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VALUING THE COSTS AND BENEFITS OF IMPROVED WASTEWATER MANAGEMENT

AN ECONOMIC VALUATION RESOURCE GUIDE FOR THE WIDER CARIBBEAN REGION

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VALUING THE COSTS AND BENEFITS OF IMPROVED WASTEWATER MANAGEMENT:

An Economic Valuation Resource Guide for the Wider Caribbean Region

Submitted by:

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World Resources Institute

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**The views in this report represent the personal views of the authors and do not necessarily represent the views of WRI.*

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Report Components:

PART I: SUMMARY REPORT

PART II: ECONOMIC VALUATION GUIDANCE

ANNEX 1: CHARACTERIZATION FORM AND TECHNICAL SUMMARY TEMPLATES

ANNEX 2: SUPPLEMENTARY MATERIALS

A. GLOSSARY
B. ECOSYSTEM IMPACTS TABLE
C. HUMAN HEALTH IMPACTS TABLE
D. WASTEWATER INFRASTRUCTURE COMPARISON TABLE

ANNEX 3: CHARACTERIZATION RESULTS

A. ISLA COLON, PANAMA
B. SOUTHWEST TOBAGO
C. CHAGUANAS, TRINIDAD

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Table of Contents for Part I

1. Introduction

The GEF CReW project

Wastewater management in the Wider Caribbean Region is a major challenge – the lack of resources and infrastructure to properly treat wastewater has led to water pollution resulting in negative impacts to important coastal and freshwater ecosystems and to human health. Across the region, 80% of domestic wastewater entering the Caribbean Sea remains untreated; 51.5 % of households lack sewer connections; and only 17% of households are connected to acceptable collection and treatment systems (GEF CREW 2012).

The Caribbean Regional Fund for Wastewater Management (GEF CReW) project was established to help remedy the regional wastewater problem. The four year project is funded by the Global Environment Facility (GEF) and is being implemented by the United Nations Environment Program (UNEP) and the Inter-American Development Bank (IDB). The overall objective of the project is to, "in the context of the Cartagena Convention and LBS Protocol[1], pilot revolving financing mechanisms and their wastewater management reforms that can be subsequently established as feasible instruments to provide sustainable financing for the implementation of environmentally sound and cost-effective wastewater management measures." The GEF CReW project is segmented into five components covering: I) investment and innovative financing; II) capacity building for reforms of wastewater management; III) communication, outreach and training; IV) monitoring and evaluation; and V) project management.

WRI study objectives

Under Component II of the GEF CReW project, the World Resources Institute (WRI) initiated a study in 2014 to examine the trade-offs between ecosystem and human health and the costs of investing in improved domestic wastewater management for three pilot sites in Trinidad and Tobago and Panama. The overarching objectives of the study are to improve the regional understanding of the connections between wastewater treatment and human and ecosystem health and to enhance the capacity within the Wider Caribbean Region for conducting economic valuations related to wastewater management investments. The main research question address by this resource valuation study is:

> *What are the benefits to ecosystems and human health compared to the costs of investing in improving domestic wastewater management?*

The main components of this study include three pilot economic valuation studies in Trinidad and Tobago and Panama, and development of a generalizable economic valuation approach (applicable for any Caribbean country) interested in this research question. The three pilot sites were selected from within Trinidad and Tobago and Panama based on input from the in-country executing focal points. The executing focal points for the study are the Trinidad and Tobago Environmental Management Authority (EMA) and the Panamanian Ministry of Environment (MdA). The pilot sites selected were the Buccoo Reef / Bon Accord area in Southwestern Tobago; the Borough of Chaguanas, near the Caroni Swamp in Trinidad; and Isla Colon in Bocas del Toro Provence, Panama.

[1] The Protocol on the Control of Land Based Sources of Marine Pollution (LBS Protocol).

The economic valuation approach is meant to be highly participatory. As such, steering committees were established for both countries to assist with valuation design, data collection, and dissemination of results. Additionally, introductory workshops were held in all three pilot sites in October or November of 2014 to raise awareness of the study objectives, gain input on data sources and key ecosystem and human health impacts to consider, and help define current and future wastewater management alternatives. Follow-up workshops were also held in each country in June or July of 2015 to share the valuation approach, present preliminary results to raise awareness and request data clarification, and conduct further data collection for the pilot sites. Workshop participants included steering committee members and a wider audience of applicable stakeholders with a direct or indirect interest in wastewater pollution issues.

Why economic valuation?

Economic valuation is frequently promoted and/or required by government agencies that need to prioritize infrastructure investments to: a) meet the needs of a growing population; b) plan for disaster risk management; or c) meet regulatory or environmental quality objectives (Talberth et al. 2013). Many studies have recently called for more economic valuations to facilitate design and implementation of water resources management (Birol and Koundouri 2006) and to bridge the gap between scientists and decision-makers (Korsgaard and Schou 2010) in understanding the biophysical connection between public investments and ecosystem and human health impacts. In the Wider Caribbean Region, economic valuation of coastal ecosystems has contributed to better informed and more holistic decision-making about resource use, justified policies and investments that protect coastal ecosystems or promote their sustainable use, and identified sources of finance for coastal conservation (Kushner et al. 2012). An economic perspective on natural resource management and human health is indispensable for decision makers who invariably have to struggle with resource constraints and trade-offs while designing and implementing development policies.

Overview of report contents

This report is intended to serve as a comprehensive resource guide for conducting an economic analysis for the main research question – a comparison of the costs of investing in improved domestic wastewater management with the benefits to ecosystems and human health. The report is divided into two parts and three annexes:

- Part I (this summary) provides an introduction to the study, the challenges associated with wastewater management in the Wider Caribbean Region, an overview of the proposed economic valuation approach for comparing the costs and benefits of improved wastewater management, and brief technical summaries of results from the three pilot sites.
- Part II provides guidance on conducting either a qualitative multi-criteria decision analysis or a quantitative benefit-cost analysis, based on data availability for the site of interest. This provides the reader with a recommended method for implementing a comparison of the costs and benefits of potential future investments in wastewater treatment.
- Annex 1 provides the “Characterization Form” which provides a structure for collecting and organizing information to be used in the comparison of costs and benefits.
- Annex 2 provides supplementary reference materials including:

A. A glossary of wastewater-related terms
B. A table providing examples and references of ecosystem impacts from wastewater pollution
C. A table describing human health impacts from wastewater pollution
D. A table comparing wastewater treatment technologies appropriate for the Wider Caribbean Region in terms of costs and design

- Annex 3 provides completed Characterization Forms for the three pilot sites in Panama, Tobago and Trinidad.

2. Wastewater management challenges in the Wider Caribbean Region: The need for improved treatment and valuation

This section provides a brief overview of wastewater management challenges in the Wider Caribbean Region and impacts to aquatic ecosystems and human health that result from the release of untreated or partially treated wastewater. Additional examples and documentation on impacts from wastewater can be found in the supplementary materials in Annex 2 (See sections B and C).

Status of wastewater treatment

Wastewater refers to water that has been used for domestic, manufacturing, industrial, agricultural, or commercial purposes. Domestic wastewater (often referred to as sewage) refers to wastewater from houses, public facilities, and businesses (e.g., hotels, inns, motels). Domestic wastewater can be divided between greywater and blackwater. Blackwater refers to wastewater from toilets (i.e., sewage), containing fecal materials and urine, while greywater is wastewater captured from sinks, showers, laundry machines, and dishwashers (UNEP 2001).

Untreated domestic wastewater contains a variety of pollutants including nutrients (e.g., total nitrogen and total phosphorus), fecal matter, pathogens (e.g., bacteria, viruses, parasites), organic particles, toxins (e.g., pesticides, herbicides), pharmaceuticals, solids (e.g., diapers, needles), and fats, oil, and grease (Pescod 1992).

Typically, wastewater treatment and coastal and fresh water quality standards are established by governments to limit the release of untreated domestic wastewater to receiving water bodies (e.g., oceans, rivers), and ensure that pollutants do not exceed a certain level that is deemed dangerous to ecosystem and human health. Some countries also establish bathing water quality standards for fresh and/or coastal water bodies. In 1999, Governments of the Wider Caribbean Region recognized the importance of wastewater pollution issues by signaling their commitment to reduce marine pollution from untreated wastewater by agreeing to the Protocol on the Control of Land Based Sources of Marine Pollution (LBS Protocol). The LBS Protocol is a regional mechanism designed to help United Nations Members in the Wider Caribbean Region meet their commitments under two international agreements – the United Nations Convention on the Law of the Sea and the Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities (UNEP CEP 2015). The LBS Protocol forms part of the only legally binding regional agreement for the protection and development of the Caribbean Sea – the Cartagena convention. Under the LBS Protocol, Caribbean signatories agree to reach specific water

quality standards (in addition to national water quality standards) to reduce impacts of wastewater on the marine environment.

