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Integrated Large-Scale Action on Habitat Restoration and Pollution in the CLME+ Region: Baseline and Pre-Feasibility Assessment Report on the Needs and Opportunites for Investment - Caribbean Environment Programme (UNEP-CEP) and The Ocean Foundation Technical Report No. 03

Catalyzing implementation of the Strategic Action Programme for the Caribbean and North Brazil Shelf LME's (2015-2021)

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ACRONYMS

CARICOM	Caribbean Community and Common Market
CBO	Community-Based Organisation
CCAD	Central American Commission for Environment and Development
CEP	Caribbean Environment Programme (UNEP)
CERMES	Centre for Resource Management and Environmental Studies
CFMC	Caribbean Fisheries Management Council
CITES	Convention on the International Trade of Endangered Species
CLME	Caribbean Large Marine Ecosystem
CLME+	Caribbean and North Brazil Shelf Large Marine Ecosystems (CLME Project)
CRFM	Caribbean Regional Fisheries Mechanism
DSS	Decision Support system
EAF	Ecosystem Approach to Fisheries
EBM	Ecosystem-based Management
EcoQO	Ecosystem Quality Objective (CLME SAP)
FAO-WECAFC	Food and Agricultural Organisation of the United Nations - Western Central Atlantic Fisheries Commission
GDP	Gross Domestic Product
GEF	Global Environment Facility
GPA	Global Programme of Action for the Protection of the Marine Environment from Land Based Activities
ICCAT	International Commission for the Conservation of the Atlantic Tuna
ICM	Integrated Coastal Management
IGO	Inter-Governmental Organisation
ILO	International Labour Organisation
IMO	International Maritime Organisation
IOC	Intergovernmental Oceanographic Commission of UNESCO
IOCARIBE	IOC UNESCO Sub-commission for the Caribbean Sea and Adjacent Regions
IUU	Illegal, Unreported and Unregulated fishing
IWECO	Integrating Water, Land and Ecosystem Management in Caribbean Small Island Developing States (GEF)
LBS	Protocol concerning Pollution from Land-Based Sources and Activities (Cartagena Convention)
LME	Large Marine Ecosystem
LMR	Living Marine Resources (CLME Project)
MARPOL	International Convention for the Prevention of Pollution from Ships
MCS	Monitoring, Control and Surveillance
NAP	National Action Plan
NBSLME	North Brazil Shelf Large Marine Ecosystem
NGO	Non-Governmental Organisation
NPOA	National Plans of Action
OSP	Oil Spills Protocol (Cartagena Convention)
OSPESCA	Central America Fisheries and Aquaculture Organisation
REMP	Regional Environmental/Ecosystem Monitoring Programme (CLME Project)
RFMO	Regional Fisheries Management Organisation
RGF	Regional Governance Framework (CLME Project)
SAP	Strategic Action Programme (CLME Project)
SBO	Societal Benefits Objective (CLME SAP)
SD	Strategic Direction (CLME SAP)
SGP	Small Grants Programme (GEF)
SIDS	Small Island Developing States
SLMR	shared Living Marine Resources (CLME Project)
SPAW	Specially Protected Areas and Wildlife Protocol (Cartagena Convention)
TDA	Transboundary Diagnostic Analysis (CLME Project)
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation

FOREWORD

The increasingly severe effects of climate change on coastal communities are resulting in recurring and widespread loss of property and human lives. The devastation inflicted by strengthening storm events and routine flooding has rippling effects throughout the economy and society. Furthermore, increasing amounts of nutrient and sediment runoff from agricultural and urban development is rapidly degrading coastal ecosystems and creating harmful algal blooms that pose a dire threat to people, plants, and wildlife.

Yet, the number of people living near coastal areas and floodplains that are highly vulnerable to climate risk and the effects of pollution continues to grow. Simultaneously, the expansion of man-made infrastructure and paved surfaces along coastlines results in the degradation and destruction of a community's most enduring and cost-effective natural defense mechanisms–coastal ecosystems, including seagrass meadows, mangrove forests, and coral reefs.

Healthy coastal ecosystems act as extremely effective natural wave barriers that protect communities all around the world–from the wealthiest urban district to the most remote rural fishing village. Yet, man-made coastal construction projects can quickly destroy entire coral colonies and other marine habitats, undermining the chances of survival for wildlife and the people that depend upon them. Coastal armoring structures in particular, which are built in reaction to erosion and storm surges, inadvertently degrade essential coastal habitats by blocking vital nutrient and sediment flow.

Coastal wetlands represent one of our best solutions to directly confronting climate change by serving as a critical sink for "blue carbon"–the carbon from the atmosphere that is sequestered through coastal vegetation and stored for very long periods of time in the sediments below. It is estimated that healthy coastal blue carbon ecosystems can store up to 10 times the amount of carbon per hectare relative to terrestrial forest ecosystems–and the degradation of these systems can release large amounts of stored carbon back to the atmosphere. In addition, healthy coastal ecosystems play a critical role in filtering water to remove excess nutrients and sediment, thereby significantly improving water quality and mitigating stressors to the environment, like ocean acidification, which threaten our livelihoods and marine biodiversity.

However, despite the many benefits afforded by coastal ecosystems, habitats like seagrass meadows, mangrove forests, and coral reefs are in sharp decline. And, with the loss of these resources, our climate resilience and natural security is dramatically diminished.

In Part I of this report, we explore the current state of these key coastal habitats in the Wider Caribbean Region, as well the growing negative effects of pollution and how the health of these ecosystems is tied directly to what is going into the water, including fertilizer, herbicides, pesticides, toxic waste, and sediments. Through this baseline review, we have created a scorecard-based methodology that enables practitioners and decision-makers, from local community members to scientists and government officials, to examine the need and feasibility of coastal habitat restoration and pollution reduction projects and prioritize sites accordingly. Our methodology advocates for a "seascape" approach that takes into account the symbiotic nature of coastal ecosystems and how a holistic strategy that includes multi-habitat restoration projects in conjunction with pollution reduction efforts can yield better, more sustainable results in the long-term.

In Part II, we emphasize the importance of blended finance models that take into account ecosystem valuation to support the idea that restoring coastal habitats and reducing sources of point and nonpoint pollution can result in a substantial return on investment--not to mention the preservation of existing marine resources. Through three case studies, we identify key challenges, stakeholders, and opportunities for intervention that are designed to work in tandem across seagrass, mangrove, coral reef, and pollution reduction projects. But, identifying sites is not enough. We must equip key stakeholders across the region with the tools, technical expertise, and policy frameworks to achieve large scale climate risk reduction through habitat restoration and pollution reduction. By supporting instructional workshops and educational outreach, we can build local capacity by connecting experts with community practitioners to provide guidance and support at all stages of a coastal restoration and pollution reduction projects. We can amplify our impact by working with government officials and community leaders on developing policies that support the restoration and conservation of coastal ecosystems through new stewardship approaches and financial strategies that address development and pollution pressures.

Above all, we need to address geographic and institutional gaps to ensure support reaches the communities who need it the most: those that face the greatest climate risk. And, this goes beyond simply preserving what is left. We must seek to actively restore abundance and enhance the productivity of coastal ecosystems in order to help communities all around the world thrive despite increasing resource needs and climate threats.

As the world continues to struggle with the COVID-19 pandemic, the Wider Caribbean Region, with its economic reliance on tourism, has been essentially hard-hit. We recognize a unique opportunity to “build back blue” in order to create a more resilient, sustainable blue economy that also enhances climate resilience. Through a blended finance approach, we can bring in new sources of investment that allow us to restore coastal ecosystems and reduce pollution while providing significant financial, environmental, and social returns.

Seagrass meadow in Vieques, Puerto Rico. Source: Ben Scheelk / The Ocean Foundation (2020).

INTRODUCTION

CLME+ Region

The Caribbean and North Brazil Shelf Large Marine Ecosystems (the "CLME+ region") is one of 66 Large Marine Ecosystems (LMEs) around the world. LMEs are large areas of coastal waters characterized by ocean currents, undersea topography, and marine productivity. They are highly productive and provide vital ecosystem services, such as fisheries, shoreline protection, and carbon sequestration--and the CLME+ region is no exception (GEF LME:LEARN 2017).

The CLME+ region encompasses 26 countries and 18 territories from the United States in the north to Brazil in the south (Figure 1). The region's diverse and productive ecosystems support more than 100 million people who live on or near the coast (Caribbean Natural Resources Institute 2020b). The CLME+ region is home to globally significant percentages of coral reefs, mangroves, and seagrasses that are bio-physically connected, making it one of the most productive and diverse systems in the world. This important coral reef-mangrove-seagrass complex, however, is facing an overall trend of habitat degradation and loss through the CLME+ region due primarily to invasive species, direct overexploitation, pollution, climate change, and strengthened tropical storms (Caribbean Natural Resources Institute 2020b).

The purpose of this report is to inform future coral, seagrass, and mangrove restoration and pollution reduction efforts in the CLME+ region. Part I provides a methodology for prioritizing coastal habitat restoration sites in the CLME+ based on feasibility, need, threat, and a set of ecological and socio-economic criteria. Part II outlines strategies for developing investment plans for funding large-scale coastal habitat restoration and pollution reduction in the CLME+ region.

Fig. 1 | The CLME+ region includes the Caribbean Sea LME and the North Brazil Shelf LME. Source: UNDP/GEF CLME+ Project (2017).

PART I: Methodology for Analyzing Seagrass, Mangrove, and Coral Restoration Potential in the CLME+ Region

Project Need and Rationale

In 2013, countries bordering and/or located within the CLME+ region adopted a 10-year Strategic Action Programme (SAP) for the Sustainable Management of the Shared Living Marine Resources of the Caribbean and North Brazil Shelf Large Marine Ecosystems, the "CLME+ SAP." This SAP, which has been politically endorsed by more than 20 countries, provides a roadmap towards sustainable marine resource management through strengthening and consolidating cooperative governance arrangements at the regional and sub-regional levels. The follow-up five-year UNDP/GEF CLME+ project is working to "Catalyse the Implementation of the SAP for the Sustainable Management of Shared Living Marine Resources in the CLME+ region" (2015-2021). The Secretariat to the Cartagena Convention, serving as the Caribbean Regional Coordination Unit (CAR/RCU) under the United Nations Environment Programme (UNEP) (herein referred to collectively as the Cartagena Convention Secretariat), was identified as uniquely positioned to coordinate and execute elements of the project which focus on the marine environment (thematically and geographically) in the Wider Caribbean Region (WCR). Under a UN2UN Agreement with UNOPs, the implementation of specific elements (and their associated activities) of the CLME+ Project outputs were the responsibility of CAR/RCU in coordination with regional stakeholders.

In accordance with the Project Cooperation Agreement (PCA) developed with UNEP, The Ocean Foundation (TOF) was selected to develop the following products:

- A baseline and (pre-) feasibility assessment report on the needs and opportunities for investments to reduce the impacts of pollution on human well-being and to safeguard the goods and services delivered by coastal ecosystems and associated living resources to human society (this report).
- An investment plan for large-scale action on habitat protection and restoration including pollution prevention, reduction and/or mitigation, with special attention to habitats of critical importance in terms of current and potential future provisions of ecosystem goods and services ("blue growth"), and contributions to Global Environmental Benefits (GEBs) (associated report).

This consultancy directly contributes to regional agreements and commitments such as the Specially Protected Areas and Wildlife (SPAW) Protocol, CLME+ SAP and CCI while supporting international efforts such as the Decade of Restoration (2021-2030)[1], which calls for the restoration of degraded and destroyed ecosystems to combat the climate crisis and improve food security, water supply, and biodiversity; the Sustainable Development Goals (SDGs)[2], specially SGDs 6, 13, 14, and 15; the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets[3].

Key Background Documents

The State of Nearshore Marine Habitats in the Wider Caribbean (SoMH)

The SoMH is the first of two regional reports developed by the SPAW Sub-programme of the Cartagena Convention Secretariat and the CLME+ Project as part of the effort towards implementation of the 10-year politically endorsed Strategic Action Programme (CLME+ SAP) (Caribbean Natural Resources Institute, 2020a).

The report supports the objectives of the SPAW Sub-programme component on Conservation and Sustainable Use of Coastal and Marine Ecosystems to:

- Mobilize the political will and actions of governments and other partners for the conservation and sustainable use of coral reefs and associated ecosystems such as mangroves and seagrass beds; and,
- Effectively communicate the value and importance of coral reefs, mangroves, and seagrass beds, including their ecosystem services, the threats to their sustainability, and the actions needed to protect them (UN Environment 2017).

SoMH focuses on three habitats: coral reefs, mangroves, and seagrasses. These three habitats were selected because they make up the reef fisheries ecosystem, one of the three focal sub-ecosystems of the CLME+ SAP.

The report highlights the status and trends of the three habitats, identifies the drivers and pressures, summarizes the interventions to address the pressures, identifies gaps in response, emerging challenges, and proposes actions to improve management of the target habitats. The information is based on a review of literature gathered by the Caribbean Natural Resources Institute (CANARI), including publications shared by Cartagena Convention Secretariat, CLME+ Project Coordination Unit, SPAW Protocol countries, regional intergovernmental organizations, regional academic institutions, and civil society organizations.

[1] NGA resolution A/RES/73/284
[2] UNGA resolution A/RES/73/284
[3] CBD. COP 10 Decision X/2

The report also provides information and context for the development of the regional strategy and action plan for the conservation of these habitats in the Wider Caribbean (strategy summarized below). SoMH also contributed to the State of the Marine Environment and Associated Economies (SOMEE) in the CLME+ region document.

Regional Strategy and Action Plan (RSAP) for the Valuation, Protection and/or Restoration of Key Marine Habitats in the Wider Caribbean.

The RSAP is the second of two reports developed by the SPAW Sub-Programme of the Cartagena Convention Secretariat and the CLME+ Project in implementation of the CLME+ SAP (Caribbean Natural Resources Institute 2020b). The RSAP prioritizes addressing transboundary issues related to coral reefs, mangroves, and seagrass beds that affect multiple countries and benefit from a regional approach. It seeks to address gaps in implementation at the national level and support action-oriented regional strategies to safeguard "Blue Economy" resources for the good of livelihoods.

The overarching goal of the RSAP is to strengthen national and collective action by Member States to manage coastal ecosystems, particularly coral reefs, mangroves and seagrasses, in order to maintain the integrity of the habitats and ensure the continued flow of ecosystem goods and services necessary for national development. Detailed goals and objectives are provided in Table 1.

Goal	Objectives
Goal 1: Strengthen ecosystem health, biodiversity, and resilience.	***Objective 1.*** Restore and enhance ecological integrity and function of coral reefs, mangroves and seagrass beds. ***Objective 2.*** Reverse habitat loss. ***Objective 3.*** Support species diversity within the three habitats.
Goal 2: Sustainably use coastal and nearshore marine resources for national and regional development.	***Objective 4.*** Mainstream the coral reef sub-ecosystem in sectoral, national and regional policies and plans, as well as national budgets, accounting, and reporting systems. ***Objective 5.*** Reduce threats to the habitats from coastal/marine-based sectors and development activities that impact coral reefs, mangroves, and seagrasses.
Goal 3: Strengthen regional governance systems and partnerships for the management of the marine/coastal resources of the Wider Caribbean.	***Objective 6.*** Reduce program conflicts and gaps to improve program synergies. ***Objective 7.*** Improve environmental governance at national and regional levels.
Goal 4. Effectively manage the marine/coastal resources of the Wider Caribbean.	***Objective 8.*** Improve science-based decision-making in policy, planning, and management of coastal ecosystems. ***Objective 9.*** Improve the effectiveness of resource and protected areas management institutions and the impact of management interventions. ***Objective 10.*** Enhance the sustainability of financing mechanisms for protected areas and other site-based conservation efforts.

Table 1 | RSAP goals and objectives. Source: SPAW Sub-Programme of the Cartagena Convention Secretariat and the CLME+ Project (2020).

The SPAW Sub-Programme coordinates the delivery of the RSAP and its regional activities and is supported by the Regional Activity Centre for the Protocol Concerning Specially Protected Areas and Wildlife for the Wider Caribbean Region (SPAW–RAC), under the technical direction of the Cartagena Convention Secretariat.

State of the Cartagena Convention Area Report: An Assessment of Marine Pollution from Land-Based Sources and Activities in the Wider Caribbean Region (SOCAR)

The Wider Caribbean Region (WCR), in particular Small Island Developing States and Island Territories (SIDS), are heavily dependent on the ocean for socio-economic prosperity and human well-being, however, there are threats to this prosperity and well-being. The SOCAR focuses specifically on land-based sources and activities in the WCR that include growing human populations, poorly planned urbanization, harmful production, consumption, and dumping which creates pressure on the marine environment. The Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) remains to-date the only regional legally binding agreement for the protection, sustainable development, and use of the region's coastal and marine resources. SOCAR is the first region-wide assessment undertaken by the Cartagena Convention Secretariat to allow governments to fully comply with their reporting obligations. It is complemented by SoMH so that together with SOCAR they feed into the State of the Marine Environment and Associated Economies report (SOMEE). SOCAR acts as a call to action for states and territories to reduce and eliminate land-based pollution and encourage the following existing protocols, targets, and goals (Heileman and Talaue-McManus 2019).

The report looks at eight water quality indicators: dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), chlorophyll-a, dissolved oxygen, turbidity, pH, and *Escherichia coli* and *Enterococcus* species, as well as a brief review of pollution in the form of marine litter and mercury. The report also looks at key drivers of environmental change, local pressure, the current state of the environment, the effects of environmental changes, and responses by actors to help alleviate stressors and address these changes.

SOCAR states that the WCR has a long path ahead to reach the targets set forth under the United Nations' Sustainable Development Goals, especially those related to pollution, despite greater attention in the region to environmental concerns. The main drivers of environmental change in the region include population growth, urbanization and tourism centered around the coast, and climate change. SOCAR reports that nutrient loading from watersheds and untreated wastewater are the major causes of land-based pressure leading to potentially severe negative effects in the marine environment. There is evidence that groundwater inundated with fertilizer may have more pronounced effects than runoff, and domestic sewage may be the largest source of nitrogen in coastal Caribbean waters. Based on water quality assessments nearly all countries have some sample sites that receive "poor" results or otherwise outside of acceptable range, showing the wider Caribbean region continues to be acutely polluted. The poor results tend to be particularly pronounced during the rainy season and in areas of river discharge. There is direct evidence that land-based pollution is responsible, in part, for the degradation of coral reefs and seagrass beds, damaging the economically valuable marine ecosystems on which many of the region's residents rely.

The report recommends increasing monitoring and assessments that adhere to standard collection protocols, increasing efforts to build capacity and training programs (particularly laboratory capacity for microplastics and ocean acidification), encouraging regional partnerships and the development of national action plans, fully engaging stakeholders to ensure buy-in at the local level and to increase awareness by decision makers, and promoting sustainability.

In order to establish a framework for a reduction from excess nutrient loads on priority coastal and marine ecosystems in the WCR, the Regional Nutrient Reduction Strategy and Action Plan for the Wider Caribbean Region is currently being developed. The Action Plan outlines eight guiding principles to be considered when implementing waste reduction projects in the region:

1. *Science-based approach, using the best available science, data and information, and incorporating local/traditional knowledge;*
2. *Building on the existing foundation established by regional and global initiatives;*
3. *A ridge to reef, integrated watershed approach that considers nutrient sources in watersheds to their impacts in coastal waters, and the heterogeneity among the WCR countries and territories in terms of biogeophysical characteristics and sectors contributing to nutrient pollution;*
4. *Balancing ecological, social, and economic imperatives in decision-making throughout the upstream-downstream continuum;*
5. *Alignment of objectives and targets with relevant national, regional and global policies, frameworks and targets to achieve multiple benefits;*
6. *Strategic, preventative actions at source that are feasible and cost-effective;*
7. *Engagement of all key stakeholders including private sector within a multiscale governance*

framework that encompasses all policy cycle stages;

8. *Adaptive management based on robust monitoring and evaluation processes.*

These principles should also be adopted by habitat restoration projects in the WCR to ensure interventions are effective. Aspects of these principles are incorporated into the site prioritization methodology presented in this report.

Review of the TDAs of the CLME+ Region

The UNDP/GEF CLME+ Project supported a Regional Transboundary Diagnostic Analysis (TDAs) based on TDAs of three fisheries ecosystems of regional significance: the reef, pelagic and continental shelf fisheries ecosystems; and a regional governance analysis. A TDA is a frequently-used tool within GEF International Waters projects to provide a scientifically objective assessment of the causes of the main problems affecting transboundary and shared systems. These reports aim to provide concrete evidence as well as new data to guide development and suggest potential actions (Phillips 2011).

These analyses cover diverse issues such as the dumping of garbage, land-based pollution and oil spills, the shipment of toxic wastes, the conservation of biodiversity, and sustainable fisheries, which are all highly pertinent to the three transboundary issues identified in the CLME (Whalley 2011). By describing the importance of the coral reef-mangrove-seagrass complex and providing guidance on prioritizing areas for restoration and decreasing pollution in order to maximize restoration effectiveness in the WCR, our report aligns well with the TDA of the reef fisheries ecosystem. A healthy and functioning coral reef-mangrove-seagrass complex will lead to a healthier reef fisheries ecosystem, thereby supporting the region's commercial fisheries.

Overview of CLME+ Region Environmental, Social, and Economic Benefits

The Caribbean region, with its 37 countries and overseas territories, is renowned for its diverse marine life, rich cultural diversity, turquoise waters and spectacular beaches. As one of the most biologically rich marine environments in the Atlantic, the Caribbean is home to 10% of the world's coral reefs, 1,400 species of fish and marine mammals, and extensive coastal mangroves. The marine and coastal resources of this region, its coral reefs, beaches, fisheries and mangroves, serve as an economic engine, supporting jobs, income, and economic prosperity. Perhaps more than any other region, the Caribbean is highly dependent on its marine and coastal resources (Figure 2). Seventy percent of its population lives along the coast and tourism, the region's largest economic sector, is inextricably linked to a healthy and thriving marine and coastal environment.

Important Economies in the Wider Caribbean Region (Caribbean Challenge Initiative, 2016)

- Tourism in the Caribbean generates US $25B of revenue annually, supporting 6 million jobs and accounting for nearly 50% of total income.
- Marine life attracts 60% of the world's scuba divers, generating tens of millions of dollars and thousands of jobs annually.
- Coral reefs and coastal mangroves protect coastal communities, hotels, roads, and other infrastructure along shorelines from storm damage.
- Fisheries (fish, lobster, and conch) provide US $400M of revenues across the region, livelihoods and food security for millions.
- Total annual value of Caribbean coral reefs is estimated at approximately US $2B (from tourism, fisheries, and shoreline protection services).

Fig. 2 | Important Economies in the Wider Caribbean Region. Source: Caribbean Challenge Initiative (2016).

The COVID-19 pandemic has placed additional stress and uncertainty on these industries, particularly tourism. In the Caribbean, tourism is reliant on clean beaches and healthy reefs. We hope this report will help emphasize the need to better incorporate and account for natural resources in all economic and policy decisions. Also, the post-COVID tourism industry in the Caribbean will most likely draw less mass tourism ("sun and fun" and cruise tourism) and smaller, ecologically sustainable enterprises that focus on smaller groups of tourists who may prize more intimate experiences in more pristine areas. As a result, restoring natural ecosystems will heighten the experience while employing more local people in bioremediation. It also has the benefit of involving local communities in the process and planning of bioremediation, thereby enhancing stewardship.

In recent decades, the growing impacts of unsustainable coastal development, climate change, overfishing, and land-based sources of sediment and pollution threaten the viability of the region's marine and coastal ecosystems. A number of authoritative studies document a dramatic decline in the condition of the region's marine and coastal ecosystems. Many experts have concluded that we have reached a critical crossroads for action.

- 75% of coral reefs across the Caribbean currently face medium or high levels of threat (World Resources Institute, 2011).
- Coral reefs across the region are on the verge of collapse, with less than 10% of the reef area showing live coral cover (World Conservation Union, IUCN, 2012).

- 70% of the beaches in the region are eroding at a significant rate, in part due to declining coral reefs.
- Tourism developments can result in loss and degradation of critical marine / coastal ecosystems. Unsustainable tourism can strain natural ecosystem limits, sometimes to a point beyond recovery (Caribbean Sea Ecosystem Assessment 2007).
- All major commercially important fishery species are "fully developed" or "over-exploited", and 70% of reefs across the region are threatened with overfishing (Caribbean Sea Ecosystem Assessment 2007).

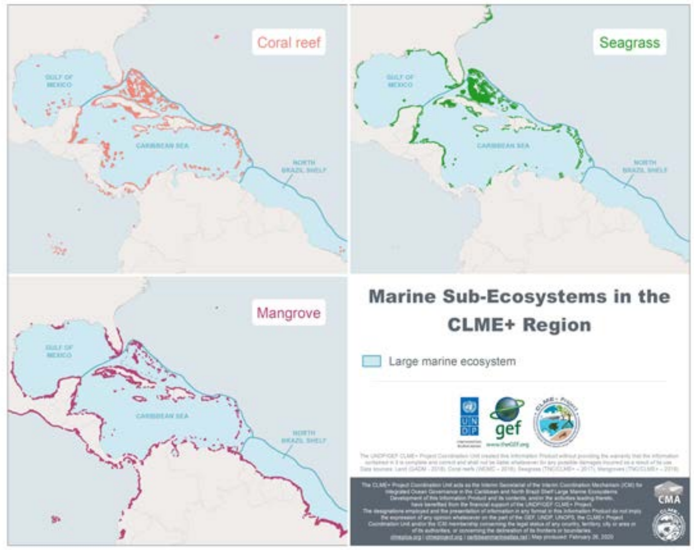


Fig. 3 | Distributions of coral reef, seagrass, and mangrove sub-ecosystems in the CLME+ region. Source: UNDP/GEF CLME+ Project Coordination Unit (2020).

Biodiversity Hotspots in the Wider Caribbean

The Caribbean is a marine biodiversity hotspot and is ranked in the top 12 richest centers of species endemism globally. The region is home to expansive coral reefs, one of the most biologically diverse marine ecosystems, yet the survival of these habitats is being threatened by human activities and a changing climate (Roberts et al. 2002). Other key coastal ecosystems, including seagrasses and mangroves, are also widely distributed throughout the region (Figure 3).

Within the Caribbean, the IUCN has identified Key Biodiversity Areas (KBAs), which are identified based on globally agreed criteria. These 11 criteria are grouped into five categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability (BirdLife International 2020). The WCR hosts more than 300 KBAs (Figure 4).

Other internationally recognized frameworks have designated areas within the WCR as biodiversity hotspots. The Caribbean region hosts 15 Ecologically or Biologically Significant Areas (EBSA), which is an area of the ocean that has special ecological and biological importance as identified by the Convention on Biological Diversity; nearly

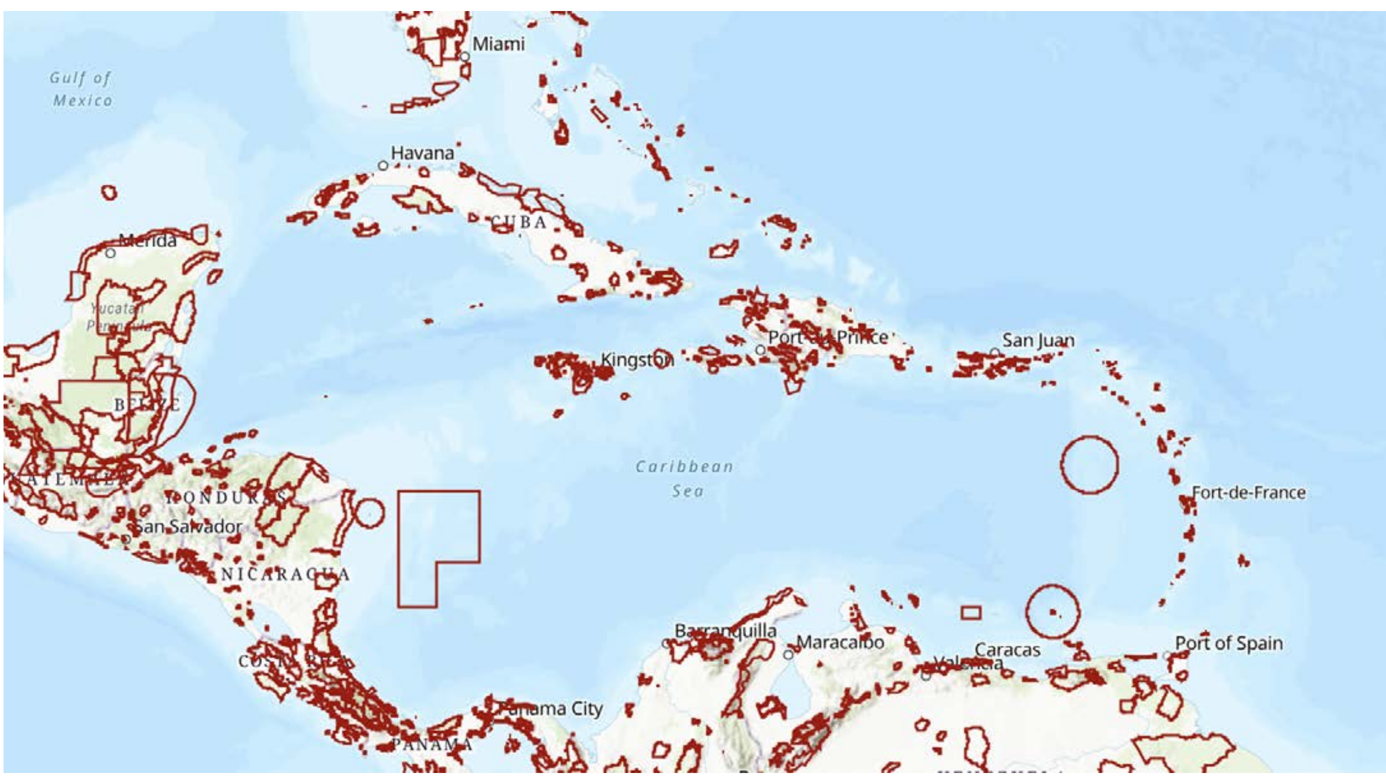


Fig. 4 | Map of key biodiversity areas in the Wider Caribbean Region (BirdLife International, 2020)

100 sites under the Ramsar Convention on Wetlands of International Importance; 35 protected areas under the Specially Protected Areas and Wildlife Protocol of the Cartagena Convention; and six UNESCO World Heritage Sites. It is also home to the Mesoamerican reef, the largest barrier reef in the Western Hemisphere (Caribbean Natural Resources Institute, 2020).

Pollution Hotspots in the Wider Caribbean

Humanity is highly dependent on the health of the ocean. All of the planet's 7.5 billion residents depend on the ocean in fundamental ways. The three billion people who live in coastal communities have an even closer link, depending directly on the oceans for their livelihoods and diets (OECD 2016). According to the Ocean Health Index (OHI), there are general categories of chemicals that are of particular concern in the marine environment: oil, toxic metals, and persistent organic pollutants that can affect habitats, food web, species diversity, and may lead to changes in overall ecosystems (OHI 2020).

One of the largest sources of pollution is nonpoint source pollution, which occurs because of runoff. Nonpoint source pollution can originate from many sources, such as septic tanks, vehicles, farms, livestock ranches, and timber harvest areas. Nutrients are key parameters in the

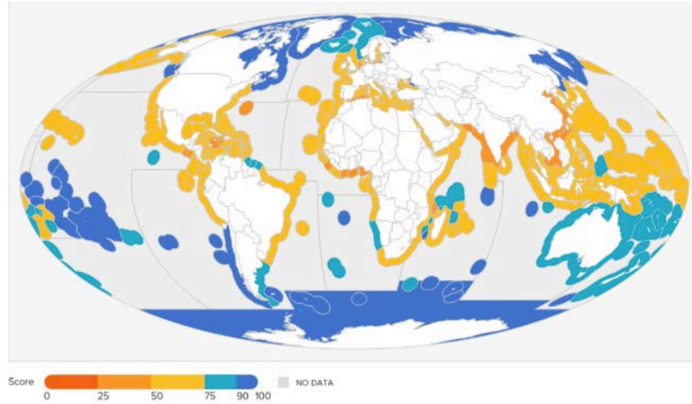


Fig. 5 | Map of "clean water" in the ocean in which 0 is very poor and 100 is very good. Source: OHI (2020).

biogeochemical cycles of the ocean, although, the concentration varies from one region to another either for natural or anthropogenic processes; therefore, ecosystem adaptation/response to these concentrations will be site specific (Diez et al. 2019).

As pollution varies by site-to-site there are particular "hotspots" that have particularly high levels of pollution (Figure 5). It should not be assumed that because many Caribbean nations have few major industries, that pollution is not generated from land-based sources. There are a

Source: UNEP-CEP 2010. Map elaborated by World Bank GIS Lab.

