational Analysis – Regional Sectoral Overview of Wastewater Management in the Wider Caribbean Region.

¹⁵ MEGJC (2019) National Water Sector Policy and Implementation Plan 2019, pp. 75-76

¹⁶ MEGJC (2019) National Water Sector Policy and Implementation Plan 2019, pp. 75

¹⁷ https://www.indexmundi.com/jamaica/sanitation_facility_access.html

This lack of compliance is mainly due to issues such as improper plant designs, old technology, overloading, lack of maintenance, and improper operations.¹⁸ Regulatory agencies are well known to tolerate breaches of the regulations, and decision makers and the public generally place a low priority on wastewater management compared with other issues. There is also a lack of public awareness of wastewater issues and their effects on the environment and a general “out of sight, out of mind” attitude.

The use of traditional mechanical treatment plants is widespread and typically more common in Jamaica than in other Caribbean countries. The use of NBS for wastewater management over the last few years has increased. The most commonly used NBS for wastewater management in Jamaica are:

- Constructed wetlands, mostly reed beds;
- Waste stabilization ponds;
- Anaerobic digesters/reactors;
- Natural wetlands (e.g., mangroves); and
- Reuse of treated effluent for irrigation.

The use of these types of systems seems to be driven by the cost of construction, but not necessarily the cost of maintenance. Typically, if the NBS is more expensive to construct and the costs of maintenance is not a primary concern of the operators, then there is a high probability that grey solutions will be used. Typically, the costs of maintaining the natural system is less expensive compared to the mechanical treatment plants, meaning potential savings could be accrued over the short- and long-term in a natural system.

The NBS most commonly used in Jamaica (such as constructed wetlands and stabilization ponds) often require substantially more land than mechanical plants, and if land prices are high or land is unavailable, the systems are considered too expensive and impractical. Mechanical systems while requiring less land area, often require a higher energy input, more frequent maintenance, and more skilled personnel. In some cases, engineers may suggest hybrids of natural and mechanical solutions to overcome the disadvantages of each.

There are no ardent policy mandates that drive or encourage the use of NBS in any significant way for wastewater management, so the use of NBS seems to be driven more by the client’s specific situation and the design recommended by the specific engineer, based on their own experience and competence.

¹⁸ GEF CReW+ Project, Appendix 23 National Package for Jamaica

Figure 3: Examples of Natural Wastewater Treatment (Passive) Systems Installed in Different Sectors in Jamaica¹⁹

SECTOR	WASTEWATER TYPE	SITUATION	TREATMENT SOLUTION	OUTCOME
Baking	Medium BOD* > 1000 ppm High FOG** > 500 ppm	Untreated wastewater trucked from site on a regular basis—high financial demand	Anaerobic reactor, reed bed, disinfection/irrigation	High-quality final effluent disposal on site
Ecotourism	Low BOD < 300 ppm	Partially treated sewage being disposed on site	Anaerobic reactor, reed bed, disinfection/irrigation	High-quality final effluent utilized for irrigation
Commercial	Low BOD < 300 ppm	Poorly designed system on site not meeting standards	Anaerobic reactor, reed bed, disinfection/irrigation	High-quality final effluent utilized for irrigation
Housing	Low BOD < 300 ppm	New development needs National Environment & Planning Agency approval for construction	Anaerobic reactor, reed bed, disinfection/irrigation	High-quality final effluent utilized for irrigation
Fast Food	Medium BOD > 500 ppm Medium FOG < 300 ppm	Untreated wastewater trucked from site on a regular basis—high financial demand	Anaerobic reactor, reed bed, disinfection/irrigation	High-quality final effluent utilized for irrigation

* BOD (biological oxygen demand) refers to the amount of oxygen required to remove waste organic matter from water during decomposition and is an index of the degree of organic pollution in water.

** FOG (fats, oils, and grease)

In some cases, permit requirements have led to the use of NBS. For example, improved building codes, industrial effluent, and development permitting requirements dictate that wastewater treatment systems exist or are improved to operate legally. There are also positive spinoffs that can occur when wastewater management has to be improved due to legislative directives to meet effluent standards. In some cases, implementation of new NBS systems has required water-intensive industries to find ways to reduce their overall water consumption and water-use requirements so that they can take advantage of more affordable NBS approaches.

¹⁹ Bailey, O. Chief Engineer, Isratech Jamaica Limited. Received by Anna Ebanks-Chin via email on February 3, 2021.

Case Studies

Dunns River Falls and Park²⁰ is one of the most popular tourist attraction sites on the north coast of Jamaica and accommodates up to 10,000 visitors per day. The Dunns River is surrounded by lush vegetation and empties into the sea, west of a white sand beach. The park facilities include parking, a gift shop, a craft park, picnic areas, and a children's water park. The Park is part of a 276-acre Belmont property entrusted to the Urban Corporation of Jamaica (a Government of Jamaica entity).

