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The use of Benefit Cost Analysis to assess Adaptation and Mitigation Interventions in the Caribbean: Case Studies

The Commonwealth

Caribbean Community Climate Change Centre

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List of Abbreviations

ACCC	Adaptation to Climate Change in the Caribbean
ATP	Ability to Pay
AusAID	Australian Agency for International Development
BAU	Business as Usual
BCA	Benefit Cost Analysis
BCEOM	French Engineering Consultants
BCR	Benefit Cost Ratio
CAMMA	Canaries Marine Management Area
CARICOM	Caribbean Community
CBA	Cost benefit analysis
CBBRAS	Coconut Bay Beach Resort and Spa
CBD	Convention on Biological Diversity
CC	Climate Change
CCCCC, 5C's	Caribbean Community Climate Change Centre
CEA	Cost Effective Analysis
CIA	Central Intelligence Agency
CO2	Carbon Dioxide
CPACC	Caribbean Planning for Adaptation to Climate Change
CWSA	Central Water and Sewerage Authority
DOMLEC	The Commonwealth of Dominica Electricity Company Ltd.
DOWASCO	The Commonwealth of Dominica Water and Sewerage Company Ltd.
EC$	Eastern Caribbean Dollar
FOB	Freight on board
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Global environmental objectives
GHG	Greenhouse Gases
ICC	International Code Council
ICC	International Code of Council
ICIS	Integrated Compliance Information System
ICIS	Integrated Compliance Information System
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
MACCC	Mainstreaming on Adaptation to Climate Change in the Caribbean
MCA	Multi-Criteria Analysis
MDGs	Millennium Development Goals
MDNP	Morne Diaboltin National Park
MTPNP	Morne Trois Pitons National Park
MwH	Megawatt per Hour
NEMO	National Emergency management Organization
NPV	Net Present Value
PDO	Project Development Objectives
pH	Percent Hydrogen
PV	Photovoltaic system
RUMs	Random Utility Models

SFP	Small Foot Print
SIDS	Small Islands Developing States
SMMA	Soufriere Marine Management Area
SOC	Social opportunity cost
SPACC	Special Programme on Adaptation to Climate Change
SRTP	Social Rate of Time Preference
SWRO	Salt Water Reverse Osmosis
TCM	Travel Cost Method
UNCCD	United Nations Convention to Combat Desertification
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNFCCC	United Nations Framework Convention on Climate Change
UN-OHRLLS	United Nations Office of the High Representative for the Least Developed Countries
US$	United States Dollar
US-EPA	United States Environmental Protection Agency
UWI	University of the West Indies
VINLEC	Saint Vincent Electricity Services
WASCO	Water and Sewerage Company Inc., St. Lucia
WRI	World Resources Institute
WTA	Willingness to accept
WTP	Willingness to pay
WWTD	Waste water Treatment and Disposal

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The case studies presented in this document are the pilot adaptation interventions, which emerged out of the Special Programme on Adaptation to Climate Change (SPACC). The CCCCC wants to express its gratitude to the experts and organizations, who contributed to the development of this document and the project appraisals documented within. The CCCCC wants to acknowledge the contributions of the Kenrick Leslie (Executive Director), Neville Trotz (Science Advisor), Earl Green (Project Manager of SPACC), all of the CCCCC that contributed towards the completion of this manual.

The Centre is also indebted to the Commonwealth Secretariat[1], and in particular Janet Strachan and Joel Burman for the technical and financial support they were able to source to facilitate this publication.

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[1] *Disclaimer:* Produced with the assistance of the Commonwealth Secretariat. The contents of this publication are the sole responsibility of the authors. Views and opinions expressed in this publication are the responsibility of the author[s] and should in no way be attributed to the Commonwealth Secretariat nor the Caribbean Community Climate Change Centre.

Foreword

The Commonwealth Secretariat is delighted to partner with the Caribbean Community Climate Change Centre (CCCCC) in publishing this insightful set of case studies. The case studies set out the practical application of Cost-Benefit Analysis to help clarify and guide decision making within highly climate vulnerable countries of the Caribbean to build resilience, both economically and socially, and to cope with the impacts of climate change.

This publication has grown out of work supported by the Commonwealth Fund for Technical Co-operation through the attachment of an Environmental Economist within the CCCCC. The objective of this support was to develop methodologies for the use of Cost-Benefit Analysis in the context of small states and applied to climate change adaptation and mitigation options in the water, agriculture and tourism sectors. It was hoped that the application of Cost-Benefit Analysis to adaptation and mitigation interventions pursued in the islands of Saint Lucia, Saint Vincent and the Grenadines and Dominica, would convince policy makers that the investment in such options can be worthwhile. The result is a clear set of case studies detailing analysis of the following projects:

- A salt water reverse osmosis system in Saint Vincent and the Grenadines
- A hybrid rain water, sewerage and irrigation system in Saint Lucia
- The retrofitting of the Marchand community centre in Saint Lucia; and
- The development and implementation of a management plan for Dominica's national parks.

These case studies provide examples of how data and information limitations can be overcome. They also examine the range of criteria that can might be applied in deciding whether a project should proceed, including value for money, the issue of equity (who benefits, who pays) and considerations such as the need to build resilience to external shocks. This study also emphasises the need for further research on the impacts of climate change on the ecosystems and economies of the Caribbean, an area where the partnership within the Commonwealth will remain vital.

The case studies demonstrate the value of mitigation and adaptation projects within critical sectors, and provide a rich picture of some of the complexities involved in making decisions on projects that have long time frames, significant degrees of uncertainty and a range of benefits that lie outside the project itself. Experience from the case studies has shown that projects which have both mitigation and adaptation goals were the most successful.

Cost-Benefit Analysis adds transparency to the project appraisal process by setting out the decision making process in a systematic way. The case studies also show that mitigation and adaptation benefits can be achieved in conjunction with, rather than in separation from, one another; and highlight that it is possible to make informed choices about adaptation and mitigation options based on sound science and taking into consideration the costs and benefits of both climate action and inaction for society. Our hope is that the case studies will be widely shared and reviewed; and that the lessons learned will be taken up, not just within the Caribbean, but across other regions by small states facing similar challenges.

Janet Strachan
Ag. Director, Economic Policy Division
Commonwealth Secretariat

Introduction

Small Island Developing and Low-lying Coastal States (SIDS), and particularly those in the Caribbean Community (CARICOM) have considerable concerns about the severe threats posed by a changing climate to their development prospects and have come to the conclusion that both mitigation and adaptation options will require a significant and sustained investment of resources that the Member States will be unable to provide on their own (CCCCC, 2012). Climate variability and change and their associated impacts are profoundly impacting the region's islands and countries' geophysical, biological and socio-economic systems through affecting economic activities in the tourism, agricultural, mining and agro-processing sectors, productive capacities, freshwater systems, infrastructure, coral reefs, fisheries and other marine-based resources, livelihood activities, health and environmental security of the populations, energy consumption, trading abilities, and simultaneously depleting national budgets. Moreover, they are compromising the ecological services provided by some of these fragile ecosystems, such as corals in Belize[2], vital for sustaining lives and livelihoods in these states and improved human development.

Additionally, CC is leading to increased intensity of extreme meteorological events in the form of hurricanes (Jamaica, Grenada, Cuba), floods (Belize and Guyana), and droughts (Eastern Caribbean), many already being manifested and having profound impacts on national economies.[3] These events have led to increased inundation, storm surges, and erosion and other coastal hazards, threatening vital infrastructure, settlements and facilities that support the livelihood of communities in these states. But the CC challenge faced by Caribbean SIDS is aggravated by the fact that the states are generally classified within a distinct group of developing countries confronted with specific economic, environmental and social vulnerabilities[4] and risks[5]. They are often characterised by, *inter alia*, narrow resource base depriving them of the benefits of economies of scale; significant debts that reduce the fiscal space

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[2] Belize has the second longest barrier reef in the world after the Great Barrier Reef in Australia.

[3] CARICOM Climate Change Centre (2009) *Regional Strategic Framework to Address Climate Change in the Caribbean*, Belmopan.

[4] According to Schneider, S.H., S. Semenov, A. Patwardhan, I. Burton, C.H.D. Magadza, M. Oppenheimer, A.B. Pittock, A. Rahman, J.B. Smith, A. Suarez and F. Yamin, (2007): Assessing key vulnerabilities and the risk from climate change. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Vulnerability to climate change in this document is viewed as the degree to which the region is susceptible to, and unable to cope with, potential adverse impacts.

[5] The concept of risk, which combines the magnitude of the impact with the probability of its occurrence, captures uncertainty in the underlying processes of climate change, exposure, impacts and adaptation interventions.

within which they operate, small domestic markets, extreme openness of their economies and heavy dependence on a few external and remote markets; high costs for energy, infrastructure, transportation, communication and servicing; long distances from export markets and import resources; low and irregular international traffic volumes; little resilience to natural disasters and climate extremes; growing populations; high volatility of economic growth; limited opportunities for the private sector and a proportionately large reliance of their economies on their public sector; and fragile natural environments with low adaptive capacity that exacerbate their vulnerabilities while simultaneously reducing their resilience to growing global challenges, such as climate variability and change. They are, therefore, identified as being highly disadvantaged in their development process, hence requiring special support from the international community and development partners.[6]

In fact, the Commonwealth Expert Group on Climate Finance[7] indicated that climate variability and change are reversing some of the gains made on poverty alleviation, economic growth and stability across the world under the Millennium Development Goals (MDGs). The challenges posed by climate variability and change are existential for many small Islands like Grenada in the Caribbean where a low category 3 hurricane destroyed 200% of the Island's gross domestic product (GDP) in 2004 from which it is yet to recover, with damages estimated at EC$2.2 billion in that year; or in Guyana in 2005, where a 1 in 100 year flood event destroyed 62% of the country's GDP and moved the country from a positive growth position to a negative one.

It is evident, therefore, that strategies adopted for these states cannot be predicated on a "business as usual" (BAU) approach and contentions that have lost their usefulness and relevance, but rather, on flexible, proactive, sensible, and contextually relevant measures seeking to respond to these global challenges while simultaneously exploiting the opportunities they present. It is within this context that Caribbean SIDS have strategically been strengthening their capacity to respond to climate change through policy improvements and implementing initiatives aimed at achieving low carbon development.

The Caribbean Community Climate Change Centre (CCCCC), which is mandated to coordinate the regional response to climate change and its effort to manage and adapt to its projected impacts, is

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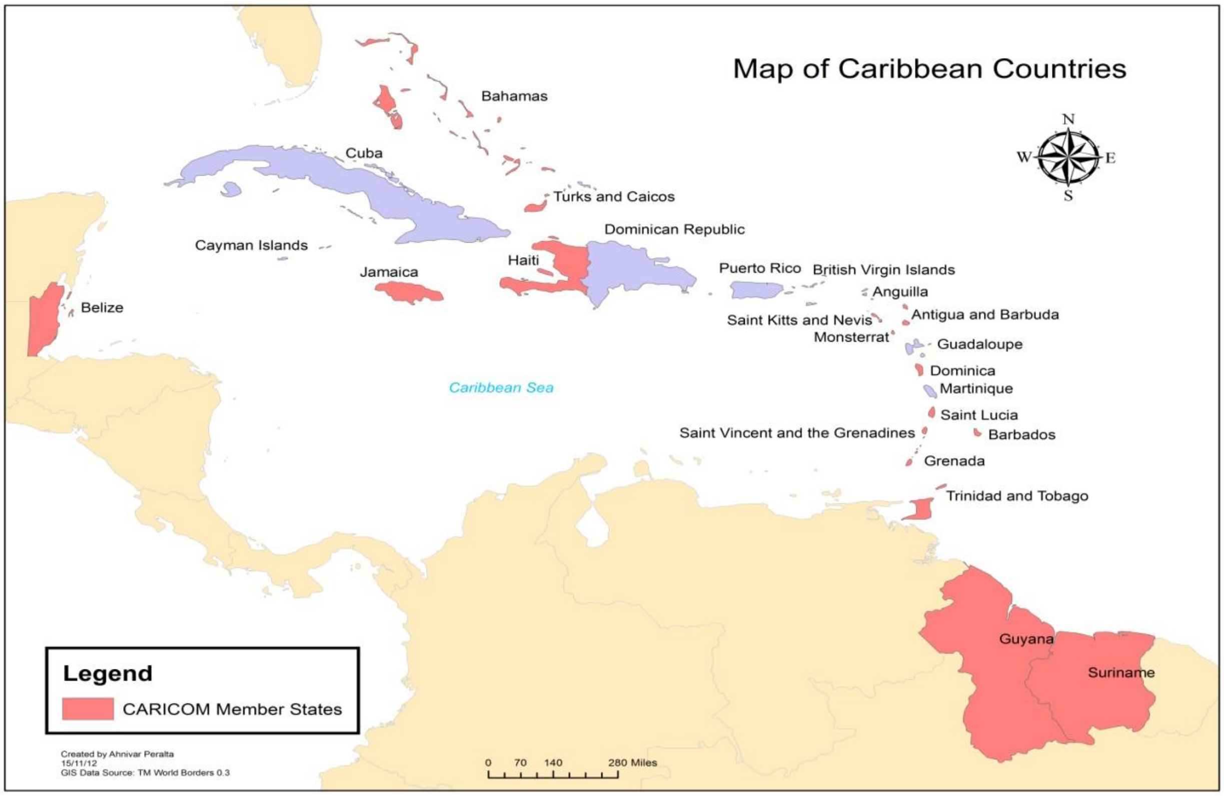
[6] United Nations - Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS) (2011) Small Islands Developing States: Small Islands Big(ger) Stakes. New York, United Nations, pp 2-3.

[7] Commonwealth Secretariat (2014) Commonwealth Expert Group on Climate Finance to the Commonwealth Heads of Government Meeting 2013. London: Commonwealth Secretariat, pp 25.

working at addressing these concerns. One most notable stage in the process of addressing the concerns of the region was the implementation of the Special Programme on Adaptation to Climate Change (SPACC).



Source: Caribbean Community Climate Change Centre (2009)

The SPACC aided in the development and implementation of pilot projects aimed at developing resilience and mitigating the negative effects of climate variability and change. Subsequent to SPACC, the CCCCC developed the CARICOM Regional Framework for Achieving Development Resilient to Climate Change (2009 – 2015) and its accompanying Implementation Plan (2011-2021). These documents outline the Region's strategic approach for coping with climate change for the period 2011 – 2021 which involves:

- Integrating climate change into the sustainable development agenda and work programmes of public and private institutions in all Caribbean Community countries at all levels,
- Promoting systems and actions to reduce the vulnerability of Caribbean Community countries to global climate change wherever possible,

- Promoting measures to derive benefits from the prudent management of forests, wetlands, and the natural environment, in general, and to protect that natural environment,
- Promoting actions and arrangements to reduce greenhouse gas emissions, including those aimed at energy-use efficiency by increasingly resorting to low-emission renewable energy sources, and
- Promote implementation of specific adaptation measures to address key vulnerabilities in the Region.

For the Caribbean to totally manage the effects of climate variability and climate change there are four main questions that must be answered. These are (see Figure 2):

1. Where and from what are we at risk?
2. What is the magnitude of the expected loss?
3. How could we respond?
4. How can we implement necessary actions?

Questions 3 and 4 speak specifically to the identification of adaptation and mitigations interventions that will improve the welfare of the region, which was the main thrust of the SPACC project. However, to answer questions 3 and 4, Questions 1 and 2 must have been answered prior. For the Caribbean Questions 1 and 2 were answered under Caribbean Planning Adaptation to Climate Change (CPACC) (1997-2001), Adaptation to Climate Change in the Caribbean (2001-2004) and Mainstreaming Adaptation to Climate Change (MACC) (2004-2008)[8].

The Caribbean's approach to adaptation mirrors the three stages for adaptation recommended by the Inter-Governmental Committee of the United Nations Framework Convention on Climate Change (UNFCCC) that adumbrated:

Stage 1: *Planning for adaptation* – essentially 'enabling activities' required to initiate the first steps in the adaptation planning and management process, including the establishment of climate change focal points, conduct of vulnerability studies of the possible impacts of climate change to identify specific vulnerable countries or regions and the identification of policy options for adaptation;

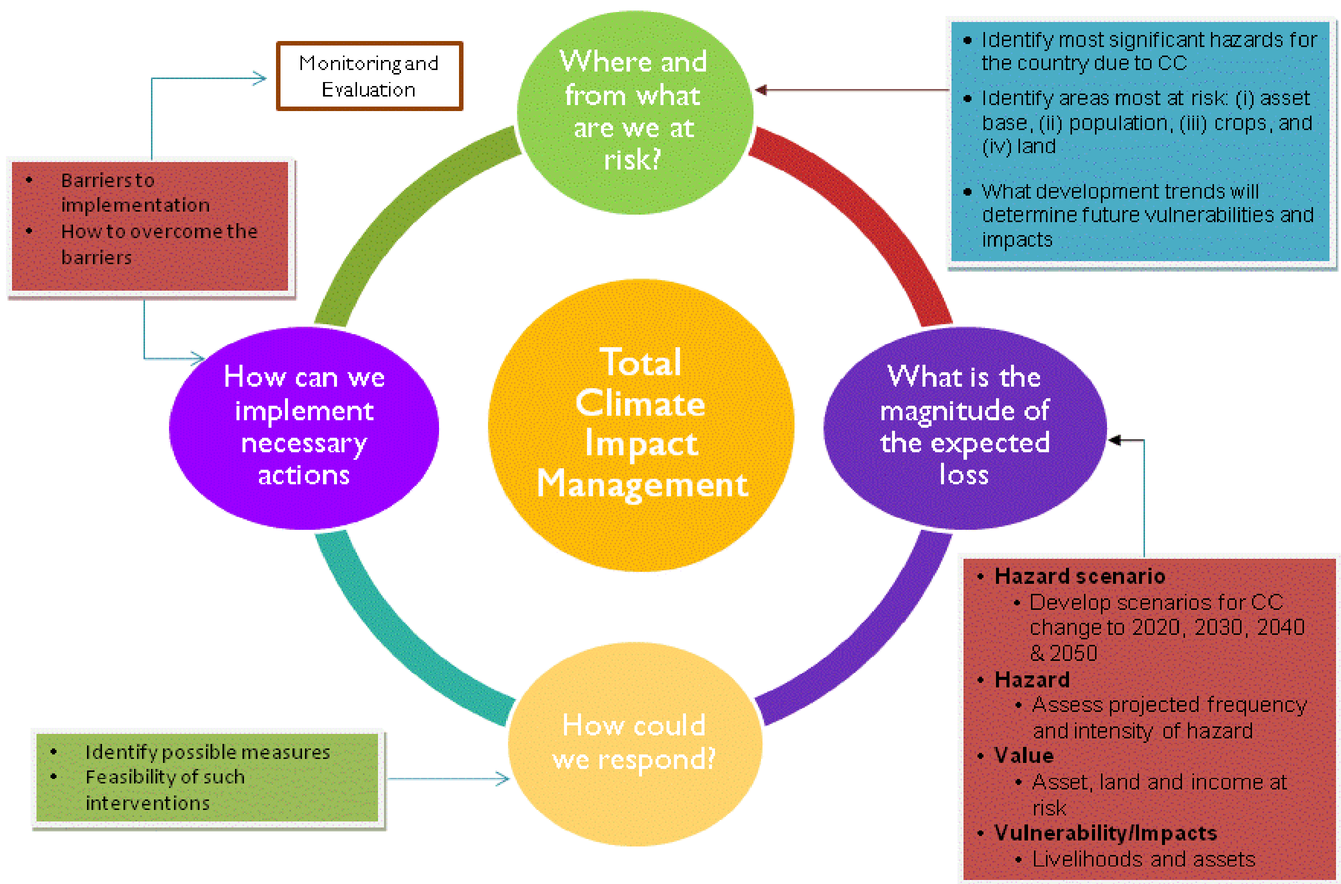
[8] For further information on CPACC (1997-2001), ACCC (2001-2004) and MACC (2004-2008) please see the CCCCC website. Link: http://www.caribbeanclimate.bz/projects/projects.html

Stage 2: ***Measures to prepare for adaptation***, including further ***capacity building;*** and

Stage 3: ***Measures to facilitate adequate adaptation***, including actual adaptation interventions and risk transfer mechanisms, such as climate risk insurance.

Subsequently then, SPACC emerged and helped to in the identification of how the region could respond and how to implement these responses. The process of moving from identification to implementation requires justification; as such after identifying possible respond measures, feasibility of such interventions must be conducted as well as the identification of barriers to implementation and monitoring and evaluation framework.

Figure 2: Total Climate Impact Management



Source: Developed by the Authors

Given the vulnerability[9] of the Caribbean to the effect of climate change and the limited existing resources, resource allocation towards efforts of mitigation and adaptation are imperative but must be done optimally and in a cost-effective manner for the Caribbean. To achieve the optimal allocation of resources, to combat the potential impact of climate change, it is important that the stakeholders' involvement is coupled with statistical and empirical analysis. Additionally, it is imperative that resources are allocated to mitigation and adaptation interventions and strategies that considers and satisfies criteria such as efficiency, effectiveness, equity, urgency, flexibility, robustness, practicality, legitimacy, synergy and or coherence of adaptation options (UNFCCC, 2011). This document is aimed at identifying and discussing the three approaches that could be used to aid decision makers in their efforts to allocate resource optimally. These include benefit cost analyses (BCA), cost effectiveness analysis (CEA) and multi-criterion analysis (MCA)[10]. This document further illustrates, through application, how BCA is used to aid in the region's efforts in identifying the benefits and costs of mitigating and adapting to climate change beyond the 'doing nothing option' or 'business as usual' scenarios, specifically in an islands' context.

For SPACC, four (4) pilot adaptation strategies were identified and implemented in three islands in the Caribbean. These were:

- The installation of a Saltwater Reverse Osmosis (SWRO) System, using a renewable energy source on the Island of Bequia in Saint Vincent and the Grenadines;
- A Strengthened Critical Infrastructure in the form of the Marchand Community Centre and Hurricane Shelter in Castries, Saint Lucia;
- A Public-Private Partnership arrangement that saw the construction of a Hybrid Rainwater, Sewerage and Irrigation System for Coconut Bay Beach Resort and Spa, in Vieux Fort, Saint Lucia; and

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[9] According to Schneider, S.H., S. Semenov, A. Patwardhan, I. Burton, C.H.D. Magadza, M. Oppenheimer, A.B. Pittock, A. Rahman, J.B. Smith, A. Suarez and F. Yamin, (2007): Assessing key vulnerabilities and the risk from climate change. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Vulnerability to climate change in this document is viewed as the degree to which the region is susceptible to, and unable to cope with, potential adverse impacts.

[10] This document does not exclusive cover all the possible tools that could be used by decision makers.

- The Development and Implementation of Management Plans for The Commonwealth of Dominica's National Parks at the Morne Trois Pitons National Park and Morne Diaboltin National Park, The Commonwealth of Dominica.

To summarise then, this publication aims at:

- Emphasizing the importance of resource management and 'efficient' allocation of such resources, given scarcity, reduced fiscal space and increasing demand for these resources.
- Giving an overview of the Special Programme on Adaptation to Climate Change (SPACC);
- Identifying some possible tools which could be used to appraise adaptation and mitigation strategies in the Caribbean as well as identifying the strengths and weaknesses associated with the identified methodologies;
- Showcasing how BCA has been used by the CCCCC to assess adaptation and mitigation interventions; and
- Highlighting the lesson learnt from the adaptation and mitigation interventions implemented under SPACC and how the information gleaned may be useful in modifying such initiatives with a view towards possible replication and scaling up these approaches.

