Abu Dhabi Global Environmental Data Initiative (AGEDI)

Abu Dhabi Blue Carbon Demonstration Project

Finance Feasibility Assessment Report

Table of Contents

List of Tables

List of Figures

List of Figures

The Abu Dhabi Blue Carbon Demonstration Project

The Abu Dhabi Blue Carbon Demonstration Project was commissioned by the Abu Dhabi Global Environmental Data Initiative (AGEDI) on behalf of the Environment Agency – Abu Dhabi (EAD) to help improve our understanding of the services the Emirate's coastal and marine ecosystems, provide, with a focus on carbon sequestration and storage. In addition, the outcomes endeavor to contribute to the improved understanding of this relatively new concept on both a regional and international level.

The project ultimately aims to inform a science-based approach to making decisions through policies and appropriate management, in particular in relation to sustainable ecosystem use and the preservation of their services for the current and future generations.

The project outcomes are highlighted in a series of project reports (see below). To achieve a comprehensive understanding of the project it is recommended that all project reports be read in their entirety. To gain an over view of the project the *Blue Carbon Ecosystems in Abu Dhabi* report is suggested. The project reports (each with its own Executive Summary) include:

- **Baseline Assessment Report: Coastal Ecosystem Carbon Stocks**
  This includes the details of how baseline Blue Carbon stock was quantified in Abu Dhabi, as well as results, analysis and recommendations for the future management and protection of these ecosystems.

- **Spatial Data Assessment Report**
  This includes details and results of an assessment of spatial coverage of Blue Carbon ecosystems in Abu Dhabi, and how these can be viewed, assessed and updated through the Abu Dhabi Blue Carbon Mapping Toolkit.

- **Ecosystem Services Assessment Report**
  This includes a description of the further Blue Carbon ecosystems' services, and how this relates to their condition, their potential values, the importance of ecosystems integrity as well as present threats which could be addressed by focused management.

- **Abu Dhabi's Blue Carbon Policy**
  This describes the outcome of a process to develop an integrated policy framework to sustain and enhance the productivity of blue carbon ecosystems in the Abu Dhabi Emirate, while contributing and supporting national/global blue carbon ecosystem management efforts. The resulting policy framework consists of 5 key components and 10 specific policy actions that build off other Blue Carbon Demonstration project outcomes and incorporate stakeholder perspectives.

- **Financial Feasibility Assessment Report (this report)**
  This includes a brief rapid financial feasibility assessment for carbon and ecosystem services credits, and a description of the financial perspective to the 3 recommended specific Options including a specialized compensation fund.

These are supported by:

- **Abu Dhabi Blue Carbon Mapping Tool**
  Includes: An online assessment tool which illustrates the latest ecosystem information and associated carbon stock data at http: bluecarbon.unep-wcmc.org

- **Building Blue Carbon Projects: An Introductory Guide**
  This outlines the components and approaches of existing Blue Carbon Projects of recommendations and basic principles of how to undertake a Blue Carbon Project, based on project experience.

The overall project findings are described in the Project Publication, which also has a separate Executive Summary:

Blue Carbon Ecosystems in Abu Dhabi

This is an overview of the Blue Carbon ecosystems in Abu Dhabi, their relevance in terms of carbon sequestration and other ecosystem services; and recommendations for their future management.

Additional project publications include:

- **Infographic:** Illustration of the relative sequestration and storage of carbon in Blue Carbon ecosystems, and their overall value in monetary terms;
- **Edible Postcard:** A summary of the valuable services provided by Blue Carbon ecosystems;
- **Monthly Newsletter:** Project updates and video footage;
- **Project Website:** Please visit: abudhabi.**bluecarbonportal.org**

Executive Summary

The Financial Feasibility Assessment Component of the Abu Dhabi Blue Carbon Demonstration Project was originally designed to estimate the financial value of Blue Carbon and associated ecosystem services in Abu Dhabi.

One of the most important findings of the assessment was that eligibility requirements for developing Blue Carbon credits, combined with the prevailing low demand and prices for international carbon credits and the high opportunity costs of protecting Blue Carbon ecosystems in Abu Dhabi, led to the conclusion that it would be more feasible to pursue alternative approaches to the promotion of Blue Carbon and other ecosystems within Abu Dhabi. As a result, the focus has been primarily on estimating the financial value of the combined ecosystem services that the conservation of marine and coastal ecosystems in Abu Dhabi could generate and how such estimates would help inform the establishment of a Specialised Fund to promote the provision of such ecosystem services in the future. Net Present Value (NPV) calculations are used to convert the estimated future benefits and costs into current financial values, using discount rates of 5% and 10% for comparative purposes.

The financial analysis is based on a number of critical assumptions including the percentage of total marine and coastal ecosystems that would be protected, the opportunity costs of these ecosystems, and the establishment and management costs of protection. The analysis assumes that 50% of mangrove and salt marsh, and 20% of the much larger and more remote seagrass ecosystem would be protected beyond existing protected areas. Coastal sabkha and algal mats are excluded from this analysis given the relative lack of data on these ecosystems in terms of ecosystem valuation. In addition, the analysis also incorporates "low", "medium" and "high" carbon price scenarios, of US$2, US$5 and US$10 per metric ton of carbon dioxide (CO_2), and projections over a 25-year time horizon. Mangrove afforestation is based on the planting of 5,000 hectares over the same time horizon (200 hectares annually on average).

Based on these assumptions and estimations, under all the carbon price and discount rate scenarios, the NPV values for the Blue Carbon ecosystem benefits are very significantly negative, as the estimated discounted costs dramatically exceed the estimated discounted values. Even under the best-case scenario (US$10 per ton of carbon dioxide (CO_2) and a discount rate of 10%), the NPV for the protection of these ecosystems is negative US$184 million. For mangrove afforestation, under the same best-case scenario, the estimated NPV is negative US$58 million. The development of Blue Carbon ecosystems for financial returns in terms of carbon benefits is therefore not viable in Abu Dhabi at present.

Conversely, and encouragingly, when the associated other ecosystem services, in combination with the carbon, are accounted for, the estimated total combined NPV for these bundled ecosystem services ranges from approximately US$1.66 billion to US$1.71 billion, with a discount rate of 10%, and from US$2.57 billion to US$2.63 billion, with a discount rate of 5%, as the carbon price varies from US$2 to US$10 per metric ton of carbon dioxide (CO_2).

While the preliminary results of the financial analysis regarding the combined suite of ecosystem services that Abu Dhabi's marine and coastal environments provide have to be

considered as highly inconclusive and provisional at this stage, given the numerous assumptions that have been made and the lack of detailed local data and analysis, they do suggest that the financial benefits could be quite significant. In addition, the methodology developed for calculating such values provides an important framework that can be further built upon as additional data and information become available. It also allows Abu Dhabi Emirate to prepare for the future should existing market conditions change and eligibility issues be resolved.

The recognition that these ecosystems have a significant economic value is an important first step, particularly for future marine spatial planning and associated financial planning frameworks. In the future, it will be important to support additional scientific research and analysis regarding the various marine and coastal ecosystems to more accurately assess the range of ecosystem service benefits they are providing, their condition and their ability to continue to provide these services. It will also be necessary to investigate actual costs associated with ecosystem protection and/or restoration, and to explore and clarify the various assumptions made in this preliminary financial analysis. Importantly, this would allow Environment Agency – Abu Dhabi (EAD), in consultation with other appropriate stakeholders, to determine the most cost effective allocation of funds for the protection and management of these ecosystems.

Analysis, based on the scientific findings of the *Abu Dhabi Blue Carbon Demonstration Project* has facilitated the development of recommendations, including interim measures for the development of such a Specialised Fund.

Main Recommendation:

That a Specialised Fund be established to improve the protection and management of critical ecosystems, and the associated provision of ecosystem services in Abu Dhabi.

The Specialised Fund has been recommended to help streamline existing environmental permitting and compensation requirements, improve economic linkages and enhance stakeholder engagement. At present, for example the existing policy of compensation for the removal of mangroves is the requirement to replace and plant taken with two seedlings (2:1 compensation). The *Abu Dhabi Blue Carbon Demonstration Project* has determined that, based on science, this may no longer be appropriate as:

1. Mature mangroves sequester and store relatively more carbon than planted mangroves, and during their excavation it is likely that carbon dioxide would be released;
2. Blue Carbon ecosystem service values provision is assumed to increase with increased carbon;

Continuing to use this compensation model therefore will most likely result in a net loss of carbon and degradation in the delivery of ecosystem services in Abu Dhabi.

Rather than putting the responsibility of replanting on developers in Abu Dhabi it is proposed that they pay a compensation fee into a Specialised Fund. This would allow the regulatory authority to priorities marine and coastal conservation and restoration activities and seek to optimize the outcomes, rather than the alternative of having decisions made by other actors who may typically be motivated primarily by financial considerations. In the future the Specialised Fund could also be developed to include the concepts of habitat banking, biodiversity offsets, and system benefits change models.

It is also recommended that the design of the Specialised Fund be flexible in order to integrate other forms of support or additional finance in the future. These include the potential for obtaining such support from Corporate Social Responsibility (CSR) and philanthropic contributions, and potential from the legal system where fines or other financially punitive actions taken against those who violate environmental legislation could be provided by the Fund.

To inform the establishment of such a Specialised Fund, it is recommended that, building on the analysis conducted under the *Abu Dhabi Blue Carbon Demonstration Project,* future projected costs and benefits of various protection and management scenarios are compared. Such analysis could include:

1) Development of a case study of the regarding the requirements for mangrove compensation by the real estate developer Bunya LLC., on Reem Island to highlight alternative approaches for such compensation that could apply under a Specialised Fund;
2) Development of a broader case study involving several property developers to examine the implications for adopting an alternative to the business-as-usual approach for development permitting, approval, compensation and monitoring in other areas of the Emirate under a variety of conditions.

It is anticipated that the focus of such analysis would be on mangrove ecosystem and compensation via the establishment of new mangrove areas, under the guidance of EAD. However, as expressed through the Carbon Baseline and Ecosystem Services Assessment outcomes of this Abu Dhabi Blue Carbon Demonstration Project, it will also be advisable to ensure that:

a. Priority areas which store significant quantities of carbon and provide significant ecosystem service benefits are protected;
b. Marine and coastal development is considered in a holistic manner.

It will also be advisable to ensure that a comprehensive ecosystem approach is taken, and that this expands beyond Blue Carbon ecosystems to include all ecosystems in Abu Dhabi. If this approach is not taken there is an inherent risk that some ecosystems may be protected in favour of others, and, as a result, that the fine balance between, and the integrity of, the environment could be compromised.

Secondary Recommendation:

Given that it is likely to take some time to conduct robust, additional research within Abu Dhabi to generate the scientific data and analysis required to support such informed compensatory decision-making, an interim strategy seems to be necessary.

One approach for developing such a strategy would be to prioritise the identification of high value combined ecosystem services regions, as has already been suggested in the Ecosystem Services Assessment report, as part of a larger, more ambitious marine spatial planning process. These areas could then be designated as the initial focal areas for the Specialised Fund where the current policy of requiring compensation on a 2:1 ratio could be replaced by alternative requirements.

There are several existing mechanisms and models that could be explored by the analytical team to inform the types of approaches that the Specialised Fund could consider supporting in the future. These include the concepts of:

- **Biodiversity Offset:** This is a way to demonstrate that an infrastructure project can be implemented in a manner that results in no net loss or a net gain of biodiversity. Biodiversity offsets are voluntary agreements, versus regulatory requirements, and tend to be entered into once an investment has been made;
- **Mitigation or Habitat Banking:** these are established by acquiring land for the creation, or enhancement and management, of ecosystems for a particular environmental resource. The asset is valued in terms of credits, and the better the condition of the habitat in terms of its conservation objectives, the greater the value and the larger the number of credits. Credits may also be purchased, held, and traded in a process analogous to carbon credit trading. Such banks tend to be established to comply with regulatory requirements, and are often established in advance of damage occurring in a given area;
- **Under a Systems Benefit Change Model,** a systems benefits charge is a fee levied on users designed to fund certain "public benefits" that are placed at risk in a more competitive industry. The use of these charges has been pioneered in the public utilities sector to assist low-income consumers and to fund renewable energy, research and development, energy efficiency, etc. Such charges could be levied in Abu Dhabi within various industry sectors to help support the protection and restoration of Blue Carbon ecosystems in the future.

This project component has sought to build local capacity primarily by involving relevant AGEDI and EAD personnel in the process of analysing current constraints to the development of standard Blue Carbon credits within Abu Dhabi and to articulating, with input from other project components, a number of alternative options to examine and evaluate, leading to the current focus of the financial analysis that follows. As a result of this engagement, AGEDI and selected EAD staff now have a more extensive understanding of the existing Blue Carbon standards and methodological issues, eligibility requirements and constraints, and a more detailed appreciation of the financial analysis that can be undertaken at present and in the future to support the development of alternative options.

Further to these recommendations, specific actions have been identified by the Blue Carbon Policy and ecosystem service reports, on the role of the National Communications and Greenhouse Gas Inventories, Nationally Appropriate Mitigation Actions (NAMAs), and the application of Marine Spatial Planning and Ecosystem-based Management.

Abu Dhabi Emirate has a great opportunity to use scientific based data and information to inform the development of this Specialised Fund and protect and manage their Blue Carbone ecosystems on a local level, setting an example at a regional and international level.

