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VALUING THE COSTS AND BENEFITS OF IMPROVED WASTEWATER MANAGEMENT

PART II: ECONOMIC VALUATION METHODOLOGY GUIDANCE

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VALUING THE COSTS AND BENEFITS OF IMPROVED WASTEWATER MANAGEMENT:

An Economic Valuation Resource Guide for the Wider Caribbean Region

Part II: Economic Valuation Methodology Guidance

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Overview of Report:

PART I: SUMMARY REPORT

PART II: ECONOMIC VALUATION GUIDANCE

ANNEX 1: CHARACTERIZATION FORM AND SUMMARY TEMPLATE

ANNEX 2: SUPPLEMENTARY MATERIALS

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

ANNEX 3: CHARACTERIZATION RESULTS

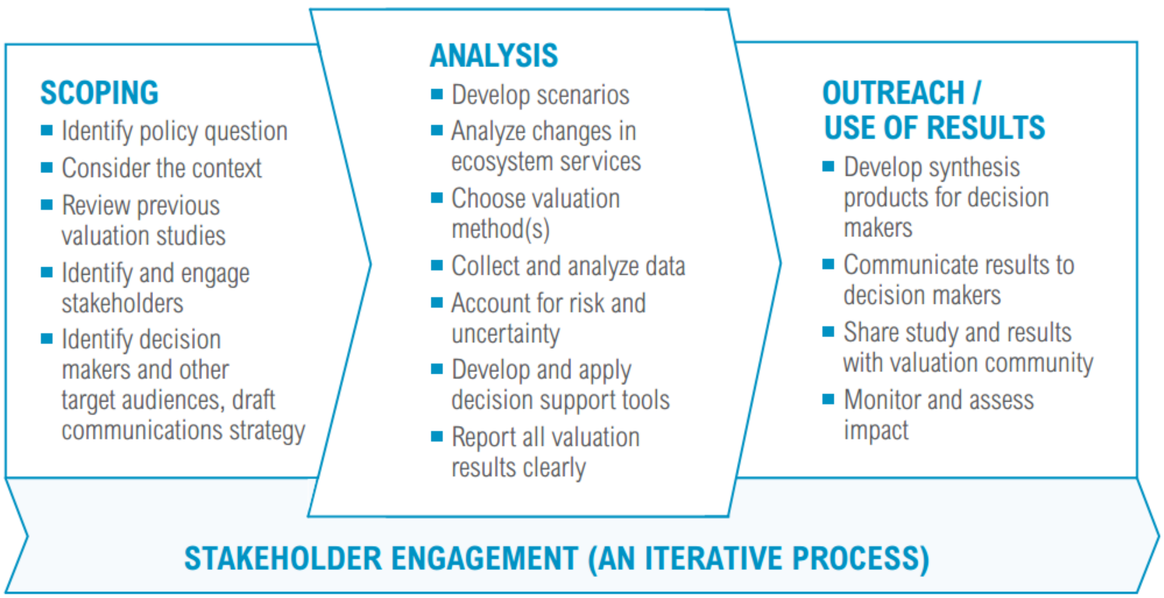
A. BOCAS DEL TORO, PANAMA
B. SOUTHWEST TOBAGO
C. CHAGUANAS, TRINIDAD

Table of Contents for Part II

1. Overview of methodology contents

Our recommended approach to economic valuation to influence decision-makers on investment in wastewater treatment follows the three-phased approach recommended by Waite et al., 2014 in *Coastal Capital: Economic Valuation for Decision-making in the Caribbean* – (1) Scoping; (2) Analysis; and (3) Outreach and communications (see Figure 1). This section of the report (Part II: Economic Valuation Methodology Guidance) is intended to lead valuation practitioners through the scoping and analysis phases. Outreach and communication of results was covered in Part 1: Summary Report.

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



Steps in the scoping and analysis phases have been adapted for application to the particular circumstances of benefits of improved wastewater treatment.

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

The **Analysis Phase** promoted here deviates from Figure 1 to allow for integration of human health impacts and to directly address the wastewater research question. It also offers two distinct options for evaluating the costs and benefits of different scenarios – either through a quantitative or qualitative approach. The Analysis Phase follows four key steps as outlined in Figure 2: 1) Identify the key decision-making criteria; 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 a quantitative analysis using Benefit-Cost Analysis (BCA), or whether a qualitative analysis using Multi-Criteria Decision Analysis (MCDA) is more appropriate; and 4) Compare costs and benefits of wastewater management options using either BCA or MCDA. Both BCA and MCDA are decision support tools that allow comparison of costs and benefits – these tools are explained more in depth in the following sections.

2. Phase 1: Scoping

The scoping phase is intended to bring key stakeholders together to agree on the policy or research question and the valuation approach, to identify key influence targets, and to help ensure results are understood and disseminated. The Scoping phase follows the steps shown in Figure 1.

1.1 Identify the policy question

The policy question that relates to this report is,

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

This policy question was identified by GEF CReW stakeholders as being critical to the GEF CReW objectives and mission of improving wastewater management in the Wider Caribbean Region and increasing awareness of wastewater issues.

1.2 Consider the context of the study area to determine if economic valuation is the right approach

This step is intended to help the valuation practitioner decide *whether* an economic valuation should be conducted at all, based on the presence of enabling factors or key contextual considerations for the study area, which make it more likely that economic valuation results will be used to inform a decision, such as:

- Are there visible or impending threats to human, ecosystem, or economic health?
- Are there currently any impacts due to inadequate wastewater treatment?
- Is economic dependence on key ecosystems high?
- Are there local in-country champions that will promote valuation efforts?
- Is there good governance in the country and study area (e.g., is there transparency and public participation in decision-making and do legal frameworks exist for protecting environmental and human health)?
- Is there a low rate of institutional turnover (to help with knowledge retention and awareness of the valuation study)?

Chances are, if you are reading this guide and have advanced to this step, you are interested in conducting an economic valuation and have already considered some of these conditions.

1.3 Conduct a literature review of relevant studies

This step is designed to provide the economic valuation practitioner with a starting point for analysis by identifying past and present economic valuation efforts related to wastewater, ecosystem, and human health. The Characterization Form has questions to identify relevant literature. Reviewing relevant valuation studies can help leverage and complement previous work and avoid duplicating efforts. Additionally, these studies can be a good source of data and provide context for developing value estimates from other, possibly similar locations that can be used to complement or compare with valuation results. The Coastal Capital Guidebook also provides a list of online libraries and databases for ecosystem valuation studies that can be consulted for a literature review (Waite et al. 2014).

1.4 Identify and engage relevant stakeholders

Relevant stakeholders should be identified early on in the economic valuation effort to support the following:

- Study design appropriate to the local context and relevant to local issues
- Data collection, including the integration of local and traditional knowledge
- Local ownership of the analysis
- Legitimacy and credibility of results
- Identification of opportunities for outreach and influence, tracking of influence, and ways to lessen conflicts and overcome obstacles.

Relevant stakeholders include individuals and groups including: people impacted by wastewater management decisions for the study area (i.e., primary stakeholders); decision-makers (in terms of wastewater investments and selection of infrastructure) and those who can influence decision-making processes (i.e., secondary stakeholders); and those who are not significantly impacted by the valuation but whose interests are affected and can influence decisions (i.e., external stakeholders) (Waite et al. 2014). Examples of relevant stakeholders to engage in the valuation process for the targeted research question include:

- **Wastewater management authorities/utilities** and associated engineers/consultants that design and manage operations of wastewater facilities
- **National environmental/water/natural resource agencies or ministries** that conduct environmental impact statements; monitor water quality and marine ecosystems; process certificates or permits related to water quality, especially for wastewater management authorities; and regulate wastewater effluent discharges
- **National health agencies or ministries** responsible for collecting data on and studying human health issues
- **National financial, economic, and planning agencies and ministries** that manage national and local infrastructure budgets and/or have a voice in water infrastructure decisions
- **Non-governmental organizations** involved in ecosystem, human health, water quality, tourism, or other relevant issues

- **Communities and community organizations** whose members are impacted by wastewater management decisions
- **Academic and research institutes** that conduct research on ecosystem and human health issues in relation to water pollution
- **Regional or national census bureau/statistical agencies** that collect data on population, economic activities, human health, tourism, and other economic activities (e.g., Caribbean Tourism Organization; national census bureaus)
- **Regional or national tourism agencies/ministries/organizations** that monitor and collect data on tourism (specifically, ecotourism)
- **Tourism operators and other local businesses** (e.g., dive shop owners) whose businesses would be negatively impacted by degradation of water quality

1.5 Identify decision-makers and other target audiences. Draft a communications strategy

This step requires developing a strategy to identify decision-makers (e.g., those who decide upon a wastewater investment or inform the decision process) and other target audiences for the purpose of disseminating valuation results and ensuring results are used in the decision-making process. This audience may differ slightly from the stakeholders identified in the previous step.