A report by UNEP (2001) provides an overview of wastewater treatment in the Wider Caribbean Region. The report states that, "*For the most part the degree of [wastewater] collection is poor. Even in places where most of the population is served by collection, as in Trinidad and Tobago, the degree of treatment is very poor resulting in reduced environmental quality of rivers and coastal areas*." The report further states that operational conditions of sewage/wastewater treatment plants in the region are poor, with approximately two-thirds of wastewater treatment plants being poorly maintained. The most widely used wastewater treatment method in the region is on-site treatment, including septic tanks, soakaways, and pit latrines. In areas where soil conditions do not permit sewerage, wastewater effluent is disposed of in street drains. Finally, in terms of the policy and institutional frameworks for the Wider Caribbean Region with regards to wastewater, the report states, *"The degree to which these legal instruments are applied varies from country to country, and in many cases, the legislation is not enforced. The enforcement of the regulations of these legislation is also hampered by the lack of the necessary infrastructure. Moreover, these regulations tend to be dispersed in general environmental legislation such as fisheries, navigation, etc. There is little doubt that the enforcement of the above regulations may at times conflict with other local interests such as the rapid development and diversification of new industries and resort complexes, particularly in those countries with economies in transition […] Consequently, it is very clear that for many countries of the WCR to meet the obligations of the LBSP Protocol in the future, it will be necessary to seriously consider appropriate strategies to cope with increasing pollution loads affecting their coastal areas."*

In general, the region has experienced a lack of investment in wastewater infrastructure for the following reasons (IADB 2012 and Janson 2014):

- Low priority given to investment in wastewater treatment (relative to water provision)
- Capacity constraints of many utilities and other service providers
- A lack of sufficient and stable long-term funding for utilities
- Households and businesses have a low willingness to pay for wastewater services
- Low level of risk mitigation mechanisms
- Inadequate and poorly enforced policies and laws
- Poor communication and collaboration amongst involved agencies
- Limited awareness, knowledge and understanding of alternative and appropriate treatment technologies
- Limitations in technical capacity for environmental management

Lack of investment in wastewater infrastructure and infrastructure maintenance, use of some wastewater treatment technologies which are difficult to maintain, and a lack of or poorly enforced political and institutional framework for monitoring wastewater effluent can lead to severe negative impacts to ecosystems and human health, and hence, economic costs for Caribbean countries. These impacts are briefly discussed below, with additional information provided in Annex 2, Sections B and C.

Why is untreated and poorly treated wastewater a concern?

i. Ecosystem issues related to wastewater

Freshwater, coastal, and marine ecosystems can be impacted by partially treated and untreated wastewater effluent. Numerous Caribbean ecosystems are vulnerable including rivers, forests, wetlands, mangroves, coral reefs, beaches, and seagrasses. These ecosystems provide valuable services to society (i.e., ecosystem goods and services) that have demonstrable market and/or non-market value. For example, Burke et al. (2008) found that the Buccoo Reef in Tobago provides valuable shoreline protection, tourism and recreation, and fisheries habitat services. In total, these services provided an estimated annual value of $120 - $164 million USD. Table 1 provides examples of the goods and services provided by coastal ecosystems:

Table 1: Ecosystem goods and services provided by coastal ecosystems (Source: Waite et al. 2014)

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Provisioning services				
Food (e.g., fisheries)	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources	X	X		X
Genetic resources	X	X		X
Regulating services				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Cultural services				
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Supporting services				
Primary production	X	X	X	X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X

The primary pollutants of concern from wastewater for aquatic ecosystems include nutrients (e.g., total nitrogen and total phosphorus), pharmaceuticals, total suspended solids, heavy metals, and pathogens (e.g., bacteria). Nutrient pollution is a primary concern for ecosystems because of eutrophication, whereby increased nutrients result in algal growth or toxic algal blooms that deplete water bodies of oxygen, and can harm marine animals, coral reef, seagrass beds, and mangroves (UNEP CEP 2015b). Sediment pollution is also a concern for coral reefs and seagrass, which require sunlight to thrive (Burke

et al. 2011). Finally, pharmaceuticals contain chemical compounds which can be dangerous to marine life (NOAA 2015).

ii. Human health issues related to wastewater

Domestic wastewater contains enteric bacteria, viruses and protozoa which can cause several types of diseases in people exposed to these waters. Some of the most common ailments include gastroenteritis, acute respiratory disease (ARD), and eye, ear, and skin infections (Dwight et al. 2005; Fleisher et al. 1993; Fleming et al. 2006). Additionally, exposure to toxins associated with algal blooms poses significant human health risks. Human excreta can also result in contraction of numerous infectious diseases including cholera, typhoid, and hepatitis (UNEP 2001).

The primary pollutants of concern for human health include microbial pathogens (frequently found in human and animal excreta), nutrients, heavy metals, chemicals (including pharmaceuticals), and other organic compounds (UNEP 2001). Exposure pathways for wastewater-related illnesses include bathing or swimming in contaminated water, eating contaminated seafood, inhalation of contaminated waters, exposure to an infected person, and mosquito bites.

In 2003, a study by Shuval estimated that polluted coastal waters generate 120 million excess cases of gastroenteritis and 50 million excess cases of ARD annually, resulting in a global cost of $12 billion per year in public health expenses.

Economic valuation of wastewater management

A review of peer-reviewed and grey literature found that, overall, there have been very few economic valuation studies that estimate ecosystem and human health impacts related to improving domestic wastewater management - reflecting the challenge of addressing this research question.

Studies that have tried to value ecological or environmental impacts related to wastewater have generally employed stated-preference valuation methods like contingent valuation or shadow pricing (Hernandez-Sancho et al. 2009; Molinos-Senante et al. 2010). For example, Molinos-Senante et al. (2010) conducted a benefit-cost analysis to compare the economic feasibility associated with implementation of different wastewater treatment plant (WWTP) infrastructure options for a study site in Spain. The authors state, “The quantification of the costs associated with the operation of WWTPs is straightforward because these costs are strictly controlled by the operating companies.” To calculate environmental benefits, the authors employed a shadow pricing approach, whereby prices are established for undesirable outputs (e.g., pollutants) obtained from wastewater treatment as a proxy for environmental impacts. The authors assume that the benefit to the environment is equal to the price associated with the price of extracting contaminants because “if they were dumped in an uncontrolled manner they would cause a negative impact on the environment.” The benefit of this approach is that the valuation practitioner does not need to estimate a change in water quality or a change in ecosystem and ecosystem service condition. However, the shadow pricing approach for estimating environmental impacts has been heavily criticized (Koorsgaard and Schou 2010). Shadow pricing does not truly capture the benefits related to ecosystem health improvement precisely because it does not attempt to understand how ecosystem conditions change in response to water quality improvements, and the

value society places on related ecosystem services. As such, this report does not recommend use of the shadow pricing method.

Other studies have tried to capture ecosystem improvements through non-market valuation methods, primarily stated-preference approaches like contingent valuation which rely on estimates such as a populations' willingness to pay for wastewater treatment or improvement in environmental conditions (Bergstrom et al., 2000; Bateman et al., 2006; Birol et al., 2006; Del Saz et al., 2009; Genius et al. 2005; Tziakisa et al. 2009). Use of stated-preference approaches, however, is also controversial. While methods like contingent valuation can be useful for understanding a local population's willingness to pay to improve wastewater quality improvement, there is no consensus in the scientific literature on the validity of this approach for valuing ecosystems goods and services (Molinos-Senante et al. 2010). Additionally, there are inherent biases associated with stated preference approaches as it may be difficult for people to value trade-offs, for example between cost of wastewater infrastructure and ecosystem health, which they have not personally experienced or are knowledgeable about (e.g., if they have not visited a specific ecosystem) (Koorsgaard and Schou 2010).

Some studies have focused on a specific ecosystem service such as tourism. For example, preliminary results from an analysis of tourism response to a change in environmental attributes in Barbados suggest that coastal water quality is a very important factor for tourists in selecting a travel destination. Approximately two-thirds of respondents stated that they would probably not or definitely not return to Barbados if the quality of seawater were to diminish such that the probability of a stomach infection were to increase by any amount.[2]

In terms of valuing human health impacts from improved wastewater management, the literature has focused on using dose-response relationships to determine the population at risk of contracting an illness like gastroenteritis due to exposure to water contaminated with domestic wastewater (Given et al. 2006; Dwight et al. 2005). The cost of illness is then estimated based on health damages (e.g., medical costs due to hospital visits and medication, lost income due to illness). Annex 2, section C provides more details on human health illnesses and relevant wastewater pollutants.

Challenges related to economic valuation of wastewater

Valuing the ecosystem and human health benefits of improved domestic wastewater treatment is challenging and requires multiple stages of analysis – estimating how reduced pollutant loading will influence water quality; how ecosystem condition and human health will change in response to the change in water quality; how the change in ecosystem condition (such as live coral cover on a coral reef) will influence ecosystem service provision (such as tourist visitation to the reef); and how people value a change in ecosystem service provision and human health risks. Some of the particular challenges are:

- For many areas of the world, water quality data simply aren't available, so tracking changes in water quality and ecosystem and human health response is not possible.