Recommended Next Steps

To further investigate and plan the development of a Specialised Fund and build an interim strategy for implementation the following actions are recommended:

- Convene a meeting of the primary stakeholders for the proposed Specialised Fund to discuss the financial, and other, analysis that could be conducted in the short-term to inform its establishment and operation. If stakeholders agree, form a working group to make recommendations regarding the structure, functions and other aspects of the Fund;
- Analyse the financial dimensions of an alternative test case, such as the development on Reem Island by Bunya LLC;
- Expand this analysis to include a small number of other developers operating in various sites; develop a case study of their experiences, comparing the current, business-as-usual, scenario to alternative, preferred future scenarios;
- As part of the planning process for the establishment of a Specialised Fund, reassess the rationale for the current policy regarding the permitting of and compensation for the destruction and/or gradation of Blue Carbon ecosystems within the Emirate. This process could be combined with the recommendation from the Ecosystem Services Assessment Report of focusing on improved marine spatial management in the 5 areas that have been identified as having high combined ecosystem services. The Fund could consider applying alternative options to the current practices for development projects in these areas, including potential support by developers for conservation of existing natural marine and coastal ecosystems instead of the establishment of new mangrove, and other Blue Carbon ecosystem, areas;
- Review the assumptions and estimates in the current preliminary financial feasibility assessment to develop a more appropriate/realistic model that can be used in the future to conduct financial analysis as more site-specific data within Abu Dhabi becomes available.

1 Introduction

1.1 Project Context

"Blue Carbon" refers to the functional attributes of coastal and marine ecosystems to sequester and store carbon. Blue Carbon ecosystems of the United Arab Emirates (UAE) include mangrove forests, salt marshes and seagrass beds. Another potential Blue Carbon ecosystem identified as a result of this project is cyanobacterial "blue-green algal" mats (hereafter called algal mats). When these ecosystems are destroyed, buried carbon can be released into the atmosphere, contributing to global warming. In addition to their climate related benefits, Blue Carbon ecosystems provide highly valuable *Ecosystem Services* to coastal communities. They protect shorelines, provide nursery grounds for fish and ss for a wide range of terrestrial and aquatic species, and support coastal tourism. They also have significant cultural and social values.

The Abu Dhabi Blue Carbon Demonstration Project aims to improve understanding of carbon sequestration and the additional services that coastal and marine Blue Carbon ecosystems provide in the Emirate and, in addition, contribute to the improved understanding of this relatively new concept on a regional and international level. The project will enhance local capacity to measure and monitor carbon in coastal ecosystems and to manage associated data. The project also identifies options for the incorporation of these values into policy and management, which can lead to sustainable ecosystem use and the preservation of their services for future generations.

1.2. International Context

The Blue Carbon concept has strengthened interest in the management and conservation of coastal marine ecosystems, supporting climate change mitigation efforts. However, there are still gaps in the understanding of blue carbon, and incentives and policies are needed to ensure more sustainable environmental management practices.

The experience and knowledge gained from the project will help guide other Blue Carbon projects and international efforts, such as the International Blue Carbon Initiative[1] and the Global Environment Facility's (GEF) Blue Forests Project, of which the Abu Dhabi Blue Carbon Demonstration Project is a key part. The *Abu Dhabi Blue Carbon Demonstration* project provides a carbon stock inventory for intertidal and subtidal natural Blue Carbon ecosystems, as well as planted mangroves, in an arid region, reducing gaps in the global database. Recognition of algal mats as a Blue Carbon ecosystem emphasises the importance of understanding coastal carbon cycling in arid regions of the world. The project also has helped develop Blue Carbon science and data management through the production of tools and the testing of methodologies that can be utilised and up-scaled to the international arena to enhance international Blue Carbon cooperation and training.

[1] http://thebluecarboninitiative.org/

1.3. Project Setting

In just over 40 years, Abu Dhabi has evolved from a small fishing community to the largest of the seven Emirates of the UAE. With the vision and direction from His Highness the late Sheikh Zayed Bin Sultan Al Nahyan, the environment has become an intrinsic part of the heritage and traditions of the people of the UAE. This national affinity to the sea has led to the initiation of the Abu Dhabi Blue Carbon Demonstration project in order to explore the values which coastal ecosystems provide the UAE, and to help preserve its environmental and cultural heritage. The project, commissioned by the Abu Dhabi Global Environmental Data Initiative (AGEDI) will run until the end of 2013.

1.4. Project Structure

The project is comprised of five components:

1) A **carbon baseline assessment** that has quantified the stocks of carbon for coastal ecosystems, and rate of carbon sequestration associated with mangrove afforestation;
2) A **geographic assessment** that has mapped Abu Dhabi's Blue Carbon ecosystems and provides a carbon analysis tool to support informed decision making;
3) An **ecosystem services assessment** that investigated the goods and services beyond carbon sequestration that Blue Carbon ecosystems provide Abu Dhabi;
4) A **policy component** that identifies the most suitable options for incorporating Blue Carbon and Ecosystem Services in Abu Dhabi's policy and governance frameworks; and
5) A **Blue Carbon and ecosystem services finance feasibility assessment** that recommends the most feasible policy and market options for implementing Blue Carbon projects in Abu Dhabi (subject of this report).

1.5. The Finance Feasibility Assessment Team

Frank Hicks, of Forest Trends, spearheaded the finance feasibility assessment with significant input from other project component members, particularly Gabriel Grimsditch and William Dougherty who led the Policy Component, and also Emma Corbett, Christian Neumann and Steven Lutz of GRID-Arendal. Steve Crooks and Tundi Agardy, who lead the Carbon Baseline and the Ecosystem Services Assessment components, respectively, also provided helpful contributions. In addition, Huda Petra Shamayleh, of AGEDI, and Maria Cordeiro and Eva Ramos, of EAD, also provided valuable guidance and insights regarding the analysis and reporting.

Frank Hicks is currently Manager of the Katoomba Group Incubator Initiative for Africa at Forest Trends. In this role, Frank is responsible for leading and strengthening the Incubator projects in East and West Africa and for developing a strategy for growth and coordination with other partner organisations' initiatives in the region. Frank also works as a consultant with a number of other organisations on sustainable business and agricultural development. Previously he was Vice President for Latin America with Bio-Logical Capital. Prior to working with Bio-Logical Capital, Frank was Director of the Business Development Facility at Forest Trends. He also was Director of the Sustainable Agriculture Program at Rainforest Alliance, and Vice President with Organic Commodity Products based in San José, Costa Rica. Frank has also worked as

Program Manager for TechnoServe in Ghana. He was the regional representative based in the Philippines for the Biodiversity Conservation Network and worked as a Program Officer with the Ford Foundation based in Nigeria and New York City. Frank earned a master's degree in Public Policy from Harvard University's Kennedy School of Government, with a focus on international development, and a bachelor's degree from Stanford University in Human Biology.

1.6. Linkages with other Project Components

This report builds on the findings of all the other project components, notably the Carbon Baseline and Ecosystem Services Assessments (which in turn are based on the Geographic Assessment component), and has close linkages to the Policy component. The recommendations from the Policy Component have largely determined the most feasible short to mid-term management options and the type of financial assessment that will be most relevant to support future decision-making. This document constitutes the finance feasibility assessment.

1.7. Capacity Building

Local capacity has been built in terms of the financial assessment component primarily by involving relevant AGEDI and EAD personnel in the process of analysing current constraints to the development of standard Blue Carbon credits within Abu Dhabi and to articulating, with input from other project components, a number of alternative options to examine and evaluate, leading to the current focus of the financial analysis that follows. As a result of this engagement, the AGEDI and EAD personnel have had the opportunity to build upon their existing understanding of: Blue Carbon standards and methodological issues; eligibility requirements and constraints; and, subsequently, gain a heightened appreciation of the financial analysis that can be undertaken at present and in the future to support the development of alternative options.

1.8. Report Organisation

This report summarises findings of the financial feasibility analysis of Blue Carbon and associated ecosystem services in Abu Dhabi. It is organised into the following sections:

1) Financial assessment of Blue Carbon and associated ecosystem services, including the current limitations to conducting such analysis;

2) Proposed alternative approaches to achieving the project's objectives; and

3) Conclusions, recommendations and next steps.

The major focus of this report is forward-looking. As such, it describes the type of analysis that could be conducted as additional information becomes available in the future, ideally via a second phase of the project.

1.9. Acknowledgements

Frank Hicks has prepared this *Finance Feasibility Assessment Report* document under the overall guidance of Dr. Fred Launay, Acting Director of AGEDI at EAD. Ms. Huda Petra Shamayleh and Ms. Jane Glavan of AGEDI and Ms. Emma Corbett from GRID-Arendal provided very helpful guidance regarding the institutional landscape and relevant policy and economic issues, in addition to facilitation of the stakeholder consultative meetings and the incorporation of stakeholder views to help inform the development of this document. While there were many EAD staff members who shared their knowledge and expertise during the course of this process, Ms. Maria Cordeiro and Ms. Eva Ramos were particularly helpful and generous with their time, guidance and assistance. Linwood Pendleton, of Duke University, also provided leading advice regarding some dimensions of financial analysis. Thanks is also due to the array of stakeholders whose input and advice have contributed to this financial feasibility analysis and associated findings and recommendations. Stakeholders consulted during this process in addition to EAD included representatives from: Municipality of Abu Dhabi City (ADM); Abu Dhabi Tourism and Cultural Authority; Abu Dhabi National Oil Company; Abu Dhabi Urban Planning Council; Critical Infrastructure and Coastal Protection Agency; Emirates Wildlife Society – World Wide Fund for Nature; Masdar; Mubadala Petroleum; New York University - Abu Dhabi; Tourism Development Investment Company; UAE Ministry of Environment and Water; UAE Ministry of Foreign Affairs - Department of Energy and Climate Change; and Zayed University.

2 Background and Context

2.1 Financial Assessment of Blue Carbon and Other Ecosystem Services

2.1.1 Objectives

The Financial Feasibility Assessment Component of the Abu Dhabi Blue Carbon Demonstration Project was originally designed to estimate the financial value of Blue Carbon and associated ecosystem services in Abu Dhabi.

Such financial analysis typically compares the projected economic benefits of Blue Carbon credits, and other related ecosystem services, to the costs required to develop the credits and payments, to determine if a given project is financially viable.

Eligibility requirements for developing such Blue Carbon credits according to existing international standards, combined with the prevailing low demand and prices for international carbon credits, however led to the conclusion that alternative approaches to the promotion of Blue Carbon and associated ecosystem services within Abu Dhabi may be more effective. Subsequently, the focus has been on estimating the financial value of the combined ecosystem services that the conservation of marine and coastal ecosystems in Abu Dhabi could generate to help inform the establishment of a Specialised Fund to promote the provision of such ecosystem services in the future.

2.1.2 Methodologies

Typically net present value (NPV) calculations are employed in the analysis of Blue Carbon credits and other ecosystem services. This involves the use of an appropriate discount rate to express projected future benefits and costs in current financial values. In general terms, a higher discount rate is associated with high-consumption and/or rapidly growing economies, or with the higher risks and shorter-time preferences that tend to prevail in developing countries. A higher discount rate results in a lower NPV.

Recommendations for the type of financial analysis that could be conducted in a future planning phase are described in more detail in section 4. This includes the comparison of future projected costs and benefits of various scenarios.

2.2 Focus of the Financial Feasibility Assessment

The following observations and recommendations emerged from the initial assessments regarding the financial feasibility of developing international Blue Carbon credits:

1) Abu Dhabi Blue Carbon initiatives are unlikely to meet international carbon credit standards (both for the regulatory market, which is based on the Clean Development Mechanism standard and methodologies, and; the voluntary markets, where there are several competing standards, however currently few approved methodologies for Blue Carbon Credits), due to:
   a. The lack of a national definition of "forest"; this precludes compliance with existing Blue Carbon methodologies;
   b. The challenge of demonstrating " additionality" i.e. that mangrove afforestation (or wetland restoration) would be motivated primarily by the offer of international carbon finance, when the Emirate has a stated, and enforced, compensation policy of mangrove afforestation. There are also numerous examples of other actors already committed to planting mangroves without regard for such financial incentives;
   c. State ownership of the vast majority of land within the Emirate, which makes the task of meeting additionality eligibility requirements all the more challenging;
   d. The lack of existing standards and Blue Carbon methodologies for avoided deforestation and degradation of mangroves, or restoration of seagrass.

2) As the total areas for the type of ecosystems that could be covered under existing Blue Carbon methodologies, i.e. mangroves and salt marsh (on the assumption that these could meet eligibility requirements) are: relatively small; the carbon stocks and sequestration rates in these are on the low end of the international ranges; and that demand and price for international carbon credits are currently low, the costs of developing Blue Carbon credits are likely to significantly exceed the potential revenue that might be obtained;

3) The combined value of other marine and coastal ecosystem services will be significantly higher than the value of Blue Carbon stocks and annual carbon sequestration volumes: these other services include shoreline buffering/nature based infrastructure, beach production and erosion control; water quality maintenance; support to fisheries (in particular recreational fishing); tourism and recreation; and cultural and intrinsic values of Blue Carbon ecosystems and associated biodiversity;

4) The future value of several of these other ecosystem services, notably shoreline buffering/nature based infrastructure, beach production and erosion control, is likely to increase significantly given projections regarding future rises in sea level and more extreme and erratic weather events;

5) Unlike Blue Carbon, which has an international market, the value of the non-carbon ecosystem services is applicable only at a local or national level, and is also based on the willingness of potential buyers to pay for such services, which is still an untested concept.

Based on these observations, during the mid-term review meetings, the following four options were recommended as potential alternative approaches for promoting a Blue Carbon Policy, based in large part upon the valuation of the carbon sequestration and other ecosystem services that Blue Carbon ecosystems within Abu Dhabi provide at an international, regional, national and local level:

1) **Focus on Blue Carbon Ecosystem Services at a local level in the short-term and Blue Carbon at an international level in the medium-term**
Assess Blue Carbon and other ecosystem services values with the aim of: In the short-term (over the next 3 years) informing robust marine and coastal planning and development activities; and over the medium-term (3-5 years) position Blue Carbon to be included into future National Communications on Greenhouse Gas Inventories or as part of future Nationally Appropriate Mitigation Actions (NAMA)/Economic Diversification Plan initiatives.

2) **Focus on Blue Carbon Ecosystem Services at a local level**
Establishment of a Specialised Fund that property developers and others could contribute to. This fund could support a range of activities associated with blue carbon ecosystems and associated ecosystem services, such as mangrove restoration and improved protection of seagrass.