The Coastal Capital Guidebook states, "Whenever possible, valuations should target immediate opportunities for application, including market mechanisms (such as payments for ecosystem services or user fees) or policy processes (such as legislation, regulations, or permitting). A well-developed communication and outreach strategy, drawing on diverse media platforms such as traditional and social media, allows for both widespread and targeted communication of results. It is best to think about the target audience and develop a communication strategy early in the process, to enable decision-makers to be involved from the outset. The communication strategy can be sharpened as the valuation results become clearer."

In terms of developing a communications strategy, the Coastal Capital Guidebook recommends key questions to ask, including:

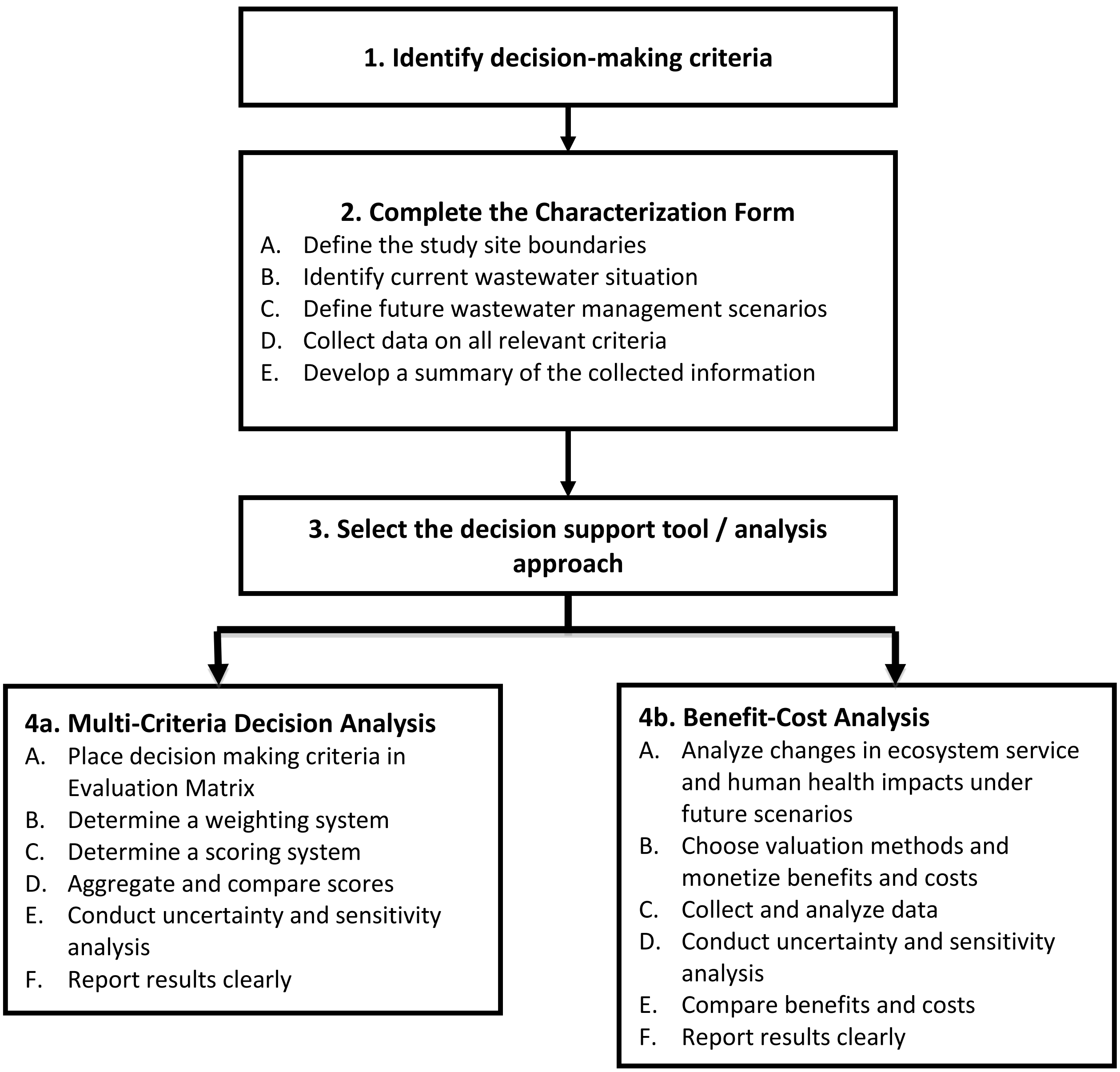
- Who is the target audience? Whose behavior or policies are targeted for change?
- Who are other messengers that can help raise awareness about the valuation's findings?
- How can practitioners engage the target audience early in the analysis to get their input on the scope and objectives of the analysis, to enhance relevance to key questions they face?
- What is the "hook" for this audience? In other words, what is new and exciting about the valuation?
- What is the best strategy to deliver the valuation results to the target audience? Who has the best access to that audience? What kind of materials or products would be most effective in communicating results?
- What are the best communication channels to reach the target audience (e.g., through direct outreach, email, conferences, or the media)? How can online tools and social media help drive interest in the valuation findings? What stories or experiences will help bring the valuation results to life for the target audience?

- What actions or approaches will build and sustain interest in the findings over time? What events or conferences offer venues for sharing the valuation findings? Are there other opportunities to extend the life of the analysis and results?

2. Phase 2: Analysis

The Analysis phase loosely follows the three main steps in Figure 1 but has been altered to fit the research question. Figure 2 presents the Analysis Phase steps showing a general three-step process: First, decide on relevant decision-making criteria with key stakeholders and update the Characterization Form template (if needed); second, complete the Characterization Form; and third, complete either a MCDA or a BCA depending on data availability.

Figure 2 - Analysis steps for conducting a wastewater valuation



Step 1: Identify decision-making criteria

In relation to the wastewater management research question, it is important to work with stakeholders, especially those responsible for informing or making a decision on wastewater management investments, to determine what criteria are most important for selecting a domestic wastewater management option. Criteria are defined as specific, measurable objectives (at least qualitatively measurable), and should be chosen such that they fit with the overall objectives of the economic valuation (i.e., select the best wastewater infrastructure management scenario based on infrastructure costs compared to ecosystem and human health benefits) (Department of Communities and Local Government 2009).

In general, some key guidance points for selecting criteria include:

- Criteria should be measurable and unique (i.e., easily distinguishable from one another) (European Commission 2005). Take care to insure there is no double-counting of criteria.
- Criteria should represent the differing points of view of key stakeholders identified in steps 1.4 and 1.5 (European Commission 2005).
- Stakeholders will likely differ in terms of which criteria are most important to them (e.g., Environmental NGOs may want more ecosystem impact-related criteria while infrastructure costs and ease of operation of infrastructure may be more important to wastewater utilities). Stakeholder workshops and meetings may be useful to reconcile different points of view and narrow the number of criteria to a reasonable range.
- The number of criteria should be kept low but should be consistent with making an informed decision. A typical range may be 6 to 20 criteria (Department of Communities and Local Government 2009).
- Care should be taken to avoid excessive numbers of criteria to provide detail on a single topic, creating an imbalance in the evaluation, such as having five indicators related to improved ecosystem condition and one focused on finance. (If such a situation occurs, criteria could be grouped in a hierarchy and weighted.)
- Criteria should be representative of decision-making processes and policies already in place such as governmental procurement guidelines and water quality and environmental legislation (e.g., environmental impact statements). For example, the European Union has established a Green Public Procurement instrument that has established criteria for wastewater infrastructure projects for consultancy services, construction contracts, and life cycle costs (European Commission 2005). National public wastewater investment criteria and relevant environmental, water quality, and health requirements should be reviewed for relevance. For example, in Trinidad and Tobago, the wastewater treatment utility must obtain a certificate of environmental clearance to install new infrastructure, and must complete an environmental impact statement – both of these documents would be useful for identifying relevant criteria.