Overview of SPACC

The Special Programme on Adaptation to Climate Change (SPACC) was designed to pursue actual adaptation measures for Caribbean countries, especially the Small Island Developing States (SIDS) of the region, to precisely develop resilience and mitigate the negative effects of climate change. This initiative materialized as a result of a phased regional climate change response consisting of several strategic initiatives, which commenced with the Caribbean Planning for Adaptation to Climate Change (CPACC) in 1997, followed by the Adaptation to Climate Change in the Caribbean (ACCC) in 2001 and later the Mainstreaming on Adaptation to Climate Change (MACC) in 2004. The SPACC project materialized with a grant of US$2.1 million from the Special Programme for Adaptation of the Global Environment Facility (GEF), February 1, 2007 to December 31, 2011 (WorldBank, 2012). The CCCCC was the Executing Agency and the World Bank the Implementing Agency. SPACC, developed as a Regional Implementation of Adaptation Measures in Coastal Zone Projects, consisting of a central objective, that of, implementing pragmatic adaptation measures directed at addressing the impacts of climate change on natural resource bases, primarily focusing on biodiversity and land degradation along coastal and near-coastal areas within the Caribbean region (World Bank, 2012). The SPACC project effectively carried out its central objective by identifying countries that required urgent intervention actions to protect their natural resources. The pilot countries selected for this project were Saint Lucia, Saint Vincent and the Grenadines and the Commonwealth of The Commonwealth of Dominica.

These countries were selected due to their projected climatic vulnerability in the region, conservation value and present climate change policies. Given the projections of the Intergovernmental Panel on Climate Change (IPCC), which estimates an increase of 1.4°C to 5.8°C in global average surface temperature by 2100 (IPCC, 2007) with greenhouse gas emissions to "very likely" augment during the 21st Century, these small islands are most vulnerable to the effects of climate change[11]. The IPCC expects that sea level rise will intensify inundation, erosion and other coastal hazards which will likely threaten essential infrastructure, marine and ecological resources, water resource and other vital coastal resources required to maintain community livelihoods (IPCC, 2007). In terms of ecological values, the effects of climate change will disrupt the ecosystem functioning and services provided by coastal and near coastal biodiversity. Among those at high risk[12] are coral reefs, fish stocks, sea grass, mangrove forests and coastal lagoons which communities dependent on for economic gains, food security and aesthetic values.

Additionally, the pilot countries also favoured the SPACC Project due to various climate change policies and strategies they had approved at the local and national levels. These three countries were among the first to create a comprehensive adaptation framework which gave them an advantage to execute adaptation action when compared to the other Caribbean countries (WorldBank, 2006). The developed framework allowed the countries to take fundamental steps of incorporating climate change concerns

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[T]he Fifth Assessment Report of the Inter-Governmental Panel on Climate Change (IPCC's), concludes that: (i) our climate has changed, is changing and continues to change, to the detriment of many vulnerable and at risk communities, (ii) atmospheric carbon dioxide (CO_2) concentrations have increased by about 40% since 1750 due to human activities and currently hovers around 400 ppm, (iii) sea levels have been rising by about 3 mm a year since the early 1990s, leading to continued flooding from storm surges, submergence, coastal erosion and saltwater intrusion in low-lying areas, (iv) some low-lying developing countries and small islands states are expected to face very high impacts, that in some cases, could have associated damage and adaptation costs of several percentage points of their gross domestic product (GDP). Some studies put the impact on annualized GDP at between 4% and 6% which is tantamount to being in a state of perpetual recession, and the cost of adaptation in excess of US$20 billion annually, and (v) global marine-species, redistribution and marine-biodiversity reduction in sensitive regions will challenge the sustained provision of fisheries productivity and other ecosystem services.

[12] The concept of risk, which combines the magnitude of the impact with the probability of its occurrence, captures uncertainty in the underlying processes of climate change, exposure, impacts and adaptation interventions.

into national development agendas and introducing national climate change plans. This gave them valuable knowledge and allowed them to be readily prepared for contribution to the implementation of the SPACC project. Additionally, these countries had all ratified the international climate change and biodiversity agreements such as the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD) and the Convention on Biological Diversity (CBD).

The objectives of SPACC can be broadly categorized into two categories: the project development objectives and the global environmental objectives (World Bank, 2012). The project development objectives (PDO) of SPACC focused on the implementation of specific (integrated) pilot adaptation measures to address the impacts of climate change on the natural resource base, with emphasis on biodiversity and land degradation along coastal and near-coastal areas of the Commonwealth of The Commonwealth of Dominica, Saint Lucia and Saint Vincent and the Grenadines. This was achieved through: (i) the detailed design of pilot adaptation measures to reduce expected negative impacts of climate change on marine and terrestrial biodiversity and land degradation; and (ii) the implementation of pilot adaptation investments. The PDO contained 13 indicators which when disaggregated contributed to specific actions in the three small island states. The Commonwealth of Dominica had 6 indicators which consisted of projects such as: (1) protected areas park management plan, (2) ecological variables database, (3) the installation of a meteorological station at one of the national parks, and (4) capacity building for water management. Saint Lucia accounted for 5 indicators in the PDO which were: (5) documentation of rain water harvesting and wastewater treatment plant for capacity building, (6) reduction of dependence from utility water source, (7) governmental approval for water harvesting techniques for tourism activities, (8) erection of a wastewater treatment plant and (9) gathering information on the Marchand Community Building and Hurricane Centre. Lastly, the programme for Saint Vincent and the Grenadines contained 4 indicators, namely: (10) institutional and operational viability of the Bequia desalination plant and distribution water system, (11) technical viability of the desalination plant and distribution water system along with solar energy integration, (12) financial viability of the water system and (13) Governmental capacity building to manage water stress (World Bank, 2012).

The global environmental objectives (GEO) was focused on producing knowledge, of global value, on how to implement adaptation measures in small island states which can be applied to other countries in the Caribbean as well as other islands outside of the Caribbean. In meeting the GEO, two components emerged, namely: (14) dissemination of lessons learnt by CCCCCC on its website and (15) University of the West Indies (UWI) received climate modelling data for regional climate research and teaching.

The SPACC project catered for a wide cross-section of beneficiaries at the local, national and regional levels. The adaptation interventions implemented under SPACC focused directly on biodiversity, land degradation, water resources and the reduction of greenhouse gas (GHG) emissions. This improved the capacities of the selected countries to continue efforts of addressing the effects of climate change through national dialog and policy formulation. The benefits of the adaptation initiatives under SPACC also included knowledge building as the lessons learnt from these pilots make it easier to replicate these projects in similar countries and small islands such as those of the Pacific Islands, while simultaneously indicating areas that need greater attention. This project has also brought partnership and cooperation with the international community on the agreed agenda of addressing climate change issues both at present and for the future via initiatives such as the UNFCCC, UNCCD and CBD. The Commonwealth of Dominica gained significantly from the pilot activities at their National Parks and their surrounding communities through information and monitoring capabilities. Saint Lucia benefited in the areas of water resource management, infrastructure retrofitting to prepare against increased hurricane intensity and coastal protection. Lastly, Saint Vincent and the Grenadines was aided by reducing the intense pressure on freshwater aquifers and allowed the accessibility of water to locals through the installation of a desalination water plant. The plant is powered by photovoltaic panels, which produce more than enough energy to operate the plant. This allows the excess energy to be fed into the gird and the revenue gained therefrom, used to assist with the maintenance of the SWRO plant. This is an example of coupling adaptation and mitigation efforts in a single initiative.

Review of Approaches for Assessing the Benefits and Costs of Adaptation and Mitigation Strategies

Benefit Cost Analysis (BCA)

Benefit cost analysis (BCA) is an economic tool used to support decision making since it provides greater understanding of the impacts of alternative courses of action in terms of benefits and costs. It involves comparing the values of the impacts of a measure or programme, designed to assess whether the advantages (benefits) of the measure or programme exceeds the disadvantages (costs). Where the marginal cost to society is less than the marginal benefit to society then the project is said to be worthy. The potential maximum net benefit of a programme occurs when the marginal cost to society is equal to the marginal benefit i.e. the point at which the cost of implementing the programme is minimized and the benefits to society is at its maximum (see Figure 3).

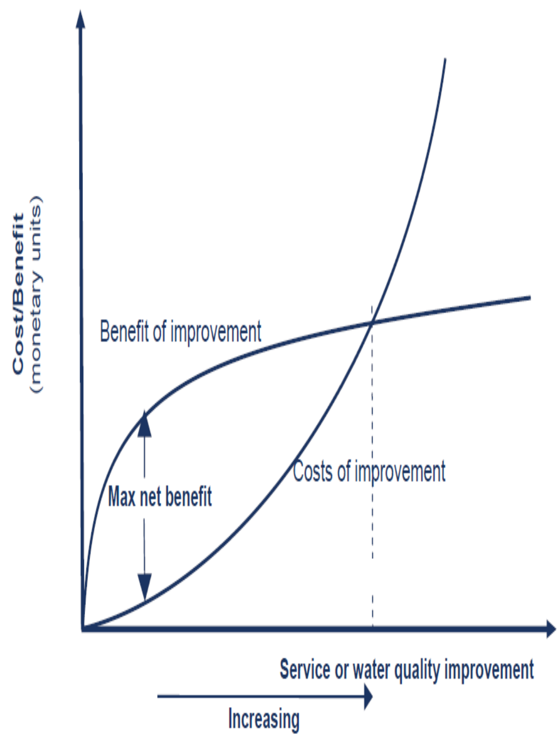


Figure 3: BCA "Fish Diagram"

The broad purpose of BCA is to facilitate a more efficient allocation of resources, demonstrating the convenience for society of a particular project or programme against the alternatives. BCA is not suitable for appraising the macroeconomic impact of a project on, for example, regional GDP growth or trends in unemployment (European Commision, 2008). BCAs are useful in:

1. determining pre-conditions necessary for an activity to successfully occur and;
2. informing the progress of an activity;
3. giving a decision-maker a better understanding of the impact of alternative courses of action in terms of costs and benefits; and

4. helping a decision-maker identify alternatives that are the most beneficial, comparing projects that differ in magnitude and duration.

Various stages have been identified in the development of a BCA model (see Figure 4)

Types of Analyses Undertaken Under the BCA Framework

There are different types or methods of analyses conducted under the BCA framework to determine the economic efficiency or feasibility of a project. These are:

- Net Present Value (NPV)
- Benefit Cost Ratio (BCR)
- Incremental Cost Benefit Ratio
- The Payback Period

The Net Present Value (NPV)

The NPV method considers the difference between the total discounted benefits and total discounted costs. Projects with positive NPVs are considered to be viable and a project with a higher NPV as compared with another project with a lower NPV is measured to be less lucrative. In other words, the higher the NPV the greater the calculated benefits of the project. The formula is:

$$NPV = [\Sigma B_i / (1+d)^i] - [\Sigma C_i / (1+d)^i] \text{ summed over } 1 = 0 \text{ to } n^{th} \text{ year}$$

where:

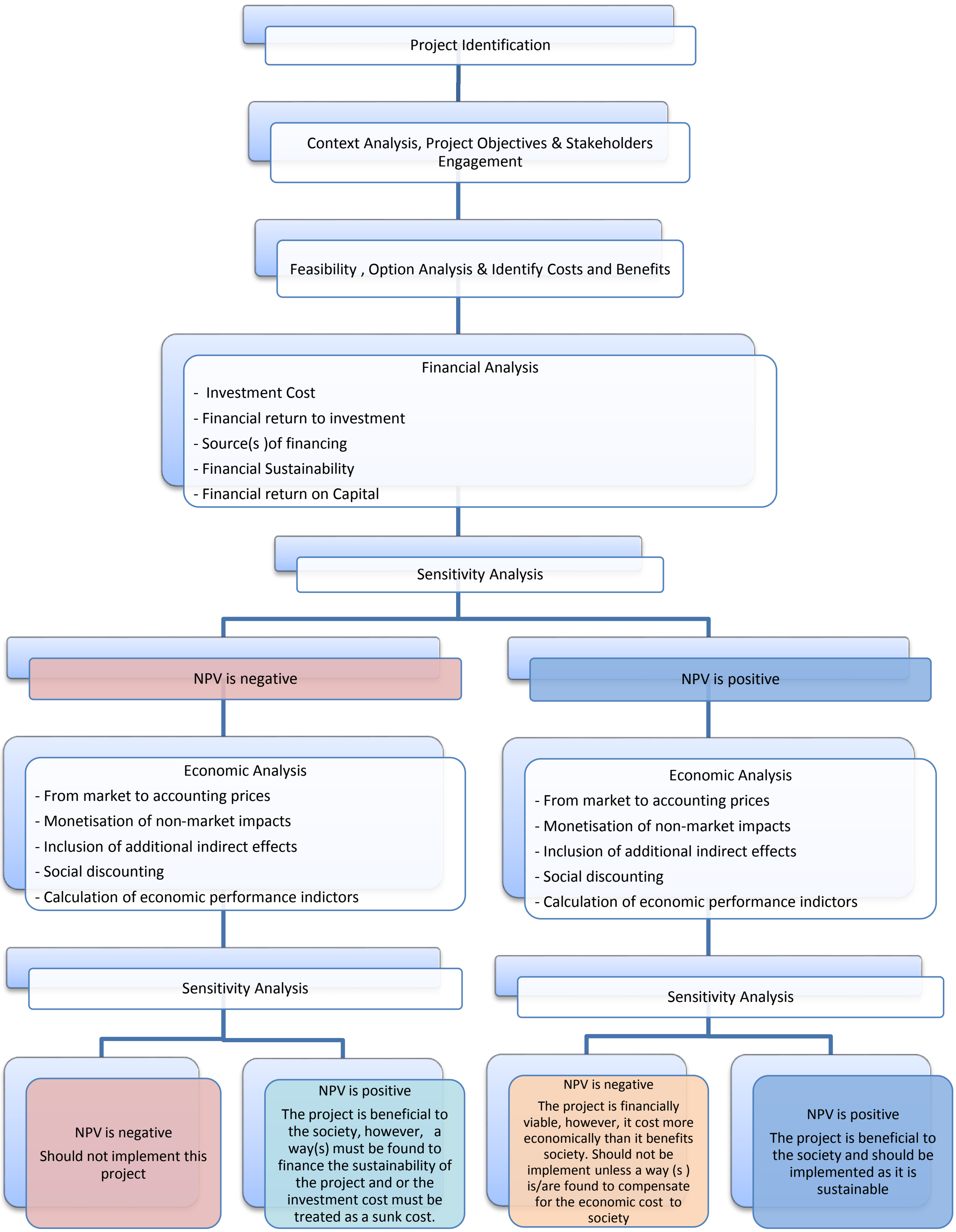
B_i = the project's benefit in year i, where i = 0 to n^{th} years

C_i = the project's costs in year i, where i = 0 to n^{th} years

n = the total number of years for the project duration/life span

d = the discount rate

Figure 4: Procedure for Project Appraisal using BCA at the CCCCC



Source: Adapted and modified from (European Commision, 2008)

Benefit Cost Ratio (BCR)

This is the ratio of project benefits versus project costs. It involves summing the total discounted benefits for a project over its entire duration/life span and dividing it over the total discounted costs of the project BCR = summed over 1 = 0 to n^{th} years

$$BCR = [\Sigma B_i / (1+d)_i] / [\Sigma C_i / (1+d)_i]$$

where:

B_i = the project's benefit in year i, where i = 0 to n^{th} years

C_i = the project's costs in year i, where i = 0 to n^{th} years

n = the total number of years for the project duration/life span

d = the discount rate

The simple steps in this methodology are:

- Determine the discounted benefits for each year of the project
- Determine the discounted costs for each year of the project
- Sum the total discounted benefits for the entire project duration
- Sum the total discounted costs for the entire project duration
- Divide the total discounted benefits over the total discounted costs

Understanding the results of the BCR

BCR < 1	BCR = 1	BCR > 1
In economic terms, the costs exceed the benefits. Solely on this criterion, the project should not proceed.	Costs equal the benefits, which means the project should be allowed to proceed, but with little viability.	The benefits exceed the costs, and the project should be allowed to proceed.

This method does not give a result of the projected total gains or losses of one project compared with another project. This can be done using the incremental BCR methodology.

Incremental Benefit Cost Ratio (IBCR)

This method helps to determine the margin by which a project is more beneficial or costly than another project. It is used to compare alternative options to help determine which is more feasible over the other(s).

The steps in this methodology are:

- List the projects from the least costly to the most expensive in ascending order.
- Take the least costly project and compare it to the second cheapest option by subtracting the total discounted benefits for each project and dividing this by the difference in the total discounted costs for each project.

$$\text{Incremental BCR} = (SB_1 - SB_2) / (SC_1 - SC_2)$$

where:

SB_1 = total benefits for project '1'
SC_1 = total costs for project '1'

- If the incremental BCR obtained is higher than the target incremental BCR, then discard the lower-cost option (project 1 in this case) and use the higher-cost option (project 2) to compare with the next project on the ascending cost list.
- If the incremental BCR obtained is lower than the target incremental BCR, then discard the higher-cost option (project 2 in this case) and use the lower-cost option (project 1) to compare with the next project on the ascending cost list.
- Repeat these steps (2-4) until all of the project options have been analysed.
- The project which has the highest cost and an incremental BCR equal to or greater than the target incremental BCR.

Payback Period

This is the time period required for the total discounted costs of a project to be surpassed by the total discounted benefits. This can be easily done, say in excel, by calculating the cumulative discounted benefits and cumulative discounted costs of a project for each consecutive year of a project. The year that the cumulative benefits exceed the cumulative costs is the payback period year of the project. In other words, the year following the project payback period will see net profits or benefits to the project.

Strengths and Weaknesses of BCA Framework

BCA is a widely accepted methodology, which simplifies complex concepts and processes used in the evaluation of projects and policies. Results from BCAs can be generated rather quickly to inform the decision making phase through the provision of a clear indication of the net cost or benefit of a specific project or policies.

BCAs require all costs and benefits to be expressed in monetary units. However, it is sometimes difficult to express in monetary terms some cost and benefits, such as non-market environmental goods and services. Even though methods have been developed to estimate non-market values, limitations in the accuracies and reliability of results still exist in some areas. Therefore, applying non-market valuation becomes a time consuming and costly process which may lead to omission of significant costs and benefits. Another limitation is that BCAs do not always consider the source and distribution of the costs and benefits. Therefore, factors such as environmental justice, indirect impacts, uncertainty and equity may not be considered. There have been efforts to deal with the issues of uncertainty and equity, such as weighting costs and benefits, however, the determination of the appropriate weight are subjective and/or complex. Lastly, and possibly the most conceptual difficulty with BCA is what discount factor to apply. This issue become more acute where issues of inter-generational equity, particularly when applied to natural resources and environmental goods.

Valuing Costs and Benefits, Uncertainty and Equity

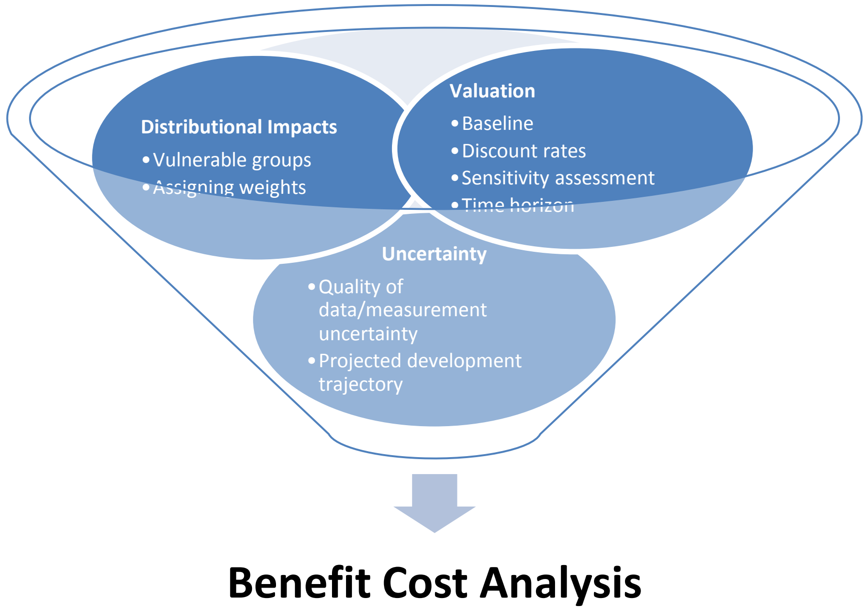
UNFCCC (2011) identifies three broad categories of limitation when conducting a benefit cost analysis. These are namely valuation, equity and uncertainty (see Figure 5).

Valuation

Identifying the Baseline and Valuing Benefits and Costs

Identifying the baseline is one of the most important steps when conducting a benefit-cost analysis. The baseline provides the 'do nothing' scenario again which all other scenarios will be compared. In the context of climate change and climate variability, defining the baseline can be difficult as uncertainty and distributional equity are issue that must be resolved. Additionally, putting a precise value on the state of the existing climatic condition and by extension the environment is an impractical task, given limited resources.

Figure 5: Limitation to Conducting an Effective CBA



Although valuing climatic condition and environment might be challenging several methodologies have been developed to provide quantifiable accurate measures. There are four broadly defined methods for valuing costs and benefits, namely: direct market price methods, revealed preference methods, stated preference methods and benefit transfer method.

Direct market price method uses a direct observable market price, that is, the price at which goods and services are bought and sold. This method is hinged on the assumption that the marginal utility or benefit derived from consuming or producing the good or service is equal to the price and as such this method excludes the possibility of consumer and producer surpluses.

Revealed preference methods use information gathered about the actual behaviour of economic agents. This model identifies changes in the demand for and/or supply of a marketable good due to changes to the environment. One example of revealed preference method is the hedonic pricing method. The hedonic pricing method uses market valuations, mainly those observed valuations in the real estate market. By using statistical techniques to separate the environmental and non-environmental effects on real estate prices, it is possible to place a value on how society values its environment. Another revealed preference method is the travel cost method (TCM). The TCM values the environment by examining the economic cost travellers foregoes to visit an area. In some instances, by combining the characteristics of the sites and the information collected from travellers to sites, Random Utility Models (RUMs) can be developed to assess how environmental value changes with the quality of the site. Other revealed preference methodologies includes:

- Replacement cost method,
- Damage cost avoidance approach,
- Mitigating expenditure method,
- Net factor Income Approach, and
- Production function method.

Unlike the revealed preference methodologies, the stated preference methodology involves using qualitative and quantitative information gather from the society through willingness to pay (WTP), ability to pay (ATP) and willingness to accept (WTA) surveys, to place a value on environmental asset's importance and quality. Using the survey information gathered, consumers' surplus, producers' surplus and RUMs can be estimated.

Another methodology used to value benefits and costs is the benefit transfer methodology. This involves using pre-existing information for, and studies done for, a similar location or project to estimate economic values for the environmental assets. The benefits transfer methodology allows for the easy estimation of the avoided damage cost and replacement cost approaches, although hinged on reliability of secondary information.

Discounting

The decision to invest in an adaptation or mitigation strategy, gives rise to benefits and costs over time. In comparing these benefits and costs associated with each project over time, a discount rate is used to adjust the expected/estimated future benefits and costs. The majority of the literature on social discount rate and discounting related to climate change identifies two types of social discount rates: the social opportunity cost (SOC) of capital and the social rate of time preference (SRTP). The SOC is drawn from the descriptive school of thought, where the social discount rate is determined based on the efficient allocation and use of the funds, that is, it is based on the premise that publicly funded projects should be discounted based on the potential rate of return the funds could have otherwise derived. The SRTP, on the other hand, emerged from the prescriptive school of thought and is often used when present projects are intended to affect the future generations. The definition of the SRTP hinges on the assumption that consumers prefer to consume now rather that in the future, as in future we may all be dead and by our very nature we are myopic, thus future consumption must be discounted.

