Financial and Economic Analysis Report and Action Plan including Non-Technical Summary

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Contents

Glossary

1. BACKGROUND

The Government of Barbados, Barbados Water Authority (BWA) and the Caribbean Community Climate Change Centre (CCCCC) is developing a Green Climate Fund (GCF) project aimed to build climate resilient into the wastewater systems of Barbados. The projects address challenges facing the wastewater systems particularly those caused and exacerbated by climate change. The BWA wastewater division propose to support increased adaptation and resilience to climate change in Barbados by introducing mechanisms which reduce its carbon footprint and greenhouse gas emissions and, in so doing, set a standard and example for the Caribbean in wastewater management for reuse.

There are currently two Sewage Treatment Plants on the island – The Bridgetown Sewage Treatment Plant and the South Coast Sewage Treatment Plant. Both Treatment Plants discharge the effluent water out to sea but the sludge generated from the Treatment Plants is disposed of on land. Building resilience and addressing the climate hazard affecting these plants will enable the systems to function efficiently and effectively. On the other hand, adopting systems that enhances the wastewater systems would enable the country to access water resources that otherwise would not have been put into productive use. This could help to alleviate the some of the water scarcity issues, which are exacerbated by climate change, affecting the island. These actions will also complement ongoing activities aimed at building climate resilience in the water sector of Barbados.

It is against this background that project preparation funding has been secured which has allowed the preparation of studies for the development of a full funding proposal for a project titled, "The R's (Reduce, Reuse and Recycle) for Climate Resilience Wastewater Systems in Barbados (3R-CREWS)". The work covered in this report is one part of the preparation studies. As such it draws on the other studies, principally the Conceptual Design Report and the Feasibility Report prepared by Integrated Sustainability Ltd., the South Coast Pre-feasibility Study by AECOM and the Cost-Benefit Analysis: Provision of Reclaimed Water for Irrigation Purposes prepared by the Barbados Ministry of Agriculture and Food Security. These reports detail the proposed engineering works and the associated capital and operational costs.

2. Objective

The main objective of this work is to assist the Barbados Water Authority to deliver a financial and economic analysis (FEA) for the "The R's (Reduce, Reuse and Recycle) for Climate Resilience Wastewater Systems in Barbados (3R-CREWS)". This is in compliance with the GCF and Barbados' requirements, including a financial and economic summary of works to be conducted under the project. The FEA is to evaluate and recommend appropriate financial and economic instrument and management alternatives for the implementation of the project. In addition, the consultancy will prepare conceptual financial and economic designs for the wastewater management infrastructure and identify effluent reuse avenues in Barbados.

The specific objectives are, inter alia:

1. To provide the Government of Barbados through the BWA, the CCCCC and GCF with sufficient financial and economic information to justify acceptance, modification or rejection of a proposed list of financially ranked wastewater treatment project interventions with a climate change adaptation dimension. The list would include priority components within the projects, which would support the implementation of the proposed objectives of

the Project 'Building Resilience of wastewater management to climate change in Barbados',

2. To provide the Government of Barbados through the BWA, the CCCCC and GCF with guidance in the selection process of the most suitable and relevant projects for further project formulation, based on the amount of funds available under the GCF, in support to the implementation of the Project 'Building Resilience of wastewater management to climate change in Barbados',
3. To provide the related documentation for selected projects prepared for submission to the BWA and for consideration for financing.

3. Scope of Work

The work reported on in this document falls under Task 3: Conduct a Financial and Economic Analysis and Action Plan of the Terms of Reference, which states.

"The Analysis and Action Plan is intended to provide a description of the project implementation structure, outlining legal, contractual, institutional, and financial arrangements from and between the potential financers (such as the GCF), implementing and executing entity(ies) and beneficiaries. It should also provide information on the financial flows needed at various stages of the project implementation and the required implementation arrangements between the implementing agencies and beneficiaries. Provide a brief overview of the capacity the implementing partners to manage the financing required for the execution of the various activities. This could include a description of the experience and track record of the implementing partners to execute the activities that are expected to undertake as part of the 3R-CReWS project. The Analysis and Action Plan should include a diagram(s) or organogram(s) that maps the implementation arrangements among the implementing and executing entities including the governance structure, legal arrangements, and the flow and reflow of funds between entities.

The Analysis and Action Plan should also identify and make recommendation on the most appropriate blend of financing for the implementation of this project as well as the market failure that is being addressed with funding to be provide by the GCF. Consider the risk sharing structure between the public and private sectors, the barriers to investment and the indebtedness of the recipient, the Analysis and Action Plan should provide justification on why the level of concessionality of the GCF financial instrument(s) is the minimum required to make the investment viable. Additionally, how does the financial structure and the proposed pricing fit with the concept of minimum concessionality? Who benefits from concessionality? Finally, it should identify how the project/programme sustainability (financial, institutional, social, gender equality, environmental) will be ensured in the long run after project closure, including how the project's results and benefits will be sustained.

Describe how the recommended financial structure is adequate and reasonable in order to achieve the proposal's objectives, including addressing existing bottlenecks and/or barriers, and providing the minimum concessionality to ensure the project is viable without crowding out private and other public investments."

4. Structure of the Report

The Report is structured in two parts. The first part covers the use of the model and its outputs, and includes:

1. An overview of the modelling approach based on the Baseline Report and the Financial and Economic Dynamic Model will be provided.
2. Outputs from the model of the various options and scenarios will be presented.

The second part considers the implications of the model outputs and covers:

1. The project implementation structure and financial arrangements,
2. The financial flows and the capacity to manage them.
3. Concessional financing.
4. Sustainability.

In addition to the formal report a Non-Technical Summary of the findings and recommendations is provided.

Part 1: Financial and Economic Modelling

5. Introduction

5.1 General

There are two centralised sewerage systems serving Barbados, the Bridgetown and the South Coast Sewerage Systems. Together they serve approximately 5% of the population and together have approximately 3,500 connections to the systems. The Bridgetown system serves the highly urbanised centre of Bridgetown, its commercial businesses and the many Government facilities. The Sewage Treatment Plant provides secondary treatment of the wastewater flows with treated effluent being discharged via a sea outfall. The South Coast system was initiated to serve the tourist orientated area and to address the deterioration of the coastal marine environment linked to nutrient flows. The South Coast Sewage Treatment Plant provides primary treatment with effluent discharged via a long sea outfall.

There are several emerging issues associated with the existing wastewater management arrangements. Both treatment works have suffered from operational deficiencies including plant failures and breakdowns associated with maintenance and ageing challenges. The Cartagena Convention's Annex III Land-based sources of Marine Pollution targets the discharge of sewage effluent along with standards for marine water quality – complemented by Barbados' own Marine Pollution Control (discharge) Regulations. However, the most important consideration is that for a water scarce country, the discharge of wastewater to the marine environment is a waste of an increasingly valuable resource. To put this in context, Barbados currently abstracts 85-95% of the sustainable safe yield of its groundwater aquifers. With climate change the sustainable safe yields of the groundwater aquifers can be expected to decrease. The discharge of an increasingly scarce resource, in the form of treated wastewater as a practice is a waste of a valuable resource and one that could be harnessed to enhance water security.

5.2 Treatment Plant Upgrading Options

In order to utilise wastewater discharges the existing sewerage systems and in particular the treatment plants will require upgrading to be able to treat the water to a standard suitable for use. The other consideration is what beneficial uses could treated, reclaimed wastewater be put to. The two questions are interlinked as standards of treatment can be tailored to particular uses.

The engineering studies carried out have primarily focused on the upgrading and improvement of the two Sewage Treatment Plants. The sewage collections systems, apart from considerations such as how to address the ingress of stormwater into the sanitary sewers, have not been a focus. In terms of the level of treatment to be provided through the upgrade, this has been guided by two complementary reuse options; for indirect potable water recharge (IPR) and/or for irrigation.

The basic engineering parameters and associated capital and operational costs for the upgrading of the two Sewage Treatment Plants have been set out in the reports by consultants. For the Bridgetown Plant these have been set out in the Conceptual Design Report and the Feasibility Report, for the South Coast Plant these are taken from the Pre-Feasibility Study. The reports make assumptions regarding the required treatment capacity of the Plants and base their estimation of operational costs on a steady state flow through the plants.

However, the volume of wastewater entering the plants to be treated varies depending on the timescale considered and will be influenced by a host of factors. This work requires projections of future wastewater flows, for a 30-year horizon, which we have taken up to 2050. Over such a period of time the generation of wastewater flows will be influenced by factors such as demographic changes, economy and development, all of which cannot be predicted with a high level of certainty. The pattern of future wastewater flows will therefore directly drive operational costs. Furthermore, the volume of water available for reuse is directly related to the volumes entering the treatment plants. Taken together, wastewater volumes have a direct impact not just on operational costs but also on the potential generation of revenue from the uses of treated wastewater. To accommodate the uncertainty several alternative scenarios were developed. The development scenarios are based on various sources of information including development applications, the provisions of the Physical Development Plan 2017, ministerial announcements, and previous sewage development plans.

In addition to how developments influence the generation of future flows of wastewater there are other variables that over the longer term can have an influence. These include the impact of technological change on water consumption patterns, demographic changes and the impact of climate change. Climate change is expected to affect both water consumption and water availability. In respect of water consumption, climate change is expected to increase unit consumption whilst on the supply side to decrease availability.

5.3 Treated Wastewater Reuse Options

Two broad options for the reuse of the treated wastewater flow volumes have been considered. The one is the use of the reuse of the treated water to support irrigated agriculture. The other is to use for indirect potable reuse by infiltration into the groundwater aquifers. For use to support irrigated agriculture, the Ministry of Agriculture and Food Security undertook a Cost-Benefit Analysis of the use of water from the South Coast Sewage Treatment Plant. The report recommended the reuse of treated wastewater to support irrigation development at River Plantation in St Philip, a Land Lease area supported through the Barbados Agriculture Development and Marketing Corporation (BADMC). With respect to the use of treated water from the Bridgetown Plant several options were considered. The Technical Working Group has recommended the option of supplying water for irrigation in the general area of Salters, Lears, Neils, Waterford and Codrington, along and adjacent to the ABC Highway. In reaching their decision, the Technical Working Group also recommended that this be seen as a first phase, with further phases seeing the extension of the wastewater infrastructure to Spring Hall in St Lucy. In both cases provision is made for IPR during those periods when water for irrigation is not required. A further option of using the treated wastewater from both Plants for IPR was considered but was not recommended.

5.4 Determination of Financial and Economic Parameters

As indicated the determination of the financial and economic parameters to be included in the model were derived from reports produced by consultants. The Baseline Study and Wastewater Demand/Market Analysis Report sets out in detail the assumption, options and basis on which capital, operational and maintenance costs were derived. Because volumes of wastewater flow depend on which scenario option might be selected, operational costs were converted into costs per m^3 treated. With respect to the economic benefits, the scale of some such as greenhouse gas emissions avoided, are driven by the wastewater volumes. Other benefits, such as

Renewable Energy, potential health and environmental benefits are not driven by flow volumes. These are accounted for separately.

5.5 Summary of the findings of the Baseline Study

The following is a summary taken from the Baseline Study regarding the various findings.