Based on input from stakeholders in Panama and Trinidad and Tobago, criteria used for the development of this report and for comparing wastewater management scenarios include:

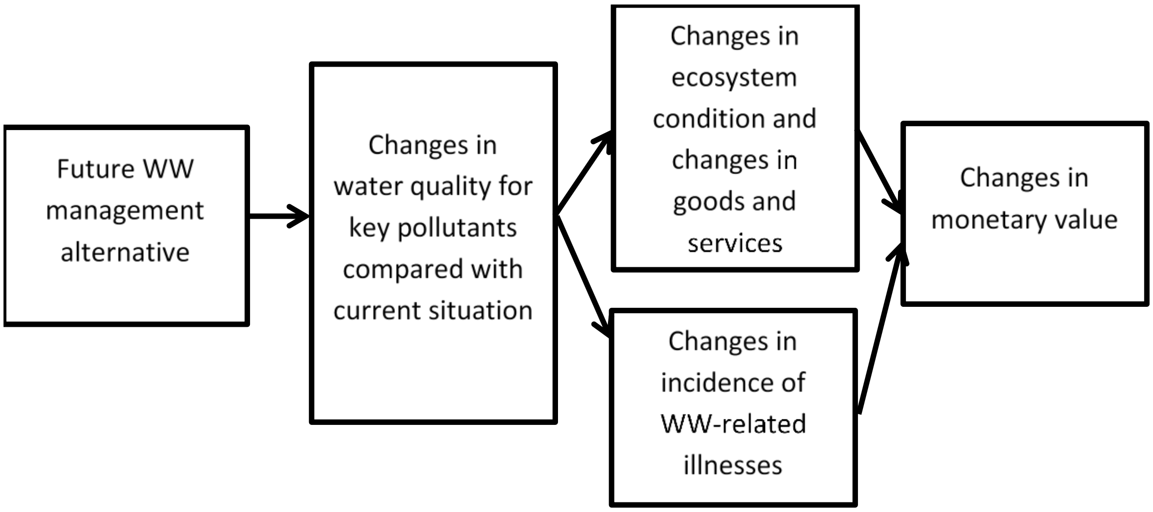
1. **Capital/investment costs**: One-time initial investment costs for wastewater equipment/infrastructure
2. **Annual/recurring costs**: Recurring operations and maintenance expenses including staffing/labor, energy, and operations and maintenance expenses
3. **Energy consumption:** The overall annual energy demand for the investment scenario
4. **Operational complexity:** Is the wastewater management system easy to operate and maintain in terms of accessibility and operability?
5. **Wastewater treatment capacity:** The volume of wastewater that can be treated
6. **Vulnerability:** The ability of the wastewater management system to withstand projected changes in vulnerability drivers (e.g., climate change, sea level rise, increased storm intensity, increased rainfall variability, warmer air and sea temperatures, earthquakes, hurricanes)
7. **Ambient water quality impact:** Impact of the wastewater management system on fresh and coastal water quality (for key pollutants found in the Water Pollution Rules)
8. **Pollutant removal effectiveness:** The effectiveness of the treatment technologies in place to remove pollutants found in the Water Pollution Rules
9. **Untreated wastewater:** The amount of wastewater that escapes the wastewater management system and goes untreated into receiving water bodies
10. **Ecosystem impacts:** The expected impact of the wastewater management system on the overall health of key ecosystems (e.g., mangroves, rivers, coral reefs, seagrasses, beaches)
11. **Ecosystem Service impacts:** The expected impact of the wastewater management system on key goods and services provided by key ecosystems (e.g., fisheries production by coral reef, tourism and recreation provision by coral reefs and mangroves)
12. **Human health impacts:** The expected impact of the wastewater management system on human health (e.g., gastroenteritis, ear infections, eye infections, salmonella poisoning, etc.)
13. **Economic growth or disruption:** The expected impacts on the local economy due to impacts on ecosystems and their goods and services (e.g., will the wastewater management system improve/reduce tourism to coral reefs? Will the wastewater management system reduce filtration costs for industries like hospitals and bottling companies?); Economic disruptions to wastewater related construction (e.g., disruption of business due to noise/construction)

It is important to note that criteria may change depending on the study site context. If criteria are removed or added to this list, the valuation practitioner may desire to edit the Characterization Form template (in Annex 1) so that additional data will be collected on that criteria. Additionally, the criteria will be used for the MCDA analysis and should be updated accordingly. Criteria are more relevant to MCDA than BCA analysis as MCDA will actually compare infrastructure scenarios based on these criteria, but the Characterization Form is needed for collecting data for both MCDA and BCA.

Step 2: Complete the Characterization Form

Step two of the Analysis Phase is to complete the Characterization Form in Annex 1. The Characterization Form is designed to help the economic valuation practitioner understand the key relationships between a change in wastewater management and ecosystem and human health conditions. Below is a general framework for thinking about this research question (Figure 3):

Figure 3 - Framework for economic valuation of wastewater investments (Based on Keeler et al. 2012)



In general, the future wastewater management alternative(s) must be *compared* to the current situation or the "do nothing" scenario whereby it is assumed current infrastructure and operating and maintenance efforts are maintained. To do this, it is necessary to compare the *change in costs* of infrastructure options. For benefits, the *change* in benefits should be estimated for ecosystem and human health, which necessitates understanding the *change* in water quality that results from the future wastewater management alternative. To estimate this change, it is necessary to understand current or baseline water quality conditions, ecosystem conditions for key ecosystems, and human health conditions AND to understand the biophysical relationship between a change in water quality and the resulting change in human health and ecosystem service provision.

The Characterization Form was developed by the World Resources Institute (WRI) with expert consultation from wastewater management authorities, researchers, and economists familiar with the Wider Caribbean Region. The form design is rooted in traditional economic and financial analysis for public investment decisions, to help weigh trade-offs between investment costs and societal benefits.

Completion of the Characterization Form will allow for completion of the following steps necessary for conducting an economic analysis (using either MCDA or BCA):

a. Define the study site boundaries
b. Identify the current wastewater management scenario
c. Define future wastewater management scenarios
d. Collect data on all relevant criteria established in Step 1 of the Analysis Phase
e. Develop a summary of the collected information

Objectives: The main objective of the Characterization Form is to lead the valuation practitioner through a series of questions designed to compile information to characterize the current situation in the study site, any impairment which might be the result of inadequate wastewater treatment, and develop a description of what improvements to ecosystems (and their goods and services) or human health are likely to result from the proposed wastewater treatment improvements. The information compiled can be used in up to three ways:

- To develop a written narrative description of the costs and benefits of investment in wastewater treatment, AND
- To provide input to support decision making based on relevant criteria, using either:
    - A *qualitative* Multi-Criteria Decision Analysis, including completion of the Evaluation Matrix OR
    - A *quantitative* Benefit-Cost Analysis (if sufficient data are available).

Who fills this out? This Characterization Form is intended for the economic valuation practitioner(s). The practitioner could be an economist or analyst with the wastewater authority or utility, planning, or finance agency. It may also be an economist with a non-governmental organization or other party interested in exploring wastewater issues. The practitioner is the central person for data collection and analysis.

The practitioner is led through a series of questions to define and characterize the study site, the current wastewater management situation, future wastewater management alternative(s), and a series of other questions to provide data on other decision-making criteria (including ecosystem and human health benefits).

Data Sources: To complete the Characterization Form, the practitioner will need to consult the literature (e.g., peer-reviewed literature, grey-literature, government documents) and should also seek expert input from relevant stakeholders (e.g., government officials, non-governmental organizations, and academia). The Characterization Form template in Annex 1 provides additional guidance in each section on relevant literature and potential stakeholders – although this will vary by country. For example, when completing information on wastewater infrastructure, the stakeholder should contact the local wastewater authority/utility to fill in the questions – additionally, they may use the questions provided here as guidance for developing a formal (or informal) data request. The person filling out the form should be sure to cite resources throughout the document!

Supportive data and information that can be used to help fill out this questionnaire are also provided in Annex 2:

- Section A. Glossary of common wastewater terms
- Section B: Wastewater pollution and ecosystem impacts (examples and references)
- Section C: Human health risks from exposure to wastewater pollution
- Section D: Comparison of wastewater treatment technologies applicable to the Wider Caribbean Region

Table 1 provides a list of the sections and example questions from the Characterization Form (Please note that it is not comprehensive so practitioner should use the full form available in Annex 1).

Table 1: Characterization Form contents (full template available in Annex 1)

1.	**DEFINE THE STUDY AREA**
•	Please define the study area by providing a detailed description.
•	Can you put it on a map?
•	What are the major land uses in the study area?
2.	**POPULATION**
•	How many people live in the study area?
•	Can you disaggregate this by neighborhood / area / housing development / smaller administrative unit?
•	What is the population projection for the study area over the next 20, 30, and/or 50 years (for each period if data are available)?
3.	**ECONOMIC ACTIVITIES**
•	Rate the relative level of importance of the following sectors to the local economy (ideally for the study area)?
	o Tourism?
	o Agriculture?
	o Fisheries?
	o Industry?
4.	**KEY ECOSYSTEMS (and ecosystem services)**
•	What are the key ecosystems in the study area (e.g., coral reefs, mangroves, seagrass beds, beaches, forests, wetlands), especially downstream from population, sewage discharge, or treated wastewater discharge?
•	What goods and services do these key ecosystems provide (i.e., what are each of the ecosystems used by people for?)?
•	Are there any existing estimates of the economic values of these uses of ecosystems for this study area or nearby (e.g., through peer-reviewed or grey literature)?
•	Do you have statistics on visitation/tourism (both foreign and national) to key ecosystems and/or statistics on visitation/tourism for the country for eco-tourism?
5.	**CURRENT WASTEWATER MANAGEMENT SITUATION**
On-site wastewater treatment coverage:	
•	Please estimate the percentage of the total population and commercial and industrial establishments within the study that uses each type of on-site system (septic systems, pit latrines, soakaway systems or other).
•	What percentage of on-site systems (septic systems, pit latrines, soakaway systems, etc.) are properly maintained (i.e., regularly pumped out, drain fields not clogged, etc.)?
Wastewater collection system (i.e., sewerage):	
•	Please estimate the percentage of the total population and commercial and industrial establishments within the study that are connected to a centralized sewerage system.
•	What is the estimated annual percentage of total wastewater generated that is untreated and released into water bodies? What is the estimated annual volume?