Fig. 6 | Domestic Wastewater Treatment Rates in the WCR. Source: Diez et al. (2019).

number of industrial hotspots around the Gulf of Mexico that discharge substantial pollutant loads into the environment that can find their way to the waters of other countries: "The smallest industrial pollutant loads come from the western Caribbean (the Central American countries), while in the eastern Caribbean, Trinidad and Tobago contributes the largest industrial pollutant loads to the marine environment, due to the increased industrial development, notably oil facilities" (Diez et al. 2019).

Plastic pollution is both a point and nonpoint source of pollution. The most common types of plastic pollution include plastic water bottles, foam containers, cigarette butts, bags, satchels, as well as abandoned or lost fishing gear (Ocean Conservancy 2019). Studies have measured the concentration of plastic litter across the Caribbean and found as many as 200,000 pieces of plastic per square kilometer in the northeastern Caribbean. Marine litter in this hotspot has been found to originate from the Caribbean as well as from northern waters. These plastics settle throughout the water column, fragmenting into smaller pieces called microplastics, now considered an emerging marine pollutant. As marine litter accumulates in the ocean, SIDS are often exposed to concentrations of litter that are disproportionate to their own consumption and population (Diez et al. 2019). Further, they have fewer and more scattered facilities to dispose of, let alone recycle it.

It is estimated that only about 60% of the Latin America and Caribbean's population is connected to a sewage system, and only about 40% of the region's water is treated (Figure 6). Untreated or partially treated domestic wastewater is the number one point-source of marine pollution in the WCR. Untreated wastewater can cause or increase the probability of an area becoming a pollution hotspot. Untreated or partially treated domestic wastewater is also a multiple stressor as it could result in excess sediments, nutrients, metals, pathogens, microplastics, and emerging contaminants such as hormones, pharmaceuticals, and endocrine disruptors. If these pollution hotspots are not treated, then it is more likely that any restoration efforts will be futile. Wastewater should be considered a resource rather than a liability. With proper planning, management, and financing, wastewater could transform into a key feature of the circular economy.

Marine pollution damage goes beyond marine ecosystems and biodiversity, it can greatly affect human health and major economic activities in the region such as tourism, fisheries, and shipping. The destruction of marine ecosystems such as coral reefs, mangroves, and seagrass beds pose threats to the livelihoods of people working in tourism and fisheries and diminishes natural protection from storms and hurricanes (Figure 7).

Habitat Restoration in CLME+

Our understanding of ecological restoration is historically skewed toward terrestrial ecosystems. In general, ecological restoration is defined by the Society of Ecological Restoration (SER) as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004). Thus, ecosystem restoration, in a broad sense, is any activity which improves the overall ecological condition (structure or function) of a natural community or disturbed site, including the return of a community or ecosystem to a pre-disturbance condition. Active restoration has been commonly implemented in

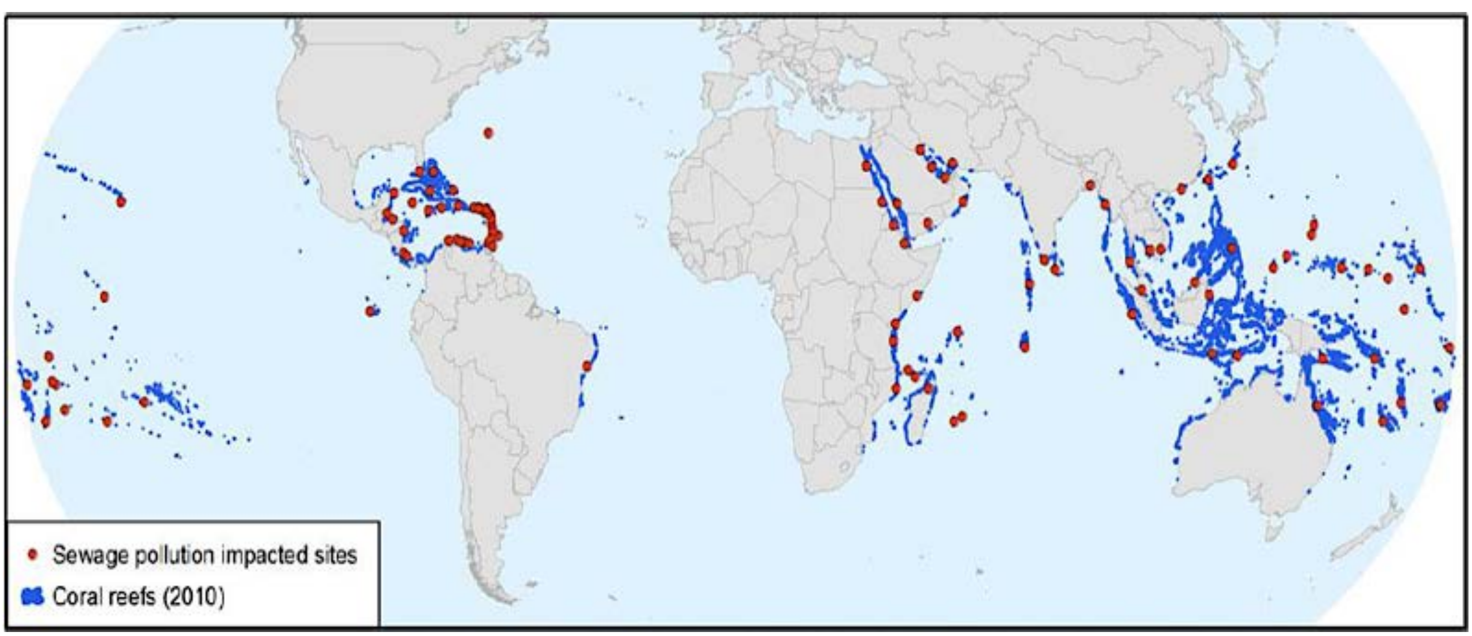


Fig. 7 | Coral reefs affected by sewage pollution worldwide. Source: Wear and Thurber (2015).

Ecosystem	Restoration Activity	Cost/ha (2010 $US)	Location	Literature
Coral	Coral gardening	$351,661	Global	Boström-Einarsson et al. (2018)
	Coral gardening - nursery phase	$5,616	Global	Boström-Einarsson et al. (2018)
	Coral gardening - transplantation phase	$761,864	Global	Boström-Einarsson et al. (2018)
	Direct transplantation	$73,893	Global	Boström-Einarsson et al. (2018)
	Larval enhancement	$523,308	Global	Boström-Einarsson et al. (2018)
	Substrate addition - Artificial reef	$3,911,240	Global	Boström-Einarsson et al. (2018)
	Substrate stabilization	$467,652	Global	Boström-Einarsson et al. (2018)
Seagrass	Transplanting seagrass (cores or plugs)	$32,348	Texas, Australia	Bayraktarov et al. (2016)
Mangrove	Hydrological restoration	$3,750	Gulf of Mexico	Herrera-Silveira et al. (2016)
	Planting mangroves	$1,821	Philippines, Nigeria, Ecuador, Florida	Bayraktarov et al. (2016)

Table 2 | Median costs per hectare in 2010 USD of coastal habitat restoration activities. Source: Bayraktarov et al. (2020), Bayraktarov et al. (2016), and Herrera-Silveira et al. (2016).

other ecosystems such as forests, streams, wetlands, oyster beds, seagrasses, and mangroves; and include activities such as biological or hydrological manipulation, population enhancement of vulnerable species, control and elimination of invasive species, and cleanup of environmental contaminants (Thorhaug 1986, Coen and Luckenbach 2000, Callaway 2005, Simenstad et al. 2006, Bosire et al., 2008, Aerts and Honnay 2011, Pandolfi et al., 2014).

Ecological restoration, when implemented effectively and sustainably, has contributed to protecting biodiversity, improving the health and well-being of people, increasing food and water security, delivering goods, services, and economic worth, and promoting resilience and adaptation to climate change (SER 2004, Gann et al. 2019). The ecological, economic, and natural capital benefits of restoration activities will be outlined further in Part II of this report.

Habitat restoration is occurring throughout the region with restoration of seagrasses, mangroves, and coral reefs typically conducted independently from one another rather than in combination at the ecosystem level. Coral reef restoration is the most common in the region, followed by mangrove restoration, and lastly seagrass restoration. Much of the conservation activities in the CLME+, such as habitat restoration, are funded by multilateral sources like the Global Environment Facility (GEF) or the European Union, bilateral sources in developed countries, and also from national budgets (Caribbean Natural Resources Institute 2020b). Table 2 provides median costs of coastal habitat restoration activities, primarily in the Caribbean region. In the following section, we provide an overview of the seagrass, mangrove, and coral reef restoration activities in the CLME+ region (Figure 8).

Overview of Recent Efforts

Seagrasses

Seagrass Habitat Function

Seagrasses are foundation species in Caribbean coastal ecosystems that provide a broad range of ecological functions and services including both direct and indirect biophysical and ecological connectivity with coral reef and mangrove habitats (Orth et al. 2006, Waycott et al. 2009, Grech et al. 2012, Unsworth et al. 2019). The consequences of failing to develop policies and implement actions to conserve and restore seagrasses in the WCR will result in region-wide declines in marine biodiversity, declines in fisheries production, increased stress on endangered species (e.g., green sea turtles, manatees), coastal water quality degradation, and decreased resilience to tropical cyclones. The livelihoods of coastal communities and their economies are tethered to healthy and productive seagrass ecosystems, making these ecosystems even more important to protect.

Seagrass Habitat Degradation

A major threat to seagrass habitat in the region is coastal development, particularly related to hotel construction for tourism. In particular, beachside construction leads to increased erosion and sedimentation of the flat, shallow areas where seagrasses thrive and, once hotels are built, increased use of wading areas leads to trampling of seagrass habitats by tourists and boat craft. Also, increased pulses of effluent from hotels can compromise water quality to which seagrasses are highly sensitive. Other threats include watershed degradation, impaired coastal water quality, water diversion, modified hydrology, boating, aquaculture, overfishing, sea level rise and increasing sea surface temperatures. These threats often occur simultaneously (Orth et al. 2006, Waycott et al. 2009, Unsworth et al. 2012).

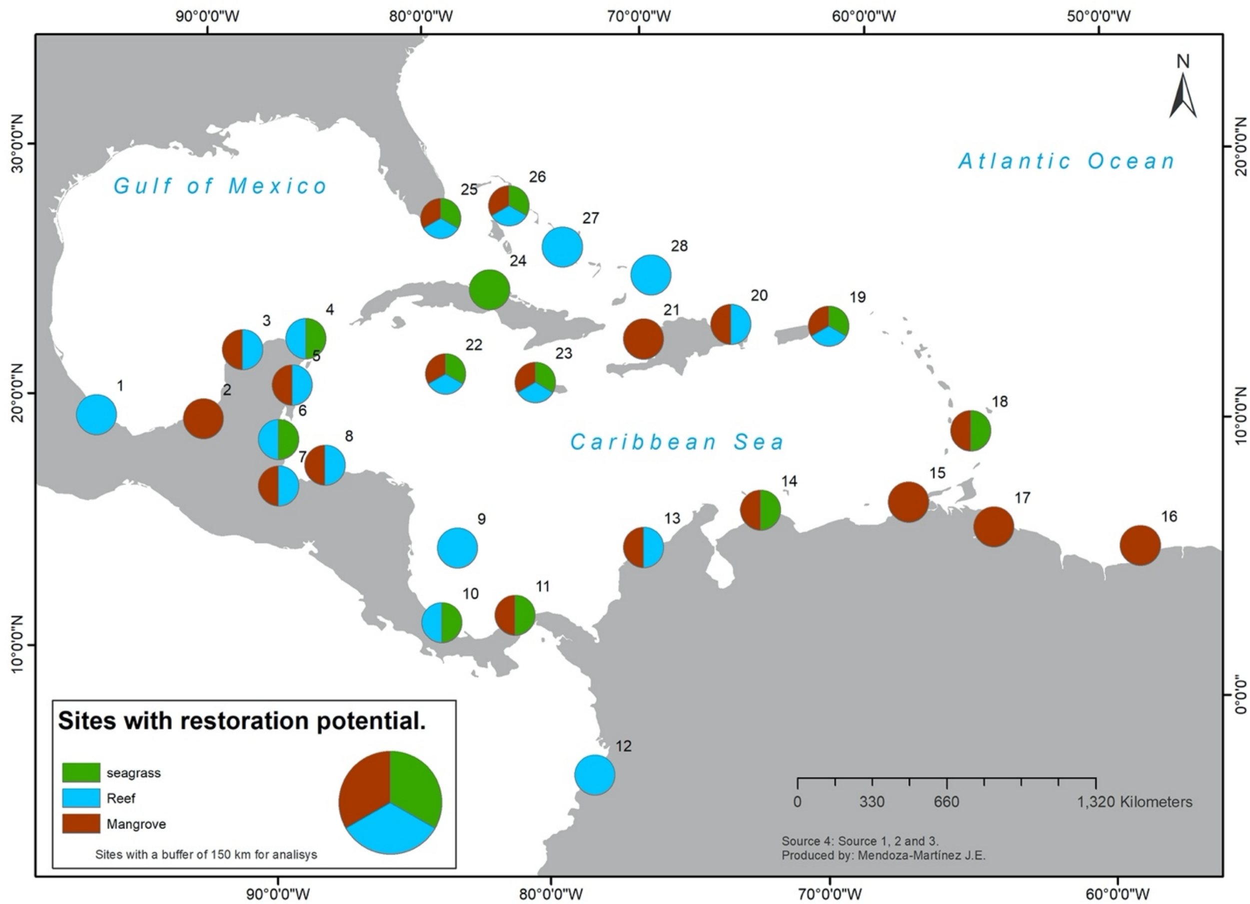


Fig. 8 | Sites where coral reef restoration projects (blue) and mangroves (red) have been carried out, and potentials for the restoration of seagrasses (green). Circles are placed on specific sites within countries. Source: Jorge A. Herrera-Silveira (2020).

The Caribbean Coastal Marine Productivity (CARICOMP) program has monitored seagrass communities in the Caribbean from 1992-2007 for changes in biomass and productivity. With data taken from 52 monitoring stations across the Caribbean, Van Tussenbroek et al. (2014) assessed the impact of human activities on seagrass habitats. Forty-three percent of the seagrass communities at 35 of the long-term monitoring stations showed changes in biomass and productivity associated with environmental degradation. The authors argued that increased terrestrial run-off (sewage, fertilizer, and/or sediments) is the major anthropogenic influence on seagrasses in the Caribbean. These effects will likely increase in the near future and become more widespread if no action is taken.

An example of how human activity can alter seagrass communities in South Florida was demonstrated by a study conducted in western Biscayne Bay (Lirman et al. 2014) which found that the proximity of the major metropolitan center, Miami, and changes in hydrology due to efforts to restore freshwater flow into the Everglades have caused major shifts in coastal salinity and water quality. These changes in turn have altered the composition of seagrass communities composed primarily of *Thalassia testudinum, Syringodium filiforme, and Halodule wrightii* species. Changes in salinity and nutrient availability initiated the decline of these seagrass dominated communities in exchange for macroalgae communities. As has been demonstrated in other coastal ecosystems, this study revealed how the association of human development and high population densities can have serious consequences for coastal seagrass ecosystems.

In an evaluation of coastal resource degradation, Wilkinson and Salvat (2012) assessed possible management solutions to help protect coral reefs, mangroves, and seagrasses. These resources have often been described as "commons," open for access to anyone, but in reality, these resources generally fall under the control of local coastal communities. To manage seagrasses, effective policies must be implemented at the local level. However, there is a disconnect between the regions of conservation research (developed nations), and the primary regions of seagrass habitat (developing nations). If seagrasses are to be protected using comprehensive coastal management and marine protected areas (MPAs), there must be greater cooperation between governments, policy makers, and scientists both at the national and international level (Wilkinson and Salvat 2012). The global status of seagrass species and the current threats facing them have been

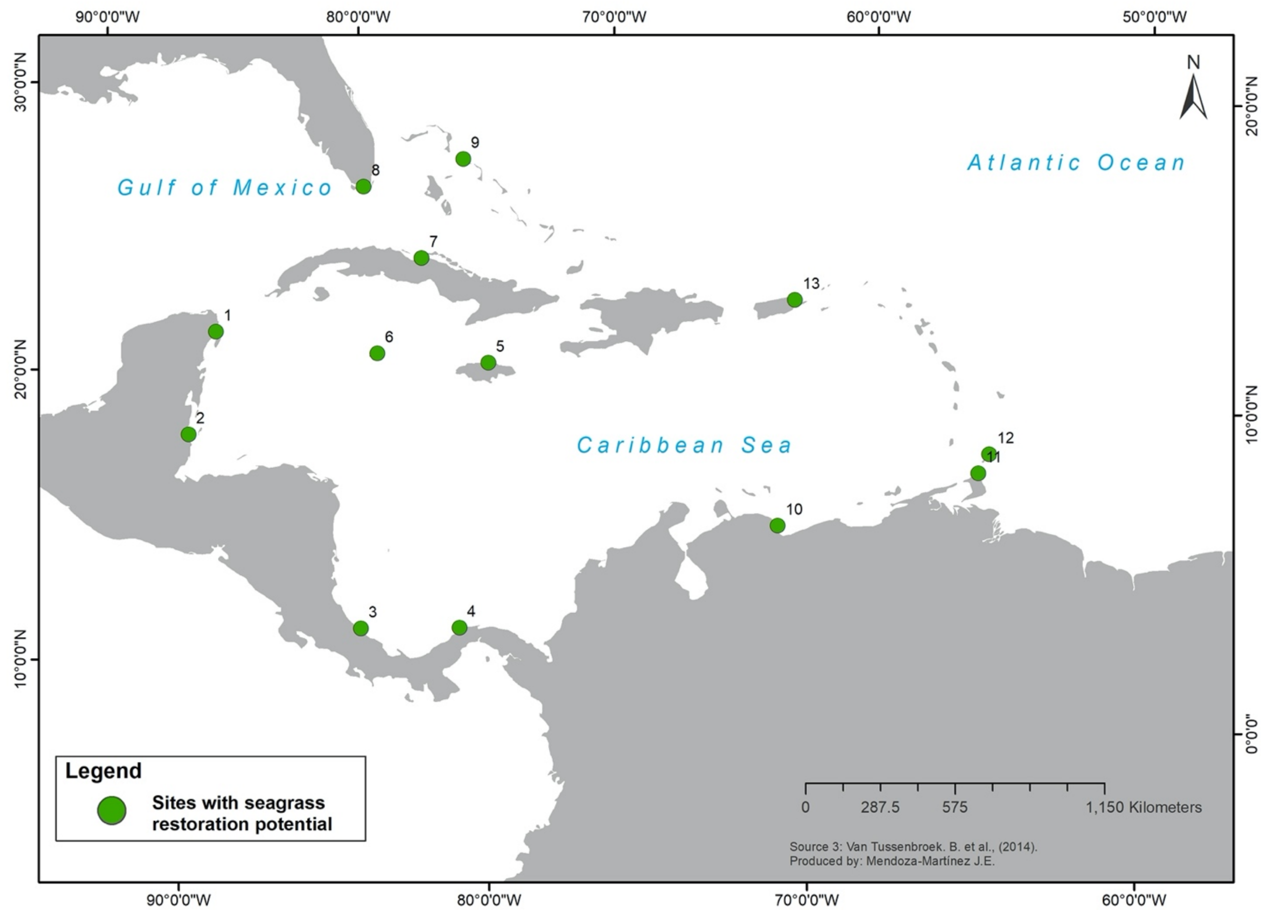


Fig. 9 | Sites where deterioration of seagrasses has been identified, which could represent sites with restoration potential within the Wider Caribbean Region. Source: Jorge A. Herrera-Silveira (2020).

established and while more research will certainly be beneficial, there is an urgent need to focus on reducing the impacts of human activities (Waycott et al. 2009, Orth et al. 2006). For the benefit of future generations, the best possible management effort will consider all users of seagrass ecosystems, so that they can be utilized but not overexploited.

Seagrass Habitat Restoration Methods

We define seagrass restoration as the process of attempting to return an area to its pre-existing habitat composition with the general intent of restoring seagrass habitat, structure and function, and the ecosystem services they provide (Lewis 1987). Figure 9 shows several sites that have been directly identified in the region where significant habitat detioriation is occurring. Restoration conveys the meaning of a return to pre-existing conditions; however, our definition also recognizes that the disturbance responsible for the loss of seagrass may have altered the state of the system. Lingering stressors for seagrass growth that are not easily seen or detected may limit or prevent a return to pre-existing conditions. For instance, following system degradation and seagrass die off, the sediments in a system can accumulate high sulfide concentrations, which in turn may last for decades and prevent seagrass growth (Christiaen et al. 2013). Similarly, climate change, through altered rainfall patterns, storms and increased heat waves, can also hinder seagrass establishment in a-priori restorable sites (McDonald et al. 2020). In these examples, the process of returning to a predefined restored state may be temporarily or even permanently substituted with a new resilient state that includes seagrass as the foundation species for the success criteria, but not necessarily to the original species composition. Sometimes this is referred to as seagrass rehabilitation and considered an approximation of the condition prior to restoration (Gordon 1996, Paling et al. 2009). Furthermore, our definition of restoration is not to be confused with either mitigation or creation of seagrass meadows in the regulatory context (Lewis 1987, Fonseca et al. 2002); however, many of the issues related to the methods and success of seagrass restoration can be equally applied to mitigation efforts and the creation of seagrass habitat.

For this report we divide seagrass restoration into two categories: 1) seagrass transplanting, and 2) ecosystem-based seagrass restoration. The difference between the two categories is largely a matter of scale and approach. In the case of seagrass transplanting (putting plants in the ground taken from another location) most of the efforts have been restricted to relatively small planting scales and abbreviated time periods; in a majority of cases < 1,000 shoots/seeds initially planted and monitored for < 3 years (van Katwijk et al. 2015). Many of the transplant trials (1786) reported in the van Katwijk et al. (2015) global review were small in size (<1 km^2) and either designed to gain more knowledge about seagrass restoration methods (54%), restore natural function (31%), or mitigate for damage and loss of seagrass (15%).

Of the 1786 seagrass transplanting trials evaluated in the van Katwijk et al. (2015) meta-analysis, 1060 were used to evaluate survival. The overall survival rate of the plantings was 37% but increased to 42% for the largest scale (>100,000 shoots). This meta-analysis revealed the low probability of success for small-scale seagrass transplanting in general, and reinforced some of the most important considerations when attempting to transplant seagrass including: the transplant site characteristics, planting methods, species planted, planting stock source, and the need for long-term monitoring of restoration sites to confirm success or failure (Fonseca et al. 1998, Fonseca et al. 2002, Paling et al. 2009). Time and again, the characteristics of a potential transplanting site and the process used to select locations for restoration have been one of the most common obstacles for achieving success. While it is generally not advised to transplant into areas without a history of seagrass presence, it is also not a guarantee that historical presence assures a high probability of success. For improved success, reliable habitat suitability models are needed to assess candidate locations before establishing and monitoring "test plots" and ensuring that a site is suitable for larger-scale planting (Fonseca et al. 1998, Calumpong and Fonseca 2001, Short et al. 2002, Campbell 2002).

Generally, we can divide seagrass transplanting methods into four categories: 1) Seagrass with sediment, 2) Sediment-free methods, 3) Sowing of seeds, and 4) Laboratory micro-propagation. The popularity of each of these methods has varied over the years since seagrass transplanting was first considered a form of coastal restoration (Addy 1947, Fonseca et al. 1998, Fonseca 2011). As interest in seagrass restoration has expanded, each of these general categories have undergone experimental testing, practical application, and economic scrutiny with further development of sub-categories designed to meet the specific restoration needs in a wide range of coastal environments.

The chronically low probability of transplant success together with the use of habitat suitability indices for selecting appropriate sites and a general acceptance of ecosystem-based management practices, has drawn more attention to the alternative concept of "seagrass ecosystem restoration." This concept is based on the premise that if the stressors responsible for seagrass loss are mitigated or in the best-case scenario, eliminated, seagrasses will recover naturally. While there are no specific examples of this approach for seagrass restoration in the Wider Caribbean Region, there is a particularly relevant example of its success in the southwestern Gulf of Mexico that can be applied to the Caribbean seagrass ecosystem (See Greening and Janicki 2006, Tampa Bay Estuary Program 2017, Greening et al. 2014).

A benefit of an ecosystem-based seagrass restoration approach is the cascading positive effects on other components of the coastal system. Mitigation of stressors (e.g., nutrient and sediment loading, water circulation, water delivery) that impacted seagrasses are certain to have widespread and significant positive effects on other benthic flora and faunal communities, including fisheries, coral reef health and mangrove forests, all of which contribute to the health of these interconnected systems and the well-being and livelihood of coastal communities that depend on these natural resources.

Seagrass Restoration Costs

A recent study conducted by Bayraktarov et al. (2016) performed a synthesis of 235 studies with 954 observations from restoration or rehabilitation projects of coral reefs, seagrass, and mangroves worldwide, and evaluated the cost, survival of restored organisms, project duration, area, and techniques applied. Their findings were compelling showing that while the median and average reported costs for restoration of one hectare of marine coastal habitat were around US$80,000 (2010) and US$1,600,000 (2010), respectively, the real total costs (median) are likely to be two to four times higher. Justification for these restoration activities will be discussed in Part II of this report.

Seagrass along with corals are among the most expensive per hectare ecosystems to restore in the Wider Caribbean while mangroves are the least. Most marine coastal restoration projects reported were conducted in Australia, Europe, and USA, while total restoration costs were significantly (up to 30 times) less expensive in countries with developing economies. Community based restoration projects usually have lower costs (as is the case for The Ocean Foundation's ongoing seagrass and mangrove projects in Puerto Rico). Median survival of restored marine and coastal organisms varies and are often assessed only within the first one to two years after restoration. The global median success rate for seagrass restoration is 38% and depends primarily on the ecosystem, site selection, size of restoration project, and the techniques applied.

Mangroves

Mangrove Habitat Function

Like all other tropical coastal habitats, mangroves have an enhanced role in mitigating pollution. Due to their deep underlying layers of peat, they have a natural ability to act as a sink (an area that captures human waste as opposed to producing it) for anthropogenic and industrial pollutants.

Mangrove ecosystems are involved in numerous natural cycles (e.g. carbon and nutrient cycles, sediment characteristics, tidal conditions) and therefore affect the bioavailability of contaminants (Bayen 2012). They can also arrest and bioremediate certain pollutants (like fluoride) in the local environment (Murray 1985, Akhand 2012). They not only act as a sink, but also oxidize the metals present in the sediment by oxygenating anoxic soil through aerial roots (Scholander et al. 1962).

Mangrove wetlands are often found in isolated areas and due to their thick undergrowth, they are often used as dumping grounds for unwanted refuse (Chu et al. 2000, Mitchell 1978). An increase in industrialization and uncontrolled anthropogenic pressure on virgin mangrove stands has increased in recent years; however, mangrove ecosystems are able to absorb much of this pollution into their tissues and underlying peat. Mangrove soils/sediments are usually fine-grained, water-logged, and receive allochthonous organic matter from terrigenous origins (Lewis et al. 2011). Chemical contaminants in mangrove ecosystems are present in pore water, overlying water, and solid phases such as sediment, suspended particulate matter, and biota (Lewis et al. 2011).

The inundation of mangroves generally results in the depletion of oxygen in the organic rich sediments (Bayen 2012). Since sulfate ions are usually present in large supply, sulfidic conditions will also arise. The stratification of redox conditions, from suboxic to anoxic and sulfidic, was reported for unvegetated sediments and those covered with mangrove plants. In the sulfidic zones, the co-precipitation of trace metals together with other sulfide minerals (e.g. iron sulfide) is described as a major process leading to the immobilization of metals in mangroves. Physio-chemical changes in the rhizosphere are also associated with changes in the concentration and speciation of trace metals (Bayen 2012). Mangroves are characterized by highly anoxic reducing soil, with high decomposer activity (Valiela et al. 1974). It is argued that these ecosystems have sediment with high sorption capacity, which could be used in a primary sewage treatment process where the nutrient from the sewage load would also be instrumental in boosting the productivity of the ecosystem and protect the adjacent submerged coral and seagrass habitat (Giblin et al., 1980). Reports on red mangrove (*Rhizophora mangle*) marshes at Sepetiba Bay, Rio de Janeiro showed that 95% of the total concentrations for Fe, Cu, Cd, Pb, and Cr, exist in strongly bound faction and are unavailable to the plants (Silva et al. 1990). Different mangrove forest areas across the world have varying levels of pollution load. A correlation is observed between total organic carbon (TOC) and heavy metal concentration (Qiu et al. 2011). Salinity in estuaries is also responsible for changes in adsorption processes for metals (Laing et al. 2009). The increase of the salinity is associated with an increase in the concentrations of major cations (Na, K, Ca, Mg) that compete with heavy metals for the sorption sites.

The high variability of the sites where the studies have been carried out does not permit drawing general conclusions; however, there does seem to be consensus on the ability of mangroves to be sinks of pollutants, mainly those that come from urban and agricultural areas.

Mangrove Habitat Degradation

Caribbean mangroves can be characterized in different ways depending on their geographical location. Those that are in continental coastal zones or large islands are more directly related to processes of terrestrial origin and large basins with greater runoff. The mangroves of cays or small islands are more dominated by their internal nutrient dynamics and the effect of tides and waves, as well as by their relationships with other associated ecosystems such as coral reefs or seagrass beds.

One of the characteristics of mangroves is their close functional relationship with other coastal and terrestrial ecosystems, marine ecosystems, and atmospheric processes. These functional relationships imply that different sources of damage occur from natural origin (e.g., siltation, erosion, the direct and indirect effect of tropical storms or tsunamis) or are induced by anthropogenic activities (e.g., pollution, land use policies, overharvesting, aquaculture, altered hydrology and hydroperiod).

This multilevel damage on mangroves produced losses in the Caribbean region that have not been accurately assessed. However, with information from different sources and integrated into the webpage: https://maps.oceanwealth.org/mangrove-restoration/ and grouped according to the regions proposed by Dinerstein et al. (1995), some estimates can be made. The Mesoamerican Reef System region has the largest degraded area (Figure 10). In the case of archipelagos,

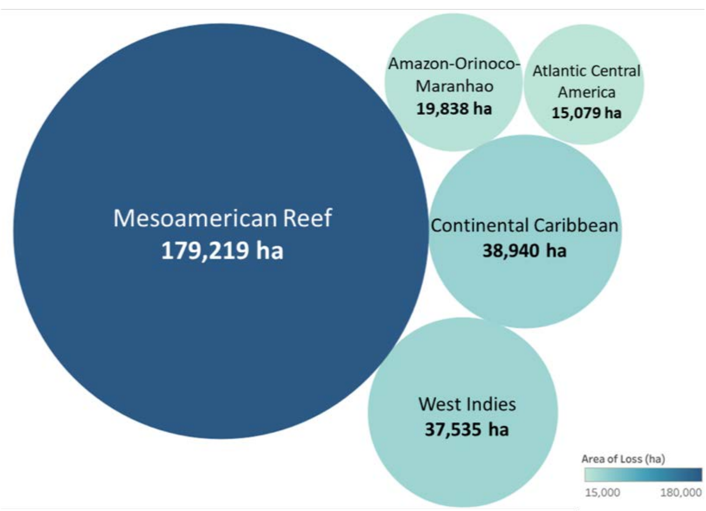


Fig. 10 | Lost mangrove coverage in the Caribbean region, classified by subregions. Source: Dinerstein et al. (1995) and with data from: https://maps.oceanwealth.org/mangrove-restoration/ (2020).

Fig. 11 | Sites Different impacts illustrated in the mangroves of the Caribbean region: road construction (top, Mexico), shrimp farming (second, Honduras), urban development (third, Panama), and hurricanes (bottom, The Bahamas). Source: Claudia Teutli and Jorge A. Herrera-Silveira (2020).

Cuba and the Bahamas stand out in the number of hectares impacted. Standardized maps under the same methodology as part of a monitoring program is one of the pending tasks in the region. In accordance with the connectivity that mangroves have with other ecosystems, just one of the sources of damage, pollution, has serious consequences for the functioning of the coastal ecosystems of the Caribbean, with evidence in seagrasses and coral reefs (Carruthers et al. 2005, Mutchler et al. 2007, Solís et al. 2008). The poor quality of the water sources that reach the mangroves, mainly those related to freshwater, can impact the functions of the mangrove ecosystem. However, due to the biogeochemical characteristics of mangrove sediments, hydroperiod variability and natural changes in salinity, these ecosystems have been studied experimentally and in pilot projects as systems that reduce the load of pollutants (nutrients) and suspended particulate matter from urban wastewater and aquaculture (Gautier et al. 2001, Cordeiro et al. 2010, Zaldívar-Jiménez et al. 2012).