To accommodate the uncertainty regarding wastewater flows through the two Treatment Plants use has been made of a scenarios approach; four scenarios with different growth assumptions have been set out. Work by Drakes, et al. (2020) indicated that assumptions of socio-economic development had a greater impact on water demand than climate change assumptions.

The review of the impact of climate change on Barbados and its water resources focused on two aspects. The first aspect was the potential impact on future available safe aquifer yields, given that Barbados presently relies on groundwater for a large part of its water supply. The review of available literature indicates that safe yields could decrease by around 50% from current levels. The second aspect was the potential impact on water consumption and hence wastewater generation. There is some evidence that water consumption increases with temperature, once average temperature reaches a tipping point of between 28ºC and 30ºC.

The current state of wastewater services and management in Barbados has been reviewed. There is a clear need, irrespective of whether or not this project goes ahead for the management of wastewater service to be improved. Similarly, the day-to-day operation of wastewater services needs to be improved, which has been commented on by other consultant's reports. Without attention to these two aspects, the upgrading of the two wastewater collection and treatment systems are more than likely to show some initial improvement but would be followed by deterioration of plant and service. The general state of the Barbados Water Authority's record keeping, and Management Information Systems leaves much to be desired if it is judged by the quality and timeliness of information provided to this study. The cost information provided by the BWA is to be used as basic information for the model to inform calculations. However, discussions with BWA personnel point to questions over the accuracy of the information provided with respect to operational expenditures.

In order to estimate the volumes of wastewater flows, in the absence of measured inflows to the two treatment works, water consumption records of customers connected to the two systems were analysed. The analysis demonstrates the impact that Covid-19 has had on consumer behaviour; increasing residential demand and decreasing commercial activity, with the hotel sector being the most heavily impacted. What emerges from the analysis is that in general wastewater flows have been over-estimated, even before the impact of Covid-19. The conclusion is drawn that the two Sewage Treatment Plants are operating at well below capacity.

In making future estimation of wastewater generation, the known developments have been included, where appropriate, using information from applications to the Town and Country Development Planning Office. The suggestion of extending the Bridgetown sewer collection system to service the Greater Bridgetown Area has been re-evaluated and it is our conclusion that the previous work has over-estimated the potential wastewater generation. The scenarios approach has been built into the Financial and Economic Model, enabling the impact of different scenarios to be evaluated. The implication of the analyses is that for the foreseeable future there is little need to expand the capacity of the Bridgetown Treatment Plant but an urgent need to upgrade it.

The potential uses of treated wastewater and by-products have been considered and based on information contained in other reports and estimations have been made with respect to volumes. With respect to the use of reclaimed treated wastewater, interviews and discussions with the agricultural community suggest broad support and a willingness to use the product. This does not seem to be an issue, more of an issue – raised by farmers – was the attitude of the public and the need for assurances around food safety.

The financial aspects considered the capital and operational costs that would be associated with different solutions to the use of reclaimed treated wastewater. The main focus has been on its reuse for agricultural purposes, noting that the MAFS is seeking to expand agricultural production, particularly in the lands in and around River Plantation in St Philip. The limiting factor is the available volume of reclaimed treated wastewater, there is more than sufficient land suitable for irrigation and based on discussions with the farming community, demand would outstrip supply.

The potential economic benefits considered have included:

- Public health benefits,
- The benefit of maintaining and improving the environmental vitality of the marine environment and its ability to attract visitors to Barbados and their contribution to the national economy,
- The sale of treated reclaimed wastewater to support the expansion of irrigated agriculture,
- The expansion of irrigated agriculture would result in increased income to farmers and also create addition employment opportunities which would benefit local economies through increased disposable incomes and contribution to government revenues,
- Increased food security and import substitution,
- Income generated from the implementation of a renewable energy photo-voltaic component through the sale of power generated to offset operating costs of the project and displacing power generated through the use of fossil fuels,
- By implementing the renewable energy component GHG emissions associated with the use of fossil fuels will be avoided and this has a benefit calculated through the associated the social cost of carbon.

Additional to the above benefits, the use of treated reclaimed wastewater would contribute to the off-setting of the impact of climate change in reducing water availability and the ability to maintain economic activity, particularly in the agricultural sector. Some of the benefits are dependent on the volume of wastewater that can be generated, for example how much water could be sold, whilst other benefits result from the establishment of the project irrespective of wastewater flow volumes, for example public health and marine environmental benefits.

The content of the report provides the basis for the Financial and Economic Cost Model. After the submission of the Baseline Study, further information and studies were made available. These developments have led to some refinements, which were not developed in the initial Study, being incorporated into the Financial and Economic Model.

6. Financial and Economic Model

6.1 Introduction to the Model

The Dynamic Economic and Financial Model (DEFM) is a planning evaluation support model to provide financial and economic information and indicators on the performance of any chosen

option and set of variables. It has the capacity to produce forecasts of the operating and financial performance of the sewerage systems under different upgrading options for both Bridgetown and South Coast Sewage Systems. In addition to the current situation of no climate, it includes two main climate change scenarios. The Model has the following specific purposes:

- Project the amount of wastewater transformed by the sewage system under different development expansion programme and different climate change scenarios, to.
- Calculate revenues arising from expansion of sewage services in both Bridgetown and South Coast Sewage Systems.
- Analyse the impact of development phases on sewage system of operating efficiencies, capital programmes, the macro-economic environment, income, and other key variables.
- Track and link costs and revenues from other activities associated with the development of the sewage system such as reuse of wastewater for irrigation, renewable energy, and nutrient production.
- Investigate the impact of climate change scenarios (No Climate Change, RCP 4.5, RCP 8.5) on wastewater projections, and on economic and financial performance.
- Estimate the avoided greenhouse gas emission associated with upgrading the two sewage systems under climate change scenarios.
- Investigate the impact of more efficient water-using technology on water demand and hence wastewater production.

The Model uses the most recent data available (2020, 2019, 2018) to establish the number of connections to the systems, the demand on potable water broken down by connection type to project wastewater flow volumes, and multiply such data by the average share of tariff income generated per connection type to calculate direct service revenue. In addition, the model calculates the associated capital and operational costs with different development phases as well as the income generated from renewable energy schemes, the sale of treated wastewater for irrigation, and sale from nutrient production. The model calculates wastewater production, costs and revenues under a choice of climate projections, being no climate change and two climate scenarios, RCP 4.5 and RCP 8.5.

The results are contingent on the quality of information provided or maintained within the Model.

6.2 The Model

The model has been developed in Excel and consists of 25 interlinked and connected sheets. The sheets are broken down into those that are Data Sheets (yellow), those that are Calculation Sheets (Blue) and those that are Output Sheets (purple). The Model is designed to be used at two levels. The first is the “Basic Method” which can be used to make changes to the main assumption associated with; different expansion phases of the sewage services, climate change scenarios, macro-economic factors such as inflation rate, level of potable water consumption, and water tariff charges. The second level “Advanced Method” allows the revisiting of the model assumptions themselves. This second mode of use requires more understanding of the logic behind the assumptions associated with the development phases and climate scenarios. In this case, users would need to make necessary changes in the technical sheet by altering the parameters used for all variables in the model.

Using the ‘Basic Method’, the variables that can be adjusted using the Dashboard include the following:

- Change in Potable Water Tariff %
- Technological change %
- Tariff for Agricultural Water Reuse ($)
- Annual Inflation (%)
- Technology Improvement %
- Domestic demand increase %
- Non-Domestic demand increase %
- Bridgetown Development Phases
- South Coast Development Phases
- Reuse Options
- Climate Change Scenario
- Nutrient Production (ON/OFF)
- Biomass Production (ON/OFF)

Using the 'Advanced Method' requires the user to gather information from other sources and enter it in the Model Datasheets rather than using the single-step variables in the Dashboard. The Datasheets include:

- Capital investment schedules
- Number of staff
- Impact of climate change
- Population growth
- Growth in number of connections broken down by consumption type: domestic and commercial
- Changes in average water consumption per connection and by development phase
- Changes in tariff charges for water and reuse of treated water
- Other financial considerations in the Financial Statements

The results of the calculations of the Model are summarized in two places: Dashboard charts and Result/Output Sheets. The Dashboard Charts include results showing operational income and total net revenue, net revenue by activities, cashflow, wastewater projection, avoided GHE, Internal Rate of Return, and selected Key Performance Indexes. The Result/Output sheets contain detailed results and outputs for the different components of the model, including; financial statement, income statement, cashflow, Key Performance Indicators, projection of wastewater flows, depreciation, and cost-benefit analysis. All of this provide the user with a forecast over 30.

A full description of the Dynamic Economic and Financial Model, how it works and how to go about making changes is detailed in the User Guide Manual.

7. Model Outputs

7.1 Baseline Outputs

The Dynamic Economic and Financial Model (DEFM) is a flexible tool that allows for the exploration of the influence of a range of variables on the outcomes. As such, it is capable of producing a wide range of outputs. This can potentially be confusing, with key insights being lost. In order to avoid this a limited number of scenarios are investigated and supplemented by sensitivity analysis, in which a few key input variables are changes to gauge their impact on the financial and economic outcomes.

The flows going through the two Sewage Plants are the key drivers for most parts of the analyses. The expected flows are dependent on the assumptions made regarding the future developments and their connection to the collection systems. The other important consideration, which flows from the determination of flows, is how those flows are to be utilised. This question has been answered; the treated reclaimed wastewater flows are to be used to support irrigated agriculture, and furthermore, the location for the proposed usage has been agreed upon. This is therefore taken as a given in the DEFM. The other major influence is that of climate change; three options are included in the model as indicated above. A description of the cases considered follows and a summary of the cases investigated through the DEFM is provided in Table 1 below.

The' Base case' assumes the following:

- No expansion of the existing collection systems for both Bridgetown and the South Coast.
- No population growth and no economic growth.
- No reuse of treated wastewater from either Plant.
- No climate change.

The 'No growth' is as set out in the Baseline Study and extended to include other aspects, it assumes the following:

- The planned developments extending the collection system in Bridgetown plus the connection of the Hyatt Ziva are implemented, for the South Coast there is no expansion to accommodate new developments.
- No population or economic growth occurs.
- Treated wastewater is reclaimed and used to support irrigated agriculture at Codrington, Neils, Lears and Salters in the case of Bridgetown and River Plantation in the case of the South Coast.
- The impact of climate change is considered using both RCP4.5 and RCP 8.5.

The 'Business as usual' also follows from the Baseline Study and assumes:

- Planned and proposed developments in Bridgetown are included as well as further tourism and commercial development of the South Coast.
- Population and commerce are assumed to increase by 1%.
- Treated wastewater is reclaimed and used to support irrigated agriculture at Codrington, Neils, Lears and Salters in the case of Bridgetown and River Plantation in the case of the South Coast.
- The impact of climate change is considered using both RCP4.5 and RCP 8.5.

The 'Growth & development' case assumes the full development of options for Bridgetown and the South Coast:

- Planned and proposed developments in Bridgetown plus the extension of the collection system to take in Greater Bridgetown are included as well as further tourism and commercial development, and expansion of the collection system of the South Coast.
- Population and commerce are assumed to increase by 2%.
- Treated wastewater is reclaimed and used to support irrigated agriculture at Codrington, Neils, Lears and Salters in the case of Bridgetown and River Plantation in the case of the South Coast.
- The impact of climate change is considered using both RCP4.5 and RCP 8.5.