These rates can be determined by using a secondary source, for example an already established identifiable discount rate or by estimation using for example Ramsey's equation and weighted average market rates. It is however important to note that the literature suggest that this rate could have some correlation with time and uncertainty; therefore the discount rate could evolve with time. It is against this back ground that some practitioners have made it a point of duty to conduct sensitivity analysis by presenting their findings using a range of discount rates, which proves the robustness and validity of the findings. This is of particular relevance in SIDS where uncertainties are exponentially greater than in larger, more robust economies.

Time-horizon

The life span of an intervention (option) coupled with the selected discount rate can determine whether it is worth undertaking or not. In the context of climate change, adaptation options range from medium-term to long-term. In conducting benefit cost analyses, all costs and benefits accumulated over the life span of the project must be identified and where possible valued and discounted. The time-horizon of an adaptation intervention option, therefore, can also influence the discount rate that is chosen as there is greater uncertainty with a relatively long time horizon.

Equity

Questions of, "who will benefit most?" "who has standing?" and "who should pay for the cost of implementing an adaptation projects?" are often brought to the forefront of climate change adaptation projects. Climate change will impact 'all' but some more than others based on differing resilient capacities. When implementing an adaptation strategy, although tedious, it is important at a macro-level to identify the space that will be impacted and the benefits to be derived from that space. And at a micro-level, the questions of:

- Is it the poor or the rich that will be benefitting?

- Should the population within that space bear the cost of implementation? or
- Can the population in that space afford to bear the cost of implementation?

must be answered if the issue of equity in cost benefit analysis is to be dealt with.

The literature suggests ways in which equity can be brought into benefit cost analysis. For example, weighting the benefits and costs is one such way but this is problematic because the weights are subjective. Besides ignoring the equity component, others have taken the route of presenting the aggregate benefits and costs along with a disaggregate analysis which identifies those who benefit and suggest those who should pay.

Uncertainty

In making a decision which involves planning for the future there is uncertainty. Despite the presences of some degree of uncertainty, there are several non-probabilistic criteria such as the precautionary principle, maximin, minimax, maximax and Hurwicz criterion which helps to improve the decision making process (Beukering, Brander, Tompkins, & McKenzie, 2007). In the context of climate change, there are three things related to uncertainty which hinders the effectiveness of benefit cost analysis. These are:

- Uncertain future climatic conditions- the uncertainty of what the future climate will look like can cause one to over- or under-estimate the benefits and costs of an adaptation intervention. It is contingent upon practitioners in this field to advice policymakers in pursuing flexible, no-regret interventions given the level of uncertainty, such as mangrove reforestation, rip-rap sea defence structures, and protected agriculture. Since the basis for adaptation is build on expected climatic changes, it is important to factor in as much climate change scenarios as possible, while simultaneously updating the data/information and research as new data/information becomes available.
- Uncertain economic growth and socio- economic development – this point is linked to the one above. In that, the uncertainty of climatic conditions in future could have an impact on a country's ability to grow or even the socio-economic conditions of that country. Conversely, newly-emerging economies seeking to attain a certain level of economic growth may chose pathways that are environmentally destructive, such as the pursuance and subsidization of coal-fuelled energy plants. The uncertainty surrounding climatic conditions and, furthermore,

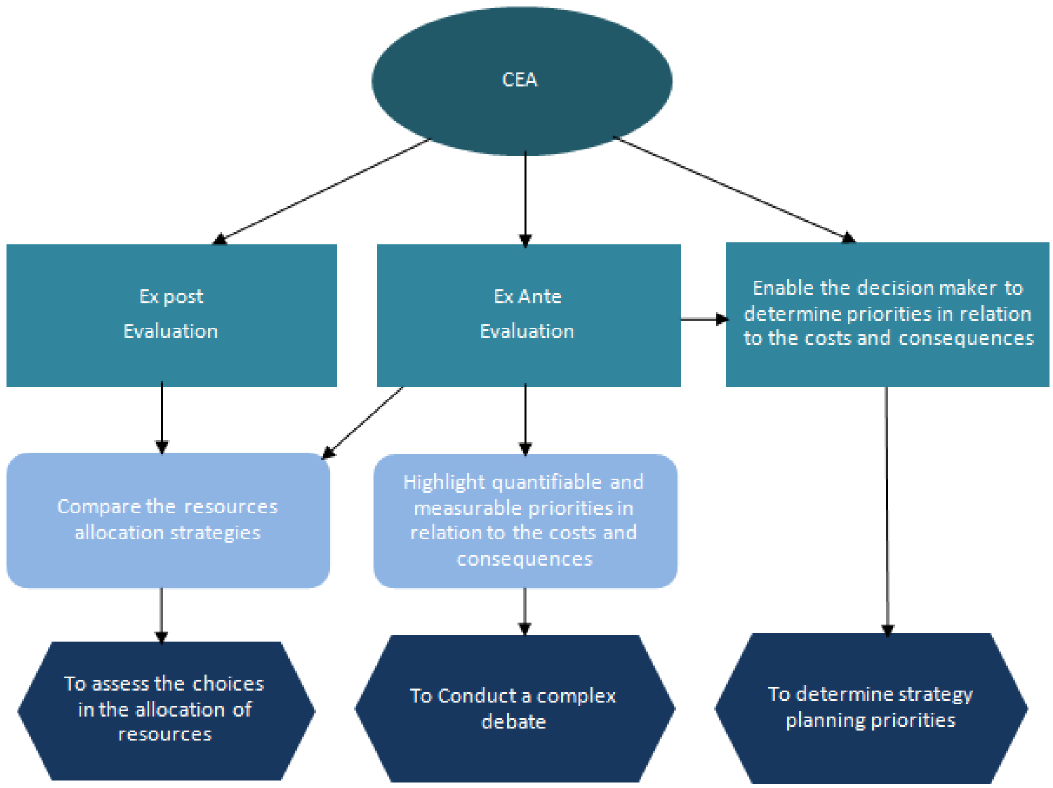
the economical and social implications makes it even more difficult to be precise about the quantitative analysis associated with BCAs. Like above, it is imperative that as many climatic scenarios are factored into the growth or development models to derive more accurate possibilities of future growth and development trajectories.

- Discounting under uncertainty – Discounting under uncertainty has the potential to over- or under-estimate the worthiness of an adaptation intervention. Note that this problem is linked to the above two points as one does not know what future climatic condition will be like or the socio-economic condition that will exist. Therefore, finding a range of discount rates is one way of overcoming this problem. Additionally, there are techniques to estimate the discount rate taking into consideration uncertainty.

Cost-Effectiveness Analysis (CEA)

Another method can be used to appraise the worthiness of a project, if the data needed to conduct a benefit cost analysis is not available or the results of a benefit cost analysis are not reliable, is the Cost Effectiveness Analysis (CEA). Cost Effective Analysis (CEA) is a decision tool that judges the desirability of a project according to the cost of attaining a particular objective (Beukering, Brander, Tompkins, & McKenzie, 2007). CEA can be used to discuss the economic efficiency of a Programme or a project (European Commission, 2006). It is applicable when considering between options to achieve a single specific goal and where all costs can be expressed in monetary terms. Where it differs from the benefit cost analysis is that it is not strictly based on the comparison of benefits and costs, however, it is based on finding the least cost associated with meeting an objective or objectives. To find the least cost necessary to meet a specific objective, an optimization procedure is usually used. This does not mean that the method leads to efficiency at all times as it is dependent on a predetermined objective which may or may not be efficient. i.e. All efficient polices are cost effective, but not all cost effective policies are efficient (Beukering, P. V., Brander, L., Tompkins, E., & McKenzie, E. (2007).

Figure 6: Cost Effective Analysis



Source: (European Commission, 2006)

When conducting benefit cost analyses net benefits are maximized when the marginal benefit is equal to the marginal cost, however, in conducting CEA, the least-cost means of achieving a target would have been achieved when the marginal cost of all possible means of achievement are equal (T.Tietenberg & Lewis, 2009). If all the marginal costs are equalized, it is impossible to find any lower-cost way of achieving the specified objective(s). CEA can be conducted *ex post* evaluation (after implementation) or *ex ante* evaluation (before implementation) and is useful when choosing how to allocate resources or in determining strategy planning priorities or to contribute to a debate (European Commission, Evaluation Methods for the European Union's External Assistance (Evaluation Tools Vol4), 2006).

In the context of climate change, where the broad objective is, adapting to, and mitigating, the potential impacts of climate variability and climate change, it is important that the adaptation and mitigation objectives are identified as well as the possible adaptation and mitigation options. If the cost of the adaptation or mitigation option cannot be quantified then the CEA cannot be used. The method is useful if the adaptation or mitigation actions have results that are identifiable and the cost associated with the action is measurable. For the results of an adaptation or mitigation option to be identifiable, there must exist some established baseline. Establishing the baseline when dealing with environmental goods and eco-services can be challenging, however, there are several techniques such as the travel cost method, contingent valuation techniques such as the ability and willingness to pay, and market valuation that have been applied to identify and measure environmental goods and eco-services. Besides establishing a baseline, the cost associated with each adaptation and or mitigation option must be quantified. These can be direct, indirect or opportunity costs. Once the baseline is established and the cost of each option is identified, it is possible to compute the 'cost-to-effectiveness' of each option based on the resulting deviation/variance from the baseline and cost associated with that option.

Figure 7: The Process of Conducting a Cost-Effectiveness Analysis

Source: UNFCCC, 2011

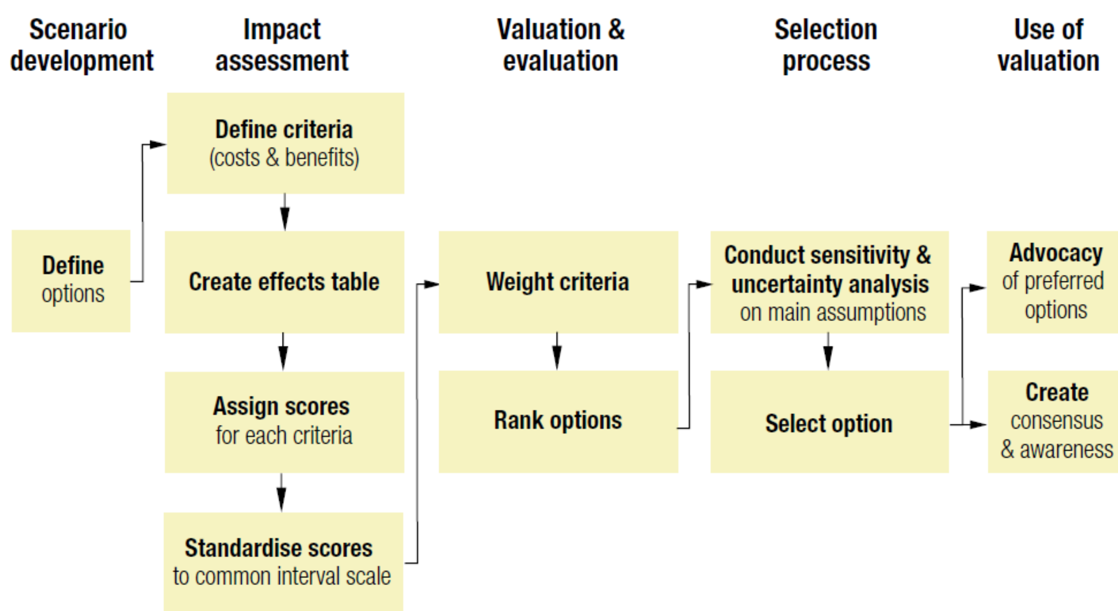
Multi-Criteria Analysis (MCA)

Multi- Criteria Analysis (MCA) is used for evaluating alternative options against several criteria, and combining the separate evaluations into an overall evaluation (UNECE, 2011). MCA describes any structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives (UNFCC, 2011). MCA can be used to zero in on a single option or a subset options as might be required to meet a specific objective or a set of objectives. The objectives need to be measured in monetary terms or a common unit; however, it is often quantified by ranking and scoring. The objectives are weighted so as to develop a quantifiable selection criterion. Usually the selection criterion is specified such that the option with the highest score, that is, the option that meets the most objectives is selected for implementation. The following are steps involved in conducting a multi-criteria analysis:

- Define the objectives of the Programme and identify the assessment criteria to be applied.
- Analyze the relative importance of the criteria identified. This is usually the weighting process.
- Analyze performance by scoring. This can be done using a jury of experts, determining performance against criterion-specific function that defines gradual progression from the worst to the best performance or judging the performance of the option against each other.

- Multiply weights and scores for each of the options and derivation of their overall scores
- Analyze sensitivity to changes in scores or weights. This is important, especially in the case where uncertainty is present, in determining how sensitive the results are to changes in the weights assigned.
- Identify the option to be implemented

Figure 8: The Process of Conducting a Multi-Criteria Analysis (MCA)



Source: Beukering, P. V., Brander, L., Tompkins, E., & McKenzie, E. (2007)

Strengths and Weaknesses of MCA Framework

One of the primary strengths of MCA is the ability to quantify all impacts in separate units and further rank them in order of importance. This method avoids expensive and complex valuation studies on all environmental impacts. Additionally, it relies on the judgment of the decision-makers in identifying and estimating the options or criteria for the analysis; however, this could be seen as a limitation since the decision-maker chooses the objectives, criteria and weights. MCA could be regarded as a subjective tool from the standpoint of prioritizing options and the non-standardized weights. Another limitation is that it cannot measure the utility or disutility derived from the implementation of a Programme as well as there is no basis on which the costs or benefits explicitly enter the MCA methodology. However, information about benefits and costs could aid to prioritize the options. Table 1 shows the similarities and differences between the BCA and MCA.

Table 1: Comparing and Contrasting MCA and BCA

Features Unique to MCA	Similarities with BCA and MCA	Features Unique to BCA
1. Design the socio-technical system for conducting the MCA. 2. Describe the consequences of the options. 3. Check the consistency of the scores on each criterion. 4. Assign weights for each of the criteria to reflect their relative importance to the decision. 5. Calculate overall weighted scores at each level in the hierarchy. 6. Look at the advantages and disadvantages of selected options, and compare pairs of options. 7. Repeat the steps until a 'requisite' model is obtained	1. Establish context and justification for action. i. Establish aims and rationale for the analysis. ii. Consider the context and scope of the appraisal. Is government intervention warranted? 2. Identify objectives and criteria i. Organise criteria (outputs against which options will be appraised) and objectives in a hierarchy. 3. Identify options i. List possible policies, strategies or actions to achieve the objectives. 4. Appraise the options i. Value the costs and benefits of the options on the criteria. 5. Derive an overall valuation i. MCA: Calculate overall weighted scores. BCA: Calculate the net benefits or costs. 6. Examine results i. Identify the 'best' option. 7. Conduct sensitivity analysis i. Consider the impact of alternative scenarios and changes in key variables.	1. Discount costs and benefits to 'present values', when appropriate. 2. Adjust for differences in tax between options. 3. Adjust for risk and optimism. 4. Determine the affordability of options. 5. Devise implementation plans. 6. Present the results. 7. Implement the solution. 8. Track the success of the policy, Programme or project in achieving its objectives.

Source: (Phillips & Stock, 2003)

Methodology

Benefit cost analysis was used to evaluate the pilot projects under SPACC with the aim of: (1) putting a monetary value on the worth of the project; and (2) providing a baseline on which such projects can be replicated across the Caribbean region. The framework adapted by the Caribbean Community Climate Change Centre (CCCCC) for assessing adaption projects involves:

1. Examining the adaptation objectives (*must be quantifiable*)
2. Reviewing the baseline (*the situation without the adaptation intervention*)

3. Quantifying and aggregating the costs over specific time periods (*direct and indirect – social welfare losses and transitional costs*)
4. Quantifying and aggregating the benefits over specific time periods (*market values, avoided losses, contingent valuation*)
5. Calculating net benefits (*NPV, BCR, IRR)*

Adaptation Objectives and Revision of Baseline

Under SPACC the adaptation objectives were derived from stakeholders. Stakeholder from the different Islands identified priority sectors which were most vulnerable to climate change. These objectives were geared towards the implementation of a specific pilot adaptation measure to address the impact of climate change on the natural environment and which could be easily replicated in other parts of the Caribbean. The objectives are generally aimed at reducing the impact of, and risk associated with, climate change and improving the welfare of people and its environment without simultaneously making others worse off, whether presently or in the future.

A revision of country specific climate change and extreme events reports as well as additional research and consultations with stakeholders assisted in establishing the baseline for the various sectors identified as priority under SPACC. This process also aided in the identification of some of the potential benefits and costs of implementing the adaptation intervention.

Quantifying and aggregating the Benefits and Costs

To quantify the various costs and benefits associated with the projects under the SPACC, which can be deemed medium to long term adaptation strategies, various approaches were used namely the: (i) market value approach; (i) reveal and stated preference technique, and (iii) benefit transfer[13].

[13] Note that the examples provided below are just a few of the ways in which each method was applied. For greater details on assumptions and valuation techniques see the individual case studies.

Market Value Approach

In valuing benefits and costs using the market value approach direct observable market valuation through an already existing price mechanism is used, more so, from the real estate market. For the case study, Strengthened Critical Infrastructure in the Castries Area: Retrofitting the Marchand Community Centre, the total space available for rent was valued using the cost to rent such property in the area similar to the property, while the Salt Water Reverse Osmosis (SWRO) System in Bequia, in Saint Vincent and the Grenadines was valued using observable market prices. For the Hybrid Rainwater, Sewerage and Irrigation System for the Coconut Bay Resort and Spa project, water and treatment costs were valued using direct observable market prices.

Willingness to Pay and Ability to Pay

This methodology was used mainly with the Salt Water Reverse Osmosis (SWRO) System in Bequia, Saint Vincent and the Grenadines. The survey was commissioned by the Caribbean Environmental Health Institute (CEHI) in 2006, and has come to be known as the BCEOM and Stewart Engineering Limited, *Windward Water Supply Project: Socioeconomic Feasibility Study - Water Demand in the Grenadines in 2006*. This survey was used to gather information about the communities' willingness and ability to pay for regularize tapped water on the Island of Bequia.

Benefit transfer

Given the time constraints associated with the BCAs and the lack of resources to carry out primary data collection, the benefit transfer method was applied in all the case studies. Secondary data was gathered from previous studies, projects and project documents, and accounting records. In the case of the SWRO, a similar plant is installed in at Caye Caulker in Belize for which secondary information was readily available and on which some assumptions were hinged. In the case of the Hybrid Rainwater, Sewerage and Irrigation System for Coconut Bay Resort and Spa studies such as (Burke, Greenhalgh, Prager, & Cooper, 2008) and (Simpson, 2012) provided the basis for the assumptions and estimation of avoiding damaged involved in having the system. In the case of the Strengthened Critical Infrastructure in the Castries Area: Retrofitting the Marchand Community Centre avoided losses due to hurricane winds were estimated using secondary information from the UNECLAC reports.

Calculating net benefits

In BCA, calculating the net benefits of a project required two sequential actions, firstly, discounting future cash flow and selecting appropriate method(s)(net present value, benefit/cost ratio and internal rate of return) to illustrate the merit of the project.

Discounting

In the context of climate change impacts on small islands, the decision to invest in social and public projects, which are viewed as adaptation and mitigation interventions, are based on the prioritized needs of the society. Given the relevance of these strategies, great care must be taken when selecting the social discount rate, since the benefits of adaptation and mitigation interventions accrue over long period of time and the choice of a acceptable social discount rate can make a significant difference in whether the present value of an adaptation or mitigation intervention is positive or negative, or in other words, desirable or undesirable. Recognizing this, the CCCCC estimated benchmarks for the SRTP for selected Caribbean Countries.

Although, the CCCCC has benchmarked these rates (used internally), further research is needed to provide more precise and robust measures. When using Ramsey's equation[14] to estimate the SRTP, a major component/parameter is the growth rate of the economies of the Caribbean as such more scenarios related to the potential impact of climate change on the growth rate of the economies is desired. Furthermore, research is also needed to understand if and how the social discount rate differs across projects as well as its evolution with uncertainty and over time.

For Saint Vincent and the Grenadines discount rates of 3%, 5.5% and 8% were used in this analysis. The discount rates used for Saint Lucia were 2%, 4.5% and 7% .Discount rates of 3%, 4.5%% and 7% were used for The Commonwealth of Dominica. These rates were selected based on the CCCCC estimates of the SRTP for selected Caribbean countries, which included the three countries selected under SPACC. The SRTP for Saint Vincent and the Grenadines was estimated at 3.58%; however, sensitivity analysis suggested it could range from 3% to 8%. The SRTP for Saint Lucia was found to be 4.59%; however, sensitivity analysis suggested that it could range from 2% to 7%. Similarly, the Commonwealth of Dominica's SRTP was estimated at 4.12%; however, sensitivity analysis suggested that it could range

[14] (Ramsey, 1928)

from 3% to 7%. Given the estimated lower and upper bounds for the SRTPs, the discount rate was applied using three scenarios: the lower bound, midpoint and upper bound. This, it is believed, better equip policy-makers to make an informed and reasoned decision.

Net Present Value, Benefit to Cost Ratio and Internal Rate of Return

The net present value (NPV), benefit cost ratio (BCR) and the internal rate of return (IRR) are indicators used to assess the worth of the adaptation interventions under SPACC. Given that the investment costs were treated as sunk costs the analyst did not find that any of the projects had an acceptable payback period and these were therefore excluded from the analysis.

In CBA, the internal rate of return is the rate at which the present value of benefits is just equal to the present value of costs. This indicator is important as it can be compared to the discount rate.

Data

The analyses relied primarily on secondary data sources, even though some primary information was gathered via observations, and face to face and telephone interviews. Secondary data was gathered from project and bid documents, accounting records, previous surveys and studies, journals articles, the World Bank, the Chicago Climate Exchange, and the CIA Factbook.

Application of BCAs and Lessons Learnt

Salt Water Reverse Osmosis (SWRO) System: Bequia, Saint Vincent and the Grenadines

Overview

These analyses were carried out to determine the financial and economic viability of installing a Saltwater Reverse Osmosis (SWRO) system on Paget Farm, Bequia, Saint Vincent and the Grenadines, using a photovoltaic (PV) system to aid in the generation of the freshwater.

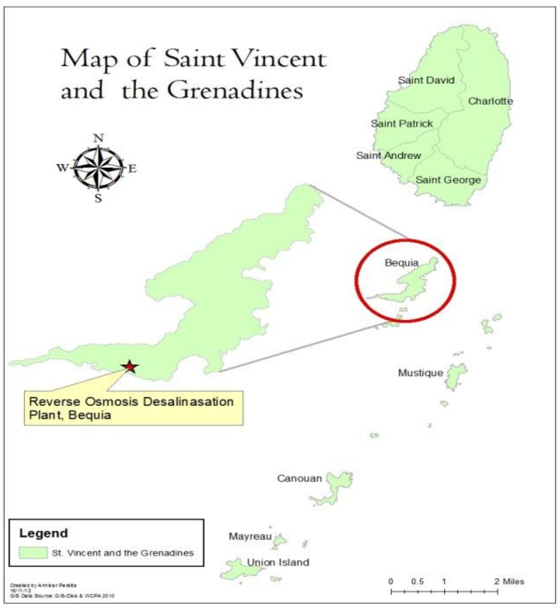


Figure 9: Map of Saint Vincent and the Grenadines

Figure 10: Locals waiting for Water to be Barged to Bequia

Table 2: Benefits and Costs of the SWRO for Bequia

Options	Costs	Benefits
Do nothing	▪ Water shortage due to dependence on a rudimentary rain water harvesting system	▪ The forgone cost of designing, constructing, maintaining and operating the SWRO system
Implementation of SRWO	▪ Capital cost of designing and constructing SWRO system ▪ Incremental operational and maintenance cost	▪ Greater energy and water security for Bequia. ▪ A modular design provides for easy expansion to meet an expanding community demand in Bequia. ▪ The project provides a baseline from which replication to other small island states, including the other islands in the Grenadines, the offshore cayes in Belize, and the Bahamas can be assessed.