The causes of deterioration in mangrove ecosystems also depend on the history of each place, as well as on the economic development of each country. For example, in the Virgin Islands, Honduras, Antigua and Barbuda, the Dominican Republic, The Bahamas, and Mexico, tourism has had a strong impact on the mangrove communities. In other places shrimp farming, the construction of shelter ports, agriculture (rice crops), salt retention ponds (Panama, Honduras), as well as the construction of roads that obstruct the flow of water (Mexico) have seen substantial impacts on the mangrove communities (Figure 11). Natural events such as hurricanes have also had a strong adverse impact on these ecosystems. Harvesting mangroves for charcoal and construction materials is also a cause of deterioration. Using remote sensing technologies, it would be relatively easy to determine the level of impact and resilience of these ecosystems relative to hurricane events. This is a pending task at the local and regional level.

Mangrove Habitat Restoration

Mangrove restoration projects, and the impact of pollution in mangroves in the greater Caribbean, are documented both in scientific journals, in reports, and on Internet pages. Many of the projects and reports in the gray literature and internet reports do not provide data to quantify project results. In many of them, the success indicator of the project is that they were able to gather community members, make them participate in the project and plant a set quantity of propagules and/or seeds.

Lack of legislation plays an important role in the deterioration of mangrove ecosystems. In many countries land tenure is not defined, and authorizations are needed to change land uses. However, as with Mexico, mangrove

Group of Data	Variables
Hydrological Variables	Frequency, flood level, flood time, residence time of water.
Biological Components	Fish and plants.
Fish	Abundance, biomass, density, diversity, species, wealth.
Plants (Function)	Leaf litter fall, root productivity.
Plants (Structure)	Height, density, diameter, basal area, species.
Biogeochemical Processes	Storage and cycle of carbon, nitrogen and phosphorus, characteristics of interstitial water and accumulation of organic matter.
Carbon storage	Total in sediment, organic carbon.
Nitrogen storage	Total nitrogen, organic nitrogen.
Phosphor storage	Total phosphorus, PO_4.
Interstitial water	Salinity, pH, redox potential, sulfuric.
Accumulation of organic matter	Soil organic matter, density.

Table 3 | Variables evaluated in Caribbean restoration projects. Source: Claudia Teutli and Jorge A. Herrera-Silveira (2020).

species are protected by the General Law of Ecological Balance. Environmental impact assessments (EIA) which help mitigate negative impacts of construction projects and even offer alternatives to compensate for environmental deterioration. However, EIAs are carried out by consulting companies that do not have expertise in mangrove ecosystems. The consequence is that proposed mitigation and compensation measures, mainly those related to restoration, are not adequate and are not based on a comprehensive strategy.

Mangrove Restoration Methods

The review of restoration projects in the Caribbean reveals three groups of data that are commonly reported: 1) hydrology, 2) biological and 3) biogeochemical (Table 3). The most evaluated variables are those of the biological component with an emphasis on characteristics of the forest structure (density, survival, height). Other components of the ecosystem that are indicators of the success of the restoration have been the fish communities (Arceo-Carranza et al. 2016). Few projects have measured the functional characteristics of restored ecosystems such as litter or root productivity (Teutli-Hernández 2017). Looking at hydrology, the parameter most frequently evaluated is interstitial salinity (Table 3). Several projects report that mangrove mortality was a result of hypersalinity and recommend hydrological reconnection to offset salinity stress. With this action, the ebb and flow of the water is recovered, bringing salinity into balance to promote the development of the mangrove ecosystem and associated faunal communities. When the hydrological condition has recovered, the secondary succession process begins allowing facilitating species such as *Batis sp* and *Salicornia sp* to arrive first (Teutli-Hernández et al. 2019). Some projects have made topographic modifications of the ground level and created nuclei dispersion (dispersion centers) that (Figure 12) accelerate the extension of the vegetation cover (Herrera-Silveira et al. 2017).

Fig. 12 | Mangrove restoration through topographic modifications and nuclai dispersion (disperse centers) in Sian Ka´an, Mexico. Source: Claudia Teutli and Jorge A. Herrera-Silveira (2020).

When analyzing the social component of restoration programs in areas where communities are located, long-term success will depend on the direct and indirect participation of these communities. For that to occur, the project must be socially acceptable. However, at projects carried out in the Caribbean, although it is evident that the local communities participated, it is not clear how the project improved their livelihoods.

A literature search indicated that at least sixty mangrove restoration projects have been carried out and documented in the Caribbean area (Figure 13). As has happened in other parts of the world, the main restoration action to occur has been reforestation with Rhizophora propagules (Dale et al., 2014). The second restoration action carried out is hydrological rehabilitation. Common actions have been the opening and/or unwinding of canals, as well as reconnection with water sources (lagoon, river, sea) (Lewis, 2001; Teutli- Hernández and Herrera-Silveira, 2016). Recently, two authors of this report Herrera-Silveira and Teutli-Hernández have developed projects where the combination of more than one restoration action has been required, making them complementary. These include topographic modifications, reforestation of dispersion centers, hydrological rehabilitation, and induction of facilitating species (Figure 14). This diverse set of actions has allowed increased intervention coverage and induced environmental heterogeneity (Herrera-Silveira et al. 2020). The goal is to make the restored mangrove sites resilient as opposed to using only one species for reforestation. The strategy to carry out the successful ecological restoration of

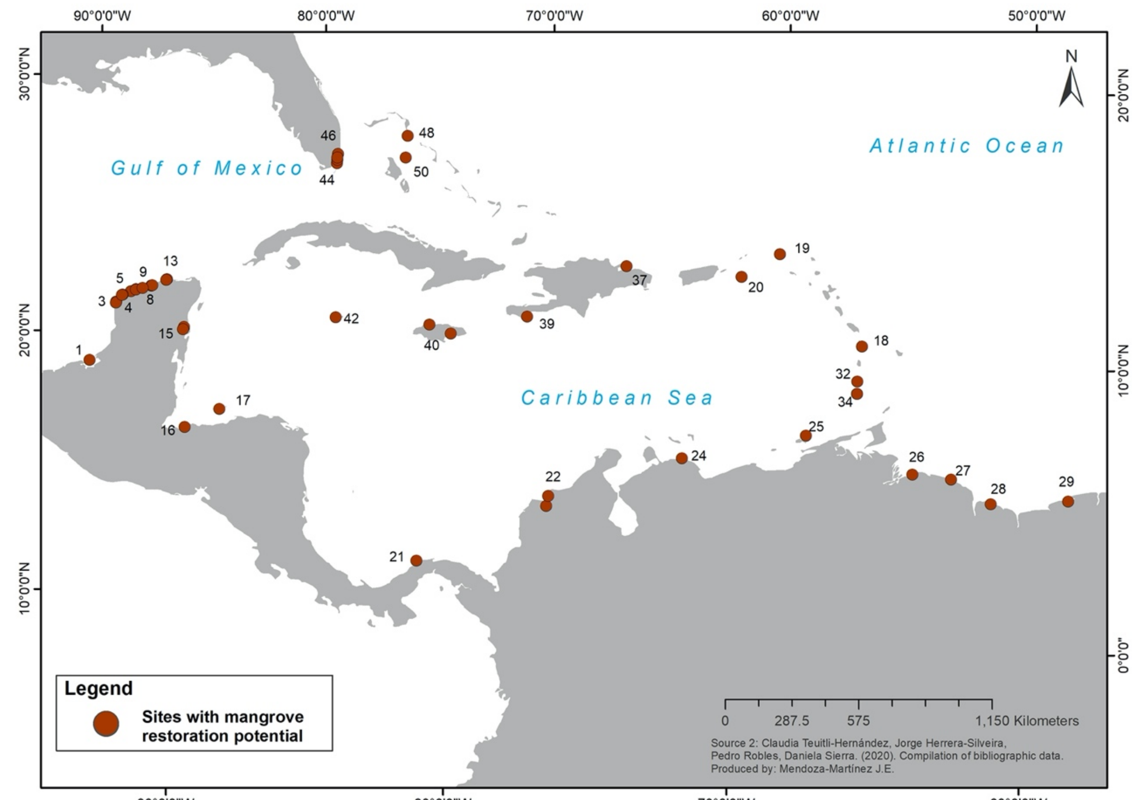


Fig. 13 | Sites where mangrove restoration projects have been carried out in the Caribbean. Source: Jorge A. Herrera-Silveira (2020).

Fig. 14 | Restoration actions carried out in the Caribbean region. Top: Channel opening. Photo: Jorge A. Herrera-Silveira. Bottom: Dispersion nuclei. Source: Claudia Teutli and Jorge A. Herrera-Silveira (2020).

mangroves must be based on the relationships between geomorphology, hydrology, structural characteristics, and functionality of the mangrove ecosystem. In addition, we should consider the perception of the inhabitants of the areas surrounding degraded mangroves as well as authorities, academics, and funders. The strategy developed by the authors of this section of the report is a phased process that includes the planning, implementation, and monitoring of the restoration program, always accompanied by compliance with institutional arrangements (Figure 15) (Teutli-Hernández and Herrera-Silveira 2016).

This strategy should consider the following components:

- **Identification of the site to be restored and establishment of clear objectives and achievable (realistic) goals of the restoration.** What you want to recover should be defined (function, process, structure, or the configuration of the environment, the landscape, or a particular characteristic or species of the ecosystem) as well as the extent of the restoration. Restoration can be divided into stages providing the opportunity to assess the level of performance of restoration actions.
- **Characterization of the site to be restored and a reference site.** In this step, the hydrological, geomorphological, ecological, and contextual characteristics of each site are determined, both locally and in the landscape. Local and/or regional causes of mangrove losses are identified (forensic ecology). The reference site not only refers to a site in a good state of conservation but should also include an analysis of a site that remains degraded, since both represent the extreme points in the restoration trajectories. Monitoring both reference ecosystems (conserved and degraded) can identify whether the recovery is the result of restoration actions, or if it is a process of natural recovery, or both.
- **Implementation of appropriate site-specific restoration actions.** Aspects such as what type of actions are defined (hydrological rehabilitation, topography management, dispersal centers, establishment of facilitating species, reforestation, among others). The implementation plan for restoration actions must include the following specifications: where they are executed, how they are carried out, and when they are carried out in addition to the costs involved in each of them. Each process of implementing the restoration action is specific. Copying and/or moving actions directly from one site to another without the proper analysis process have led to failure.
- **Monitoring of restoration actions.** Specific variables that act as indicators for restoration programs (physiological, hydrological, structural characteristics of landscape vegetation, physicochemical variables of the sediment, diversity of organisms, among others) must be selected. These variables must be measured both in the restored site and in the reference site(s), both in the one in good condition and in the one that remains degraded. Monitoring of these indicator variables permits--if required--changes in the type of actions due to the low level of success of the goals initially proposed, following an adaptive management approach. The importance of defining these variables lies in establishing the short, medium, and long-term indicators of the success of the restoration.
    - For example, in wetlands, the return of ecosystem services may not be evident even when the wetlands appear to be biologically restored, so long-term evaluations are required to identify the limitations that prevent the recovery of wetlands worldwide (Moreno-Mateos et al. 2012) and the restoration actions that favor it.
- **Linking and socializing ecological restoration.** The results of ecological restoration should be published and disseminated. Although ecological restoration of mangroves is not a novel activity, there is little documentation of the success or failure of restoration. Both good experiences and those that were not successful should be reported. Both provide lessons to inform progress toward success and help to avoid making the same mistakes that other projects have. Dissemination can be through research documents, dissemination, social networks, formal and informal training, community monitoring, and formation of organized stakeholder groups. This component of the restoration process is one that increases the likelihood that the restored site will become part of the community's environmental assets or natural capital.
- **Institutional and/or group arrangements.** An element of cohesion is needed between components of the restoration strategy and the

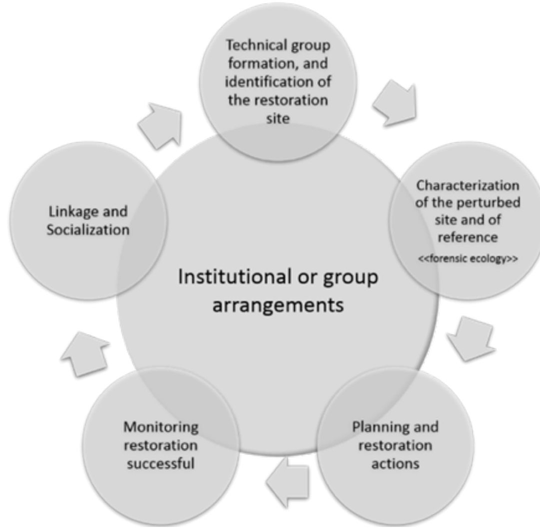


Fig. 15 | Strategy and essential components of the ecological restoration of mangroves. Arrows indicate connection between components. Source: Claudia Teutli and Jorge A. Herrera-Silveira (2016).

participants in it. Institutional arrangements allow for good communication between groups or institutions, encourages the transfer of information, and favors the success of financing to carry out restoration actions, including monitoring. The link between communities and the authorities encourages the sustainable use of the restored site and can provide for financial viability to the maintenance of the restoration actions. Currently, ecosystem-based adaptation strategies are those that are expected to have the greatest environmental and social impact in the short and medium term. Mangrove restoration could be part of these adaptation strategies as essential environmental services such as storm protection and improved water quality, among others, are recovered.

There are also thematic gaps. It is recognized that for a mangrove restoration project to be successful, it must incorporate all economic, social, and ecological considerations (Comín et al. 2005). The review of mangrove restoration projects in the Caribbean indicates that most of them are not carried out within the framework of a strategy that involves the three considerations, which may be one of the reasons for the poor success rate of mangrove restoration projects in the region.

Mangrove Restoration Costs

While there is little information about the costs of mangrove restoration projects in the Caribbean, it is important to consider that any restoration project must be economically efficient. A cost-benefit analysis of the ecological restoration of mangroves, as well as the incorporation of direct and indirect benefits as part of the assessment of the ecosystem services resulting from the restoration is still pending (Teutli-Hernández 2017). Only one report in the Gulf of Mexico reveals the cost per hectare (US$3,750 / ha) where the main restoration action was hydrological reconnection, which resulted in regrowth of the habitat (Herrera-Silveira et al. 2016).

The review paper by Bayraktarov et al. (2016) on the costs and success of global restoration projects show that mangrove restoration is cost-effective. Mangrove restoration is relatively inexpensive (US$9,000-$40,000) and the spatial scope of restoration projects is large. Mangrove restoration does not require skills such as diving, which increases the potential for community participation.

Restoration projects in the Caribbean have been financed mainly by government agencies in each country or by foreign governmental and non-governmental organizations. While government agencies hire local consulting firms, foreign institutions and organizations are accompanied by technical groups from their own countries, mainly from Europe and U.S.A. In both cases, restoration projects do not include training and strengthening local staff as part of their strategy. This implies that the local groups that carry out the actions depend on consulting companies or foreign institutions and organizations. Funding sources have come from, among others: The Nature Conservancy (TNC), World Bank, UNDP, GIZ (Germany), MarFund, FAO, USFWS, NAWCA, USAID, federal funds (ministries of the environment), and private (real estate owners of hotels, which must pay for environmental compensation measures).

Coral Reefs

Coral Reef Habitat Function

Coral reefs support the local economies and culturally rich livelihoods of nearly 44 million people in the region. Covering more than 26,000 km^2, these reefs are also one the most threatened ecosystems, thus making their conservation of regional significance. Maintaining a healthy and diverse coral reef ecosystem is important given they provide biodiversity, food security, tourism, shoreline protection and intrinsic value. Caribbean reef corals have declined significantly, with coral cover decreasing by 50 percent in the 1970s to less than 10 percent of original range now, due to regional episodes of bleaching, disease and algal overgrowth and a long history of human impacts including overfishing, pollution and coastal development (Kramer 2003, Gardner et al. 2003, Jackson et al. 2014).

Caribbean reefs have high economic importance, valued at US$3.1–$4.6 billion per year generated through food production from fisheries (US$310 million), tourism and recreation (US$4.7 billion), and shoreline protection (US$740 million to US$2.2 billion) (Burke and Maidens 2004). Yet these economically important ecosystems have suffered long-term degradation, with many Caribbean reefs shifting from net accretional to net erosional states and a subsequent loss of fish biomass, which has resulted in reduced income for fisheries and tourism and increases in the vulnerability of coastal communities to inundation and shoreline erosion (Brander et al. 2007, Brander, and van Beukering 2013, Kuffner and Toth 2016, Spalding et al. 2017, Perry et al. 2018, Beck et al. 2018).

More than 70% of Caribbean reefs are at continued risk to overfishing and >25% at risk to marine-based pollution, coastal development, and watershed-based pollution (Burke et al. 2011). Climate-related threats due to increasing thermal stress are likely the largest regional threat and are projected to increase the proportion of reefs at risk to 90 percent in 2030, and up to 100 percent by 2050 (Burke et al. 2011).

Coral Reef Habitat Degradation

To understand coral reef restoration, it is important to first understand how coral reef ecosystems in the Caribbean have become destabilized or degraded. On Caribbean reefs, there are a few “driving” species that play a critical role in reef processes or functions. Significant changes in Caribbean coral reefs over the past several decades include the loss of major reef building species, a shift on

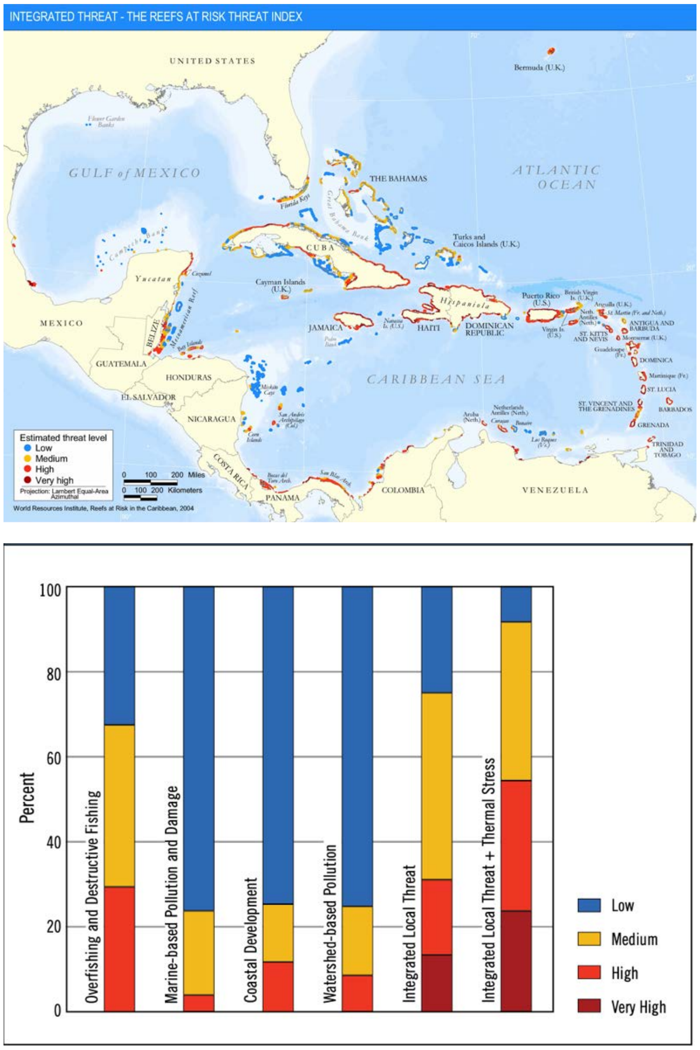


Fig. 16 | a). Map of Caribbean Reefs at Risk. b). Ranking of risks (low to high) - coral reefs are classified by estimated present threat from local human activities, overfishing and destructive fishing, coastal development, watershed-based pollution, marine-based pollution and damage. Source: Reefs at Risk (2020).

some reefs from coral dominated to macroalgal dominated systems, a decline of key fish species and a loss of important structural and functional processes (Figure 16). Acroporid corals, such as *Acropora palmata* (elkhorn) and *Acropora cervicornis* (staghorn), play a major role on Caribbean reefs by providing the three-dimensional structure for numerous invertebrates, fishes and other organisms (e.g., Adey 1975, Hubbard et al. 1994, Aronson and Precht 1997). These corals have suffered a drastic decline, with populations reduced by 95% in many areas, due in part to a region wide disease event in the 1980s. Subsequently, they were listed as endangered on the U.S. Endangered Species List in 2006 and critically endangered on The IUCN Red List of Threatened Species (Aronson et al. 2008). The structural and ecological roles of *Acroporid* corals, with their rapid accretion rates and structural complexity, are unique and cannot be filled by other coral species, thus their loss has had impacts on overall reef condition, changing many coral reefs from three-dimensional living structures to flattened, less diverse seascapes, as well as reducing carbonate production and potential for future reef growth (Alvarez-Filip et al. 2009, Graham and Nash 2013, Perry et al. 2015).

Herbivory (the consumption of plant material by fish and invertebrates) is probably the single most important factor influencing interspecific interactions or functions on Caribbean reefs. Corals and fleshy macroalgae compete for reef space, and the presence or absence of herbivores to eat the macroalgae can tip the scales one way or the other. Reduced herbivory rates can rapidly result in a significant shift from a (calcifying) coral-dominated community to a (non-calcifying) macroalgae-dominated community (e.g., Mumby 2006, Mumby et al. 2007). Sea urchins and fishes (such as parrotfish) are the two most important groups of reef herbivores as they control the abundance and species composition of both corals and algae particularly larger fleshy macroalgae that are in direct competition for space with corals. In 1983, a lethal disease outbreak rapidly killed over 90% of *Diadema antillarum* (black-spined urchins) throughout the Caribbean, which has contributed to a shift in many coral reefs from coral to macroalgal dominance. With the loss of *Diadema*, herbivorous fishes have replaced *Diadema* as functionally important grazers of algae; however, unsustainable fishing practices have reduced herbivorous fish numbers, especially parrotfish. The decline of these key species has resulted in a significant loss of reef function and structure.

Coral Bleaching

Coral bleaching occurs when a coral's symbiotic zooxanthellae (single-celled algae) are released from the original host coral due to stress (e.g., unusually high or low water temperatures, high or low salinities, or excessive sedimentation). Mass bleaching events — which are almost always associated with elevated sea surface temperatures (SST), sometimes in combination with elevated light levels (due to calm seas) were unknown before 1979. Likely the first significant mass bleaching event in the Caribbean occurred in 1995 and 1998 with ~50% to 90% of corals bleaching in some areas like the Mesoamerican area, Bahamas, and northern Caribbean. In 2005 and 2010, mass bleaching events affected areas in the eastern Caribbean. Subsequent bleaching events continue to occur, with 2017 being one of the longest more severe events. Human-induced global warming is believed to be responsible for recent increases in sea surface temperature, with prediction models for the next 100 years suggesting that the warming trend will continue and that bleaching events will become more frequent and more extreme. One concern is the linkage between coral bleaching events and the increase in coral diseases.

Coral Disease

Coral diseases have played a significant role in the widespread mortality of important reef-building coral species in the Caribbean over the last couple of decades.

The main concern is that coral diseases are infecting a greater number of coral species, increasing in frequency and distribution, and are spreading to new areas faster than previously observed. Increases in coral disease have been associated with increased sea surface temperatures and bleaching. It is still unclear whether heat stress related bleaching causes corals to be more susceptible to opportunistic pathogens, or if pathogens normally present exacerbate levels of bleaching and bleaching-related mortality. Some coral diseases may be linked to human sewage and other contaminants, as well as increasing temperatures.

While coral diseases have been present for decades, the Caribbean is currently experiencing likely the most catastrophic disease even in recent history, which has and will continue to change the landscape and approach on how coral restoration is implemented. Stony coral tissue loss disease (SCTLD) is a new lethal disease first reported in Florida in 2014. The cause of the disease is unknown, but it is affecting >20 species of corals, especially brain, pillar, star, and starlet corals. The disease spreads quickly causing high coral mortality (Alvarez-Filip et al. 2019). Outbreaks of SCTLD have been confirmed in the Caribbean off Jamaica, Quintana Roo (Mexico), St. Maarten, Sint Eustatius, U.S. Virgin Islands, Dominican Republic, Turks and Caicos Islands, Belize, St. Eustatius , Cayman Islands, The Bahamas, British Virgin Islands, Guadeloupe, St. Lucia, Roatan, Honduras, and Martinique (Kramer et al. 2019).

Pollution and Corals

Agriculture and improper use of agrochemicals (e.g., insecticides, fungicides, herbicides and fertilizers) is a major source of land-based pollution in the Caribbean. Nutrients and contaminants from urban and industrial development, aquaculture discharge, and atmospheric deposition also affect coral reefs as well. Even if these activities are located a great distance from coastal areas, they can still impact downstream estuaries, lagoons, seagrass beds and reefs. Changes in land use (e.g., deforestation, agriculture, aquaculture, and dredge and fill operations) often result in increased erosion. Sediment transported out to sea decreases water clarity and the amount of light reaching the seafloor. Increased water turbidity reduces photosynthesis and growth rates of corals and seagrasses, and in severe cases, corals can be smothered by sediment (Fabricius 2005).

Many countries in the Caribbean have little to no sewage treatment making untreated or partially treated domestic wastewater as one of the most widespread pollutants. Elevated nutrient levels present in sewage encourage blooms of plankton that block light and have other detrimental effects on corals (Abaya 2018). Scientists have identified a direct link between the human pathogen (*Serratia marcescens*) found in sewage and white plague disease which has caused wide-spread mortality of Caribbean corals (Sutherland et al. 2011). Pollutants and toxic chemicals also adversely affect the growth, reproductive success and overall fitness of corals and other marine organisms (Rawlins 1998, Guzmán and Garcıa 2002). Nitrogen pollution has been found to exacerbate the severity of coral bleaching (Donovan et al. 2020). Oil spills/contaminants can also have long term effects (Loya and Rinkevich 1980); several years after an oil spill off Panama, corals had reduced reproductive viability (Guzman and Holst 1993). New research is being conducted to examine pollutant effects on different coral genotypes in order to identify susceptible and hardy nursery stocks, which is an important factor in improving success in coral restoration practices (Baer et al. 2017).

Coral Reef Habitat Restoration

Due to the high value of coral reefs and the significant deterioration in reef condition, a variety of threat reduction and management actions have been implemented over the years, although the field of coral restoration is relatively new (Young et al. 2012). Early on, reef restoration included using structures (e.g., artificial) to reduce shoreline erosion and restore reefs damaged by ship groundings (e.g., reattaching dislodged corals) (Precht 2006).

With the decline in coral cover, particularly the substantial loss of the major shallow reef-building acroporid corals, and the growing belief that reefs would not recover without human intervention, efforts moved towards actively facilitating stony coral recovery through coral nursery/gardening projects and have become quite successful in population enhancement in the Caribbean (e.g., Rinkevich 1995, Bowden-Kerby A. 2001, Johnson et al. 2011, Young et al. 2012, Lirman and Schopmeyer 2016, Boström-Einarsson et al. 2020a).

At least 33 countries/territories in the Wider Caribbean Region have coral restoration projects (Figure 17), which is nearly every country in the CLME+ region (Moulding et al. 2018 and a review of published literature and unpublished sources). Most of the countries that have signed the SPAW Protocol have some level of coral restoration.

Establishing specific goals and objectives can help improve the success of coral restoration as they define, guide, and measure the activities and outcomes of restoration projects. Common coral restoration goals include (Goergen et al. 2020):

- Ecological (Ecosystem) Restoration
- Socio-Economic Restoration
- Event Driven Restoration
- Climate Change Mitigation
- Research

The goals of coral restoration projects have varied in the Caribbean. Early efforts aimed to increase coral populations on degraded reefs, although several projects were related to reef stabilization after a disturbance (e.g., dredging, ship grounding, hurricane) (Young et al. 2012).

Fig. 17 | Map of countries in Caribbean with coral restoration projects. Blue indicates presence of coral restoration in those countries. Dots indicate specific coral restoration projects. Most countries do coral gardening with *Acropora cervicornis* and *A. palmata*. Source: Patricia Kramer (2020).

Recent case studies from Spanish-speaking Caribbean countries categorized the purpose of their projects by goals, which included biotic goals like enhancement (42%), experimental (42%), idealistic (8%), and pragmatic (8%). Their primary objectives were to optimize or scale-up restoration approaches (51% of the projects) and provide alternative, sustainable livelihood opportunities (~15%) (Bayraktarov et al., 2020). Most coral restoration projects focus on just two species: *Acropora cervicornis* and *A. palmata* (Moulding et al. 2018), although restoration is expanding to include 6 other coral genera (e.g., *Porites*, *Favia*, *Madracis*, *Orbicella*) and 9 coral species (Boström-Einarsson et al. 2020b).

There are numerous scientific publications and practitioner guides that provide detailed information on how to design and optimize restoration goals and projects (Edwards and Gomez 2007, Johnson et al. 2011, Bowden-Kerby 2014, Goergen et al. 2020).

Coral Restoration Methods

Considering the wide variety of reef types in the Caribbean, differences in their current condition, and the varying levels of natural and human impacts, there is no "one size fits all" coral reef restoration method or approach that applies to all locations and environmental conditions. Therefore, propagation and restoration activities should be adaptive and flexible enough to account for the inherent variability in the response of corals to their local environment, as well as the variety of stakeholder preferences, capacity, funding, and political support.

Coral restoration methods are based on three main types:

- Asexual propagation methods (e.g., coral gardening, nurseries, outplanting, microfragmentation).
- Sexual propagation methods (e.g., larval enhancement).
- Substratum enhancement methods (e.g., artificial reef, stabilization, electric current).

Overall, coral gardening has been the most common low-cost method used in the Caribbean (Rinkevich 1995, Bowden-Kerby 2001, Young et al. 2012), with a recent increase in expanding larval propagation and micro-fragmentation (Forsman et al. 2015) techniques. The field of coral reef restoration science continues to advance significantly including new efforts with genetic banking and assisted evolution (see Boström-Einarsson et al. 2020 a, b for review).

To complement coral population enhancement restoration, new efforts to restore key reef functions are emerging such as restoring key herbivores like *Diadema antillarum* sea urchins (Williams 2016), implementing regulatory measures to protect herbivorous fish, especially parrotfish (McField et al. 2020) and restoring Caribbean king crab (Spadaro and Butler 2020). Coral reef conservation (passive restoration) efforts have also increased including actions to reduce local stressors such as unsustainable fishing, pollution and invasive species; increase education, awareness and eco-tourism; as well as establish marine protected areas as a management tool. An overarching challenge to large-scale coral restoration is whether current efforts will be sufficient to help reefs survive with the continued growing impacts of global warming (Mumby et al. 2007, Hoegh-Guldberg et al. 2017). Coral restoration needs to incorporate reef “resilience”, the capacity of a reef to withstand stressors while maintaining its structure and functions in the face of disturbance, as well as the capacity to adapt to future challenges. The National Academy of Sciences (NAS) suggested to maintain reef resilience, management and restoration efforts need to include a) new interventions to increase coral reef persistence (e.g., genetic, physiological, population-level, environmental interventions), b) a decision framework to integrate these interventions into management and c) implementing an adaptive management plan that incorporates societal input and values (Board 2019, NAS 2019).

While there has been success with coral gardening methods, they focus mainly on small scale population enhancement of a few coral species and not on restoring ecosystem structure and function, and rarely with abating threats such as pollution or climate change (e.g., heat stress and ocean acidification).

There is a great need to expand coral restoration to address these issues especially with scaling up coral restoration and addressing climate change. The temporal (project lifespan) and spatial scales (area of restored area) of coral restoration projects in the Caribbean tend to have short project lifespans and small aerial coverage, which is similar to global patterns (Boström-Einarsson et al. 2020b). Of 56 projects in the Caribbean, the median lifespan of a restoration project was only 12 months. Only seven Caribbean projects lasted more than five years. The median restoration size of 30 Caribbean projects was small, covering 1,000 m^2. The largest project, the Antigua Maiden Island Reef Ball project, covered between 10,000 and 10,499 m^2, included moving >5000 corals from a construction project to a safe area along with installing 1000 modular reef balls as artificial reef structure.

In a closer look at 12 restoration case studies in Spanish-speaking Caribbean countries, the median spatial extent of coral reef restoration project was ~1 ha (± 1.3 ha SE), with a range of 0.06 ha and 8.39 ha and the median project duration was 3 years; however, there were restoration projects that had lasted up to 17 years (Bayraktarov et al. 2020).

The level of monitoring during restoration projects varies and is often lacking or limited due to limited funding or capacity. Of 54 studies in the Caribbean, only an average of 15% conducted restoration monitoring (Boström-Einarsson et al. 2020b). Most monitoring activities focused on coral survival and growth, and less than 5% on reef fish communities. Goergen et al. (2020) developed a set of universal metrics to monitor restoration projects. Incorporating monitoring is essential in order to track how restoration projects are progressing and incorporate findings in an adaptive management approach.

Coral Restoration Costs

Coral reef restoration often relies on the availability of funding, which determines the scale, duration, and methods of a project (instead of the other way around). Restoration funding comes from various sources (e.g., donors, governments, or private), but is usually limited or inconsistent. In recent years, several groups like Coral Restoration Foundation (U.S. Keys), Fragments of Hope (Belize), and Reef Renewal (Bonaire) have engaged volunteer citizen scientists to help maintain nurseries (i.e., regularly removing algal growth) and outplanting (e.g., divers, dive boats) to help keep operation costs down.