Constructed wetlands treatment systems such as reed beds utilize the growing cycle of reed-type plants to treat wastewater. Reeds are planted in a basin and water is allowed to flow through it. The process mimics the natural processes of a wetland, including sedimentation, filtration, and biodegradation, albeit in a more controlled way. The rate at which these processes occur is based on the design and the type of reed bed system.

There are two main types of reed beds: surface flow and subsurface flow. In the subsurface flow type (also called a horizontal reed bed), which is more common in Jamaica, water flows through a bed of gravel, with the water surface below the top surface. There is also a vertical flow reed bed, which offers some advantages over the horizontal flow model. It is more effective at ammonia removal, due to increased oxygen levels, and can cope with stronger effluents as a result. Vertical flow reed beds also have a smaller footprint area than horizontal flow gravel reed beds, so may be better suited to small sites.

The Dunns River Falls treatment plant consists of a septic tank and constructed wetlands with reed beds. The initial cost for constructing reed beds was relatively low compared to its mechanical equivalent. The majority of the savings can be achieved by using earth berms to form the basin for the bed with an impermeable plastic liner. The gravel fill for the bed was readily available, as were the reeds, which are normally transplanted from gullies or other wetland areas. Very little skill is required to construct such a system or plant the reeds, and a general contractor can undertake this work. Reed beds are typically three to five feet deep.

The major enabling factors for a plant in this location are the availability of land and the fact that no electricity is required. Land availability is crucial, as this plant utilizes approximately one acre of land. This type of system is usually scalable and is normally built in parallel and/or in a series, where additional cells can be added to increase the capacity.

NBS SNAPSHOT

Locations: Dunns River Falls and Hellshire

Type of NBS: Constructed wetlands (reed beds) and stabilization ponds

Costs: Inexpensive, compared with grey infrastructure

Driving Factors for NBS: Available land and costs

²⁰ Source: Case study received from Urban Development Corporation via email to Anna Ebanks-Chin on February 8, 2021.

Contrary to popular belief, this type of treatment system is not maintenance-free. However, the maintenance inputs are low and do not require highly skilled labour. The primary need is simply to cut the reeds once they have matured. In addition, the pores of the gravel bed can become clogged over time and may necessitate changing the gravel at some interval.

The design of reed bed systems is one challenge that must be overcome. At the domestic level, the typical dimensions for a septic tank are based on the number of people who will depend on it. This information is not available for reed beds, however, which are designed for the expected volume of influent rather than on the population. Designing for non-residential purposes requires more experience with NBS, data analysis and wastewater characterization studies to identify the type of influent before the system can be designed. This requirement often limits natural treatment system mainly to residential purposes because of the small scale and more predictable flow of wastes.

The Hellshire sewage treatment facility²¹ is an example of a typical stabilization pond system. The pond system treats the equivalent of a population of 6,200 people, the majority of the residents in the Hellshire area. The pond was designed for 1,400 cubic meters and covers 7.5 acres.

Sewage stabilization ponds utilize naturally occurring processes to treat sewage, including solar radiation, wind, microorganisms, and algae. The ponds are normally configured with numerous cells of various depths, with each cell performing a different process. While there may be a varying numbers of ponds, they fall into three types: anaerobic, facultative, and maturation.

The anaerobic pond is the deepest of the three types and is the first pond in the series. In this stage, excess solids settle and are digested. The pond acts as a buffer tank and prevents any shock loads on the plant, pretreating the sewage before passing it on to the other ponds. Next in the series is the facultative pond, which reduces the pollutants. The final step is the maturation pond, which removes pathogens. This is the shallowest of the ponds (less than four feet deep) and the pathogens are reduced by sunlight penetrating the water.

Sewage stabilization ponds take up a substantial amount of land area, as the shallow ponds require a sizeable surface area to perform the wastewater treatment. The construction of such a large system takes a substantial amount of time. The berms are also made of earth with an impermeable liner.

Ponds are a well-established system used mostly for residential sewage treatment, where land is available. Many large-scale communities utilize this type of system, as the larger the system, the more cost-effective it is. The overall cost of maintenance over the lifespan of the plant is less than its mechanical equivalent.

²¹ Source: Case study received from Urban Development Corporation via email to Anna Ebanks-Chin on February 8, 2021.