Main Facts and Assumptions of the Model[15]

Various methodological approaches were used in the conduct of the financial analyses. These included:

- Using data from the project and bid documents,
- Using information from studies conducted on the Island, in particular, to acquire willingness to pay (WTP) and ability to pay (ATP) estimates, and supplementing these with information from international sources like the World Bank, the Chicago Climate Exchange and the CIA Factbook, and
- Observations, discussions and financial statistics from a similar system that has been in operation since February 2010 at Caye Caulker in Belize.

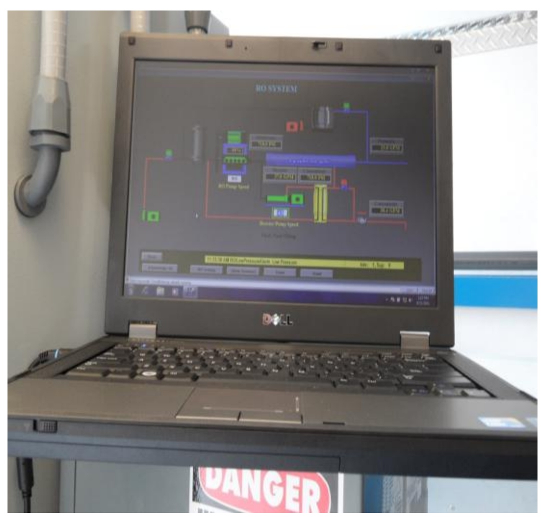


Figure 11: SWRO Plant Monitoring System

[15] Please see Annex I for a more detail list of the facts and assumptions of the model.

Furthermore, the analysis follows established best practices and norms for the conduct of this type of study. It applied various scenarios, moving from what it considers the high cost, to the moderate cost to the low cost alternatives. These scenarios are provided to aid policy-makers in making a more informed and reasoned decision. Additionally, the financial analyses add various elements of rigor by looking at the project with and without the investment costs being incorporated into the cost estimates.

Figure 12: Reverse Osmosis Process

Figure 13: Reservoir Tanks

The analysis is based on a number of assumptions and conditions, largely due to information provided in the project and bid documents. Where such information was not available, the analyst used information from other reputable sources, such as the World Bank socio-economic statistical database, the ICIS Databases and the Chicago Climate Exchange. There are some assumptions that are peculiar to the respective scenarios and these will be highlighted under these scenarios. However, there are some general assumptions and these are documented below. The general assumptions include:

- The lifespan of the SWRO and the PV are projected at 20 years,
- The Population at Paget Farm was estimated at 902 persons (or 200 households),
- Water demand for the project is projected at 18,040 imperial gallons per day when all households are connected (Note no projection is made for an increase in demand. However, it should be noted that the SWRO is only projected to work at 15.9 hours a day. Thus, the plant can accommodate any increase in demand),
- Water production capacity has been projected at 29,036 imperial gallons per day,
- Individuals/households will be charged a flat rate per gallon of water consumed rather than a marginal cost pricing approach,

- It is estimated that the plant will require 14.4 kwh of energy to produce 1,000 imperial gallons (the bid document assumed 12 kwh/1,000 US gallon),
- Energy consumption in the first year is estimated at 33,361.63 kw, and 90,240.49 kw in the second year until the ending of the project,
- Tons of CO2/MwH from diesel was projected at 0.86, while the floor price for CO_2 on the Chicago Climate Exchange at the time of writing this report was US$10 per ton (note the UK Government in its 2011/2012 budget set the floor price of CO_2 at £16 per ton or US$25.60),

Cost Scenarios and Pricing Assumptions

Operational and Maintenance Cost

The financial analysis was conducted under various price scenarios, low, moderate and high.

- Scenario 1: High Operational and Maintenance Cost Scenario
- Scenario 2: Moderate Operational and Maintenance Cost Scenario
- Scenario 3: Low Operational and Maintenance Cost Scenario

Figure 14: Filtration System

The pricing assumptions

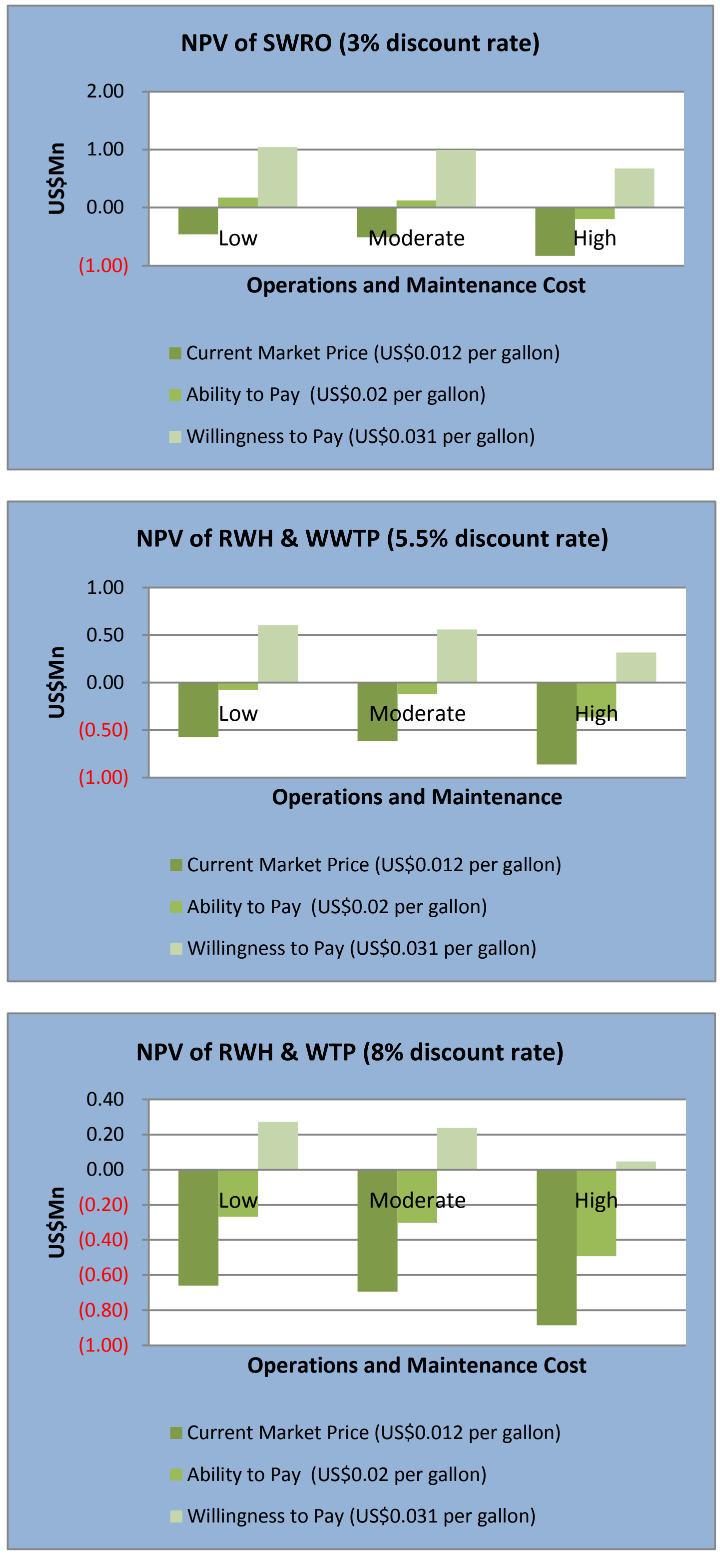
- The price per gallon (imperial gallon) of water under this scenario would be charged at US$0.012. This is comparable with the cost of water for a much larger system that derives more scale economies at Caye Caulker in Belize.
- The ATP estimate was derived from the BCEOM (2006) Survey, using an estimate of what persons already pay

Figure 15: Freshwater Production

for rainwater harvesting and pumping charges.

- The WTP estimate was derived from the BCEOM (2006) survey; using household's expressed willingness to pay 2.2% of household income, using the average household size of 4.5 persons, and the average household income to make this estimation.

Figure 16: Financial Analysis of SWRO for Bequia



Results

Financial Analysis

The financial analysis was conducted using the three aforementioned pricing and cost assumptions/scenarios as well as three different discount rates, 3%, 5.5% and 8%.

Across all discount rates and operational and maintenance cost, the project is not financially feasible if a market price of US$0.012 is charged per gallon of water consumed. However, if a moderate price is set at US$0.020 per gallon (population's ability to pay), the project is financially feasible, with a discount rate of 3% and if the operational and maintenance costs are low to moderate. If the operational and maintenance costs are high and the discount rate is set above 3%, the project becomes financially undesirable (*see* Figure 16).

When sensitivity analysis was conducted the finding indicated that the net present value of the project is sensitive to the demand for the service as well as the length of time the population takes to connect to the SWRO. Delayed connection beyond 2.5 to 3 years will put the feasibility of the project at risk. It is therefore important to continue to engage the community to enhance the potential for take-up of the service as soon as possible. Additionally, combining the SWRO with renewable energy, in this case the PV system provided greater benefits and hence greater desirability for the project. Another interesting finding is the treatment of the initial investment, if the initial investment is treated as a sunk cost, the project is feasible across all presented scenarios of discount rates and operational and maintenance costs.

Figure 17: PV Panels for SWRO System

Figure 18: Excess Energy for Paget Community

Economic Analysis

Besides the financial analysis, an economic analysis was also conducted, which captured further benefits related to carbon offset and health. The difference in the analyses was that the benefit stream was expanded, even though remaining extremely conservative. Moreover, the consumer surplus or willingness to pay (WTP) was used as an indication of the price at which water should be priced. The

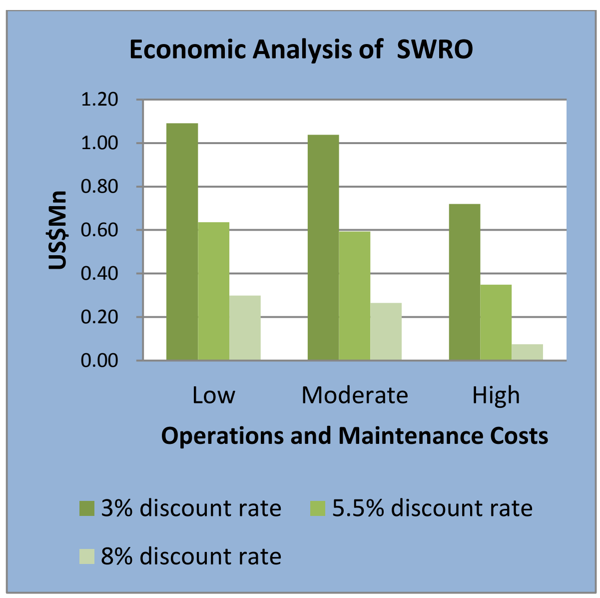


Figure 19: Economic Analysis of SRWOS for Bequia

three (3) operational and maintenance scenarios were once again applied. For all three scenarios it was found that the project would be feasible at the applied discount rates. The greatest net benefit was derived under a low operational and maintenance scenario where it is estimated the project will lead to derivation of benefits valued at between US$0.3million to US$1.1 million over its life (*see* Figure 19).

Summary

The project is feasible based on the assumptions made and the price of water instituted. Under all the scenarios outlined, however, the most practical measure to adopt under the financial analysis may be the ATP scenario (moderate pricing option) as this is a direct indication of what consumers are currently paying for freshwater on the Island.

Under the economic analysis, the willingness to pay was used rather than prices actually paid because many of the project impacts that are to be included in the economic analysis either will be non-marketed, for example, improved freshwater supply and quality. Furthermore, many project impacts that are marketed will be bought and sold in markets where prices are distorted by various government interventions, by macroeconomic policies, or by imperfect competition. This analysis clearly demonstrates the feasibility of the project to the Island of Bequia.

Hybrid Rainwater, Sewerage and Irrigation System for Coconut Bay Resort and Spa

Overview

This section captions an economic assessment, in the form of a cost-benefit analysis, for the hybrid rainwater harvesting, irrigation and sewage recycling facility at the Coconut Bay Resort and Spa property, in Saint Lucia. This project was a collaborative effort between the Special Programme on Adaptation to Climate Change administered by CCCCC (SPACC-southern component) and Coconut Bay Beach Resort and Spa (CBBRAS). The hybrid rainwater harvesting, irrigation and sewage recycling facility is aimed at assisting with the water problems encountered by CBBRAS as well as the surrounding community. These problems include: in the dry time, shortages as a result of depleted water stock at the Water and Sewerage Company Incorporated (WASCO) storage facilities; and during the wet season, high turbidity and clogged systems. It is also aimed at reducing the environmental impact that CBBRAS has on the marine environment. In doing so, this project improved the old treatment plant for wastewater and the freshwater system of the CBBRAS property hence eliminating the released of effluent or 'under-treated' water into the ocean and instead using it for irrigation purposes. This aspect of the project was particularly important to marine life, fisherfolks, sea-based tourism activities and sea-based local recreational activities.

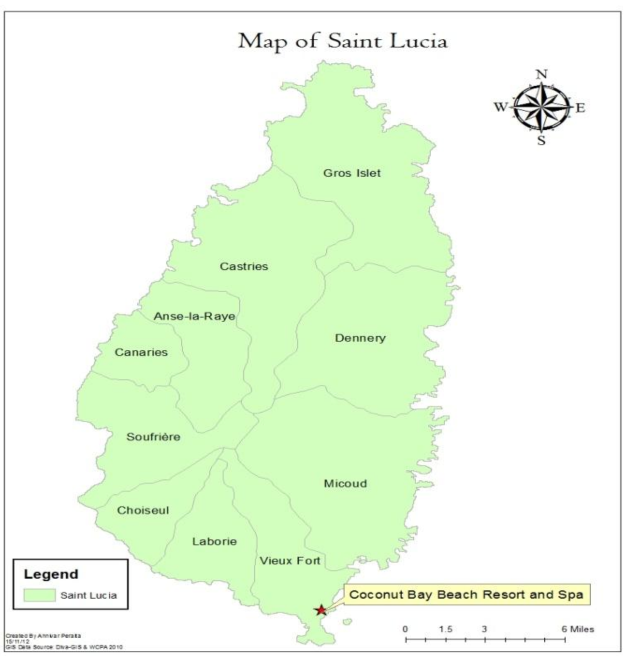


Figure 20: Map of Saint Lucia

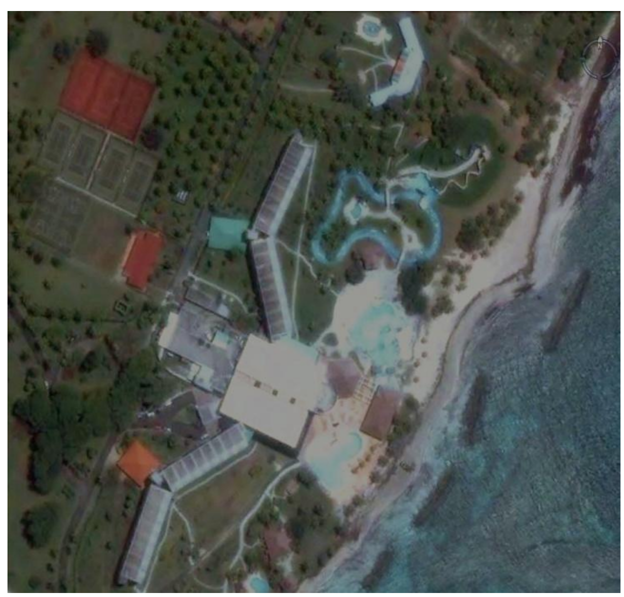


Figure 21: Ariel View of Coconut Beach Bay Resort and Spa

Table 3: Benefits and Costs of Rainwater Harvesting and Waste Water Treatment, CBBRAS

Options	Costs	Benefits
Do nothing	▪ Water Storage in Dry season ▪ High turbidity and clogged water systems in wet season ▪ Environmental Damages to coral reefs	▪ The forgone cost of designing, constructing, maintaining and operating the rain water harvesting system ▪ The forgone cost of retrofitting, maintaining and operating the sewerage treatment and irrigation system.
Implementation of Hybrid Rainwater, Sewerage and Irrigation System	▪ Capital cost of designing and constructing rain water harvesting system and retrofitting the sewerage and irrigation system ▪ Incremental operational and maintenance cost	▪ Mitigate water problems encountered by CBBRAS and the surrounding community. ▪ Reduce the environmental impact that CBBRAS has on the marine environment and, most importantly, the coral reefs. ▪ Health and other social benefits due to greater availability of water. ▪ The project provides a baseline from which replication and policies recommendations can be drawn for incorporation into the operations of other hotels

Main Facts and Assumptions of the Model[16]

- The model assumes a lifespan for the project of 20 years.

Figure22: CBBRAS Swimming Pool

Figure 23: CBBRAS Lazy River

[16] Please see Annex I for a more detail list of the facts and assumptions of the model.

Figure 24: Design of Hybrid Rainwater, Sewerage and Irrigation System

Cost

Initial Capital Expenditure

- The initial investment was US$325,000.

Operational and Maintenance Cost

- The model presents maintenance and operational costs under two scenarios. These are as follows:

Scenario 1

- The maintenance and operational costs are assumed to be a percentage of the initial investment under the following conditions.[17] These are:
    - 10% assumed to be a low cost operational and maintenance cost;
    - 20-30% assumed to be a high cost operational and maintenance cost;
    - 40% assumed to be a high cost operational and maintenance cost.

The above maintenance and operation costs exclude labour and insurance costs.

[17] The Caribbean Environmental Health Institute, (year) suggested in a study titled, 'Financial Assessment for Wastewater Treatment and Disposal (WWTD) in the Caribbean', that where space availability is limited a Small FootPrint (SFP) type system is the preferred option. The study further estimates that the operational and maintenance cost associated with a SFP type system is approximately 30-40% of the cost of the system (Caribbean Environmental, 2008).

Scenario 2

- Expected expenditure is computed for the various maintenance activities associated with both systems (see ***Annex I*** for details).

Insurance

- The Hybrid Rainwater, Sewerage and Irrigation Systems are estimated to increase the insurance premium of the property by 1% collectively. At the time of the evaluation, CBBRAS paid an annual insurance premium of US$548,447.

Labour Cost

- There was one person employed to monitor and maintain the sewerage system. That employee was paid approximately US$800 per month. The analyst assumed that the wastewater treatment plant and rainwater harvesting system will be brought under a single maintenance and monitoring regime and, as such, additional labour will be required. Going forward, the labour force associated with both the rainwater harvesting system and the wastewater management system is expected to consist of:
    - An Engineer (0.2% of the time) **-** paid approximately 20% of US$22,284.64 annually.
    - A Plummer (0.2% of the time) - paid approximately 20% of US$4,269.66 annually.
    - Two full-time monitoring and maintenance personnel, an engineer's assistant and a handyman – paid approximately US$9,438.20 and US$4,269.66 annually respectively.
    - Four labourers - each employed 80 hours per year and paid approximately US$8 per hour. These labourers will help with the disposal of sludge and tank cleaning activities.
    - A security personnel – paid approximately US$500 per month

Figure25: Sand Filter

Benefits

- Using data for the past five years on daily rainfall, it was deduced that the rainwater system could potentially harvest 7.3 million gallons of water per year. However, given the size of the tanks (totalling approximately 25,000 gallons) and the expected daily water consumption of used of 2,000 gallons, the analyst assumed that approximately 3,000 gallons of water will be consumed per day for 360 days per year. This was placed as a benefit derived. This amounted to 1.08 million gallons per year or approximately 15% of potential rainwater to be harvested. This 1.08 million gallons of water is valued at the going rate of EC$22/US$8.15 per 1,000 gallons to hotels for water from WASCO. The water is valued using WASCO going price as this represents the opportunity cost (forgone cost or the avoided cost) of using water from the rainwater harvesting system versus WASCO produced water.
- 190,000 litres of water per day is expected to be made available from the sewerage treatment system, however, the capacity of the recycle catchment tank is 40,000 litres. As such more than 75% of the recycled water will be disposed of. It is assumed that of the total recycled water 60% will reach and replenish the aquifers. This quantity of water is valued at 70% of that which WASCO charges hoteliers for water.

Figure26: Rainwater Harvesting Storage Tank

The captured recycled water will be used for irrigation purposes. According to information gathered from personnel working at the resort the usage of such water will be dependent on the number of rain days and quantity of rain and as such it was suggested that on a non-rain day about 70% of the captured recycled water will be used. According to information garnered from the Saint Lucia's Meteorology Office, the Island over the past five years has averaged approximately 173 non-rain days. The benefit is estimated at 173 non-rain days times 70% of capacity of the catchment/storage tanks valued at the going rate of EC$22/US$8.15 per 1,000 gallons. This current market rate was used for the same reason given above.

- Environmental Benefits – The environmental benefits to be derived are mainly as a result of the replenishing of the aquifers (mentioned above) and the maintained coastal reefs. The benefits associated with the maintenance of the coral reefs include the:
    - avoided loss in revenue from tourists' reef related activities,
    - avoided loss in revenue from reduced fishes caught and landed,
    - avoided loss in beach and sea recreational activities,
    - avoided property damage.

Of the above, the analyst could not put a value on 1-3. This is due primarily to data unavailability. With time and resources a travel cost method may be applied to derive such a benefit.

In valuing the avoided property damage/loss, we utilized estimates from (Burke, Greenhalgh, Prager, & Cooper, 2008). Burke et al (2008) defines vulnerable lands as, any areas that are 5m or less in elevation within 1 km of the coast, and all areas immediately adjacent to the coast (within 25m resolution coastal grid cells), while shoreline segments protected by coral reefs were defined as those within 100 m of a fringing reef, or in bays protected by a reef. Adapting these definitions and studying geological presentations from Burke et al (2008), the approximately 1 mile of beach front property of Coconut Bay Resort was deemed vulnerable. According to Burke et al (2008) approximately a third of all vulnerable lands are protected by reefs. This same ratio was used to estimate the amount of the 1.61km beach front property (1 mile) protected by reefs. The model further assumes that if the resort were, to instead of treating its wastewater, dump its wastewater into the sea immediately in front of the resort, 100% of the reef would be lost within 100 years. Holding the ratio constant at 1% per year, the analyst further assumes that 20% of the reefs will be loss in 20 years (life span of the project).

Note that the value of the reefs is estimated based on the value of CBBRAS vulnerable land protected by reefs. This is believed to be a grossly underestimated value of the reefs and hence the environmental benefit of having this system as it ignores reef-related tourism, fisheries and recreation.