3) **Focus on Blue Carbon and Blue Carbon Ecosystem Services at a local level**
Establishment of a national Blue Carbon ecosystem services payment system, akin to those in place in Costa Rica, Mexico, etc., where Blue Carbon could either:

   i. Be merged with other ecosystem services, via a "blended" approach, or;
   ii. Be separated from these, via a "stacked" approach

   Either system could be developed using a "jurisdictional, nested" approach, versus a project-by-project, approach and could combine avoided destruction of mangroves, seagrass and other ecosystems with restoration.

4) **Focus on Blue Carbon at an international level**
Develop a Blue Carbon offset policy with a focus on international project development (this could be combined with the above options). Such a policy would likely have close connections to UAE's foreign aid program and/or to the operations of Abu Dhabi/UAE entities, for example oil and gas, airline and other entities.

AGEDI subsequently requested that the project team, and notably the Policy and Financial Feasibility Assessment components, focus on the development of Option 2, the establishment of a Specialised Fund, and, secondarily, Option 1, separating the marine spatial planning dimension, which could be developed within Abu Dhabi in the short-term, from the international reporting dimension, which could be developed for UAE by national organisations in the medium-term.

This report focuses only on Option 2, as the national-level dimensions of Option 1 regarding marine spatial planning and the potential for including Blue Carbon valuations as part of future Nationally Appropriate Mitigation Actions (NAMA)/Economic Diversification Plan initiatives are addressed by other project components, notably the Policy and Ecosystem Services components. Even so, the financial feasibility analysis presented in this report does address some of the underlying issues that would be taken into consideration as part of future marine spatial planning. The potential international dimensions of this option will be determined in the future, and are likely to focus on national and international carbon accounting protocols, which are currently difficult to assess in terms of financial feasibility.

It is worth underscoring that the nature of a demonstration project, such as this one, is to explore new areas and to determine which approaches are likely to be most feasible. The decision to make a mid-course adjustment in terms of the focus for ongoing analysis is fully in keeping with the objectives of such an innovative undertaking and is considered to have ensured the delivery of focused project outcomes.

3 Financial Assessment Methodology for Blue Carbon and Ecosystem Services in Abu Dhabi

3.1 Overview

The financial assessment described in this section is based on the total area of Blue Carbon Ecosystems in Abu Dhabi, provided by the Geographic Assessment Component, and the estimated carbon stocks and sequestration rates and valuation of other ecosystem services, provided by the Baseline Carbon Assessment and Ecosystem Services Assessment, respectively. It is also based on estimations of the associated activities and costs likely to be incurred for such ecosystem services to be provided in the future.

The analysis utilises the approach and methodologies presented by Murray, et al. in *Green Payments for Blue Carbon – Economic Incentives for Protecting Threatened Coastal Habitats*.[2] This methodology is used to investigate whether monetary payments for Blue Carbon, carbon captured and stored by coastal marine and wetland ecosystems, can alter economic incentives to favor protection of coastal ecosystems such as mangroves, seagrass meadows, and salt marshes, to retain rather than emit Blue Carbon and preserve biodiversity as well as a variety of other ecosystem services at local and regional scales. While this approach focuses on the Blue Carbon and other ecosystem services that can be realised by the avoided conversion of marine and coastal ecosystems, the financial assessment presented here also includes some indicative analysis of the value of Blue Carbon sequestration as a result of projected mangrove afforestation in Abu Dhabi.

The approach used by Murray et al., is highly relevant given the nature of the proposed marine spatial planning and the activities that a Specialised Fund could support. In addition, this approach can also be utilised to assess the combined ecosystem services value of the entire Blue Carbon environment in Abu Dhabi, and given that this area is relatively small compared to other significant Blue Carbon nations, doing so would seem to be strategic in helping to make the strongest case for the benefits that the whole Blue Carbon environment generates.

The use of this credible methodology, which is well regarded within the international Blue Carbon community, will also allow for estimations of financial values that are based on accepted underlying assumptions and analysis. This can also help to ensure consistency with other regions where this approach is likely to be used in the future and thereby help to facilitate comparisons between Abu Dhabi and other regions, and the sharing of experiences and lessons learned.

[2] Murray, Brian C., Pendleton, Linwood, Jenkins, W. Aaron, and Sifleet Samantha., 2011. Green Payments for Blue Carbon – Economic Incentives for Protecting Threatened Coastal Habitats. Nicolas Institute Report, Duke University, USA.

3.2 Economic Models

3.2.1 Estimation of the Annual Green House Gas (GHG) Benefit Flux in Areas Protected from Conversion

The economic model for avoided conversion of Blue Carbon ecosystems that Murray et al., utilise first quantifies Green House Gases (GHG) benefits as emissions that would be avoided and sequestration maintained through a Blue Carbon project that protects one of the focal coastal ecosystems. The GHG benefit fluxes of Blue Carbon avoided-conversion projects take this general form:

$$\textbf{GHG Benefit Flux}_{it} = \textbf{CS}_{it} + \textbf{AvCO2}_{it} - \textbf{M}_{it}$$

where:
i is the ecosystem type;
t is time, expressed in years;
CS is the annual carbon sequestration rate, which continues as the ecosystem is retained;
AvCO2 is the carbon dioxide (CO_2) emissions avoided from the ecosystem's conversion;
M represents the annual methane emissions that continue to be emitted as the ecosystem remains intact.

Methane emissions reduce the GHG benefits of protecting ecosystems but tend to be small relative to the magnitude of the carbon sequestration rate and especially the CO_2 sequestration rates in conserved saltwater ecosystems. All quantities are expressed in CO_2 equivalent units.[3]

GHG benefits flows are monetised by multiplying the annual GHG fluxes by a stream of expected carbon prices (US$/tCO2) over a time horizon of length *n*. The resulting cash flow streams are then discounted using a financial discount rate (d)[4] to arrive at present value estimates of the Blue Carbon benefits of an avoided conversion project, as expressed in the following formula:

$$\textbf{Blue Carbon Value}_i = \sum_{t=0}^{n} \frac{\textbf{GHG Benefit Flux}_{it} + \textbf{Price (\$/t CO2e)}_t}{\textbf{(1 + d)}_t}$$

A second comparison incorporates the estimated values of other Blue Carbon ecosystem services

3. All carbon (C) fluxes are multiplied by 3.67 to convert to CO2 equivalent units (CO2e). All methane fluxes are multiplied by 25, which is the IPCC global warming potential value for methane to make one metric ton of methane equivalent to one metric ton of CO_2 in terms of impact on global warming.

[4] In general terms, a high discount rate (such as 10%) is usually associated with a high consumption society and/or rapidly growing economy – were the concerns tend to be more about short-term benefits; the associated NPV is smaller compared to using a lower discount rate (such as 5% or less), which tends to be more relevant in a low consumption or more slowly growing economy, where concerns tend to be more about longer-term benefits.

(ES) provided by intact ecosystems. These ES values will likely vary across ecosystems and regions, and could be greater than the Blue Carbon value. They show that the social returns of protecting coastal ecosystems extend beyond simply the Blue Carbon value.

The overall ES values of the ecosystems are compared to the protection costs. Thus, avoided conversion projects would be economically justified in a given habit type if:

Blue Carbon Value + Other ES Values > Protection Costs

This comparison can be used to ascertain whether the total ecosystem value (Blue Carbon payments plus other ES values) is great enough to exceed the various costs of protecting the ecosystem. This analysis allows consideration of the effect that other incentives could have in combination with payments for Blue Carbon.

More specifically, under this approach, these costs consist of the initial establishment costs of protected areas, the ongoing annual management costs of these areas, and the opportunity cost of protecting the various marine and coastal ecosystems, versus using these for commercial purposes. Like the estimated benefits, these costs are projected into the future and discounted to convert the net difference into present monetary values.

Net present value (NPV) will be used to determine the viability of the project. The general formula for NPV is:

$$\mathbf{NPV} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+d)_t}$$

where:
B is the benefits of Blue Carbon ecosystem conservation;
C is the costs of blue carbon ecosystem conservation;
t is time, expressed in years;
d is the discount rate; and
n is the duration of the conservation activities.[5]

[5] In conducting the analysis in this report, the latter NPV formula is used, where B is the combined blue carbon and other ecosystem services i.e. the "Blue Carbon Values"; the associated costs are then deducted from this and that total is then discounted over time. These projected benefits and associated costs are only discounted once.

3.3 Assumptions

The following analysis using this approach has been based on several major assumptions. As a result of the Abu Dhabi Blue Carbon Demonstration Project, decision-makers now have a much more detailed and accurate understanding of Abu Dhabi's Blue Carbon ecosystems, particularly regarding the total area and carbon stocks of the various ecosystem types. As a result, for a number of important factors and values it is still necessary to use data, analysis and estimations/extrapolations from other regions, where the underlying physical, environmental and socio-economic conditions and dynamics tend to be quite different from those in Abu Dhabi. The sources of data and the justification of their use, applicability as well as recognized differences, are discussed in detail within the *Ecosystem Services Assessment Report* and have not been repeated here to ensure that they are considered in context. Therefore, it is important to recognise that this analysis is preliminary and indicative only, rather than definitive.

However, more authoritative financial feasibility analysis of this type will be possible as additional information becomes available that explicitly measures the nature and quality of the various Blue Carbon ecosystems, and the interactions between them, as these relate to the provision of various ecosystem services.

4 Blue Carbon Financial Analysis

4.1 Financial Analysis Data

4.1.1 Carbon Benefits

The carbon benefits are determined based on the results of the Baseline Carbon Assessment and the Geographic Assessment that are presented in Table 1. Table 2 shows this information in greater detail and compares above and below ground carbon storage. These figures have been used as a basis for the financial analysis. These are discussed in detail within the *Spatial Data Assessment Report* and the *Baseline Assessment Report: Coastal Ecosystems in Carbon Stocks* respectively.

Table 1 Blue Carbon ecosystem extent and associated carbon stock estimates

Ecosystem	Extent (ha)	Median C (Mg/ha^{-1})	Total C (Mg)	Total C0$_2$ (Mg)
Algal flat	10,930	129.6	1,416,729	5,194,674
Mangrove	14,117	98.3	1,387,576	5,087,778
Salt marsh	4,770	69.2	329,840	1,209,412
Seagrass	158,262	51.6	8,169,516	29,954,893
Total	**188,079**		**11,303,661**	**41,446,758**

Table 2 Summary of carbon stocks in intertidal ecosystems

C (Mg ha^{-1})		Seagrass	Algal flat	Mature mangrove	Planted mangrove	Salt marsh	Coastal sabkha
Soil[a]	range	1.9 - 109.0	18.6 - 153.3	36.7 – 155.3	50.9 – 175.8	29.5 - 163.7	51.0 - 120.5
	mean	49.1	96.3	102.3	102.3	80.4	86.1
	median	51.2	106.5	87.8	87.8	71.1	94.6
Above-ground biomass	range	no data	N/A	4.4 - 90.8	0.02 - 5.2	0.9 - 3.8	N/A
	mean	no data	N/A	32	1.9	1.9	N/A
	median	no data	N/A	26.1	1.2	1.7	N/A
Below-ground biomass	range	no data	N/A	2.5 – 12.1	0.02 - 3.9	no data	N/A
	mean	no data	N/A	8.7	1.4	no data	N/A
	median	no data	N/A	10.7	0.9	no data	N/A
Total plant biomass	range	0.3 - 1.1	N/A	7.0 – 102.9	0.04 - 9.2	no data	N/A
	mean	0.4	N/A	40.7	3.4	no data	N/A
	median	0.4	N/A	34.6	2.1	no data	N/A
Below-ground stock	range	1.9 - 109.0[b]	18.6 - 153.3	48.8 – 165.4	52.4 – 178.6	29.5 - 163.7[b]	51.0 - 120.5
	mean	49.1[b]	96.3	91.2	103.7	80.4[b]	86.1
	median	51.2[b]	106.5	83.9	87.9	71.1[b]	94.6
Total carbon stock	range	2.2 - 109.3	18.6 - 153.3	77.9 – 198.4	54.4 - 182.3	30.5 - 165.4[b]	51.0 - 120.5
	mean	49.6	96.3	123.1	105.6	82.3[b]	86.1
	median	51.6	106.5	123.3	88.1	72.4[b]	94.6

[a] = data restricted to top 100cm of soil; [b] = totals do not include below-ground biomass.

4.1.2 Estimating Carbon Sequestration Rates

Although carbon sequestration rates were not measured directly during the Abu Dhabi Blue Carbon Demonstration Project, the average sequestration rate was estimated from the annual growth in carbon, measured in megagrammes per hectare per year (Mg ha-1)[6] at two sites which supported planted mangroves of various and known ages, as shown in Table 3 below (Eastern Mangroves and Abu Al Abyad). This results in a rate of 0.63 C/ha/yr (i.e. the average of 0.92 in the Eastern Mangrove sites and 0.35 in the Abu Al Abyad sites). The CO_2 of sequestration per year is then obtained by multiplying this amount by 3.67. The total average CO_2 sequestration rate is therefore 2.31 metric tons of CO_2/ha/yr.

[6] One megagramme of carbon per hectare per year equals one metric ton of carbon/ha/yr.

Annual carbon sequestration data for salt marsh and seagrass are not currently available in Abu Dhabi, however these have been estimated in other regions. For coastal marshes, the values in other sites range from 0.01 to 62.81 metric tons of CO_2/ha/yr, with most estimates falling below 8 metric tons of CO_2/ha/yr. For seagrass annual carbon sequestration values range from -77 to 85 metric tons of CO_2/ha/yr, with most estimates falling below 7 metric tons of CO_2/ha/yr (and with a large number of estimates showing annual net losses of carbon).[7] Seagrasses can be physically destroyed by dredging activities or hurricanes and this can result in a release of carbon stored in the sediments. More commonly, seagrasses are impacted by water quality issues that can lead to die-offs and release of sequestered carbon (Short and Wyllie- Echeverria 1996).