[2] The analysis is being conducted by University of North Carolina – Wilmington, the Caribbean Tourism Organization, and the World Resources Institute.

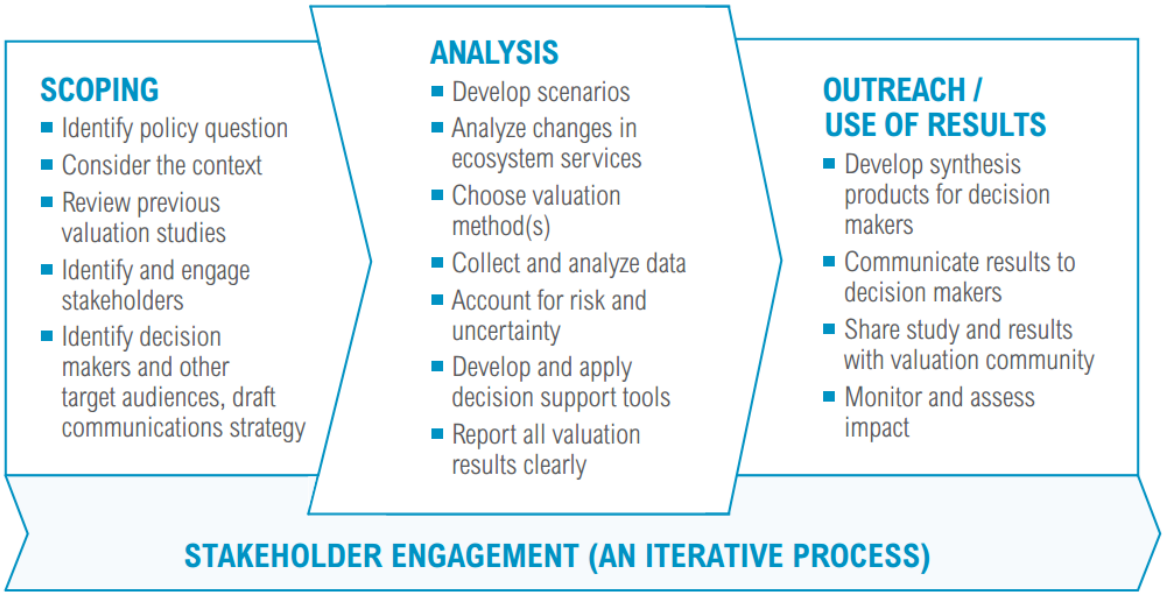
- For many areas of the world, statistics on health data (e.g., number of cases of gastroenteritis) are also not available.
- It is difficult to forecast how an ecosystem will respond to a change in water quality, either to a given pollutant or to multiple pollutants. Biophysical models are required for such analysis, and may not be available for all geographic settings. It is also difficult to forecast how ecosystem service provision will change in response to a change in ecosystem condition.
- It is difficult to determine how many cases of wastewater-related diseases like gastroenteritis are directly attributable to domestic wastewater pollution because there are other risk factors. For example, there might be additional sources of water pollution than domestic wastewater which contain the same pollutants, and some illnesses are also attributable to non-water related risks.

Given these challenges, the valuation guidance provided here is designed to provide decision support tools for comparing costs and benefits of different domestic wastewater investment scenarios for both data rich and data poor environments. The qualitative decision support tool, Multi-Criteria Decision Analysis (MCDA), provides a narrative approach for understanding these biophysical connections based on best available data and expert input, and allows those interested in the research question to weigh the benefit and cost trade-offs based on a key set of criteria deemed important for decision-making including changes in costs, water quality, ecosystem impacts, and human health impacts. The quantitative decision support tool, Benefit-Cost Analysis (BCA), requires understanding and quantifying the biophysical connections between a wastewater management investment, the resulting change in water quality, and the resulting change in provision of ecosystem services and human health risks demonstrated by incidence of wastewater-related illnesses.

3. Economic valuation of wastewater management investments

This section presents a brief overview of the economic valuation approach promoted for Caribbean stakeholders for the consideration of trade-offs of investing in wastewater management improvement. The guidance provided here builds largely on the ecosystem valuation framework established by the World Resources Institute (WRI) (Waite et al. 2014) in the guidebook, "Coastal capital: Ecosystem valuation for decision-making in the Caribbean," (hereafter referred to as the Coastal Capital Guidebook) but adjusted to include guidance on estimating health benefits. The Coastal Capital Guidebook focuses on conducting economic valuations that influence decision-making, and includes three phases: (1) Scoping; (2) Analysis; and (3) Outreach (see Figure 1). The guidance presented briefly in this section and in Part II follows this general three phase approach, although the sub-steps have been redesigned to focus on issues related to wastewater management and include an evaluation of the benefits to human health.

Figure 1 - Good practice for ecosystem valuation to influence policy (from Waite et al. 2014)



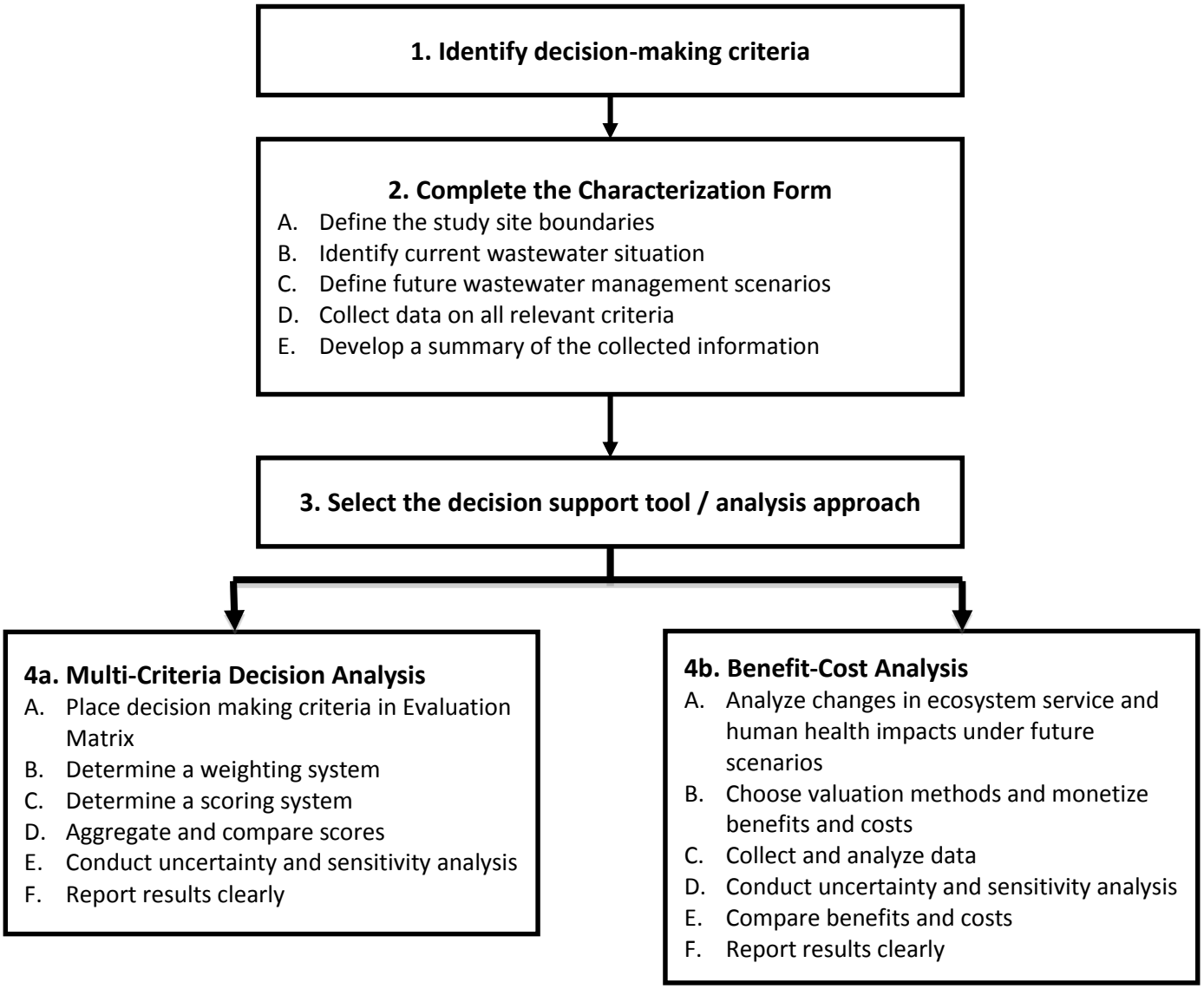
The **Scoping** phase is designed to explicitly define the policy question; identify key stakeholders to engage throughout the valuation process (for data collection, awareness raising, or decision-making purposes); identify useful literature and data including economic valuation and scientific studies to support valuation efforts; identify key evaluation criteria for decision making; and identify target audiences for dissemination and communication of results.