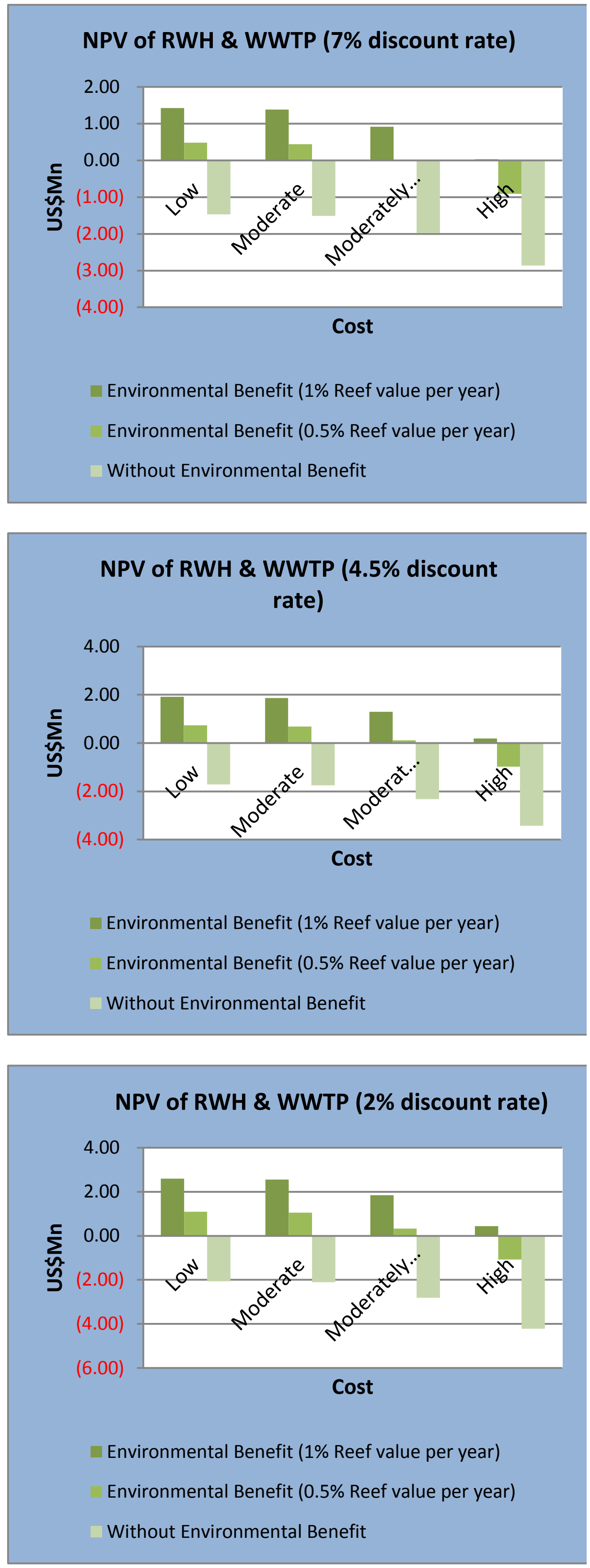
- Social Benefits – there are identified social benefit associated with this project. These include:
  - Reduced Consumption of WASCO-produced Water
  - Health and other social benefits

Results

The NPV of the project and hence our conclusion is sensitive to the system's total expected electricity usage and cost and the value placed on the environmental benefits to be derived from this project.

As the electricity cost increases, and hence the operational and maintenance costs, the project becomes less worthy. The opposite holds true for the environmental benefit to be derived. As environmental benefit reduces the project becomes less worthy. At all discount factors used in this analysis (2%, 4.5% and 7%) and under the different cost scenarios presented the project exhibits a negative NPV value both with and

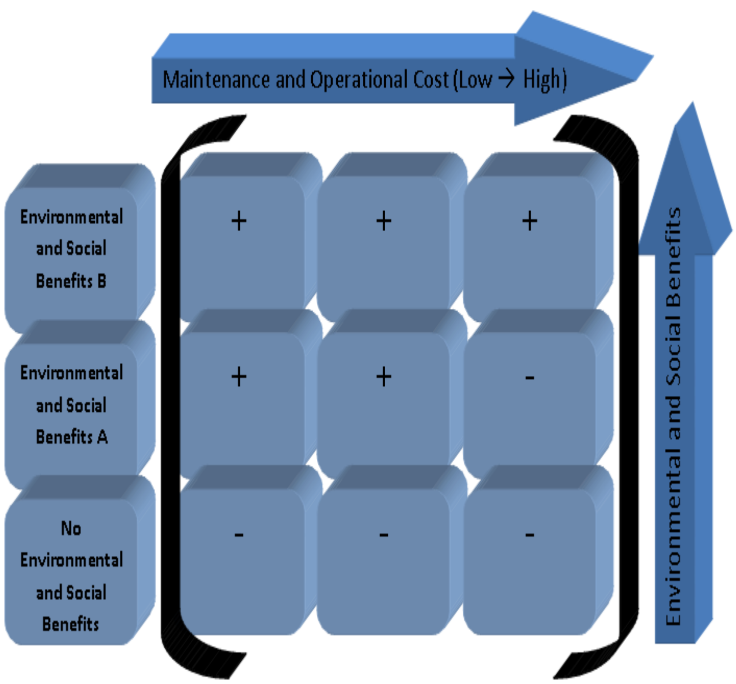
Figure 27: Net Present Value of Rainwater Harvesting and Waste Water Treatment Plant, CARBAS



without initial investment when no environmental benefit is included into the analysis. However, when the economic analysis is conducted and social and environmental benefits are included the project, under some of the cost scenarios is viable. When pure financial (marketable) benefits are considered along with the environmental and social benefits, the findings are that the NPV range from (*see* Figure 27):

- @ 2% discount factor US$1.6 million to US$4.1 million
- @4.5% discount factor US$1.3 million to US$3.2 million
- @7% Discount factor US$1.1 million to US$2.7 million

Figure 28: Evaluating Environmental and Social Benefits vs. Maintenance and Operational Cost



In other words, given the different cost scenarios, the project can be considered worthy if it is believed that the economic, social and environmental benefit, at 2%, 4.5%, or 7% discount factor, is equal to or greater than the lower bound of the range presented above. Figure 28 shows that as the value placed on the environmental benefit increases, the net present value becomes more positive. As stated before several economic, social and environmental benefits were not included in this analysis due to lack of credible and sufficient data which may have indicated a greater feasibility of this intervention.

It follows that from a financial perspective CBBRAS must seek to minimize the cost associated with this system. Despite our analysis suggesting that the project is not worthy financially, CBBRAS might see it differently as some of the cost included in our analysis, such as labour cost, which was based on the cost scenarios ranging from 12% to 33% of annual total cost, which can be looked at as business as usual, there may also have been existing economies of scale and cost saving measures that this analysis does not capture. Furthermore, the intangible benefits such as improved marketing of the entity as an environmentally friendly tourism resort, improved community relations with surrounding residents and reduced health impacts on workers are all areas that the analysis did not capture because of a lack of sufficiently credible information.

Summary

- Electricity cost is very high for CBBRAS and this venture will add to that cost if efficient and environmentally friendly means are not found to power the rainwater harvesting system and the sewage treatment facility.
- The system will alleviate CBBRAS' water woes, hence leaving WASCO to provide great quantities to the surrounding communities.
- The proper treatment of sewage/wastewater is important, in that it helps to protect the coral reefs and replenishes the aquifers. Protection and maintenance of the coral reefs reduces the risk associated with storm surges and hence protects the vulnerable lands of CBBRAS and by extension Saint Lucia. Additionally, the protection and maintenance of the reefs is important to tourism, recreation and fisheries. The replenishment of aquifers allows for greater water availability and security on the island.
- With the exception of Trinidad and Tobago, most of Caribbean Islands, inclusive of Saint Lucia are dependent on imported oil to drive their economic activities. This openness of the region causes the absorption of the movements in the world's oil prices which are further passed on to consumers through the price they pay for electricity. Recent movement in world oil prices have increased the cost of electricity in the region and it is against this background that the analyst suggests the installation of a renewable energy source at this facility, while simultaneously seeking for energy efficient options at the resort. These would be beneficial in reducing the cost of energy and the amount of energy consumed and can enhance the competitiveness of the facility, while at the same time helping with the global goal of mitigating the emission of green house gases. This can become a double dividend for the facility.
- Sludge produced is currently been underutilized as it is disposed of rather than utilized as a by-product or an intermediated good. As it is or after further processing it could be used as manure or in energy production. Workshops with stakeholders could help to alleviate some of the problems associated with waste management and hence maximize the environmental and social benefits of an efficiently 'Green Society'.

- As a general rule, the implementation of adaptation strategies across the Caribbean region must operate efficiently for the maximum benefit to be derived. At CBBRAS the efficient use of rainwater harvested and wastewater recycled is important to the success of the project. As an aside, where the pools, water slides and irrigation systems do not utilize all the harvested rainwater and recycled water, avenues should be sought to ensure the rainwater and recycled water are efficiently utilized. This could include selling the excess to WASCO or through social responsibility sharing with neighbour communities as the scale economies derived are likely to outweigh the cost of doing so.

Strengthened Critical Infrastructure in the Castries Area: Retrofitting the Marchand Community Centre

Overview

This section elaborates an economic assessment, in the form of a BCA, for the Marchand Community Centre in Castries, Saint Lucia. Under the SPACC Programme the Marchand Community Centre was retrofitted to mainly withstand categories 4 and 5 hurricanes. This retrofit came against the background that climate change will cause increased intensity in hurricanes and as such the need to develop and adapt new and effective building codes. The design for the retrofitted Marchand Community Centre was informed by the International Code Council (ICC), who engineered based on the probability of hurricane intensity a new building code. This new design is to become standard for St. Lucia. With the new design and the vision of the Government of Saint Lucia, the Marchand Community Centre, which will act as a shelter in the event of a hurricane, will be expected to withstand hurricane winds of the intensity identified above. Additional features of the centre are:

- Rainwater harvesting and water storage capabilities,
- Water conservation technologies,
- Photovoltaic\solar panels technology for energy generation, and
- Food and emergency items storage,

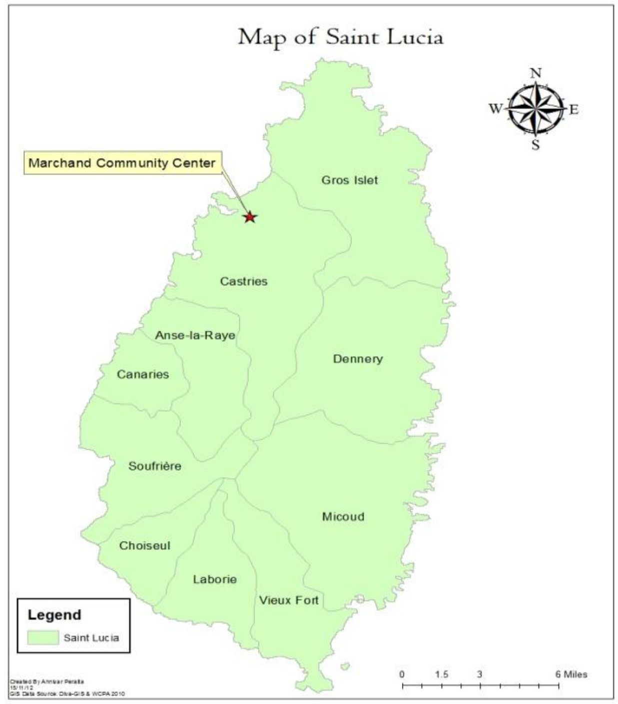


Figure 29: Map of Saint Lucia

Figure 30: Marchand Community Centre

As was set out in the Project Concept Note, the ultimate goal of the project is to give due recognition of the anticipated impacts of climate change, specifically increased severity of hurricanes, is the institution of revised design hurricane wind speed standards to facilitate enhanced designing, construction and retrofitting in Saint Lucia, for public and commercial buildings in the first instance.

Figure 31: Marchand Community Centre Dilapidated Roof

Figure 32: Deteriorated Walls of the Marchand Community Centre

Table 4: Costs and Benefits of Retrofitting the Marchand Community Centre, St. Lucia

Options	Costs	Benefits
Do nothing	▪ No emergency shelter ▪ Lose of Lives due to tropical cyclones ▪ The continued dilapidation of the community centre, which hinder recreational activities ▪ Substandard building code	▪ The forgone/avoided cost of designing, retrofitting, equipping and maintaining the community centre
Implementation of Hybrid Rainwater, Sewerage and Irrigation System	▪ Capital cost of designing and retrofitting the Community Centre ▪ Outfitting the Centre with a rain water harvesting system and Photovoltaic\solar panels technology ▪ Incremental maintenance cost	▪ Revised design hurricane wind speed standards to facilitate enhanced designing, construction and retrofitting in St. Lucia. ▪ Health, mortality and other social benefits due to the implementation of a emergency centre which in case of emergency will have electricity and water available. ▪ The project provides a baseline from which replication and policies recommendations can be drawn for incorporation into the building codes of other building in the Caribbean.

Main Facts and Assumptions of the Model[18]

Cost

- The initial cost to retrofit the centre was US$768,269.
- The model assumes a lifespan for the project of 20 years.
- Maintenance and replacement cost is assumed to be:
  - 1% under the low cost maintenance scenario
  - 3% under the moderate cost maintenance scenario
  - 5% under the high cost maintenance scenario.
- An additional scenario (identified maintenance cost) is provided where values are estimated for expected maintenance activities such as painting, roof checks and repairs and other provisional expenditure associated with the maintenance of the building.
  - Painting is assumed to be done every five (5) years
  - Roof checks and minor repair is assumed to be done annually
  - Replacement cost related to door, windows, among other things to be done every three (3) years, starting in year three (3).
- Electricity usage is estimated at 2,000KWH per month valued at US$657.
- The average cost of monthly water service to the Community Centre is approximately EC$350/US$130 per month. Using the government's rate of EC$14/US$5.19 per 1,000 gallons, it is estimated that the Centre uses 25,000 gallons per month which is about 300,000 gallons per year. Given that retrofitting the Centre entails the installation of a rainwater harvesting system, it is estimated that the Centre will consume approximately 272,000 gallons per year from WASCO and the additional 28,000 gallons per year from the rainwater harvesting system.

Benefits

- It is estimated that Saint Lucia is affected by a significant hurricane every 3.1 years[19] and suffers a direct hit on average every 11.58 years[20] (Hurricane City, 2011). In 2010, Hurricane Tomas, a category two hurricane, killed 8 people and Hurricane Dean in 2007, a category two hurricane,

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[18] Please see Annex I for a more detail list of the facts and assumptions of the model.
[19] National Emergency Management Organization (2010)
[20] Source: Hurricane City , 2011. Retrieved on September 30, 2011, from: http://www.hurricanecity.com/city/saintlucia.htm.

killed one person. More recently, a topical depression that brought unprecedented precipitation in a 24 hour period on December 24, 2013 killed at least 5 persons on the island. The most number of persons killed in Saint Lucia by a hurricane/tropical storm is 45. This occurred in 1988 when tropical storm Gilbert passed over the island. Hurricane Allen, the only noted category four hurricane to hit Saint Lucia in 1980 claimed the lives of 18 persons.

- The installation of the PV system will result in, revenue from that sale of electricity generated and supplied to the grid; and the avoidance of greater CO_2 emission in the production of electricity. It is estimated that the PV system would generate on average 1,869KWH per month. This is valued at 70% of the market value of a unit of electricity in Saint Lucia.


Figure 33: Rehabilitated and Retrofitted Marchand Community Centre with PV System Installed

- The benefit of housing and storage is estimated as the cost forgone in renting that space. The average cost for renting commercial space in and around the Castries area is approximately EC$2.10 per square foot monthly[21]. Of an approximate total of 3,660 square feet for both the ground and first floor, NEMO occupies approximately 1150 square feet of the ground floor, excluding storage and warehouse capacity; the Boxing Gym occupies about a quarter of the 980 square feet auditorium; and the storage and warehouse areas total approximately 670 square feet. It was further assumed that the Community Centre will host 20 community activities per year at a cost of EC$0.7 per square foot to rent the auditorium per event.

[21] As quoted by the National Development Corporation, St. Lucia.

- The potential rainwater harvested is estimated using the noted fact that 1 inch of rainfall on a 1 square foot surface area is equal to 0.624 gallons. The roof area of the Marchand Community Centre is approximately 2196.55 square feet and annual average rainfall for the period 2001-2010 for the Castries area[22] was determined to be 1,917.4 millimetre (75.49 inches). This approximates to 103,470 gallons of potential rainwater per year. The Centre is equipped with a plastic 800 gallons tank for harvesting rainwater. It is, therefore, not expected that the Centre will efficiently harvest and utilize all the rainwater. It is assumed that the Centre will utilize less than a third of the potential rainfall per year. In other words, the tank is expected to be 'cycled' (used and refilled) about 40 times per year at 700 gallons per 'cycle'. This amounts to 28,000 gallons per year and is valued at the going water rate per gallon to government building charged by WASCO. Note that this does not account for the welfare gain of having water in times of water shortage especially those caused by natural disasters.

- The new building code developed and adapted for this project will also have far-reaching benefits. According to the damage assessment reports for Saint Lucia in relation to category 2 Hurricane Dean, 2007, and category 2 Hurricane Tomas, 2010, damages to houses, schools and hospitals totalled approximately EC$3 million/US$1.11 million and EC$190 million/US$70.4 million respectively. For this analysis, we used 50% of the estimated cost for damages associated with Hurricane Dean to value the avoided loss in building infrastructure after a hurricane if the new building code is adapted by schools, hospitals, other public buildings, businesses and private individuals.

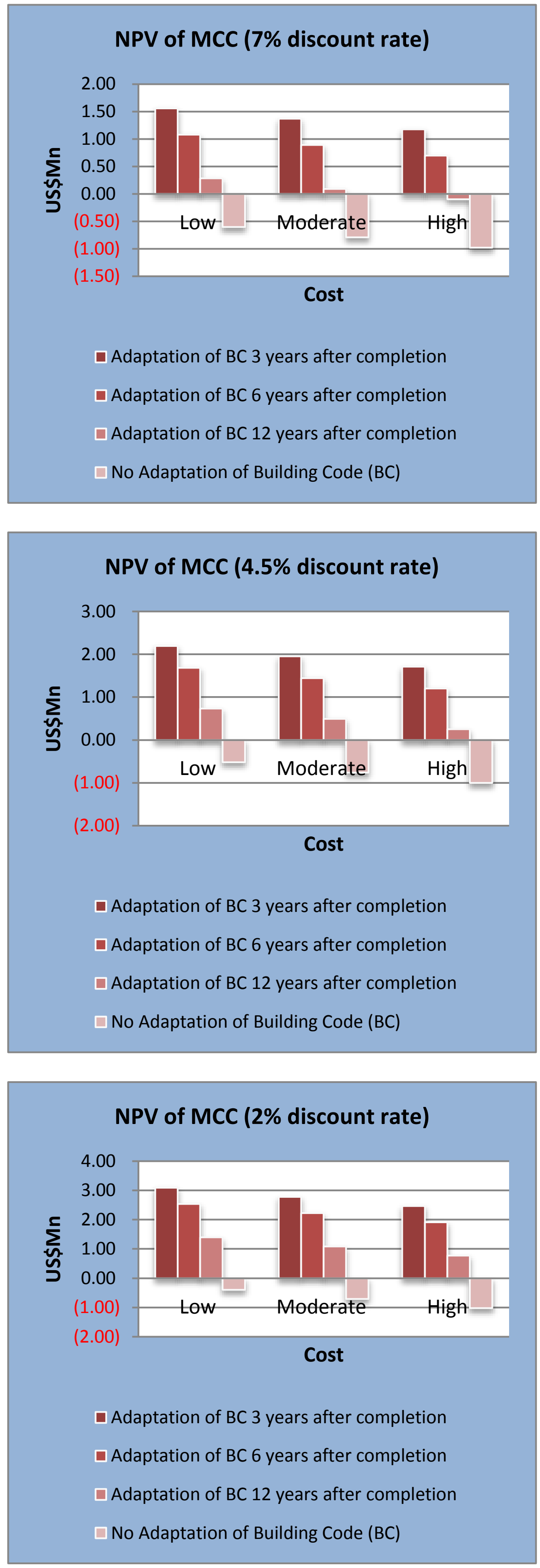
  The realized benefit associated with the adaptation of the new building code is presented in four scenarios. These are that the benefits will be realized every three years starting in year 3, year 6, year 12 and none at all. Note that this estimate grossly underestimates the value of the newly developed building code as it ignores the multiplier effects associated with the injection of money each year into the economy as well as the positive externality associated with the improved aesthetics.

[22] As proxy by the data captured at George F L Charles Airport.

Results

The initial investment for the project was US$0.786 million. Using a discount rate of 7%, maintenance cost of 1%, 3% and 5% of the investment cost, and assuming that the benefits associated with the new building codes begins in year 3, the NPV of the project was estimated at US$1.56 million, US$1.37 million and US$1.18 million respectively under the various maintenance regimes identified above. If the benefits from the improved building code are realized six years after the completion of the project, the NPV of the project at maintenance cost of 1%, 3%, and 5% of initial investment was estimate at US$1.08 million, US$0.89 million and US$0.70 million respectively. If no value is given to the benefits to be derived from the improvement in the building code, the NPV of the project would be negative at all maintenance cost (*see* Figure 35).

Figure 34: Net Present Value of Retrofitting the Marchand Community Centre



Using a discount rate of 4.5%, maintenance cost of 1%, 3% and 5% and assuming that the benefits associated with the new building codes begin in year 3, the NPV of the project was estimated at US$2.2 million, US$2.0 million and US$1.71 million respectively. If the benefits from the improved building codes are realized six years after the completion of the project, the NPV of the project at maintenance costs of 1%, 3%, and 5% of initial investment was estimated at US$1.68 million, US$1.44 million and US$1.2 million respectively. If no value is given to the benefits to be derived from the improvement in the building code, the NPV of the project would be negative at all maintenance cost (*see* Figure 35).

Using a discount rate of 2%, and maintenance cost of 1%, 3% and 5% and assuming that the benefits associated with the new building codes begin in year 3, the NPV of the project was estimated at US$3.09 million, US$2.78 million and US$2.47 million respectively. If the benefits from the improved building codes are realized six years after the completion of the project, the NPV of the project at maintenance cost of 1%, 3%, and 5% of initial investment was estimated at US$2.54 million, US$2.22 million and US$1.91 million respectively. If no value is given to the benefits to be derived from the improvement in the building code, the NPV of the project would be negative under all maintenance cost scenarios (*see* Figure 35).

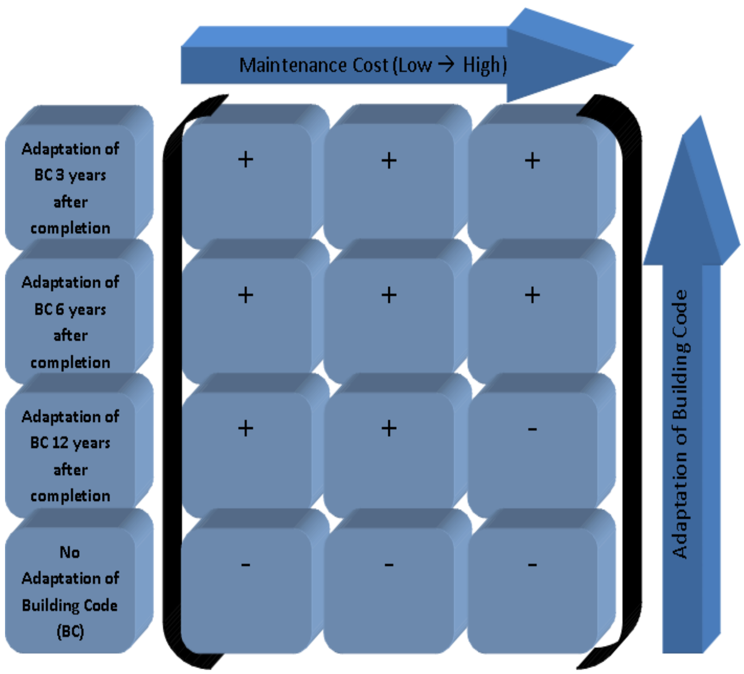


Figure 35: Adaptation of Building Code Vs. Maintenance Cost

Across all discount rates presented above, i.e. 2%, 4.5% and 7%, if the initial investment of retrofitting the Community Centre is treated as a sunk cost the NPV of the project is positive for low to medium maintenance cost scenarios.