For the purposes of the financial analysis it is assumed that mangrove ecosystem sequesters carbon at a slightly higher rate than in the sampled sites on average in Abu Dhabi, and so an average figure of 3 metric tons of CO_2/ha/yr is used. It is also assumed that salt marsh sequesters 2 metric tons of CO_2/ha/yr and that seagrass sequesters 1 metric ton of CO_2/ha/yr. These relatively low estimates are used based on input from the project's carbon baseline assessment team. The low rates parallel the low carbon sequestration rates for mangrove ecosystem compared to many other mangrove sites in other locations internationally.

[7] From Sifleet, S., Pendleton, L., Murray, B. 2011. State of the Science on Coastal Blue Carbon: A Summary for Policymakers. Nicolas Institute Report, Duke University, USA.

Table 3 Summary characteristics and carbon stocks of planted mangroves

Site	Density (ha^{-1})	Crown Area ($m^2 ha^{-1}$)	Basal Area ($m^2 ha^{-1}$)	Tree biomass ($Mg ha^{-1}$)		C ($Mg ha^{-1}$)
				Above-ground	Below-ground	
Eastern Mangrove 3 yr	5570.4 ± 435.9	389.9 ± 42.3	0.3 ± 0.04	0.8 ± 0.1	0.7 ± 0.1	0.7 ± 0.1
Eastern Mangrove 7 yr	4933.8 ± 464.0	5389.6 ± 906.5	2.7 ± 0.4	7.7 ± 1.2	7.2 ± 1.1	6.5 ± 1.1
Eastern Mangrove 10 yr	28488.7 ± 4781.3	7006.3 ± 1544.7	3.8 ± 0.9	10.9 ± 2.5	10.1 ± 2.3	9.2 ± 2.3
Abu Al Abyad 3 yr	625.0	15.9 ± 1.4	0.02 ± 0.002	0.05 ± 0.004	0.05 ± 0.004	0.04 ± 0.004
Abu Al Abyad 5 yr	830.7	139.4 ± 14.4	0.2 ± 0.02	0.4 ± 0.06	0.4 ± 0.1	0.4 ± 0.1
Abu Al Abyad 10 yr	1463.9	934.3 ± 102.5	1.4 ± 0.2	4.1 ± 0.5	3.8 ± 0.5	3.5 ± 0.5
Abu Al Abyad 15 yr	889.9 ± 424.2	4458.2 ± 1017.7	1.9 ± 0.4	5.8 ± 1.2	5.4 ± 1.1	no data

4.2 Financial Analysis of Blue Carbon Ecosystems

4.2.1 Estimating Avoided Carbon Dioxide (CO_2) Rates

To estimate avoided CO_2 emissions it is important to note that there are various factors and dynamics that affect these. For example, if mangrove, or other coastal Blue Carbon ecosystems, are covered or in-filled, then the belowground carbon will likely be trapped and not released into the atmosphere, whereas if these areas are drained and not covered CO_2 would be released. Similarly, if seagrass is dredged, CO_2 from that area would be released, however if the seagrass in a given area dies, due to high seawater salinity or temperatures for example, it is not clear that the belowground carbon would be released, or, if so, what percentage and at what rate. As identified as part of the Abu Dhabi Blue Carbon Demonstration Project, the presence of coastal sabkha is also important, as this ecosystem appears to cover historic Blue Carbon ecosystems. Therefore, the excavation of sabkha would also result in a net release of CO_2.

In general the dynamics regarding GHG emissions from seagrass are less well understood than for other ecosystems. Furthermore, for the mangrove and salt marsh areas that are drained, rather than covered, the majority of the CO_2 emissions would occur in the first year (primarily the above ground carbon stocks). After the first year there is a significant decrease in the volume per hectare that would be released over time (the below ground carbon stocks);[8] for seagrass that was dredged the emissions would be generated from below ground stocks and it is likely that all of the CO_2 would be released in Year 1.

Based on the data presented in Table 2, the estimated total avoided CO_2 emissions can be calculated for as follows:

1) **Year 1 Emissions:**

The CO_2 values are calculated by multiplying the carbon values by 3.67 (the difference in the molecular weight of CO_2 compared to C);

2) **Average Annual CO_2 Emissions after year 1:**

The annual CO_2 emissions are calculated by multiplying the carbon values by 3.67 and then dividing the total by 25 (the number of years for the financial analysis).

The totals are presented in Table 4.

Table 4 Total avoided carbon dioxide (CO_2) emissions for Blue Carbon ecosystems

Ecosystem	Year 1 CO_2 Emissions (metric tons)	Total and average CO_2 Emissions per year (metric tons CO_2/yr)
Mangrove	30 C x 3.67 = **110.1 CO_2**	(90 C x 3.67)/25 = 333.3 CO_2 /25 = **13.21 CO_2/yr**
Salt marsh	2 C x 3.67 = **7.35 CO_2**	(80 C x 3.67)/25 = 293.60 CO_2/25 = **11.74 CO_2/yr**
Seagrass	50 C x 3.67 = **183.5 CO_2**	0

[8] The average stocks are divided by 25, the number of years for the NPV analysis, to arrive at an average annual rate, though it is likely that the carbon would be released as carbon dioxide sooner than over such a long period.

4.2.2 Estimation of the Annual GHG Benefit Flux in Areas Protected from Conversion

The Blue Carbon sequestration and avoided CO_2 emission rates are a function of the total area of the various ecosystem types and the percentage of these areas that would be protected from conversion.

$$\textbf{GHG Benefit Flux}_{it} = \textbf{CS}_{it} + \textbf{AvCO2}_{it} - \textbf{M}_{it}$$

where:
i is the ecosystem type;
t is time, expressed in years;
CS is the annual carbon sequestration rate, which continues as the ecosystem is retained;
AvCO2 is the CO_2 emissions avoided from the ecosystem's conversion;
M represents the annual methane emissions that continue to be emitted as the ecosystem remains intact.

Coastal sabkha and algal mats are not included in the analysis, as the data for these ecosystems are not as comprehensive, with the exception of soil and below ground total Carbon stocks. Methane emissions are also excluded from the calculations, as this data has not been collected during the current phase of the project. A critical assumption in this model is the percentage of the focal ecosystems that would be protected in the future. Abu Dhabi already has several marine and coastal protected areas and there is good potential to expand this area in the future. The analysis is based on the following assumed future protection:

- 50% of the current mangrove ecosystems
- 50% of the current salt marsh ecosystem
- 20% of the current seagrass ecosystem

While these percentages are used for illustrative purposes, and are quite arbitrary, it is worth noting that at the 2003 World Parks Congress, the International Union for the Conservation of Nature (IUCN) members called for a global system of marine protected area (MPA) networks to exist by 2012, including "strictly protected areas" amounting to at least 20-30% of each ecosystem.

In light of the overall small size of salt marsh and mangrove ecosystems in Abu Dhabi, seeking to protect at least 50% of these areas would seem reasonable, while protecting 20% of the seagrass ecosystem would be in keeping with IUCN recommendations.

For the purposes of the financial analysis, the areas used do not include currently protected sites within Abu Dhabi.[9]

[9] These assumptions presume that in the absence of protection the total area of each ecosystem type would be completely deforested or degraded, which is probably quite unlikely, especially regarding seagrass, as it seems improbable that without protection 20% of this vast area could be dredged; still some estimates need to be made as the basis for this type of analysis – the percentage levels can be adjusted in the future based on new information and decision making.

The calculations in Table 5 illustrate the outcomes of the analysis. Estimations have been based on the available information and judgments made by the team members, with input from other external experts who have also undertaken similar analysis previously.

Table 5 Estimated annual GHG benefit flux in areas protected from conversion

Ecosystem Type	Total Area in Ha.	% of Total Area Protected	Est. annual Carbon Seq. rates (CS)/ha	Est. initial avoided CO_2 emissions/ha ($AvCO_2$) Year 1	Est. annual avoided CO_2 emissions/ ha	Total annual CS (CS/ha)	Total $AvCO_2$ that would be released in Year 1	Total annual $AvCO_2$
Mangrove	14,117	50%	3	110	13.21	21,176	776,435	93,243
Salt marsh	4,770	50%	2	7.35	11.74	2,385	17,530	27,800
Seagrass	158,262	20%	1	183.50	0	15,826	5,808,215	0

4.2.3 Calculating the potential financial value of Blue Carbon in Abu Dhabi

The annual carbon values as described within Table 5 can also be multiplied by a range of prices for temporary carbon credits[10] that could be available in the international regulatory and voluntary carbon markets to arrive at the total revenue that could be obtained. For this analysis three prices are used reflecting the current low international demand for such credits: US$2, US$5, and US$10 per metric ton of CO_2. These represent the “low”, “medium” and “high” ranges under prevailing conditions. The total financial benefits in future, versus discounted present terms, are shown in Table 6.

[10] Carbon credits associated with afforestation and reforestation or avoided deforestation and degradation under the Clean Development Mechanism and various voluntary market standards are temporary credits, and have a lower market price than permanent credits associated with other types of credits, such as energy efficiency and energy switching credits.

Table 6 Potential financial benefits that could be generated from Blue Carbon Ecosystems in Abu Dhabi under various carbon price scenarios

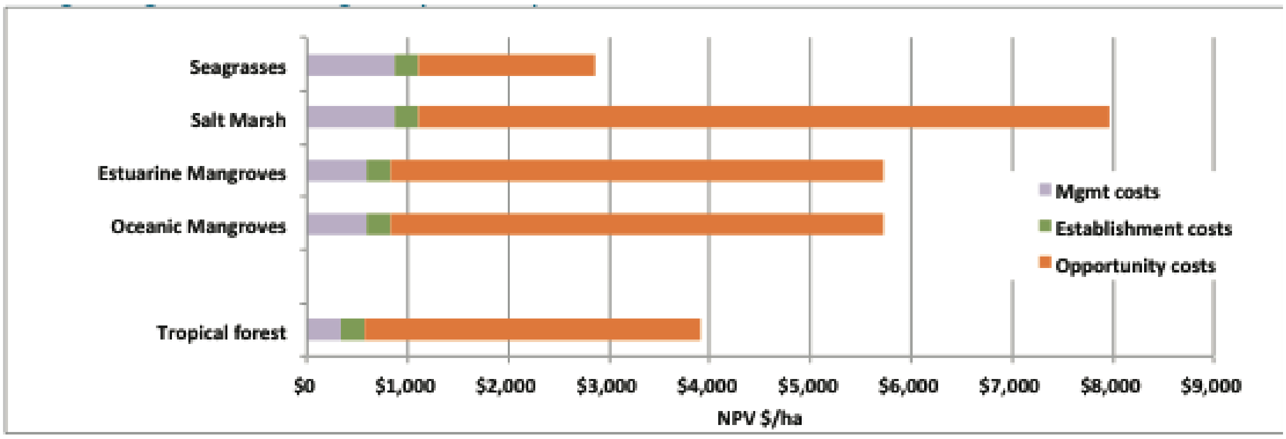
Ecosystem type and estimated carbon price per metric ton of carbon	Financial value of annual carbon sequestration rate (over 25 years) CS – 25 years (US$)	Financial value of the carbon dioxide emissions avoided from ecosystem conversion (Year 1 + 24 years) $AvCO_2$ (US$)	Total Financial Value – 25 years (US$)
Mangrove (US$2/MT)	1,058,755	6,028,524	7,087,291
Mangrove (US$5/MT)	2,646,938	15,071,309	17,718,247
Mangrove (US$10/MT)	5,293,875	30,142,618	35,436,493
Salt marsh (US$2/MT)	238,500	1,379,770	1,618,270
Salt marsh (US$5/MT)	596,250	3,449,426	4,045,676
Salt marsh (US$10/MT)	1,192,500	6,898,851	8,091,351
Seagrass (US$2/MT)	1,582,620	11,616,431	13,199,051
Seagrass (US$5/MT)	3,958,550	29,041,077	32,997.627
Seagrass (US$10/MT)	7,913,100	58,082,154	65,995,254
Total ecosystem (US$2/MT)	2,880,220	19,024,725	21,904,945
Total ecosystem (US$5/MT)	7,199,738	47,561,812	54,761,549
Total ecosystem (US$10/MT)	14,399,475	95,123,623	109,523,098

As illustrated in Table 6, under the most optimistic scenario the total value of potential financial benefits of Blue Carbon in Abu Dhabi, based on the prevailing international prices of temporary carbon credits, is estimated at approximately US$110 million in future, non-discounted, terms, over a 25-year period.

4.2.4 Estimated costs of areas protected from conversion

Murray et al., developed a range of costs for the establishment and management of protected areas in different regions of the world, and also made observations about the factors that determine the valuation of opportunity costs for blue carbon ecosystems in terms of the forgone commercial activities due to protection. This information is presented in Figure 1.

Figure 1 Costs of protection (PV US$/ha, 25-year horizon, 10% discount rate) for the focal coastal ecosystems and tropical forest. Average costs across each ecosystem type are presented for each cost category. For mangroves, averages are calculated using mangrove area weights by Country.



Source: Murray et al., Green Payments for Blue Carbon

In the absence of specific information regarding these costs in Abu Dhabi, the financial analysis is based on a number of major assumptions, including:

- The average establishment and annual management costs for the protection of different ecosystems (these costs are likely to vary significantly in remote marine areas versus coastal and near shore environments)
- The average opportunity cost of coastal and marine ecosystems (it is not practical within the Abu Dhabi Blue Carbon Demonstration Project to estimate this for various sites)[11]

Table 7 details these estimates, with a brief justification based on comparisons used by Murray *et al*.

[11] Coastal land with alternative uses for various forms of property development in urban and resort areas, and industrial development sites, will have a high opportunity cost, whereas other coastal areas not approved for such development, particularly in more remote areas, will have a much lower opportunity costs; the opportunity cost for seagrass, by far the largest ecosystem area, is probably quite low on average, but this estimate has major bearing on the analysis given the total area involved.