Wastewater treatment plants:
• Please describe the number and type of wastewater treatment plants (WWTP) currently in place in the study area, and complete tables on technology, performance, and costs.
6. WATER QUALITY
• What water quality standards/requirements apply for the study area?
• What data or information do you have about water quality in the study area (both freshwater (ground and surface) and coastal waters)?
• Are any water quality standards being violated in lakes, non-tidal streams and rivers, and coastal areas? Please provide frequency and severity.
• What are the pollutants causing the violation and what are their sources (e.g., untreated wastewater, WWTP effluent, onsite septic systems, soakaways, pit latrines, sources from other sectors such as mining or agriculture)?
7. ECOSYSTEM IMPACTS
• Within the study area, are any of the following causing ecological impacts, such as algal blooms or damage to coral reefs:
○ Discharge of untreated or partially treated sewage?
○ Irregular release of wastewater from a WWT system due to overflow, rainwater events, power failure, etc.?
• Have any studies been conducted within the study site or your country or region that link wastewater pollution to ecosystem health? If so, what are the findings?
• Is there evidence of the following in any of the key ecosystems present in the study area (e.g., freshwater, wetlands, mangroves, beaches, coral reefs, forests, wetlands):
○ Is it unsightly due to pollution? Are there algal blooms or obvious evidence of pollution?
○ Is there odor due to pollution?
○ Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?
○ Are you seeing a change in ecosystem health and/or growth?
• Do you have a sense of the relative contribution from wastewater to overall pollution of key ecosystems compared to these other sources? If so, please describe.
• Are there any economic or cultural uses of the key ecosystems that are in decline due to wastewater discharge issues (from untreated or improperly treated wastewater)?
• Do tourists have any awareness of water quality issues and do they modify activities/ visitation?
8. HUMAN HEALTH IMPACTS
• Please describe any known human health impacts, such as gastrointestinal illness, respiratory illness, ear infections, eye infections, or skin rashes/lesions that are occurring in the study site that relate to wastewater.
• What activities seem to be contributing (e.g., swimming, eating contaminated seafood)?
• Have any studies been conducted within the study site or your country or region that link wastewater pollution to human health?
○ Do any of these studies estimate a dose-response relationship between a given wastewater pollutant and a human health illness (e.g., gastroenteritis)?
• Do you have a sense of the relative contribution from wastewater to overall health impacts compared to these other sources? If so, please describe.

9.	**FUTURE WASTEWATER MANAGEMENT SCENARIO(S)**
•	What option or options are under consideration for improving wastewater management in the pilot area?
•	What are the evaluation criteria for choosing an infrastructure option and who decides what these criteria are?
•	What sort of improvements are expected from each future wastewater management scenario?
	○ Increased coverage in terms of population with treated wastewater?
	○ Reduced pollutant loading?
	○ Improvement in water quality of receiving water bodies and downstream water bodies?
•	Will the new wastewater treatment technology allow any reuse of water? Has anyone estimated the potential cost savings associated with reuse of this wastewater?
•	Have any engineering or financial analyses been conducted for future wastewater management alternatives? Do they provide cost data? Fill in a table covering capital and operating costs for each scenario.
10.	**CHANGES TO ECOSYSTEM AND HUMAN HEALTH UNDER IMPROVED WASTEWATER MANAGEMENT SCENARIOS**
•	Have any evaluations, studies, or environmental impact statements been conducted that estimate the impact on key ecosystems and human health under each new wastewater management scenario *compared to the current wastewater management situation*? If so, please describe these findings.
•	Does the scenario:
	○ Reduce the annual loading of pollutants on receiving water bodies?
	○ Reduce odor?
	○ Reduce the incidence of harmful algal blooms and/or nutrient over-enrichment?
	○ Reduce human health risk and/or the number of cases for illnesses previously identified?
	○ Improve ecosystem health conditions for the key ecosystems identified previously?
	○ Improve the provision of key ecosystem goods and services identified previously (e.g., increased likelihood of tourist visits, increased productivity of fisheries due to improved coral reef and mangrove health)
•	Can you establish a quantitative relationship between an improvement in water quality due to the future wastewater management alternative and a change in provision of ecosystem services for each key ecosystem?
•	Can you monetize or value the change in ecosystem service provision (e.g., what is the economic value of reduced coral reef degradation in terms of fisheries improvement – this is often quantified by estimating the market value of fish sold in a marketplace)?

Filling out the Characterization Form achieves the following information compilation, described under a. through d.

a. Define the study site boundaries

Defining the study site boundaries is necessary for limiting the economic analysis to a specific geographic area.

Key data needs include:

- Study site area
- Wastewater catchment
- Receiving water bodies of wastewater effluent (e.g., rivers, lakes, oceans where there exists a wastewater outfall or occurrences of untreated wastewater)
- Upstream and downstream water catchments
- Population within the wastewater catchment AND population living in downstream water catchments that may be exposed to untreated wastewater from the wastewater catchment
- List of key ecosystems
- List of ecosystem services provided by key ecosystems
- List of wastewater related human health illnesses that have been experienced in the area
- Population that needs improved wastewater management
- Population that is exposed to wastewater pollution in receiving water bodies or downstream of receiving water bodies

The valuation practitioner may wish to conduct a mapping exercise with stakeholders whereby stakeholders identify on a map of the study site the key ecosystems and populations they think are *currently* being impacted by wastewater pollution.

b. Identify the current wastewater management situation

The current situation (i.e., "do nothing scenario") describes the existing domestic wastewater infrastructure in place, associated recurring capital and O&M costs, and design features such as pollutant removal effectiveness. The "do nothing scenario" serves as the baseline for the economic valuation and represents what *would happen* if no improvement is made in wastewater management in the study site. In other words, the "do nothing scenario" assumes that the current infrastructure that is in place stays in place, as well as current O&M procedures (despite exogenous changes such as population growth and increased impact from vulnerability drivers like sea level rise or changes in air and water temperatures).

Key data needs include:

- Wastewater infrastructure components, useful lifetimes, and other key design features
- Wastewater capital, recurring O&M costs, and opportunity costs (e.g., foregone land value from land needed for wastewater infrastructure)

c. Develop future wastewater management scenarios

Water quality, ecosystem, and human health impacts must be evaluated based on a change from the "do nothing scenario" to a future wastewater management scenario (or scenarios). A future scenario should represent a plausible future of domestic wastewater management investment based on input from key stakeholders. Scenario development should be a highly participatory process.

Often times, wastewater management decision-makers will have a good idea of the infrastructure that would be best suited for a given area, or they may have already completed or contracted a consultant to conduct an engineering or design study to estimate the costs and environmental and social impacts of an infrastructure or management scenario (the details of these types of reports will vary depending on national water regulations for the country). However, it may be the case that future wastewater management options have not yet been defined. In this case, the valuation practitioner may need to engage additional wastewater resource experts to help determine the infrastructure options best suited. Annex 2, Section D provides information on wastewater treatment technologies applicable to the Wider Caribbean Region along with key considerations to help valuation practitioners define future scenarios.

d. Collect data on all relevant criteria

The Characterization Form is designed to gather information on all decision-making criteria identified in Step 1 of the analysis (e.g., ecosystem conditions, human health condition, etc.).

e. Develop a summary of the collected information

The practitioner may wish to summarize information from the Characterization Form, supporting a narrative description of the current wastewater situation, impacts, options for the future, and costs and benefits of these options. Annex 1 provides a template for such a summary. Examples of these summaries are included for the three pilot sites in Part I, section 5 of this report.

Step 3. Select the decision support tool / analysis approach

Once you have completed the Characterization Form, you should have a good idea of data availability on key wastewater issues related to the policy question and should be able to decide whether you have enough data to conduct either a MCDA or a BCA.

In general, the following data are needed to conduct a robust BCA:

- Current wastewater infrastructure components and costs, including capital, operation and maintenance (O&M), and opportunity costs[1]
- Wastewater effluent pollutant loadings for key pollutants at discharge locations
- Pollutant loadings from untreated wastewater
- Water quality in receiving water bodies

[1] Opportunity costs reflect the foregone value from land use that is relevant if the wastewater utility must purchase or acquire land for wastewater operations.