Summary

This BCA uses a simple market based technique to evaluate the benefits and costs associated with the Marchand Community Centre and in some instances overestimated the costs and underestimated the benefits. Nonetheless, this analysis provides some very important insights into the worthiness of the venture. The NPV of the project is sensitive to the maintenance cost of the Community Centre as well as the value placed on the aesthetics, design and building code of the building.

For this venture to be worthwhile the cost associated with the Community Centre must be minimized and at the same time ensuring that it meets the objectives for which it was intended, which includes being able to withstand categories four to five hurricane winds and act as a safe haven and a temporary home for the surrounding population in the event of a natural disaster.

Another important finding is that the NPV of the project is dependent on the value given to the design of the Centre and the time taken to adapt the design. It is, therefore, imperative that the building code is adapted by private individuals, businesses, schools and other public buildings, and enforced by the relevant authorities. To ‘fast-track’ the process policy-makers should spend as little time as possible deliberating over the new building code and instead institute such a building code into law.

The Development and Implementation of Management Plans for The Commonwealth of Dominica's National Parks: Morne Trois Pitons National Park and Morne Diaboltin National Park[23]

Overview

This section of the manual captures the economic assessment, in the form of a BCA conducted for the development and implementation of Management Plans for the Morne Trois Pitons National Park and Morne Diaboltin National Park, in the Commonwealth of Dominica. The development of the management plans for these two national parks was funded under the Special Programme on Adaptation to Climate Change (SPACC-southern component) along with other initiatives by the CCCCC, such as assistance under supplementary projects from the Hellenic Republic of Greece and the Australian Agency for International Development (AusAID). The two parks are characterized by their ecological biodiversity with rare and unique natural features, a variety of natural attractions and a number of watershed areas and domestic water catchments. These features make the parks very important to The Commonwealth of Dominica's tourism industry, population and economy. It is also essential for the creation of 'environmental balance' on the island.

An aspect of the management plans included the proposal to manage the potential impact of climate change on the national parks. There has been no scientific studies on and or management strategies to deal with the impact of climate change on the parks and as such the Caribbean Community Climate Change Centre and the government of the Commonwealth of Dominican Government saw the importance of putting in place facilities, Programmes and equipment necessary to conduct such an assessment and hence minimize the potential impact of climate change on the national parks. Their objectives include (MDNP, 2011):

- Understanding the impact of climate change on the parks and sensitize policy makers, communities and other stakeholders.

[23] Only the development of the management plans and some implementation aspects were funded under SPACC. The analyst felt that to get a holistic BCA, it was important to not only consider the development of the management plans but also take on the implementation and recommendations as put forward in the management plans.

- Working with all stakeholders to undertake research and monitoring and to develop and implement adaptation measures to increase the resilience of the parks to the impact of climate change.
- Increasing the resilience of the parks by reducing non-climatic sources of stress, redesigning boundaries and buffer zones to facilitate migration of species and reducing carbon footprint.
- Undertaking ex-situ research to maintain the genome of endemic and indicator species of the parks.
- Collaborating, co-operating and sharing best practises and knowledge.

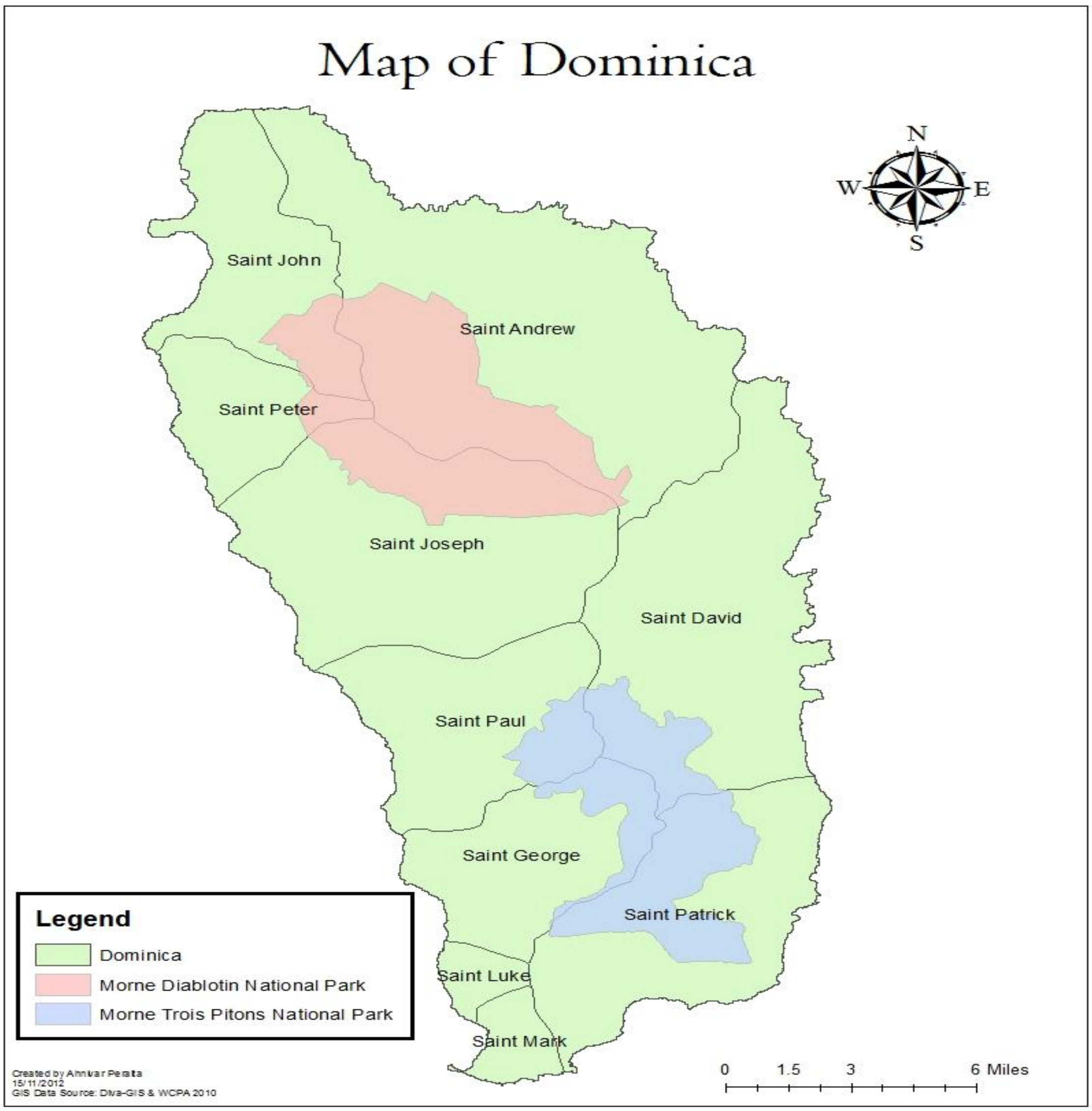


Figure 36: Map of The Commonwealth of Dominica with two (2) Protected Areas

According to the management plans, the following guiding principles are recommended for managing the impact of climate change on the national parks (MDNP, 2011):

- Utilization of available scientific information and traditional knowledge in the decision making process
- Assessment of impacts through appropriate research, monitoring, vulnerability assessment and risk preparedness measures
- Building of public support through the establishment of partnerships with policy markers, the landowners, farmers, communities and other stakeholders in the development and implementation of Programmes to manage the impact of climate change
- Minimizing the impact on the gene pool, on species and their diverse habitat
- Increasing the resilience of sits by reducing non-climatic sources of stress
- Undertaking capacity building, research and sharing of information
- Developing successful and appropriate management responses to include climate change vulnerability analysis, risk assessment and preparedness and adaption management strategies
- Developing and implementing best practises and sharing this information with management partners and key stakeholders.

Major Proposals for the Management of the National Parks

The following activities were identified as critical to the management and development of the national parks[24].

- Demarcation of Boundaries
- Establishment of Buffer Zone
- Establishment and demarcation of zoning plan
- Public/Visitor use Programme
- Infrastructure Design and Implementation
- Development of a Surveillance and Enforcement Programme
- Institutional Development
- Research and Monitoring
- Community, Education and Public Awareness

[24] For great detail on each activity see MTPNP, 2011.

Besides the implementation of the above, the proposal was also made for the management unit, which is currently an arm of the Forest and Wildlife Division, to be an independent entity that is self-sustained. Currently, the National Parks Unit is funded by the budgetary allocation made to it by the Commonwealth of Dominican Government annually. The operations of the parks on the other hand are however funded by the revenue generated by the parks. The management plans identified these sources of revenue as:

- User fees
- Tour operators annual license fee
- Vendors' annual license fee
- Researchers/media personal permits
- Animal impounding fee
- Park fines

Revenue and Cost Estimates

The management plans present estimates of the costs associated with implementing and maintaining the activities listed above over a five year period as well as potential revenue over the same five year. For the purpose of this BCA the same costs and revenues estimates were used but projected beyond five years. All capital expenditure is limited to the first five years of the project, however, the maintenance costs is extended up to 50 years.

Main Facts and Assumptions of the Model[25]

- The model assumes a lifespan for the project of 50 years.
- All dollars are quoted in US$ and inflation is assumed to be 2.17%. This is the average inflation rate for The Commonwealth of Dominica for the period 2001-2010.
- An exchange rate of US$1: EC$2.7 is used in this model

Cost

- The cost to develop the management plans and implement such a plan over five years is as follow[26]:

[25] Please see Annex I for a more detail list of the facts and assumptions of the model.

- Research and Development
  - Year 0 – US$90,800 (SPACC)[27]
- Implementation
  - Year 1 – US$313,781
  - Year 2 – US$236,013
  - Year 3 – US$62,584
  - Year 4 – US$19,790
  - Years 5 –US$12,107

- **National Park Unit/Authority** - It was expected that National Park Unit will become an independent entity with the responsibility to manage and protect the national parks and other protected areas in The Commonwealth of Dominica. For this model, the analyst assumes that the cost associated with the operations of the independent unit will be equal to the budgetary expenditure of US$0.677 million for the fiscal year 2009/2010 adjusted for inflation[28]. This expenditure includes both direct and indirect spending by the National Parks Unit. Direct spending was identified and calculated as the sum of: salaries, travelling allowance, commuted mileage, social security contribution, vendors' commission and park warden uniform. Indirect spending includes: personnel emoluments, wages (causal labour), non-salaried allowances, travel and subsistence allowances, training, supplies and materials, operational and maintenance services, rental of assets, professional and consultancy services, insurance, sundry expenses, ticket printing and other machinery and equipment.

- **Morne Trois Pitons National Park –** Table 5 details the budgetary allocation to the different components as set out in the management plan for five years[29]. The budget below excludes the recommended additional labour needed for MTPNP. The management plan indicated that the staff should be expanded to include:
  - Warden (2)

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[26] These estimates are based on those seen as capital expenditure presented by the consultant in the management plans.
[27] This figure is underestimated as this represents monies paid by CCCCC under SPACC, however, there were other consultancy (research) carried out besides those by CCCCC, which lead to the development of the management plans and their implementation.
[28] The assumption is that the increase in expenditure to the unit will be as result of the implementation of the Management Plans for each park which are budgeted for below.
[29] For greater details of the budgetary allocation see the MTPNP Management Plan, 2011.

- Human Resource and Training Officer (1)
- Public Awareness Officer (1)
- Maintenance Manager (1)
- Financial and Accounting Officer (1)
- Research Officer (1)

Wage information was garnered for the above and included in the BCA.

Table 5: Summary budget for the Implementation of Management Plan for PTPNP

Summary by budget category						
Budget Category	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Subtotal**
Personnel						
Staff Training	60,000	60,000	75,000	75,000	60,000	330,000
Boundary Marking Programme	180,000	100,000	80,000	20,000	20,000	400,000
Zoning Programme	60,000	-	90,000	90,000	50,000	290,000
Visitor Use Programmeme	-	70,000	-	-	-	70,000
Infrastructure Design and Implementation	110,000	55,000	55,000	65,000	55,000	345,000
Legislation and Regulations	-	5, 000	-	-	-	5,000
Scientific Research and Monitoring	62,423	116,000	32,000	20,000	36,000	239,423
Monitoring	30,000	30,000	35,000	32,000	41,000	168,000
Surveillance and Enforcement	10,000	10,000	10,000	10,000	10,000	50,000
Communication, Education and Public Awareness	80,000	80,000	80,000	80,000	80,000	400,000
Community Outreach and Livelihood Development Programmeme	40,000	40,000	40,000	40,000	40,000	200,000
Other Operating Expenses	18,000	18,900	19,800	20,800	21,800	99,300
BUDGET CATEGORY TOTALS	**550,423**	**584.9,900**	**516,800**	**542,800**	**413,800**	**2,594,723**

Source: MTPNP Management Plan, 2011.

- **Morne Diaboltin National Park -** The estimates included in the management plan for MDNP were dated 2009-2014. No capital expenditure was estimated before 2012 and as such the analyst decided to use the 2012-2014 estimates. The estimated cost before 2012 were recurrent expenditure such as wages, training, fuel, maintenance and insurance. These were also accounted for beyond 2012.

  The capital expenditure for this park includes: observation platform and construction of Type A, B and C trails. Expenditure on managing the impact of climate change in this park is estimated to cost approximately US$45,361.

Currently, there is no one employed full-time and directly to this park, however, with the implementation of the plan it is expected that the park will require:

- Park Manager (Part-time)
- Technical Officer (1)
- Ranger (Forester 1)
- Guard (2)
- Warden (1)
- Accounts Clerk (1)
- Driver (1)

- **Meteorological Unit-** the implementation and operational and maintenance cost to the Meteorological Unit, which will be an arm of the park authority, is mainly associated with the purchase of equipment, maintenance of those equipment and labour. The cost for equipment is budgeted at US$34,700 as is provisioned by CCCCC. The maintenance of the equipment is accommodated under the budget for each park. The model assumes that the Unit will need a Technical Officer whose duties will include but not limited to research, data compilation and dissemination, maintenance, and monitoring. The model further assumes that 20% of a Forester's time will be required to conduct field checks on the equipment.

Benefits

Financial Benefit

- Revenue is expected to be generated from the sources listed below in Table 6.

Table 6: Sources of Revenue for the National Parks

No	Revenue Source	Amount
1	Site/Attractions User Fees	US$3.00 for organized tours US$5.00 for private tours US$12.00 for a week pass
2	Tour Operators' Annual License Fee	Not stated
3	Vendors' Annual License Fee	EC$100
4	Tour Guide Annual License Fee	Not stated
5	Researchers/Media Personnel Permits	Not stated
6	Animal Impounding Fee	From $100 to $250
7	Park Fines (penalties for offences)	Fines up to $350

Source: National Park Unit, The Commonwealth of Dominica.

Of the above identified sources of revenue, we were only able to ascertain data on revenue generated from user fees and vendors' annual licensing fees.

The revenue stream was presented in scenarios. With limited data available, the analyst was left to examine revenue based on expected increases in revenue over the fifty year period. The revenue scenarios are: 1%, 3%, 4% and 5% increase in revenue year on year for fifty years. An additional scenario of 2.17%, which is the average inflation rate over the past ten years in The Commonwealth of Dominica, is also presented.

Economic and Social Benefits

Carbon Sink – The parks are carbon sinks.
Shan et al, 2001 and Nabuurs et al, 1995 examined the storage capacity of carbon per acre of pine and fir forests for one year respectively. Shan et al 2001 estimated and concluded that pine forests store approximately 1.24 metric ton of carbon per acre per year, whereas, Nabuurs et al 1995, estimated and concluded that fir forests store approximately 1.32 metric ton of carbon per acre per year. The US-EPA used the results of these two reports and concludes that, t*he average of these two values is 1.28 metric tons of C per acre per year, which corresponds to 4.69 metric tons of CO_2 per acre of pine or fir forests.*

Using the above estimates and the fact that the MTNP is approximately 17,000 acres and the MBNP is approximately 8,425 acres; the CO_2 capture by these parks per year is approximately 79,730 and 39,513 metric ton respectively. These quantities are valued at US$21 per tonne, which is the estimated US 'Social Cost of Carbon' (Bell & Callan, 2011).

- Water shed/catchment – the parks hold some of The Commonwealth of Dominica's most valuable watershed. These are essential in providing water to the public as such valuing this benefit is also important. The management plans convey that on an ongoing basis research must be conducted to help authorities manage the resources of the parks. In the case of the watersheds further research is needed to develop watershed management techniques in the parks as the parks contain the headwaters of most of the major streams and rivers in the southern half of the island and provides potable water to approximately 60% of The Commonwealth of Dominica's population. The watersheds are also important to the production of hydroelectricity. The Commonwealth of Dominica Electricity Company Ltd (DOMLEC). This company currently operates three (3) hydro-stations on the Roseau River Watershed and produce on average 27gwh annually which constitutes approximately 30% of their total production.

Against the background of watershed and water-catchment management, the management plans suggest that to mitigate any future impacts of climate change it is essential that there is greater management of the watersheds and the continued preservation of the water catchment areas in the park.

- For this BCA analysis, the watershed and catchment areas are value based on their current domestic use. That is, the benefits to the population in terms of water supply. The implementation of the management plan will mitigate contamination of the water supply and the preservation of its worth to the society. The non-implementation of this plan could result in the contamination of watersheds and the depletion of water catchments areas as well as the ripple effect of further damage to the ecosystem.

- The Dominican Water and Sewerage Company (DOWASCO) indicated that it withdraws approximately 7.3 million cubic meters of water annually from the parks, 1 million cubic meters from MDNP and 6.3 million cubic meters from MTPNP. Using the established rule that 1 cubic meter of water is 264.17 metric gallons, the 6.3 million cubic meters is converted to gallons and valued at 50% of the average price of EC$11.85/US$4.39 charged to domestic, commercial and industrial users.

  Note that the use of the watersheds in the production of electricity was not valued and included as the production of hydroelectricity is not heavily dependent on whether the water is contaminated or not but on the rate at which the river flows.

- Other benefits identified but not yet valued and entered into this analysis[30]:
  - Indirect employment creation – the parks employ persons such as the vendors indirectly as such a measure of the indirect employment created could help to capture the importance of the park in the creation income for families and to some extent the multiplier effect of the operations of the park.
  - Local (The Commonwealth of Dominicans) recreation/visitation – Locals do not pay to visit the park, however, the fact that they visit is a signal that there is utility to be derived from having the park at their disposal.

[30] Efforts are still on the way to value these economic, environment and social benefits.

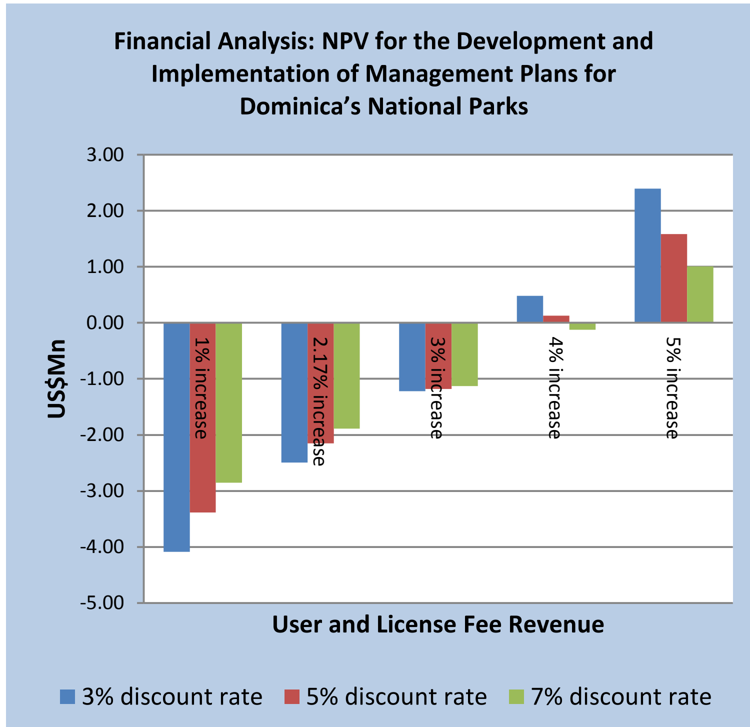
- Potential avoided damage – The installation of the met instruments will help the park managers to be better informed about the climatic conditions in the park and hence mitigate flooding, landslides and forest fires.

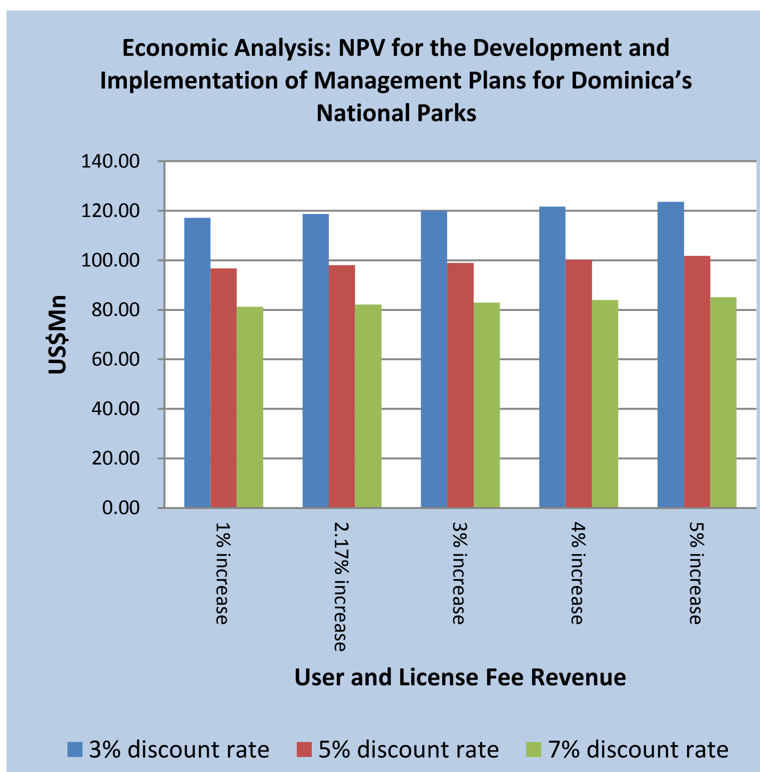
Results

Our findings suggest that from an economic perspective the implementation of the recommended management plans is desirable; however, from a financial perspective the average growth rate of revenue over fifty years for the parks will determine whether it was a worthy financial investment.

Using a discount rate of 7%, and assuming revenue will grow on average between 1-5% per year over fifty years the net present cumulative value from a financial perspective over fifty years is between -US$2.9 million and US$1.0 million. In fact, for the project to be feasible financially revenue must grow, in nominal terms, marginally below 5% year on year. On the contrary, from an economic perspective, that is if revenue grows between 1-5% and the parks' tree stock are valued as carbon sinks and their water supply valued, then the implementation of the management

Figure 37: Financial and Economic Analysis





plans are desirable. From an economic outlook the net cumulative benefits over fifty years, ranges from US$81.2 million to US$85.1 million. At a discount rate of 5%, the financial outlook over fifty years is similar to that at 7%. The net present cumulative value from a financial perspective is between -US$3.4 million and US$1.6 million. From an economic perspective the net cumulative benefits over fifty years ranges from US$96.8 million to US$101.8 million (*see* Figure 37).

At a discount rate of 3%, the net present cumulative value from a financial outlook over fifty years is between –US$4.1 million and US$2.4 million and from an economic outlook the net cumulative benefits over fifty years ranges from US$117.2 million to U$123.6 million.

If the cost associated with research and development and the implementation of the project is treated as a sunk cost the financial outlook over the fifty year improves slightly. That is, it would require revenue growth of on average 4% year on year (marginally below 4%) to cover the annual overhead cost associated the parks. It is important to note that the model assumed that cost would increase by 2.17% (inflation rate), therefore, if the cost associated with research and development and the implementation of the project is treated as a sunk cost, holding all other things constant, revenue must grow in real terms by no less than 1.83% for the project to be financially feasible. Otherwise revenue must increase in real terms by 2.83%.