Table 7 Establishment and management costs for the protection of different Blue Carbon Ecosystems as well as estimated opportunity costs

Type of Cost	Estimate Used	Justification
Protected Area Establishment Costs	US$300/ha for all ecosystem except seagrass; US$150/ha for seagrass	Murray et al., use US$232/ha for all ecosystem types; this is adjusted higher for Abu Dhabi coastal areas due to high development standard and costs; it is lower for seagrass as the establishment costs should be lower than for terrestrial sites
Protected Area Annual Management Costs	US$100/ha/year	Murray et al., use US$25/ha per year for less developed countries, US$50 and US$100 for various emerging countries, and US$250/ha/yr for the wealthiest/most developed countries and small island states: US$100 /ha/yr seems to be a reasonable "midpoint"
Average Opportunity Costs	Value for mangrove and saltmarsh: US$50,000/ha; seagrass US$50/ha	Murray et al., use a very wide range of potential values; the opportunity cost used here is a very rough estimate of an average value between high value and lower value coastal and near shore regions

Other important assumptions regarding the estimates outlined in Table 7 include:

- The average protected area establishment and annual management costs used are on the lower end of the international range provided by Murray et al., primarily as the access to these areas in Abu Dhabi is relatively easy compared to many other countries (given the relatively short distances involved) and also given the Emirate's high level of infrastructure, telecommunications and use of remote sensing technologies;
- Annual management costs are assumed to include regular monitoring of protected areas;
- For opportunity costs, the financial assessment assumes an annual forgone rental fee as a percentage of the estimated opportunity cost (5%), rather than a one time payment in the first year of the model;
- The estimated benefits and costs are projected over a 25-year period, and then discounted, using two discount rates (10% and 5%), to be consistent with the approached used by Murray et al., though that analysis only uses a 10% discount rate.

Estimated total costs are detailed in Table 8.

It is important to note that the estimated future benefits and costs do not make provision for inflation.

Table 8 Total (estimated) costs of protecting Blue Carbon ecosystems from conversion

Ecosystem Type	Area Protected (ha)	Establishment Costs – Yr 1 (US$)	Management Costs – 25 Yrs (US$)	Opportunity Costs – 25 Yrs (US$)	Total Costs (US$)
Mangrove	7,059	2,117,550	17,646,250	441,156,250	460,920,050
Salt marsh	2,385	715,500	5,962,500	149,062,500	85,857,135
Seagrass	31,652	4,747,860	79,131,000	1,978,275	155,740,500
TOTAL	41,096	7,580,910	102,739,750	592,197,025	702,517,685

As is evident, even under the most optimistic scenario for the estimated value of the carbon ecosystem service benefits (US$10/MT/$CO_2$), the total of US$110 million is much less than the estimated total future, non-discounted, costs of US$703 million.

The assumptions regarding the opportunity costs of the various ecosystems, the total area that would be protected from conversion, and the annual management costs are the most critical, and these need to be analysed in more detail in the future. It is recommended that this activity be undertaken in conjunction with government agencies, such as Critical Infrastructure and Coastal Protection Agency (CICPA), as well as EAD.

4.2.5 Estimated Net Present Value (NPV) of Blue Carbon for Avoided Conversion

Based on these estimated benefits and costs and assumptions, the NPVs using the stated range of carbon prices and two discount rates (10% and 5%) over a 25-year period are presented in Table 9.

Table 9 Estimated Net Present Value (NPV) of Blue Carbon using a range of carbon prices and 2 discount rates.

Price/MT CO_2 (US$)	Net Present Value (NPV) 10% discount rate (US$)	Net Present Value (NPV) 5% discount rate (US$)
US$ 2	(244,179,557)	(381,609,319)
US$ 5	(221,633,345)	(355,529,773)
US$ 10	(184,056,196)	(312,063,616)

Under all these price and discount rate scenarios, the NPV values are very significantly negative, as the estimated costs dramatically exceed the estimated values. Even under the best-case scenario (US$10/MT/CO2 and a discount rate of 10%), the NPV is negative US$184 million.

4.2.6 Estimated Blue Carbon Benefits in Planted Mangrove Areas

The total area of mangrove plantations that already exists in Abu Dhabi, as a percentage of the total natural mangrove area (14,117 ha), and the annual area that is afforested, on average, each year, requires further clarification (please refer to the *Spatial Data Assessment Report).* Mangrove planting is being implemented by a number of different organisations within the Emirate, both on a voluntary basis and in compliance with compensation requirements, and it does not seem that the total figures are currently complied by a single agency. This was recognised as part of the *Abu Dhabi Blue Carbon Policy* Assessment where support for continued collaboration was advocated.

For the purposes of this analysis, it is assumed that a total of 5,000 ha of new mangrove areas will be established over the 25-year time period, i.e. a total of 200 ha per year on average. Assuming that the average planting density of mangroves would be based on what seems to be the prevailing practice of using a 2-meter by 2-meter spacing pattern, this results in an average of 2,500 mangroves per hectare (ha). Therefore, a total of 12.5 million mangrove seedlings would be planted, or 500,000 seedlings on average per year.

Given the data on carbon sequestration for planted mangroves (Table 3), which sampled 7 different mangrove areas, with mangroves of different, known ages in two sites (Eastern Mangroves and Abu Al Abyad), the average carbon sequestration rate is 0.64 C (Mg ha-1) per year, or multiplying this by 3.67, 2.31 metric tons of CO_2 per ha/year. As in previous analysis, this rate has been increased to 3 metric tons of CO_2 per ha/year (on the assumption that the average growth rate of mangroves would be higher than in the Abu Al Abyad mangrove site).

While most mangrove systems contain significant below soil carbon stocks, in the mangrove plantation sites that were sampled during the Carbon Baseline Assessment there was no discernable difference in below ground stocks over the growth period for the plantations (where the oldest planted areas were 15 years), although significant variability in below soil carbon stocks was observed (Table 2 and Table 3 respectively). As outlined in the *Baseline Assessment Report: Coastal Ecosystem Carbon Stocks* this indicates that in the first years of restoration, carbon sequestration occurs primarily in the plant biomass. For this reason this analysis does not include soil carbon for mangrove afforestation; only above ground stocks are used.

The estimated financial benefits based on these figures for the same range of carbon prices are presented in Table 10.

Table 10 Estimated financial benefits for mangrove afforestation

Price per MT CO_2	Annual mangrove area planted (ha)	Average annual CO_2 sequestration rate MT per ha	Annual Value (US$)	Total Value - 25 Yrs (US$)
US$ 2	200	3.00	1,200	390,000
US$ 5	200	3.00	3,000	975,000
US$ 10	200	3.00	6,000	1,950,000

While these estimates assume a steady average sequestration rate, in reality the rates would vary significantly over time.

The associated mangrove afforestation costs are presented in Table 11.

Table 11 Estimated mangrove afforestation costs

Activity	Costs (provided on a per mangrove tree basis) (US$)	Number of seedling per ha	Hectares planted annually (ha)	Annual Costs (US$)	Total Cost over 25 Years (US$)
EIA and Permitting					50,000
Seedling purchase	4.09	2,500	200	2,043,597	51,089,918
Seedling planting	1.36	2,500	200	681,199	17,029,973
Monitoring (annual for 3 years)	2.72(1 year); 8.16 for 3 years	2,500	200	1,362,398[12]	98,092,643
TOTAL COSTS				4,087,194	166,262,534

Source: information provided by EAD Marine Department

It is important to note that these financial benefits and cost estimates do not include the requirements and restrictions that would apply if the goal were to develop Blue Carbon credits in compliance with international standards. On the cost side, that would include the development of

[12] Note: Annual monitoring costs would increase to US$2,724,796 in Year 2, and to US$4,087,193 in year 3, and then remain at that level until Year 25 (though for those mangroves planted in Years 24 and 25, the monitoring costs would need to continue through Year 26 and 27 respectively; these additional monitoring costs are not included in the financial analysis).

a Project Idea Note (PIN), a Project Development Document (PDD), most likely methodology validation costs, and periodic verification by an accredited certification agency. These initial, one time costs would total US$150,000, as a conservative estimate; in addition there would be costs incurred for periodic verification visits by the standard organization throughout the life of the project. On the benefits side, if the Verified Carbon Standard (VCS) Wetland Restoration Standard were utilised, then approximately 25% of the credits would need to be maintained in a "buffer account" and not sold until the final stages of the project to ensure that the projected volumes of carbon would be delivered to the buyers. Thus costs would be higher and the cash flow would be delayed (leading to a lower NPV).

Instead, these estimates include a one-time cost of US$50,000 for the Environmental Impact Assessment (EIA) and permitting process that would be required. This estimate is probably low, as presumably additional operational environmental management plans and monitoring requirements would be requested to assess the long-term integrity of the planting.

The financial analysis is based on the assumption that every year 200 ha of mangroves would be planted and that the area would be monitored during that year and for another two years. It also assumes that the monitoring costs cover the replacement of any mangroves that don't survive in years 1-3.

This analysis does not make any provision for increases in average sea level, increased salinity and more extreme climatic events, all of which are likely to occur over the next 25 years.

The NPV estimates of planted mangroves in terms of their Blue Carbon potential are presented in Table 12.

Table 12 Net Present Value estimation from Blue Carbon benefits of planted mangroves

Price/MT CO_2	NPV, 10% discount rate (US$)	NPV, 5% discount rate (US$)
US$ 2	(58,182,989)	(92,046,652)
US$ 5	(58,044,790)	(91,779,673)
US$ 10	(57,814,476)	(91,334,709)

As in the previous Blue Carbon financial analysis (section 4.1.7), under all the scenarios the estimated costs greatly exceed the estimated revenues, and even under the best case this activity would result in a loss of US$58 million in present value terms.

As with other blue carbon ecosystems, these planted areas would, over time, provide a range of other ecosystem services, though as identified as part of the Abu Dhabi Blue Carbon Demonstration Project, planted mangrove areas would likely not provide the same level of other ecosystem services as natural mangrove ecosystems, and would require many years to offer the same suite of services. Even so, it is highly recommended that these other ecosystem services be included in any more comprehensive financial analysis of planted mangrove areas in the future.

4.3 Analysis of other Ecosystem Services

The Abu Dhabi Blue Carbon Demonstration Project identified that Blue Carbon ecosystems in Abu Dhabi generate four main classes of ecosystems services, in addition to carbon, including:

1) Shoreline stabilisation, erosion control, and buffering land and property from storm surges;
2) Maintenance of water quality;
3) Enhancement of fisheries production;
4) Support to biodiversity and ecological communities; and, in turn, maintenance of cultural, aesthetic, and recreational values.

Hypothesised ecosystem services values have been estimated for mangrove, seagrass and salt marsh ecosystems. At present the values of coastal sabkha and algal mats are currently insufficiently understood to provide such estimates.

Currently there are only reasonable credible, specific ecosystem services economic estimates for one of these four classes, the enhancement of fisheries, based on estimates from fisheries statistics for Abu Dhabi collected by EAD. In 2010, the total commercial value of commercial fish landings was estimated as AED127 million, or approximately US$34.60 million, of which 86%, or approximately US$29.76 million, can be attributed to being supported by Blue Carbon ecosystems.

In the absence of economic valuations for other ecosystem services the estimates rely on published studies from other regions of the world where these ecosystems exist. This approach is replicated by Dr. Rula Qalyoubi, in her “Economic Valuation of Mangrove Ecosystem in Abu Dhabi” report prepared for EAD in 2012, which discusses net present value of mangrove based on proxy information taken from other studies around the world. This report also discusses the derivation of mangrove values as performed in landmark studies, appropriate discounting rates, and ways that other ecosystem services and other ecosystems could be further assessed. This recommendation was applied in the Abu Dhabi Blue Carbon Demonstration Project.

The *Ecosystem Services Assessment* utilised known values of annual per hectare service value, as summarised by Barbier and his colleagues (2011) for the major classes of ecosystem service addressed to provide some indication of the range of possible values arising from these ecosystems. Using conservative estimates of the low end, totals across the few ecosystem services that have been quantified in terms of economic value, can be calculated. This is presented in Table 13.

Table 13 Total estimated financial benefits of Blue Carbon Ecosystems in Abu Dhabi

Ecosystem (projected % of total area to be projected)	Total Protected Area (ha)	Estimated value of combined services per ha per year (US$)	Estimated Economic Value (US$ per year)	Total Estimated Economic Value (US$ in 25 years)
Mangrove (50%)	7,059	13,353	94,252,151	2,356,303,763
Seagrass (20%)	31,652	2,529	80,048,920	2,001,222,990
Saltmarsh (50%)	2,385	14,699	35,057,115	876,427,875
Total	41,096	28,082	130,258,838	5,237,954,628

However, extrapolation from other areas may not elucidate true values in Abu Dhabi as:

1) Many ecosystem services such as water quality maintenance, disease regulation, support to biodiversity, and cultural/spiritual values, are not included in the total and, therefore, these values may be an underestimate of the total values;

2) Proxy values may not reflect the amount of service actually being delivered in Abu Dhabi's Blue Carbon Ecosystems, as in general these ecosystems are less diverse, less extensive and productive, and less well-established than those in the wet tropics of Australia, Asia, Latin America, the Caribbean, or the Pacific region on which the majority of the proxy data has been based.

In terms of value, the Ecosystems Services Assessment of the Abu Dhabi Blue Carbon Demonstration Project determined that there are sites that are doing more than their fair share of supporting ecosystem function, and are thus generating potential ecosystem services. But the value of those ecosystem services is a function of location, linkage to things that humans value, and the perception that services have economic value in addition to other social values. For this reason, it is important to know, in general terms, what assets and parts of the marine and coastal areas of Abu Dhabi are highly valued.