Typical issues with ponds include short circuiting, often the result of a design flaw, in which the water travels the shortest possible route. This causes a reduction in the treatment time and ultimately a lowered removal efficiency. In addition, a layer of scum can form in the maturation pond and must be removed manually. Crocodiles can also use ponds as a habitat and may endanger maintenance personnel. Pathogen removal may be reduced during storms and periods of prolonged overcast weather that reduce solar radiation.

There is no universal guidance on pond designs, as the design must take into consideration various onsite considerations. Only professional engineers trained in this specialty should design sewage stabilization ponds, which limits the use of these systems.

Moving Forward

The success of interventions often begins with hiring a professionally qualified person to do the initial design, taking into consideration the specific issues that it is meant to resolve and the capacity (financial and human) of the owner/operator. The correct operation, maintenance, and monitoring programs must be established and executed, and personnel involved in construction, operation, and maintenance must be appropriately trained. The interventions may also have other benefits, such as reduced amount of wastewater going into the system due to improved efficiency, and reuse of treated effluent (e.g., for irrigation or energy production) that allows less consumption of other resources. Where the construction, operation, maintenance, and monitoring are properly resourced with financial and human capacity, the likelihood of success will improve as well.

In many cases, poor design, construction, operation, and maintenance have led to the failure of wastewater solutions. Failure at any one of these points can have disastrous effects on the function of the intervention. In addition, in some cases the intervention may not be successful because the system is simply overloaded beyond its original design capacity.

It is important that the particular NBS being used is appropriate for the type and amount of waste. For example, in a comparison of reed beds and stabilization ponds, reed beds may appear more aesthetically pleasing and produce a clearer effluent, while stabilization ponds produce a greener effluent that may be less aesthetically pleasing. Anaerobic digesters tend to be more suitable for highly organic waste, such as dunder (the liquid remaining after rum distillation) or coffee production wastewater. Sometimes, additional measures need to be put into place to produce effluent to the appropriate standard, such as chlorination of effluent after it passes through the reed bed.

Not monitoring the effluent produced by these interventions and not appropriately adjusting and applying solutions can result in poor-quality effluent. At times, the wastewater volumes may temporarily increase beyond the norm, and the natural systems may be unable to cope (e.g., flooding after a storm). Insufficient allocation of resources to effectively maintain and monitor treatment facilities is an issue, as some owners/operators do not understand that natural solutions require maintenance.

In general, there is poor monitoring of wastewater treatment by both the operators and regulators of wastewater management systems in Jamaica, as well as general leniency by regulators toward noncompliant entities. This has contributed to operators placing a low priority on maintenance actions that may be needed to ensure the proper functioning of these NBS systems and that, if not done, can result in them not meeting water treatment objectives. An increased focus on compliance and monitoring would help to encourage and support the adoption of NBS for wastewater.

GRENADA

Ecological and Social Context

Grenada is comprised of the island of Grenada and the two smaller islands of Carriacou and Petite Martinique, which together contain approximately 110,000 people, 348 km² in area, including 121 km of coastline. Grenada has a mountainous interior with slopes descending gently to the coastline, which is ringed by extensive coral reefs, sea grass beds, and some mangrove swamps. The state is home to rich marine and coastal biodiversity, pristine beaches, and valuable turtle nesting sites. Like many Caribbean nations, Grenada is largely dependent on these marine resources to support livelihoods, provide food, protect the coasts, and ensure economic prosperity, particularly through the tourism and fisheries sectors. Further, most of its population, towns, and critical economic and social infrastructure are located along the coast.

In Grenada, sewage management touches on the mandate of several ministries and government agencies. The principal institution is The National Water and Sewerage Authority (NAWASA) where it is coupled with water resources management and distribution. With respect to sewage, NAWASA has oversight for operation, maintenance, and monitoring the performance of the sewage systems and advises the Housing Association of Grenada on sanitation solutions for their developments. Other key agencies include the Environmental Health Department and the Fisheries Division, both of which share mandates related to the control of water pollution, namely monitoring water quality and sanitation and water quality relating to marine life, respectively. The Physical Planning Unit also contributes to sewage management through its regulatory functions on development activities.

In this regard, cross-sectoral coordination is critical for creating coherence and synergies among these key entities – including other actors and stakeholders – to ensure effective management. Experts agree that this cross-sector coordination of water, land, coastal areas and public health issues is a critical and urgent need in Grenada. The likely contributors to this “silo approach” are: (i) no formal coordination arrangements or institutional agreements to support cross agency or intragovernmental collaboration; (ii) inadequacies in management and leadership; (iii) resistance to information sharing (particularly for water quality data); and (iv) limited human and financial resources and technical capacity.