The **Analysis** phase includes extensive data collection, followed by evaluation of that data to inform the choice of a valuation approach and decision support method. Figure 2 provides a summary of the analysis steps and options. The main steps in the process are 1) Identify the key decision-making criteria for evaluating wastewater treatment options; 2) Use a Characterization Form to define the study site, develop an understanding of the current wastewater management situation, identify future wastewater management scenarios, and collect data on relevant decision-making criteria; 3) Decide whether the available information is sufficient to support quantitative analysis (BCA), or whether qualitative analysis (MCDA) is more appropriate; and 4) Compare costs and benefits of wastewater management options using either a MCDA or BCA. As many sites in the Wider Caribbean Region are data-poor, the guidance in Part II is designed to be pragmatic and flexible to accommodate varying degrees of data availability and knowledge regarding wastewater infrastructure investments.

Both BCA and MCDA are decision-support tools relevant to situations where decision makers are interested in comparing infrastructure investment scenarios (or options) based on both benefit and cost considerations. BCA allows decision-makers to compare scenarios based on a quantitative metrics and requires monetization of benefits and costs. The infrastructure scenario that maximizes net benefits can easily be identified as the best investment option. MCDA is a qualitative decision-support tool that can be used to determine overall preferences among different investment options by scoring and ranking

infrastructure scenarios for a key set of decision-making criteria (UNFCCC 2014). MCDA is applicable in situations where decision-makers are interested in comparing benefits with costs but where not all benefits and costs can be monetized. It also has the advantage of allowing decision-makers to weigh the trade-offs for infrastructure scenarios based on non-quantitative factors (e.g., operational complexity of wastewater infrastructure). Key outputs from MCDA can include a single preferred infrastructure scenario for consideration, a ranking of options, a condensed list of scenarios for future consideration, and/or a characterization of acceptable or unacceptable scenarios (UNFCCC 2014).

Figure 2 - Analysis steps for conducting a wastewater valuation analysis



The Scoping and Analysis Phases are discussed in depth in Part II of this report.

Finally, the **Outreach** step is designed to communicate economic analysis results to target audiences to influence decision-making regarding wastewater investments. More information on Outreach is provided in the next section.

4. Outreach

This section provides general guidance on developing a communications strategy for sharing and raising awareness of valuation results. This section is informed both by the Coastal Capital Guidebook and by discussions with stakeholders through workshops conducted in the pilot site countries. The following steps are included in an outreach strategy for release of economic valuation results:

1. Develop synthesis products for valuation results for targeted stakeholders (as identified in the Scoping phase)
2. Communicate valuation results to decision-makers
3. Share the study and results with the wider coastal valuation community
4. Monitor and assess the impact of the economic valuation study

Develop synthesis products

Synthesis products of valuation results can range from comprehensive and summary technical reports to non-technical reports, brochures, and videos, as well as press releases, blogs, and other media-friendly products. Products should be tailored towards the intended audience. For example, administrators within relevant government agencies or ministries (e.g., the Minister of Environment or the Minister of Finance) may appreciate a short technical report with valuation results and key talking points. Conversely, community members including local residents, tourism operators, and businesses might respond better to non-technical products (e.g., blogs, newspaper articles, educational videos, or short pamphlets).

The Coastal Capital Guidebook provides other valuable tips for developing synthesis products including:

- It is important to be adaptive and revisit the communications strategy to accommodate changing circumstances such as changes in local or national government.
- Release of synthesis products should target "windows of opportunity" whenever possible to improve uptake of results (e.g., impending legislation, policy debates, investment decisions).
- Social media and other online outlets should be leveraged to raise awareness.
- Synthesis products should consider what metrics best reach their target audiences. Example metrics include:
    - Changes in GDP
    - Changes in employment (e.g., due to wastewater-related illnesses)
    - Changes in tourism income or revenue due to a decline in ecosystem and human health
    - Damages avoided to ecosystems
    - Incidence of wastewater-related illnesses
    - Distributional effects (winners and losers)

- Synthesis products should include visuals to help display results and trade-offs between wastewater costs and benefits. Visuals can include charts, graphs, summary tables, pictures, and maps.

Through completion of the Characterization Form, which is a questionnaire designed to collect data on important decision-making criteria for wastewater investments, the economic valuation practitioner will have gathered a lot of data and information. The Characterization Form is intended to provide the background data for the economic valuation practitioner to complete a BCA or MCDA. Additionally, the Characterization Form can be used to develop outreach materials to raise awareness that the study is being conducted and to help with data collection by highlighting key wastewater, health, and ecosystem issues, data gaps, and wastewater scenarios in a format more accessible for key stakeholders. For example, the technical summary template in Annex 1 could be used *before* the analysis is complete. Additionally, the Characterization Form could be used to inform a written narrative, such as a press release or brochure that communicates the story behind the analysis.

There are also several options available for presenting results from the economic analysis using either BCA or MCDA. More technical audiences from the financial, economics, wastewater or environmental sectors may wish to know the details and assumptions behind the economic analysis. For example, the technical summary template (provided in Annex 1) could also be used *after* completion of the analysis to again highlight key issues, knowledge gaps, and wastewater scenarios, but also to highlight MCDA or BCA results. This template was used for the three pilot site summaries found later in this section. Additional technical synthesis products might include white papers, working papers, or detailed reports.

Less technical audiences, including community members and tourism organizations, might be less interested in the analysis details and more interested in lessons learned or take-away messages – that is, what do results mean for them in terms of their health, their environment, and access to wastewater treatment? Synthesis products might include brochures, press releases, videos, or other educational materials.

Communicate valuation results to decision-makers

It is important to include decision-makers in the production, interpretation, and dissemination of results. Valuation practitioners and others involved with outreach should consider what type of messaging is likely to reach decision-makers, as well as channels for reaching decision-makers. The Coastal Capital Guidebook states that "results co-produced with partners, other stakeholders, and local 'champions' within decision-making bodies tend to achieve the greatest influence." Examples of channels for communicating and disseminating results and recommendations include:

- Traditional media
- Social media (e.g., Facebook, Twitter)
- Launch events
- Stakeholder workshops or other public meetings
- Partners' networks
- Targeted private meetings

- Relevant conferences and events information campaigns—advertisements or social marketing
- Tourist education (e.g., on importance of coral reefs and responsible diving)
- Websites

During the scoping phase, the practitioner may wish to engage stakeholders to understand which communication channels are best suited for the study area and for certain stakeholder groups. For example, government agencies may respond better to targeted private meetings, conferences, and press releases, whereas community members may respond better to social media and tourist education.

Share the study and results with the wider coastal valuation community

Beyond sharing results with valuation study stakeholders identified in the scoping phase, it is also important to disseminate results more widely, with the coastal valuation community. The Coastal Capital Guidebook provides examples of ecosystem valuation databases commonly used by economists (e.g., MESP - http://www.marineecosystemservices.org/, Ecosystem Services Partnership—http://www.es-partnership.org/esp, Environmental Valuation Reference Inventory-- https://www.evri.ca/).

Monitor and assess the impact of the economic valuation

Finally, it is important to track the impact of synthesis products and the economic valuation itself to see if it is being used by decision-makers. If not, the communications strategy may need to be revisited. Tracking influence can be difficult and can take weeks to years. However, the Coastal Capital Guidebook provides simple steps to do this:

- Build influence tracking into the valuation project through open communications between the valuation practitioner, partners, target audiences, and other stakeholders. Practitioners can follow up with partners and stakeholders periodically, even after all formal outreach activities have occurred, to see if there have been any additional uses of the study in decision making.
- Encourage local stakeholders—especially those interested in conducting their own valuations—to contact the valuation practitioner when an outcome occurs, and to engage directly with the wider valuation community (to help publicize cases of use of valuation in decision making and to increase the effectiveness of ecosystem valuation as a tool to further conservation and sustainable development goals).
- Work with the valuation community to develop more standard and systematic approaches to monitor, evaluate, and report on the use of coastal valuations in decision making. As a first step, databases such as MESP could be augmented to include a field to describe the observed uses of each valuation study, which could be updated over time as new uses are observed.

5. Overview of results for pilot sites in Panama, Tobago and Trinidad

This section presents short technical summaries of characterization and MCDA results for the three pilot sites in Trinidad and Tobago and Panama.

The data required to implement a full BCA were not available for any of the pilot sites. As such, MCDA was employed for each of the three pilots. In general, the three pilot sites lacked sufficient data on water quality (wastewater discharge, freshwater and coastal water quality); lacked sufficient detail on projections of future wastewater infrastructure options and costs, or estimates of costs for current wastewater infrastructure components and operations; and had limited data on ecosystem health or human health impacts related to wastewater. Another similarity is that while both countries have water quality standards in place for coastal water bodies, both faced constraints in terms of technical capacity and financing to monitor water quality.

Beyond data limitations, the pilot sites were also similar in terms of ecosystems being impacted by wastewater pollution. The major ecosystem types considered for the analyses include coastal mangroves, rivers, seagrass beds, beaches, and coral reefs.