- Production functions for key ecosystems (e.g., fish production from coral reefs or mangroves)
- Estimates of established or forecasted impacts on key ecosystems for changes in levels of key pollutants either through biophysical modeling or established relationships set forth in the literature
- Estimates of established or forecasted impacts on ecosystem service provision based on changes in ecosystem health based on biophysical modeling or established relationships set forth in the literature
- Dose-response relationships for key human health illnesses (e.g., gastroenteritis)
- Estimates of population exposed to contaminated water bodies within the study site (e.g., number of swimmers that bath/swim in contaminated water bodies)
- Estimated cases of key illnesses for the study site
- Estimates of costs of human illnesses (e.g., medication costs, hospitalization costs, duration of stay in hospitals, value of lost wages due to illnesses)

If quantitative relationships between wastewater investments, water quality changes, ecosystem service and human health changes, and economic costs cannot be constructed, then a MCDA may be the best decision support tool to use for your study site.

Both MCDA and BCA require an understanding of the environment and the likely benefits resulting from the investment, but BCA requires more advanced training in economics and monetization methods for costs and benefits (UNFCCC 2014a and 2014b). As such, valuation practitioners that lack economics expertise may wish to work with an economist to (1) implement the BCA; and (2) interpret results.

Step 4a: Multi-Criteria Decision Analysis - The qualitative approach

In most sites in the Wider Caribbean Region, it is likely that the MCDA method will be chosen due to data limitations. Although MCDA does not produce a quantitative metric (e.g., like a net present value, benefit cost ratio or internal rate of return as BCA does), it does provide a means of comparing different scenarios to each other or to the current situation to determine which option is best for the study area.

MCDA is a decision support tool that allows the valuation practitioner to rank and compare different wastewater investment scenarios (e.g., future scenarios vs. the "do nothing scenario") by scoring the scenarios against a pre-determined set of criteria deemed important for the study site (e.g., costs, health benefits, ecosystem benefits, economic benefits). Outputs from an MCDA analysis 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 2014b).

Wastewater investment scenarios are compared using an "Evaluation Matrix". The pre-determined criteria should have been decided upon in Step 1 of the Analysis Phase, but for the purpose of this report, the following criteria have been selected to compare wastewater management scenarios or options (see the evaluation matrix in Table 3 for definitions):

1. Capital/investment costs
2. Annual/recurring costs

3. Energy consumption
4. Operational complexity
5. Wastewater treatment capacity
6. Vulnerability
7. Ambient water quality impact
8. Pollutant removal effectiveness
9. Untreated wastewater
10. Ecosystem impacts
11. Ecosystem service impacts
12. Human health impacts
13. Economic growth or disruption

Under Step 2 of the Analysis Phase (the Characterization Form) the valuation practitioner should have ideally already collected information to support a comparison of wastewater management scenarios against these criteria and (might have) prepared a summary technical document.

Following completion of the Characterization Form, key steps for conducting the MCDA and filling in the Evaluation Matrix include:

a. Place decision making criteria in the evaluation matrix
b. Determine a weighting system
c. Determine a scoring system and assign scores to both the current and future scenario(s)
d. Aggregate scores over the range of criteria and compare scenarios
e. Conduct an uncertainty and sensitivity analysis
f. Report results clearly

It is recommended that all stakeholders involved with selecting criteria and comparing wastewater investment scenarios refer to the Characterization Form and/or a short technical summary (as presented in Part I) when completing the Evaluation Matrix.

It is recommended that the economic valuation practitioner bring a key set of stakeholders together to complete the evaluation matrix. The stakeholders may include the same set of decision makers used to establish criteria, or an expanded or condensed list based on expert guidance. Below, general guidance is provided on the main steps listed above.

a. Place decision making criteria in the evaluation matrix

Under Step 1 of the Analysis Phase, the economic valuation practitioner was asked to identify relevant criteria for decision making with respect to wastewater infrastructure investments. These criteria should be placed in the evaluation matrix (see Table 3).

b. Determine a weighting system

Criteria should be weighted in order to measure their relative importance for decision-makers (e.g., preferences). There are various methods available to weight these criteria. A simple approach would be to weight criteria on a scale, from 1-5 or 1-10, for example, where the criteria deemed most important for decision making receive higher weights. Different stakeholders may view the importance of each criteria differently. As a result, it may be necessary to hold meetings or workshops with relevant stakeholders to come to a consensus on a weighting system that makes sense for the pilot site. Stakeholders may wish, for example, to use a mean weight based on input from relevant decision-making agencies. The selection of weights could be done in conjunction with determining the decision-making criteria or a later stage when scoring infrastructure scenarios (see next step).

c. Design a scoring system and assign scores to both the current and future scenario(s)

Scoring allows decision-makers to compare the criteria across each investment option and aggregate them. For example, decision-makers may choose to score each investment option's costs according to a scale of 1 to 5, whereby 5 is the best performance score (e.g., lowest cost or best improvement in ecosystem conditions) and 1 is the worst. Decision makers should establish a scoring system that is appropriate for the study site and the research question.

It is also recommended to apply a common scoring method across the criteria to make it easier to aggregate results and weight each criterion. The scoring scale does not matter as much as ensuring a consistent scoring scale is used for all evaluation criteria. Additionally, it is important to determine the direction of scale, or in other words, the higher the ranking the better the option (or vice versa). Following this scheme where the high values are favorable, a "high" value (either described as "high" or the highest numerical value) is associated with the lowest costs, the more positive ecosystem and human health impacts, and a greater ability to meet water quality standards and address vulnerability drivers. In this scheme, a "low" value is associated with the highest costs, most negative ecosystem and human health impacts or smallest reduction in impacts, and a lower likelihood of meeting water quality standards and addressing vulnerability drivers. *It is recommended that when criteria can be evaluated quantitatively, that quantitative data are still provided.* This allows for easier rating. It is still necessary in this case, to rate the options – this can be done on the small scale as for other criteria where qualitative data are only available (e.g., low – high, or 1-5).

d. Aggregate scores over the range of criteria and compare scenarios

The next step is to aggregate results over the range of criteria for each scenario in the Evaluation Matrix (Table 3) so that scenarios can be compared and an informed decision can be made. 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).

Example methods for comparing scenarios include a weighted sum approach (which we have used in our three pilot sites) or the outranking method. Other methods are available and are included in the resource documents listed below.

i. Weighted sum method

The weighted sum method is the simplest method for evaluating infrastructure investment options. The criterion's score is multiplied by the weight, and then total scores are summed across all criteria to arrive at a final score. The weighted sum method is shown in Table 2. In this example, the criteria have been assigned simple weights for importance (where 5 is the most important on a scale of 1-5). Additionally, we assume all criteria are ranked on a scale of 1-5, where a 5 is the best in terms of performance (e.g., societal or economic benefits) and 1 is the worst performance. By multiplying the score by the weight, a final score is given for each criterion. The scenario with the highest aggregated score would represent the best investment decision. Based on the example in Table 2, the future scenario outranks the current situation (or baseline scenario).

Table 2: Example weighing and scoring system

Criterion	**Weight**	**Current Situation – Score (x Weight)**	**Future Scenario – Score (x Weight)**
CAPITAL COSTS	5	4 (x5) = 20	3 (x3) = 9
ENERGY CONSUMPTION	3	2 (x3) = 6	4 (x3) = 12
WASTEWATER TREATMENT CAPACITY	2	1 (x2) = 2	4 (x2) = 8
VULNERABILITY	2	1 (x2) = 2	4 (x2) = 8
TOTAL SCORE		**30**	**37**

ii. Outranking method

The outranking method is popular in some European countries for governmental investment decisions. "One option is said to outrank another if it outperforms the other on enough criteria of sufficient importance (as reflected by the sum of the criteria weights) and is not outperformed by the other option in the sense of recording a significantly inferior performance on any one criterion. All options are then assessed in terms of the extent to which they exhibit sufficient outranking with respect to the full set of options being considered as measured against a pair of threshold parameters" (Department for Communities and Local Government 2009).

e. Conduct an uncertainty and sensitivity analysis

As MCDA is rooted in understanding decision-makers' definitions of objectives, criteria, and scoring, as well as personal preferences in terms of weighting, there is a good deal of uncertainty associated with MCDA results. As such, it is important to conduct an uncertainty and/or sensitivity analysis to ensure robustness of results and representativeness of stakeholder opinions. The Department for Communities and Local Government guidance document (2009) provides options for conducting sensitivity analysis:

- Stakeholders that have participated in the study (through workshops or other engagement) can be consulted to ensure that the MCDA model includes criteria that are of concern to them.
- Examine how the aggregate scoring may change by having different stakeholders score and weight the criteria.