The growing tourism industry, increase in urbanization, and increasing city populations (of residents and tourists) are increasing the pressure on Grenada's critically important marine and coastal environments. One major threat to its marine assets has been large amounts of wastewater—particularly sewage, the inadequate disposal of which not only pollutes and damages the critical assets on which the tourism sector and national economy so heavily depend, but also poses serious public health risks to tourists and citizens alike. Interventions to support the proper management of sewage are therefore crucial to Grenada's sustainable economic, social, and environmental development.

The current disjointed sewage disposal system is considered inadequate and an urgent problem of national importance, so much so that an interviewee described it as a “ticking time bomb.” This is largely due to substantial sewage leakages and pollution entering Grenada's water courses, ocean, and groundwater supply, causing significant contamination and sanitation issues, health risks, and severe threats to marine life and habitats.

A variety of disposal methods are in use in Grenada: septic tanks, self-contained treatment systems, pit latrines, and disposal of sullage (used kitchen and bath water that does not contain human waste) into surface drains. According to national census data from 2011, approximately 62 percent of Grenadian households have indoor toilets, including 58 percent linked to septic tanks and four percent connected to sewer systems. A significant 30 percent of the population still use pit latrines, and the Pan-American Health Organization estimates that 67 percent of the island's low-income families use pit latrines.²² Meanwhile, five percent of Grenadians do not have access to any excreta disposal facility. Several Grenadian interviewees indicated that open defecation into rivers and drains is still practiced in several rural communities, and a World Health Organization/UNICEF study²³ places this figure at 3.5 percent of the population. One hotel is reported to have its own treatment facility that is not functioning properly.²⁴

During periods of heavy rainfall and flooding, a significant amount of wastewater from home systems (pit latrines and septic tanks) overflows and is discharged into the ocean through runoff from the upper watersheds. This problem is exacerbated by pollution from poorly constructed pit latrines and malfunctioning septic tanks. Unplanned development over the years has resulted in the unregulated expansion of communities bordering the capital city of St. George's, including several informal or slum-like areas.

There are also numerous cases around the island of dense housing developments that discharge wastewater into rivers and tributaries, from which it eventually finds its way into the sea. Sewage leakages and run-off not only affect the river and coastal waters in Grenada, but also can affect freshwater supply. In several cases, sewage has seeped into and contaminated the groundwater, particularly in areas below sea level or with higher water tables such as Grenville. By and large, the topography and geology of Grenada allows for the safe application of septic and soakaway options. Further, the Environmental Health Department has standard

²² Pan American Health Organization. 2012. Health in The Americas, Grenada Country Report.

²³ WHO / UNICEF Joint Monitoring Program. JMP (2015. www.wssinfo.org).

²⁴ OECS Grenada Wastewater Management Project Final Report. 1999. Howard Humphreys and Partners, Ltd.

designs for septic tanks and soakaways, the specifications of which are based on the number of persons in the household. The challenge is the poor design, construction, and/or placement of septic tanks and pit latrines, due to the limited monitoring and enforcement of the Physical Development Department.

Case Studies

While there are limited direct NBS for wastewater management projects in Grenada, several projects that are underway or proposed have the potential for co-benefits for wastewater management.

Executive leadership within the government of Grenada and key regulatory agencies are taking a proactive interest in and leading efforts to address Grenada’s sewage pollution and management challenges. The bulk of this effort is around sourcing funding and mobilizing resources for infrastructural work, including treatment plans and expanded sewage systems. However, NBS have been finding their way into the national conversation and some projects, albeit at a relatively small scale and with the benefits to water quality and management as a co-benefit rather than the primary objective.

In 2007, the Government of Grenada, led by the Physical Planning Unit, developed the Greater Grenville Local Area Plan (GGLAP). The GGLAP documented the climate and socioeconomic risks experienced by the Grenville Bay Area communities and proposed solutions to address them. In 2013, TNC, the community, and partners developed a Living Edge Plan that building on the GGLAP to develop a series of linked ecosystem-based adaptation interventions that would increase the resilience of the communities. Both “At the Water’s Edge” and “Resilient Islands” are ongoing initiatives by TNC that were designed to help achieve the Living Edge Plan’s objectives.