For all cases the variables covering Technological change, Inflation rate, Discount rate and water tariffs are held constant.

The Inflation rate is assumed to be 4%, as per the Baseline Study report. The Baseline Study report did not propose a discount rate but rather offered a range. For initial purposes a rate of 6.7% is adopted being the interest rate used for low concessionality loans by the Green Climate Fund. An alternative, as also discussed, would be to adopt a Social Discount Rate of 3% as suggested by Campos et al (2015) – see the Baseline Study Section 8.2.2.

Table 1: Summary of Scenarios Investigated

	Base case	No growth	Business as usual	Growth & development
Development option • **Bridgetown** • **South Coast**	 Core Core	 Hyatt Ziva Core	 Bridgetown CDB Phase I	 Bridgetown expansion Phase II
Population & economic growth	None	None	1% 1%	2% 2%
Wastewater reuse	No reuse	Agricultural use	Agricultural use	Agricultural use
Climate change scenario	No climate change	RCP4.5	RCP4.5	RCP4.5

Base on the assumptions set out above, the DEFM was used to derive the associated financial and economic indicators. It should be noted that the DEFM does not calculate the Public Health and Environmental Benefits, these have been calculated following the method set out in the Baseline Study report. These benefits are assumed to be common across all cases considered, similar to similar assumptions made in the West Coast Sewage Master Plan. Net farm revenues generated and the multiplier effect of additional farming employment and its contribution to government revenues are calculated in the model as these are driven by wastewater volumes. The assumptions regarding import substitution are discussed in the Baseline Study report.

Table 2: Summary of Financial and Economic Indicators

	Base case	No growth	Business as usual	Growth & development
Capital Costs				
• Bridgetown Plant & collection system	US$38.253	US$59.098	US$59.098	US$59.098
• Greater Bridgetown collection system				US$48.000
• Bridgetown treated water transfer system		US$7.300	US$7.300	US$7.300
• South Coast Plant	US$71.460	US$71.460	US$71.460	US$71.460
• South Coast collection system				US$20.000
• South Coast treated water transfer system		US$41.300	US$41.300	US$41.300
• RE PV systems	US$0.840	US$0.840	US$0.840	US$0.840
• Total	**US$110.553**	**US$179.998**	**US$179.998**	**US$247.998**
NPV Capital Cost	US$86.527	US$150.673	US$150.673	US$203.401
NPV Operational Costs	US$123.175	US$151.087	US$152.087	US$169.485
Total NPV Capital & Operational Costs	**US$209.702**	**US$302.760**	**US$302,760**	**US$372.886**
NPV Benefits				
• GSC	US$44.180	US$51.647	US$94.849	US$299.031
• Sale of treated water		US$58.760	US$71.095	US$123.309
• RE income	US$29.191	US$29.191	US$29.191	US$29.191
• Total	**US$73.371**	**US$139.598**	**US$195.167**	**US$451.531**
Benefit Cost Ratio	0.34	0.46	0.64	1.21
IRR	-	-	-	9.1%
GHG emissions				
• Tonnes avoided	42,800	75,155	90,971	164,713
• NPV Avoided costs	US$0.453	US$0.776	US$1.816	US$3.098
Net farm revenues generated	-	US$121.578	US$148.866	US$258.877
Multiplier effect of additional farming employment	-	US$5.601	US$6.858	US$11.926
Import substitution	-	US$21.748	US$43.495	US$72.492
Public health benefits	US$0.342	US$0.342	US$0.342	US$0.342
Environmental benefits				
Maintaining reef condition	US$548.692	US$548.692	US$548.692	US$548.692
Diving	US$18.769	US$18.769	US$18.769	US$18.769
Submarine tours	US$14.000	US$14.000	US$14.000	US$14.000
Total	**US $581.462**	**US $581.462**	**US $581.462**	**US $581.462**

The results from the model's runs indicate the sensitivity of the outcome to the volume of wastewater flow generated and made available to support irrigated agriculture. The analyses indicate that it is only when investments are made that enable wastewater volumes to increase that the financial viability of the project improves. This is mostly due to a combination of the ability to generate and provide wastewater to support irrigation, and the generation of additional income to farmers from the expansion of irrigated agriculture. In addition expansion of the collection system also captures connected properties which would directly contribute to increased attributable revenue generated through the Garbage and Sewage Contribution (GSC) levy. The Cost-Benefit ratio improves as more wastewater is generated, and the Internal Rate of Return also improves. The results indicate that whilst the capital and operational costs increase from Business as Usual to the Growth and Development Cases by 23%, the benefits increase by over 130%.

When the economic benefits are taken into account the Social Cost Benefit Ratio improves across the board mainly due to the benefits generated from increased agricultural activity and the contribution of the maintenance of the marine environment and the important role it plays in supporting Barbados' tourism sector. The relative Social Cost Benefit ratios across each of the cases considered are shown in **Table *3***, all of which are positive. This reflects the wider social and environmental benefits that would flow from the implementation of the project.

Table 3: Social Cost Benefit Ratios

	Base Case	No Growth	Business as Usual	Growth & Development
Social Benefit-Cost Ratio	3.1	3.1	3.5	4.1

7.2 Sensitivity Analyses

The DEFM has the built-in ability to change a range of variables which allows the exploration of the sensitivity of the outputs to changes in assumptions. This could generate many model outputs so to simplify the sensitivity analyses, the Business-as-Usual case is used as the starting point. Five sets of sensitivity are explored:

- Alternative assumptions of inflation and discount rates,
- The impact of water savings technology,
- The effect of Climate Change,
- Alternative tariffs for water supplied to agriculture, and
- Alternative Development Scenarios.

The import substitution, public health benefits and environmental benefits are assumed not to be impacted by the variables and so will not have an effect on the outcomes.

7.2.1 Sensitivity of Inflation and Discount Rates

As mentioned above an alternative to a 4% inflation rate and 6.7% discount rate would be to use a social discount rate for public projects. There is a large literature on social discount rates for public projects (e.g. Moore & Vining, 2018). Such a rate can be taken as representing society's preference to invest now for future benefits. Although a range of rates have been proposed a rate of 3% represents a level of consensus.

Table 4: Sensitivity to changes in Inflation and Discount Rates

	Inflation Rate = 4% Discount Rate = 6.7%	Inflation Rate = 0% Discount Rate = 3%
NPV Capital Cost	US$150.673	US$153.081
NPV Operational Costs	US$152.087	US$172.679
Total NPV Capital & Operational Costs	US$302,760	US$325.759
NPV Benefits	US$195.167	US$184.759
Benefit Cost Ratio	0.64	0.57
IRR	-	-
NPV Irrigation Income	US$148.866	US$145.383
NPV Contribution to Govt Revenues	US$6.858	US$6.698

Removing the inflation rate and reducing the discount rate has the effect of giving more weight to expenditures or incomes in the near term at the expense of those in the longer term. The effect

is to increases the capital and operational costs at the expense of future income streams. Overall it reduces the Cost-Benefit ratio by 11%. The outcome is relatively insensitive to the choice of inflation and discount rates and would not change the relative outcome of the analysis.

7.2.2 Effect of Water Savings Technology

It can be expected that over the long-term changes in the design of water using appliance and the application of technology to inform and optimise water consumption will have the effect of increasing water use efficiency and conserving water resources. To explore this, it is assumed that by 2050, technology would have led to a 20% reduction in water consumption.

Table 5: Sensitivity to Changes in Water Savings Technology

	No Change in Technology	Technology Reduces Consumption by 20%
NPV Capital Cost	US$150.673	US$150.673
NPV Operational costs	US$152.087	US$151.773
Total NPV Capital & Operational Costs	US$302,760	US$302.447
NPV Benefits	US$195.167	US$184.727
Benefit Cost Ratio	0.64	0.61
IRR	-	-
NPV Irrigation Income	US$148.866	US$136.131
NPV Contribution to Govt Revenues	US$6.858	US$6.271

The reduction in flows have a minor impact reducing operating costs and a slightly greater effect on reducing benefits derived from the use of the treated wastewater. The impact is acarried through to the irrigation incomes as these depend on wastewater flows. The outcomes are insensitive to the impact of changes in technology, leading to a 5% decrease in the Cost-Benefit ratio and an 8% decrease in the NPV of Irrigation Income.

7.2.3 Impact of Climate Change

In the scenario considered it is assumed that the available water resources would be able to meet consumption. The effect of climate change is therefore looked at on the demand side rather than the supply side. Under these conditions the effect of climate change is to increase water consumption as people adapt to climate changes such as higher temperatures.

Table 6: Sensitivity to the Impact of Climate Change on the Demand-side

	RCP4.5	RCP8.5
NPV Capital cost	US$150.673	US$150.673
NPV Operational costs	US$152.087	US$152.135
Total NPV Capital & Operational Costs	US$302,760	US$302.808
NPV Benefits	US$195.167	US$196.772
Benefit Cost Ratio	0.64	0.65
IRR	-	-
NPV Irrigation Income	US$148.866	US$150.822
NPV Contribution to Govt Revenues	US$6.858	US$6.948

The effect of increasing consumption resulting from climate change has a positive financial impact as it leads to greater wastewater flows. As a result the Cost-Benefit ratio improves slightly and has a slight positive impact on irrigation income. The impact of climate change on the supply-side is discussed in a subsequent section.

7.2.4 Impact of Tariff

Changes in the tariff at which treated reclaimed wastewater is provided impacts the income side of the financial analysis without having an effect on costs. Thus from a project point of view the impact will be positive. The Cost-Benefit ratio improves by 30% for an almost doubling of the tariff, and the Internal Rate of Return moves into positive territory – 4.1%, but less that the discount rate of 6.7%. An underlying assumption is that irrigation farmers will still be willing to 'take' the price without changing their consumption habits.

Table 7: Sensitivity to Changes in Irrigation Tariff

	Agricultural Tariff Bds$2.48	Agricultural Tariff Bds$4.66
NPV Capital cost	US$150.673	US$150.673
NPV Operational costs	US$152.087	US$152.087
Total NPV Capital & Operational Costs	US$302,760	US$302,760
NPV Benefits	US$195.167	US$257.679
Benefit Cost Ratio	0.64	0.85
IRR	-	4.1%
NPV Irrigation Income	US$148.866	US$148.866
NPV Contribution to Govt Revenues	US$6.858	US$6.858

7.2.5 Alternative Development Scenarios

In this analysis the impact of the expansion of the South Coast collection system (Phase II) is considered to explore what the impact of adding additional wastewater flows to the system would be. Adding Phase II increases the capital and operational costs but also increases the benefits derived. The impact of increased flows also carries through to the irrigation sector as more land can be brought into irrigated cultivation.

Table 8: Impact of Development Scenarios

	Business-as-Usual	Business-as-Usual + South Coast Phase II
NPV Capital cost	US$150.673	US$167.620
NPV Operational costs	US$152.087	US$157.719
Total NPV Capital & Operational Costs	US$302,760	US$325.340
NPV Benefits	US$195.167	US$276.961
Benefit Cost Ratio	0.64	0.85
IRR	-	4.1%
NPV Irrigation Income	US$148.866	US$199.524
NPV Contribution to Govt Revenues	US$6.858	US$9.192

The impact of extending the collection system improves the financial position of the project and the effect is similar to the impact of increasing the irrigation water tariff. Overall though this is more favourable and more robust than increasing tariffs. Agricultural output could be increased with positive knock-on effects on local employment, food security and import substitution. Together with the results from the Growth and Development Case it underlines the importance of collecting sufficient wastewater flows as the key to improving the financial viability of the project.