The pilot sites varied in terms of the current infrastructure in place, the types of technologies that would likely be put in place in the future, the population size, and main economic drivers. For example, southwest Tobago and Isla Colon are largely eco-tourism driven economies, which include focus on coral reef ecosystems, whereas Chaguanas is a growing commercial center with limited tourism, though some visitors to Trinidad visit the Caroni Swamp.

The Characterization Forms for the pilot sites (See Annex 3) were all completed by WRI with support from wastewater and environmental authorities. During workshops organized by the in-country focal agencies in summer of 2015, stakeholders were asked to review Characterization Form and summary results, and to complete an MCDA exercise by completing an evaluation matrix. The Evaluation Matrix allows weighting and scoring of scenarios against a list of key criteria established by workshop participants. The scenario with the highest score is assumed to be the best option. Weighting and scoring both used a scale of 1 – 5, with 5 being the highest weight (most relevant criteria) and 5 being the highest score (best performance or lowest cost). (Guidance on conducting and interpreting MCDA results is presented in Part II.)

The short technical summaries for each pilot site, along with the results of the MCDA analyses, are included in the following pages. The MCDA exercise was useful in helping to generate MCDA guidance provided in Part II.

Overall, MCDA results for each pilot site suggest that the forecasted benefits from investment in improved wastewater management exceed the costs, as indicated by a higher score for the future scenario(s) as compared with the current wastewater management situation. The following brings out some common themes and some differences in the results:

- **Isla Colon, Bocas del Toro, Panama –** The pilot site in Panama centers on Isla Colon, which forms part of an archipelago in Bocas Province off the East coast of Panama. Two future scenarios were constructed with stakeholders during the follow-workshop held in Panama City in June 2015 by WRI and the Ministry of Environment. Both future scenarios received a score of 151 compared to the score for the current situation of only 122, which supports investment in improving wastewater management for the island. Reduced vulnerability appeared as an important factor in both scenarios. The two scenarios differed in terms of wastewater treatment capacity, which was offset by the scenario with better treatment capacity also having higher capital and recurring costs. All other criteria had identical scores. It should be noted that the understanding of the future scenarios has changed since the June workshop – the new understanding is reflected in the Summary and the Characterization Form for Panama in Annex 3.

- **Southwest Tobago -** Results from two workshops are summarized. In both cases, the future scenario is favored over the current situation - total scores of 195 and 162 for the future scenario vs. 111 and 97 for the current scenario (at the Port of Spain and Tobago workshops, respectively). Both sets of results support investment in the "future scenario," driven mostly by anticipated benefits in increased wastewater treatment capacity, improved ambient water quality, and (to a lesser extent) reduced impacts to ecosystems and human health.

- **Chaguanas, Trinidad** - The scenario for which the Water and Wastewater Authority (WASA) of Trinidad and Tobago had provided data was the focus of the MCDA, though WASA is now exploring a revised scenario for the area. Analysis results support investment in the future scenario evaluated, driven mostly by anticipated benefits in increased wastewater treatment capacity, improved ambient water quality, and (to a lesser extent) increased pollutant removal efficiency, reduced recurring costs and reduced ecosystem and human impacts.

Results for these pilots represent preliminary results. Ideally, in-country stakeholders will use these results as a starting point and conduct a more robust MCDA analysis following recommendations from this resource guide. Additionally, this report does not attempt to interpret results presented below and in Annex 3 beyond providing initial scores developed during workshops. Results should be interpreted by decision-makers in-country with guidance from the economic valuation practitioner(s).

Summary for Study Site: Isla Colon, Panama

Site Location:
The study site is Isla Colon, in Bocas del Toro Province in Panama. The study area includes the entire island (including Bocas Town), and coastal waters adjacent to the island. Bocas Town (the main population center) lies south of a narrow isthmus. The northern part of the island is primarily forest with some development, including new residential and commercial development. Isla Carenero is the neighboring island to the west of Isla Colon.

Figure 3: Google Earth image of Isla Colon (and Isla Carenero)

Key ecosystems in the area:

- Mangroves (Punto manglare)
- Coral Reefs (southern and western coast)
- Beaches
- Seagrass beds

Key ecosystem services and their values:

- Tourism – a primary source of GDP for Panama. Tourism and recreation in Isla Colon contributed approximately 1.8 million in 2014. Key tourism activities include boat tours, beach recreation, wildlife viewing, snorkeling, diving, kayaking, surfing, windsurfing, fishing, and visits to Smithsonian Tropical Research Institute.
- Fisheries – nearshore fisheries in la Isla Colon have not been assessed.
- Shoreline protection – the "damages avoided" due to the presence of coral reef and mangrove ecosystems have not been assessed.
- Carbon sequestration – mangroves, seagrasses, and associated soil are important stocks of carbon.

Population and Wastewater treatment

- Population estimate based on 2010 census data for Isla Colon is ~13,500 people.
- About 80% of Bocas Town (which houses the majority of the island's population) is connected to the WWTP. Approximately 523 indigenous families living in informal settlements near the treatment plant do not currently have any wastewater treatment so their sewage is disposed of directly in coastal mangroves.
- It is not clear whether the remaining 20% of the population in Bocas Town is using on-site wastewater treatment (e.g., pit latrines or septic tanks) or not using any form of wastewater treatment. Additionally, there may be developments north of Bocas Town (and the isthmus) that are not connected to the plant (or may not be managing wastewater treatment at all).
- IDAAN has a 5-year investment plan for Panama under the 100-0 plan (100% access to water and 0 pit latrines by 2019).

Current WW treatment situation / technology	Condition / Issues / Limitations	Operating Costs
One oxidation lagoon with an aeration system. The adjacent lagoon is not in use. The oxidation lagoon was established in 1991 and the aeration system was added in 2010.	- Current WWTP capacity is limited - Storm overflow events are frequent and release untreated sewage into adjacent coastal waters - Mangroves near WWTP receive discharge from adjacent indigenous population - IDAAN is not sure how many hotels and residences north of the isthmus have wastewater connections.	Estimated by IDAAN to be roughly $8,000/month.

Observed or likely impacts due to WWT situation:	Potential Economic loss:
• Water quality health risks, espcially for indigenous population who are thought to have a higher infant mortality rate that may be associated with exposure to untreated domestic wastewater in mangroves. • Ecosystem degredation (reduced biodiversity at Starfish beach, degradation of mangrove forests, possible degradation of coral reefs) • Decreased tourism may result if either of these conditions is realized and publicised.	- Loss of money from tourism. - Price of importing water or having to buy fish elsewhere if fish become contaminated. - Increased health costs related to gastroenteritis, food poisoning, and ear, eye, and skin infections, especially for swimmers, divers, and snorkelers.

WW Improvement Scenario 1[3]	Anticipated impacts	Cost (Capital and annual O&M costs)
• Connect Isla Carenero (a neighboring island) to WWTP in Bocas town by creating new sewerage lines. • Refurbish/expand the existing oxidation lagoon/aeration system for treatment. • Convert the non-functional lagoon into a dry lagoon for sludge.	• Increased capacity to treat wastewater and connect people in Isla Carenero to WWTP. • Reduced untreated wastewater entering coastal water bodies.	IDAAN and CONADES have estimated a budget of $12 million needed to improve the wastewater situation in Isla Colon – it is not clear if this applies to WW improvement option 1 or 2.
WW Improvement Scenario 2	**Anticipated impacts**	**Cost (Capital and annual O&M costs)**

[3] Note – since June, 2015, the understanding of the future wastewater management options for Isla Colon has changed. The Ministry of Environment states that the new understanding of future plans for wastewater treatment in Isla Colon is that the current WWTP in Bocas Town will be decommissioned and a new plant will be constructed. Additionally, the sewerage network will be extended to cover the entire population of the island. Not included in the scenario, but relevant for understanding ecosystem and health impacts for the island, is that a new WWTP will also be constructed for the neighboring island of Isla Carenero. Additionally, the sewerage network will be extended on that island. The total estimated cost for both islands is 15.5 million dollars.

• Connect Isla Carenero to WWTP in Bocas town by creating new sewerage lines • Refurbish/expand the existing oxidation lagoon/aeration system for treatment • Convert the non-functional lagoon into a second oxidation lagoon/aeration system.	• Increased capacity to treat wastewater and connect people in Isla Carenero to WWTP. • Reduced untreated wastewater entering coastal water bodies.	IDAAN and CONADES have estimated a budget of $12 million needed to improve the wastewater situation in Isla Colon – it is not clear if this applies to WW improvement option 1 or 2.