The cost of restoration varies depending on the purpose of restoration and activities involved and will be quite different for a project that plants a certain number of corals to a reef to increase populations versus one that is restoring the structure and function of a degraded or damaged reef. For example, ship grounding restoration costs in the Caribbean, which involved extensive physical restoration of the sites, had estimated costs of US$2.0 million - $6.5 million per hectare, while the expense of low-cost transplantation was estimated to be US$2,000-13,000 per hectare in the Philippines, although larger-scale projects could cost US$40,000 per hectare (Edwards and Gomez 2007). From a recent global study, only 19% of 338 projects reported on costs involved with restoration but few distinguished between capital and operational expenses (Boström-Einarsson et al. 2018). Costs varied depending on the restoration objective. The most expensive costs reported were for substrate addition - artificial reefs with $US 3,911,240/ha, while the nursery phase of a coral gardening project cost $US5,616/ha (Table 4). In case studies from Spanish-speaking Caribbean countries, the median annual expense for projects was US$93,000 USD/ha, with a range of US$10,000 - $331,802/ha for an average project size of

Restoration technique	Restoration cost (2010 US$/ha)			
	n	Median (± SD)	Minimum	Maximum
Coral gardening	3	351,661 (± 136,601)	130,000	379,139
Coral gardening - Nursery phase	5	5,616 (± 22,124)	2,808	55,071
Coral gardening - Transplantation phase	2	761,864 (± 1,033,831)	30,835	1,492,893
Direct transplantation	21	73,893 (± 867,877)	4,438	3,680,396
Enhancing artificial substrates with an electrical field	0			
Larval enhancement	6	523,308 (± 1,878,862)	6,262	4,333,826
Substrate addition - Artificial reef	15	3,911,240 (± 36,051,696)	14,076	143,000,000
Substrate stabilisation	8	467,652 (± 9,015,702)	91,052	26,100,000

Table 4 | Restoration costs by method used from global database. Source: Boström-Einarsson et al. (2018).

	Total cost per year (2018 USD)	Spatial extent (ha)	Project duration (yrs)	Feasibility (best guess)
Median	93,000 (± 32,731)	1.00 (± 1.30)	3.0 (± 1.5)	0.7 (± 0.03)
Min	10,000	0.06	1	0.5
Max	331,802	8.39	17	0.8
N	11	7	12	11

Table 5 | Restoration costs for Spanish-speaking Caribbean countries. Source: Bayraktarov (2020).

1 ha (Bayraktarov 2020) (Table 5). Depending on the restoration site, cost effective approaches can be used and there should be justification for the investments in restoration as we discuss in Part II.

A recent global survey found the two most common barriers to successful coral restoration are funding and political support, as well as lack of trained people, research and infrastructure (ICRI 2019). Important enablers to advance coral restoration are greater international collaboration, more community engagement, better training, planning and guidelines, and increases in organizational support (ICRI 2019). Two key factors identified for all restoration efforts are the importance of including people in the restoration efforts and the need to reduce reef stressors, such as pollution, prior to restoration.

Restoring Coral Reefs in a New Era of Coral Disease

The current outbreak of Stony Coral Tissue Loss Disease (SCTLD) throughout the Caribbean has changed the priorities and responses to coral restoration. For example, management efforts in the Florida Keys have expanded from active coral restoration to applying intervention actions for disease response. This included focused monitoring of the disease outbreak, increased targeted science and research on causes of the disease, as well as experimenting with applying antibiotics/probiotics to high value corals. An intensive rescue effort has been started to rescue representative healthy corals to conserve and protect the genetic diversity of Caribbean coral species, increase the number of corals available for future outplantings on the Florida Reef Tract, as well as try cryopreservation of coral sperm. Response efforts in the Caribbean vary but includes increased monitoring (Alvarez et al. 2019), experimenting with various natural treatments and antibiotic, and increasing awareness about the disease to reduce human impacts, with many of these efforts in need of increased funding. Currently, there is not a framework to establish national or regional coral rescue efforts, although some localized efforts (e.g., Mexico) are trying to establish rescue for key species like pillar and brain corals. Future coral restoration will need to consider the presence of SCTLD outbreaks and potential responses. A useful tool to monitor the spread of the disease is the Caribbean SCTLD Tracking Map (Kramer et al. 2019) and the SCTLD Dashboard (Roth et al. 2020). Long-term funding for strategic, innovative, and scaled-up restoration efforts is urgently needed.

Despite advancements in both active and passive coral restoration, in order to achieve meaningful ecosystem recovery in the Caribbean, coral reef restoration needs to be significantly scaled up and new innovative approaches need to be developed, especially with the SCTLD outbreak and increasing climate change impacts.

Pollution Reduction in CLME+

Caribbean coastal systems and associated living marine resources are being degraded by the production and consumption patterns of a burgeoning human population and its activities, both on land and in the sea, compounded by the impacts of a changing climate. Degradation of these ecosystems and the loss of biodiversity undermines ecosystem functioning and resilience and threatens the ability of ecosystems to sustain the flow of goods and services for present and future generations. There is undisputed evidence that pollution, including from land-based sources, is a serious and pervasive threat to the marine environment and human health. So great and widespread is the concern over pollution that this issue is reflected in every international framework related to the environment and sustainable development that has been developed and to which countries across the globe have committed to in recent decades. Pollution in the waters of the Caribbean can be primarily traced to the following sources: sewage, oil hydrocarbons, sediments, nutrients, metals, pesticides, solid waste and marine debris, toxic substances (UNEP 1994).

An inherent issue with addressing pollution includes issues with the adopted legal instruments that control domestic and industrial wastewater disposal. One inventory of 25 countries in the WCR found that only nine countries provided relevant documents related to legislation on land-based sources of marine pollution, and enforcement varies significantly from country to country, and in some no enforcement was found.

> <<*The enforcement of the regulations of these legislation is also hampered by the lack of the necessary infrastructure. Moreover, these regulations tend to be dispersed in general environmental legislation such as fisheries, navigation, etc. There is little doubt that the enforcement of the above regulations may at times conflict with other local interests such as the rapid development and diversification of new industries and resort complexes, particularly in those countries with economies in transition.*>> (UNEP 1994)

In many locations, the coastal ecosystems of the Caribbean are endangered by pollution, development, and overuse. According to the World Resources Institute group, the capacity of Caribbean countries to treat sewage has not kept up with the large numbers of tourists and a growing coastal human population (https://www.wri.org/publication). Seagrass, mangrove and coral reef areas have been contaminated by fertilizer from farms and untreated wastewater and the seagrass beds and reefs have been further degraded by human contact and destructive fishing practices. Due to the floating nature of plastics and the intricate roots and branches of mangroves, plastic flotsam accumulates and is difficult to remove. In a recent study in the Red Sea and Arabian Gulf, Martin et al. (2020) found that microplastics dominated in mangrove sediment cores dating to the 1930s, to the extent that they are scarce in surface waters. As such, mangroves have become plastic sinks.

This level of pollution results in a decline in economic revenue for coastal communities because many tourists travel to the Caribbean's coastal areas to experience pristine marine environments.

Land-based sources of marine pollution have been identified as a major problem. Pollution is discharged either directly into the sea or enters the coastal waters through rivers, groundwater submarine discharges, and by atmospheric deposition. Organic persistent compounds, metals, microorganisms and nutrient pollution, particularly from sewage, is widespread and is possibly the most serious marine pollution problem in the Caribbean. The Pan American Health Organization estimated in 1993 that only about 10% of the sewage from the Central American and Caribbean Island countries is properly treated before being released into the Sea (https://www.paho.org/salud-en-las-americas-2012/dmdocuments/health-americas-1993-1996-vol2). A lack of capital investment funds to install the appropriate infrastructure to deal with sewage and other effluents is a major stumbling block to solving the problem of marine pollution in the Caribbean. Other factors include customs and traditions, lack of environmental education, low level of social commitment, political will and administrative and legal structures to regulate human development activities. The major sources of coastal and marine pollution originating from the land vary from country to country. The nature and intensity of development activities, the size of the human population, the state and type of industry, aquaculture and agriculture are but a few of the factors contributing to each country's unique pollution problems.

Overview of Recent Pollution Reduction Efforts

In this section several relevant projects will be presented as references on nature-based pollution reduction initiatives in the Wider Caribbean Region.

Integrated Coastal Watershed Conservation in Mexico
In the coastal watershed in Mexico, landscape level planning and management, including protected areas and productive landscapes, were key to address drivers of environmental degradation (Figure 18). This integrated landscape approach became possible through effective intergovernmental collaboration across territorial areas from the design to implementation of the project.

Agencies involved in the project are responsible for protected area management, mitigation of climate change through reduction of deforestation, monitoring of land use change, reduction of biodiversity degradation and associated carbon stocks, and improving socio-economic factors in local communities. This effective cross-agency collaboration also produced innovative community-based monitoring tools on integrated watershed management. Successful implementation of this project is strongly associated with active engagement of local organizations and communities, and building trust with them, which has been achieved through the tangible benefits that local communities realized during the project. Local organizations were heavily involved in design and implementation of sub-projects to improve sustainable watershed management and community livelihoods. The sub-projects directly provided socio-economic benefits to local communities and the community members recognized the value of ecosystem services provided by the watersheds. They were actively involved in not only the sub-projects, but also more broadly in project monitoring activities. The community-based monitoring information was highly valuable data for the development of appropriate integrated watershed action plans.

With clear benefits for both the environment and human wellbeing, this new integrated approach caught the attention of the national government and other municipalities. The Mexican government has now widely

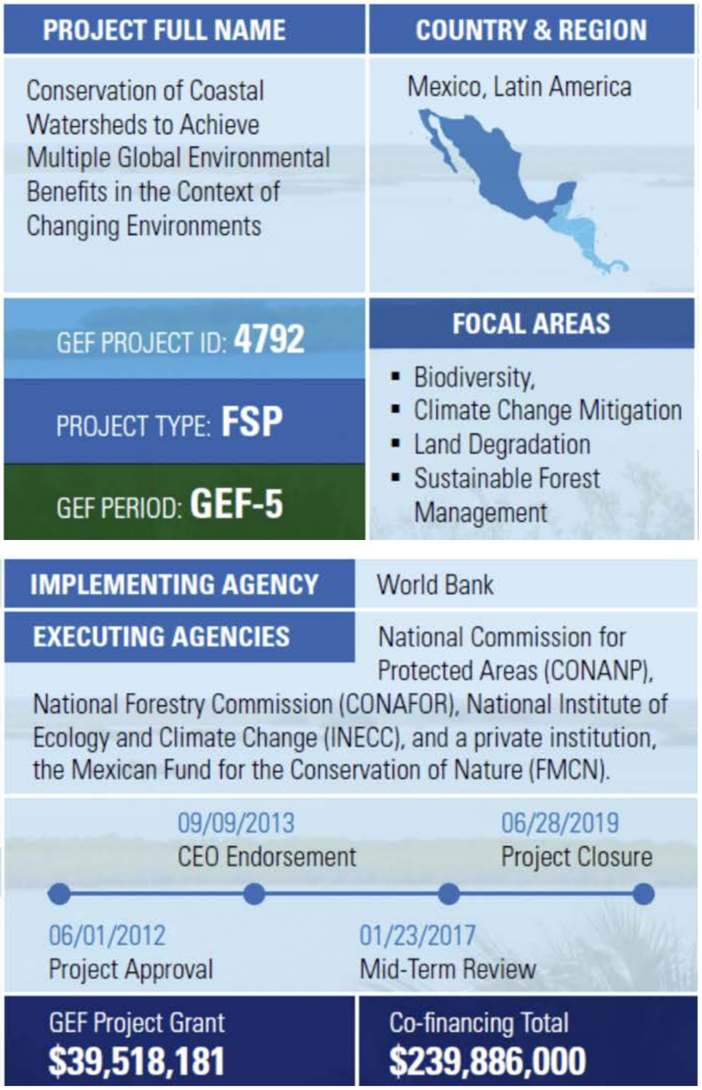


Fig. 18 | Graphical abstract of GEF project on Conservation of Coastal Watersheds to Achieve Multiple Global Environmental Benefits in the Context of Changing Environments. Source: GEF (2012).

disseminated lessons learned from this innovative watershed level approach to other local governments. This model of landscape conservation will be shared nationally with the aim of scaling up the experience and approach in other watersheds.

Community-based Waste Management in South Eleuthera, Bahamas

Throughout the Bahamas waste management has posed a severe problem for many years. Eleuthera is no exception. With seven major landfills in South Eleuthera alone and several unauthorized dumping sites, the roadsides are often littered with refuse. Furthermore, landfills are only allotted a certain amount of land, therefore trash must be burned regularly to make space for new garbage. This leads to harmful chemicals such as nitrogen oxides, volatile organic compounds, carbon monoxide, and particle pollution being released into the air, all of which lead to both public health and environmental problems. Many people are unaware of the importance of recycling and the benefits this could bring to their lives, homes and health. A major reason for Eleuthera's waste issues is that there are no alternative means of disposing of trash and other unwanted items. In order to improve waste disposal, a new project was implemented in Eleuthera. Results to date from that project are presented in Table 6.

Country	Duration	Funding	Key Results
Bahamas	Jan 2015 - Dec 2015	US $72,885	• Increased collection and recycling of plastic waste • Increased knowledge of the benefits of recycling in community • Decrease in waste at landfill

Table 6 | Community-based Waste Management in South Eleuthera, Bahamas. Source: GEF Small Grants Program (2015).

Communities installed recycling bins at the five primary schools throughout South Eleuthera and during major public events. South Eleuthera Emergency Partners' current collection facility strengthened its capacity to collect, sort, temporarily store and further distribute recyclable materials for recycling. Plastics and aluminum cans are now weighed and shipped to Cans For Kids, a non-profit recycling organization located in nearby New Providence island, where they are further directed for recycling internationally. Some plastics are used to create waste receptacles or repurposed as storage containers. Glass bottles are sorted and either shipped to the brewery in New Providence used by local artists in craft work or made available to locals who use them to preserve tomatoes, peppers and other foodstuffs. Awareness raising takes place through advertisements, presentations, public events, volunteer opportunities and other activities. This activity focuses largely on primary school students as they are successful at influencing their parents, guardians and other adults (Figure 19).

Fig. 19 | Children in action. Source: United Nations Development Programme (2019).

Drop-off locations for recyclables increased from just one to a total of 27 bins. Additionally, the South Eleuthera Emergency Partners (SEEP) Recycling Depot was strengthened. At the end of the project 1.4 tons of garbage had been collected and distributed at the depot, including 270 kilograms of plastics, 80 of cans, and 900 kilograms of

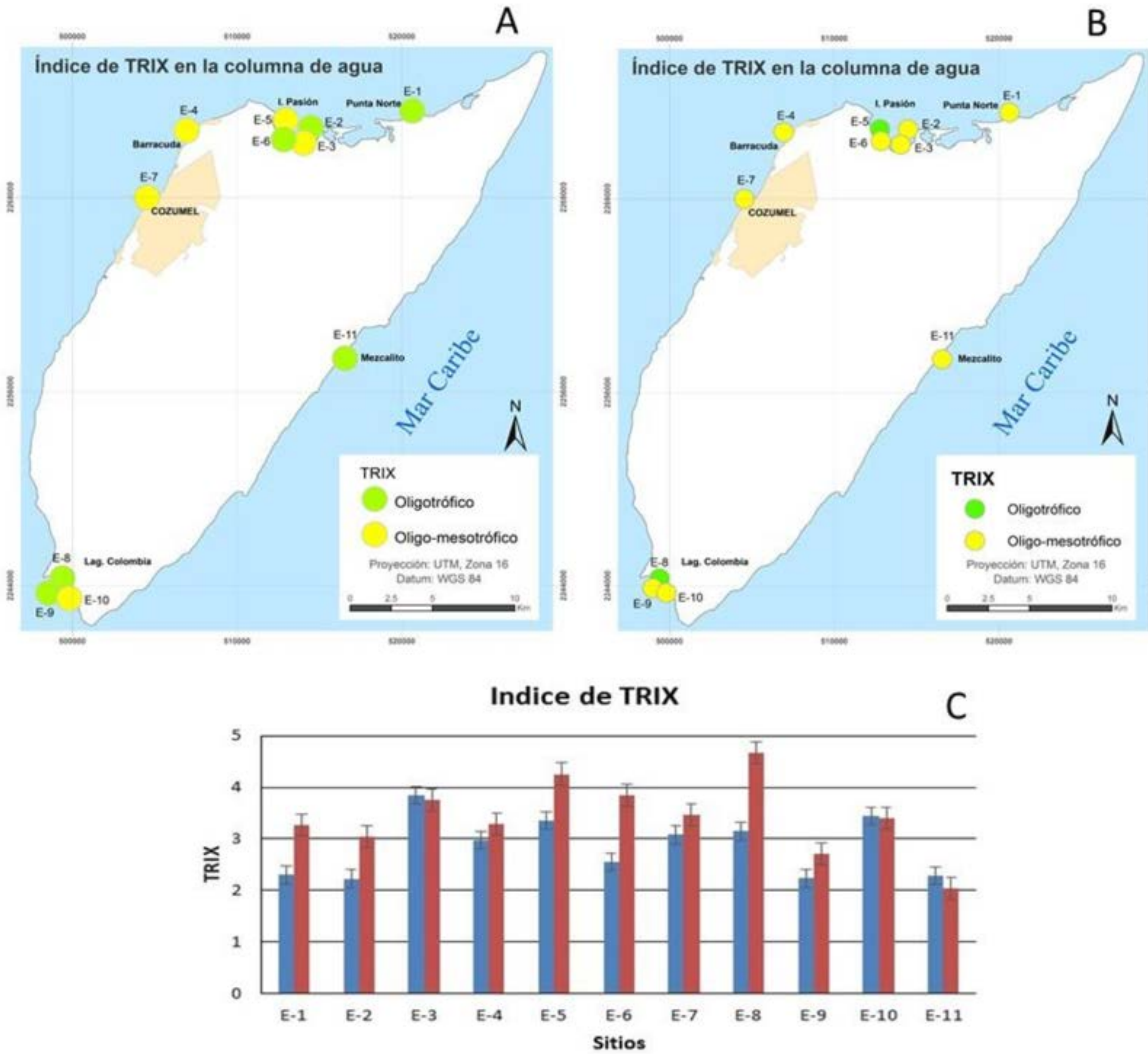


Fig. 20 | TRIX index for Cozumel island in A) August, B) November and C) August (blue) and November (red) comparison. Herrera-Silveira et al. (2016).

glass. Within the community, knowledge was increased regarding recycling and its benefits, and of alternative uses for solid waste. Also, 679 students received training about recycling and nearly 200 people were reached through several awareness-raising events. Follow-up surveys conducted in schools in South Eleuthera indicate that an average of 85 percent of students retained the information they received on recycling and 92 percent of them now recycle frequently. Due to awareness-raising in the community, some local restaurants and events have started to use biodegradable plates, cups and other items, and stores have increased the availability of biodegradable products for sale.

This project shows communities can be key drivers in offering innovative solutions to reduce, reuse and recycle plastics for promoting a circular economy. It also lays out SGP's experiences and lessons learned for other communities, governments and private-sector agents to consider when seeking to address the challenge of managing plastic waste. Considering the limited size and duration of the projects, none can be said to embody a complete circular economy regarding plastic waste management, but they are steps in that direction that could influence a society to promote relevant practices and policies.

Monitoring Mangrove Health in Cozumel, Mexico

This project "Health Status Monitoring of Mangroves on Cozumel Island" merits mention as it provided local groups and governments relevant information regarding mangrove health. It also provided to the scientific community with a new methodological approach to fully understand the impacts of pollution and wastewater on mangrove systems. Coordinated by Dr. Jorge Herrera-Silveira of the Mexican Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional-Unidad Mérida. The project's objective was to evaluate the mangrove health status in the natural protected area of Cozumel over one year. The project monitored interstitial water, sediments, seawater, mangroves, physicochemical parameters, caffeine, and nutrients. Results showed most of the areas are starting to show a mesotrophic state (Figure 20) that is expected to change over time to eutrophication as a consequence of the exponential growth of the tourism industry.

GEF-Funded Projects

A list of recent and ongoing projects funded by the Global Environment Facility (GEF) and UNEP that are relevant to pollution of the Caribbean Coastal Systems.

Title	**Location /Duration**	**Amount Allocated (USD)**	**Relevant Results/Objectives**
Rehabilitation of Heavily Contaminated Bays	Wider Caribbean Apr 2002 - Dec 2011	20,037,598	Develop integrated investment action plans for the rehabilitation and management of the bays and surrounding coastal areas.
Demonstrations of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean	Colombia, Costa Rica, Cuba, Jamaica April 2002-Dec 2011	6,910,000	To support the implementation of good agricultural practices (GAPs) to educe environmental impact, increase food safety and ameliorate workers welfare, while enabling better marketing opportunities.
Reducing Pesticide Runoff to the Caribbean Sea	Colombia, Costa Rica, Nicaragua Oct 2003-June 2011	4,290,000	To support measurable reductions in pesticide applications in the three participating countries (Colombia, Costa Rica and Nicaragua), resulting from the adoption of good agricultural practices (GAPs) that were focused on integrated pest management (IPM) methods. Reductions in the use of all pesticides on demonstration sites ranged between 18% and 61% for banana, plantain, pineapple and African Palm; and between 90% and 97% for bean and rice crops according to project reports.
Environmental Protection and Maritime Transport Pollution Control of the Gulf of Honduras	Belize, Guatemala, Honduras April 2005-June 2012	4,800,000	Improved institutional arrangements with functioning systems to help each country manage and dispose effectively of waste generated by ships.
Integrating watershed and coastal areas management in the Caribbean small island developing states (IWCAM)	Cuba, Hispaniola, Jamaica, Barbados, The Bahamas, Antigua, Dominica, Grenada, St. Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Tobago July 2006-July 2011	13,382,000	A Membrane Bio-Reactor (MBR) sewage treatment plant with the capacity to treat 20,000 gallons per day of sew-age was installed, and McKinnon Pond partly rehabilitated in Antigua; collection, treatment and disposal systems in place, together with strategy and management body in The Bahamas; the artificial wetland wastewater treatment, the re-forestation program, as well as the monitoring techniques introduced by the demo will likely be sustained due to the interest demonstrated by several of the stakeholders, including the THA, the private sector and the NGO community in Trinidad and Tobago; among others.
Improved Management and Release Containment of POPs Pesticides in Nicaragua	Nicaragua Oct 2008 - Oct 2013	3,059,900	The project objective is to minimize risk to humans and the environment of exposure to POPs pesticides through strengthened governmental, institutional, and stakeholder capacity for life-cycle management of these substances.
Testing a Prototype Caribbean Regional Fund for Wastewater Management (CReW)	Antigua and Barbuda, Barbados, Belize, Costa Rica, Guatemala, Guyana, Honduras, Jamaica, Panama, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago Dec 2010-Dec 2017	20,000,000	To increase coverage and improve quality of land-based solid waste management services (collection, transport, and disposal) in each participating country.

Conservation of Coastal Watersheds to Achieve Multiple Global Environmental Benefits in the Context of Changing Environments	Mexico Jun 2012 - Jun 2019	267,797,181	To ensure the integrated management of coastal watersheds that drain to the Gulf of Mexico and the Gulf of California as a means to achieve multiple global environmental objectives and mitigate climate change impacts.
Integrating Water, Land and Ecosystems Management in Caribbean Small Island Developing States (IWEco)	Antigua and Barbuda, Barbados, Belize, Costa Rica, Guatemala, Guyana, Honduras, Jamaica, Panama, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago March 2012-Active	20,720,000	To improve the management of fresh and coastal water ecosystems, land resources, and forests. Builds upon the work of previous regional projects.
Development of National Capacity for the Environmentally Sound Management and Disposal of PCBs	Colombia Feb 2013 - Present	19,705,093	Increase national capacity to identify, manage and dispose of existing PCBs in Colombia in an environmentally responsible manner in order to meet Stockholm Convention country commitments and minimize the risks to the population and the environment posed by PCB exposure.
Integrated PCB Management in Costa Rica	Costa Rica Oct 2013 - Sep 2017	10,709,274	The objective of the project is to minimize risks of exposure from PCBs to people and the environment in Costa Rica. The project is working to decrease the barriers for achieving sound PCB management.
Piloting Sustainable Community-based Waste Management in South Eleuthera	Bahamas Jan 2015 - Dec 2015	72,885	Increased collection and recycling of plastic waste; increased knowledge of the benefits of recycling in community; decrease in waste at landfill.
Disposal of Obsolete Pesticides including POPs, Promotion of Alternatives and Strengthening Pesticides Management in the Caribbean	Wider Caribbean Apr 2015 - Present	30,876,239	The project objective is to promote the sound management of pesticides in the Caribbean throughout their life-cycle in ways that lead to the minimization of significant adverse effects on human health and the global environment.
Sound Management of POPs Containing Waste	Mexico Sep 2015 - Present	28,920,000	The five-year project will help Mexico to fulfill its requirements under the Stockholm Convention. Consistent with this objective, the project addresses POPs release sensitive e-waste stream in the recycling, dismantling and treatment processes of electronic waste (e-waste) and the environmentally sound elimination and management of obsolete POPs pesticides stockpiles.
Environmentally Sound Management and Disposal of Polychlorinated Biphenyl (PCB) - Containing Equipment and Disposal of DDT Wastes, and Upgrade of Technical Expertise	Guatemala Oct 2015 - Present	15,856,100	To strengthen national capacities on BAT/BEP for the environmentally sound management of PCBs, including disposal of PCB-containing oil and wastes, PCB-contaminated equipment, and DDT (up to 400 tons PCB and PCB-waste and 15 tons DDT, to be verified during PPG).

Strengthening the Enabling Framework for Biodiversity Mainstreaming and Mercury Reduction in Small and Medium-scale Gold Mining Operations	Guyana Jul 2016 - Present	34,343,083	To strengthen the regulatory framework and institutional capacity for the management of small -scale gold mining and promote greater adoption of environmentally-friendly mining techniques in Guyana In order to protect globally significant biodiversity, reduce mercury contamination, enhance local livelihoods and human health.
Reducing UPOPs and Mercury Releases from Healthcare Waste Management, e-Waste Treatment, Scrap Processing and Biomass Burning	Colombia Oct 2016 - Present	38,865,018	To introduce BEP and BAT to reduce the release of unintentionally generated POPs and Mercury from the treatment of healthcare waste (HCW), the processing of Waste Electrical and Electronic Equipment (WEEE), secondary metal processing and biomass burning.
Environmentally Sound Management of Products and Wastes Containing POPs and Risks Associated with Their Final Disposal	Honduras Jan 2017 - Present	30,170,325	To minimize global impacts and risk to environment and to human health in Honduras, enhancing Environmentally Sound Management of old- and new POPs pesticides, PBDEs, PCBs and UPOPs, by implementing PPPs, enforcing regulations, introducing institutional models, raising knowledge/awareness and reducing unsound both rural and health care waste management.
Risk Mitigation Instrument for Land Restoration	Latin America and Caribbean Sep 2017 - Present	135,000,000	To restore 22,500 hectares of land under sustainable forest management and/or restoration practices.
Integrated Environmental Management of the Rio Motagua Watershed	Guatemala, Honduras Mar 2018 - Present	33,507,328	To improve the integrated management of the Río Motagua watershed and reduce land-based sources of pollution and produced emissions from unintentional formed persistent organic pollutants (U-POPs) to mitigate impacts on coastal-marine ecosystems and the livelihoods of the local populations.
Implementing Sustainable Low and Non-Chemical Development in SIDS (ISLANDS)	Latin America and Caribbean May 2019 - Present	483,214,560	Caribbean regional priorities are guided by the UNEP Caribbean Waste Management Action Plan. The goal is to define both regional and island-specific waste management strategies and systems that are environmentally and financially sustainable; and most importantly, supported by civil society.

Table 7 | Recent and ongoing projects that are relevant to pollution of the Caribbean Coastal Systems. Source: GEF (2020).

Lessons Learned

Overall, the Caribbean suffers from a lack of quality-assured environmental data about its waters, because only a few countries have the necessary systems in place to collect such data. Policy decisions need to be based on solid scientific information. Therefore, regular collection of strategic data on pollutants and how pollution affects marine habitats, local economies, and populations needs to be improved at the regional and national levels. Pollution data should be transformed into decision-support information tools and there needs to be an integrated approach for combining pollution and marine biodiversity data. Monitoring efforts should be integrated into relevant regional assessments and reporting efforts, particularly those established under the Cartagena Convention and its Protocols (SOCAR report) and the report on the State of the Marine Ecosystems and Associated Economies (SOMEE) of the CLME+ SAP, which calls for information on habitat degradation, fisheries status, and marine pollution. Pollution management in the marine environment entails a series of challenges of varying degrees that must be taken into account to increase the positive impact and overall scope of the proposed projects (Table 8).

In order to reduce pollution in coastal areas, it is necessary to establish a series of integrated strategic actions that regularly reduce, decrease and mitigate pollutants in coastal areas. Coastal ecosystems provide various environmental services, which are affected by being impacted or degraded by pollution. The Caribbean region is an area with important biological and cultural marine coastal ecosystems. Caribbean countries present wide differences at the environmental, social, economic and political levels that must be taken into account for the development of environmental restoration projects.

Actions and strategies	Actions	Cost (High, Medium, Low)
Knowledge	Generation, documentation and systematization of knowledge on the problem of pollution in coastal areas, its impacts to ecosystems and biodiversity, and the associated economic cost	High
	Promotion of citizen science	Medium
	Development of tools for access to information and decision making	Medium
	Identification of pollution hotspots and their major sources	High
	Identify ways to reduce impact of domestic wastewater loads on human health	High
Conservation and restoration	In situ conservation through priority conservation areas for biodiversity	Medium
	Restoration of degraded ecosystems (micro-remediation)	High
	Increase coastal and marine areas being monitored and develop regional indicators for monitoring	High
Sustainable use and management	Promote sustainable activities that reduce or eradicate coastal pollution	Medium
Environmental pressure factors	Pollution prevention, control and reduction	Medium
	Orderly use of the territory and sustainable urban development	Medium
Environmental education, communication and culture	Environmental education in the National Educational System	Medium
	Environmental education for society	Medium
	Environmental communication and dissemination	Medium
	Assess behavior associated with consumption, waste generation, and littering	High
Integration and governance	Harmonization and integration of the legal framework and of policy across government sectors	Medium
	Consolidation of the institutional framework and public policies for integration and mainstreaming	Medium
	Social participation for governance	Medium
	Strengthening cooperation and compliance with international commitments	Low
	Incentivize private corporate participation and identify opportunities and risks for involvement of private sector	High

Table 8 | List of actions necessary to reduce pollution in coastal areas. Source: OECD (1996), de Groot (2012), CONABIO (2016), Waite et al. (2018), Acosta et al. (2020).

Existing Methods for Comparing and Prioritizing Restoration Sites

Various strategies have been used to identify and prioritize sites for habitat restoration. Below are examples of some approaches with the first approach used when information is limited and relies on logic (logic approach) and second approach for when more detailed data is available to guide priorities (analytical approach) (see Beechie et al. 2008).

Logic Approach (where data is limited)

- *Project Type:* restoration proceeds on a hierarchical logic based on likelihood of success, response time, and longevity and progresses in the following order: a) protect high quality, intact habitats, b) remove migration or connectivity barriers of intact habitat, c) restore watershed processes (e.g., water quality, ecosystem functions) and d) population enhancement.
- *Refugia Approach:* rooted in restoring best habitat first then expanding restoration outward from protected sites (i.e., intact sites will be more resilient, have greater seed stocks, have protection in place, etc.).
- *Decision Support Systems:* semiquantitative tools for prioritizing restoration actions. A scoring or ‘‘score sheet’’ approach where important values for each project (e.g., benefit, cost, likelihood of success, social impacts, education value) are assigned unweighted or weighted scores and the total score is used to rank project priorities; more complex: usually computer models that calculate total scores based on a more-complex suite of values and scores.

Analytical Approach (where data and spatial tools are available)

- *Single Species or Habitat:* focuses on restoration or rehabilitation of a single species (e.g., endangered status) or a single habitat (population enhancement of corals, mangroves etc.).
- *Multispecies or Multiple Habitats:* focuses on restoration of multiple species or habitats with an emphasis on ecosystem or watershed functions.
- *Cost Effectiveness:* incorporates the role of restoration costs; often funding or regulatory agencies request projects be prioritized to achieve the most restoration benefit at least cost.
- *Socio-Economic:* incorporates the importance of socio-economic factors and ecosystem services into restoration implementation and likelihood of success.
- *Governance/Policy:* incorporates the role of “if, how, and to what extent” policies and regulations will affect restoration action.