7.2.6 Summary

Coming out of the analysis there are three main points. The first one is that the analysis demonstrate the importance from a financial standpoint of having sewerage systems that are able

to collect and treat sufficient volumes of wastewater for reclamation and onward provision for reuse. The onward provision for reuse of treated wastewater is critical to generating income to offset the capital and operational costs. The initial costs of establishing the sewage and distribution infrastructure will be high, the marginal capital cost of treating and supplying treated wastewater decreases with each addition unit of volume. At the same time the marginal benefit of having an extra unit of volume increases. The financial Benefit-Cost ratios become positive as more water is collected and provided for irrigation. The Benefit-Cost ratio increases to greater than 1 when the benefits from the development of irrigated agriculture are added for the Business-as-usual case. The ratio continues to increase as more water is made available for reuse.

The second point that follows from the sensitivity analysis is that the financial outcome is sensitive to the assumption of the tariff for the provision of irrigation water. Whilst changes in tariffs have a similar effect as increasing wastewater collection volumes, increasing tariffs is less desirable due to the likely substitution and income effects (Hicksian substitution). Increases in tariffs might affect the level of economic activity by irrigation farmers with other effects on the local economy and food imports.

The economic assessment of the project includes the benefits identified in the Baseline Study report shown in Table 2. This indicates that beyond the financial benefits there are significant social and environmental benefits that would flow from the project. Taking these into account the project has a significantly positive Benefit-Cost ratio. According to Green (2003) projects with a Benefit Cost ratio of 3 or more should be regarded as 'certain projects', in otherwords the case to move ahead with them is compelling.

Investment in the capital works that on the one side increase the volume of wastewater collected and on the other make it available for productive reuse is a necessity in order to realise the potential benefits.

8. Impact of Climate Change on Water Supply

Climate change has a twofold effect, on the one hand it is expected that increases in temperature, humidity and evaporation rates will increase the demand and consumption of water. On the other hand, the same effects together with changes in precipitation patters are expected to have a negative effect on the safe yields of water resources. For Barbados studies have shown that there will be an increase in aridity, more frequent dry spells, and decreases in precipitation. These changes can be expected to decrease safe yield and water availability. Less water availability could result in conditions of constrained demand, where demand is greater than available supply and has to be restricted to the available supply. The DEFM model allows for a basic assessment of the impact of climate change on water availability and supply for any combination of variables included in the model.

The methodology is described in the Baseline Study Report. In summary, the approach draws on the expected changes in safe aquifer yields for RCP4.5 and RCP 8.5, taken from the literature. This available supply is augmented by the existing installed desalination capacity. On the demand side, the projected water consumption by development of the Bridgetown and South Coast areas is used. However, this is a proportion of the whole island consumption, to take this into account assumptions were made regarding the likely development in water consumption of the rest of the island. Combining the two provided estimates by development scenario of the islandwide consumption. To this was added Non-Revenue Water estimates, assuming that over time the percentage of NRW would decrease from present levels to 25% of total municiple consumption

by 2035. The last item included is the current estimate of private abstraction. The total demand for the different development scenarios is compared to the safe yield and any surplus/deficit calculated.

The results for each of the climate scenarios, no climate change, RCP4.5 and RCP8.5 are shown in the following figures. The values of surplus (Black) / deficit (Red) are given in millions of m^3.

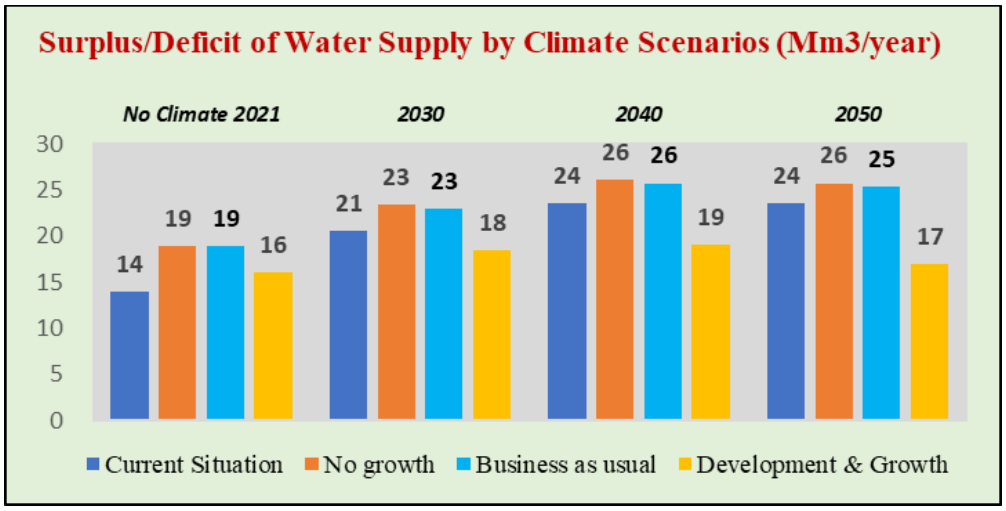

Figure 1: Water Availability - No Climate Change

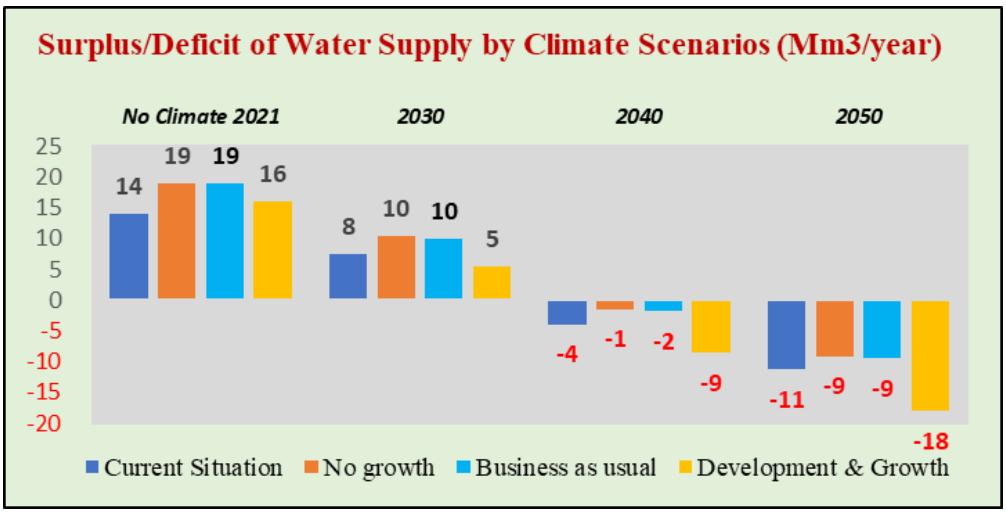

Figure 2: Water Availability - RCP4.5

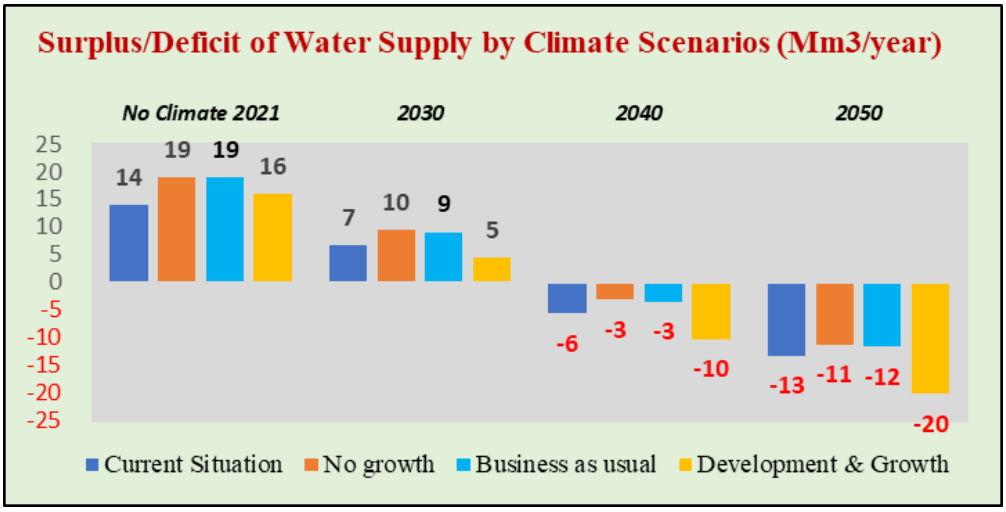

Figure 3: Water Availability - RCP8.5

All three figures shown that under all of the Development Cases considered in Table 1 there should be sufficient availability – on average – to meet demand. The apparent increase in availability under the No Climate Change scenario from Current to the others is a result of more desalination capacity coming on-line (an extra 5Mm^3 per year). By around 2037 availability has declined and a deficit situation develops and gradually worsens toward 2050 under both RCP4.5 and RCP8.5. By this stage, Barbados will have to consider its options for increasing the supply of water and increasing water use efficiency if it is to avoid a situation of constrained demand.

There are implications for wastewater flows and the onward provision of reclaimed water for irrigation. These are that if the reclaimed water were not made available then agricultural expansion would have to rely on increased groundwater abstraction to meet irrigation demand. Thus reusing treated reclaimed wastewater can be seen in this context as a climate change adaptation, especially as it offsets the need to employ the next available solution for maintaining water supply.

Part 2: Analysis and Action Plan

8. Implementation Structure

In accordance with the Accreditation Master Agreement, the Green Climate Fund will enter into a Funded Activity Agreement with CCCCC, in the form of a grant agreement, under which CCCCC, in its capacity as the Accredited Entity, shall administer the relevant GCF Proceeds to be used for the financing of the Project. The Caribbean Community Climate Change Centre (CCCCC) as the Accredited Entity (AE) will implement this project in accordance with its accreditation credentials as well as guided by the terms to be agreed in the funding agreement between the Barbados Water Authority, the Caribbean Community Climate Change Centre and the Green Climate Fund. For the implementation of the Project, the Accredited Entity shall sign a Subsidiary Agreement with BWA, as a co-Executing Entity (Implementing Agency). The Subsidiary Agreement will be legally binding. The CCCCC will not on grant any monies to BWA, nor will BWA, on grant monies to the CCCCC. Although BWA, will have responsibility for the expenditures related to its co-financing, it will report to the CCCCC all procurement, expenditure and accounting records associated with its Co-financing. The CCCCC will manage, procure and account for all activities associated with the GCF proceeds.

The Project will be implemented over five-year period jointly by the CCCCC and the BWA. Both the CCCCC and the BWA will act as an Executing Entity (Implementing Agency). Each will be responsible for specified and identified Components of the Project. The Government of Barbados, through the BWA will provide counterpart funding for the Project. This funding will directly support Project Components falling under capital works associated with the Bridgetown Sewage System and its upgrading. In addition, the Government of Barbados will provide funding for the South Coast Sewage System and its upgrading capital works; this does not form part of the work supported by the GCF but runs in parallel. The two sets of work are seen as two complementary and necessary parts of a whole.