Comparing Wastewater Improvement Option(s) with Business as Usual

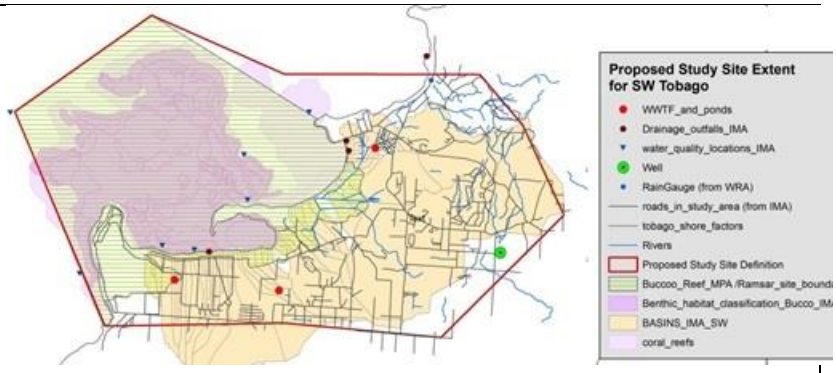
Based on data collected for Isla Colon through the Characterization Form, a MCDA exercise was conducted to determine which scenario – the current situation vs. two future wastewater management improvement scenarios – would be preferred. Stakeholders at a Ministry of Environment / World Resources Institute workshop in Panama City on June 25th, 2015 filled out an Evaluation Matrix by weighting and scoring a set of pre-established criteria for each scenario.

The Evaluation Matrix allows weighting and scoring of scenarios against a list of key criteria established by workshop participants. The scenario with the highest score is assumed to be the best option. Weighting and scoring both used a scale of 1 – 5, with 5 being the highest weight (most relevant criteria) and 5 being the highest score (best performance or lowest cost). Both future scenarios were rated as improvements over the current situation, with the two future options tied with a total of 151, compared with 122 for the current situation. The same weights are used for all scenarios. Reduced vulnerability was an important factor in both scenarios - this criteria has the highest weight (5) and was rated a two-point improvement (from 1 to 3). Scenario 2 was rated more highly on wastewater treatment capacity (with a two-point improvement). This is balanced by scenario 1 being more appealing in terms of capital and recurring costs (a two-point, as compared with one-point improvement). All other criteria had identical scores.

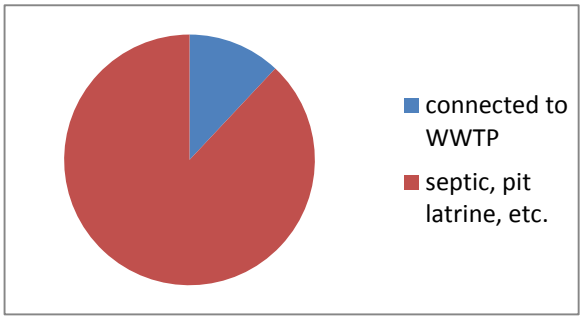
Multi-Criteria Decision Analysis results for Isla Colon pilot site

Criteria	**Weight**	**Score**		
		Current Situation	**Future Scenario 1**	**Future scenario 2**
Capital and recurring costs	5	3	2	1
Energy consumption	3	3	2	2
Wastewater treatment capacity	5	3	4	5
Vulnerability	5	1	3	3
Ambient water quality impact	5	3	4	4
Pollutant removal effectiveness	5	3	4	4
Untreated domestic wastewater	2	3	4	4
Ecosystem impacts	5	3	4	4
Human health impacts	5	3	4	4
Economic disruption/growth	4	3	3	3
Tally (Weight * Score)		**122**	**151**	**151**

Summary for Study Site: Southwest Tobago

Site Location:	
The study area is in SW Tobago, including most of St. Patrick's and parts of St. Andrew's parishes. The area includes the Buccoo Reef / Bon Accord ecological complex; the Courland, Buccoo, and Bon Accord water catchments; and the Bon Accord, Milford Court, Samaan Grove, Coral Gardens, and Buccoo communities.	

Key ecosystems in the area:	**Key ecosystem services and their values:**
• Coral reefs – the Buccoo Reef • Bon Acord Lagoon (including Nylon Pool) • Mangroves • Seagrass • Beaches	• Tourism – the primary source of GDP for Tobago. Over 60% of visitors to Tobago go on snorkel or glass-bottom boat trips to Buccoo Reef and many visit the Nylon pool. Tourism and recreation at Buccoo Reef contributed between US$7.2 and $8.8 million during 2006, and the amount is likely higher today. • Fisheries – coral-associated fisheries in Tobago contributed between US$0.8 and $1.5 million in 2006. • Shoreline protection – the "damages avoided" due to the presence of the Buccoo Reef are valued between US$140 and $250 million over a 25-year time period. • Carbon sequestration – mangroves, seagrasses, and associated soils are important stocks of carbon.

Population and Wastewater treatment	
• The study area included about 15,000 people (5,000 households) in 2011, based on a pro-rating of data from CSO. • Current population growth is ~1.2% per year. • Within Tobago, about 12% of the population is connected to a wastewater treatment plant (WWTP), with the remaining 88% using pit latrines, on-lot septic or soakaway systems.	

Current WW treatment situation	**Condition / Issues / Limitations**	**Operating Costs**
• Bon Accord / Milford Court WWTP – membrane bioreactor since 2003 • Buccoo / Coral Gardens WWTP - membrane bioreactor since 2004	- Not meeting water quality standards - Equipment past lifetime - Current needs exceed system capacity - During heavy rains, untreated wastewater is released into Bon Accord Lagoon and Buccoo Bay - Coastal waters also receiving pollutants from unauthorized	Annual capital expense TT$1.0 million per plant. There is also periodic (~ every 5 yrs) investment for major swap-out (maintenance) costing

• Waste stabilization ponds (WSPs) at Golden Grove and Bon Accord • Grey water from many homes is discharged directly into storm drains	developments, a fish processing plant, gray water discharge, and malfunctioning septic tanks, pit latrines, and soakaways	about TT$2-3 million per plant Annual operating expense TT$0.5 million per plant

Observed or likely impacts due to WWT situation:	**Potential Economic loss:**
• Elevated wastewater pollution during wet season; • Increased nutrient pollution in lagoon and on inner reef; • Higher biomass of micro-algae in lagoon and on reef; • Some occurance of algal blooms; • The inner portion of Buccoo Reef (facing lagoon) is degraded relative to the outer reef; • Mangroves are doing well under increased nutrients; • Seagrass harmed by increased sediments and competition with macro-algae. Shifts to turtle grass are a symptom of WW pollution. • **Possible health impacts are less clear.** Pathogens from WW are found in the study area, where people swim and fish. Diving companies report incidences of ear infections.	Tourism and recreation respond to degradation of coral condition, as well as to information about water quality impairment (for swimming on beaches, at nylon pool or snorkeling/diving). A degraded Buccoo Reef provides less protection of the shoreline, so increases risk of erosion and flooding.

WW Improvement Scenario 1 (Short-Medium Term Solution)	**Anticipated impacts**	**Cost (Capital and annual O&M costs)**
WASA funded a contractor (Alpha Engineering) to develop a short to medium-term solution for SW Tobago. Funding for implementation not yet identified. The plan includes expanding collection systems (using gravity lift stations), and linking more homes to waste stabilization ponds at Bon Accord and Golden Grove. • At Bon Accord, a small-bore system will transport liquid waste to the Bon Accord WSP, allowing elimination of dysfunctional package plants. • The Milford Court WWTP will be converted to anaerobic tanks, with effluent going to Golden Grove (GG) WSP. • The small-bore systems for Bon Accord and Milford Court will not treat gray water. • At Coral Gardens / Buccoo, the WWTP will be converted to anaerobic tanks, with effluent piped to GG WSP. Septic tanks will be upgraded. A full-bore gravity collection main will collect sewage from the school, goat race facility, community center, fish depot, and pan yard. Both black and grey water will be treated from the lower Buccoo area.	• More people connected to WWT system • Meet Water Pollution Rules • Fewer outfall locations • Lower O&M costs than current situation (due to removal of package plants) • Protect tourism reputation	**Capital Costs: TT$ 147 million** (this total is likely outdated, but included): • TT$ 5 million engineering design • TT$ 22 million land management • TT$ 120 million capital cost The capital cost estimate did not include the cost of connecting houses. **O&M Costs: TT$30 million /yr**

Multi-Criteria Decision Analysis exercises were conducted with stakeholders at both an informal workshop in Tobago on July 9th held at the WASA Lowlands office, and the EMA/WRI workshop in Port of Spain, Trinidad on July 14th. These MCDA exercises were based on data collected for Southwest Tobago through the Characterization Form (See Annex 3B) and the short summary above. The two workshops considered different criteria therefore present slightly different results. Results from the workshop in Port of Spain present an average score from five groups of stakeholders at that workshop. Both sets of results support investment in the "future scenario," driven mostly by anticipated benefits in increased wastewater treatment capacity, improved ambient water quality, and (to a lesser extent) reduced ecosystem and human impacts.