Ecosystem-Based Management

Several ecosystem management strategies have approaches that can be adapted for restoration. Ecosystem-based management (EBM) is a holistic ecosystem management approach that includes interactions between different parts of an ecosystem. Several core elements of the EBM process including 1) Recognizing connections within and across ecosystems, 2) Utilizing an ecosystem services perspective, 3) Addressing cumulative impacts, 4) Managing for multiple objectives and 5) Embracing change, learning, and adapting (UNEP 2011). Marine Spatial Planning (MSP) analyzes three dimensions--ecological, economic, and social objectives--with the goal to create a comprehensive plan or vision for management implementation. UNESCO has provided a guide to MSP and outlines the following 10 Steps for MSP – many of these are applicable to ecosystem restoration assuming restoration is prioritized in the MSP process (Ehler and Douvere 2009).

- Step 1: Defining need and establishing authority
- Step 2: Obtaining financial support
- Step 3: Organizing the process (pre-planning)
- Step 4: Organizing stakeholder participation
- Step 5: Defining and analyzing existing conditions
- Step 6: Defining and analyzing future conditions
- Step 7: Developing and approving the spatial management plan
- Step 8: Implementing and enforcing the spatial management plan
- Step 9: Monitoring and evaluating performance
- Step 10: Adapting the marine spatial management process

With the increase in threats and global climate change, new management strategies incorporate the consideration of management in a changing climate. Resilience-based management (RBM) incorporates knowledge of current and future drivers affecting ecosystem function in order to prioritize, implement, and adapt management actions that enhance both ecosystem and social resilience (Mumby et al. 2014, Mcleod et al. 2019). Resilience is the capacity of a system to withstand stressors, so that the system maintains its structure and functions when disturbed and adapts to future challenges.

Below are two examples of how MSP has been used in the Caribbean:

U.S. Virgin Islands Case Study – NOAA, with numerous partners, developed a decision support framework for prioritizing management of reefs in the U.S. Virgin Islands. The framework, including spatial data on coral reef distribution, biodiversity, and ecosystem services, used ecological criteria to map and rank coral reefs based on physical and biological complexity, ecological connectivity, and other important features (endangered species, spawning sites, biodiversity hotspots, and connected seascapes). Local stakeholder knowledge on the condition, uses and threats to coral reefs was collected through a Google Maps tool and questionnaire. The products are providing useful tools to guide strategic management actions (NOAA 2017).

St. Kitts & Nevis Case Study – The goal of this Marine Spatial Planning project was to lay the groundwork for future implementation of marine zoning in St. Kitts and Nevis by assisting in the development of a marine zoning design. Interestingly, was how St. Kitts & Nevis was selected as a priority site. Several other Eastern Caribbean island nations were considered as potential sites; however, St. Kitts & Nevis was selected as a priority geography as it met all of the criteria including:

- Project team had a presence on the ground and working relationship with the government.
- Potential conflicts between users/uses have been identified and were solvable.
- Various governments were interested in applying zoning as a useful management approach.
- Potential for stakeholder engagement (both relationships and appropriate venues).
- Potential policy instruments for implementation were present.
- Spatial information representing multiple uses existed and a rapid assessment of available data had been completed.

The project had two primary guiding principles: (a) rely on the best available science for making decisions and (b) engage stakeholders in a participatory process and included these basic steps: 1. Engage Stakeholders; 2. Establish Clear Marine Zoning Objectives; 3. Build a Multi-objective Database; 4. Develop Decision Support Products; 5. Generate Draft Zones for Multiple Use. In order to analyze and visualize a variety of management actions across the seascape, they used Marxan (Ball et al. 2009) and Marxan with Zones tool as the Marie Spatial Planning tool (Watts et al. 2010, Watts et al. 2009). St. Kitts and Nevis recently declared its first marine management area, based in part on the MSP process. The area encompasses a two-mile radius around its entire coastline, covering approximately 50% of the coastal and nearshore area of the twin-island state.

Additional Relevant Methods

Forest Landscape Restoration Approach (FLR) - An early strategy to prioritize and plan forest restoration was the Forest Landscape Restoration approach (FLR) (Orsi and Geneletti 2010). In 2000, the International Union for Conservation of Nature (IUCN) and the World Wildlife Fund (WWF) proposed Forest Landscape Restoration (FLR) strategy as an innovative approach to regain ecological integrity while enhancing human well-being. FLR shifted away from single site restoration to the landscape, with the idea that redesigning the landscape mosaic can better conserve biodiversity, improve ecological functioning and benefit people. One of the first steps is the identification of priority areas for intervention and often depends on the objectives of the reforestation action. FLR incorporates Multicriteria analysis (MCA) and Geographical Information Systems (GIS) to provide spatial decision support. This GIS-based method identifies reforestation priorities, designs several landscape-scale reforestation options, and evaluates them with respect to a set of ecological and socioeconomic criteria. Restoration prioritization is based on two main factors: the NEED and the FEASIBILITY. Suitability maps are generated and assessed for ability to conserve ecosystem biodiversity and improve livelihoods of local communities by introducing additional ecological and socioeconomic criteria. Finally, sensitivity analysis is used to test the robustness of the assessment.

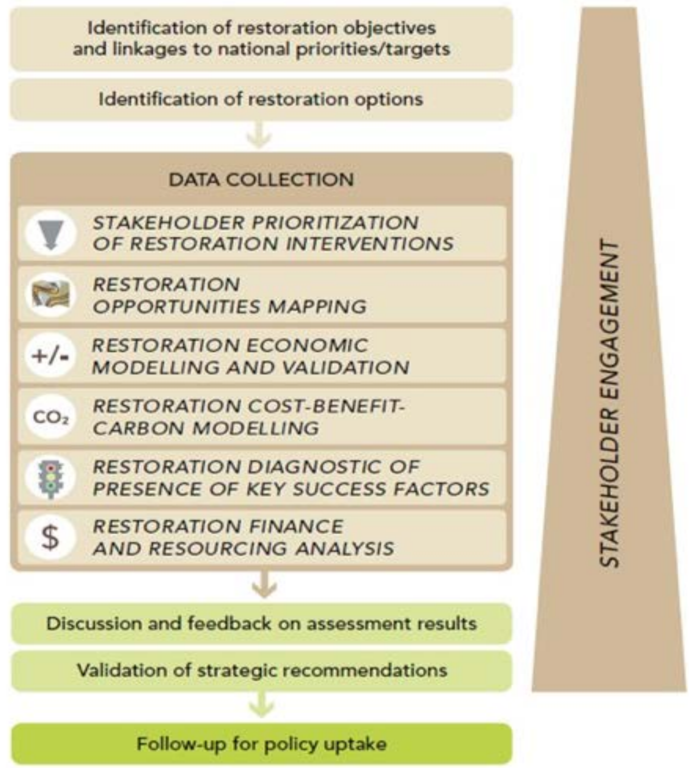


Fig. 21 | Key steps in a typical ROAM process. Source: IUCN and WRI (2014).

Restoration Opportunities Assessment Methodology (ROAM) - The Restoration Opportunities Assessment Methodology (ROAM), developed by IUCN and World Resources Institute (WRI), is a framework for identifying opportunities for forest landscape restoration and developing strategies for implementing restoration at a landscape scale (IUCN and WRI 2014). ROAM provides guidance on pinpointing where forest landscape restoration is feasible; identifying which restoration approaches are most appropriate economically, socially, and ecologically and quantifying the benefits of restoration (Figure 21). The framework entails a stepwise approach which includes:

1. Mapping where restoration is geographically possible
2. Identifying candidate landscapes for restoration
3. Defining restoration goals in a candidate landscape
4. Quantifying economic, social, and environmental benefits of potential restoration
5. Developing strategies by identifying which key success factors of forest landscape restoration are missing in the candidate landscape and identifying approaches for addressing them
6. Determining what types of restoration are most appropriate socially and ecologically
7. Involving stakeholders in the entire process.

Need for Focused Efforts on Seascape Restoration

Most of the restoration efforts discussed thus far were conducted at a site level and there are few, if any, national or large-scale restoration strategies or plans (although some are currently under development). Restoration efforts in the WCR have traditionally focused on one habitat--seagrasses, mangroves, or corals--rather than restoring all three habitats simultaneously. There is a great need to take a larger seascape perspective for restoration, especially if we are to achieve ecologically functioning ecosystems. The connectivity between seagrass, mangrove, and coral reef habitats enhances their collective capacity to function and provide ecosystem services, making it strategic to conserve all three of these habitats simultaneously (Caribbean Natural Resources Institute, 2020a):

> *<<Connectivity strengthens capacity to mitigate climate impacts. The transfer of materials, nutrients and energy that occurs among the three ecosystems is important in sustaining the high productivity and biodiversity of the coastal zone (Granek et al. 2009 cited in Rodríguez-Ramírez et al. 2010). Connectivity even seems to play a role in the habitats' capacity to mitigate climate impacts. There is evidence that coral reefs located within or immediately downstream of seagrass beds may be more resistant to ocean acidification (Camp et al. 2016; Manzello et al. 2012). The general understanding of 'blue' carbon storage by mangroves, seagrasses, and tidal marshes at the seascape scale, and over appropriately long timescales, is at an early stage. But, evidence suggests that these habitats act together to sustain and enhance their collective capacity to trap and store carbon: seagrasses support mangrove function by protecting them from waves and mangroves protect seagrass beds from excess nutrients and sediment (Huxham et al. 2018). Ignoring connectivity is a short-sighted approach. Impaired functioning of any of the habitats will directly or indirectly affect the others; this makes it strategic to conserve coastal habitats simultaneously to ensure better provision of ecosystem goods and ecosystem services. Ignoring habitat connectivity and the broader seascape when considering the coral reef-mangrove-seagrass complex is a short-sighted approach.>>*

Developing an overarching framework to select priority areas for seagrass, mangrove, and coral restoration in the Caribbean is helpful in ensuring prioritization is done systematically, consistently, repeatable, and based on as much information available as possible. Such a framework will also ensure that areas with highest priority and likelihood of success are being restored and restoration is done in the most cost-effective manner. Thus, it is essential to set priorities in order to optimize available funding and human resources, solve the most urgent problems, and contribute to the effective protection and restoration of biodiversity. In order for restoration efforts to be successful, it is important to first identify pollutants and the sectors that are contributing those pollutants to the ecosystem and second to reduce pollution in the restoration area before initiating restoration activities.

Guiding Principles of Seascape Restoration

Prioritization is a long-standing and essential element in systematic conservation planning but setting priorities for restoration and management is relatively new, especially at larger spatial scales or for seascapes. Seascape restoration is a growing field with many lessons learned from ecosystem conservation planning, restoration of other ecosystems or specific projects. Some underlying principles to consider for seascape restoration include:

- A clear motivation - decision makers, landowners, and/or citizens need to be inspired or motivated to catalyze processes that lead to landscape restoration (Parkyn et al. 2010).
- Enabling conditions in place - several ecological, market, policy, social, and institutional conditions need to be in place to create a favorable context for landscape restoration (Parkyn et al. 2010).
- Capacity and resources for sustained implementation - capacity and resources need to be available to implement landscape restoration on a sustained basis (Parkyn et al. 2010). Restoration projects need a clear definition of goals, objectives and actions with monitoring using measurable indicators and over sufficient time periods (Wilson et al. 2009, Zaldívar et al. 2010, Gann et al. 2019).
- Efficient ecological restoration maximizes beneficial outcomes while minimizing costs in time, resources, and effort (Keenleyside et al. 2012).
- Restoration incorporates socio-economic and cultural values, allows for multiple benefits, and aims to generate a suite of ecosystem goods and services (IUCN and WRI 2014).
- Engaging restoration collaborates with partners and stakeholders, draws on many types of

knowledge, and promotes participation (Keenleyside et al. 2012, Gann et al. 2019).

- Effective restoration focuses on entire landscapes, restores ecological functionality and processes, seeks the highest level of recovery attainable, is informed by native reference ecosystems, gains cumulative value when applied at large scales, is part of a continuum of restorative activities, addresses pollution or threat issues, and also considers environmental change (Keenleyside et al. 2012, IUCN and WRI 2014, Gann et al. 2019).
- Restoration is prone to uncertainty and risk, yet this information can be included in the priority- setting process to improve conservation decision-making, thus an adaptable and flexible approach with a multiple suite of intervention options is essential to ensure actions effectively respond to opportunities and improve knowledge (Wilson et al. 2009, IUCN and WRI 2014).

Report Objectives

The goal of this report is two-fold. First, we present a systematic approach to prioritizing sites for seascape restoration in the CLME+ region based on a series of "need" and "feasibility" indicators, as well as goal-driven approaches, derived from our literature review and comparison of existing methodologies. Using the methodology our team developed, we then scored 17 of some of the most promising restoration sites in the CLME+ region by country. The second goal of this report (Part II) is to present strategies for developing investment plans for large-scale coastal habitat restoration in the CLME+ region using 3 of the 17 sites as case studies. The final sites we identify for the case studies are designed to be geographically representative of the region and present different intervention strategies that require different forms of investments.

Methodology

Data Collection: Workshops with Experts, Reports, and Literature Review

In order to design a systematic approach to prioritizing sites for seascape restoration in the CLME+ region, the consultancy team conducted an intensive three-month long data collection process from March to June 2020. The data collection process consisted of a literature review, workshops, and reports from six experts and The Ocean Foundation (TOF) consultancy team. These experts all have decades of experience in pollution issues or mangrove, seagrass, and/or coral restoration in the WCR.

The first activity was a kick-off workshop followed by a series of reports submitted by the experts to TOF and workshops after each deliverable to discuss data collected and next steps. Experts were divided into four different groups depending on their expertise: mangrove restoration, seagrass restoration, coral restoration, and pollution reduction.

The first deliverable was an initial summary report where experts answered the following questions:

1. What are the coastal habitat restoration and/or pollution reduction projects you have either participated in or know of in the WCR?
2. What literature would be helpful in understanding coastal habitat restoration and pollution reduction initiatives in the WCR?
3. What are the most popular and/or cost-effective methods for restoring coastal habitat?
4. What are the priority geographic focus areas for coastal habitat restoration in the WCR?
5. What are the current gaps (geographic, thematic, institutional, etc.) in pursuing large-scale coastal habitat restoration in the WCR?
6. What are the key environmental, social, economic, and political indicators / criteria in determining site-suitability for large-scale habitat restoration?

The experts then prepared an analytical report reflecting on the inputs of the other expert consultants from the first deliverable in the areas of seagrass restoration, mangrove restoration, coral restoration, and pollution reduction to identify overlaps and differences among site selection indicators. In these reports, each expert group suggested a methodology for how to prioritize restoration sites in the WCR, including indicators that should be used in the selection process.

After the two deliverables were submitted by the experts, TOF facilitated three separate workshops with all experts to combine and refine the proposed methodology to come up with one methodology on which all experts agreed. Experts then used this site selection methodology to determine priority regions, countries, and sites within the countries for restoration across the WCR.

Simultaneously, throughout the process of preparing and reviewing reports, TOF conducted a literature review on relevant publications on coral, mangrove, and seagrass restoration and pollution in the WCR. We reviewed approximately 160 documents (peer-reviewed publications, white papers, or reports) that included information on status and restoration of habitats (mangrove, seagrass, and coral reefs), levels of pollution in the region, and contamination reduction efforts. The most relevant documents from the literature review are included in the Introduction and Background section of this report and were used to inform the restoration site prioritization methodology.

Initial Assessment of Country-Level Need and Feasibility Criteria

In order to identify the need and feasibility of coastal habitat restoration and pollution reduction at the country-level in the CLME+ region, we identified three "Indicators of Need" and five "Indicators for Feasibility" that have existing, widely accepted data to provide a preliminary assessment and guide future development of our site prioritization scorecard. "Need" indicators were selected partly because of the availability of mapping tool data. "Feasibility" indicators were selected due to their relevance in commitments to Global and Regional Programs (see UNEP's "Regional Strategy and Action Plan (RSAP) for the Valuation, Protection and/or Restoration of Key Marine Habitats in the Wider Caribbean Report," which lists four main goals of restoration and how those goals fit into the goals of Regional and Global Programs/Strategies).

Need Indicators:

Country	Mangrove Restoration Potential	Coast at Risk	Pollution Index	SDG 14 Goal Progress	Aichi Target 8 Pollution reduced	Aichi target 10 Pressures reduced	Aichi target 11 Protected areas increased	OHI Index	Total Score
St Kitts & Nevis	69	20	42	1	2	3	2	66	205
Guatemala	63	5	67	5	0	0	3	61	204
Dominican Republic	49	15	48	10	2	1	4	70	199
Bahamas	61	20	36	5				76	198
Sint Maarten	56		56		*3*	*3*	*4*	73	195
Jamaica	55	20	56	1				58	190
Mexico	59	10	36	5	2	3	4	68	187
Martinique	65		39		*3*	*3*	*4*	71	185
Belize	53	20	31	5	1	2	4	68	184
Columbia	63	5	38	10	2	2	3	60	183
Haiti	52	15	57	1				56	181
Cuba	50	15	42	1	2	3	5	62	180
Panama	63	10	35	5	0	0	3	64	180
Aruba	46		43		*3*	*3*	*4*	81	180
Honduras	52	10	40	5	0	3	3	65	178
Florida	61	10	26	10				70	177
Costa Rica	67	1	30	10	2	3	4	60	177
Puerto Rico	37	*10*	44	10				71	172
Venezeula	57	10	36	5				61	169
Antigua and Barbuda	22	20	34	5	2	1	3	81	168
Grenada	37	20	31	10	2	2	3	60	165
Bonaire	52		29		*3*	*3*	*4*	72	163
Turks and Caicos	55		35					71	161
Trinidad and Tobago	37	10	37	5				72	161
Curacao	33		38		*3*	*3*	*4*	79	160

Table 9 | Notes: Mangrove Restoration potential and OHI are scored 1-100, with 100 being highest. Coasts at Risk are scored as Very High (20 pts), High (15), Medium (10), Low (5), Very Low 1). Pollution Index (inverted OHI Clean Water) score 1-100 with higher being higher pollution. SDG 14 scores are provided by SDG as Goals Achieved (15 points), Challenges Remain (10), Significant challenges (5), Major Challenges (1). Aichi Targets (based on National reports) are scored as: 5 – On track to exceed the target, 4 – On track to achieve the target, 3 – Progress towards the target but at an insufficient rate, 2 – No significant change, 1 – Moving away from the target, 0 – No information, * - National report received but not yet reviewed, N – No report received.

- *Mangrove Restoration Potential (Mapping Ocean Wealth)* – This Index uses data to create a unique mapping tool to allow decision-makers to identify areas where mangrove forest restoration can succeed by highlighting places where they once thrived, and where conditions remain suitable for restoration. (Mapping tool: http://maps.oceanwealth.org/)
- *Coasts at Risk (MOW)* – This index uses data in a mapping tool to identify the exposure risk to natural hazards (cyclones, floods), environmental condition (mangroves, reefs) and ability of communities to adapt to this risk. (Mapping tool: http://maps.oceanwealth.org/)
- *Pollution Index (OHI Index Clean Waters Index inverted)* – there are few tools to measure pollution risk. The OHI Clean Waters was used as an inverted value to represent Pollution. This goal measures contamination by chemicals, excessive nutrients (eutrophication), human pathogens, and trash. (https://ohi-science.org/goals/#clean-waters)

Feasibility Indicators:

- *UN Sustainable Development Goal 14 Life Below Water* – This goal measures a country's progress on conserving and sustainably using the oceans, seas and marine resources for sustainable development.
- *Aichi Biodiversity Target 8* – By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity (Convention on Biological Diversity: https://www.cbd.int/doc/strategic-plan/targets/compilation-quick-guide-en.pdf).
- *Aichi Biodiversity Target 10* – By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

- *Aichi Biodiversity Targets 11* – By 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative, and well-connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes.
- *Ocean Health Index* – A scientific framework used to measure how healthy oceans are based on environmental, social, and economic goals.

Initial Restoration Need and Feasibility Results to Guide Prioritization of Countries in the CLME+ Region

Using the indicators above, the TOF consultancy team developed a preliminary table that summarized the degree to which countries are “at risk,” the potential for restoration, and progress towards meeting regional/global commitments. We collated and analyzed data for the eight indicators above for most Caribbean countries (Table 9). Data was not available for all indicators, which affects the scores. For instance, total scores are heavily influenced by indicators with score ranges of 100 vs. scores 1-5 or 1-20.

While this information served as a useful guide for preliminary assessment and country prioritization, TOF’s consultancy team decided country-level scores would better serve as the first step in a 4-part process of selecting sites based on a combination of restoration need and feasibility as well as restoration goals.

Importance of Restoration Goals During Process to Select Restoration Sites

Most countries have National Action Plans that identify their commitment to Regional and Global Programs. Restoration of mangroves, seagrasses and coral reefs can play an important role in helping to achieve these goals. Thus, prioritizing sites for restoration should take into consideration broader restoration goals and objectives at the national level while considering options for scaling up and adapting to other countries. Our methodology incorporates goals from UNEP’s “Regional Strategy and Action Plan (RSAP) for the Valuation, Protection and/or Restoration of Key Marine Habitats in the Wider Caribbean Report”. This report identifies a series of restoration goals (Table 10). It states:

> <<“*The overarching goal of the RSAP is to strengthen national and collective action by Member States to manage coastal ecosystems, particularly coral reefs, mangroves and seagrasses, in order to maintain the integrity of the habitats and ensure the continued flow of ecosystem goods and services necessary for national development.*” >>

Final Country-Level Need and Feasibility Criteria

Pillar 1. Ecosystem health and resilience	Goal 1. Strengthen ecosystem health, biodiversity and resilience
Pillar 2. Sustainable use	Goal 2. Sustainably use coastal and nearshore marine resources for national and regional development
Pillar 3. Governance and partnerships	Goal 3. Strengthen regional governance systems and partnerships for the management of the marine/coastal resources of the wider Caribbean
Pillar 4. Enabling systems and capacity	Goal 4. Effectively manage the marine/coastal resources of the wider Caribbean

Table 10 | The RSAP is structured around four interdependent strategic pillars with corresponding goals. Source: SPAW Sub-Programme of the Cartagena Convention Secretariat and the CLME+ Project (2020).

Following the initial country-level assessment, the consultancy team collapsed the “Need” and “Feasibility” indicators into broader categories that allow for more general assessment of the countries identified for site selection. The preliminary assessment served as a reference document to inform each expert's scoring. Country-level scores provide general context for the specific sites identified in Step 2.

Site-Level Restoration Potential: Seascapes

After determining the need and feasibility at the country-level, the experts then analyzed restoration potential at the site-level based on indicators that include ecological (structure and function), socioeconomic (ecosystem services), feasibility, and threat abatement. These indicators are a combination of the experts’ input and publications on site selection indicators. High scoring countries were selected based on each expert’s respective experience and ability to identify specific sites for scoring. Figure 22 below demonstrates how these indicators are structured, including sample considerations under each category. Figure 23 shows the various indicator categories (ecological condition, ecosystem services, feasibility, threats) used to select priority areas for seascape restoration. And, Table 11 provides examples of indicators in each category used to select priority areas for seascape restoration.

No single indicator can capture the complexity of restoring seascapes and social well-being, yet a long list of independent indicators not integrated at some level will be of little use to decision-makers. The approach presented here is to assemble an integrated menu of indicators that are interconnected in order to illuminate an understanding of restoring at the seascape level yet provide some flexibility in terms of which indicators are selected.

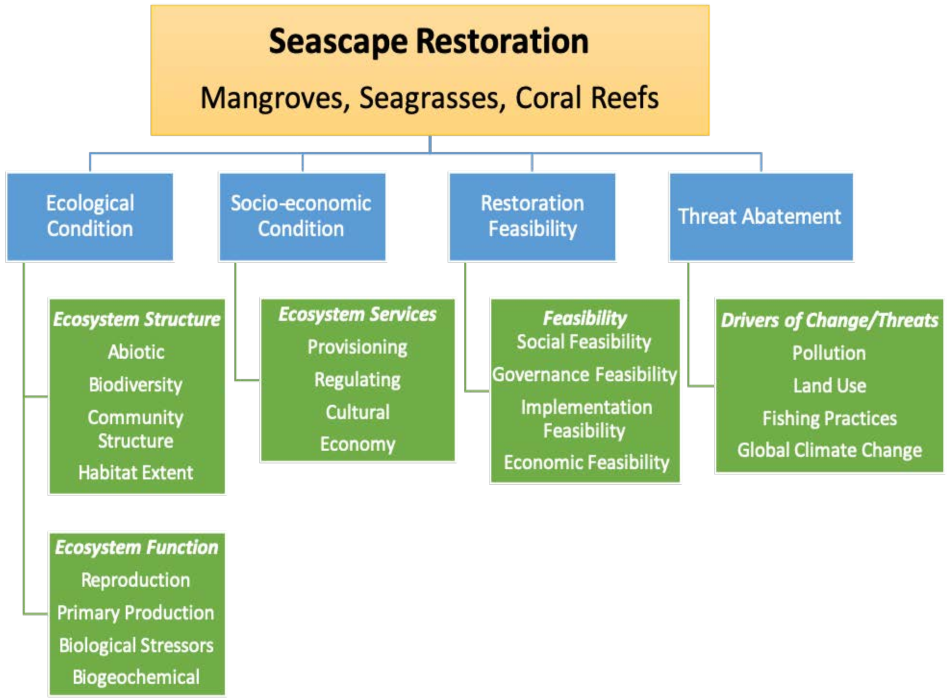


Fig. 22 | Indicators (green boxes) organized into categories (blue boxes) to prioritize sites for seascape restoration. Source: Patricia Kramer

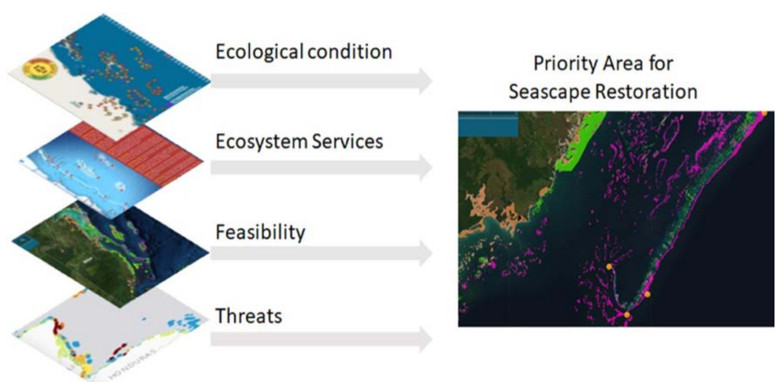


Fig. 23 | Indicator categories (ecological condition, ecosystem services, feasibility, threats) used to select priority areas for seascape restoration. Source: Patricia Kramer (2020).

Highest Priority Seascape Restoration Indicators (Examples of Specific Indicators)			
Structure/ Function	**Socio-economic**	**Feasibility**	**Threats/Drivers of Change**
• Presence of all three habitats • Adjacent to other habitats/corridors • Hydrogeology • Herbivory/competition • Nutrient cycling	• Coastal protection • Economic contribution • Cultural value • Compatible food, materials	• Stakeholder support • Policy to support • Ability to manage • Cost effectiveness • Exportability	• Ability to track pollutants • Land conversion • Land sources of pollution • GCC-Sea surface temps

Table 11 | Examples of indicators in each category used to select priority areas for seascape restoration. Source: Patricia Kramer (2020).

Large-Scale Coastal Habitat Restoration Site Prioritization Scorecard

The final large-scale coastal habitat restoration methodology consists of a 4-part scorecard that starts at the country-level and narrows its focus down to specific habitat restoration sites. The template for the scorecard is shown below:

Step 1. Country Restoration Potential
The expert practitioner selected one country and reviewed information available on restoration potential () and other resources available. The practitioner reviewed and scored the criteria below to provide a quantitative/qualitative analysis on the level of need and restoration potential for that country.

Need and Feasibility Criteria: The expert practitioners scored the following as Highest (5 points), High (4), Moderate (3), Low (2), Unknown (1). Highest possible combined score was 40.

Country Name:	
Level of Need	**Score**
Seascapes are present (both functioning reference and impaired states in need of restoration)	
Impaired seascape condition / intervention needed	
Several important areas (e.g., protected areas) will benefit by seascape restoration	
Numerous communities will benefit from seascape restoration	
Feasibility Potential	**Score**
High support and motivation for restoration likely	
Legislative frameworks or policies in place	
Sufficient funding and capacity can likely be secured	
Scalability of restoration approach to other areas	
Total Score	

Table 12 | Need and Feasibility Criteria.

Step 2. Criteria for prioritizing sites for restoration
Within the country selected, the expert practitioner identified 1-3 seascapes as candidates for restoration, keeping in mind the overall objectives of restoration and potential restoration actions to be taken. The experts reviewed available information including online maps, resources below, and National Action Plans. The criteria were scored as High (4), Medium (3), Low (2), Unknown (1). Each category receives the same weight.

Country Name:	**Site 1**	**Site 2**	**Site 3**
Ecological Criteria (Structure)			
Abiotic factors are present and suitable to support restoration (e.g., flow, water quality, light sediments)			
Biodiversity sufficient to support restoration (diversity of species, presence of endangered or unique species)			
Community structure is fairly intact (presence of all 3 habitats, abundance of species, biogeochemical factors)			
Habitat extent will support restoration (sufficient size, proximity/connectivity to adjacent habitats, migratory corridors/ spawning grounds)			

Ecological Criteria (Function)			
Reproduction / Condition is sufficient to sustain restoration (presence of recruitment, low mortality/disease, link to breeding areas)			
Primary / Secondary Production intact to support restoration (trophic dynamics or food webs intact)			
Biological Stressors are low/will not prevent restoration success (i.e., not too high of herbivory, low competition, no invasive species)			
Biogeochemical Processes are intact (nutrient cycling, litter dynamics, reef accretion)			
Socio-Economic / Ecosystem Services Criteria			
Provisioning (restoration will provide raw materials, food, fisheries)			
Regulating (restoration will improve coastal protection, erosion/sediment stabilization, water purification, carbon sequestration)			
Cultural (restoration will improve livelihoods, environmental perceptions, human health, history/heritage, social equity/stability)			
Economy (restoration will improve economic services like tourism, recreation, gender equality and employment, and economic productivity and stability			
Feasibility			
Social Feasibility (sufficient interest / motivation to restore area, likelihood for citizen science participation in the restoration project)			
Governance feasibility (policy / legislation in place to support restoration)			
Implementation feasibility (restoration feasible because factors like clear goals, ability to abate threats, access to site, restoration methods available)			
Economic feasibility (sufficient funding likely, cost effective / not prohibitive, cost benefit analysis can be done, compliments other management efforts)			
Drivers of Change / Threats			
Pollution is (or can be) abated, water quality is sufficient to support restoration; nutrient loads, bacteria and metals are low, water quality programs in place, and mechanisms in place to identify, track, address, and remediate land-based sources of pollution			
Land use (coastal, tourism, agriculture) does not impact restoration or can be mitigated, Management plans adopted; direct and indirect impacts from land use are avoided in restoration area			
Fishing practices are sustainable; regulations/enforcement are established; certified fisheries products standardized; replenishment zones and protected fish spawning aggregations established in or near restoration areas			
Global climate change effects are (or will be) considered in restoration planning and implementation and address resilient refugia, SST, ocean acidification, sea level rise and increased hurricanes			
Total Scores			

Table 13 | Criteria for Prioritizing Sites for Restoration.

Step 3. Comparison of Candidate Sites

The expert practitioner compared the candidate sites by doing a strengths, weaknesses, opportunities, and threats (SWOT) analysis.

Potential Sites **For ____________**	**Site 1**	**Site 2**	**Site 3**
Restoration Objectives: *Examples:* *Goal 1. Strengthen ecosystem health, biodiversity, resilience* *Goal 2. Sustainably use coastal and nearshore marine resources* *Goal 3. Strengthen restoration governance & partnerships* *Goal 4. Effectively manage the marine/coastal resources* *Goal 5: Enhance new sustainable job and livelihood opportunities*			
Potential Restoration Actions: *Examples:* *Improve water flow/connectivity, population enhancement, control invasive species, remove hard structures, improve management or protection, increase social benefits, increase resilience to climate change, other*			
Strengths: *Examples:* *What can help improve likelihood of success? Community, financial, or political support, adjacent to healthy habitat, within protected area, proven technologies*			
Weaknesses *Examples:* *What are potential for restoration? Cost prohibitive, likelihood of failure, lack of community engagement, lack of capacity, technology, etc.*			
Opportunities *Examples:* *Are there opportunities to improve success? Build on existing projects, partnerships, transboundary cooperation, private or existing financing, integrated approaches etc.*			
Threats *Examples:* *Lack of funding, community support, or governance, land tenure, unaddressed pollution or other threats reduce restoration success.*			
Score (Need / Feasibility Step 2)			

Table 14 | Comparison of Candidate Sites.

Step 4. Select Highest Priority Site & Develop Scorecard

After conducting the SWOT analysis for potential restoration sites, the expert practitioner selects one final site to fill out the scorecard based on Steps 1-3. The final site does not necessarily have the highest score or is the least expensive. Rather, the site represents a balance between the various indicators and is informed by the expert's ability to characterize the site from a variety of different perspectives. Whichever site is selected, the expert practitioner provides restoration objectives, rationale, and justification.