The BWA as one of the two Executing Entity (Implementing Agencies) will report to the CCCCC and be guided by the terms set out in the Funding Agreement, Procurement Guidelines of the CCCCC and/or those of the Government of Barbados. The Government of Barbados, through the Ministry of Transport Works and Water Resources Management, will provide some oversight for the project. The BWA's Board of Directors is expected to report to the Ministry on the status of various activities identified in the proposal.

Those Components identified as falling under the purview of the CCCCC will be executed under the CCCCC Project Management Office. Those Components identified as falling under the purview of the BWA will be executed under the management of the Project Management Office (PMO) of the BWA headed by the Project Manager, through a dedicated Project Team, additional to the existing Core Staff complement. The Project Team will be staffed with a Project Manager, a Project Coordinator, Project Engineer and Administration Assistant. The Project Team will be provided with the assistance of the Procurement and Finance Officers as well as Administrative Support from the Core Staff team. The Project Team will also draw upon the available collective resources of the BWA and project implementation partners.

In addition, the Project will be monitored by a Project Steering Committee comprising key stakeholders and chaired by the BWA General Manager. The PMO will report to the General

Manager, who in turn will report to the BWA Board of Directors and the Project Steering Committee (PSC). Additionally, the CCCCC Project Management Office will also report to the PSC. The PSC is to provide a mechanism for support, feedback, guidance, stakeholder participation and interagency coordination during project implementation, and to act as a catalyst for an ongoing coordination mechanism after implementation has been completed. Given the nature of the project the PSC will also have responsibility towards the works associated with the South Coast Sewerage System upgrades. The Committee will be required to meet as required, but not less than quarterly. The duties of PSC shall be as follows:

a. familiarisation with the arrangements for project implementation, including the intended project outcome, outputs, scope, financing arrangements, reporting requirements, implementation schedule, and other details contained in the appraisal report and financing agreements;
b. monitor progress in implementation of the Project towards achievement of the project output and project outcome;
c. ensure that potential threats to timely project implementation are identified and addressed;
d. facilitate the taking of policy decisions by the relevant authorities to ensure timely fulfilment of loan conditions;
e. review work plans on a semi-annual basis and ensure that recommendations with respect to adequate budgetary allocations are made, procurement activities are executed as scheduled, and that adequate controls;
f. ensure that stakeholder participation is appropriate and sustained throughout implementation and that stakeholder expectations are addressed;
g. ensure that the Project remains aligned to the policy and strategic objectives of GOB;
h. discuss the perspective of the entities from which its members are drawn on various issues, informed by the consultation of PSC members with their respective organisations;
i. monitor the performance of the Project Implementation Team; and
j. champion the Project, advocating for achievement of the project outcomes.

The PSC will be chaired by the General Manager of the BWA, with Project Manager (PM) or Project Coordinator (PC) serving as Secretary. In addition, PSC shall comprise the following members:

a. Permanent Secretary (PS), Ministry of Transport Works and Water Resources Management, or their nominee;
b. PS, Ministry of Agriculture and Food Security or their nominee;
c. PS, Ministry of Finance Economic affairs and Investment or their nominee;
d. PS, Ministry of Health and Wellness, or their nominee;
e. PS, Ministry of Environment and National Beautification, or their nominee;
f. PS, Ministry of Energy Small Businesses and Entrepreneurship
g. Director, Environmental Protection Department, or their nominee;
h. Director, Planning and Development Department, or their nominee;
i. Director, Coastal Zone Management Unit, or their nominee;
j. Head of the Bureau of Gender Affairs, or their nominee;
k. Representative, Barbados Chamber of Commerce;
l. Representative, Barbados Agricultural Development and Marketing Corporation;
m. Representative, Barbados Agricultural Society;
n. Representative, Government Press and Public Relations

The Implementing Project Management and Reporting Structure is shown in Figure 4.

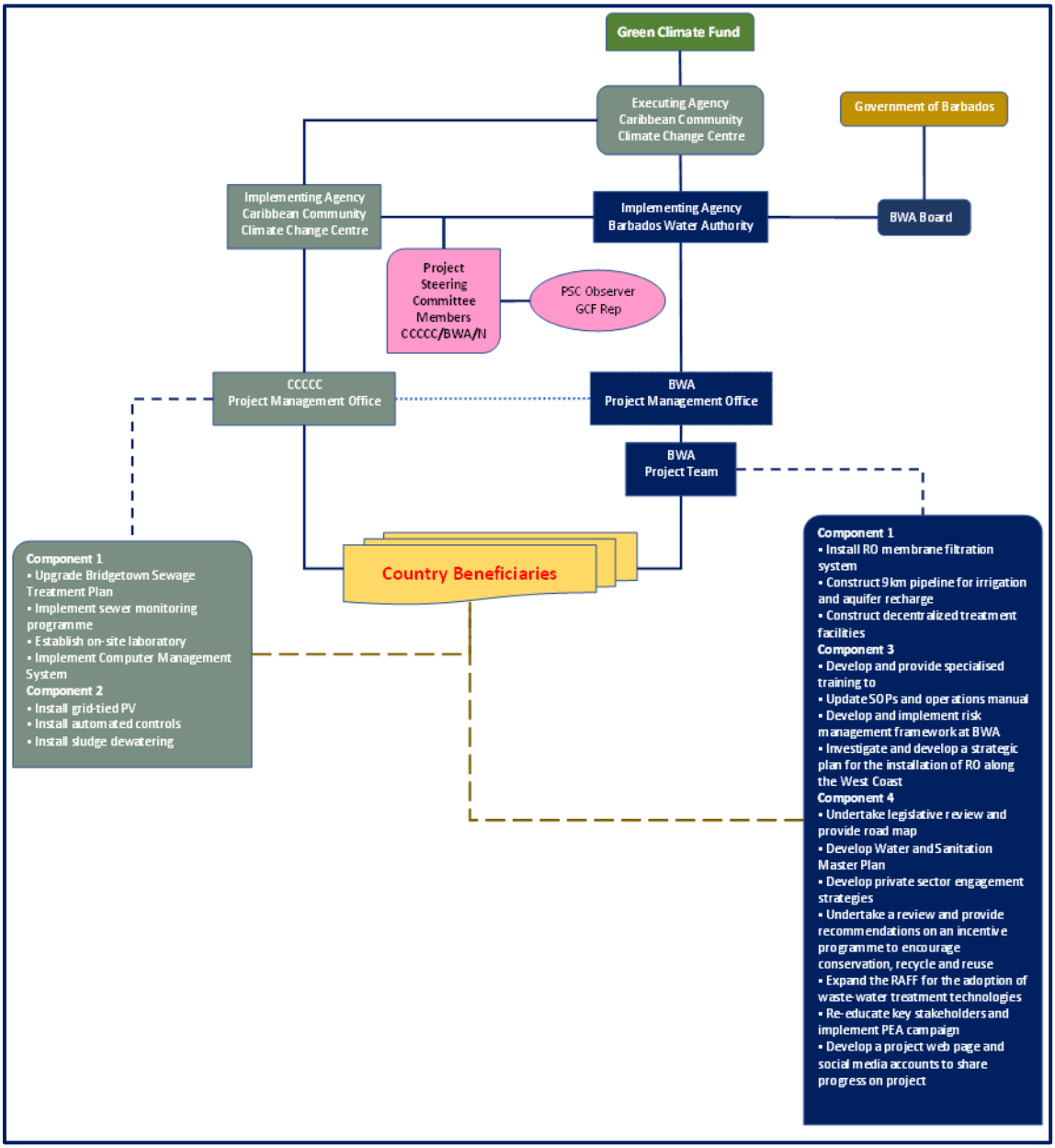

Figure 4: Project Management and Reporting Structure

The Activities to be carried out for the implementation of the specific Outputs, and the entities responsible for such Activities, are described below in Figure 5.

Component	Sub-Components	Activities	Executing Entity in Charge
Component 1: Enhanced availability, management and use of tertiary level treated wastewater to improve the water sector's resilience to climate change	Output 1.1:The Bridgetown Sewage Treatment Plant (BSTP) is upgraded to treat wastewater to a tertiary water-quality standard.	Activity 1.1.1: Install Conventional Activated Sludge Biological Treatment process	CCCCC
	Output 1.2: Tertiary wastewater is available to supplement non-potable use	Activity 1.2.1: Install Reverse Osmosis filtration system	BWA
		Activity 1.2.2: Construct 9 km pipeline for irrigation and aquifer recharge	BWA
	Output 1.3: Decision-support tools and infrastructure implemented to mitigate potential climate change risks to the wastewater collection and treatment systems	Activity 1.3.1: Implement sewer monitoring programme	CCCCC
		Activity 1.3.2: Establish on-site laboratory	CCCCC
		Activity 1.3.3: Implement Comuterised Real-time Management System	CCCCC
	Output 1.4:Decentralized treatment plants or cluster treatment facilities installed	Acitivity 1.4.1: Construct 2 decentalised treatment facilities in Zone A - BelleVue & Belle Tenantry	BWA
Component 2: Climate resilient net zero carbon operations achieved at BSTP	Output 2.1: Energy efficiency and renewable energy technologies are implemented	Activity 2.1.1: Install additional grid-tied Photovoltaic RE system	CCCCC
		Activity 2.1.2: Install automated controls	CCCCC
		Activity 2.1.3: Install sludge dewatering technologies at BSTP	CCCCC
Component 3: Enhanced capacity and capability to support a preventative maintenance (PM) and climate resiliency programme public awareness of water reuse safety measures and water availability benefits.	Output 3.1: Improved capabilities of wastewater technical personnel to operate, maintain and monitor and implement climate change adaptation planning strategies for wastewater management	Activity 3.1.1: Develop and provide specialised training to BWA (and other Ministries, Department and Agencies, as applicable)	CCCCC
		Activity 3.1.2: Update Standard Operating Procedures (SOP) and Operations and Maintenance Manual with operational duties and responsibilities documentation specific to climate change adaptation and preventative maintenance.	CCCCC
		Activity 3.1.3: Develop and implement risk management framework at BWA	CCCCC
	Output 3.2: A strategic plan is developed to guide the replication of the brackish water RO treatment plant along the west coast corridor	Activity 3.2.1: Investigate and develop a strategic plan for the installation of RO along the west coast	CCCCC
Component 4: An enabling environment is created for wastewater technologies and reuse in the public and private sectors	Output 4.1: Governance and planning roadmaps updated/developed to enable wastewater reuse in the public and private	Activity 4.1.1: Undertake legislative review and provide	CCCCC
		Activity 4.1.2: Develop Water and Sanitation Master Plan	BWA
	Output 4.2: Mechanisms developed/expanded to encourage the adoption of wastewater treatment and reuse applications by private individuals and businesses	Activity 4.2.1: Develop private sector engagement strategies	CCCCC
		Activity 4.2.2: Undertake a review and provide recommendations on an incentive programme to encourage conservation, recycle and reuse	CCCCC
		Activity 4.2.3: Expand the RAFF for the adoption of waste-water treatment technologies	CCCCC
	Output 4.3: Gender Sensitive Public Education and Awareness Campaign Implemented.	Activity 4.3.1: Re-educate key stakeholders and implement PEA campaign	CCCCC
		Activity 4.3.2: Develop a project web page and social media accounts to share progress on project	CCCCC

Figure 5: Implementation Activities

9. Financial Arrangements

9.1 Financial Flows and Reporting

The funding for the 3R CReWS project will come from two principal sources, being the Green Climate Fund and through the Government of Barbados. In the case of the Government of Barbados the source of funding will be through the Barbados Water Authority and the Ministry of Finance Economic Affairs and Investment. The Barbados Water Authority's contribution will be self-financed from income revenue generated by the Garbage and Sewage Contribution levy. The balance will be provided through the Ministry of Finance Economic Affairs and Investment which has already sourced most of the co-funding required for the successful implementation of the Project. A breakdown of the source of funds and the amounts are shown in Table 9.