- **At the Water’s Edge**—This highly innovative, unique, multi-year hybrid Ecosystem-Based Adaptation project is being implemented by TNC in the community of Telescope, within the Grenville Bay Area. It has two major components: (i) construction of an engineered coral reef array composed of rock-filled metal rebar baskets mounted along the crest of a 300-meter length of fringing coral reef; and (ii) a set of NBS interventions, including coral restoration (nursery and out-planting), mangrove restoration (nursery and plantings), and beach revegetation to help provide long-term coastal stabilization.
- **Resilient Islands: Integrating Ecosystem and Community-based Approaches to Enhance Climate Change Adaptation in the Caribbean**—This four-year project, which is being implemented by TNC and the International Federation of the Red Cross and Red Crescent Societies, seeks to integrate community and ecosystem-based adaptation into

NBS SNAPSHOT

Locations: Grenville Bay and Telescope

Types of NBS: Coral reef restoration, mangrove restoration, beach restoration, natural retention ponds, and seamount farms

Costs: Varied among different projects

Driving Factors for NBS: Climate resilience, community involvement, and costs

local and national decision making and policies. Its goals are to reduce climate vulnerability and boost adaptive capacity, as well as to advance disaster risk reduction decisions at the local and regional level. It involves working with communities and governments to design innovative decision tools, training local leaders, and implementing demonstration projects in vulnerable coastal areas. Utilizing a “Source to Sea” approach, and building on the successes of the earlier “At the Water’s Edge” project, a Water Quality Remediation Plan will be developed that will identify the main sources of pollution for each surrounding watershed, map their movement from land to sea, and recommend sustainable management practices. The aim is to improve the quality and quantity of runoff from the watersheds, thereby leading to improved water quality within the Grenville Bay and better floodwater control.

More recent NBS-related projects include:

- The Restoration and Community Co-Management of Mangroves project—This project, which is being piloted in Telescope, is geared toward improving the health of the surrounding mangrove forest and associated ecosystems. It is part of the Grenadian-German Pilot Programme “Integrated Climate Change Adaptation Strategies” funded by the German Federal Ministry for the Environment, under its International Climate Initiative and implemented jointly by the Government of Grenada, the Deutsche Gesellschaft für Internationale Zusammenarbeit, and the United Nations Development Programme.
- Building community resilience via sustainable land management initiatives to reduce flood risk in Grenville Bay, Grenada—This project (scheduled for April 2021) was awarded funding under the Karayib Klima program and supports the Water Quality Remediation Plan. It involves a series of sustainable land management measures (including buffer zones, natural retention ponds, slope stabilization, and rainwater harvesting) in four watersheds to provide effective flood risk reduction downstream and improved water quality in the Grenville Bay.
- Innovative Nature-Based Solutions to Enhance Community Resilience in Grenada—This proposed project was submitted by the Windward Islands Research and Education Foundation for funding under the Caribbean Biodiversity Fund’s Ecosystem-Based Adaptation Facility and is awaiting final approval. Through a series of targeted, complementary, and innovative nature-based interventions, including coral reef restoration, a mangrove island, seamoss farms, and shoreline stabilization, the project will provide significant social, environmental, and economic benefits to the community. Like the other activities being implemented in the Grenville Bay area, this initiative will support and contribute to the cumulative improvement of the water quality in the Grenville Bay through the expansion of seamoss farms using red algae, proven to absorb excess nitrogen and phosphorus generated from land-based sources of pollution.

The opportunity for NBS in Grenada and its applications to address wastewater challenges are “quite exciting,” according to one interviewee. Several others noted that constructed wetlands

to treat wastewater should be considered and explored more deeply. Several interviewees agreed that greater awareness and knowledge of NBS are needed among policymakers and professional staff of governing agencies.

Moving Forward

Despite some efforts, Grenada's sewage management situation has improved little over the past decades, yet several NBS projects are currently in the works. On a large scale, proposed interventions have suffered from a lack of funding and financial sustainability, and policy-related initiatives seem to have poor political commitment and follow-through. On a regional level, there are opportunities and interest in institutional collaboration and knowledge sharing, as initiated in 2014 at a meeting titled Regional Partners in the Caribbean Water and Wastewater Sector. Hosted by The Global Water Partnership-Caribbean and the United Nations Environment Programme, Caribbean Regional Coordinating Unit, the meeting covered priorities for water security and climate resilience, including the need for collaboration between regional institutions working on water issues.

More recently, there are a number of national and regional initiatives supported through various multi- and bi-lateral organizations, to address gaps and deficiencies in the sector. Grenada is receiving readiness support from the Green Climate Fund for the development of the Climate Resilient Cities: Grenada Project, aimed at building climate resilience in its coastal cities. A key component of the project is a Wastewater Resource Recovery Facility that will include a wastewater treatment system, an energy recovery system, and a resource recovery system, to address sewage and wastewater challenges. A noteworthy regional initiative that touches down in Grenada is the CReW+ project, "An integrated approach to water and wastewater management using innovative solutions and promoting financing mechanisms in the Wider Caribbean Region." This project aims to provide support in policy reforms, data management, capacity building, financial mechanisms, innovative technologies for wastewater and water management, and knowledge and communication.