Priority Seascape Restoration Score Card (Country, Site Name)

Country-Level Need and Feasibility: *Enter results from Step 1*

Need & Feasibility	Score	Comments
Need Score		
Feasibility Score		
Restoration Score		

Table 15 | Country-Level Need and Feasibility.

Site Restoration Priority Potential: *Enter results from Step 2*

Restoration Potential	Score	Comments
Structure		
Function		
Ecosystem Services		
Feasibility		
Threat Abatement		
Total		

Table 16 | Site Restoration Priority Potential.

Restoration Success Potential: *Enter results from SWOT Analysis*

Potential for success	**Comments**
Restoration Objectives	
Potential Restoration Actions	
Strengths	
Weaknesses	
Opportunities	
Threats	
Score (Need / Feasibility Total Score from Step 2)	

Table 17 | Restoration Success Potential.

Results

In this section, we provide the results of 47 different sites in the CLME+ region across 15 different countries (Table 19, Appendix A) that were scored using the above methodology. The sites were selected by seagrass, mangrove, or coral restoration experts in collaboration with a pollution expert. The TOF consultancy team selected sites based on knowledge of and experience in the countries and/or sites identified in order to provide informed scores. Six of the CLME+ ecoregions are represented by the selected sites (Eastern Caribbean, Western Caribbean, Greater Antilles, Bahamian, Southern Caribbean, and Southwestern Caribbean). Scorecards were created for 17 sites and are included in Appendix B. A map of these sites is included in Figure 24.

	LEVEL OF NEED				FEASIBILITY POTENTIAL				
COUNTRY	Seascapes are present (both functioning reference and impaired states in need of restoration)	Impaired seascape condition/ intervention needed	Several important areas will benefit by seascape restoration	Numerous communities will benefit from seascape restoration	High support and motivation for restoration likely	Legislative frameworks or policies in place	Sufficient funding and capacity can likely be secured	Scalability of restoration approach to other areas	TOTAL SCORE
Bahamas	5	5	5	5	5	5	3	5	38
Belize	4	3	4	3	4	3	3	3	27
Colombia	5	4	5	5	5	4	3	5	36
Costa Rica	5	4	4	5	4	3	3	3	31
Cuba	4	3	5	5	4	5	2	3	31
Dominican Republic	4	4	4	4	3	4	3	5	31
Guatemala	5	5	4	5	5	5	5	4	38
Honduras	5	5	5	5	4	3	4	4	35
Jamaica	3	4	5	4	3	2	2	1	24
Mexico	5	4	5	5	5	5	4	5	38
Martinique	5	5	4	4	5	3	4	5	35
Nicaragua	4	3	4	4	3	2	2	3	25
Puerto Rico	5	5	5	5	5	5	3	4	37
St. Kitts & Nevis	5	4	4	5	3	4	4	5	34
Sint Maarten	5	4	5	3	5	4	4	5	35

Table 18 | Scores for Level of Need and Feasibility Potential by country (Step 1). See Appendix A for the full-size version.

Country	Site	Restoration Potential					Total
		Structure	Function	Ecosystem Services	Feasbility	Threat abatement	
Bahamas	Central Andros	16	16	15	15	13	75
	Bone Fish Pond National Park	16	16	15	13	13	73
	Bahamas Harbour Island Bay	16	16	15	13	12	72
	West Coast of Abaco	16	16	15	13	12	72
Belize	Placencia	14	11	16	14	11	66
	Turneffe	15	11	15	13	13	67
	Corazal	8	9	12	13	8	50
Colombia	La Guajira	16	16	16	16	15	79
	Archipelago de San Andres	16	14	16	14	10	70
	Choco	16	16	14	16	16	78
	Islas del Rosario (Cartagena)	16	12	16	16	16	76
Costa Rica	Cahuita National Park	15	16	15	15	12	73
	Tortuguero National Park	13	13	15	11	11	63
	Gandoca-Manzanillo National Wildlife Refuge	14	14	13	8	9	58
Cuba	Gulf of Batabanó/Guira de Melena	12	13	11	14	11	61
	Cayo Coco	12	12	12	12	11	59
	Havana	9	11	14	9	13	56
Dominican Republic	Samana Beach	15	15	13	15	16	74
	Haina	15	14	14	19	15	77
	Punta Cana	11	11	14	15	11	62
Guatemala	Laguna Grande	13	10	16	15	15	69
	Bahía la Graciosa	14	13	14	10	13	64
	Bahía Santo Tomás	12	14	16	14	10	66
Honduras	Guanaja, Bay Islands	13	14	16	15	12	70
	Cuero y Salado Wildlife Refuge	16	16	16	15	12	75
	Bahía de Tela Marine Wildlife Refuge	16	16	16	13	12	73
Jamaica	Portland Bight Protected Area	13	9	12	14	8	56
	Negrill Marine Park	11	8	12	10	7	48
	Ocho Rios Marine Park	8	7	9	8	8	40
Mexico	Complejo de Sian Ka'an	16	16	16	15	14	77
	Nichupte	11	10	15	12	12	60
	Arrecifes de Cozumel	14	10	15	12	10	61
Martinique	Bay of Fort-de-France-Cohé du Lamentin	13	11	15	12	11	62
	Marin-Baie du Marine-Sainte Luce Area	11	12	12	13	12	60
	Le Rober-Baie du Report PA	12	12	13	13	13	63
Nicaragua	Cayos Miskitos	14	13	14	10	10	61
	Cayos Perlas	13	11	15	7	8	54
	Cerro Silva	15	8	15	9	8	55
Puerto Rico	Laguna Condado	12	8	15	15	14	64
	Culebra Bay	15	13	15	15	12	70
	Jobos Bay	15	13	14	15	12	69
St. Kitts and Nevis	The Narrows	16	15	16	14	13	74
	Nevis-Quarry	12	12	13	13	12	62
	Great Salt Pond, St. Kitts	13	12	13	14	12	64
Sint Maarten	Simpson Bay	16	14	16	15	15	76
	Embouchure Bay	16	14	14	15	15	74
	Great Bay	6	5	15	10	14	50

Table 19 | Scores of Restoration Potential for each site (Step 2). Colored boxes signify the following Restoration Potential scores: Red=5-7, Orange=8-10, Yellow=11-13, Light Green=14-16, and Dark Green=17-19. Total scores range from 40 (lightest grey) to 79 (darkest grey). Sites outlined in blue are those that have a complete scorecard (Step 4).

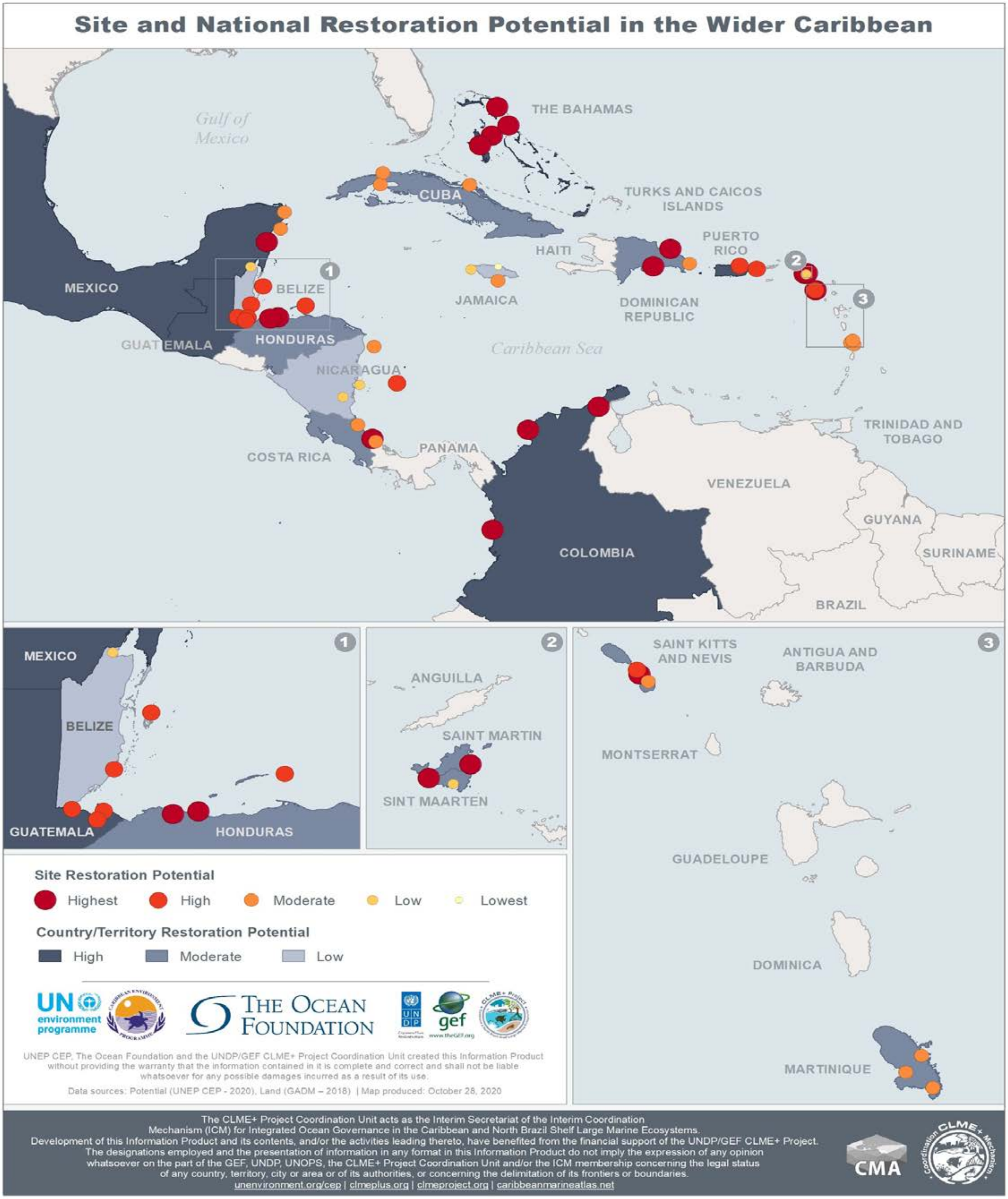


Fig. 24 | Locations of restoration sites (circles) and countries scored by experts and restoration potential level indicated by legend.

Final Sites for Case Studies

From the 17 scorecards completed, the consultancy team, in collaboration with the CLME+ project, identified three different sites that serve as “case studies” for illustrating a variety of investment strategies tailored for the region: (1) Guanaja, Bay Islands, Honduras; (2) Central Andros, The Bahamas; and (3) La Guijara, Colombia. While the three sites identified did not necessarily receive the highest “score” through our site prioritization methodology, the three case studies are designed to showcase different environmental, social, and political contexts that require diverse approaches and financing mechanisms. These considerations will be discussed in detail in Part II of this report.

Methodology Qualifications and Refining Future Applications

In Part I, we present a framework centered around a scorecard-based system to assist scientists, resource managers, and decision-makers in quickly characterizing and prioritizing large-scale sites for coastal habitat restoration and pollution reduction. Given the objectives of the restoration project, the relative weight among various indicators--including environmental, socio-economic, and governance aspects--will vary among different stakeholders and locations. For instance, the COVID-19 pandemic (beginning in 2019) has crippled industries throughout the region, especially tourism, which many countries depend upon as a primary source of livelihood. There have been widespread calls to “build back blue” through investments in natural infrastructure and sustainable economic development to encourage recovery in a way that also provides other long-term benefits, like climate resilience. Given this goal, socio-economic criteria may figure even more prominently in the completion of a country’s scorecard in light of the pandemic or other health and economic recovery related goals.

In addition, the scorecards included in this report represent perspectives of a limited subset of stakeholders. We recommend that more in-country specialists be included in future applications, since the scoring will be more refined for those involved in existing projects taking place within a country. Moreover, it is important to take into account traditional knowledge and pursue more participatory approaches than what was possible in this report given the number of sites identified. While a large number of stakeholders were engaged in the completion of our scorecards, including communities, nonprofit organizations, indigenous groups, governmental, and intergovernmental organizations, the size and diversity of the region requires more extensive engagement at the local level. The scorecard represents a starting place for more in-depth analysis by in-country stakeholders to refine scoring and identify new sites in a participatory fashion.

PART II: Developing Investment Plans for the CLME+ Region

Introduction: A *Blended Finance* Approach for Large Scale Habitat Restoration and Pollution Reduction

Healthy marine ecosystems are crucial for food security and livelihoods. There are increasing opportunities to support the health and long-term productivity of marine ecosystems through more sustainable economic sectors, improved resource management, and reduction of stressors and anthropogenic effects such as pollution. These opportunities can be funded via mainstream finance (notably bank loans and project bonds) as well as more innovative structures for financing meaningful and measurable ocean conservation (such as conservation trust funds, impact bonds, and crowd financing). Realizing these opportunities requires large investments, which governments and private donors cannot provide alone. However, for many projects supporting ocean health, private capital is not easily accessible. Some activities do not have direct revenue streams or short to medium term returns, while others may have returns that benefit future generations or the global community, making it riskier and more challenging for investors to back.

Project financing options or "investment plans," for the three large-scale habitat restoration projects we are envisioning, fall into two main categories: private and public finance, as well as private and public debt. To address the challenges noted above and boost investment, our investment plans will leverage public sector funds to create investment opportunities able to attract financing from a range of sources, including the private sector. Technical assistance and funds from multilateral banks and donors, along with innovative financing instruments such as revenue guarantees and credit-enhanced blue bonds, will also be used to reduce project risks, increase investment readiness, and thus, make them "bankable."

The best way to think about the options for project financing is a blend of different finance and debt sources that will allow a project or geographic area to attract short-term start-up funding, patient capital, and then long-term investment capital. Some of these sources do not require any return other than charitable, mission-related expectations (such as philanthropy). Some require minimal returns or are willing to be subjugated to more preferred investors or primary lenders. But, once a project is mature, true market financing (or debt) can be supported after establishing a track record of a return on investment (i.e. traditional finance).

Philanthropic donors who are interested in the environment, social issues, and sustainable development may provide initial seed money for pilots, project start-ups, incubation/training, or basic prerequisites and co-requisites for successful investment (such as restorations, infrastructure construction, or investment in green technological solutions and best practices). These can be matched with national appropriations that support public sector-led policy frameworks for the development of sustainable blue economy approaches, such as scientific research, addressing sources of pollution, tech research & development, infrastructure construction, and initial transfer of technologies, as well as knowledge transfers, capacity building, and other training (this can include financial literacy and business planning capacity).

Philanthropic and government appropriations can support other indirect support for the economy, including governance reform and other enabling conditions. These include equity, safety, and security; the rule of law and transparency; strong institutions; reliable infrastructure; respect for human rights; sustainable economic development; and human development.

Such national appropriations can be channeled directly through government agencies to projects within the country. They also can be channeled through foreign direct assistance (FDA) programs that provide grants, contracts, etc. to developing countries to support a myriad of interests. In addition to government-controlled FDA, funds can also go through multilateral banks and other finance institutions, which can provide grants, investment finance, or loans. And, in some cases, long term endowment-like conservation trust funds can be established to generate and distribute funds over time.

Another category of public financing can come from revenue generated from fees or fines. These can include Marine Protected Areas user fees, fishing licenses, coastal infrastructure maintenance fees, or fines on polluters or other law violators. All of these forms of public finance, debt, and philanthropic investment are dependent on the estimated benefits that can be obtained from enhanced habitat protection/restoration and pollution reduction such as food and incomes for local communities, opportunities for tourism businesses, protection from coastal erosion, or more resilience to climate change.

Private finance sometimes will include seed financing, patient investment and project incubation. Thereafter it becomes layered capital via early-stage venture investors who support new company start-ups or provide mezzanine funding. At company maturity, private finance can also include taking a company public providing much broader equity funding.

At company maturity, it is sometimes preferable to seek debt financing that does not require giving away any ownership of the company, nor a sharing of the returns on the investment other than the agreed debt interest rate. In some cases, philanthropists or governments will act as guarantors of such debt.

And, at the national level, governments can seek credits for biodiversity conservation, storm resilience, and carbon sequestration and storage. These can come via debt swaps and debt forgiveness, including the recent creation of "blue bonds" to fund the restoration and conservation of blue carbon resources (for example, the blue bond for Seychelles to restructure nation debt as part of an agreement to protect ecosystems). This permits existing debt to be restructured for the benefit of the ocean, and it must be determined whether it makes more sense to securitize that investment through forgiveness of the debt—freeing indebted governments to invest in other social goods.

Moving forward, we also need to evaluate the development of new sectors for investment, and more innovative approaches to financing conservation including, for example, credits for combined blue carbon and resilience from natural infrastructure. It is also critical to take into account the sustainability of an investment in pollution prevention or habitat restoration often requires ongoing operations, maintenance, and monitoring. The recurring costs of any investment must be factored into the financing mechanism so they are accounted for beyond the initial construction period or restoration project. Monitoring, for instance, is crucial to evaluating success, which in turn can catalyze additional investment. The bottom line is that we must align scale, risk, and return when it comes to sustainable blue economy investment and encourage a more nuanced and blended financing approach that factors in immediate and future costs.

Economic Valuation of Ecosystem Goods and Services

Who Benefits from Ecosystem Goods and Services?
One of the most important steps of the process of economic valuation is the identification of beneficiaries of the ecosystem goods and services in order to understand the distribution of benefits and costs of actions that protect or damage them. This valuation must consider different time horizons and scales because of the long-term and regional dimension of ecosystem connections. An integrated ecosystem valuation framework is shown in Figure 25. Cultural, recreation, and aesthetic benefits are included under "life-fulfilling" ecological functions.

Identifying Beneficiaries of Restored Ecosystems
The concept of *ecosystem services* (ES) was developed to classify and quantify the benefits to human wellbeing (MEA 2005) from ecosystems. In an economic valuation exercise, ecosystems can be viewed as being on the supply side of the goods and services, while on the demand side human communities benefit as users and consumers through experience (Culhane et al. 2020). While we need biological and ecological sciences to understand the supply side, incorporating the demand side effectively makes it important to identify who is benefitting

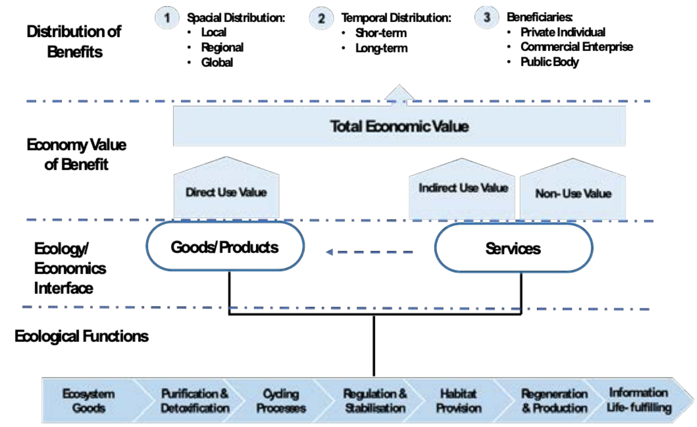


Fig. 25 | Integrated ecosystem valuation framework. Source: Adapted from Eftec (2005).

and in what way (DeWitt et al. 2020). The demand side is usually defined within the classical microeconomic framework, where the direct and indirect beneficiaries of ecosystem services become the stakeholders. In this type of analysis, a stakeholder is defined as all those who affect, and/or are affected by, the policies, decisions, and actions of the system. They can be individuals, communities, social groups, or institutions of any size, aggregation, or level in society. The term thus includes policymakers, planners, and administrators in government and other organizations, as well as commercial and subsistence user groups (Grimble et al. 1995).

There are direct and indirect benefits. For example, the owners of property protected by coastal habitats, the communities that eat and sell the products of the fisheries, and the people that rely on the supply of water and timber for their economic activities. Identifying the beneficiaries connects the specific *Final Ecosystem Goods and Services* (FEGS) approach to human wellbeing by guiding policy decisions based on what is of greatest value to specific users (Landers and Nahlik 2013). Identifying the beneficiaries inside the diverse stakeholder groups, helps the policy makers to identify and articulate the ways the community interacts and benefits from the environment.

Table 20 illustrates the connections between different stakeholder groups and the coastal ecosystem services that are of most immediate concern to them. Here, *provisioning services* are of interest to all groups, most directly to primary stakeholders, but also indirectly to governments as the source of tax revenues and income generated by tourist-based enterprises. In contrast, *cultural services* are mostly important to those people living close to the coastal ecosystems as their social norms, traditions, and spiritual beliefs may have co-evolved with these resources.

Another group, which we could call secondary stakeholders, people who might be visiting from further away, for example, to use coastal ecosystems for recreation and relaxation, will benefit from the aesthetic features and the chance to reconnect with traditional

Stakeholder groups	Coastal resources of immediate interest			Environmental services of immediate interest
	Coral Reefs	Mangroves	Seagrass	
Industrial enterprises and large businesses	Tourism is one of the world's largest cultural industries, a driver of growth for all the diverse Caribbean countries where it supports directly and indirectly the livelihoods of entire communities through consumption of local produce and services.			Provisioning Cultural Regulating Supporting
Small and medium-sized enterprises	• Coral reefs provide fish and shellfish for consumption and sale. • Coral reef areas also have extraction of raw materials such as limestone and other building.	As "blue forests", mangroves in the Caribbean region reach heights that make them a valuable source of fodder, fuelwood, charcoal, ornaments, and even timber. It is possible to harvest them for industrial inputs such as fibers, latex, and other chemicals.	Seagrass habitats are important for commercial and recreationally fish species as they act as nurseries for juveniles, as refuge or breeding grounds at various stages of the life cycles of commercial species.	
Households	• Employment mainly due the Tourism sector. • Employment for fish production. • Market introduction. • Use of resources.			
Individuals	Its more salient expression are the recreational and outdoor activities like snorkeling, scuba diving birdwatching and sightseeing tours, whose focus is on experience and aesthetic values.	Mangroves are important for the local community and primary stakeholders because these values represent an important part of their lives, livelihood, and cultural identity.	High potential for communication impact focusing on local seagrass facts such as the value of a great coastline view that can be part attributed to seagrass.	
	The opportunity for science and education to study and learn from them; and the market benefits of recreation and tourism.			
Communities	• Coral reefs provide physical protection to other coastal ecosystems and human habitats in the shoreline. • Their location and structure help to dissipate wave energy through breaking, reducing the impact of storm surge floods. • Improve water quality through the processing of nutrients and other biochemical cycling. This is linked to the supporting services of habitat protection, fundamental for different stages of the species linked directly or indirectly to commercial fisheries in the Caribbean region.	• Mangroves absorb toxins and other pollutants like heavy metals and excess fertilizer that come from land-based activities. The natural filter distinctive role in regulating waste support other coastal ecosystems like seagrass meadows and coral reefs that otherwise would be harmed by it. • Very important sources of carbon storage, interacting in this process with other coastal ecosystems, including seagrass meadows and coral reefs. These reductions can occur by reducing emissions, as well as increasing the number of sinks available.	• Their role in regulating intra-species competition for resources is one of the services recently understood by the biological sciences. • Seagrass areas play a role in the coastal dynamics that add stability and resilience to the coasts in recurrent high-energy natural events. Seagrasses protection effect has been documented as comparable to the effect of salt marsh ecosystems, reducing hazards by as much as 40%. • Supports the reduction of sedimentation due to their rhizome structure, and the water clarity is very important for seagrasses themselves who are strongly light dependent to carry out their photosynthetic activities and contribute with their productivity to the coastal habitats' foodweb. • The carbon sequestration potential of the global seagrass stock has been linked to diversified sinks and reducing emissions from degradation. The potential is closely linked to cycles connecting coral reefs and mangroves.	
National governments	• Tax revenues from extractive/productive activities and export National income from tourism and other coastal living sources enterprises. • Welfare and health costs averted. • Maintaining national well-being and environmental resilience.			

Table 20 | Coastal living resources and environmental services important to beneficiary's well-being and livelihood interests. Source: Marisol Rivera-Planter (2020).

Type of stakeholder	Characteristics	Groups
Primary stakeholder	• Experience the impacts of decisions involving natural resources and development on their livelihoods or well-being • Have little power to influence the outcome of a decision-making process • Are highly dependent on coastal resources	• Fishers • Reef tour operators and local tourism businesses (e.g., dive shops, • hotels) • Coastal communities • Local community and civil society groups • Local recreational users • Families of these groups • Future generations
Secondary stakeholder	• Not directly impacted by these decisions • People with the power to make decisions	• National government departments and ministries • Local government officials • Coastal and marine resource managers
External stakeholder	• Not significantly impacted by findings and recommendations of the economic valuation • Their interests are affected • Have the power to influence decisions	• Environmental, conservation, or sustainable development NGOs not based locally at the valuation site • Land developers • Multinationals investing in the area (e.g., cruise tourism operators) • Domestic and international tourists • Trade groups • Lobbying organizations • Universities and other researchers • Media

Table 21 | Stakeholder group categories by characteristics. Source: Adapted from Mayers (2005), Waite, R. et al. (2014).

customs and activities. Although there are obvious links between the regulating and supporting services provided by coastal ecosystems and individual well-being, one could argue the supporting services are perhaps of greatest interest to communities (SOAS, 2014a).

Coastal communities not only benefit but also influence the level of conservation of natural resources by being increasingly able to receive payments for the regulating and supporting services their blue forests, corals, and seagrasses provide. They can invest in and set aside areas for conservation, and more easily modify the actions that would otherwise have a negative impact, such as those that generate direct and/or indirect pollution of those ecosystems.

In Table 21, Mayers (2005) and Waite et al. (2014) classify stakeholders as either *primary*, *secondary*, or *external*, in terms of the type of impact received and the power of influence on project decisions. Different ecosystems could have a different mix of these stakeholders, and it is important to note that influence is endogenous, given previous actions, and several routes and strategies can empower otherwise marginalized groups.

Figure 26 presents an example of this classification, and one can notice the tension of the short-term vs long-term interests of certain stakeholders. Perhaps one of the clearest contrasts is the short-term benefit for current fishers that, if unsustainable harvest is allowed, could result in losses for future generations of fishers. The connection over time is also relevant for indirect beneficiaries. For example, research institutions would benefit immediately from learning from a healthy ecosystem and act as stakeholders for present conservation, but all fisher-

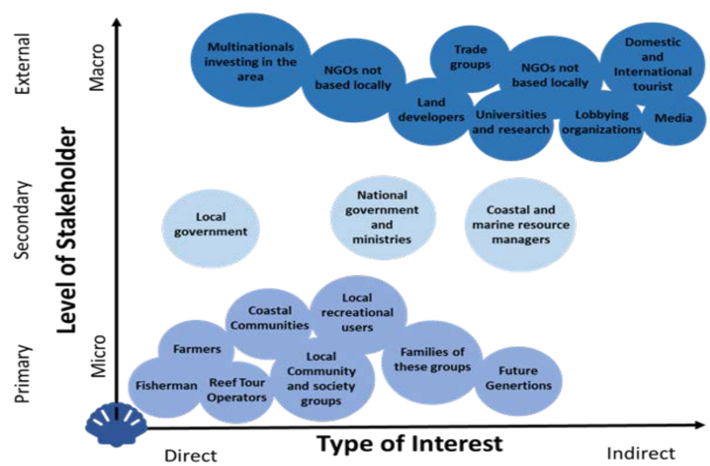


Fig. 26 | Coastal ecosystem stakeholders by level and type of interest. Source: Adapted from SOAS (2014).

communities in the future would benefit from the ecosystem connections they find.

The scale of benefits for stakeholders is relevant since the visibility of the value of ecosystem services varies across scales. The micro-level benefits are spatially located closest to coastal ecosystems and involve local concerns and local systems of decision-making. The macro-level is focused on national and global scale concerns and systems. Macro-level stakeholders would include governments; international, regional, and sectoral bodies; intergovernmental organizations and civil society; scientists and research organizations; and the wider public. Of course, no global action can succeed without local involvement, and thus, even if regional indigenous groups and local communities and businesses might appear focused on micro-scale concerns, it is the articulation of both scales that is needed for success in any of them.

Stakeholders and their different degrees of importance and influence are represented in Figure 27. Primary and direct stakeholders might have a low influence (Area A) on larger processes, while the private sector tourism industry and politicians might have a much greater ability to influence long-term management decisions (Area D).

In this political economy analysis, the four different groupings enable appropriate engagement strategies to be built by resource managers. For example, engagement with Group A would be about involvement, capacity building, and empowerment, whereas with Group D it would be about monitoring, defending, and mitigating potential impacts of the stakeholder actions. Group C may not be worth involving beyond monitoring, and Group B actions might involve closer collaboration and alliance building as well as negotiating interests and outcomes.

There is relevant analysis of the effectiveness of stakeholder engagement activities–monitoring, empowerment, alliance building, etc.–in the literature (Tompkins 2002, Partridge 2006, Schwermer 2020) and it is important to keep track of what strategies work best in different circumstances and balances of current use, threats and opportunities for the conservation of coastal and marine ecosystems. In this analysis of stakeholder importance and influence, the four different groupings enable appropriate engagement strategies to be built by the coastal managers.

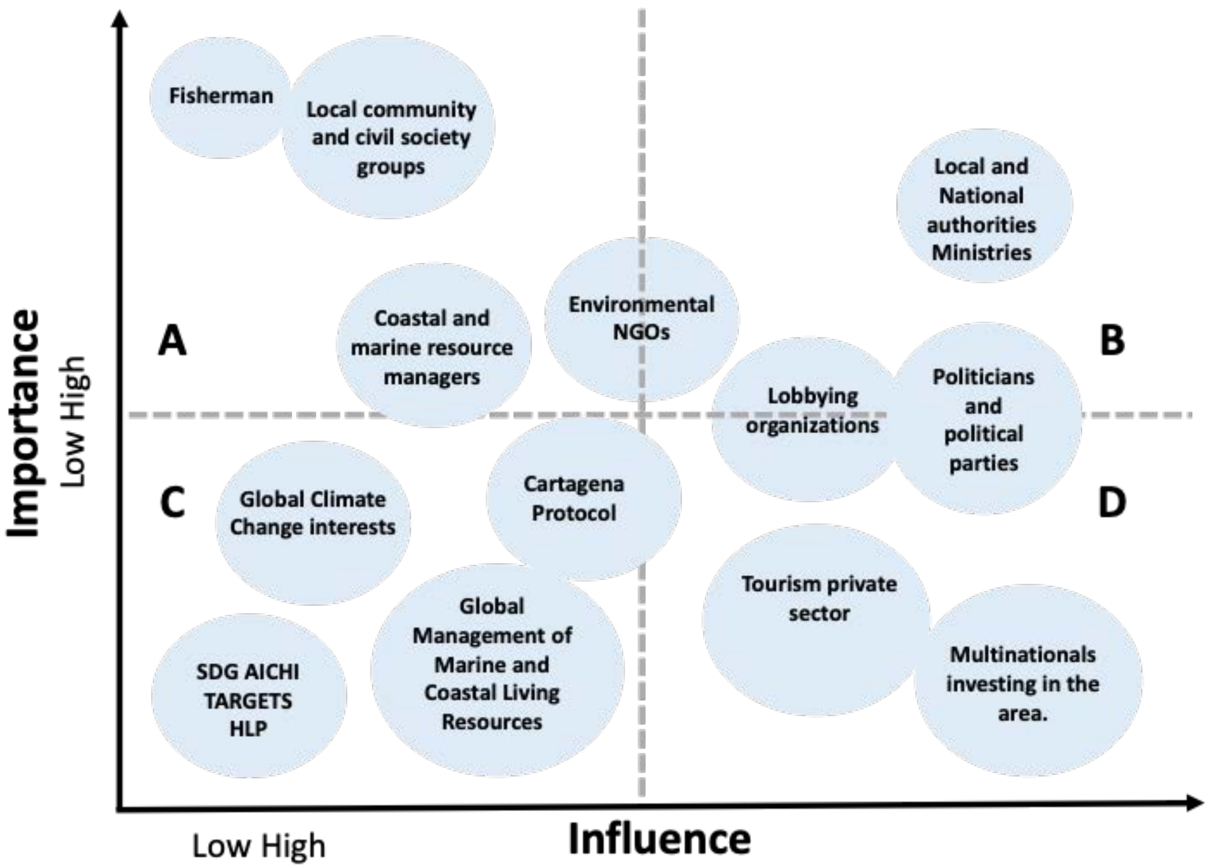


Fig. 27 | Coastal ecosystem stakeholders and their different degrees of importance and influence. Area A: High importance, low influence; Area B: High importance, high influence; Area C: Low importance, low influence; Area D: Low importance, high influence. Source: Adapted from SOAS (2014).