For an uncertainty analysis, the valuation practitioner may wish to add an "uncertainty" column to the evaluation matrix that allows stakeholders to rank their degree of uncertainty. An uncertainty column can be added as a general column applicable to all scenarios, or uncertainty columns can be added for each scenario. Uncertainty can also be rated on a scale of 1 – 5, whereby 1 is highly uncertain and 5 is certain. The uncertainty score would *not* be used in the calculation to estimate the total aggregated score for each scenario, but could simply be used as a visual to demonstrate the degree of uncertainty associated with each criteria and each scenario.

f. Report results clearly

To ensure that MCDA results are useful for decision makers, it is important for the valuation practitioner(s) to be transparent in terms of the method(s) used, general assumptions made, and uncertainties, limitations, and caveats associated with data and assumptions when reporting results. This also helps other valuation practitioners who may look towards analysis results for guidance in their own country. The Coastal Capital Guidebook provides further information on best practice guidelines for reporting results from economic analyses (Waite et al. 2014). Specifically, for MCDA, it is important to document why a BCA could not be conducted, challenges associated with completing the Characterization Form and evaluation matrix, and assumptions regarding the benefits of investment in improved wastewater treatment, as well as listing the stakeholders involved in determining the weighting and scoring process.

Table 3: Multi-Criteria Decision Analysis - Evaluation Matrix

CRITERION	*Weight*	*SCORE*		*Uncertainty*
		Current situation	*Future Scenario*	
CAPITAL/INVESTMENT COSTS *One-time initial investment costs for wastewater equipment/infrastructure*				
ANNUAL/RECURRING COSTS *Recurring operations and maintenance expenses including staffing/labor, energy, and operations and maintenance expenses*				
ENERGY CONSUMPTION *The overall annual energy demand for the investment scenario*				
OPERATIONAL COMPLEXITY *Is the wastewater management system easy to operate and maintain in terms of accessibility and operability?*				
WASTEWATER TREATMENT CAPACITY *The volume of wastewater that can be treated*				
VULNERABILITY *The ability of the wastewater management system to withstand projected changes in vulnerability drivers (e.g., climate change, sea level rise, increased storm intensity, increased rainfall variability, warmer air and sea temperatures, earthquakes, hurricanes)*				
AMBIENT WATER QUALITY IMPACT *Impact of the wastewater management system on fresh and coastal water quality*				

POLLUTANT REMOVAL EFFECTIVENESS *The effectiveness of the treatment technologies in place to remove pollutants found in the Water Pollution Rules*				
UNTREATED DOMESTIC WASTEWATER *The amount of wastewater that escapes the wastewater management system and goes untreated into receiving water bodies*				
ECOSYSTEM IMPACTS *The expected impact of the wastewater management system on the overall health of key ecosystems (e.g., mangroves, rivers, coral reefs, seagrasses, beaches)*				
ECOSYSTEM SERVICE IMPACTS *The expected impact of the wastewater management system on key goods and services provided by key ecosystems (e.g., fisheries production by coral reef; tourism and recreation provision by coral reefs and mangroves)*				
HUMAN HEALTH IMPACTS *The expected impact of the wastewater management system on human health (e.g., gastroenteritis, ear infections, eye infections, salmonella poisoning, etc.)*				
ECONOMIC GROWTH/DISRUPTION *The expected impacts on the local economy due to impacts on ecosystems and their goods and services (e.g., will the wastewater management system improve/reduce tourism to coral reefs? Will the wastewater management system reduce filtration costs for industries like hospitals and bottling companies?)* *Economic disruptions to wastewater related construction (e.g., disruption of business due to noise/construction)*				

Step 4b: Benefit-Cost Analysis - The quantitative approach

If you believe you have the data needed to conduct a Benefit-Cost Analysis (BCA), you can conduct the following recommended steps. In general, the key steps for conducting a BCA for the research question include:

a. Analyze changes in ecosystem service and in human health impacts under different future scenarios
b. Choose valuation methods and monetize benefits and costs
c. Collect and analyze data
d. Conduct uncertainty and sensitivity analysis
e. Compare benefits and costs using BCA
f. Report results clearly

a. Analyze changes in ecosystem services and human health impacts under future scenarios

Analyzing changes in ecosystem service provision and human health impacts necessitates analyzing the biophysical relationships between a change in wastewater investment or management, resultant changes in water quality, and then resultant changes in ecosystem service provision and human health impacts due to changes in water quality. This is likely the most complicated step in conducting the economic valuation.

There are several approaches to understanding and/or quantifying these biophysical relationships. Each option has a different implementation cost and accounts for uncertainty in a different way. The approaches include (Waite et al. 2014):

- **Modeling**: This approach uses models (including biophysical models and production functions) to estimate each step in the causal chain under each scenario, including (a) the expected change in water quality for key water bodies/ecosystems from an improvement in wastewater effluent; (b) the ecosystem state resulting from the scenario; (b) the change in ecosystem service; and (c) the resulting change in benefits.
- **Expert Opinion**: This approach can be an extension of participatory scenario development, where participants go beyond describing the policy and trends to be explored in a scenario, but also project the effect on human health and the ecosystem and the changes in ecosystem services.
- **Rough estimation through informed function or information transfer**: This approach examines relevant studies, values, and biophysical relationships to approximate ecosystem conditions and ecosystem services provision in the location of interest.

The Coastal Capital Guidebook provides further guidance on these three approaches, including useful ecosystem modeling tools and decision support tools that have relevance for the wastewater policy question. There are also human health models available to estimate impacts of water pollution events and infrastructure decisions on changes to public health. For example, the U.S. Environmental

Protection Agency has a model called the Water Health and Economic Analysis Tool (WHEAT) that is designed to assist wastewater utilities in quantifying an adverse event's impacts on public health (U.S. EPA 2014).

i. Analyzing changes in ecosystem services

Analyzing changes in ecosystem services necessitates understanding how a change in water quality first impacts the health of key ecosystems (key ecosystems should be identified via the Characterization Form), and how a change in ecosystem health results in a change in provision of key ecosystem goods and services (key ecosystem services for each key ecosystem should be identified via the Characterization Form). The Coastal Capital Guidebook lists key questions to consider when analyzing changes in ecosystem services:

- Where is the impacted area and what are its current (baseline) physical, biological, social, and economic features?
- How, and to what extent, will the future wastewater management scenario(s) change the environment (e.g., ecological, economic, cultural, aesthetic, health and safety, social impacts)?
- What methods could be used to assess the impacts of the scenarios on the ecosystem and ecosystem services?
- Are data available to assess these impacts?
- Who are the key stakeholders likely to be affected by the different scenarios, and how will these groups be engaged/consulted?
- What is the relative significance of the environmental impacts to key stakeholders under the different scenarios?
- What measures would reduce or minimize the negative impacts of the alternative scenarios?

Under this step, it is important that most of these questions can be answered with results from the Characterization Form.

ii. Analyzing changes in human health impacts

Estimating changes in human health impacts as they relate to wastewater investments is rooted in understanding how changes in water quality correspond to changes in morbidity and mortality. Human health valuation generally focuses on estimating changes in risk of morbidity and mortality for targeted populations in relation to exposure to key pollutants (U.S. EPA 1999). Human health risk is a key concept in human health impact valuation because there are generally multiple sources of risk or causes of illness. As a result, it can be difficult to determine the exact contribution of environmental factors like changes in water quality from untreated or improperly treated wastewater effluent to the development of death and disease (Remoundou and Koundouri 2009). The key steps in valuing human health impacts include first estimating populations at risk of contracting a specific illness for a given pollutant or pollutants, estimating changes in incidences of that illness, and then estimating relevant costs associated with that illness. Annex 2, section C provides a list of key illnesses that can result from contamination to wastewater pollution by pollutant.

Dose-response methods are able to assess the effects of changes in water quality and the risk of contracting specific illnesses. Dose-response models estimate the *risk* of contracting a disease based on information on exposure to a specific pollutant or contaminant (i.e., number of people exposed to fecal bacteria, duration of exposure, etc.) and a given level of that pollutant found in a water body. If dose-response models have not been established for a specific wastewater-related illness, then the risk of illness can be estimated based on known cases of that illness, and expert opinion on the percentage of illnesses attributable to a wastewater-specific pollutant. It is important, however, to identify with stakeholders other sources of water pollution for a specific water body to which a population is exposed, to get a clear sense of confounding factors.

Key questions to consider when analyzing changes in human health impacts may include:

- Where is the impacted area and what are its current baseline economic features?
- How, and to what extent, will the scenarios change human health impacts related to wastewater pollution?
- What methods could be used to assess the impacts of the scenarios on human health?
- Are data available to assess these impacts?
- Who are the key stakeholders likely to be affected by the different scenarios and how will these groups be engaged/consulted (e.g., populations that regularly swim or fish from impacted marine and freshwater areas)
- What is the relative significance of human health impacts to key stakeholders under the different scenarios?
- What measures would reduce or minimize the negative impacts of the alternative scenarios?
- Are some populations more at risk than others (e.g., children, the elderly, pregnant women)?