RECOMMENDATIONS

In each country studied, and in the Caribbean region as a whole, the data and information regarding wastewater management are limited. There is even less information on the role of NBS to address wastewater management in the region. But what we do know is promising, and the potential for increased use of NBS for wastewater management is significant.

As countries explore wastewater management solutions, IUCN has developed an NBS self assessment tool to help determine readiness for NBS on a project or in a country²⁵. This tool includes evaluation of the local policy framework, the appropriateness for NBS for a project, public involvement and support, and other factors. This tool is a good place to start as NGOs

²⁵ <https://www.iucn.org/theme/nature-based-solutions/resources/iucn-global-standard-nbs>

and governments look to implementing NBS for wastewater management. In addition to this tool, we have several recommendations for addressing this issue and increasing the use of NBS in the Caribbean.

Policies and Governance

- Policymakers and technical staff need to be more educated about the benefits of NBS and the range of appropriate options, and to develop strategies that will encourage their use in a tangible way. Lack of knowledge by policymakers and technocrats sometimes means that RFPs (requests for proposals) and TORs (terms of reference) for wastewater treatment systems are limited in their scope and refer only to the mechanical systems with which they are familiar.
- The policies and programs on reuse of treated effluent and appropriate enabling conditions need to be strengthened. They should include awareness of the safety of treated wastewater as an agricultural input and the streamlining of incentives that will encourage wastewater producers to reuse effluent, form public–private partnerships, encourage private sector investment, and overcome the psychological barriers that surround wastewater treatment.
- Relevant permitting and licensing laws, regulations, and standards should be revised and updated to codify NBS and clarify appropriate systems and guidance for implementing NBS as a preferred and normal engineered response.
- Existing laws, standards, and regulations should be enforced more consistently by regulatory entities, to reduce or eliminate tolerance for breaches in regulations.
- Regulatory agencies need to be empowered and funded to better monitor and enforce regulations. Without stronger regulation, wastewater facilities will not adhere to monitoring and maintenance best practices, and improper maintenance of facilities will give NBS a poor reputation for meeting standards.
- Policy directives and the associated environmental agencies should encourage the use of NBS for wastewater management specifically.
- The roles and responsibilities of the multiple government entities involved in the management of wastewater should be clarified under various pieces of legislation. This approach would foster collaboration and coordination and reduce the inefficiencies of the existing management mechanisms.

Education, Awareness, and Design

- Public awareness of wastewater issues needs to increase. A joint campaign with national water conservation organizations could share actions that the general public can take to improve wastewater management.

- Engineering teaching (degree and other) programmes and continuing education for practicing engineers should codify and clarify that NBS is one type of engineered system. This coursework should clearly convey how NBS differs from traditional grey solutions, what options hybrid solutions offer, and what benefits and costs are associated with NBS.
- Newer technologies need to be introduced to overcome the large land requirements of some of the commonly used NBS and still meet the effluent standards.
- Deep cultural issues and psychological barriers need to be overcome with respect to discussion of wastewater in general. There is an “out of sight, out of mind” attitude to wastewater and the issue is often only discussed when incidents are affecting people or communities personally. Public awareness campaigns can change the cultural perception and associated barriers, over time.
- More data are needed on wastewater facility design, operation, maintenance, monitoring, and effluent quality to help assess the current situation and inefficiencies. One national entity could house all such data to enable more efficient analysis, planning, and execution of wastewater management measures.

Funding and Prioritization

- Sustainable, dedicated funding for NBS for wastewater management is needed. Local and national government agencies have both human and financial resource constraints that affect their ability to supply potable water, a higher priority issue that leaves fewer resources available to tackle wastewater treatment.
- Wastewater should be promoted as a resource, and related policy and enabling conditions should be aligned to encourage or mandate its use as a resource.
- Public–private partnerships should be supported to engage in the large-scale reuse of treated wastewater and associated byproducts.

CONCLUSION

As Caribbean countries continue to grapple with the serious implications for biodiversity and human health of untreated and poorly treated wastewater, it is clear that NBS can and will play an important role. Pilot projects are proving successful, and local and global research on different NBS for wastewater management show that these types of projects are viable in the Caribbean.