Those Blue Carbon ecosystems that occur in close proximity to rich fishing grounds (commercial and recreational), areas of high biodiversity and spectacular scenic value, sites of cultural and archaeological importance, and carefully developed areas of high asset value (luxury beach and island resorts, civil engineering infrastructure that are particularly influenced by the sea, such as corniches, ports, and marinas, private residences, desalination plants, and aquaculture operations) can be said to have particularly significant ecosystem services value (Figure 2). For the purposes of this assessment, analysis is concentrated on the current situation, however planned development must also be considered when determining where valuable Blue Carbon Ecosystem Services are being delivered.

The Assessment continues to identify that Blue Carbon ecosystems and the ecological community they support provide different ecosystem services, the most valuable areas will be those that have a combination, or mosaic, of these ecosystems, especially those in relatively close proximity to assets of value. It notes five areas within Abu Dhabi stand out in this regard:

1) A large portion of the western region, centred on the area between Yasat Island and Dalma, especially in the southern reaches of the polygon;
2) The area around Marawah Island, particularly off its southern and eastern coast;
3) The west and north/northeast portions of Abu al-Abyad,
4) The marine and peninsular areas east of Bul Syayeef Marine protected Area; and
5) The eastern mangroves and environs of Saadiyat Island

These areas are illustrated in Figure 2. The polygons within this Figure are not precise in the sense that the boundaries are somewhat subjective; nonetheless each area captures maximum ecosystem services by including areas in which the combination of Blue Carbon ecosystems, and associated ecosystems of value such as coral reefs, is optimised. Furthermore, these areas capture highest level of productivity (carbon and other), maximum capacity for shoreline buffering and erosion control, sites important for water quality maintenance, special areas for species across bird, dugong, sea turtle, and other taxa, important fish spawning and traditional use (buhour) areas, and archaeological and cultural areas of importance.

The westernmost priority area is notable due to its seagrass ecosystems, support to a wide range of biodiversity, and the ability of Blue Carbon ecosystems within that region to stabilise seafloor and shorelines, especially as future new developments come online. Other priority areas are in close proximity to cultural and historic areas, and their role in reducing hazard risk to these important sites is immeasurable. In the eastern region, priority sites have value in supporting fisheries (recreational and commercial), and providing both water quality maintenance and aesthetic and recreational values. These values will need to be further defined, and economically quantified, in the future, through a targeted research program.

SOURCE: AGEDI, 2013

Abu Dhabi Blue Carbon Demonstration Project

Figure 2

Estimated areas of highest concentration of Blue Carbon co-benefits arising from Blue Carbon Ecosystems

It is important to note that while these areas would seem to be strong candidates for ecosystem protection and conservation in the future, as is contemplated in the financial analysis model, these sites have not been examined in detail regarding the associated estimated projected Blue Carbon and other ecosystem services or the associated conservation and opportunity costs.

4.3.1 Estimated costs of other associated Ecosystem Services

The costs of the other associated ecosystem services in addition to carbon are the same as those presented for Blue Carbon (section 4.2 and Table 8).

Comparing potential financial benefits (Table 13) with potential costs (Table 8) the total estimated economic value can be calculated (Table 14) and the standard discount rates applied to obtain present estimated value.

As can be seen in comparing Table 12 with Table 13 above, the total estimated economic value of these combined ecosystem services of US$ 5.23 billion in non-discounted terms, significantly exceeds the total estimated costs of US$702 million – being almost 8 times greater.

The NPVs of these combined other ecosystem services are presented in the table below:

Table 14 Net Present Value (NPV) of the total estimated financial benefits of Ecosystem Services

Ecosystem	NPV, 10% discount rate (US$)	NPV, 5% discount rate (US$)
Mangrove	687,022,750	1,067,714,390
Seagrass	692,841,725	1,077,957,279
Salt marsh	261,277,656	406,015,057
Total	**1,641,142,131**	**2,551,686,726**

As illustrated in Table 14, based on the various assumptions, the estimated total financial benefits of the other ecosystem services is approximately US$1.64 billion in current dollar terms using a discount rate of 10% and approximately US$2.55 billion using a discount rate of 5%.

4.4 Financial Assessment of Blue Carbon and Ecosystem Services (Bundled Ecosystem Services)

The consideration of integrating Blue Carbon benefits and the Ecosystem Services that these provide, is referred to "Bundled Ecosystem Services". When combining these NPVs of the other ecosystem services with those for Blue Carbon (excluding mangrove afforestation estimates), the result, the NPV of bundled ecosystem services from blue carbon ecosystems, is a significantly positive value, with the estimated values of the other ecosystem services more than making up for the negative estimated NPVs of Blue Carbon alone.

The combined NPV estimates for other ecosystem services and Blue Carbon varies by the price of carbon dioxide (CO_2) per metric ton and the two discount rates used (5% and 10%). It is important to note that because the same costs are involved in obtaining the Blue Carbon and other ecosystem services, the additional revenue from Blue Carbon is not offset by any additional costs, so the total NPV values increase. This is illustrated in Table 15.

Table 15 Net Present Value (NPV) of Bundled Ecosystem Services from Blue Carbon Ecosystems in Abu Dhabi

CO_2 Price/MT (US$)	Bundled NPV (Combined NPV Other Ecosystem Services and Blue Carbon) – 10% discount rate (US$)	Bundled NPV (Combined NPV Other Ecosystem Services and Blue Carbon) – 5% discount rate (US$)
US$2	1,656,173,067	2,569,073,337
US$5	1,678,719,280	2,595,152,883
US$10	1,709,237,928	2,631,224,421

Under these assumptions, and subject to the various caveats and qualifying statements regarding these and the financial analysis that have been made in regards to the Abu Dhabi Blue Carbon Demonstration Project, the estimated total combined NPV for bundled ecosystem services for Blue Carbon Ecosystems in Abu Dhabi ranges from approximately US1.66 billion to US$1.71 billion, with a discount rate of 10%, and from US$2.57 billion to US$2.63 billion, with a discount rate of 5%, as the carbon price varies from US$2 to US$10/MT. Given that the same protection costs are incurred in order to obtain both the carbon and other ecosystem services, the revenue from the carbon increases the total NPV when combined with the other ecosystem services (even though when the carbon financial benefits are viewed in isolation the NPVs are negative, given the significantly higher costs of protection).

It is important to note that if the NPV for mangrove afforestation was added to these combined NPV values, the total would decline as the associated negative values are based on additional costs to those incurred under the protection of the three other ecosystem types.

It is worth underscoring that the estimated financial benefits of such combined ecosystem services will be greatest where the opportunity costs are also the highest. This is likely to complicate the "trade off analysis", where various stakeholders will likely have differing opinions, regarding future development and environmental conservation decision-making in marine and coastal environments.

Finally, there is an alternative method that is used to estimate the total cost of carbon emissions, or the benefits of avoided emissions, known as the Social Cost of Carbon. Using this method would result in a very different estimation of the benefits – of US$390 million over a 25-year period (in present terms, for 2020 using US$ 2007). This is explained in Box 1.

Box 1: The Social Cost of Carbon (SCC)

The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, conventionally one metric ton, in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO_2 reduction). The SCC is meant to be a comprehensive estimate of climate change damages and includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk. However, given current modeling and data limitations, it does not include all the important damages. As noted by the *Intergovernmental Panel on Climate Change (IPCC); Fourth Assessment Report* it is "very likely that [SCC] underestimates" the damages. The models used to develop SCC estimates, known as integrated assessment models, do not currently include all of the important physical, ecological, and economic impacts of climate change recognised in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research. Nonetheless, the SCC is a useful measure to assess the benefits of CO_2 reductions.

Various organisations estimate the net present financial value of SCC by using a range of discount rates. For example the US Environmental Protection Agency (EPA) uses discount rates of 2.5%, 3% and 5% to calculate the social cost of CO_2 emissions from 2015-2050 in present terms. Using 2011 dollar values these costs for 2050 range from US$28 (5% discount rate) to US$105 (2.5% discount rate)/ha/yr; for 2020 the costs range from US$13 to US$69 for the same discount rates.

Pendleton et al., estimated the cost to the global economy of the emissions resulting from coastal ecosystem conversion, multiplying the global emissions estimates for each ecosystem type by a recent estimate of the global economic cost of new atmospheric carbon of US$41 per ton of CO_2 (for 2020 in US$2007). They note that although the SCC estimate is an estimate of the environmental damages that can be avoided by reducing emissions, it does not necessarily equal the price that the market will pay for reducing emissions, since that market price is determined by the avoided cost of regulatory controls on carbon and not avoided damages per se.

Using the figure of US$41 per ton of CO_2 and the annual estimated total emissions for year 1 and then for years 2-25 (Table 6) the total estimated global financial benefits of the avoided emissions that could be generated in Abu Dhabi if the suggested percentages of the three ecosystems were protected from conversion in the future are US$271 million and US$4.97 million, respectively. Over a 25-year period this comes to a total estimated global benefit of US$390 million (in US$2007).

Source: http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

Pendleton, Linwood, et al. (2012). Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems. PLoS ONE 7(9), which cites United States Government (USG) (2010) Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. United States Environmental Protection Agency website.

4.5 Recommendations

It is evident that developing a Blue Carbon project for the international market is not financially viable for Abu Dhabi at this time. However, while the preliminary results of the financial analysis regarding the bundled ecosystem services that Abu Dhabi's marine and coastal environments provide have to be very qualified that this stage, given the numerous assumptions that have been made and the lack of detailed local data, they do suggest that the financial benefits could be quite significant.

The recognition that these ecosystems provide a range of services with significant financial benefits is an important first step, particularly for future marine spatial planning and associated financial planning frameworks. In the future, it will be important to support additional scientific research and analysis on these ecosystems regarding the provision of a range of ecosystem services to more accurately assess the benefits they are providing, their condition and their ability to continue to provide these services into the future. It will also be necessary to investigate actual costs associated with ecosystem protection and/or restoration, and to explore and clarify the various assumptions made in this preliminary financial analysis.

Analysis undertaken also anticipates that a Specialised Fund would likely generate more significant biodiversity and ecosystem service benefits via the support of improved or expanded conservation of existing natural ecosystems versus supporting compensation activities that focus on the establishment of new ecosystem areas. Importantly this would allow the Environment Agency – Abu Dhabi (EAD), in consultation with other appropriate stakeholders, to determine the most effective allocation of funds for the protection and management of these ecosystems.

5 Alternative approaches for the implementation of Blue Carbon and other Ecosystem Services in Abu Dhabi

5.1 Developing an Alternative Approach

As previously mentioned, given the current constraints to developing Blue Carbon credits that could comply with existing international standards and methodologies, and the significantly higher financial value of the other ecosystem services, a more feasible option is to investigate the potential for establishing a Specialised Fund that could be used to promote improved marine spatial planning objectives and to enhance institutional cooperation in this arena.

This section focuses on the financial analysis that could be conducted in the future to help inform the establishment of such a Specialised Fund for Abu Dhabi.

5.2 The Need for a Specialised Fund

During the stakeholder engagement process a number of organisations were contacted specifically for their comments on the financial component of the project. These were complementary to the consultations undertaken for the Policy Assessment. Key points that emerged from these specific consultations in relation to finance feasibility in particular include:

- The current system of environmental assessment, permitting and compensation for marine and coastal development is a complex, time-consuming and expensive process for all involved;
- The importance of a holistic approach to environmental management and the consideration of ecosystem based management is imperative to ensure the environment as a whole is protected (i.e. focus should not just be on Blue Carbon ecosystems, although this initial focus is considered to have been extremely beneficial);
- Resources to monitor the outcomes of permitting decisions are currently limited;
- Current compensation requirements for the destruction of mangroves (Blue Carbon ecosystem) place the responsibility for the location and implementation of the planting on the developer, who usually has little, if any, experience in this area;
- Outcomes in terms of well-informed and consistent marine and coastal spatial planning and environmental conservation impacts are often less than optimal;
- The current system appears to involve considerable uncertainty, particularly for the developers, regarding the likely time required for the various processes to be completed, which translates directly into more problematic investment decision-making and ultimately higher development costs;
- Although the *Estimada* principles and the associated Pearl Rating System are highly regarded, the project team was advised that the system is really designed for the built environment, focusing on issues of energy efficiency and other building specifications, rather than the natural environment;

- Some stakeholders also noted that the Pearl Rating System is currently dealing with a backlog of applications, and that the review process is delayed as a result;
- While there seemed to be general agreement that at some point in the future the *Estidama* principles could be applied to the blue carbon/marine and coastal environment, in the short-term the advice that the team received is that it would be advisable to focus on a separate mechanism that could improve the development planning, review and, where applicable compensation, systems and processes.

A particular concern raised by several stakeholders is that despite the shortcomings of the current system, the quality of compensatory practices for approved marine and coastal ecosystem destruction or degradation is often questionable, given that developers typically outsource mangrove afforestation, or other required environmental restoration actions, to third party organisations. Not surprisingly, as rational economic actors, such third party operators tend to make decisions about where and how to conduct mangrove planting activities based primarily on cost considerations, and so afforestation activities typically occur in areas that are more accessible and easier to work in than in other areas that might be of higher priority from a marine and coastal conservation and ecosystem services provision perspective.

The establishment of a Specialised Fund would help address this limitation, and also allow EAD to prioritise marine and coastal conservation and restoration activities, seeking to optimise the outcomes, rather than to have such decisions be made by other actors who would typically be motivated primarily by financial considerations.

Also in general, the team was advised that it would be preferable to have a financial mechanism that is based on clear policy and regulatory guidance as this will help to define the requirements that developers and others would be expected to comply with and also help to ensure more effective implementation in the future.

For these various reasons, there now appears to be a growing sense within the Emirate that there is an opportunity to develop an alternative approach that can result in a more efficient and predictable process for developers, a more streamlined and better coordinated government decision-making system, and improved environmental conservation and compensation results.

5.3 Design Considerations for a Specialised Fund

Given that there are several government institutions involved in the current marine and coastal development planning, permitting and compensation approval process, and that multiple developers and consultants interact with these agencies, it will be important to seek input from these various stakeholders in the analytical process that will inform the design of the proposed Specialised Fund.