MCDA results for the Tobago pilot site from the formal EMA/WRI workshop in Port of Spain, Trinidad

Criteria	Weight	Score	
		Current Situation	Future Scenario
Capital costs	4.8	4.0	2.3
Annual recurring costs	3.8	2.8	2.5
Energy consumption	2.3	2.3	3.0
Ease of operation	3.8	1.8	3.3
Wastewater treatment capacity	4.8	1.3	4.5
Vulnerability	4.8	2.0	3.3
Ambient water quality impact	5.0	1.5	4.0
Pollutant removal effectiveness	4.8	1.3	4.3
Untreated domestic wastewater	4.3	1.3	3.3
Ecosystem impacts	5.0	1.3	4.3
Ecosystem service impacts	4.8	1.5	3.8
Human health impacts	5.0	1.5	3.5
Economic disruption/growth	4.0	3.8	2.3
Tally (Weight * Score)		**111**	**195.4**

MCDA results for the Tobago pilot site from the informal workshop in Tobago (WASA Lowlands office)

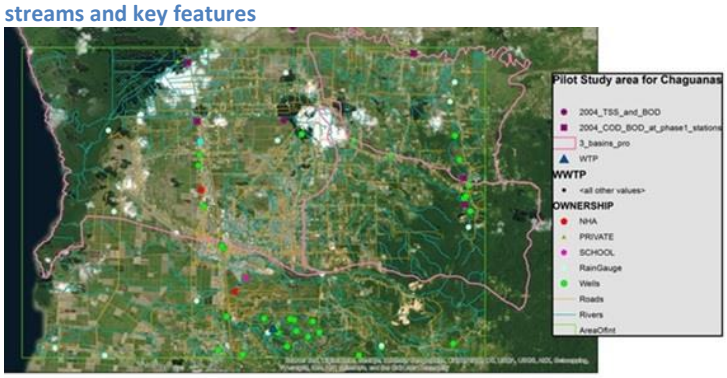
Criteria	Score		
	Weight	Current Situation	Future Scenario
Capital costs	5	5	3
Annual recurring costs	n/a*	n/a	n/a
Energy consumption	5	2	4
Ease of operation	n/a	n/a	n/a
Wastewater treatment capacity	5	2	4
Vulnerability	3	2	2
Ambient water quality impact	5	1	4
Pollutant removal effectiveness	5	1	3
Untreated domestic wastewater	5	1	3
Ecosystem impacts	5	2	3
Ecosystem service impacts	5	2	3
Human health impacts	5	1	3
Economic disruption/growth	2	3	3
Tally (Weight * Score)		**97**	**162**

* n/a – not applicable because not discussed at workshop

Summary for Study Site: Chaguanas, Trinidad

Site Location: Chaguanas is rapidly growing, and its sewerage catchment definition is evolving to accommodate this growth. The study area includes the Cunupia, Guayamare watersheds and part of the Caparo watershed, which discharge into the southern part of the Caroni Swamp (known as the Felicity section). The Chaguanas study area is ~ 3,000 – 5,000 hectares and includes ~9-12 sewerage catchments (this value might increase).

Figure 4- Chaguanas study site with satellite imagery, watersheds, streams and key features



Key ecosystems in the area:

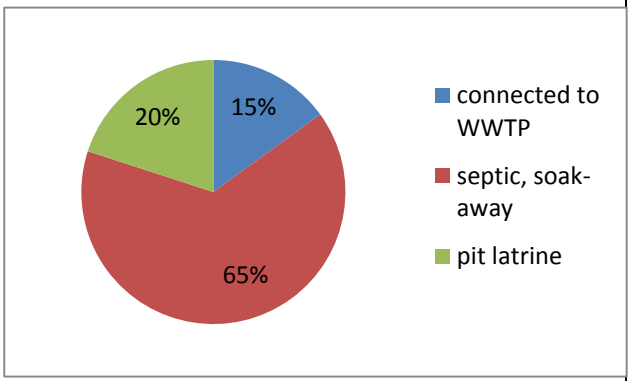
- Caroni Swamp (a Ramsar protected site) that includes eight species of mangrove and herbaceous marsh
- Rivers and streams

Key ecosystem services and their values:

- Tourism and recreation (kayaking, boat tours, and birding in Caroni Swamp – viewing the Scarlet Ibis; recreational fishing)
- Fisheries (oysters and fish in Caroni Swamp)
- Flood attenuation (the swamp stores and mitigates)
- Species protection/Biodiversity (home to 190 bird species)
- Raw materials (wood from mangroves)
- Carbon storage (in mangroves and seagrass)
- Nutrient and sediment filtering (by mangroves and seagrass)
- Genetic and medicinal resources
- One economic valuation of fisheries and tourism and recreation in the Caroni Swamp estimated they were contributing TT$2020 per hectare in 1974. It is likely much higher today.

Population and Wastewater treatment

- In 2011, the population of the Borough of Chaguanas was 83,516 (CSO). This includes 24,644 households. Annual population growth has been 2% from 2000 - 2011.
- WASA and CSO estimate that the population will be ~123,000 – 151,000 by 2040.
- Wastewater – 14-15% of the population is connected to a sewerage system / wastewater treatment plant (WASA & CSO 2000); 65% are on septic or soak-away; 20% have pit latrine; and <1% have no treatment. (CSO 2000).



Current WW treatment situation / technology	Condition / Issues / Limitations	Operating Costs

• There are currently 14-15 package plants and possibly more planned. Some of the smaller package plants are in dire disrepair. WASA has received approval to refurbish 2 package plants (Homeland Gardens, Orchard Gardens, and Point Pleasant). Orchard Gardens is currently discharging raw sewage. • The major plants (Edinburgh 500, Penco, Lange Park, and Charlieville) are operated satisfactorily by WASA.	• The current infrastructure was put in place before 2001 (and before the Water Pollution Rules were developed), so environmental impact statements and monitoring of discharge is not required. • Population will exceed capacity of current plants. • Local conditions are not really conducive for on-site treatment (high water table levels, inadequate soil conditions, flood prone areas). • Some package plants are in disrepair and are discharging raw sewage (e.g., Orchard Gardens). • There are some unauthorized /unplanned developments • Grey water is not treated from the 86% of the population using on-site treatment. This water can have high bacterial, fat, and grease content.	Costs vary by plant type (based on size and technology). Average package plant investment / capital costs run (depending on loading) ~$10 million TT, and average O&M might run ~ $20 – 30K TT /plant/ month (excludes electricity and major capital); Orchard Gardens costs are lower. Average lifetime of package plants is ~10 years.

Observed or likely impacts due to WWT situation:	**Potential Economic loss:**
• Ecosystems – Raw sewage is discharged into receiving streams. These are tributaries to the Caroni Swamp. • Human health – several foodborne pathogens found in the study area have links to wastewater - *salmonella, Shigella*, rotavirus, and norovirus. Contaminated shellfish are a risk to human health (via food poisoning).	Info not available. Some portion of current ecosystem services listed above.

WW Improvement Scenario 1: Two regional wastewater treatment plants (WWTPs)	**Anticipated impacts**	**Cost (Capital and annual O&M costs)**
This plan includes the refurbishment of the Edinburgh 500 plant to treat developments in the southern area and the development of a new WWTP (the Chaguanas WWTP) to treat developments in the northern section, with sewerage connections to connect everyone in the Borough to these two WWTPs. • The Edinburgh 500 plant would have a capacity of 12,000 m^3/day, and would use an activated sludge-extended aeration process. The Chaguanas WWTP would have a capacity of 54,000 m^3/day but the technology is unknown. • Both grey and black water will be treated; treated wastewater could be reused based on this solution. • All current WWTPs and package plants would be decommissioned.	Better control of treatment; More households connected to reliable treatment; Less untreated wastewater.	TT$1,391.31 million total for capital expenses.

WW Improvement Scenario 2: One regional wastewater treatment plants (WWTP)	Anticipated impacts	Cost (Capital and annual O&M costs)
The plan includes the construction of a regional wastewater treatment plant and sewerage connections with the goal of connecting everyone to this centralized system. • Treatment technology would likely include anaerobic digesters and clarifiers (conventional treatment). • The population that is difficult to connect will use septic systems with added disinfection. • All current WWTPs and package plants would be decommissioned. • Both grey and black water will be treated; Treated wastewater could be reused based on this solution.	Better control of treatment; More households connected to reliable treatment; Less untreated wastewater.	Will be estimated by a contractor. (WASA is in the planning stage of hiring a consultant to conduct a cost-effectiveness analysis and identify a future wastewater management strategy.)

A Multi-Criteria Decision Analysis was conducted by stakeholders at the EMA/WRI workshop in Port of Spain, Trinidad on July 14th 2015 by filling out an Evaluation Matrix - weighting and scoring a set of pre-established criteria. The WW Improvement Option #2 was the only future scenario considered because at the time of the workshop, this was the only scenario provided by WASA. Results in the following table present an average score from five groups of stakeholders at the Port of Spain workshop. Analysis results support investment in this "future scenario," driven mostly by anticipated benefits in increased wastewater treatment capacity, reduced untreated wastewater, improved ambient water quality, and (to a lesser extent) increased pollutant removal efficiency, reduced recurring costs and reduced ecosystem and human impacts.