Table 9: Source of Capital Funds

Source of Funds				
Capital Cost Item	Green Climate Fund	Govt of Barbados BWA	Govt of Barbados Ministry of Finance	Total
Capital Costs Bridgetown				
• **Bridgetown Plant Upgrade**	US$38.682			US$38.682
• **Renovations and Upgrades**		US$1.770		US$1.770
• **Renewable Energy System**	US$0.840			US$0.840
• **Reclaimed Water Distribution**		US$7.300		US$7.300
• **Expansion of Sewer Collection System**				
○ **Phase I**		US$10.070		US$10.070
○ **Phase II**		US$4.050		US$4.050
○ **Phase III**		US$2.675		US$2.675
○ **Phase IV**		US$4.050		US$4.050
○ ***Phase V***			*US$48.000*[1]	US$48.000
Subtotal	US$39.522	US$29.915	*US$48.000*	US$117.437
Capital Costs South Coast				
• **South Coast Plant Upgrade**			US$64.050	US$64.050
• **Renovations and Upgrades**		US$1.410		US$1.410
• **Renewable Energy System**		US$0.840		US$0.840
• **Rehabilitation of Sea Outfall**			US$12.000	US$12.000
• **Reclaimed Water Distribution**			US$41.300	US$41.300
• ***Expansion of Sewer Collection System***			*US$20.000*[2]	*US$20.000*
Subtotal		US$2.250	US$131.350	US$133.600
Total	US$39.522	US$32.165	US$179.350	US$251.037
	15.7%	12.8%	71.5%	100%

1 Future expenditure for expansion of the sewer collection system to service Greater Bridgetown – post 2030.

2 Expenditure for the expansion of the sewer collection system to service the South Coast area – 2025.

The planned capital expenditure for the expansion of the sewer collection systems for the South Coast and Greater Bridgetown would occur after the completion of the upgrades to the two Sewage Treatment Plants.

The financial cashflows are shown in Figure 6. Although the cashflow is shown up to 2050, for the purposes of this Project the appropriate period to consider is up to 2026. Expenditures after that point relate to the proposed expansion of the sewage collection systems.

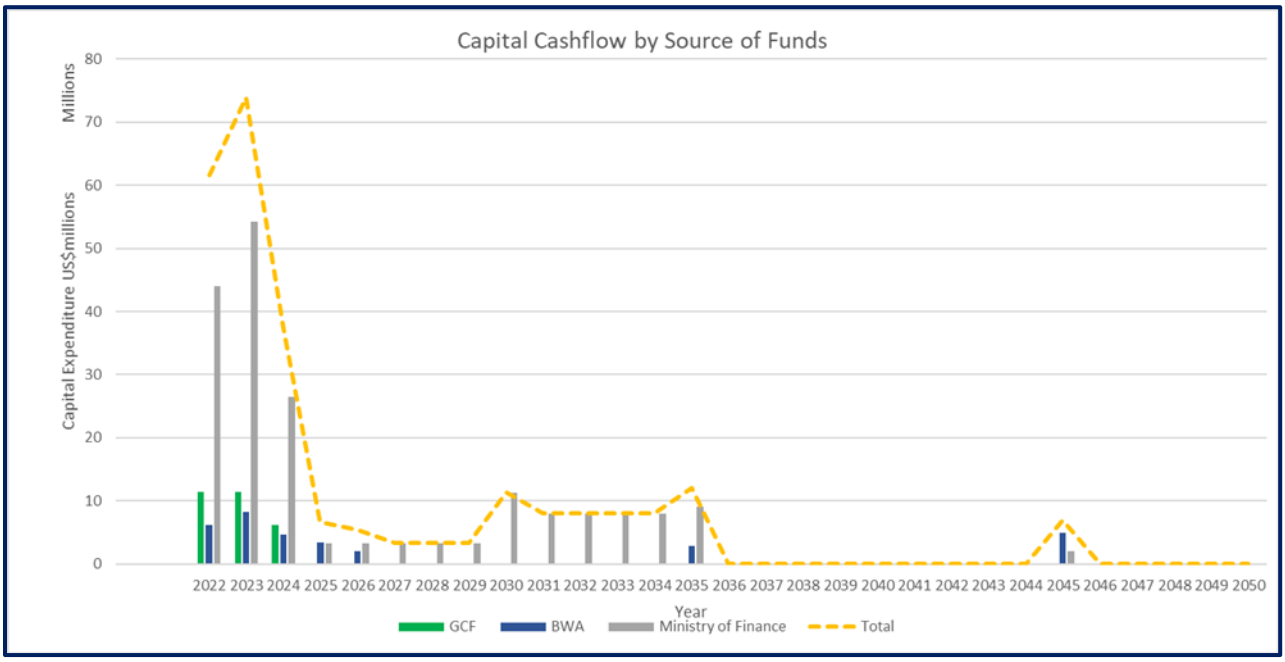

Figure 6: Capital Cashflows by Source of Funds

With respect to the items funded internally by the BWA the expenditures are managed internally. The internal expenditures past and planned are reported on as part of the Authority's reporting responsibilities to the Minister regarding estimates of income, capital expenditure and recurrent expenditure. The BWA may motivate requests for funding from the Government's Consolidated Fund. Requests would be made through and negotiated with the Ministry of Finance Economic Affairs and Investment. The policy currently is to minimise Government transfers to State Owned Enterprises such as the BWA under the International Monetary Fund supported Barbados Economic Recovery and Transformation programme (BERT). In addition, the Authority through its Board, may borrow from sources approved by the Minister taking into account the amounts and sources of the loans and subject to the terms and conditions on which a loan is effected.

The BWA negotiates with external institutions regarding loans and other forms of financial assistance for the use for specific identified purposes and prepares the necessary documentation. It must however liaise with the Ministry of Finance Economic Affairs and Investment as any loans would be included in Government accounts and level of debt servicing. It is for this reason that a distinction is made between those parts of the 3R-CReWS project that would be funded internally by the BWA and those parts that would be supported by other forms of financing.

For the financial support provided through the Caribbean Community Climate Change Centre (CCCCC), the BWA would enter into an agreement with the Centre regarding the implementation of the project. For this the financial flows would be dependent on the Component of the project. For Component 1: Improve the water sector's resilience to climate change by enhancing

availability, management and use of tertiary level treated wastewater, Outputs 1.1 to 1.4[1] and Component 2: Achieve climate resilient net zero carbon operations at BSTP, Output 2.1[2] the Centre would be the Implementing Agency. The direct proximate beneficiaries would be vendors, consultants and contractors undertaking the work.

Component 3: Enhance capacity and capability of the BSTP through preventative maintenance (PM) and climate resiliency programmes, Outputs 3.1.and 3.2[3] and Component 4: Create an enabling environment for wastewater technologies and reuse in the public and private sectors, Outputs 4.1 to 4.3[4] would be jointly implemented by the BWA and the CCCCC. The proximate and ultimate beneficiaries of these two components would be vendors and suppliers, consultants, contractors, the BWA's staff, communities, teachers, students, farmers, businesses, visitors, and greater social inclusion of disadvantaged persons.

Although concessional financing is being sought only for the parts of the programme associated with the Bridgetown System, the financial and reporting flows for both the Bridgetown and South Coast parts of the work are shown in Figure 7 and Figure 8. It should be noted that as per Table 9 the source of funding for the capital works associated with the South Coast will be through the Government of Barbados and would be a mix of internal finance, transfers, grants and loans.

[1] Output 1.1: The Bridgetown Sewage Treatment Plant (BSTP) is upgraded to treat wastewater to a tertiary water-quality standard. Output 1.2: Tertiary wastewater is available to supplement non-potable use. Output 1.3: Decision-support tools and infrastructure implemented to mitigate potential climate change risks to the wastewater collection and treatment systems. Output 1.4: Decentralized treatment plants or cluster treatment systems installed.

[2] Output 2.1: Energy efficiency and renewable energy technologies implemented.

[3] Output 3.1: Improved capabilities of wastewater technical personnel to operate, maintain and monitor and implement climate change adaptation planning strategies for wastewater management. Output 3.2: A strategic plan is developed to guide the replication of the brackish water RO treatment plant along the west coast corridor.

[4] Output 4.1: Governance and planning roadmaps developed to enable wastewater reuse in the public and private sectors. Output 4.2: Mechanisms developed/expanded to encourage the adoption of wastewater treatment and reuse applications by private individuals and businesses. Output 4.3: Gender Sensitive Public Education and Awareness Campaign Implemented.