Another important consideration in the design process is to maintain flexibility regarding other stakeholders and financial mechanisms that such a fund could incorporate in the future. Of particular note in this regard is the potential for contributions that could be made from various corporations that are based in or have significant operations in Abu Dhabi Emirate and/or UAE, including international businesses, whether from a commercial, corporate social responsibility (CSR) or philanthropic motivation perspective. These contributions could be of a general nature to support the Fund's various activities or linked to specific initiatives, including the sponsorship of projects or events.

In addition, provision could be made to establish linkages with the legal system regarding the enforcement of environmental laws, so that fines and/or the confiscation and sale of property and equipment for those actors who are found guilty of serious environmental legal violations could also result in potential revenue for the Fund.

Also, instead of the Fund being used only to support compensatory activities, an alternative approach could be to require relevant developers to contribute instead to the protection of other high-value areas, that are equal or superior, in terms of biodiversity and/or combined ecosystem services values (based on the "like for like" principal for ecosystems). Such support could be to improve the management of existing marine protected areas and/or to help establish new protected areas. Regarding the latter, the use of habitat banking and/or biodiversity offsets would represent a credible approach, under a regulatory or voluntary system, respectively. Another approach that could be relevant to examine is the "systems benefits charge model" which is being used by some regulatory authorities, such as public utility agencies, where surcharges paid for by energy developers are used to ensure the overall health and benefits of a given system; such a model could also be applied to marine and coastal development in Abu Dhabi.

It is important to note that although the promise for the establishment of such a Specialised Fund seems to be widely appreciated, to date the financial feasibility assessment team has not been able to obtain specific information regarding the time and costs incurred by the various stakeholders under the current systems and procedures, so it has not been possible to make even preliminary, indicative analyses comparing alternative approaches to the "business-as-usual" scenario. As a result, the focus of the following sections is on suggesting the type of analysis that could be conducted going forward to shed light on the advantages that the proposed Specialised Fund could confer, as more detailed information becomes available.

5.3.1 Outcomes from other Project Components that Can Inform the Development of the Specialised Fund

As noted earlier, this report is most closely aligned with the findings of the Policy Component Final Report, which makes recommendations for the development of a strategic framework for *Abu Dhabi's Blue Carbon Policy,* and identifies as key objectives "support for the operation of a future Specialised Fund through activities that improve management practices, develop enhanced knowledge networks, promote coordinated action across emirate-level institutions, build local capacity, and support global actions."

It also notes that stakeholder consensus emerged on five (5) key components that represent the organising framework for the Policy, namely:

- **Improve information management systems**
- **Sustainably manage Blue Carbon ecosystems**
- **Enhance institutional coordination**
- **Engage in and support international actions on Blue Carbon**
- **Promote public awareness of Blue Carbon benefits**

While these are all potentially areas that the proposed Specialised Fund could support over time, in the short-term the Fund should probably focus on: the sustainable management of Blue Carbon ecosystems, enhancement of institutional coordination, and the promotion of public awareness of Blue Carbon benefits, given that support for improved information management systems and support for international actions on Blue Carbon are likely to be provided by other existing initiatives and/or other agencies.

The Policy Component Final Report also goes on to recommend ten (10) specific Policy Actions. Of these the following four (4) recommendations seem more immediately relevant for the Specialised Fund to focus on:

- **Policy Action #4: Blue Carbon Management Objectives**
  This aims to establish Blue Carbon ecosystem management objectives that represent a consensus among Emirate-level/national government agencies, the private sector, and non-governmental organisations. The process of consensus-building will embed Blue Carbon ecosystem management within other marine, land, soil, water, air, biodiversity, climate change, and wildlife conservation policies, as well as economic and coastal development policies. It will also help to ensure that Blue Carbon is harmonised with overall national land use and maritime planning objectives and jurisdictional and legal responsibilities concerning Blue Carbon ecosystems clarification;

- **Policy Action #5: Blue Carbon Ecosystem Priority Areas**
  The objective is to identify priority Blue Carbon ecosystems for near-term management planning. Blue Carbon ecosystems, being attractive sites for development activities since the 1960s, have witnessed intensive coastal development activities, leading to ecosystem loss, fragmentation, and degradation. Given the recent emergence of Blue Carbon Ecosystems' services in the international climate change policy debate, along with the growing body of knowledge on their values, there is currently no systematic way to account for this information as indicators that can help define priority areas.

- **Policy Action #6: Blue Carbon Management Plans**
  This aims to develop special management plans for the priority Blue Carbon ecosystems identified through the previous Policy Action (i.e. Policy 'Action #5). A management plan represents a way to introduce increased specificity in protecting significant Blue Carbon resources and resolving development and protection conflicts where Blue Carbon ecosystems affect the interests of multiple stakeholder communities. Such plans encompass the identification, study, and evaluation of functions to be protected, stakeholder values and interests, and development/investment requirements regarding protection and regulation.

- **Policy Action #10: Promote Awareness**
  It is essential that civil society groups and individuals operate from a common understanding about the role of Blue Carbon in meeting the challenge of climate change. This will help to mobilise public support for new policies. In particular, it will be important to reach out to young people. Children, youth and teachers represent the potential for a future citizenry be sensitised to the valuable role of these ecosystems. Raising awareness among this group will likely involve targeted awareness-raising events rather than updates to school curriculum.

5.4 Financial Analysis to Inform the Design of a Specialised Fund

Until additional studies and analysis can be conducted in the future regarding the provision of ecosystem services from various ecosystems in Abu Dhabi, the most practical financial analysis that could be undertaken seems to be on demonstrating how the existing marine and coastal development, permitting and compensation approval and verification processes could be improved, and ideally how doing so via the creation of a Specialised Fund would result in a "win-win" outcome for the various stakeholders involved. This approach would also use Net Present Value (NPV) calculations to compare estimated future benefits and costs in present terms for various alternative scenarios.

5.4.1 Case Study Involving Several Property Developers

While the circumstances on Reem Island involving Bunya LLC., could be very instructive in informing the type of activities that a Specialised Fund could support in the future, the fact that the context is atypical undermines the applicability of the findings to other settings and conditions within the Emirate. Drawing on a single example is also not advisable as the basis for designing such a potentially transformative financial mechanism.

Therefore, it would be more informative to examine the implications for adopting an alternative to the business-as-usual approach for development permitting, approval, compensation and monitoring with a range of developers in other regions of the Emirate under a variety of conditions.

A key initial step in this process would be to carefully document the current, business-as-usual processes for each of the selected developers, and the time and cost of their interactions with the various government agencies. It will be equally important to document and analyse the associated time and cost spent on these interactions by the various government agencies. Doing so with both sets of actors will establish a clear baseline for future comparisons with alternative approaches implemented in the future.

It will also be important to clearly define and articulate how these business-as-usual practices comply, or otherwise, with existing legislation and required procedures, as the implementation of alternatives approach could also entail future amendments to and/or modifications in the interpretation and enforcement of existing legislation and regulations.[13]

In an ideal situation, this analysis would be applied, versus theoretical, and involve entering into alternative arrangements with a small number of selected developers (3-5 perhaps), regarding specific on-going, or soon to be implemented, property or infrastructure projects, who would be willing to share actual comparative cost and benefit data with those conducting the analysis. This comparison would ideally be forward-looking to help ensure accuracy, but it could also be retrospective, based on comparison with historical cost and benefit data that the participating developers and other stakeholders could make available.

Alternatively, if entering into such alternative arrangements via pilot activities wouldn't be feasible, then conducting comparative projections with the developers and other relevant stakeholders, and estimating how these would compare with the business-as-usual scenario over time, would be "a next best case" option. Although taking this approach would be less accurate, it has the advantage of being quicker and easier to conduct, as it would be based upon future estimates rather than measuring actual costs and benefits over time.

It might also be possible to combine the two approaches, starting with the estimated costs and benefits for future alternative approaches, and then, if these seem significantly positive, on

[13] Federal Environment Law No. 24 of 1999 for the Protection and Development of the Environment (Federal Law 24), which stipulates the need to assess the environmental implications of development projects prior to the commencement of activities, and also requires a project proponent for all new developments to submit a completed Environmental Permit Application to EAD for review, is probably the central law that would need to be reviewed in this regard, but there are most likely also other relevant laws and regulations that would also need to be considered.

balance, for the various stakeholders to enter into specific alternative arrangements and then to compare actual experiences with the projected outcomes. This variance analysis with the participating developers and the implications for future interactions of this nature could then be shared with the relevant stakeholders on a regular basis going forward.

As with the proposed test case for Bunya LLC., on Reem Island, the use of net present value analysis would seem to be most useful approach to enable the projected future costs and benefits of the various alternative scenarios to be expressed and compared in current costs.

Presumably the focus of such analysis would be on mangrove ecosystems and compensation via the establishment of new mangrove areas, under the guidance of EAD. However, as previously noted, it could also include some pilot initiatives to have developers support the protection of existing ecosystems, perhaps including a combination of various types of Blue Carbon ecosystems if these would be affected by the proposed developments in the selected sites.

In a related vein, such support could also potentially include requiring the developers to contribute to research in the relevant protected areas and compensation sites to establish more detailed linkages between the quality of the ecosystems and the provision of a range of Blue Carbon and other ecosystem services.

5.5 Assumptions

The primary assumption regarding the proposed approach is that the private sector developers would be willing, or could be convinced, to participate in the analytical process and also to provide specific project-level cost and other data. Playing such a role would involve costs, particularly opportunity costs of senior personnel. In addition there could be concerns on the part of the developers that providing such confidential and proprietary information would result in a competitive disadvantage, if other developers could potentially gain access to such information. There could also be concerns about reputational risks if the process results in negative publicity and/or greater scrutiny of the participating developers' activities. Hopefully, any such concerns could be addressed going forward to allow for full and active participation in the process by relevant private sector stakeholders.

There is also the related assumption that the relevant government agencies and proposed major stakeholders will be willing to engage in the proposed comparative scenario analysis and to make such involvement a priority within the near future.

Related to the potential concerns about the total direct and indirect costs involved, is an assumption about the timeframe and level of effort that would be entailed. While this will need to be determined on the basis of future interactions with various stakeholders, it would seem possible to complete the description of the test case in Reem island and simultaneously to expand to work with a small number of other developers, and to complete a case study with the proposed comparative analysis of the business-as-usual with alternative scenarios, within a one-year timeframe.

5.6 Recommendations for implementation

5.6.1 Overview

Going forward probably the most important consideration is that the key stakeholders regarding the proposed analysis, and then hopefully the design, establishment and management of the Specialised Fund itself, are fully engaged in the process and develop an effective collaborative approach and working group to move the process forward. These initial meetings could address potential concerns regarding the use of confidential information, attribution of information, and the presentation of analysis, etc.

To begin the process, it would be ideal if the stakeholders could appoint a small number of representatives to form an initial analytical team that could report on a periodic basis to senior management within the various stakeholders. Presumably they would do so via a series of meetings of senior personnel in a working group to review interim results and to provide feedback and guidance to the analytical activities.

In general terms, once the working group agrees on opportunities for improving upon the current business-as-usual scenario it could then develop a "preferred" future scenario, or several of these, that could then be compared and contrasted. Once an alternative preferred scenario has been identified, then a "critical path" for achieving the desired alternative could be articulated, and associated information and/or analytical "gaps" could be identified that would need to be investigated further in order to inform future decision-making. Then a work plan, timeframe and budget could be developed, with clear responsibility for which entities would undertake the various activities and how they would report back to the working group.

In this manner, the analysis of the test case, and subsequently the proposed broader case study, could be designed with input from all the relevant stakeholder organisations to ensure that the comparison of the business-as-usual scenario and alternative scenarios truly reflects their perspectives and captures the real, or accurately estimated, costs and benefits involved.

5.6.2 Recommendations for how a Specialised Fund could be structured

Assuming that the proposed short-term analysis results in positive findings and outcomes, a central issue is to determine how best to move from the current compensation model, which is not based on a clear principle of "proportionality" to the loss of combined ecosystem services involved, to a new system that does this in order to both to avoid the loss of critical ecosystem services and also to achieve more cost-effective results.

Given that it will probably take several years for additional research to be conducted within Abu Dhabi to generate the scientific data and analysis required to support such informed compensatory decision-making, an interim strategy seems to be necessary.

One approach for developing such a strategy would be to prioritise the identification of high value combined ecosystem services regions, as has already been suggested in the Ecosystem Services Assessment report, as part of a larger, more ambitious marine spatial planning process. These areas could then be designated as the initial focal areas for the Specialised Fund, where the current policy of requiring compensation on a 2:1 ratio (typically two hectares of new mangrove area planted for every hectare of natural ecosystem negatively affected), could be replaced by alternative requirements. In this way developers and others that are commercially engaged in these areas could be required to make contributions that exceed the current compensation ratio requirements when they are responsible for permitted ecosystem destruction or degradation, as allowed for under the EIA process. The level of such additional payments could be clearly stated as being for an interim period until further analysis has been conducted to more clearly determine the value of the forgone combined ecosystem services. Those who do not comply with the stated EIA and other permitting requirements and/or that are responsible for significant environmental damage would be required to support additional compensation. Thus, for example, over the next 5 years the compensation ratio in these areas could be increased to 3:1 for those who comply with environmental requirements, with the stated expectation that in the future, this ratio would likely be further increased based on new information and analysis. Those who do not comply with existing regulations and/or who are responsible for environmental damages could be required to support additional compensation that is proportional, and punitive, to the extent of the damage caused, as evaluated by EAD and/or other experts.

Alternatively, or in combination with the first approach, developers and others could be offered another option of providing funds to support the improved protection of existing areas and/or the protection of new priority marine and coastal ecosystems. Given the apparently high costs of establishing mangrove plantations in Abu Dhabi, and the significantly greater contribution of native mangrove and other marine and coastal ecosystems to the provision of ecosystem services, support for the protection of existing areas is likely to be considerably more cost-effective than the current compensation requirements in securing the on-going provision of these services.