Summary

- Economically, environmentally and socially the implementation of the recommend management plans will be beneficial to The Commonwealth of Dominica.
- The financial health of the parks will be dependent on how well the management can maximize revenue and minimize cost. Based on the finding of this analysis, revenue increase of on average 5% year on year would be sufficient to cover the implementation, operational and maintenance cost per year. The management plan has detailed ways in which this growth in revenue can be achieved.
- Increasing the park’s value as a carbon sink by maintaining and or increasing its tree density will benefit The Commonwealth of Dominica as the global carbon emission trade emerges.
- Majority of the water that is fed to households comes from within the parks; therefore it is imperative to balance visitors’ recreation and other park related activities and the maintenance of the watersheds.

Conclusions and Lessons Learnt

The Special Programme on Adaptation to Climate Change (SPACC), funded by the World Bank and administered by the Caribbean Community Climate Change Centre (CCCCC) developed and implemented four (4) pilot projects in three (3) Caribbean islands that could be considered small island developing states. These were namely, Saint Lucia, The Commonwealth of Dominica and Saint Vincent and the Grenadines. These countries were selected due to their projected climatic vulnerability in the region, conservation value and present climate change policies. These pilot projects were developed with the involvement of stakeholders in the selected islands and implemented by the CCCCC. Before implementation of the projects, BCA analyses were done to appraise the project's feasibility to the islands, and, by extension the region.

This document highlights how BCA was used to appraise the projects under SPACC and further advance the region's adaptation and mitigation efforts. It also identified other tools/methodologies that could be used in the decision making process. Despite some data challenges and other limitations, using best practises, BCAs were used to analyse the feasibility of the adaptation interventions from a financial and economic perspective.

The adaptation interventions under SPACC provided a wide cross-section of benefits at the local, national and regional levels. These benefits were preservation of biodiversity, land preservation, greater water resources management and the reduction of carbon dioxide (CO_2) emissions. Overall the pilot islands are now better equipped to deal with to some extent the negative effects of climate change. SPACC also forged partnerships and cooperation within the region, between governments and the private sector, as well as internationally, between governments, NGOs and donor agencies. These interactions allowed for national dialog and policy re-formulation. The Commonwealth of Dominica's National Parks Plans and their surrounding communities benefited through the information and monitoring capabilities developed under SPACC. Water resource management, infrastructure retrofitting to prepare against hurricanes and coastal protection are three areas in which Saint Lucia benefited. After the retrofitted Marchand Building was completed, the Government moved to amend the building codes on the island. Similarly, with the erection of the Coconut Bay Beach Resort and Spa (CBBRAS) government instituted a technology standard that indicated that all new hospitality facilities must implement similar technologies to reduce water consumption and increase water efficiency.

In Saint Vincent and the Grenadines, the Island identified as one of 36 most water scarce islands on the planet by the World Resources Institute (WRI, 2013), now benefits from a SWRO plant that is powered by photovoltaic panels. This system has reduced the island of Bequia's in the Grenadines dependence on rainwater and water being barged in from Saint Vincent during the dry season. It has therefore enhanced the water security on the island both in terms of quantity and water quality.

The lessons learnt under SPACC from these pilots are making it easier to replicate these projects in similar countries and small islands such as those of the Eastern Caribbean and Pacific Islands. Some of the lessons learnt are:

- Economic development is a central element of adaptation to climate variability and change, but it should not be business as usual. From this perspective therefore, and to encourage the sustainability of the intervention after the life of the funding source would have expired, it is essential to involve the communities from the project conception stage. In a region suffering with limited historical data[31], local knowledge and inputs into project design can make the difference between project failure or success.
- Data collection and management from these types of initiatives are critical if they are to be replicated. At the same time, these pilots pointed to the fact that the region needs to continue to invest in improved data management and early warning systems, enforce building codes, invest in human capital, develop competent and flexible institutions, and tackle the root causes of poverty.
- Adaptation tends to be most feasible and effective where it is complemented by mitigation efforts. This was demonstrated in at least three of the adaptation pilots. For a region that spends between 40% and 60% of its export earnings on purchasing fossil fuel to drive its economic development, move towards renewable energy consumption can be seen as a long hanging fruit.
- Adaptation to climate change should start with the adoption of measures that tackle the weather risks that countries or islands already face, for example, more investment in water capture and storage in drought-prone basins, or improved water efficiency, or protection

[31] While it is true that climate change is likely to bring changes never seen before, the historical data can provide some perspective that should not be ignored in the absence of more credible information.

against storms and flooding in coastal zones and/or urban areas. Climate change will exacerbate these risks. It is therefore important to develop a risk ethic.

- Hard and soft approaches to adaptation are two sides of the same coin. Good policies, planning, and institutions are essential to ensure that more capital-intensive measures are used in the right circumstances and yield the expected benefits.

- To get the private sector engaged it is essential to calculate an adaptation business case, including an investment plan. Creating the right incentives and economic benefits can increase the involvement of the private sector as service providers and investors in some limited cases. It was clear that unless the private sector receives concessional loans they will be slow in pursuing adaptation initiatives.

- Given that adaptation to climate change is largely a public good, the initiatives are most feasible (or sometimes only feasible) where the investment cost is excluded from the analysis. This therefore indicates that such projects require substantial grant funds or very low interest loans to make them feasible.

- Pursuing these adaptation interventions is more favorable than the 'do nothing' option. 'Do nothing' in the medium to long term puts the islands' assets, tangible and non-tangible, at a higher risk and increased vulnerability to climate variability and climate change. Pursuing these interventions will also provide a number of short-term benefits such as greater water and energy security, resilience building to the vagaries of climate change and aesthetics.

- Given the uncertainty associated with climate change, we should not rush into making long-lived investments in adaptation unless these are robust to a wide range of climate outcomes or until the range of uncertainty about future weather variability and climate has narrowed. Start with low-regret options.

- CBA needs to be complemented by CEA for better decision making. Furthermore, where there is a high degree of environmental services, contingent valuation measures need to be conducted early to capture shadow prices.

- The projects require political will and support. The major challenges encountered were often of a political and institutional dimension. Like climate change, inadequate governance remains a major threat to the region.

- There is a limit to adaptation initiatives and as such, the negotiations should continue to seek to have emission levels reduced through a binding and effective mechanism in Paris in 2015.

Annex I: Detailed Facts and Assumptions

Salt Water Reverse Osmosis (SWRO) System: Bequia, Saint Vincent and the Grenadines

Facts and Assumption of the Model

Various methodological approaches were used in the conduct of the financial analyses. These include:

- Using data from the project and bid documents,
- Using information from studies conducted on the Island, in particular, to acquire willingness to pay (WTP) and ability to pay (ATP) estimates, and supplementing these with information from international sources like the World Bank, the Chicago Climate Exchange and the CIA Factbook, and
- Observation, discussions and financial statistics from a similar system that has been in operation since February 2010 at Caye Caulker in Belize.

Furthermore, the analysis follows established best practices and norms for the conduct of this type of study. It utilises a discount factor of 10% which is higher than the rate offered on Government Bonds, i.e., between 6% - 8% currently. Furthermore, it applied various scenarios, moving from what it considers the high cost, to the moderate cost to the low cost alternatives. These scenarios are provided to aid policy-makers in making a more informed and reasoned decision. Additionally, the financial analyses add various elements of rigor by looking at the project with and without the investment costs being incorporated into the cost estimates.

The analysis is based on a number of assumptions and conditions, largely due to information provided in the project and bid documents. Where such information was not available, the analyst used information from other reputable sources, such as the World Bank socio-economic statistical database, the ICIS Databases and the Chicago Climate Exchange. There are some assumptions that are peculiar to the respective scenarios and these will be highlighted under these scenarios. However, there are some general assumptions and these are documented below. The general assumptions include:

- The life spans of the SWRO and the PV are projected to be 20 years,
- Depreciation of the SWRO and PV will take place at a 5% rate using the straight-line method,
- Water demand per person per day is projected to be 20 imperial gallons (based on project document and information gleaned from the BCEOM Socio-Economic Feasibility Study of Water Demand in the Grenadines in 2006),
- The Population at Paget Farm was estimated at 902 persons (or 200 households),

- A cost of US$165 is imputed for connecting the water main, and similarly it is projected that US$165 will be charged as reconnection fee, comparable with the practice in Belize,
- A projected annual delinquency rate of 5% is projected,
- Water demand for the project is projected at 18,040 imperial gallons per day when all households are connected (Note no projection is made for an increase in demand. However, it should be noted that the SWRO is only projected to work at 15.9 hours a day. Thus, the plant can accommodate any increase in demand),
- Water production capacity has been projected at 29,036 imperial gallons per day,
- Given an estimated 5% leakage from the system is anticipated, thus causing the system to work for 15.9 hours to produce an estimated 18,990 imperial gallons per day,
- Individuals/households will be charged a flat rate per gallon of water consumed rather than a marginal cost pricing approach,
- Electricity cost is projected at US$0.35/kwh which is US$0.01 higher than what it currenty is and US$0.05 above what it was before the most recent rise in fuel prices,
- The price at which power will be sold to VINLEC from the PV has been pegged at US$0.20/kwh
- Costs of materials are inclusive of freight on board (FOB) charges and insurance, but exclude import duties and taxes,
- Investment costs include the investment and installation costs for the SWRO and the laying of pipes,
- Monitoring and administration cost for the PV cover all labour costs associated with the operation of the system,
- Electricity will be provided by VINLEC,
- It is estimated that the plant will require 14.4 kwh of energy to produce 1,000 imperial gallons (the bid document assumed 12 kwh/1,000 US gallon),
- Energy consumption in the first year is estimated at 33,361.63 kw, and 90,240.49 kw in the second year until the ending of the project,
- The plant will operate for 122 days in year 1 and 330 days per year thereafter. The reason for the differences in the days is based on the assumption that only 70 households will connect in the first year and the remaining 140 household in thereafter (assuming a constant population figure of 200 families). The 35 days will be used to service the system,

- Tons of CO2/MwH from diesel was projected at 0.86, while the floor price for CO2 on the Chicago Climate Exchange at the time of writing this report was US$10 per ton (note the UK Government in it 2011/2012 budget set the floor price of CO2 at £16 per ton or US$25.60),
- Households will be equipped with water meters which will be read once per month by a meter reader from the Main Island,
- Water samples will be collected, stored and sent to the water authority's main laboratory for testing on a daily basis. Tests will be carried out mainly for pH, nitrates, coliform bacteria, chlorine residual from treated water, and total dissolved solids,
- The SWRO will be housed at the Fishing Complex at Paget Farm with no additional cost for rental of the facilities located therein,
- The services of the local office of the Central Water and Sewerage Authority (CWSA) that is currently used to manage waste on the island will be extended to the SWRO, and
- All payments will be made at the Post Office and/or the Commercial Bank on the Island for which a 1% service charge will be levied on revenue collected.

Cost and Pricing Scenarios and Assumptions

Scenario 1: High Operational and Maintenance Cost Scenario

The financial analysis was conducted under various price scenarios, low, moderate and high. Additionally, the feasibility of operating the system with high operational and maintenance cost and treatment of the investment costs as sunk cost was also examined and reported. **The high operational and maintenance cost scenario was hinged on the following assumptions:**

- Employ a Plant Engineer on a full-time basis (though for the first two years this person will work mainly on a part-time basis due to the projected limited number of households that will be connected and the fact that it is a turnkey operation).
- The Plant Engineer will also function as the Plant Supervisor and will be supported by a Field Worker. The Field Worker’s responsibility will be the connection of pipes and the collection of water samples that will be tested to determine the water quality. This person will be facilitated in his/her work by having access to a motorcycle.
- The motor cycle is estimated to have a life span of 10 years.
- The Plant Engineer and the Field Worker will be supported by a Customer Relations Worker, whose main responsibility will be the delivery of the bills to water users; and a Meter Reader. The Customer Relations Officer will also take complaints from customers. The Customer

Relations Worker and the Meter Reader will be part-time workers, with the assumption being that these persons will come from the main office and visit the Island once per month.

- The main costs associated with the Customer Relations Worker and the Meter Reader will be transportation costs to cover their visits to the Bequia.

The pricing assumptions/scenarios were derived according to the following:

- The price per gallon (imperial gallon) of water under this scenario would be charged at US$0.012. This is comparable with the cost of water for a much larger system that derives more scale economies at Caye Caulker in Belize.
- The ATP estimate was derived from the BCEOM (2006) Survey, using an estimate of what persons already pay for rainwater harvesting and pumping charges.
- The WTP estimate was derived from the BCEOM (2006) survey; using household's expressed willingness to pay 2.2% of household income, using the average household size of 4.5 persons, and the average household income to make this estimation.

Scenario 2: Moderate Operational and Maintenance Cost Scenario

This scenario is similar to the high operational and maintenance cost scenario; however, the following differences in the assumptions were made:

- The Project will employ a Plant Engineer on a part-time basis since the project is a turnkey operation. The Engineer (who is expected to be a resident from the Island) will work two days per week (which can be spread out over the week) and function as the Plant Supervisor.
- The Field Worker's responsibility will be the connection/disconnection of pipes and the collection of water samples that will be tested to determine the water quality. After year three when most of the connections are projected to be in place, this person will take over the responsibility for reading the meter as well.
- A meter reader from the Main Office will visit the Island once per month, for the first three years, after this the field worker will be responsible for reading the meter as well.
- A Customer Relations Worker will visit the Island once per month to distribute bills and listen to customers complaints.

The pricing assumptions/scenarios were as stated above.

Scenario 3: Low Operational and Maintenance Cost Scenario

The major differences in the assumptions made under this scenario versus the high- and moderate-cost scenarios are as follows:

- The Project will employ a Plant Engineer on a part-time basis since the project is a turnkey operation. The Engineer (who is expected to be a resident from the Island) will work one day per week (which can be spread out over the week) and function as the Plant Supervisor.
- The Field Worker's responsibility will be the connection/disconnection of pipes and the collection of water samples that will be tested to determine the water quality. After year three when most of the connections are projected to be in place, this person will take over the responsibility for reading the meter as well.
- The local CWSA Office will handle the billing and customer services in the same manner that they do currently with regards to solid waste management.

The pricing assumptions/scenarios were as stated above.

Hybrid Rainwater, Sewerage and Irrigation System for Coconut Bay Resort and Spa, St. Lucia

Facts and Assumption of the Model

- All dollars are quoted in US$ and inflation is assumed to be 2.71%. This is the average inflation rate for St. Lucia for the period 2001-2010.
- An exchange rate of US$1: EC$2.7 is used in this model
- The model assumes a lifespan for the project of 20 years.

Cost

Initial Capital Expenditure

- The initial investment is US$439,760.

Operational and Maintenance Cost

- The model presents maintenance and operational cost in two scenarios. These are as follow:

Scenario 1

- The maintenance and operational cost is assumed to be a percentage of the initial investment. This maintenance and operation cost excludes the labour cost and insurance cost.
    - The Caribbean Environmental Health Institute, (year) suggested in a study titled, 'Financial Assessment for Wastewater Treatment and Disposal (WWTD) in the

Caribbean', that where space availability is limited a Small FootPrint (SFP) type system is the preferred option. The study further estimates that the operational and maintenance cost associated with a SFP type system is approximately 30-40% of the cost of the system (Caribbean Environmental, 2008). Note that this study was only concerned with wastewater treatment plant and as such the following assumption were made.

A high operational and maintenance cost for the rainwater harvesting system and the sewerage treatment system, is assumed to be 40% of the initial investment. For completion and the presentation of additional cost assumptions, a moderate operational and maintenance cost is assumed to be 30-20% of initial investment and a low operational and maintenance cost, 10% of initial investment.

Scenario 2

- Expected expenditure is computed for the various maintenance activities associated with both systems.
  - Contamination prevention and water quality management for the rainwater harvesting system will utilize filtration, chlorination and testing.

The rainwater harvested will be used in the pools and other land base water activities and as such it is important to ensure that the water is safe, i.e. free from debris and bacteria. This system will utilize special sand filters to prevent debris from entering the water and chlorine to sanitize. The cost of filtration is estimated using the expenditures of the hotel on filter cleaning and replacement in 2010. CBBRAS **uses sand filters which are cleaned every 3-4 days. The estimated cost of filter cleaning and replacement in 2010 to CBBRAS was approximately EC$1,560 for the year.**

Expenditure on chlorine for the pools and waterslides for 2010 was EC$250,000. This translates to treatment cost of approximately 0.11 cent per gallon annually. The combine capacity of the two tanks amounts to approximately 25,000 gallons at any point in time. It is assumed that the average water held in the tank will be approximately 20,000 gallons and will cost CBBRAS the said 0.11 cents per gallon annually to treat.

It is imperative that testing be carried out to maintain the water quality. CBBRAS will conduct its own testing every two hours during day light for the level of chlorine concentrates in the rainwater tanks. The annual cost for these test kits is approximately EC$500. It is also important to have independent testing carried out. The Caribbean Environmental Health Institute is the organization that has provided such service in the pass and as such the cost associated with such an activity was calculated based on their price list. The cost of collecting and testing pool water quality is estimated at US$90 per test. The analyst assumes that independent testing will be conducted on monthly basis.

- Roof monitoring and maintenance – This is estimated to cost US$500 per year.
- Tank cleaning – based on historical practice this exercise is expected to be predominantly manual, with the use of pressure washers and small amounts of chemicals. The model assumes that with the installation of the new water tanks, two additional 'pressure-washers' system will be purchased in year 1 and is expect to serve for 10 years (depreciation of 10%). They will be replaced thereafter. These are estimated to cost on average US$750 each excluding customs and duties. An additional US$500 per year is budgeted into the analysis to cover other expenses including fuel, chemicals and protective gears for the workers.
- The sewerage treatment plant will employ chemical treatment to effluent, ensuring that it meets the standards of the St. Lucian authorities and in the case where there is excess water dispose of it into leach fields. The cost of chemical treatment is estimated based on 2010 figures. It cost CBBRAS, in 2010, EC$20,000 for chemicals to treat total wastewater generated in that year.
- The leach beds are layered with sand, gravel and other filtering material. The sand is the only material which must be replenish on a regular basis. It occupies approximately 45.33 cubic feet of each leach bed. There are currently four leach beds. The practiced is that a leach bed is replenished with sand after sludge has

been removed and the sand stock has depleted. Using the established metrics rule that 1 ton of sand approximate to 20 cubic feet, it follows that approximately 2.27 tons of sand will be required to replenish each leach bed or a total of 9.08 tons to replenish the four leach beds. It is estimated based on historical records that replenishing the sand stock will take place at least six times per year and the market price per ton for the sand used (fine sand) is EC$125.

- Testing will be carried out daily by CBBRAS, however, the Caribbean Environmental Health Institute will provide independent testing at a cost of US$130 per test as is set out in their most current price listing (2010). The analyst assumes that testing will be conducted on a monthly basis.
- The sewage treatment plant has four 34 by 4 feet leach beds. The sludge from these beds, after drying, is gathered and stored in a designated area until enough has accumulated to warrant an offsite disposal. Offsite disposal involves the hiring of a truck and use of the resort's frontend loader and employed labourers. Sludge disposal is estimated to be carried out every four months (three times per year) based on the current system. The cost of disposal is estimated using the cost of hiring a truck, EC$800 per disposal, and fuel for the frontend loader, EC$200 per disposal. The cost associated with labour is accounted for differently. The social and or environmental cost associated with the offsite disposal of sludge was ignored.[32]
- The electricity usage for the rainwater harvesting system and the wastewater treatment plant was presented as percentage estimates of CBBRAS current annual electricity cost. The electricity usage by CBBRAS average 366,984KWH per month for 2010 and was value at EC$309,983/US$114,808 per month. Against this background and the lack of a proper audit of the electrical components of the system[33], four scenarios are presented. The electricity cost was estimated at 1.5%, 3%, 6% and 10% of CBBRAS annual electricity cost.

[32] This will be dealt with in subsequent reports.
[33] The analyst made several attempt to get information about and the number of energy demanding components of the systems but to date that audit/information is still outstanding.

- Contingency sewage treatment operational expenditure is estimated at 1% of the initial investment. Contingency rainwater harvesting operational expenditure is estimated at 0.5% of initial investment**.**

Insurance

- The Hybrid Rainwater, Sewerage and Irrigation System are estimated to increase the insurance premium of the property by 1% collectively. Currently, CBBRAS pays an annual insurance premium of US$548,447.

Labour Cost

- Currently there is one person employed to monitor and maintain the sewerage system. That employee is paid approximately US$800 per month. The analyst assumed that the wastewater treatment plant and rainwater harvesting system will be brought under a single maintenance and monitoring system and as such additional labour will be required. Going forward, the labour force associated with both the rainwater harvesting system and the wastewater management system is expected to consist of:
  - An Engineer (0.2% of the time) **-** paid approximately 20% of EC$59,500 annually.
  - A Plummer (0.2% of the time) - paid approximately 20% of EC$ 11,400 annually.
  - Two full-time monitoring and maintenance personnel, an engineer assistant and a handyman – paid approximately EC$25200 and EC$11400 annually respectively.
  - Four labourers - each employed 80 hours per year and paid approximately US$8 per hour. These labourers will help with the disposal of sludge and tank cleaning activities.
  - A security personnel – paid approximately US$500 per month

Benefits

- Using data for the past five years on daily rainfall, the rainwater system could potentially harvest 7.3 million gallons of water per year. However, given the size of the tanks (totalling approximately 25,000 gallons) and the expected daily used of 2000 gallons, the analyst assumed that approximately 3000 gallons per day for 360 day per year would be the benefit derived. This amount to 1.08 million gallons per year or approximately 15% of potential rainwater to be harvested. This 1.08 million gallons of water is valued at the going rate of EC$22/US$8.15 per 1000 gallons to hotels for water from WASCO. The water is valued using WASCO going price as this represents the opportunity cost (forgone cost) of using water from the rainwater harvesting system versus WASCO produced water.

- 190,000 litres of water per day is expected to be made available from the sewerage treatment system, however, the capacity of the recycle catchment tank is 40,000 litres. As such more than 75% of the recycled water will be disposed of. It is assumed that of the total recycled water 60% will reach and replenish the aquifers. This quantity of water is valued at 70% of that which WASCO charges hoteliers for water.

  The captured recycled water will be used for irrigation purposes. According to information gather from personnel working at the resort the usage of such water will be dependent on the number of rain days and quantity of rain and as such it was suggested that on a non-rain day about 70% of the captured recycled water will be used. According to information garnered from the St. Lucia's Met Office, St. Lucia over the past five years has averaged approximately 173 non rain days. The benefit is estimated at 173 non-rain days times 70% of capacity of the catchment/storage tanks valued at the going rate of EC$22/US$8.15 per 1000 gallons. This current market rate was used for the same reason given above.

- Environmental Benefits – The environmental benefits to be derived is mainly as a result of the replenishing of the aquifers (mentioned above) and the maintained coastal reefs. The benefits associated with the maintenance of the coral reefs include:
  - the avoided loss in revenue from tourist reef related activities
  - the avoided loss in revenue from reduced fishes landed
  - the avoided loss in beach and sea recreational activities
  - the avoided property damage.

  Of the above, the analyst could not put a value on 1-3. This is due primarily to data unavailability. The resort suggested that it does not directly offer any sea-based activities. It, however, provides its guests with suggested tour packages, which would then take them to the different marine parks. St. Lucia has two important marine parks, namely, the Soufriere Marine Management Area (SMMA) and the Canaries Marine Management Area (CAMMA). These marine parks are located on the western side (Caribbean Sea) of the island and are where majority of the reef related tourism takes place. Contrary, Coconut Bay Resort and Spa is located on the eastern side (Atlantic) of the island and lot of the reef on that side of the island is unexplored. Burke et al (2008) suggest that, "The Atlantic coast [also] has some reefs but less in known about their location and extent." Against this background and the lack of credible data, the decision was taken not to value reef related tourism activities off the immediate coast of Coconut Bay Resort and Spa.