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	SEAGRASS
Provisioning services: Products derived from plants, animals, and microbes, as well as materials such as jute, hemp, silk, fuel (wood, dung, etc.), fresh water, ornamental resources, bio-chemicals, medicines, pharmaceuticals, as well as the genetic material.			
Food (e.g., fisheries)	x	x	x
Raw materials	x	x	x
Medicinal resources	x	x	x
Genetic resources	x	x	x
Regulation services: Services derived from air quality maintenance, climate regulation, water regulation, ocean chemistry regulation, erosion control or soil stabilization, hydrological regulation, water purification and waste treatment, human disease regulation, pests, biological control, and regulation of natural hazards, such as storms. They limit the effect of stresses and shocks to the system.			
Flood/storm/erosion regulation	x	x	x
Climate regulation	x	x	x
Regulation of ocean chemistry	x	x	x
Cultural services: Cover a wide range of non-consumptive uses of the environment: cultural diversity (heritage values, sense of place, social relations and the influence of ecosystem on the knowledge system developed by different cultures), the spiritual, religious, aesthetic, and inspirational wellbeing that people derive from the 'natural' world; the opportunity for science and education to study and learn from them; and the market benefits of recreation and tourism.			
Tourism and recreation	x	x	x
History, culture, traditions	x	x	x
Science, knowledge, education	x	x	x
Supporting services: Include the main ecosystem processes that underpin all other services, such as soil formation, production of oxygen gas through photosynthesis, primary production, nutrient, and water cycling.			
Primary production	x	x	x
Nutrient cycling	x	x	x
Species/ecosystem protection	x	x	x

Table 22 | Coastal ecosystem and services provided. Source: Adapted from WRI (2009) with information from MEA (2005).

What Are We Protecting?
Ecosystems services (ES) are vital to sustain human life. (Daily 1997, Costanza et al. 1997, Millennium Ecosystem Assessment (MEA) 2005). Coastal ecosystems provide services to Caribbean countries via mangroves, coral reefs, and seagrasses that attract tourists, provide fish habitat, protect shorelines from storm damage, purify water, and store nutrients and carbon. These services (Table 22) contribute to human welfare both directly and indirectly (WRI 2009, UNEP-WCMC 2011).

In Part I, we explored the many stressors that affect these critical ecosystem services, including pollution from land and marine-based sources and activities, climate change, unplanned coastal development, improper land use and planning, and overfishing, among others. It is important to keep in mind, that where there are major pollution related stressors, investments also must be made to address this threat in order to ensure the sustainability of a proposed nature-based solution.

Seagrasses

Provisioning and Regulation Services
Seagrass habitats are important for commercial and recreational fish species as they act as nurseries for juveniles, and as refuge or breeding grounds at various stages of the life cycles of commercial species. Their role in regulating intra-species competition for resources is one of the more recently understood services by the biological sciences. (Ruiz-Frau 2017, Nordlund 2018, Unsworth 2019). Seagrass also serves as food for herbivores (e.g. green sea turtles, manatees, vertebrates, invertebrates) and habitat for shorebirds and waterfowl.

Ecosystem Regulating and Supporting Services

Even if their structure would appear to hold less intuitive shoreline protection services, seagrass areas play a role in the coastal dynamics that add stability and resilience to the coasts in recurrent high-energy natural events. Seagrasses protective effect has been documented as comparable to the effect of salt marsh ecosystems, reducing hazards by as much as 40%. (Terrados and Borum 2004; Christianen et al. 2013, Ondiviela et al. 2014; Guannel et al. 2016). Seagrass supports sedimentation due to their structure, which reduces water turbidity. Water clarity is very important for seagrasses themselves who are strongly light dependent to carry out their photosynthetic activities and contribute with their productivity to the coastal habitats' food web (Nordlund 2018).

The carbon sequestration potential of the global seagrass stock has been linked to diversified sinks and reducing emissions from degradation. The potential is closely linked to cycles connecting coral reefs and mangroves. (Ruiz-Frau et al. 2017, Schile 2017).

Cultural Services
There is a high potential for communication impact focusing on local seagrass facts such as the value of a great coastline view that can be partly attributed to seagrass (Nordlund 2018).

Mangroves

Provisioning and Supporting Services
Mangroves play a similar role to coral reefs in terms of being areas for catch of fish and shellfish for fishing communities and the populations supplied by them. They are key spawning grounds, and serve as nursery, breeding and feeding areas for many living organisms, both of direct commercial importance as well as indirect value (MEA, 2005. Turner, R. 2007). As "blue forests," mangroves in the Caribbean region reach heights that make them a valuable source of fodder, fuelwood, charcoal, ornaments, and even timber. It is, also, possible to harvest mangroves for industrial inputs such as fibers, latex, and other chemicals. Traditional knowledge of medicines and new sources of pharmaceutical inputs are also some of its values, present, or as potential realizations (McBratney et al. 2017, Chamberlain 2017). In terms of water quality, mangroves absorb toxins and other pollutants like heavy metals and excess fertilizer that come from land-based activities. The natural filter's distinctive role in regulating waste supports other coastal ecosystems like seagrass meadows and coral reefs that otherwise would be harmed by it (Ewel et. al. 1998, Struve et al. 2001, MEA 2005, Brander et al. 2012, Mitsch et. al. 2015).

Ecosystem Regulating and Supporting Services
Mangroves are very important sources of carbon storage, interacting in this process with other coastal ecosystems, including seagrass meadows and coral reefs. These reductions can occur by reducing emissions, as well as increasing the number of sinks available (Albert et al. 2012, Lau 2013, Sutton-Grier and Moore 2016, Himes-Cornell 2018).

Cultural Services
Cultural services of mangroves are important for the local community and primary stakeholders because these values represent an important part of their lives, livelihood, and cultural identity (MEA 2005, Himes-Cornell 2018).

Coral Reefs

Provisioning Services
Coral reefs provide fish and shellfish for consumption and sale, which benefit coastal communities and their markets. In some communities, fishermen use methods that involve traditional knowledge-based practices and in others technical or science-based mariculture operations are more common. In either situation, sustainability remains a challenge (Cesar 2003, Leal et al. 2013, Waite et al. 2014, Albert et al. 2015, Golden et al. 2016, Grafeld et al. 2017, Burke et al. 2011, WRI 2008). The harvesting of ornamental corals and pharmaceutical inputs, is less common, but of high value (Bruckner 2001, 2002). Medicine resource chemicals produced by reef-dwelling species serve as the basis for cancer treatments, HIV, and malaria, and other diseases (Cooper et al. 2014). Coral reef areas may also face extraction of raw materials such as limestone and other building materials (Brown 2011). These activities pose a high risk to the ecosystem due to the potential chain damage that can be caused unless the strictest environmental standards are followed.

Ecosystem Regulating and Supporting Services
Coral reefs provide physical protection to other coastal ecosystems and human habitats along the shoreline. Similar to other coastal ecosystems, a coral reef's location and structure helps dissipate wave energy and reduces the impact of storm surge floods (Bellwood 1996, Wild et al. 2004; Hart and Kench 2006, Vila-Concejo et al. 2013, van Zanten et al. 2014). Reefs also improve water quality by processing nutrients and other forms of biochemical cycling. This is linked to the supporting services of habitat protection, fundamental for different stages of the species linked directly or indirectly to commercial fisheries in the Caribbean region (WRI 2008, de Goeij et al. 2013, van Zanten et al. 2014). Lastly, reefs are fundamental to the processes of photosynthesis, sand formation, primary production, species/ecosystem protection, and biological support to seabirds and turtles. In global terms, their role as carbon storage sites is linked to mitigation efforts and negative/positive climate loops (Pascal et al. 2016, Spalding et al. 2014, Perry et al. 2015, Archer et al. 2017, Elliff and Silva 2017, Reguero et al. 2018).

Cultural Services
Tourism is one of the world's largest cultural industries, a driver of growth for all Caribbean countries. Tourism directly and indirectly supports the livelihoods of entire communities through consumption of local produce and services. Its

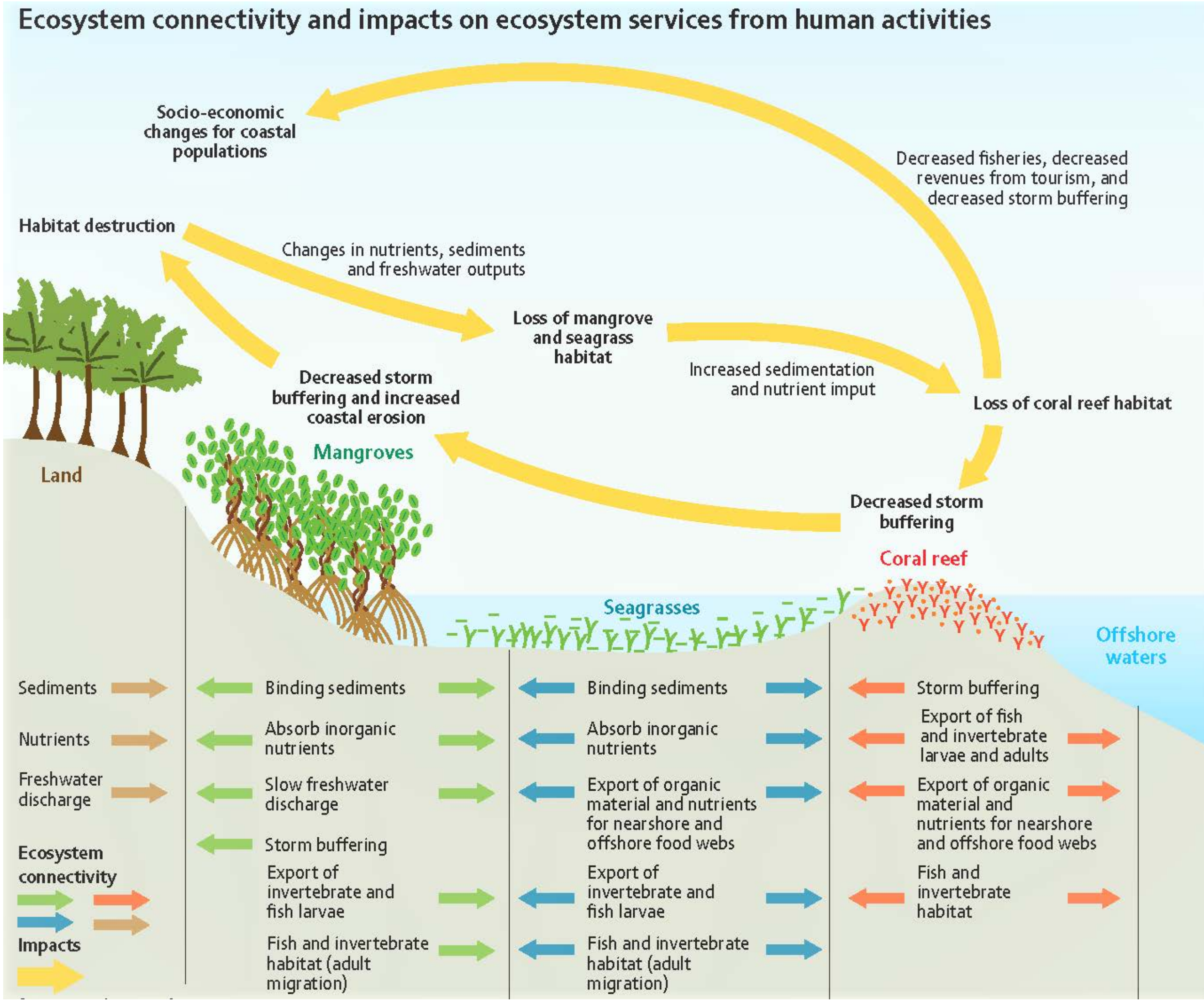


Fig. 28 | Linking impacts from human activities on ecosystem services Source: Silvestri, S. (2010).

more salient expressions are recreational and outdoor activities like snorkeling, scuba diving birdwatching and sightseeing tours that focus on experience and aesthetic values (Pendleton 1994; Green and Donnelly 2003, Brander et al. 2007, Uyarra et al. 2009, Spalding et al. 2017). Other, more conspicuous but just as important cultural services are linked to research and artistic activities, where the main objective is the expansion of knowledge and education (Lead et al. 2010). As expected, one reinforces the other, as tourism is attracted whenever more is known about the marvels of an ecosystem.

Ecosystem Service Connectivity

Coral reefs, mangroves, seagrasses, and other terrestrial coastal ecosystems do not exist in isolation. They are vastly interconnected, generating ecosystem services that flow from one habitat to another (UNEP 2011, Silvestri et al. 2010, Barbier 2017). Their physical and biological interdependence depends on nutrient flows and material exchange, including movements of marine fauna, and the outcome is that these habitats provide important goods and services both individually and through functional linkages across the sea (Silvestri, S. 2010, Barbier 2017).

Figure 28 represents the interaction of the three habitats to provide support for water pollution and sediment control, marine fisheries, and shoreline protection. Mangroves and seagrasses provide the water pollution and sediment control services that protect corals services and goods. In terms of marine fisheries, the three ecosystems strengthen support of fish and invertebrate habitat serving as nurseries and breeding that results in adult migration to coral reef fisheries (UNEP 2011, Silvestri et al. 2010, Barbier 2017). Coral reefs shelter the coastal habitats from storms, buffering the waves, and supporting the capacity of mangroves and seagrasses to provide protection as well (van Zanten et al. 2014).

The interaction and connectivity of these habitats has implications in terms of valuation of benefits of shoreline

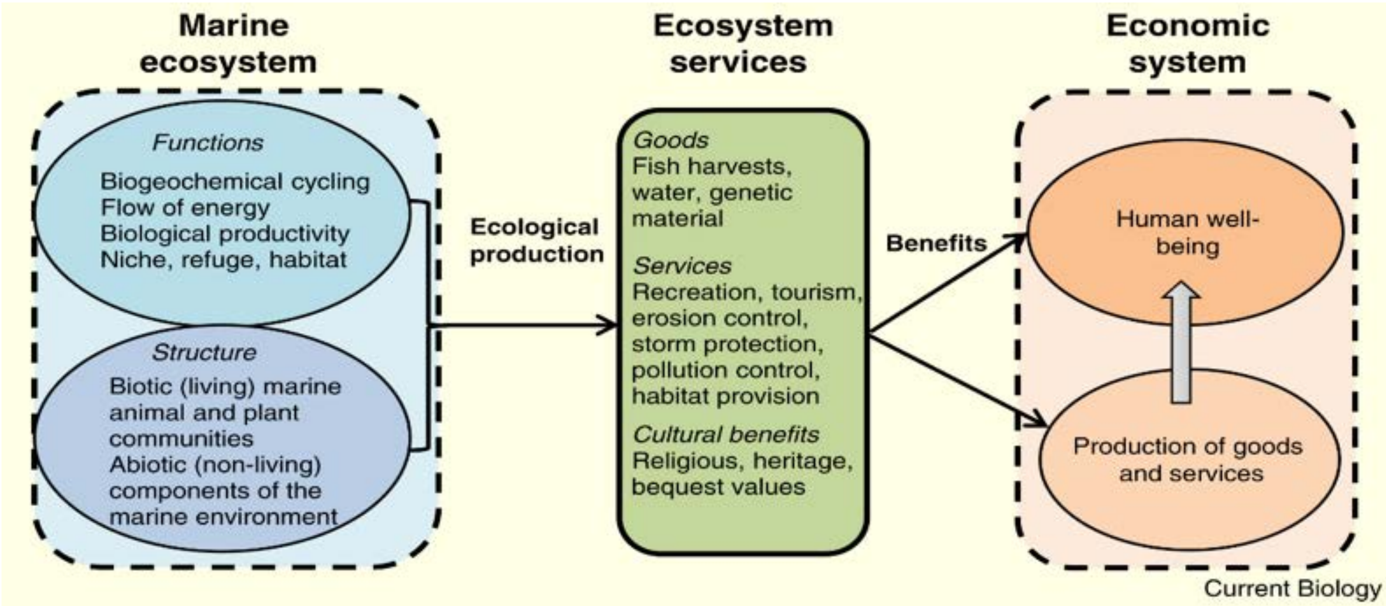


Fig. 29 | From ecosystem structure to contribution to human well-being. Source: Lead et al. (2010).

protection, fisheries habitat, pollution control, and management in coastal habitats. Any policy decision about project development, resource extraction, or habitat protection on the coast and seascape, such as protection of mangroves along the coast, will have implications in the rest of the habitats including coral and seagrass and in the goods and services provided (WRI 2009).

Fisheries management must consider economic and ecological synergies between mangrove-seagrass-coral reef habitats. Management should take into account the importance of mangroves and seagrasses as areas of nursery sites to coral reefs and marine fisheries; and, vice versa, coral reefs to coastal nurseries. It is also important to identify the nursery areas that have an unusually large importance to specific reefs and marine fisheries and to identify priority coastal sites for mangrove and seagrass bed restoration projects (Barbier 2017).

Quantifying Economic Benefits

Mainstreaming the value of natural capital into policy decision-making is vital as the consumption and enjoyment of goods and services that nature provides contribute directly and indirectly to human well-being (Figure 29) (Lead et al. 2010).

Ecosystem valuation sheds light on important policy decisions and questions (Figure 30) related to the protection, restoration, conservation and sustainable use of coastal ecosystems (Barbier 2017). Quantifying the benefits of the goods and services in economic terms is useful when any changes in the quality and quantity of the ecosystem service will be brought by a particular policy

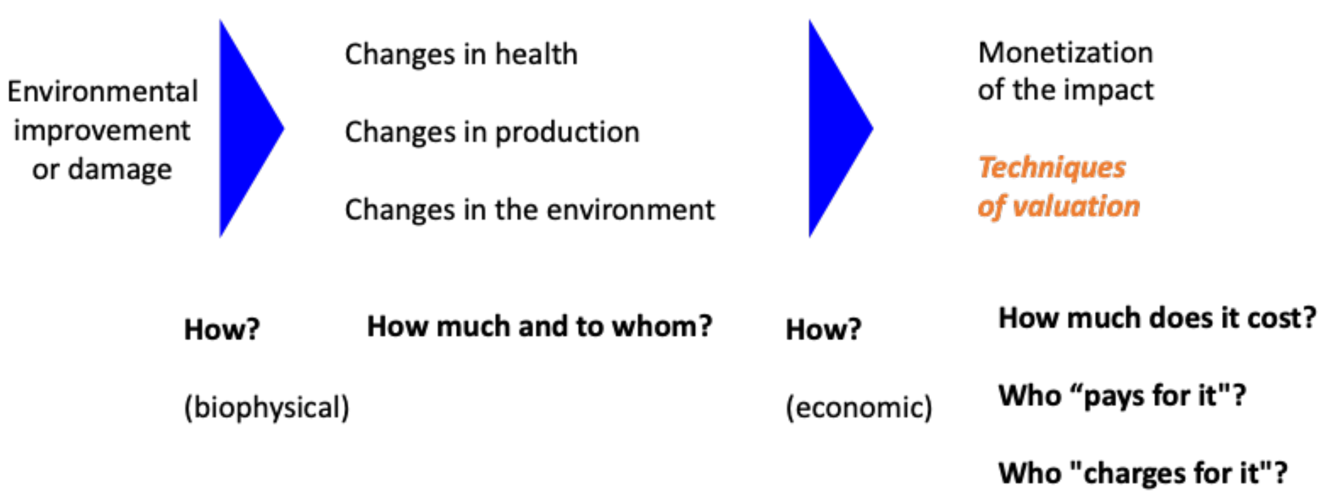


Fig. 30 | Economic valuation process. Source: Barbier (2017).

decision or project (van Beukering and Slootweg 2009). In the economic valuation process there are four steps to follow: first is the identification of the ecosystem services of the natural resource that will be affected; second is to have a basic assessment of the positive or negative impact on the resource of the policy, project, or event, measuring it in *biophysical* terms; third is to express as much as possible the biophysical effect in monetary terms; and fourth is to quantify in monetary terms using the toolbox of valuation techniques that will be used to obtain the ecosystem services values.

USE IN DECISION MAKING	POLICY QUESTION
Evaluate the environmental, social, and/or economic impact of a proposed development or policy.	**Fisheries:** What are the economic benefits of no-take zones (and other marine protected areas) to nearshore fisheries?
Justify, support, inform, and/or advocate policies that protect or sustainably use coastal ecosystems.	**Simple values for advocacy:** What is at stake if coastal ecosystems degrade?
Evaluate distribution of costs and benefits of environmental degradation/environmental improvements.	**Reduced pollution:** What are the benefits/costs (i.e. increases in coastal ecosystem service values) stemming from improved sewage treatment at the primary, secondary, or tertiary levels?
Raise awareness of the value of coastal ecosystems.	**Tourism:** How responsive are tourists to changes in environmental quality (e.g., changes in beach or water quality, or coral reef condition)? **Climate change:** How could communities adapt to climate change, maintaining important ecosystem services?
Inform green national accounting,	**Contribution to economy:** What is the annual economic contribution (or economic impact) of fisheries, tourism, and shoreline protection in a site or country?
Establish levels of damage compensation.	**Compensation:** When infrastructure has an impact on a wetland. What kind of compensation, in species, or investment, or direct payment would leave fishers at least as well off as they were before?
Determine appropriate charging rates for environmental use (e.g., marine park user fees).	**Marine spatial planning:** What are the economic returns to investing in more effective protected area management?
Design methods to extract finances from coastal ecosystem services (e.g., payments for ecosystem services schemes).	**Economic and financial instruments:** How can you target payments for ecosystem services (PES) to maximize behavior change?
Compare costs and benefits of different uses of the coastal environment and assess tradeoffs.	**Marine spatial planning:** How do you achieve equitable and sustainable use of coastal and marine environments to benefit local and global populations?
Determine the most cost-effective strategy for meeting a specific policy objective (e.g., coral reef health, water quality, climate change adaptation).	**Climate Change:** How are coastal ecosystem service values--especially tourism, fisheries, and shoreline protection--likely to change given threats such as climate change and ocean acidification? **Marine spatial planning:** How much does it cost to comply with the Aichi Target to cover a percent of marine protected areas?

Table 23 | Common applications of ecosystem valuation for decision-making. Source: Adapted from WRI (2009).

Quantifying the benefits of the goods and services in economic terms is useful when any changes in the quality and quantity of the ecosystem service will be brought by a particular policy decision or project (van Beukering and Slootweg 2009). In the economic valuation process there are four steps to follow: first is the identification of the ecosystem services of the natural resource that will be affected; second is to have a basic assessment of the positive or negative impact on the resource of the policy, project, or event, measuring it in *biophysical* terms; third is to express as much as possible the biophysical effect in monetary terms; and fourth is to quantify in monetary terms

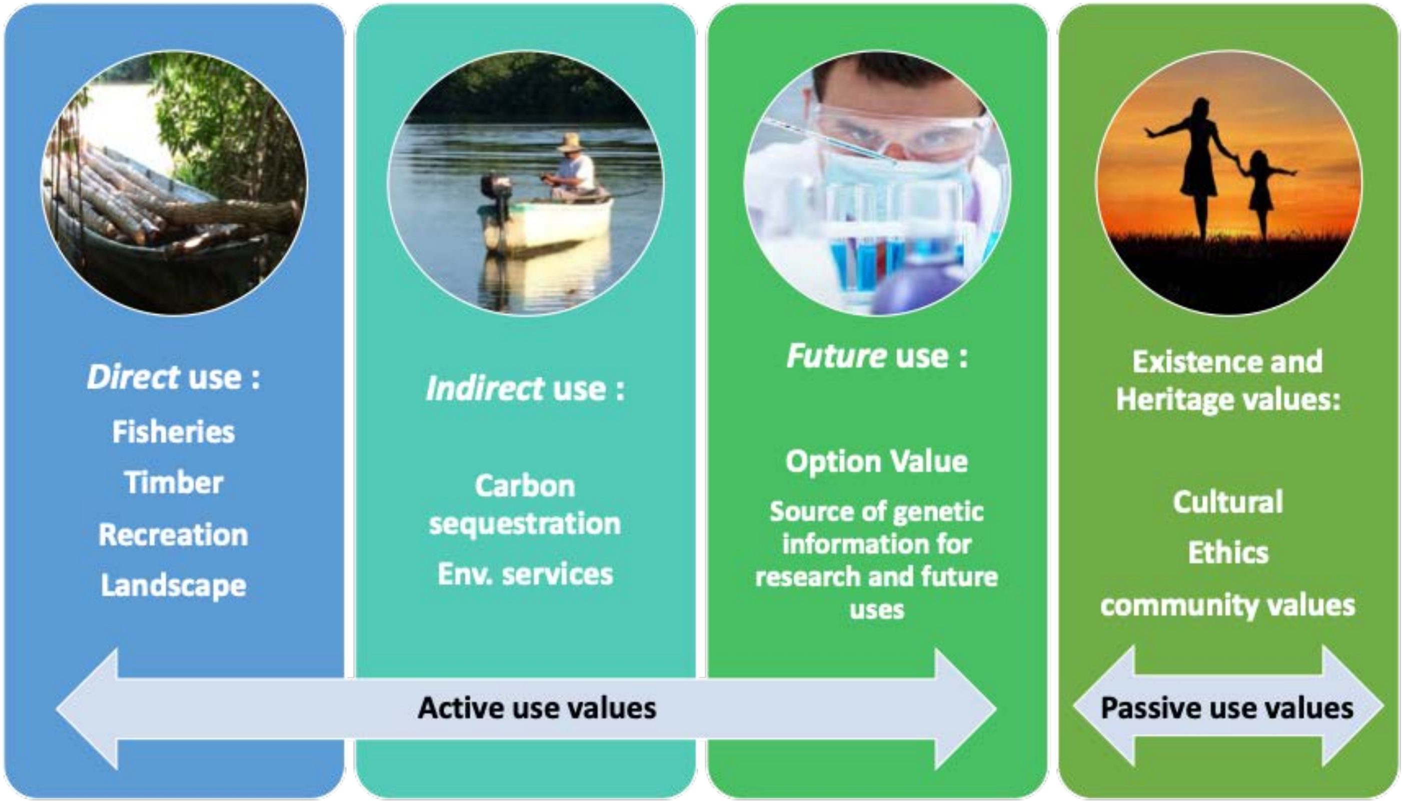


Fig. 31 | Total Economic Value. Source: Marisol Rivera-Planter based on Pearce and Turner (1990), Ledoux and Turner (2002)

using the toolbox of valuation techniques that will be used to obtain the ecosystem services values.

Type of Values

The framework most widely accepted for cost-benefit analysis for valuation of ecosystem services is the *Total Economic Value (TEV)* (Figure 31).

The Total Economic Value is the aggregation of all values provided by ecosystems.

<u>*Use values*</u> (or active values) are those derived from the actual use of ecosystem services (Pearce 2002, Hanley et al. 2007, WRI 2009, Sarkis et al. 2013):

Direct values involve an actual consumption (extractive: fisheries, timber, etc.) or a direct non-consumptive use (non-extractive: recreation, research, etc.). That is why it is often divided into extractive and non-extractive values.

Indirect values refer to the functional benefits of the ecosystems, such as biological support for species, water quality, shoreline protection among others.
Option values express the value for the conservation of the ecosystems so as to keep open the possibility of being a user in the future, i.e. coral reefs, mangroves, corals or scenery (Bishop 1982, Walsh et al. 1984, Freeman 1985).

<u>*Non-use values*</u> *(*or passive values) are derived from the own features (attributes inherent) of the ecosystem itself (Krutilla 1967, Carson et al. 1992, Hanley et al. 1998, Adamowicz et al. 1998, Windle and Rolfe 2005):

Existence values are the amount of money individuals decide to pay for knowing an ecosystem (or an environmental feature) will continue to exist in the future, irrespective of any prospect of actual use (McConnell, 1983; Randall and Stoll, 1983; Walsh et al., 1984; Stevens et al., 1991; Silberman et al., 1992; Pearce and Turner, 1990).

Bequest values (future use value) are based on the utility derived from knowing that future generations may enjoy ecosystems (McConnell, 1983; Walsh et al., 1984, Aldred 1994, O'Garra 2009).

Altruistic values are related to the utility derived for ecosystem services may be for the benefit of somebody else (Aldred 1994, Ojea and Loureiro 2009).

Valuation Techniques

The main purpose of economic valuation is to include in the cost benefit analysis the ecosystem services benefits from a monetary point of view. Individual techniques have to be selected according to the nature of goods (i.e. market/non-market, quantifiable), the socio-economic structure (e.g. proportion of population affected by the potential change),

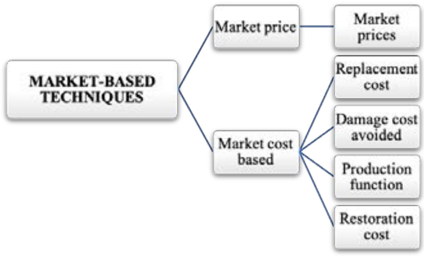


Fig. 32 | Market Valuation Based Techniques. Source: Marisol Rivera-Planter with information from Pearce et al. (2002), Lead et al. (2010).

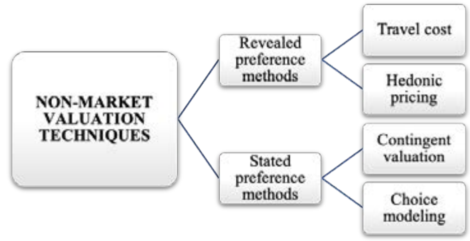


Fig. 33 | Non-Market Valuation Techniques. Source: Marisol Rivera-Planter with information from Pearce et al. (2002), Lead et al. (2010).

and the environmental situation of the location (i.e. the level of pollution/risk, etc.). The first distinction made is between market-based and non-market techniques (Pearce et. al. 2002, 2006).

Market prices: Uses observed market prices to analyze the economic activity generated by use of an ecosystem good or service (Lead et al. 2010). Some examples are commercial fisheries prices, revenues from tourists to areas of high biodiversity, marine protected areas, and the value of bio-prospecting contracts. It is usually applied to provisioning services such as timber, commercial fish and shellfish, ornamental items, raw materials limestone, and building materials coming from mangroves and coral reefs (WRI 2009).

Market Cost Based

Replacement cost: Uses the cost of replacing ecosystems or the cost paid for substitute services providing the same functions and benefits. It is useful in estimating indirect use benefits by the expenditure of the marketed goods required in the absence of ecological data to estimate the damage functions or information of services provision e.g. expenditure on irrigation systems to replace the hydrological services that a wetland has for agriculture can be used to estimate the cost of degradation of a wetland. (Pearce et al. 2002, WRI 2009, Lead et al. 2010).

Damage cost avoided: The cost that people are willing to pay to avoid damage or loss of ecosystem services. This metric is an estimation of current damages or costs incurred to reduce, adapt or cope with them (e.g., from hurricanes or floods) and captures direct and indirect uses.

Replacement cost and damage cost avoided: These methods are usually applied to ecological services, such as buffering climate change impacts (wave attenuation), shoreline protection against storms and erosion, flood impact reduction, water purification and carbon storage (i.e. regulating services).

Restoration cost: This method values an environmental good giving to the cost incurred in restoring it to its original state after it has been damaged. It is one of the widely use approach because it is relatively easy to find estimates of such costs (EU Commission 2001). It is used for the valuation of regulating services (Markandya 2016). There is an ample debate if restoration costs are a valuation technique or not because they are strictly related to costs and not to preferences. However, when the asset in question is unique, and the benefits exceed costs even on a limited inspection of the information available, then restoration cost becomes a minimum estimate of benefits (EU Commission 2001).

Production function/costs: Estimates monetary value by looking at the changes in economic activity brought by the environmental damage or benefit. These costs are linked to market goods and services and are produced with man-made and ecosystem *inputs* or unaccounted for ecosystem services. Examples include oxygen production, CO_2 absorption, carbon storage, providing fish nurseries, water purification and coastal protection (e.g. regulating services) (Lead et al. 2010, Christie et al. 2012).

Non-market methods include both revealed and stated preference techniques which are based on developing proxy markets or surveys of populations of interest.

Revealed Preference Techniques

To determine the value of an ecosystem good or service these techniques use data from other market transactions or from expenditures on markets associated with environmental ecosystem services (WRI 2009, Lead et al. 2010, Baker and Ruting 2014). The main techniques are the travel cost method and hedonic pricing.

Travel cost: Uses data about visitation to a site or set of sites to construct a demand curve for an environmental resource used value (e.g., a beach, marine natural protected area, mangroves, etc.). The visitors' preferences are revealed through the analysis of the direct and indirect expenditures (gasoline or entrance fee, meals, travel time) (Pearce et al. 2002).