Some consistent realities about NBS were clear across all countries studied:

- NBS can be applied across a range of sectors and scales – hotels, rural communities, urban areas, private sector businesses, and more;
- Public/private/civil society partnerships play an important role to make NBS viable and there is an opportunity for organizations like TNC and UNEP to work more closely together to address this issue;
- Global and regional legal frameworks and commitments have a role to play in catalyzing national policy and legislative reforms and harmonized regional approaches (e.g. United Nations Environment Assembly (UNEA) Decisions, LAC Ministers, CARICOM Ministers and OECS Ministers of Environment, Agenda 2030 and SDG Commitments especially on SDG 6 on Water and Sanitation and SDG 14 on Oceans). UNEP Global Programme of Action and their Global Partnership on Wastewater and the LBS Protocol within the UNEP Cartagena Convention which forms the framework for all of projects and activities on wastewater management has an important role to play as well;
- As the understanding of the issue of wastewater management grows in the region, the more NBS projects include wastewater management “co-benefits,” the more the ocean-based economy/blue economy of SIDS will be protected. Efforts such as SPAW and LBS are promoting integration of NBS for wastewater management as part of an overall strategy to enhance SIDS ocean-based economies; and
- The more we maximize the use of donor grant funding and existing projects available for focusing on NBS, the more we can leverage public and private dollars to address wastewater management. Approaching this work from a combined pollution control, biodiversity conservation, climate change adaptation, water security and livelihood generation provides a holistic, “Source to Sea” solution set for many related issues in the Caribbean.

While many of these efforts show great promise, barriers remain to Caribbean wastewater management solutions, including NBS and grey infrastructure. Many countries lack the legal, regulatory, and financial means to implement widespread wastewater management. And without public awareness and political leadership on the issue, wastewater solutions—green or grey—will not be scaled enough in a timely fashion to have a significant impact on biological and human health.

To truly position NBS in a more prominent role for wastewater management, the underlying barriers must be addressed in a systemic and inclusive fashion. Increasing education and awareness, improving planning and design, investing more resources in scientific analysis and monitoring, enhancing legal and regulatory functions, and developing dedicated funding for water health will all be necessary for NBS projects to succeed. Until we make these investments, we will never know the true capabilities of NBS to finally address the long-standing need for wastewater management in the Caribbean.

ANNEX – ADDITIONAL RESOURCES

DOMINICAN REPUBLIC

Government Agencies and Departments

- **Corporación del Acueducto y Alcantarillado de Santo Domingo (CAASD)** - Water Utility and Sewage management for Santo Domingo. Executive Director Felipe Subervi, info@caasd.gob.do Assistant Carlos Montas, Carlos.montas@caasd.gob.do
- **Corporación del Acueducto y Alcantarillado de Santiago (CORAASAN)** - Water Utility and Sewage management for Santiago. Executive Director Andrés Burgos, aburgos@coraasan.gob.do Assistant Jacqueline Cruz, jcruz@coraasan.gob.do
- **Instituto Nacional de Aguas Potables y Alcantarillado (INAPA)** - Water Utility and Sewage management at national level. Executive Director Wellington Arnaud, info@inapa.gob.do
- **Ministry of Environment and Natural Resources** – Responsible for issuing norms and regulation setting up limits for discharges of wastewater in superficial waters and aquifers. Deputy Minister of Coastal and Marine Resources, Jose Reyes, jose.reyes@ambiente.gob.do

NGOs and Community Groups

- **Yaque del Norte Water Fund** – Provides financial resources for the construction of wastewater management facilities. Executive Director Walkiria Estevez, direccion@fondoaguayaque.org
- **Plan Yaque** – Provide technical expertise for the design and construction of wastewater management facilities. Executive Director Humberto Checo, 27rganiza.checo@gmail.com
- **Santo Domingo Water Fund** – Provides financial resources for the construction of wastewater management facilities. Executive Director Patricia Abreu, direccionejecutiva@fondoaguasd.do
- **Fundación Reddom** – promote development initiatives that generate well-being, equity and environmental sustainability in rural areas. Executive VP Jesus de los Santos, jesus@fundacionreddom.org

HAITI

Government Agencies and Departments

- **Division of Quality of Life and Pollution Management, Ministry of Environment** – Responsible for the control of pollution and waste management and the preparation of the guidelines for the collection, disposal and treatment of waste. Executive Director, Astrel Joseph astreljo@yahoo.fr; Executive Assistant, Yvette Jean-Louis, yvettejeanlouis1976@gmail.com
- **Division of Water Resources and Division of Marine and Coastal Areas** at the Haiti Ministry of Environment- Director, Emmanuel Philippe jephilippesr@gmail.com
- **DINEPA (National Directorate of Water Supply and Sanitation)**. Water and Sanitation. Executive Director, Guito Edouard; Sanitation Director, Edwige Petit edou1@yahoo.com
- **Ministry of Public Health and Population (Ministère de la Santé Publique et de la Population)** – Responsible for solid waste management and public health in Haiti. Minister of Health and Population, Dr. Greta Roy Clement info@mspp.gouv.ht
- **Ministry of the Public Works, Transport and Communications** – Partners with waste management departments to fulfil their mission. Minister, Ing. Nader Joiseus cm@mtptc.gouv.ht; dg@mtptc.gouv.ht
- **Port Authority** – Responsible for Solid waste management. Director, Hervé ÉVEILLARD apn@apn.gouv.ht / apnpap@apn.gouv.ht
- **Service National de Gestion des Residus Solides (SNGRS), Ministry of Public Works, Transport and Communications** – Responsible for the collection and disposal of municipal waste. info@mde.gouv.ht