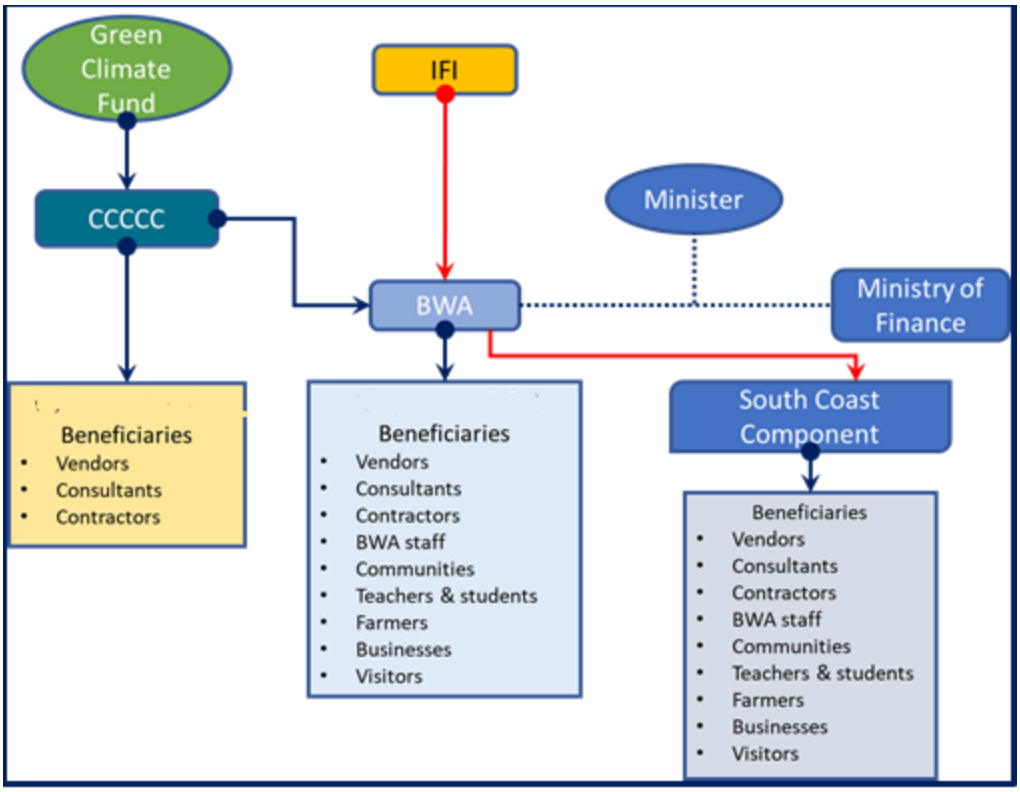

Figure 7: Financial Flows

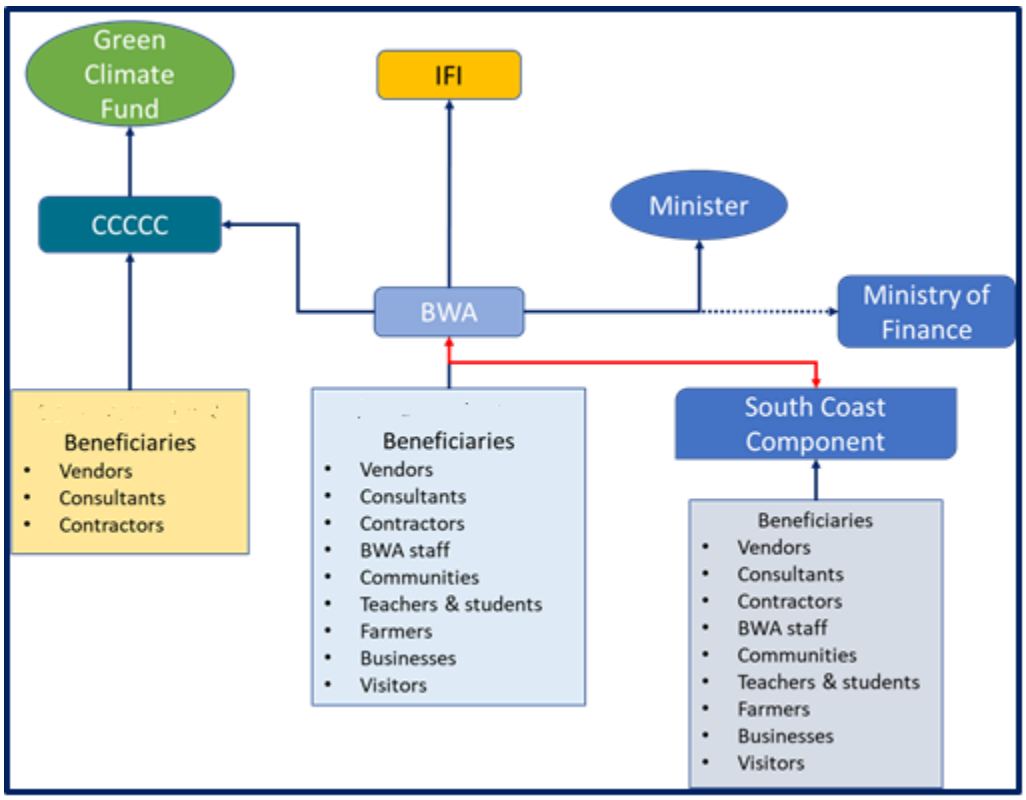

Figure 8: Reporting Flows

9.2 Capacity to Implement

9.2.1 Caribbean Community Climate Change Centre

The Caribbean Community Climate Change Centre (CCCCC) coordinates the Caribbean Region's response to Climate Change, working on effective solutions and projects on Climate Change adaptation and mitigation. The Centre is an Accredited Entity to the Green Climate Fund and as such has had in place the relevant level structure and composition for the implementation of the Programme, submission of a Funding Proposal and the execution of any resulting Funding Activity Agreement and/or Subsidiary Agreement. These powers are derived from the Agreement Establishing the Centre in 2005 and through Article XX which states that the CCCCC has full legal and juridical capacity to, inter alia, contract, acquire moveable and immovable property, and institute legal proceedings. Article XX also notes that the Centre may enter into agreements with Members, third States and other international organisations for the achievement of its objectives.

As an Accredited Entity, the Centre does ensure that appropriate due diligence is carried out to ensure that all transactions are executed with minimal transactional risk and all Executing Entities have to date, been assessed at a low or medium risk. The due diligence exercised revealed that the CCCCC has sufficient capacity and autonomy to enter into Agreements, with sufficient legal and juridical capacity in doing so. In terms of institutional due diligence, the CCCCC is properly constituted, and with Board approvals, is competent in taking on the tasks assigned in the funding proposal in their various roles.

A Technical Assessment and Legal Due Diligence Report prepared for the CCCCC concluded that there is no legal impediment to the submission of the Funding Proposal and the execution of the subsequent Agreements. However, it strongly suggested that, out of prudence, the CCCCC as the Accredited Entity and the Implementing Agency (IA) would be strongly advised to develop an Anti-Money Laundering (AML) / Countering the Financing of Terrorism (CFT) / Countering of Proliferation Financing (CPF) Policy. In addition it suggested updates to any such anti-fraud / anti-corruption policy, to fully meet the criteria of the requirements based on the GCF's Programming Manual and its AML/CFT Policy. Some legislative updates are likely required within some of the subject legislation to make provision for gender equality, as identified in other Reports. It went on to state: "These proactive measures are important to ensure the institutional integrity of the AE and the IA, particularly in the event that there is an audit by the GCF, inclusive of its Integrity Unit, and of which consequences may be dire if the requisite Policies are not in place."

The 3R CReWs project builds upon the Centre's more than 10 years of experience as a regional leader implementing catalytic pilot/ demonstration type projects in the Caribbean Region, and scaling these up with national governments. It also builds on projects carried out by the Centre including the 3Rs for Climate Resilience Wastewater Systems (CReWS) in Barbados Project Preparation Facility, the Water Sector Resilience Nexus for Sustainability in Barbados and the Arundo donax Renewable Bio-mass Fuel for Belize: Feasibility Study and Funding Proposal Preparation funded by the Green Climate Fund, the Intra-ACP GCCA+ Programme in the Caribbean: Enhancing Climate Resilience in CARIFORUM Countries funded by the European Union, the EU/CARIFORUM Climate Change and Health Project: Strengthening Climate Resilient Health Systems in the Caribbean funded by the European Union, and the Climate Change Adaptation Program (CCAP) – 2016 – 2020 funded by USAID. The Centre has established key partnerships with contributing organisations such as the Caribbean Institute for Meteorology and Hydrology, The University of the West Indies, International Atomic Energy Agency. The Centre

has an established track record in Barbados through its Project Implementation Office of implementing projects related to Climate Change adaptation and mitigation, providing local experience and knowledge that contributes to successful project implementation.

9.2.2 Barbados Water Authority

The Barbados Water Authority is a State Owned Enterprise with functions set out in The Barbados Water Authority Act 1980-42, 1980 and Regulations. The functions of the Authority under the Act are:

a. to obtain and analyse information and maintain records of the total water resources of Barbados;
b. to manage, allocate and monitor the water resources of Barbados with a view to ensuring their best development, utilisation, conservation and protection in the public interest;
c. after consultation with such persons as the Minister may direct or otherwise, to prepare and submit to the Minister from time to time proposals for the establishment of efficient, co-ordinated and economical water supply and sewerage systems capable of meeting the need for water and sewerage services throughout Barbados;
d. to prepare details of schemes for the development of water resources and for the supply of water and sewerage services, and to construct, maintain and operate such schemes;
e. to keep under constant review the quality, reliability and availability of water supply and sewerage services, and the rates to be charged for those services;
f. control and regulate the production, treatment, storage, transmission, distribution and use of water for public purposes;
g. to design, construct, acquire, provide, operate and maintain water works for the purposes of supplying water for public purposes;
h. to design, construct, acquire, provide, operate and maintain sewerage works for the purpose of receiving, treating and disposing of sewage;
i. to control and regulate the disposal of sewage through sewerage plants that are not part of the Authority's systems;
j. to conduct research programmes and prepare statistics for its purposes;
k. to disseminate information and advice with respect to the management, collection, production, transmission, treatment, storage, supply and distribution of water and where applicable, sewage;
l. to provide such facilities as may be necessary for training and educating its employees and for research;
m. to advise the Minister on the matters referred to in paragraph (e) and such other matters relating to water supply and sewerage services as the Minister refers to the Authority;
n. to perform such other functions as the Minister assigns or as the Authority considers necessary or expedient for its purposes.

In order to enable it to carry out these functions it employs approximately 800 persons. The persons are employed across departments concerned with Works and Engineering, Procurement, Finance, Administration, Project Management, Communications, Training and Public Relations. In addition it has Legal Council and Internal Audit functions.

Within the BWA Capital Works Projects are managed by the Project Management Office (PMO). Over the past two years due to the increasing number of projects being handled by the PMO, the level of staffing has been increased. The PMO has a core staff and staff to handle IFI projects. The complement of core staff stands at 13 persons comprising: a Project Manager, two Finance

Officers, a Procurement Officer, a Project Coordinator, a Project Engineer - renewable energy, two Assistant Engineers, two Administrative Officers, two Clerical Officers and a Secretary. The International Funding Institution (IFI) Projects staff comprises: a Project Manager, three Project Coordinators, two Project Engineers, an Engineering Assistant, a Technical Assistant, an Administrative Officer and Assistant. The staff for the IFI Projects are hired as part of the project implementation arrangements, meaning that there is a cadre of personnel who have experience of working with the BWA and international funding institutions and their procedures.

The PMO is currently managing 5 projects funded through loans from Development Banks and one Public Private Partnership funded project to a total value of US$82 million running through to 2024. The IFI with which the BWA has and is working with include the Caribbean Development Bank, the Inter-American Development Bank, the Latin American Development Bank, the European Investment Bank, and the Green Climate Fund. In addition to externally funded projects, the PMO also handles internally financed projects. The type of projects handled range from feasibility studies, capital works studies, design and contract documentation, managing of engineering contractors, and outreach projects. The PMO is responsible for handling payments, liaising with the Ministry of Finance Economic Affairs and Investment regarding BWA's capital works budget and the preparation of monthly progress and financial reporting on projects. The current arrangements is that based on the volume of projects and programmes being executed, the BWA reports directly to the Ministry of Finance Economic Affairs and Investment with copies to the parent Ministry.

The BWA therefore has a resourced and experienced team of professionals working within the Project Management office who have the capacity to supervise and management the implementation of capital works projects amounting to many tens of millions of US dollars. They are well experienced in all aspects of managing multi-million-dollar contracts and reporting on them in the requisite manner and through the designated channels.