As noted previously, there are several existing mechanisms and models that could be explored by the analytical team to inform the types of approaches that the Specialised Fund could consider supporting in the future. These include the concepts of habitat banking, biodiversity offsets, and systems benefits charge models.

As also mentioned earlier in this report, it would be advisable for the design of the proposed Specialised Fund to be flexible in order to integrate other forms of support or additional finance in the future. In addition to the potential for obtaining such support from Corporate Social Responsibility (CSR) and philanthropic contributions, and potentially from the legal system where fines or other financially-punitive actions taken on those who violate environmental legislation could be provided to the Fund, there would also seem to be the opportunity to enter into collaborative arrangements with companies and government entities where their staff could volunteer time and/or money to support environmental initiatives being sponsored by a Specialised Fund.

In this regard, the Specialised Fund could consider offering incentives to other organisations to join with it in seeking to improve the provision of ecosystem services and improved environmental conservation in Abu Dhabi. It could do so via the use of "challenge grants" or "matching funds", where the Fund could offer to equal, or provide some multiple of, funds that other organisations could raise or contribute for stated environmental objectives. This approach is already quite common with foundations internationally. There is also a growing trend in "crowd sourcing" support for various causes over the internet, and this approach could be even more effective where such matching support could be provided by the Fund. In a similar manner, the Fund could host annual, or periodic, fund raising events either by inviting specific stakeholders who could be asked to contribute a given amount per participant (as is the case elsewhere for "gala" events, often where high profile speakers and/or entertainers are part of the attraction). Given the high education and living standards of Emiratis and many expatriates working in Abu Dhabi (and UAE), this approach could be highly effective. Moreover, the approach could be particular relevant for schools, universities and NGOs, given the growing popularity of crowd sourcing with the youth in other countries.

In addition, it would be instructive to explore whether there are similar funds, or other organisations or structures, elsewhere that could be used as models, and then to examine these to determine the potential for drawing upon the experiences and lessons learned to inform the design and functioning of the Specialised Fund. Finally, it would also be interesting to explore whether the proposed Specialised Fund could be used to support this range of activities in other environments and ecosystems in Abu Dhabi, in addition to marine and coastal settings.

6 Conclusions

6.1 Overview

The original objective of the Blue Carbon and Other Ecosystem Services Financial Feasibility Assessment Component was to conduct analysis to estimate the financial value of Blue Carbon and other ecosystem services that could be developed in Abu Dhabi. However, initial assessments of the eligibility requirements for developing such Blue Carbon credits, combined with the prevailing low demand and low prices for international carbon credits, led to the conclusion that it would be more feasible to pursue alternative approaches to the promotion of blue carbon and other ecosystems within Abu Dhabi.

As a result, this report focuses primarily on estimating the financial value of the combined ecosystem services that the conservation of marine and coastal ecosystems in Abu Dhabi could generate to help inform the establishment of a Specialised Fund to promote the provision of such ecosystem services in the future.

Based on the various assumptions and estimations used in the financial analysis, under all the carbon price and discount rate scenarios, the NPV values for Blue Carbon ecosystem services are very significantly negative, as the estimated discounted costs dramatically exceed the estimated discounted revenues. Even under the best-case scenario (US$10/MT/$CO_2$ and a discount rate of 10%), the net present value (NPV) for the protection of such ecosystems is negative US$184 million. For mangrove afforestation the results are even more negative, where under the same best-case scenario, the estimated NPV is negative US$58 million.

Conversely, and encouragingly, when the other ecosystem services are included the estimated total combined NPV for bundled ecosystem services for Blue Carbon Ecosystems in Abu Dhabi ranges from approximately US1.66 billion to US$1.71 billion, with a discount rate of 10%, and from US$2.57 billion to US$2.63 billion, with a discount rate of 5%, as the carbon price varies from US$2 to US$10/MT.

Using an alternative method to estimate the total cost of carbon emissions, or the benefits of avoided emissions, known as the Social Cost of Carbon, would result in a very different estimation of the benefits – of US$390 million over a 25-year period (in present terms, for 2020 using US$2007, and based on a value of US$41/metric ton of CO_2).

While the preliminary results of the financial analysis regarding the combined suite of ecosystem services that Abu Dhabi's marine and coastal environments provide have to be considered as highly inconclusive and provisional at this stage, given the numerous assumptions that have been made and the lack of detailed local data and analysis, they do suggest that the financial benefits could be quite significant. In addition, the methodology developed for calculating such values provides an important framework that can be further built upon as additional data and information become available. This allows Abu Dhabi Emirate to prepare for the future should existing market conditions change and eligibility issues be resolved.

The recognition that these ecosystems have a significant economic value is an important first step, particularly for future marine spatial planning and associated financial planning frameworks. The many Blue Carbon ecosystem services currently have an implied economic value of zero within Emirate-level financial planning frameworks. Hopefully this preliminary analysis can help to correct that misperception.

In the future it will be important to support additional scientific research and analysis regarding the various marine and coastal ecosystems to more accurately assess the range of ecosystem service benefits they are providing, their condition and their ability to continue to provide these services. It will also be necessary to investigate actual costs associated with ecosystem protection and/or restoration, and to explore and clarify the various assumptions made in this preliminary financial analysis. Importantly, this would allow Environment Agency – Abu Dhabi (EAD), in consultation with other appropriate stakeholders, to determine the most effective cost effective allocation of funds for the protection and management of these ecosystems.

Analysis, based on the scientific findings of the *Abu Dhabi Blue Carbon Demonstration Project* has facilitated the development of recommendations, including interim measures for the development of such a Specialised Fund.

The main recommendation is that a Specialised Fund be established to improve the protection and management of critical ecosystems, and the associated provision of ecosystem services in Abu Dhabi. Analysis undertaken suggests that a Specialised Fund would likely generate more significant biodiversity and ecosystem service benefits via the support of improved or expanded conservation of existing natural ecosystem versus supporting compensation activities that focus on the establishment of new ecosystem areas.

The Specialised Fund has been recommended to help streamline existing environmental permitting and compensation requirements, improve economic linkages and enhance stakeholder engagement. At present, for example the existing policy of compensation for the removal of mangroves is the requirement to replace and plant taken with two seedlings (2:1 compensation). The *Abu Dhabi Blue Carbon Demonstration Project* has determined that, based on science, this may no longer be appropriate as:

1. Mature mangroves sequester and store relatively more carbon than planted mangroves, and during their excavation it is likely that carbon dioxide would be released;
2. Blue Carbon ecosystem service values provision is assumed to increase in parallel with carbon;

Continuing to use this compensation model therefore will most likely result in a net loss of carbon and degradation in the delivery of ecosystem services in Abu Dhabi.

Rather than putting the responsibility of replanting on developers in Abu Dhabi it is proposed that they pay a compensation fee into a Specialised Fund. This would allow the regulatory authority to priorities marine and coastal conservation and restoration activities and seek to optimize the outcomes, rather than the alternative of having decisions made by other actors who may typically be motivated primarily by financial considerations. In the future the Specialised Fund could also be developed to include the concepts of habitat banking, biodiversity offsets, and system benefits change models.

It is also recommended that the design of the Specialised Fund be flexible in order to integrate other forms of support or additional finance in the future. These include the potential for obtaining such support from Corporate Social Responsibility (CSR) and philanthropic contributions, and potential from the legal system where fines or other financially punitive actions taken against those who violate environmental legislation could be provided

Recommendations regarding the type of financial analysis that could be conducted to inform the establishment of a Specialised Fund in a future planning phase have also been made including:

1) Development of a case study regarding the requirements for mangrove compensation by the real estate developer Bunya LLC, on Reem Island, to highlight alternative approaches for compensation that could apply under a Specialised Fund;
2) Development of a broader case study involving several property developers to examine the implications for adopting an alternative to the business-as-usual approach for development permitting, approval, compensation and monitoring in other areas of the Emirate under a variety of conditions.

As illustrated through the *Abu Dhabi Blue Carbon Project* and in particular the *Ecosystem Services Assessment* it is advisable to ensure that in doing this:

a. Priority areas which store significant quantities of carbon and provide significant ecosystem service benefits are protected;
b. Marine and coastal development is considered in a holistic manner.

Given that it will likely to take some time to conduct robust, additional research within Abu Dhabi to generate the scientific data and analysis required to support such informed alternative compensatory decision-making, an interim strategy seems to be necessary.

One approach for developing such a strategy would be to prioritise the identification of high value combined ecosystem services regions, as has already been suggested in the Ecosystem Services Assessment report, as part of a larger, more ambitious marine spatial planning process. These areas could then be designated as the initial focal areas for the Specialised Fund where the current policy of requiring compensation on a 2:1 ratio could be replaced by alternative requirements.

There are several existing mechanisms and models that could be explored by the analytical team to inform the types of approaches that the Specialised Fund could consider supporting in the future. These include the concepts of mitigation or habitat banking, biodiversity offsets, and systems benefits charge models.

A biodiversity offset is a way to demonstrate that an infrastructure project can be implemented in a manner that results in no net loss or a net gain of biodiversity. Such biodiversity offsets need to demonstrate measurable conservation outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition and structure, ecosystem function and people's use and cultural values associated with biodiversity. Biodiversity offsets are voluntary agreements, versus regulatory requirements, and tend to be entered into once an investment has been made, or as part of the implementation process, based on an environmental impact assessment (EIA) and other mitigation processes. Forest Trends' Business Biodiversity Offset Program (BBOP) has recently developed the BBOP Standard of Biodiversity Offsets to help inform the use of such mechanisms.

A mitigation, or habitat, bank is established by acquiring land for the creation, or enhancement and management, of habitats or ecosystems for a particular wildlife or environmental resource. The asset is valued in terms of credits and the better the condition of the land in terms of its conservation objectives, the greater the value and the larger the number of credits. Where development results in unavoidable damage to an environmental or wildlife resource the damage can be mitigated by purchase of credits. In some countries, and notably in the US, where it is demonstrated that appropriate mitigation cannot be achieved at the development site, it is a federal requirement to mitigate by the acquisition of suitable credits. Credits may also be purchased, held, and traded in a process analogous to carbon trading. Such banks tend to be established to comply with regulatory requirements, and are often established in advance of damage occurring in a given area.

A system benefits charge is a fee levied on users designed to fund certain "public benefits" that are placed at risk in a more competitive industry. The use of these charges has been pioneered in the public utilities sector to assist low-income consumers and to fund renewable energy, research and development, energy efficiency, etc. Such charges could be levied in Abu Dhabi within various industry sectors to help support the protection and restoration of Blue Carbon ecosystems in the future.

Abu Dhabi Emirate has a great opportunity to use scientific based data and information to inform the development of this Specialised Fund and protect and manage their Blue Carbone ecosystems on a local level, setting an example at a regional and international level.

6.2 Recommended Next Steps

To further investigate and plan the development of a Specialised Fund and build an interim strategy for implementation the following actions are recommended:

- Convene a meeting of the primary stakeholders for the proposed Specialised Fund to discuss the financial, and other, analysis that could be conducted in the short-term to inform its establishment and operation. If stakeholders agree, form a working group to make recommendations regarding the structure, functions and other aspects of the Fund;
- Analyse the financial dimensions of an alternative test case such as the development on Reem Island by Bunya LLC.;
- Expand this analysis to include a small number of other developers operating in various sites; develop a case study of their experiences, comparing the current, business-as-usual, scenario to alternative, preferred future scenarios;
- As part of the planning process for the establishment of a Specialised Fund, reassess the rationale for the current policy regarding the permitting of and compensation for the destruction and/or gradation of Blue Carbon ecosystems within the Emirate. This process could be combined with the recommendation from the Ecosystem Services Assessment Report of focusing on improved marine spatial management in the 5 areas that have been identified as having high combined ecosystem services. The Fund could consider applying alternative options to the current practices for development projects in these areas, including potential support by developers for conservation of existing natural marine and coastal ecosystems instead of the establishment of new mangrove, and other Blue Carbon ecosystem, areas;
- Review the assumptions and estimates in the current preliminary financial feasibility assessment to develop a more appropriate/realistic model that can be used in the future to conduct financial analysis as more site-specific data within Abu Dhabi becomes available.

7 Literature Cited

Barbier, E.B., S. D. Hacker, C. Kennedy, E. W. Koch, A. C. Stier, and B. R. Silliman 2011. The value of estuarine and coastal ecosystem services. Ecological Monographs 81:169–193

Broadhead, J.S., 2011. "Reality check on the potential to generate income from mangroves through carbon credit sales and payments for environmental services". Regional Fisheries Livelihoods Programme for South and Southeast Asia (GCP/RAS/237/SPA) Field Project Document 2011/REG/2.

Gordon, D., Murray, B.C., Pendleton, L., Victor, B., 2011. "Financing options for Blue Carbon: opportunities and lessons from the REDD+ experience". Nicolas institute Report, Duke University, USA.

Murray, Brian C., Pendleton, Linwood, Jenkins, W. Aaron, and Sifleet Samantha. 2011. Green Payments for Blue Carbon – Economic Incentives for Protecting Threatened Coastal Ecosystems. Nicolas Institute Report, Duke University, USA.

Pendleton, Linwood, et al. (2012). Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems. PLoS ONE 7(9).

Qalyoubi, R., 2012. Economic Value of Mangrove Ecosystem in Abu Dhabi. EAD, Abu Dhabi.

Short, F. T., and S. Wyllie-Echeverria. 1996. Natural and human-induced disturbance of seagrasses. *Environmental Conservation* 23 (1):17-27.

Sifleet, S., Pendleton, L., Murray, B. 2011. State of the Science on Coastal Blue Carbon: A Summary for Policymakers. Nicolas Institute Report, Duke University, USA.

Juha Siikamäki, James N. Sanchirico, Sunny Jardine, David McLaughlin, and Daniel F. Morris. 2012. Blue CARBON Global Options for Reducing Emissions from the Degradation and Development of Coastal Ecosystems. Resources for the Future