Multi-Criteria Decision Analysis results for Chaguanas pilot site

Criteria	Weight	Score	
		Current Situation	Future Scenario (Regional WWTP)
Capital costs	4.6	3.8	2.6
Annual recurring costs	4.0	2.0	3.4
Energy consumption	2.2	2.0	3.0
Ease of operation	3.8	2.4	3.0
Wastewater treatment capacity	4.6	2.2	4.4
Vulnerability	3.8	2.2	3.6
Ambient water quality impact	4.2	1.6	4.0
Pollutant removal effectiveness	4.4	2.4	4.0
Untreated domestic wastewater	4.6	1.4	3.8
Ecosystem impacts	4.0	2.4	4.0
Ecosystem service impacts	4.2	3.0	4.0
Human health impacts	4.0	2.4	4.0
Economic disruption/growth	3.8	3.2	3.2
Tally (Weight * Score)		**125.2**	**190.3**

6. Conclusions

Effective management and treatment of wastewater remains a challenge across much of the Caribbean. This project and report present a new approach for evaluating the ecosystem and health benefits of investment in improved wastewater treatment, provides a summary of implementation at three pilot sites, and provides details on how to replicate the method. Part II provides guidance on the Scoping and Analysis phases for conducting an economic valuation for the research question:

> *What are the benefits to ecosystems and human health compared to the costs of investing in improving domestic wastewater management?*

Detailed guidance is provided on conducting both a qualitative MCDA and a quantitative BCA. The valuation practitioner is first guided through completing a Characterization Form to collect requisite information, which supports evaluation of which tool is most appropriate (which depends on data availability). Following completion of a MCDA or BCA analysis, the practitioner should refer back to Part I on Outreach and communicating results.

Annex 1 provides the Characterization Form template, and a template for doing a summary of the collected information.

Annex 2 provides supplementary reference materials including a glossary, tables highlighting ecosystem and human health impacts from wastewater pollution, and a comparison table of wastewater treatment infrastructure applicable for the Wider Caribbean Region. Readers can use these materials to gain a better understanding of wastewater terminology and issues, and to complete the Characterization Form and conduct an economic valuation.

Finally, Annex 3 provides characterization results for each of the pilot sites: Isla Colon in Panama; Southwest Tobago; and Chaguanas, Trinidad. These results will be of interest to the pilot countries and to the general audience interested in completing an economic valuation using the approach provided in this report.

Taken together, Parts I and II and Annexes 1 through 3, provide a comprehensive guide for conducting an economic valuation for the research question and encouraging the use of results by decision-makers for the overall GEF CReW objective of improving wastewater management in the Wider Caribbean Region.

References

Birol, E., Karousakis, K., Koundouri, P. 2006. Using economic valuation techniques to inform water resources management: a survey and critical appraisal of available techniques and an application. Sci Total Environ. Vol. 365: 105–22.

Burke, L., Reytar, K., Spalding, M., Perry, A., 2011. Reefs at Risk Revisited. World Resources Institute. Washington DC.

Burke, L., Prager, D., Cooper, E., Greenhalgh, S., 2008. Coastal capital: Economic valuation of coral reefs in Tobago and Saint Lucia. World Resources Institute. Washington, DC.

Chen R., Wang, X.C., 2009. Cost–benefit evaluation of a decentralized water system for wastewater reuse and environmental protection. Water Sci Technol 2009; Vol. 59(8): 1515–22.
Dwight, R.H., Fernandez, L. M., Baker, D.B., Semenza, J.C., Olson, B.H., 2005. Estimating the economic burden from illnesses associated with recreational coastal water pollution – a case study in Orange County, California. Journal of Environmental Management. Vol. 76 (2005): 95—103.

Fleisher, J. M., Jones, F., Kay, D., Stanwell-Smith, R., Wyer, M., Morano, R., 1993. Water and Non-Water-Related Risk Factors for Gastroenteritis among Bathers Exposed to Sewage-Contaminated Marine Waters. International Journal of Epidemiology. Vol. 22(4): 698-708.

Fleming, L. E., Broad, K., Clement, A., Dewailly, E., Elmir, S., Knap, A., Pomponi, S. A., Smith, S., Solo Gabriele, H., Walsh, P., 2006. Oceans and human health: Emerging public health risks in the marine environment. Marine Pollution Bulletin 53: 545-560.

Given, S., Pendleton, L. H., Boehm, A., B., 2006. Regional public health cost estimates of contaminated coastal waters: A case study of gastroenteritis at Southern California beaches. Environmental Science & Technology. Vol. 40 (16): 4851—4858.

GEF CReW, 2012. CReW's Lines: Newsletter of the Caribbean Regional Fund for Wastewater Management. Vol. 1 (1). Available at http://iwlearn.net/iw-projects/3766/outreach-materials/gef-crew-bulletin-june-2012.

Hernandez-Sancho, F., Molinos-Senante, M., Sala-Garrido, R., 2010. Economic valuation of environmental benefits from wastewater treatment processes: An empirical approach for Spain. Science of the Total Environment, 15 January 2010. 408(4). 953-957.

IADB, 2012. Critical financial barriers for wastewater management in the wider Caribbean. PowerPoint presentation to the Development of the Caribbean Regional Fund for Wastewater Management (CReW). Retrieved from http://www.gefcrew.org/images/project_preparation_docs/Critical_Financial_Barriers_Wastewater_Management_IDB.pdf on July 28, 2015.

Janson, N., 2014. Review of the Access to, Availability of, and Organizational Readiness for Uptake of Funding for the Wastewater Sector in Selected Participating Countries. United Nations Environment Programme, Caribbean Regional Coordinating Unit.

Keeler, B.L., Polasky, S., Johnson, K.A., Finlay, J.C., O'Neill, A., Kovacs, K., Daizell, B., 2012. Linking water quality and well-being for improved assessment and valuation of ecosystem services. Proc Natl Acad Sci Vol. 6; 109(45):18619-24.

Korsgaard, L., Schou, J.S., 2010. Economic valuation of aquatic ecosystem services in developing countries. Water Policy. Vol. 12(2010): 20—31.

Kushner, B., R. Waite, M. Jungwiwattanaporn, and L. Burke. 2012. "Influence of Coastal Economic Valuations in the Caribbean: Enabling Conditions and Lessons Learned." Working Paper. Washington, DC: World Resources Institute. Available online at http://www.wri.org/ coastal-capital.

Molinas-Senante, M., Hernandez-Sancho, F., Sala-Gorrido, R., Garrido-Baserba, M., 2010. Economic Feasibility Study for Phosphorus Recovery Processes. Ambio. 2011 June. Vol. 40 (4): 408—416.

National Oceanic and Atmospheric Administration, 2015. Pharmaceuticals in Coastal Waters. Retrieved from http://www.noaa.gov/features/protecting_1208/pharmaceuticals.html on August 19, 2015.

Pescod, M.B., 1992. Wastewater treatment and reuse in agriculture. FAO Irrigation and Drainage Paper 47. Food and Agriculture Organization of the United Nations.

Shuval, H., 2003. Estimating the global burden of thalassogenic diseases: human infectious diseases caused by wastewater pollution of the marine environment. Journal of Water and Health. Vol. 1(2), 53–64

Talberth, J., Gray, E., and Yonavjak, L., 2012. Green versus Gray Infrastructure: Nature's solutions to infrastructure demands. Solutions. Vol. 1 (4). Available from: http://thesolutionsjournal.anu.edu.au/node/1241.

Tziakisa, I., Pachiadakisa, I., Moraitakisa, M., Xideasa, K., Theologisa, G., Tsagarakis, K.P., 2009. Valuing benefits from wastewater treatment and reuse using contingent valuation methodology. Desalination. Vol. 237 (Is. 1-3): 117-225.

United Nations Environment Program – Caribbean Environment Program, 2015a. LBS Protocol. Retrieved from http://www.cep.unep.org/cartagena-convention/lbs-protocol on August 19, 2015.

United Nations Environment Program – Caribbean Environment Program, 2015b. Wastewater, sewage and sanitation. Retrieved from http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/wastewater-sewage-and-sanitation on August 19, 2015.

United Nations Environment Program, 2001. Environmentally Sound Technologies for Wastewater and Stormwater Management: An International Source Book. UNEP. International Environmental Technology Centre, UNEP.

United Nations Framework Convention on Climate Change (UNFCCC), 2014. Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change: Multicriteria Analysis. Retrieved from http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5440.php on September 29, 2015.

Waite, R., L. Burke, E. Gray. *Coastal Capital: Economic Valuation for Decision-making in the Caribbean.* Washington, DC: World Resources Institute. 2014. Retrieved from http://www.wri.org/publication/coastal-capital-guidebook on October 2, 2015.

Weldesilassie, A. B., Fror, O., Boelee, E., Dabbert, S., 2009. The Economic Value of Improved Wastewater Irrigation: A Contingent Valuation Study in Addis Ababa, Ethiopia. Journal of Agricultural and Resource Economics. 34(3): 428-449.