Most of these questions can be answered with results from the Characterization Form.

b. Choose valuation methods and monetize benefits and costs

This section provides a general overview of valuation methods available for monetizing changes in wastewater costs and ecosystem and human health benefits. This is *not* covered by the Characterization Form.

i. Valuing wastewater infrastructure costs:

This is the most straightforward part of the BCA. Infrastructure costs are generally well understood for public projects because engineering or feasibility studies must be conducted by the wastewater utility (or a consultant) that detail infrastructure options, expected lifetime, design features, and costs. Costs generally include capital costs, annual operation and maintenance costs, and opportunity costs related to land requirements to install the infrastructure. The Characterization Form contains tables to help collect cost data in the current and future infrastructure sections – this data should be sufficient to estimate the total infrastructure costs for the current and future wastewater management scenarios. The analysis is interested in the change in costs between the current and future situations.

ii. Valuing ecosystem impacts:

Valuing the change in ecosystem service benefits from improved wastewater management is perhaps the trickiest part of conducting a BCA. The Coastal Capital Guidebook provides detailed guidance for valuing coastal ecosystem service benefits (which can also be applied to freshwater and inland ecosystems). There are several valuation methods available which are detailed in Table 4 below:

Table 4: Example valuation methods for ecosystem service impacts, typical applications, examples, and limitations (Waite et al. 2014).

Valuation method	Approach	Applications	Examples	Limitations
Market-based methods				
Market price (MP)	Observe market prices to analyze the economic activity generated by use of an ecosystem good or service. (Includes economic impact analysis, which examines the impacts of spending related to the good or service, and can also include indirect impacts in related economic sectors, as well as financial *analysis*, where operating costs are subtracted.)	Coastal goods and services that are traded in markets	Fisheries, tourism, mangrove timber	Market prices can be distorted (e.g., by subsidies) and they can overestimate ecosystem values if current use is above sustainable levels. Many ecosystem services are not traded in markets.
Replacement cost (RC)	Estimate cost of replacing ecosystem service with man-made service Requires three conditions are met to be valid: (1) man-made equivalent provides the same level of ecosystem service; (2) man-made equivalent is the least-cost option of providing the service; (3) people would be willing to incur the cost rather than forego the service.	Ecosystem services that have a man-made equivalent that provides similar benefits	Shoreline protection by reefs and mangroves, water filtration by forests and wetlands	Estimates might not reflect the true value of ecosystem goods and services and might inaccurately suggest that man-made goods and services are appropriate substitutes. For example, a seawall might effectively protect the shore, but does not provide fish habitat in the way a healthy coral reef does.
Cost of avoided damage (CA)	Estimate damage avoided (e.g., from hurricanes or floods) due to ecosystem service.	Ecosystem services that provide protection to houses, infrastructure, or other assets	Shoreline protection by reefs and mangroves	Difficult to relate damage levels to ecosystem quality.
Production function (PF)	Estimate value of ecosystem service as input in production of marketed good.	Ecosystem services that provide an input in the production of	Commercial fisheries	Technically difficult to determine and model the relationship between ecosystem change and its impact on the provision

		a marketed good		of the ecosystem service. High data requirements.
Non-market methods				
Hedonic pricing (HP)	Estimate influence of environmental characteristics on price of marketed goods.	Environmental characteristics that vary across goods (e.g., houses, hotels)	Tourism, shoreline protection	Technically difficult. High data requirements.
Travel cost (TC)	Travel costs to access a resource indicate its value	Recreation sites (e.g., marine protected areas)	Tourism	Technically difficult. High data requirements.
Contingent valuation (CV)	Ask survey respondents directly for willingness to pay for ecosystem service.	Any ecosystem service (most widely used for non-market ecosystem and services)	Tourism	Expensive to implement. Vulnerable to many sources of bias and requires careful survey design.
Choice modeling (CM)	Ask survey respondents to trade off ecosystem services to elicit their willingness to pay.	Any ecosystem service (most widely used for non-market ecosystem and services)	Tourism	Expensive to implement. Vulnerable to many sources of bias and requires careful survey design. Technically difficult.
Benefits transfer				
Benefits transfer	Value transfer: Use values estimated at other locations (“study sites”). Function transfer: Use a value function estimated at another location to predict values.	Any ecosystem service	Any ecosystem service	Possible transfer errors if the “study sites” and “policy site” are different.
Meta-analysis	Synthesize results from multiple existing valuation studies, using statistical regression to estimate a value function. Meta-analysis can be used for benefits transfer.	Any ecosystem service	Any ecosystem service	Requires compilation of multiple studies and statistically significant sample size of value estimates. Adequacy of studies may vary. Can lead to a loss of important valuation information during data aggregation process.

For additional guidance, the Coastal Capital Guidebook provides more information on considerations when choosing a valuation method and steps for collecting and analyzing necessary data for ecosystem services.

iii. Valuing human health impacts:

Valuing human health impacts is based on understanding the value of risk reduction. A report from the U.S. National Center for Environmental Economics (Agee and Crocker 2002) on techniques for valuing human health impacts states, "Human exposure to pollution can result in at least five types of losses of welfare. Three of the obvious losses are the medical expenses associated with treating pollution–induced illness (including the opportunity cost of time spent in obtaining treatment), lost wages resulting from the inability to work, and defensive or averting expenditures necessary to prevent or recover from illness. The remaining two less tangible monetary measures include the pain and suffering associated with symptoms of the illness and/or lost opportunities for normal activities, and the change in life expectancy or risk of premature death."

As is the case for valuing ecosystem service impacts, there are several methods available and used in economic valuation to value or monetize human health impacts (including both market and non-market valuation options). Human health impacts are generally valued based on morbidity and mortality. For morbidity costs, economic valuations general consider health expenses (e.g., cost of hospitalization, medication, care-takers, etc.) and lost labor. Mortality costs, however, are often valued based on the "value of a statistical life" or VSL. Table 5 provides examples of frequently used methods.

Table 5: Example valuation methods for human health impacts and limitations

Valuation method	Approach	Limitations
Market methods		
Averting behavior (household production)	Values human health through real expenses paid by households for health expenses in order to prevent or "avert" an environmental or health impact such as water pollution.	Limited to cases where market defensive actions are available. Financial expenditures may substantially under-estimate the true cost of pollution.
Cost of illness	Estimates the direct and indirect economic costs of an illness (e.g., hospitalization, cost of medicine, lost earnings) and the potential savings from eradication of that illness.	Market prices related to human health can be distorted (e.g., by subsidies); does not generally account for pain and suffering.
Human capital	For morbidity, this method estimates the productivity loss (measured in workdays) due to contracting an illness. For mortality, the loss of life is valued based on foregone earnings associated with premature mortality.	Ties loss of life to foregone earnings therefore neglecting peoples' preferences for avoided pain and suffering and hospitalization.
Quality adjusted life years	Estimates changes in the quality and quantity of life by using surveys to rate different health conditions and adjust the number of life years lost to represent lost quality-adjusted life years. Estimates health quality ranges from 0 (healthy) to 1 (death) and multiplies this by the value of a statistical life.	Often used in health economics to assess the cost-effectiveness of a policy, program, or investment decision, however, the approach is still based on the value of a statistical life which is highly controversial.

Non-market methods		
Choice modeling (CM)	Ask survey respondents to trade off policy impacts to elicit their willingness to pay.	Expensive to implement. Vulnerable to many sources of bias and requires careful survey design. Technically difficult.
Contingent valuation (CV)	Ask survey respondents directly for willingness to pay (WTP) to avoid damages or for a policy intervention (i.e., morbidity and mortality associated with an illness).	Expensive to implement. Vulnerable to many sources of bias and requires careful survey design. Estimating the value of a life is also highly controversial for ethical reasons.
Hedonic pricing (HP)	Estimates the difference in housing prices based on exposure to pollution sources or estimates the difference in wages between hazardous and non-hazardous jobs.	Technically difficult. High data requirements.
Benefits transfer		
Benefits transfer	Value transfer: Use values estimated at other locations ("study sites"). Function transfer: Use a value function estimated at another location to predict values.	Possible transfer errors if the "study sites" and "policy site" are different.
Meta-analysis	Synthesize results from multiple existing valuation studies, using statistical regression to estimate a value function. Meta-analysis can be used for benefits transfer.	Requires compilation of multiple studies and statistically significant sample size of value estimates. Adequacy of studies may vary. Can lead to a loss of important valuation information during data aggregation process.

Source: Adapted from Agee and Crocker 2002; Remoundou and Koundouri 2009; and EPA 1999

c. Collect and analyze data

All valuation methods require data collection – to use valuation results as part of a formal BCA may entail collecting additional data beyond what was collected in the Characterization Form. The Coastal Capital Guidebook states that there are three main types of data that can be used:

- Market prices found through secondary data collection from private sector sources (e.g., fish markets, tourism organizations), government statistics, or international organizations.
- Local social, health, environmental, and economic information that relates to how a change in ecosystem use or management leads to a change in ecosystem function and service provision or change in human health impact. This information can be found through local surveys, modeling, and other primary data collection activities.
- Preference data generated by asking people through questionnaire surveys or interviews.