The analyst could not value fisheries activities off the immediate coast of the resort as there was no information on the quantity of fish, quality of fish and frequency of fishing activities in those waters.

Beach and sea related recreational activities by locals could not be value as there was no information on the number and frequency of visits to the beach in that area or even the willingness and or ability to pay to access such a beach front area.

In valuing the avoided property damage/loss, we utilized estimates from Burke et al (2008). Burke et al (2008) defines vulnerable lands as, "any areas that are 5m or less in elevation within 1 km of the coast, and all areas immediately adjacent to the coast (within 25m resolution coastal grid cells)" and "Shoreline segments protected by coral reefs were defined as those within 100 m of a fringing reef, or in bays protected by a reef." Adapting these definitions and studying geological presentations from Burke et al (2008), the approximately 1 mile of beach front property of Coconut Bay Resort was deemed vulnerable. According to Burke et al (2008) approximately a third of all vulnerable lands are protected by reefs. This same ratio was used to estimate the amount of the 1.61km beach front property (1 mile) protected by reefs. The model further assumes that if the resort were, to instead of treating it wastewater, dump its wastewater into the sea immediately in front of the resort, 100% of the reef would be loss over 100 years. Holding the ratio constant at 1% per year, the analyst further assumes that 20% of the reefs will be loss in 20 years (life span of the project).

Note that the value of the reefs is estimated based on the value of CBBRAS vulnerable land protected by reefs. This is believed to be a grossly underestimated value of the reefs and hence the environmental benefit of having this system as it ignores reef-related tourism, fisheries and recreation.

- Social Benefits – there are identified social benefit associated with this project. These include:

- Reduced Consumption of WASCO-produced Water- This will help to reduce the tension between Coconut Bay Resort and residents of surrounding communities. An economic value was given to this using the following reasoning. These systems, the rainfall harvesting and the sewerage treatment systems, will reduce the amount of water that Coconut Bay Resort consumes from WASCO, hence increasing the amount of water available to the surrounding communities. The estimated reduction in consumption by the resort is approximately 11.01 million litres annually. This quantity of water is converted to US gallons and valued using the average rate charged to domestic, commercial and government of EC$14.10/US$5.22 per 1000 gallons. This approach, however, ignores the residents' ability to pay and their maximum willingness to pay as well as the potential negative effects this reduction in revenue to WASCO could cause.
- Health and other social benefits – due to lack of data the model ignores health benefit to be derived by community from having additional WASCO produced water at their disposal as the reduction of effluence flowing into the open ocean.

Strengthened Critical Infrastructure in the Castries Area: Retrofitting the Marchand Community Centre, St. Lucia

Facts and Assumptions of the Model

- The initial cost to retrofit the centre is US$768269.
- The model assumes a lifespan for the project of 20 years.
- All dollars are quoted in US$ and inflation is assumed to be 2.71%. This is the average inflation rate for St. Lucia for the period 2001-2010.
- An exchange rate of US$1: EC$2.7 is used in this model
- Maintenance and replacement cost is assumed to be 1%, 3% and 5% of the initial investment. Here it is assumed that 1% represents a low cost maintenance initiative, 3% moderate cost and 5% high cost. Note that operational and administrative costs are separate and apart from the maintenance cost and are estimated as detailed below.

  An additional scenario (identified maintenance cost) is provided where values are estimated for expected maintenance activities such as painting, roof checks and repairs and other provisional expenditure associated with the maintenance of the building.

- Painting is assumed to be done every five (5) years
  - Roof checks and minor repair is assumed to be done annually at a cost of US$1000 per year, starting in year two (2).

Other provisional maintenance expenditure assumed to be 0.5% of the initial investment.

- Replacement cost related to door, windows, among other things is estimated to cost approximately US$2000 adjusted for inflation every three (3) years, starting in year three (3). This is against the background that some doors and windows may have to be replaced after a hurricane has pass.

- The cost for electricity usage was estimated using St. Lucia Electric Company's online calculator. Given the items identified and included, the online calculator estimates that the existing items would utilize 1,524KWH per month. Assuming that there could be increases in the number of energy consumption items present at the centre, the estimate of 2000KWH per month valued at US$657 as put forward by St. Lucia Electric Company for a small commercial entity is used in the model.
- According to pervious water bills, the average cost of monthly water service to the community centre is approximately EC$350/US$130 per month. Using the government rate of EC$14/US$5.19 per 1000 gallons, it is estimated that the centre uses 25,000 gallons per month which is about 300,000 gallons per year. Given that the retrofitting the centre entails the installation a rainwater harvesting system, it is estimated that the centre will consume approximately 272,000 gallons per year from WASCO and the additional 28,000 gallons per year from the rainwater harvesting system.
- Administrative cost is assumed to be 0.25% of the initial investment.
- Insurance cost is assumed to be 1% of the initial investment.
- The centre currently does not employ anyone but there are 6 volunteers to the centre. Going forward, beginning in year one (1), the centre could employ a security guard, to safe guard the equipments and infrastructure of the centre and an administrative personnel to better handle and coordinate the activities associated with the centre. Based on information received from The Statistical Institute of St. Lucia, a security guard is paid approximately US$600 per month and an administrative personnel US$800 per month as at April 2010.

- It is estimated that St. Lucia is affected by hurricane every 3.1 years[34] and suffers a direct hit on average 11.58 years[35]. In 2010, Tomas, a category two hurricane, killed 8 persons and Dean in 2007, a category two hurricane, killed one person. The most number of persons killed in St. Lucia by a hurricane/tropical storm is 45. This occurred in 1988 when tropical storm Gilbert passed over the island. Allen, the only noted category four hurricane to hit St. Lucia in 1980 claimed the lives of 18 persons.

- Given the above information, a reserve estimate of two lives every five years is used to value the avoided economical and social loss to St. Lucia. Their expected future income is used as an estimate for valuing their contribution to the St. Lucian Economy. Against the background that the poor, young and elderly are most vulnerable, the expected future income was calculated using US$400 per month, which maybe consider to be minimum wage.

- According to estimates recovered from the engineers working on the PV system the total gross energy demand for the centre for two day will be 348.26AH. After accounting for the residual power to be left in the battery and the depreciation of the battery, it is estimated that a battery capacity of 512.14AH is required. The PV system will be connected to the grid and will serve the centre only in times of emergencies. The installation of the PV system will result in, revenue from that sale of electricity generated and supplied to the grid; and the avoidance of greater CO2 emission in the production of electricity.

It is estimated that the PV system should generate on average 1,869KWH per month. This is valued at 70% of the market value of a unit of electricity in St. Lucia.

The avoided CO2 emission is calculated as the expected difference in the CO2 generate when oil is used to produce electricity and the expected CO2 emission when a PV system is used to produce electricity. According to research by the University of Sydney, 2006, the CO2 emission associated with electricity produced using oil (black coal) is 863 grams per KWH and the CO2 emission associated with electricity produced using a PV system is 106 grams per KWH. The avoided CO2 emission is taken as the difference between the two (757) and valued at US$21 per tonne, which is the estimated US 'Social Cost of Carbon' (Bell and Callan, 2011).

[34] Source: National Emergency Management Organization
[35] Source: Hurricane City , 2011. Retrieved on September 30, 2011, from: http://www.hurricanecity.com/city/saintlucia.htm.

- Note that is does not account for the welfare gain of having electricity in times of power outage especially those cause by natural disaster.

- The benefit of housing and storage is estimated as the cost forgone in renting that space. The average cost for renting commercial space in and around the Castries area is approximately EC$2.10 per square foot monthly[36]. Of an approximately total 3660 square feet for both the ground and first floor, NEMO occupies approximately 1150 square feet of the ground floor, excluding storage and warehouse capacity; the Boxing Gym occupies about a quarter of the 980 square feet auditorium; and the storage and warehouse areas total approximately 670 square feet. These areas are valued at the EC$2.10 per square foot per month. The analyst further assumes that the community centre will host 20 community activities per year at a cost of EC$0.7 per square foot to rent the auditorium per event.

- The weekly feeding Programme is estimated to cost EC$300/US$111 per week. Assuming that the benefit of this Programme is equal to or greater than the cost of having the Programme, the EC$300 per week is used to estimate the benefit of the Programme.

- The potential rainwater harvest is estimated using the noted fact that 1 inch of rainfall on a 1 square foot surface area is equal to 0.624 gallons. The roof area of the Marchand Community Centre is approximately 2196.55 square feet and annual average rainfall over the past 10 years (2001-2010) for the Castries area[37] is 1917.4 millimetre (75.49 inches). This approximate to 103,470 gallons of potential rainwater per year. The centre will be equipped with a plastic 800 gallons tank for harvesting rainwater. It is, therefore, not expected that the centre will efficiently harvest and utilize all the rainwater. The analyst assumes that the centre will utilize less than a third of the potential rainfall per year. In other words, the tank is expected to be ‘cycled’ (use and refill) about 40 times per year at 700 gallons per ‘cycle’. This amounts to 28,000 gallons per year and is valued at the going water rate per gallon to government building charged by WASCO. Note that this does not account for the welfare gain of having water in times of water shortage especially those caused by natural disaster.

- The new building code developed and adapted for this project will also have far-reaching benefits. According to the damage assessment reports for St. Lucia in relation to category 2 Hurricane Dean, 2007, and category 2 Hurricane Tomas, 2010, damages to houses, schools and

[36] As quoted by the National Development Corporation, St. Lucia.
[37] As proxy by the data captured at George F L Charles Airport.

hospitals totalled approximately EC$3/US$1.11 million and EC$190/US$70.4 million respectively. For this analysis, the analyst used 50% of the estimated cost for damages associated with Hurricane Dean to value the avoided loss in building infrastructure after a hurricane if the new building code is adapted by schools, hospitals, other public buildings, businesses and private individuals.

The realized benefit associated with the adaptation of the new building code is presented in four scenarios. These are that the benefits will be realized every three years starting year 3, year 6, year 12 and none at all.

Note that this estimate grossly underestimates the value of the newly developed building code as it ignores the multiplier effects associated with the injection of money each year into the economy as well as the positive externality associated with the improved aesthetics.

Annex II: Results

Hybrid Rainwater, Sewerage and Irrigation System for Coconut Bay Resort and Spa, St. Lucia

Discount rate of 2%

Table 7: Net present cumulative benefit of the project over 20 years with initial investment (US$)

Discount Factor 5%	High O&M Cost as a Percentage of Initial Investment (50%)	High-Moderate O&M Cost as a Percentage of Initial Investment (30%)	Moderate O&M Cost as a Percentage of Initial Investment (20%)	Low O&M Cost as a Percentage of Initial Investment (10%)	Identified O&M Cost (+Electricity Cost 1.5% of AEB)	Identified O&M Cost (Electricity Cost 3% of AEB)	Identified O&M Cost (Electricity Cost 6% of AEB)	Identified O&M Cost (Electricity Cost 10% of AEB)
Environmental and Social Benefits (1% Reef value per year, Replenishing Aquifer, increased water to the Community)	443,122	1838,150	2557,220	2600,334	2829,004	2395,849	1529,540	374,460
Environmental and Social Benefits (0.5% Reef value per year, Replenishing Aquifer, increased water to the Community)	(1069,757)	325,271	1044,341	1087,455	1316,125	882,970	16,661	(1138,419)
Without Environmental and Social Benefits	(4214,257)	(2819,229)	(2100,159)	(2057,045)	(1828,375)	(2261,529)	(3127,839)	(4282,918)

Table 8: Net present cumulative benefit of the project over 20 years without initial investment (US$)

Discount Factor 5%	High O&M Cost as a Percentage of Initial Investment (50%)	High-Moderate O&M Cost as a Percentage of Initial Investment (30%)	Moderate O&M Cost as a Percentage of Initial Investment (20%)	Low O&M Cost as a Percentage of Initial Investment (10%)	Identified O&M Cost (+Electricity Cost 1.5% of AEB)	Identified O&M Cost (Electricity Cost 3% of AEB)	Identified O&M Cost (Electricity Cost 6% of AEB)	Identified O&M Cost (Electricity Cost 10% of AEB)
Environmental and Social Benefits (1% Reef value per year, Replenishing Aquifer, increased water to the Community)	882,882	2277,910	2996,980	3040,094	3268,764	2835,609	1969,300	814,220
Environmental and Social Benefits (0.5% Reef value per year, Replenishing Aquifer, increased water to the Community)	(629,997)	765,031	1484,101	1527,215	1755,885	1322,730	456,421	(698,659)
Without Environmental and Social Benefits	(3774,497)	(2379,469)	(1660,399)	(1617,285)	(1388,615)	(1821,769)	(2688,079)	(3843,158)

Discount Factor 4.5%

Table 9: Net present cumulative benefit of the project over 20 years with initial investment (US$)

Discount Factor 10%	High O&M Cost as a Percentage of Initial Investment (50%)	High-Moderate O&M Cost as a Percentage of Initial Investment (30%)	Moderate O&M Cost as a Percentage of Initial Investment (20%)	Low O&M Cost as a Percentage of Initial Investment (10%)	Identified O&M Cost (+Electricity Cost 1.5% of AEB)	Identified O&M Cost (Electricity Cost 3% of AEB)	Identified O&M Cost (Electricity Cost 6% of AEB)	Identified O&M Cost (Electricity Cost 10% of AEB)
Environmental and Social Benefits (1% Reef value per year, Replenishing Aquifer, increased water to the Community)	195,897	1297,888	1869,925	1912,008	2105,423	1768,113	1093,492	193,998
Environmental and Social Benefits (0.5% Reef value per year, Replenishing Aquifer, increased water to the Community)	(982,227)	119,765	691,802	733,884	927,300	589,990	(84,631)	(984,125)
Without Environmental and Social Benefits	(3430,941)	(2328,949)	(1756,912)	(1714,830)	(1521,415)	(1858,725)	(2533,346)	(3432,840)

Table 10: Net present cumulative benefit of the project over 20 years without initial investment (US$)

Discount Factor 10%	High O&M Cost as a Percentage of Initial Investment (50%)	High-Moderate O&M Cost as a Percentage of Initial Investment (30%)	Moderate O&M Cost as a Percentage of Initial Investment (20%)	Low O&M Cost as a Percentage of Initial Investment (10%)	Identified O&M Cost (+Electricity Cost 1.5% of AEB)	Identified O&M Cost (Electricity Cost 3% of AEB)	Identified O&M Cost (Electricity Cost 6% of AEB)	Identified O&M Cost (Electricity Cost 10% of AEB)
Environmental and Social Benefits (1% Reef value per year, Replenishing Aquifer, increased water to the Community)	635,657	1737,648	2309,685	2351,768	2545,183	2207,873	1533,252	633,758
Environmental and Social Benefits (0.5% Reef value per year, Replenishing Aquifer, increased water to the Community)	(542,467)	559,525	1131,562	1173,644	1367,060	1029,750	355,129	(544,365)
Without Environmental and Social Benefits	(2991,181)	(1889,189)	(1317,152)	(1275,070)	(439,760)	(1418,965)	(2093,586)	(2993,080)

Discount rate of 7%

Table 11: Net present cumulative benefit of the project over 20 years with initial investment (US$)

Discount Factor 15%	High O&M Cost as a Percentage of Initial Investment	High-Moderate O&M Cost as a Percentage of Initial	Moderate O&M Cost as a Percentage of Initial Investment	Low O&M Cost as a Percentage of Initial Investment	Identified O&M Cost (+Electricity Cost 1.5% of AEB)	Identified O&M Cost (Electricity Cost 3% of AEB)	Identified O&M Cost (Electricity Cost 6% of AEB)	Identified O&M Cost (Electricity Cost 10% of AEB)

	(50%)	Investment (30%)	(20%)	(10%)				
Environmental and Social Benefits (1% Reef value per year, Replenishing Aquifer, increased water to the Community)	28,394	919,059	1384,942	1426,041	1591,321	1322,111	783,692	65,800
Environmental and Social Benefits (0.5% Reef value per year, Replenishing Aquifer, increased water to the Community)	(911,874)	(21,208)	444,674	485,773	651,053	381,844	(156,575)	(874,467)
Without Environmental and Social Benefits	(2866,208)	(1975,542)	(1509,660)	(1468,560)	(1303,281)	(1572,490)	(2110,909)	(2828,801)

Table 12: Net present cumulative benefit of the project over 20 years without initial investment (US$)

Discount Factor 15%	High O&M Cost as a Percentage of Initial Investment (50%)	High-Moderate O&M Cost as a Percentage of Initial Investment (30%)	Moderate O&M Cost as a Percentage of Initial Investment (20%)	Low O&M Cost as a Percentage of Initial Investment (10%)	Identified O&M Cost (+Electricity Cost 1.5% of AEB)	Identified O&M Cost (Electricity Cost 3% of AEB)	Identified O&M Cost (Electricity Cost 6% of AEB)	Identified O&M Cost (Electricity Cost 10% of AEB)
Environmental and Social Benefits (1% Reef value per year, Replenishing Aquifer, increased water to the Community)	468,154	1358,819	1824,702	1865,801	2031,081	1761,871	1223,452	505,560
Environmental and Social Benefits (0.5% Reef value per year, Replenishing Aquifer, increased water to the Community)	(472,114)	418,552	884,434	925,533	1090,813	821,604	283,185	(434,707)
Without Environmental and Social Benefits	(2426,448)	(1535,782)	(1069,900)	(1028,800)	(863,521)	(1132,730)	(1671,149)	(2389,041)

Strengthened Critical Infrastructure in the Castries Area: Retrofitting the Marchand Community Centre, St. Lucia

Table 13: Net present cumulative benefit of the project over 20 years (US$) with initial investment

Discount Rate 7%	Identified Maintenance	High maintenance cost (5%)	Moderate maintenance cost (3%)	Low maintenance cost (1%)
With Building Code Value from year 3	1441,272	1177,554	1367,711	1557,869
With Building Code Value from year 6	962,861	699,142	889,300	1079,457
With Building Code Value from year 12	165,455	(98,264)	91,894	282,051
Without Building Code Value	(717,319)	(981,037)	(790,879)	(600,722)

Table 14: Net present cumulative benefit of the project over 20 years (US$) without initial investment

Discount Rate 7%	Identified Maintenance	High maintenance cost (5%)	Moderate maintenance cost (3%)	Low maintenance cost (1%)
With Building Code Value from year 3	2227,541	1963,823	2153,980	2344,138
With Building Code Value from year 6	1749,130	1485,411	1675,569	1865,726
With Building Code Value from year 12	951,724	688,005	878,163	1068,320
Without Building Code Value	68,950	(194,768)	(4,610)	185,547

Table 15: Net present cumulative benefit of the project over 20 years (US$) with initial investment

Discount Rate 4.5%	Identified Maintenance	High maintenance cost (5%)	Moderate maintenance cost (3%)	Low maintenance cost (1%)
With Building Code Value from year 3	2044,197	1713,900	1955,527	2197,154
With Building Code Value from year 6	1530,622	1200,325	1441,952	1683,579
With Building Code Value from year 12	579,987	249,689	491,317	732,944
Without Building Code Value	(673,360)	(1003,658)	(762,031)	(520,404)

Table 16: Net present cumulative benefit of the project over 20 years (US$) without initial investment

Discount Rate 4.5%	Identified Maintenance	High maintenance cost (5%)	Moderate maintenance cost (3%)	Low maintenance cost (1%)
With Building Code Value from year 3	2830,466	2500,169	2741,796	2983,423
With Building Code Value from year 6	2316,891	1986,594	2228,221	2469,848
With Building Code Value from year 12	1366,256	1035,958	1277,586	1519,213
Without Building Code Value	112,909	(217,389)	24,238	265,865

Table 17: Net present cumulative benefit of the project over 20 years (US$) with initial investment

Discount Rate 3%	Identified Maintenance	High maintenance cost (5%)	Moderate maintenance cost (3%)	Low maintenance cost (1%)
With Building Code Value from year 3	2888,466	2465,927	2780,118	3094,309
With Building Code Value from year 6	2336,195	1913,656	2227,847	2542,038
With Building Code Value from year 12	1196,568	774,030	1088,221	1402,411
Without Building Code Value	(604,321)	(1026,860)	(712,669)	(398,478)

Table 18: Net present cumulative benefit of the project over 20 years (US$) without initial investment

Discount Rate 10%	Identified Maintenance	High maintenance cost (5%)	Moderate maintenance cost (3%)	Low maintenance cost (1%)
With Building Code Value from year 3	3674,735	3252,196	3566,387	3880,578
With Building Code Value from year 6	3122,464	2699,925	3014,116	3328,307
With Building Code Value from year 12	1982,837	1560,299	1874,490	2188,680
Without Building Code Value	181,948	(240,591)	73,600	387,791

Table 19: Net present cumulative benefit of the project over 50 years (US$) with Capital Expenditure

Discount Rate 7%	Financial Analysis	Economic Analysis
1% increase in revenue per year	(2852,475)	81232,402
2.17% (10 years average inflation) increase in revenue per year	(1890,895)	82191,758
3% increase in revenue per year	(1131,723)	82949,174
4% increase in revenue per year	(121,488)	83957,073
5% increase in revenue per year	1005,588	85081,543

Table 20: Net present cumulative benefit of the project over 50 years (US$) without Capital Expenditure

Discount Rate 7%	Financial Analysis	Economic Analysis
1% increase in revenue per year	(2187,461)	81897,415
2.17% (10 years average inflation) increase in revenue per year	(1225,882)	82856,771
3% increase in revenue per year	(466,710)	83614,188
4% increase in revenue per year	543,525	84622,087
5% increase in revenue per year	1670,601	85746,557

Table 21: Net present cumulative benefit of the project over 50 years (US$) with Capital Expenditure

Discount Rate 5%	Financial Analysis	Economic Analysis
1% increase in revenue per year	(3383,623)	96810,175
2.17% (10 years average inflation) increase in revenue per year	(2153,242)	98037,711
3% increase in revenue per year	(1177,768)	99010,929
4% increase in revenue per year	125,196	100310,880
5% increase in revenue per year	1584,664	101766,973

Table 22: Net present cumulative benefit of the project over 50 years (US$) without Capital Expenditure

Discount Rate 5%	Financial Analysis	Economic Analysis
1% increase in revenue per year	(2700,083)	97493,715
2.17% (10 years average inflation) increase in revenue per year	(1469,701)	98721,251
3% increase in revenue per year	(494,228)	99694,469
4% increase in revenue per year	808,736	100994,420

5% increase in revenue per year	2268,204	102450,513

Table 23: Net present cumulative benefit of the project over 50 years (US$) with Capital Expenditure

Discount Rate 3%	**Financial Analysis**	**Economic Analysis**
1% increase in revenue per year	(4086,120)	117150,703
2.17% (10 years average inflation) increase in revenue per year	(2491,158)	118741,976
3% increase in revenue per year	(1221,427)	120008,772
4% increase in revenue per year	480,834	121707,097
5% increase in revenue per year	2394,975	123616,811

Table 24: Net present cumulative benefit of the project over 50 years (US$) without Capital Expenditure

Discount Rate 3%	**Financial Analysis**	**Economic Analysis**
1% increase in revenue per year	(3382,913)	117853,910
2.17% (10 years average inflation) increase in revenue per year	(1787,951)	119445,183
3% increase in revenue per year	(518,220)	120711,979
4% increase in revenue per year	1184,042	122410,304
5% increase in revenue per year	3098,182	124320,019

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