Legislation and Policies

- **Waste and Public Health Laws: Presidential Decree (1981)** – Provides for the creation of a Solid Waste Metropolitan Collection Service and laws governing the management and the elimination of wastes and appropriate sanctions for perpetrators.
- **Fishing and Settlements and Urbanism Laws: Presidential Decree (1978)** – Sub-project B outlines regulations relative to the collection and storage of garbage in the metropolitan area of Port-au-Prince. Sub-project C relates to the clean-up, distribution and rectification of the pluvial waters existent evacuation system.
- **Marine Laws: Le Moniteur (No. 29 of 1975)** – Sanctions the Washington Convention (1972) on the prevention of the pollution of the seas resulting from the immersion of wastes.

NGOs and Community Groups

- **USAID** – WASH Program implemented through grantees
- **Cooperative Housing Foundation (CFH)** – Conducts a solid waste management programme in the Port-au-Prince metropolitan area. <http://www.globalcommunities.org/haiti>

- **EnviroSynergy** – Focuses on environmental awareness, education and conducts recycling programmes.
- **Foundation for the Protection of Marine Biodiversity (FoProBiM)** – Local Haitian NGO conducts annual beach clean-ups as part of the International Coastal Cleanup and the development of educational materials. Director, Jean Wiener jeanw@foprobim.org
- **Haiti Survie/ Friends of the Earth** – Develops solid waste management programmes and conducts awareness campaigns. Campaign for environmental issues. <http://hsurve.org/>
- **Haitian Collective for the Protection of Environment and Alternative Development (COHPEDA)** – Umbrella organization that deals with toxic waste disposal in Haiti.
- **Oxfam America** – Conducted a pilot project to support the waste collection system in the Carrefour Feuilles Community in Port-au-Prince. info@oxfamamerica.org
- **WASTEK**
- **Hydroplan** – German NGO involved in water and sanitation. Director, Gesellschaft mbH info@hydroplan.de
- **UNDP/Haiti** – Has been involved in targeted pilot wastewater projects in Haiti. Sendy Augustin Salomon augustin.salomon@undp.org
- **ONU-Environment** – Has been involved in targeted pilot wastewater projects in Haiti. Country Director, Fabien Monteils fabien.monteils@un.org
- **4ocean Haiti** – recover ocean plastic and marine debris in Haiti info@4ocean.com
- **CDC** – The US Center for Disease Control- works with DINEPA (National Directorate of Water Supply and Sanitation) in Haiti to support waste management initiatives

Marine Litter Awareness Programs/ Activities

International Coastal clean-ups – The ICC is conducted annually on the coastlines and in waterways within Haiti. The UN Stabilization Mission in Haiti (MINUSTAH) also conducts beach clean-ups and educates and informs the residents of Cap-Haitien, Les Cayes and Lully about protecting and cleaning their marine and coastal environment.

Web Articles on wastewater and waste in Haiti

- <https://www.cbd.int/doc/meetings/mar/mcbem-2014-03/other/mcbem-2014-03-115-en.pdf>
- <https://www.cdc.gov/globalhealth/stories/sanitation-saves-lives.html>
- <https://www.cdc.gov/cholera/haiti/2010-outbreak-response.html>
- <https://www.npr.org/sections/thetwo-way/2016/08/18/490468640/u-n-admits-role-in-haiti-cholera-outbreak-that-has-killed-thousands>
- <https://news.un.org/en/story/2020/01/1056021>
- <https://www.npr.org/sections/goatsandsoda/2017/07/29/537945957/you-probably-dont-want-to-know-about-haitis-sewage-problems>
- <https://www.theguardian.com/global-development/poverty-matters/2014/jun/05/haiti-drastic-plastic-problem-help-vulnerable>
- <https://www.iadb.org/en/news/idb-announces-innovative-solution-address-ocean-plastic-pollution-haiti>
- <https://www.4ocean.com/blogs/blog/4ocean-haiti-log-2-a-day-in-the-life>
- <https://www.haitilibre.com/en/news-5685-haiti-environment-new-wastewater-treatment-plant.html>

JAMAICA

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GRENADA

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Global Blue Innovation Institute	Dr. Angus Friday		angus.friday@gmail.com ; climatesmartgrenada@gmail.com			

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