10. Concessional Financing

Barbados is one of the most heavily indebted countries in Latin America and the Caribbean. In 2017 the debt to GDP ratio stood at 155% due to a combination of almost zero economic growth since 2010, increasing cost of debt servicing, and increasing fiscal debt due to a negative current account balance. In 2018 the Government entered into negotiations with the International Monetary Fund (IMF) and in return for undertaking economic reforms program fiscal support would be provided by an arrangement under the Extended Fund Facility (EFF). The program, known as the Barbados Economic Recovery and Transformation Plan (BERT) requires reforms to State Owned Enterprises (SOEs) to create fiscal space for investment in physical and human capital. Transfers to SOEs are to decline along with strengthening oversight of SOEs, revenue enhancement, cost reduction, as well as mergers and divestment. The authorities' plans to reform the pension system and introduce a fiscal rule were also introduced to support fiscal sustainability.

As of 2019, the Government of Barbados had made significant progress in introducing fiscal discipline and was on track to meet the targets set by the IMF – in fact in spite of the challenges associated with Covid-19 the Government continues to meet targets to the satisfaction of the IMF. In 2019 debt to GDP ratio had fallen to 125%. However, the impact of the pandemic has severely impacted the country's ability to continue improving its fiscal situation with revenues hit by falling tourism and increased social and health expenditures. The primary balance target for fiscal year 2020/2021 is expected to be -1.0% of GDP, a revision of the previous surplus target of 6.0% of

GDP. The fiscal gap is being financed mainly by international financial institutions (IFIs). The debt-to-GDP ratio is expected to increase to 144%, driven mainly by a sharp rise in external borrowing. In light of the Covid (Caribbean Development Bank, 2021)-19 health pandemic, the IMF is targeting a debt-to-GDP ratio of 60 percent by Financial Year 2035/36. This is to be achieved with a combination of fiscal consolidation, policies to boost growth, reform of public finances and debt restructuring. Economic growth in 2021is projected by the Caribbean Development Bank to be 1.9%. An overview of selected indicators is shown in Table 10. Although there has been a tightening of transfers to SOEs, due to the serious situation of the water infrastructure in Barbados and its role in underpinning economic activity, the Government has continued to provide financial support to enable the BWA to address its historical challenges in maintaining water services. The focus within the BERT program on requiring SOEs to improve profitability and reduce high operating costs will, once the effects of the pandemic reduce, drive improved performance of the BWA and better enable it to provide an efficient and effective service. However, it will be some time before this can be fully realised.

Table 10: Selected Economic Indicators *(Caribbean Development Bank, 2021)*

Selected indicators

	2016	2017	2018	2019	2020e
Real GDP growth (%)	2.6	0.6	-0.4	-0.1	-18.0
Average inflation (%)	1.5	4.5	3.7	4.1	3.5
Unemployment (%)	9.7	10.0	10.1	10.1	n.a.
Primary balance (% of GDP)	2.2	3.2	3.5	6.1	-1.0
Public sector debt (% of GDP)	151.2	148.4	126.3	120.0	144.0

Sources: CBB, BSS,CDB.

The 3R CReWs project is one part of the larger endeavour on the part of the Government of Barbados to adapt to the impact of climate change. The country is facing a climate crisis in which water availability to support the economy is going to be curtailed and is already impacting food security through the high cost of importation, a situation that is expected to be increasingly aggravated through the global impact of climate change on food and supply chains. To counter this, Barbados is seeking to increase food production as an adaptation measure. This ambition cannot be realised without making water accessible to farmers so it is imperative that means be found to address current and future water scarcity constraints. At present large volumes of precious water resources are going to waste through being disposed in the surrounding ocean after a single use. This linear model of water provision and use has to change. Investment in the collection and treatment of wastewater such that it can be reused for productive purposes is necessary to provide the basic infrastructure needed to move from a linear to a circular economy model. The circular economy maximises the use of scarce resources and minimises the necessity to find and then dispose of additional resources. This though can only happen if the basic infrastructure is put in place to provide the foundation on which the circular economy can take off.

The Government of Barbados is seeking to provide that basic infrastructure and to use it as a platform to launch further expansion of the Circular Economy as envisaged in the (Moore, et al., 2014) and the follow-on Partnership for Action on Green Economy (PAGE) with the United Nations Environment Programme. To this end the total envisaged capital investment in provisioning infrastructure is US$183.037 million in the short-term rising to US$251 million in the medium term. The 3R CReWS proportion of that capital investment is US$69 million in the short

term, rising to US$107 million in the medium term. As a proportion of the overall financing the amount sought from the Green Climate Fund is 22% in the short-term falling to 16% for the medium term.

Table 11: Relative Contributions to Capital Costs

Item			Green Climate Fund	BWA	GoB	Total
Bridgetown System	Short-term	Amount	US$39.5m	US$29.9m	-	US$69.4m
		%	57%	43%	-	100%
	Medium-term	Amount	US$39.5m	US$29.9m	US$48.0m	US$107.4m
		%	37%	28%	35%	100%
South Coast System	Short-term	Amount	-	US$2.3m	US$111.3m	US$113.5m
		%	-	2%	98%	100%
	Medium-term	Amount	-	US$2.3m	US$131.3m	US$133.6m
		%	-	1.7%	98.3%	100%
Total	Short-term	Amount	US$39.5m	US$32.2m	US$111.3m	US$183.0m
		%	22%	18%	60%	100%
	Medium-term	Amount	US$39.5m	US$32.2m	US$179.4m	US$251.0m
		%	16%	13%	71%	100%

For this level of contribution to the programme on which the Government of Barbados is embarked upon, concessional financing is very appropriate when compared to the overall investment being made. Furthermore, this investment is critical to the realisation of the financial and economic benefits that would flow from the programme, as demonstrated in Table 2 and Table 3. Project risk is being overwhelmingly taken on by the Government of Barbados and the Barbados Water Authority when it is considered that more than 60% of the financing will come from long-term loans. Furthermore, the Government of Barbados is also financing the on-farm infrastructure costs as well. Given the fiscal position of the Government of Barbados and that of the BWA and the need to provide a platform for development means that minimising the debt burden is imperative. The level of concessionality requested is minimal.

As indicated the investment in basic infrastructure to underpin the move to Circular Economy provides investment and development opportunities for the private sector. By investing in the infrastructure the Government is ameliorating the risks and costs to private sector and hence catalysing investment. Apart from the identified benefits to the agricultural sector, additional opportunities for private sector investment have been identified; investment in biogas generation and soil fertiliser production facility utilising sludge from the sewage treatment plants as part of the feedstock, and investment in the provision of decentralised wastewater treatment facilities and services including opportunities for laboratory, inspection, and monitoring services. There would still be financial risks but concessional financing through a GCF grant would contribute to reducing the risks to the private sector whilst not increasing the risk to the GCF.

The beneficiaries of the concessionality would be:

- Farmers through increased and assured availability of water for irrigation, enabling the expansion of irrigated agriculture for new entrants,
- Communities through increased employment opportunities,
- Local businesses supporting the farming sector through increased economic activity,
- General population through increased food availability and security,
- The BWA through the reduction in the need to exploit additional water resources to support irrigated agriculture and placing addition stress on scarce resources while meeting demand for potable water supply, exacerbated by the impact of climate change,

- Visitors to Barbados through the maintenance and improvement of the marine environment and ecosystems,
- Visitors and the general population through reduced public health risks associated with deterioration in bathing water quality,
- The BWA through improved training and capacity to manage the operation and maintenance of wastewater systems, minimisation of the cost of operation and maintenance of the collection systems and sewage treatment plants, and ability to conform to regulatory requirements concerning quality of service and water quality regulations,
- The BWA through increased income generation through the sale of treated reclaimed water,
- The Government of Barbados through increased economic activity contributing to revenue income by maintaining visitor numbers, increased economic activity and employment in the agriculture sector, and stimulation of the circular economy development opportunities,
- The general population through increased awareness of the impacts of climate change and incentives encouraging conservation, recycling and reuse.

11. Sustainability

Describe how the recommended financial structure is adequate and reasonable in order to achieve the proposal's objectives, including addressing existing bottlenecks and/or barriers, and providing the minimum concessionality to ensure the project is viable without crowding out private and other public investments.

The financial sustainability of the project is illustrated in Section 7 where it is indicated that with the capital investments proposed and with the income revenue streams that income will be greater than the capital and operational expenses. Further examination using the DEFM indicates that Opex Cover is greater than 100% and that the Operational Expense Ratio is less than 100% both indicating that the project generates revenues in excess of expenses. This assumes that GCF grant funding is made available. If it is not the case and debt financing instruments are used, then this will have a negative effect on financial performance indicators. The project has the capability of increasing revenues through opportunities to expand collection coverage, as discussed in Section 7.2.6.

Institutional strengthening will be achieved through Outputs 3.1: Improved capabilities of wastewater technical personnel to operate, maintain and monitor and implement climate change adaptation planning strategies for wastewater management, and 4.1: Governance and planning roadmaps updated/developed to enable wastewater reuse in the public and private sectors. These Outputs and their associated Activities will strengthen the Integrated Wastewater Management capacity of the BWA and its personnel enabling it to optimally manage, operate and maintain its wastewater infrastructure It will also enable it to proactively manage risks to the systems including those arising from climate change. These outputs have to be viewed in the overall context of Barbados' BERT program which aims to improve the performance of SOEs such as the BWA to improve their operational performance as a means of increasing profitability. It supports initiatives within the BWA's of structuring its activities towards a greater emphasis on forward planning and is within the context of the proposed implementation of an Innovations Division and a Strategic Planning and Regulation Division. Furthermore, as the BWA moves towards coming under greater regulation by the Fair Trading Commission it will be required to demonstrate greater efficiency as part of its Asset Management Plans.

Gender equality and social inclusion issues are to be addressed through Output 4.3: Gender Sensitive Public Education and Awareness Campaign. Furthermore, the Legal Due Diligence Report highlighted the desirability of addressing legislative updates required to make provision for gender equality. This is supported through Activity 4.1.1. The challenge though will be to develop appropriate policies and mainstream them into everyday practices. This would require some level of organisational adaptation.

The upgrading of both treatment works will have a positive impact on maintaining and improving the ecological health of the marine environment. Previous studies by Irvine, Oxenford and Suckoo (2021) have demonstrated the positive impact that the implementation of centralised wastewater systems have on the marine environment. The higher level of treatment and operation to be achieved through the upgrading, training and capacity building will ensure that the two Sewage Treatment Works continue to make a positive contribution. In addition to this, there measures under Output 4.2: Mechanisms developed/expanded to encourage the adoption of wastewater treatment and reuse applications by private individuals and businesses. The successful impetus to the private sector both through the envisaged measures and through the development of a circular economy would have two main effects. The one is that it provides support for the development of business opportunities for the private sector, creating job opportunities and having appositive multiplier effect for government revenues. The second effect would be that of improving wastewater treatment and the water quality of treated effluent. Improved water quality would result in a reduction in nutrient discharges to the terrestrial environmental and onward transmission to the marine environment. As discussed in Section 10 with respect to Circular Economy the reuse of treated wastewater as a productive input into agriculture provides a positive means of reducing demands on water resources. If this facility is not developed, then demand for water would have to be met through greater groundwater abstraction, depleting aquifers and enhancing the risk of saline intrusion.

Overall the implementation of the project will make a positive contribution to institutional, economic, social and environmental sustainability in Barbados. Furthermore, it is aligned with the development of a Circular Economy, providing green jobs and importantly making a positive contribution to the achievement of Sustainable Development Goals – all of which resonate with this project.

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