The Coastal Capital Guidebook provides additional information on data requirements for economic valuation methods and possible data sources.

d. Conduct uncertainty and sensitivity analysis

There are many sources of uncertainty in a BCA related to wastewater management, especially if biophysical data is uncertain or missing for the study site or the practitioner relies heavily on expert input. One of the easiest ways to address uncertainty is through sensitivity analysis whereby the sensitivity of valuation results is tested by altering variables one by one to see how outcomes change. For example, "maximum," "average," and "minimum" values can be used to test how outcomes change, and create a range (using lower and upper bound estimates) of possible values. It is also good practice to vary the discount rate to account for uncertainty with regards to time preferences for target populations (Waite et al. 2014).

e. Compare costs and benefits

The final step in the analysis is to compare costs and benefits using BCA as the decision support tool. There are several metrics that can be used to compare costs and benefits including net present value, benefit-cost ratio, and internal rate of return. Box 1 provides details on how to calculate these indicators. The valuation practitioner can work with decision-makers to understand which metrics are most important for making decisions in the local context.

A key first step in comparing costs and benefits is to determine the most appropriate timeframe to consider. While benefits to ecosystems and human health that result from an improvement in wastewater management may extend beyond the lifetime of a given wastewater treatment facility or management option, it is advisable to peg the period of analysis to the expected life of the future wastewater management alternative. Alternatively, the analysis period could be pegged to the payback period on bonds or any other financing instrument typically used by the wastewater authority for infrastructure investments (Talberth et al. 2013).

Benefits and costs must be placed on equal footing and, as a result, should be calculated in terms of *present value*. The best choice of discount rate is the discount rate typically used by the wastewater utility for infrastructure projects. It is recommended to use a range of discount rates to reflect the uncertainty in terms of how stakeholders' value money held today versus in the future (as part of the sensitivity analysis).

After values are placed into present value terms, the metric or metrics identified by stakeholders can be used to compare which wastewater management option (the current situation vs. future scenarios) generates the greatest economic gain to society. After completing the analysis, the practitioner should refer back to Part I of this report (Summary, Section 4) to consider outreach approaches for ensuring economic valuation results are integrated into decision making processes.

Box 1: Comparing benefits and costs through decision support criteria

A common indicator used for BCA is *net present value (NPV)*, which is the sum of the present value of costs and benefits, should be calculated. A positive NPV shows that benefits are greater than costs and the wastewater management alternative generates positive social benefits. A negative NPV shows that costs are greater than benefits and should probably not be considered as a viable future option.

$$NPV = \sum_{t=1}^{T} \frac{Benefit^t - Cost^t}{(1+r)^t}$$

Where T is the analysis period, t is the time, and r is the discount rate.

Another indicator commonly used for BCA is a benefit-cost ratio (BCR). In this case, the present value stream of benefits is divided by the present value stream of costs. A BCR greater than one indicates a worthwhile investment while a BCR below one indicates that the management alternative should not be considered a viable future option.

$$BCR = \frac{\sum_{t=1}^{T} \frac{Benefit_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{Cost_t}{(1+r)^t}}$$

Finally, benefits and costs can also be compared using an *internal rate of return (IRR).* The IRR is the discount rate at which the present value of total benefits over the analysis period equals the present value of total costs over the analysis period. The IRR should be greater than the discount rate for a project to be accepted.

$$PV(benefits) - PV(costs) = 0$$

Wastewater management alternatives can then be ranked according to either of these decision support criteria.

f. Report results clearly

As with MCDA, it is important for valuation practitioners to report BCA results clearly – that is, in a transparent and credible manner. Beyond reporting BCA results, it is important to document the valuation methods used for both ecosystem and human health benefit monetization, all analysis assumptions and underlying equations, and uncertainties, limitations, and caveats attached to results (Waite et al. 2014). As BCA presents quantitative results, it is important to consider that results can be used in future benefit transfer studies[2] for other sites in the Caribbean. Key data to report from a BCA include (based on Waite et al. 2014):

- Name of lead author(s)
- Year of publication
- Title of study
- Objective of study
- Funding source
- Country
- Location description (including longitude and latitude)
- Population description (population at risk of contracting a wastewater-related illness)
- Scale of the study site (local, province, national, regional)
- Name of ecosystem(s) (where relevant)
- Type of ecosystem(s)
- Ecosystem service(s) analyzed
- Human health risk(s) analyzed
- Ecosystem and human health valuation method(s)
- Value estimate (original currency and units)
- Units (e.g., currency, per person, hectare, month, year)
- Data sources

3. Conclusions

This section of the report, Part II, provides valuation guidance for both MCDA and BCA. After completion of the analysis and consideration of how to report results, the practitioner should refer back to Part I (Summary Report) to reflect on how to conduct outreach to ensure results are used in decision making. The guidance provided in Part II is meant to be simple yet information for economic valuation practitioners. It is important to note, however, especially for non-economists who are leading valuation efforts, that the valuation methods, especially for BCA, do require technical training. As such, it is important to consult economists familiar with valuation methods and make use of outside guidance as referenced in this report, such as the WRI Coastal Capital Guidebook for valuation of coastal ecosystem services (Waite et al. 2014). It is worth noting that the valuation of economic benefits relies either on models of biophysical relationships, or on expert knowledge or opinion on the likely benefits (to ecosystems and to human health) of the investment in wastewater treatment. As such, it is also important to include experts who can evaluate likely environmental improvement from a biophysical perspective. Additionally, practitioners may wish to meet with communications experts after finalizing results to properly message results to key decision makers and stakeholders.

[2] Benefits transfer as an economic analysis option that involves borrowing an economic value (say, from a BCA study) from one site (the “study site”) and applying it to another (the “policy site”). Depending on the context, the value may be adjusted or modified to “suit” the new site. The attraction of benefits transfer is that it avoids the cost and time involved in conducting primary valuation studies, which can be prohibitive in Caribbean countries (Waite et al. 2014).

For additional guidance on Multi-Criteria Analysis please consult the following resources:

- Multi-criteria analysis guidance from the European Commission: http://ec.europa.eu/smart-regulation/guidelines/tool_57_en.htm
- Multi-criteria analysis manual for making government policy, United Kingdom (Department for Communities and Local Government 2009): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7612/1132618.pdf
- Guidelines for applying Multi-Criteria Analysis to the assessment of criteria and indicators, CIFOR (Mendoza et al. 1999): http://www.cifor.org/livesinforests/publications/pdf_files/toolbox-9c.pdf
- Multi-criteria analysis in natural resource management: A critical review of methods and new modeling paradigms (Mendoza and Martins 2006)
- An article by Mateo (2012) on the weighted sum and weighted product method. In *Multi-criteria analysis in the renewable energy industry.* Green Energy and Technology. Springer Link.

MCDA results (including the completed evaluation matrices) for each pilot site can be found in the technical summaries in Part I of this report. Characterization Forms for the three pilot sites can be found in Annex 3.

For additional guidance on BCA, please consult the following resources:

- Agee, M.D., Crocker, T.D., 2002. On Techniques to Value the Impact of Environmental Hazards on Children's Health. National Center for Environmental Economics. Working Paper #02-08.
- Remoundou, K., Koundouri, P., 2009. Environmental effects on public health: An economic perspective. International Journal of Environmental Research and Public Health. Vol. 6: 2160—2178.
- Turner, R. K., S. Georgiou, and B. Fisher. 2008. Valuing Ecosystem Services: The Case of Multifunctional Wetlands. London: Earthscan.
- U.S. Environmental Protection Agency (EPA). 2010. Guidelines for Preparing Economic Analyses: http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf
- U.S. Environmental Protection Agency, 1999. The benefits and costs of the Clean Air Act 1990 to 2010. EPA Report to Congress.
- van Beukering, P., L. Brander, E. Tompkins, and E. McKenzie. 2007. Valuing the Environment in Small Islands: an Environmental Economics Toolkit. Peterborough, UK: Joint Nature Conservation Committee and OTEP: http://jncc.defra.gov.uk/page-4065

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Remoundou, K., Koundouri, P., 2009. Environmental effects on public health: An economic perspective. International Journal of Environmental Research and Public Health. Vol. 6: 2160—2178.

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U.S. Environmental Protection Agency, 1999. The benefits and costs of the Clean Air Act 1990 to 2010. EPA Report to Congress.

United Nations Framework Convention on Climate Change (UNFCCC), 2014a. Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change: Benefit-Cost Analysis. Retrieved from http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5314.php on September 29, 2015.

United Nations Framework Convention on Climate Change (UNFCCC), 2014a. Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change: Multicriteria

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http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5440.php on September 29, 2015.

Waite, R., L. Burke, Gray, E., 2014. 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.