Hedonic pricing: Estimate the influence of environmental characteristics or attributes on the price of the marketed goods. It is most commonly used to examine variations in hotel or real estate prices in coastal sites that reflect the value of local environmental attributes (e.g., ocean view,

Benefits/Services	USE VALUES		OPTION VALUES	NON-USE VALUES
	Direct use	Indirect use		
Provisioning services (food, raw materials, medicinal and genetic resources)	**MP, PF** **CA RC**		**CV, CM**	
Cultural services (tourism, recreation, history culture, traditions, science knowledge, education)	**MP, TC, CM, CV, HP**		**CV, CM**	**CV, CM**
Regulating services (flood, storm, erosion, climate regulation)		**RC, CA**	**CV, CM**	**CV, CM**
Supporting services (species/ecosystem protection, nutrient cycling)	**Valued through the other three categories of ecosystem services** **CM, CV, TC, HP, CA**			

Table 24 | Appropriate valuation methods economic value for coastal ecosystem services. Abbreviations of valuation methods: CA = cost of avoided damage; CM = choice modeling; CV = contingent valuation; HP = hedonic pricing; MP = market price; PF = production function; RC = replacement cost; TC = travel cost. Source: Adapted based on WRI (2009), MEA (2005), Christie et al. (2012)

distance to beach, proximity of natural areas as wetlands, air quality) (Pearce et al. 2002).

Stated Preference Methods

To determine the value of the non-marketed goods these techniques ask people directly, via questionnaires, how much they are willing to pay to change the condition of the good or service in question or to preserve it, rather than by looking at its influence on actual markets for some other goods or services (Bateman et al. 2002). The main techniques are contingent valuation and choice modelling method.

Contingent valuation: Places a value on ecosystem goods or services by directly asking people to state their willingness-to-pay (WTP) or willingness-to-accept (WTA) for a specific set of ecosystem goods and services or for changes in those goods and service. (Hanley et al. 2007, Atkinson and Mourato 2008)

Choice modeling or conjoint analysis: Allows multiple environmental attribute changes (e.g., beach width, water quality, mangroves and reef health, park entry fees) to be valued simultaneously. CM can be used to generate estimates of the relative value of multiple attributes, as well as to analyze tradeoffs that individuals are willing to make between environmental factors (Louviere and Hensher 1982, Louviere and Woodworth 1983, Louviere et al. 2000). It uses a range of formats, including rating, ranking, and choice.

Other Techniques

Benefit transfer: Is not a specific valuation technique, but a method that estimates the economic value for ecosystem services (or an ecosystem) using information from other ecosystems. It takes available value estimates from one or more studies and transfers them to a new context (Hanley et al. 2007). There are two general approaches: unit value transfer and value function transfer. Meta-analysis is also included (Brander 2013).

Deliberative monetary valuation: This approach integrates a participatory process of economic valuation that encapsulates reflection, discussion and social learning into monetary valuation of environmental ecosystem services (Bunse et al. 2015, Kenter 2017). It increases legitimacy of policy making as a result of increased public participation and better understanding of values (Howarth and Wilson, 2006, Orchard-Webb et al. 2016).

This alternative approach has potential limitations in that it operates with small samples which are not statistically representative and it is a timely process requiring facilitation skills. To reach quantitative results, this approach must be combined with other approaches (e.g. multicriteria analysis) and its success depends on participants' availability and commitment to the process (Mavrommati et al. 2017, Kieslich, M et al. 2021).

Values of Coastal Marine Ecosystems

The aim of this section is to conduct a quick review of the previous and ongoing economic valuation projects/initiatives on coral reefs, mangroves, and seagrasses worldwide and in the wider Caribbean and the Pacific at the site, national, and regional level.

In a study analyzing the economics of ecosystem and biodiversity data, de Groot et al. (2012) reviewed 300 valuation studies and 1350 data-points from over 300 case study locations. The results are shown in Table 25.

Services	Coral Reefs (USD/ha/yr)	Coastal systems (USD/ha/yr)	Coastal wetlands (USD/ha/yr)
Food	0.68	2.38	1.11
Water	n/d	n/d	1.22
Raw materials	21.53	0,012	0.36
Genetic resources	33.05	n/d	0.01
Medicinal resources	n/d	n/d	0.30
Ornamental resources	0.47	n/d	n/d
PROVISIONING SERVICES	55.73	2.40	3.00
Climate regulation	1.19	0.48	0.065
Disturbance moderation	16.99	n/d	5.35
Waste treatment	0.085	n/d	162.12
Erosion prevention	153.21	25.37	3,93
Nutrient cycling	n/d	n/d	0.045
REGULATING SERVICES	171.47	25.85	171.51
Nursery services	n/d	0,19	10.65
Genetic diversity	16.21	0,18	6.49
SUPPORTING SERVICES	16.21	0.37	17.14
Aesthetic	11.39	n/d	n/d
Recreation	96.30	0.26	2.19
Spiritual experience	n/d	0.021	n/d
Cognitive development	1.14	0.022	n/d
CULTURAL SERVICES	108.83	0.30	2.19
TEV	352.24	28.92	193.84

Table 25 | Total economic values for world's coastal ecosystems (USD/ha/year. 2007 prices). Source: Adapted on based on de Groot et al. (2012).

As presented in Table 25, coral reefs have a higher total economic value compared to other coastal ecosystems and wetlands. However, in terms of regulating services, coastal wetlands and corals have almost the same value. This highlights the importance of these services in terms of ecosystem connectivity, climate regulation, shoreline protection, and reduction of negative impacts of certain types of waste on marine and coastal ecosystems. The major contributors of a coral reef´s value are the regulating (49%) and cultural services (31%), followed by provisioning (16%) and supporting services, respectively. For wetlands (including mangroves) in this table the major contributions to the value are deregulating (88%), supporting (9%), and the rest are provision services and cultural services (3%).

Values of the Wider Caribbean Region (WCR)

Schuhmann and Mahon (2015) provides economic valuation studies of the Wider Caribbean Region (WCR) for the Caribbean Large Marine Ecosystem (CLME). After a review of 200 values, authors found that valuation has focused on a small number of benefits that are easy to measure such as recreation in Marine Protected Areas (MPA) that are measured with market information. The tourism values associated with coral reefs have been the focus of these studies whereas commercial fisheries have not been a focus. Regulating and supporting services are recognized but there are not many valuation studies. Table 26 (next page) shows some of the resource values in the WCR. A recent review by Maldonado et al. (2020) shows that in terms of coastal protection services, the Wider Caribbean Region has only a few studies associated with economic values. The studies in the Wider Caribbean emphasize extreme events with special attention given to erosion control and flooding. As mentioned, coral reefs have been the focus of most of these valuation studies. The second most popular ecosystem for valuation of coastal protection is wetlands, focusing on extreme events protection. The studies that include mangroves in WCR are so few that they are included in the wetland category.

Schuhmann and Mahon (2015) conclude that a coordination between countries and agencies is necessary to have a more comprehensive understanding of the full value of the goods and services provided by marine ecosystems in the WCR. The transition to a blue economy could bring this coordination taking into account what Patil et al. (2016) presents in a report for the Caribbean Region: *that each country should understand and measure that their economic activity is tied to their natural capital asset essential for sustainable growth.* This report suggests that Caribbean waters generated revenues of US$407 billion in 2012, equal to 14-27% of the global ocean economy, though the sea's area accounts for only 1% of the global ocean (Patil et al. 2016).

Topic Area	*Description*	*Studies*
Replicable applications	Application of common valuation methodology to numerous sites	WRI's Coastal Capital series and OAS's Reefix
Valuations of coral reef ecosystems	Overviews, summaries, compilations, and meta-analyses	Brander et al. (2006), Cesar et al. (2000), Gustavson et al. (2000), Conservation International (2008)
	Economic effects of coral loss in the Caribbean due to climate change	Vergara et al. (2009)
	Components of total economic value	Cesar et al. (2003), Ruitenbeek and Cartier (1999), Gustavson (1998, 2002), Burke et al(2008a), Cooper et al. (2009), van der Lely et al. (2013)
	Explorations of general reef-based tourism and recreation	Van Beukering et al. (2009), van Beukering et al. (2009), Hargreaves-Allen (2010b), [ETI] Estudios Técnicos Inc. (2007)
	Estimations of scuba diving and snorkeling values	Schuhmann et al., 2013; Parsons and Thur, 2008; Casey et al., 2010; Hargreaves-Allen, 2011; Beharry-Borg and Scarpa, 2010. Rudd (2001), Rudd and Tupper (2002), Rudd et al. (2001), Schuhmann et al. (2013), Hargreaves-Allen (2011)
	Estimations of species-specific values associated with reef-based recreation	Cesar et al. (2003), Estudios Técnicos Inc. (2007), Burke and Maidens (2004), Cartier and Ruitenbeek (1999), Cesar et al. (2000), van Beukering et al. (2009), van Beukering et al. (2009), Hargreaves-Allen (2010b), (2011), Burke et al. (2008a, 2008b), Cooper et al. (2008, 2009), Wielgus et al. (2010), Waite et al. (2011), Kushner et al. (2011)
Valuations of marine protected areas	General valuations of MPAs	Beharry-Borg and Scarpa (2010), van't Hof (1998), Spash (2000), Spash et al. (2000), Hargreaves-Allen (2010), Blommestein Associates (2011)
	Financial analysis of MPAs	Geoghegan (1998), Woodfield (1997), Buchan et al.(1997)
	Estimations of WTP and recreation in marine protected areas	Terk and Knowlton (2008), Thur (2010), Da Costa (2010), Woodfield (1997), van't Hof (1998), Wielgus et al. (2010), Edwards (2008), Planter and Piña (2006), Dharmaratne et al. (2000), Walling (1996), Bunce and Gustavson (1998), Bunce et al. (1999), Ruitenbeek and Cartier (1999), Gustavson (1998, 2002), Spash (2000), Spash et al. (2000), Reid-Grant and Bhat (2009), Huber (2005), Dixon et al. (1993, 1995, 2000), Pendleton (1995), Uyarra (2002), Uyarraetal. (2005), Thur (2010), Uyarraetal. (2010), Waterman (2009), Pendleton (1994)
Pelagic fishery valuations and analyses	Estimations of gross market values associated with commercial fisheries	FAO, CIA, Earth Trends, the Caribbean regional fisheries mechanism
	Estimations of commercial fishery values	Potts et al. (2003), Grant (2006), Schuhmann et al. (2009), Hargreaves-Allen (2010b), Sobers (2010)
	Exploration of economic linkages and pelagic fisheries	Mahon et al. (2007), Jaunky (2011), Nguyenand Jolly (2010)
	Estimations of sport fishing values	Hargreaves-Allen (2010b), Ditton and Clark (1994), Gillet et al. (2007)
Values associated with the continental shelf ecosystem	Explorations of the value of other recreation in the pelagic ecosystem (e.g., whale watching)	Vail (2005), Hoyt (1999, 2001), Hoyt and Hvenegaard (2002), Alie (2008), Norman and Catlin (2007), Cline (2008), Hutchinson (2008)

Table 26 | Valuation studies in the Wider Caribbean Region. Source: Schuhmann (2015).

Seagrass Economic Valuation

Ecosystem services of seagrasses have been recognized, but there are not many studies to estimate their monetary value. Dewsbury (2016) presents a review of ecological and economic studies of its ecosystem services (Table 27). The conclusion is that the indirect methods used underestimate the economic value and it is necessary to use a derivative based model linking ecological structure and function to associate to economic value.

Service	Ecology studies	Economic valuation studies	Valuation method	Value (USD)
Fiber / Ornamental Resources	Orquin et al. (1999), Orquin et al. (2001), Wyllie-Echeverria and Cox (1999), Huong et al. (2003)	Dirhamsyah (2007) Kuriandewa et al. (2003)	Market price; Travel cost	$2,287/ha/yr $80,226/ha/yr
Food / Recreation	Heck et al. (2003)	Anderson (1989)	Productivity method (commercial fisheries)	$1.8M/yr
		Watson et al. 1993, Kirsch et al. (2002)	Productivity method (prawn commercial value	$1150/ha/yr
		NOAA 1997, Gacia et al. (1999), Vithayaveroj (2003), Madsen et al. (2001)	Replacement Productivity method	$28,000–684,000/ha $203,200/yr
		McArthur and Boland (2006)	Productivity method (fish commercial value)	$103.74M/yr
		Paulsen (2007)	CVM	$960,000/yr
		Samonte-Tan et al. 2007, Sunamara (1977) Unsworth et al. (2010)	Productivity Market price	$204/ha/yr $78/ha/yr
		Guerrey et al. 2012, Spurgeon (1992)	Productivity method (multiple services)	$4585/ha
Recreation	Daby (2003)	Vassallo et al. (2013)	Market cost	$2.3M/ha/yr
Primary Production **Erosion Regulation**	McLeod et al. 2012, Mcleod et al. (2011), Fourqurean et al. (2012)Greiner et al. (2013) Fonseca and Calahan (1992) Terrados and Duarte (2000)	Pendleton et al. (2012), Lavery et al. (2013)	Carbon storage calculation	$394/ha/yr
		Costanza et al. (1997) Brenner et al. 2004, Marshall et al. (2000)	WTP Meta-analysis	$19,004/ha/yr $24,228/ha/yr
Nutrient Cycling	Short (1987)	Engeman et al. (2008), Fourqurean et al. (2012) Han et al. 2008, Haynes et al., (2007) Guerrey et al. 2012, Spurgeon (1992)	Transfer method (original WTP, King, 1998) CVM, Benefits-transfer, WTP Productivity method (multiple services)	$140,752.23/ha $100,640/ha $4,585/ha
		Vithayaveroj, (2003) Cullen-Unsworth et al., (2014)	WTP Case study analysis	US$10.43M/yr Location-specific range of positive externalities

Table 27 | Valuation seagrass studies. Source: Dewsbury (2016).

Mangrove Economic Valuation

International discussions have focused on mangrove conservation due to the services provided by mangroves and the alarming rate of their loss and degradation. Economic valuation of mangroves has increased in the last 10 years. As shown in Table 28 below, the major percentage of the value is associated with regulating services. In 2020, the provision services are most important followed by the cultural services. There are few studies of mangrove ecosystems in the Caribbean. Here we present some of the values for different services as a reference for the benefits (Himes-Cornell et al. 2018).

Ecosystem Service	Type of Values	Values USD per ha per yr	Studies
Food	Benefit transfer	$5.75	(Witt, 2016)
		$577-980.18	(Burgess et al., 2015)
		$797	(Gunawardena, 2009)
		$1,225	(Mendoza-Gonzalez et al., 2012)
		$8,700	(Souza and Silva, 2011)
		$23,613	(Mubarak Bin Daina et al., 2015)
	Production function	$52-105	(Islam and Ikejima, 2010)
		$18,849	(Vazquez-Gonzalez et al., 2015),
		$126,444	(Pascal and Bulu, 2013)
	Market price	$37	(Malik et al., 2015a)
		$48.80	(Hoberg, 2011)
		$238	(Huxham et al., 2015)
		$385-419	(Kuenzer and Tuan, 2013)
		$560.55	(Otieno, 2015)
Erosion prevention	Benefit transfer	$38.25	(Janekarnkij, 2010)
		$1,200	(Ullah et al., 2010)
		$1,340.60	(Interwies and Gorlitz, 2013
	Market price	$395	(Huxham et al., 2015)
		$660	(Quoc Vo et al., 2015)
		$3,896	(Kuenzer and Tuan, 2013)
Moderation of extreme events	Benefit transfer	$16	(Janekarnkij, 2010)
		$40	(Ullah et al., 2010)
		$639.35	(Emerton and Aung, 2013)
		$1,340	(Interwies and Gorlitz, 2013)
		$1,356.66-1,631	(Burgess et al., 2015)
		$3,116	(Mubarak Bin Daina et al., 2015)
	Replacement cost	$35	(Huxham et al., 2015)
		$660	(Quoc Vo et al., 2015)
Water	Benefit transfer	$212	(Ayanlade and Proske, 2015)
		$1,385-6,716	(Mubarak Bin Daina et al., 2015)
Raw Material	Benefit transfer	$1.45	(Mendoza-Gonzalez et al., 2012)
		$110	(Ullah et al., 2010)
		$212	(Ayanlade and Proske, 2015)
	Production function	$151	(Witt, 2016),
		$5,100	(Christensen et al., 2008
		$1,336-9201	(Kallesoe et al., 2008)
		$39,233	(Pascal and Bulu, 2013)
	Market price	$12	(Malik et al., 2015b)
		$41.54	(Otieno, 2015)
		$206	(Huxham et al., 2015)
		$2,040	(Vo, 2013)
		$30.80	(Interwies and Gorlitz, 2013)
		$694-3,767	(Malik et al., 2015b
		$1,879	(Barbier, 2012b)
	Avoided cost	$91.70	(Hoberg, 2011)
Maintenance of soil fertility and nutrient cycling	Benefit transfer	$640	(Khaleel, 2012; Ullah et al., 2010)
Regulation of water flows	Benefit transfer	$540	(Ullah et al., 2010)
		$660	(Khaleel, 2012)
Maintenance of genetic diversity	Benefit transfer	$2.43	(Witt, 2016)
		$5	(Hoberg, 2011)
		$19	(Samonte-Tan et al., 2007)
		$100	(Ullah et al., 2010
Maintenance of life cycles of migratory species	Benefit transfer	$117.14	(Janekarnkij, 2010)
		$243	(Samonte-Tan et al., 2007)
		$249	(Barbier, 2012b)

Table 28 | Valuation studies of mangroves. Source: Himes-Cornell et al. (2018).

Coral Reef Economic Valuation

Coral reef tourism generates value for the national economies of the Caribbean region. The study by Burke and Maidens (2004) presents that the annual net benefits for fisheries, shoreline protection and diver tourism sum US$3.11-4.61 billion, tourism contributing 45.55-67.52%. The benefits of tourism, fisheries and coastal protection are broken down by country in Table 29 below.

A recent 2017 report (Figure 34) presents the value of coral reefs in the Mesoamerican region. The economic revenues are US$6.647 million per annum (in 2017 prices) and 70% of the returns are from tourism (UN Environment et al. 2018).

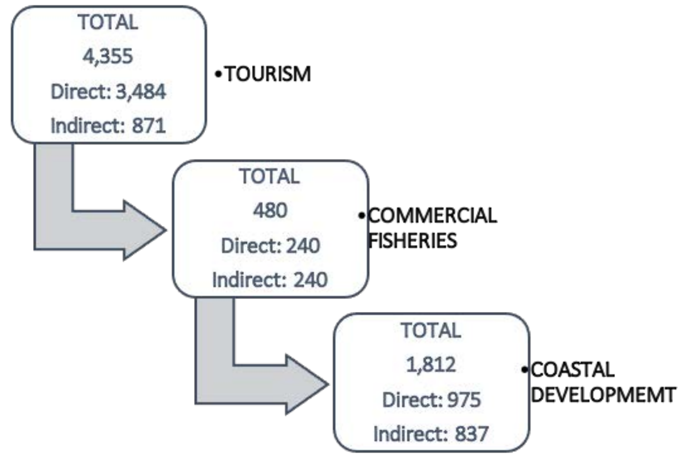


Fig. 34 | (Right) Revenues from coral reefs in the Mesoamerican Barrier (US$ million, 2017 prices). Source: UN Environment et al. (2018).

Ecosystem Protection Values	Tourism ($US millions)	Fisheries ($US millions)	Coastal Protection ($US millions)
Belize: Coral Reefs and Mangroves (2007 prices)	176-264.6	14.2-15.9	231-347
Jamaica (2011 prices)	5,000	33.1	
Tobago (2006 prices)	114.1-174.6	0.76-1.14	18-33
St. Lucia (2005 prices)	213.8-305	0.67-1.63	28-50
Dominican Republic (2009 prices)			52-100
Bonaire (2012 prices)	125		Short-term: 0.033 Long-term: 0.07
Wider Caribbean	93		

Table 29 | Tourism, fisheries, and coastal protection values (Annual US$ million). Source: Based on WRI (2009).

Environmental, Health, and Economic Outcomes

During the development of a project, a set of conditions or impacts to evaluate will be identified in different outcomes: ecosystem health, impacts of human health, economics, and social impacts caused by intervention. These criteria will serve as "measures of success." Multilateral agencies, donors, conservation NGOs, and multilateral banks are in favor of evidence-based interventions and recognize the challenge of measuring the impacts. The main reasons to do this are described as follows (IDB 2018):

- It is important to identify if the intervention succeeds or fails and the causes. There is a need for more knowledge of the links of the intervention, the biophysical changes and the outcomes on health of the ecosystem, and the socioeconomic impacts and the contribution to well-being.
- The conservation community needs evidence, transparency, and accountability to demonstrate to the financial community and donors the returns on conservation investment.
- There is a need to learn how to design cost effective interventions to demonstrate that conservation projects achieved the outcomes proposed.
- The conservation community and donors have emphasized the effect of conservation intervention on the improvement of ecosystem services and social outcomes.

Evidence based interventions and their impact evaluation in conservation and restoration projects remain scarce. This scarcity can be explained due to: a) a selection bias of locations not randomly selected because of association with conservation and sustainable management projects; b) the availability of historical data and a baseline of the biophysical status of the ecosystem service; c) the understanding of the need of a contrafactual evaluation of interventions remains limited at best; d) to carry out an evaluation when an external factor is affecting (e.g. climate change events); and, e) understanding the interaction between natural and social systems in evaluation frameworks is complicated

Maldonado et al. (2020) reviewed 51 impact evaluations that encompassed conservation policies, projects, or interventions with environmental and/or socioeconomic outcomes. The review showed that 43% of the studies focused on biophysical outcomes. Biophysical evidence is important and there is a need to capture other outcomes such as welfare impacts. Examples of socioeconomic indicators are fishing income and net earnings from commercial fisheries, economic growth, and food security, as well as health and mortality rates.

To obtain the benefits of a natural infrastructure project, it is important to take into account that projects face a number of challenges associated with the ecological production function, such as the effects from climate change.

There is a need for more knowledge of the linkages between the changes in the ecosystem structure and the production of valuable ecosystems (Barbier 2013). An ecological production function establishes a relationship between ecosystem services (products) and changes in the ecological structure (inputs), which result from an intervention to ecosystems. The main challenge associated with ecological production functions is to have accurate and reliable information to establish this relationship.

There are modelling tools that are useful to identify ecosystem services in relation to changes in ecosystem structure. InVEST identifies the ecological functions provided by ecosystems (supply), then links these functions to the demand, considering the beneficiaries of the ecosystem services (service), and finally includes social preferences to calculate the economic and social metrics (value) (Sharp et al. 2018).

Finally, it is important to take into account the economic impacts of pollution on coastal and marine ecosystems, livelihoods, and human health. By internalizing the direct and indirect costs of pollution, and by better valuing all the goods and services from ecosystems, it would justify, for example, an investment in a sewage treatment system along with a habitat restoration intervention as the benefits from these interventions may be greater than the individual costs of doing both actions.

Links to Global Goals

The services provided by coastal and marine ecosystems reviewed in the previous section are important to reach global and regional development goals.

This report aims to advance efforts on the international agenda, such as the Decade of Restoration (2021-2030) (UNGA resolution A/RES/73/284), which calls for the restoration of degraded and destroyed ecosystems to combat the climate crisis and improve food security, water supply, and biodiversity; the Sustainable Development Goals (SDGs) [UNGA resolution A/RES/70/1], especially SDGs 6, 13, 14, 15; the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Target (CBD 2010).

It is noted that all these instruments are mutually supportive and reinforcing, and the implementation of one contributes to the achievement of the others. Furthermore, the results support the objectives of the SPAW Protocol which has highlighted the need for habitat restoration.

Therefore, it is not surprising that several agreements and international initiatives have already reflected them, directly or indirectly, in their action plans or goals. This section will look at three key initiatives that include them: 1) the United Nations' Sustainable Development Goals (SDGs), 2) the Aichi Targets on the Convention of Biological Diversity, and 3), the Paris Agreement's National Determined Contributions (NDCs).

This section connects what is clear from the previous analysis, which is that ecosystem services have an economic value, expressible in monetary terms, with the other dimensions in which this value can be measured, for example in health, nutrition, and poverty reduction outcomes, or in tonnes of carbon not emitted, or units of climate risk reduction--all of which are dimensions in which the goals of these agreements and initiatives are measured.

Sustainable Development Goals

The United Nations 2030 Agenda for Sustainable Development is a commitment to eradicate multidimensional poverty and achieve sustainable development by 2030, ensuring that no one is left behind regarding the encompassing 17 Sustainable Development Goals (SDGs) and their 169 specific targets (UN 2016). The one most directly relevant, SDG-14 or "Life Under Water", aims to conserve, sustainably manage, and protect marine and coastal ecosystems from pollution, as well as address the effects of ocean acidification (UN 2016). Our argument is that in order to support the implementation of the SDG14, it is necessary to link ecosystem services conservation to long-term sustainability. The local and immediate improvement of human well-being within the carrying capacity of the biophysical system must be preserved (UN 2016).

The economic valuation of ecosystem services sheds light on the direct economic benefits of conservation and restoration investments, which are needed to achieve the implementation of the SDG goals. Without the quantification of the economic value of marine ecosystems it would be more difficult for coastal communities to be financially rewarded for their efforts towards the sustainable management and conservation of ecosystems (Rustomjee 2016). Table 30 presents the relationships between SDG and coastal ecosystem services provided by seagrasses, mangroves, and coral reefs, and how its implementation would help the conservation of each.

The following table presents the key SDG14 targets and summarizes the links that can be made between them and the conservation and restoration of the key ecosystems we are focusing on in this report. The services these ecosystems provide to the communities and economic activities are fundamental to their well-being and productivity both in the short and long run. In a sense, these can become the specific agenda to achieve those targets. Different countries would face different challenges and have different priorities, but in general, all these aspects need to be covered in all regions to address what is essentially the global marine commons, and the interconnected coastal ecosystems and communities.

The issues these targets cover span the Climate Change agenda, as well as the Biodiversity Conservation and Sustainable Use agenda. For example, Target 14.3, which aims to minimize and address the impacts of ocean acidification, recognizes the role that mangrove forests and seagrass meadows have as blue carbon sinks and storage sites. Target 14.4 aims to end destructive fishing practices, overfishing and illegal, unreported and unregulated fishing. This has a connection with the SDGs on nutrition and rule of law, as well as those that preserve economic activities and conserve biodiversity and life underwater.

Targets	***Link to Ecosystem Services***
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.	• Effective management of terrestrial ecosystems, particularly agroecosystems, is critical to minimizing nutrient losses to marine ecosystems and negative impacts on the marine environment and its resources. • Addressing pollution of coastal areas and marine resources can curb its negative impacts on health and well-being. Control, prevent, and reduce pollution from both land and marine-based sources. • Recognizing the value of regulating ES that mangroves and seagrasses have to protect water quality filtering waste trapping sediments and retaining excess nutrients and other pollutants such as heavy metals that may otherwise end up in the sea, will be key for investment in the conservation of ES.
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.	• Without integrated management of all the marine and coastal pressures, damage will be done to coastal ecosystems and their resilience will be reduced. • Ecosystem-based management aims to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans need. The approach considers the cumulative impacts of different sectors. • Restoration of mangroves, corals and seagrasses is becoming regarded as a major strategy for increasing the provision of ecosystem services as well as reversing biodiversity losses. Targeting ES in isolation will not be effective. The effectiveness of restoration has to ensure biodiversity and multiple services are enhanced and the needs of different stakeholders are met. Such approaches must be implemented if global restoration targets are to be achieved.
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.	• Carbon emission reductions are needed for mitigation. The ocean has the capacity to regulate climate. • Blue Carbon defines that coastal ecosystems such as mangroves, tidal marshes and seagrass meadows sequester and store more carbon than terrestrial forests and are recognized for their role in mitigating climate change. • Dedicated conservation efforts can ensure that ES of coastal ecosystems mangroves and seagrass continue to play their role as long-term carbon sinks, ensuring that no new emissions arise from their loss and degradation, while stimulating new carbon sequestration through the restoration of previously carbon-rich coastal habitats.
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time possible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.	• There is a need to have an ecosystem approach to fisheries to integrate exploitation and conservation in terms of the technical interactions (e.g. bycatch in mixed species fisheries) and the biological interactions (e.g. predator-prey relationships) should be integrated when providing advice on fisheries stock. • Conservation and restoration of provisioning and regulation services of mangroves, seagrass and corals as being areas for catch of fish and shellfish for fishers. They serve as nursery, breeding and feeding areas for many living organisms, both of direct commercial importance as well as indirect value. Intergenerational equity and the recognition of the intrinsic value of biodiversity are relevant for this target as well.
14.5 By 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.	• Marine Protected Areas contribute critically to the recovery, protection and increased productivity of marine ecosystems and the resultant goods and services conservation for human well-being. • Efforts to ensure effective and equitable management, and to protect a wider variety of species and ecosystems are needed.
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral	• Subsidies can lead to prices not reflecting environmental and social costs. • The key economic incentive mechanism for climate, carbon pricing is economically easier to design and implement that capturing future value of preserved natural ocean capital.

part of the World Trade Organization fisheries subsidies negotiation.	
14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.	• The ocean and coastal ecosystems are extremely important in terms of ecosystem services and their economic values. • Expansion in traditional and emerging ocean-based economic activities can help boost employment (e.g. in offshore wind energy, marine aquaculture, fish processing and port activities). • ODA to sustainable fisheries, aquaculture and tourism as well as ocean conservation and sustainable use.
14.A Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.	• Improving ocean health will improve ES quality and economic values.
14.B Provide access for small-scale artisanal fishers to marine resources and markets.	• Improve in the quality of ecosystem services and its conservation will provide small-scale fishers value in seafood value chains.
14.C Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want.	• Conservation of the ES by law enforcement.

Table 30 | SDG 14 targets and links to ecosystem services. Source: Adapted with information from OECD (2020), UN.

In Table 30, SDG 14.5 makes explicit a target for conservation of coastal and marine areas, while 14.6 goes to the economic root cause of much of the overexploitation, the “race to the bottom” of fisheries’ subsidies. The importance of having an income-generating marine ecosystem is clear in SDG 14.7, where the focus is on small island states and least developed countries, emphasizes productive ecosystems as integral part of human well-being. Among the tools, scientific research and smart enforcement of regulations are key for success.

The results of achieving SDG 14 are connected to other sustainable development goals. For example, by having healthy seagrasses, mangroves, and coral reefs, ecosystem productivity is higher, and the corresponding income contributes to the alleviation of income poverty. This is linked to both SDGs 1 and 2. Reducing poverty, in its multiple dimensions, requires sustainable economic growth. Improving human well-being, as described in the SDG3 and SDG6 for coastal communities necessarily involves maintaining ecosystem services in the areas where they live and work (Le Blanca, Freire, and Vierros 2017).

Convention on Biological Diversity (CBD)

In recognition that the condition of biodiversity is affected by a diversity of pressures and drivers that must be responded to with different policy instruments, the CBD adopted a Strategic Plan on Biodiversity that included 20 Aichi Targets 2011-2020 (CBD 2010).

The targets were designed to have a better understanding and predict biodiversity dynamics such as how biological diversity reinforces ecosystem function, and how the provision of ecosystem services is essential for human well-being. The ultimate benefits will be for local livelihoods and economic development, and is essential for biodiversity maintenance and poverty reduction (Shepherd et al. 2016, Tittensor et al. 2010).

AICHI TARGET	***Link to SDG 14***
Target 2 2 By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	14.4, 14.7
Target 3 By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio-economic conditions.	14.4,14.6

Target 4 By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	14.4, 14.6 14.7
Target 5 By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible, brought close to zero, and degradation and fragmentation is significantly reduced.	14.5
Target 6 By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	14.2,14.4, 14.7
Target 7 By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	14.4, 14.7
Target 8 By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	14.1
Target 10 By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	14.3
Target 11 By 2020, at least 17 percent of terrestrial and inland water, and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.	14.2, 14.5
Target 12 By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	14.4
Target 14 By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	14.7
Target 15 By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 percent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	14.2
Target 17 By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	14.7
Target 19 By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	14.3,14.4

Table 31 | The relationship between the Aichi Targets 2011-2020 and SDG 14. Source: UN (2020).

Climate Change Commitments

The Paris Agreement is at the center of the global response to climate change with the aim of keeping global warming to below 2°C and supporting the efforts of all countries to limit it to 1.5°C. (UN 2015). All the Parties to the Agreement are required to put forth their best efforts through the National Determined Contributions (NDC) and are asked to frequently assess their collective progress towards achieving the global goals (Doyle, A. 2019). Despite the recognition by the scientific community that the ocean, marine, and coastal ecosystems play a fundamental role in regulating climate, acting as critical carbon sinks, they had been largely left of Conference of the Parties (COP) negotiations. It was not until the Paris meeting that the global ocean began to receive the attention it deserved (Gallo et al. 2017).

Nearly 70% of NDCs in 2016 included some mention of marine issues but were exclusively focused on climate change impacts and the adaptation needs in coastal areas. Most parties paid no attention to the ocean in their NDC's mitigation efforts, even those with very large Exclusive Economic Zones (EEZs) such as Australia, Brazil, the European Union, Micronesia, New Zealand, Norway, the Russian Federation and the United States of America (Gallo et al. 2017).

In the marine-focused sections of NDCs, the current main concerns are coastal impacts, ocean warming impacts, and fisheries changes. Most NDCs include them among general adaptation needs, while some do provide specific plans to address these impacts.

- Mangrove conservation, restoration, and management plans are included in 45 NDCs, and are included in both mitigation and adaptation sections.
- Coral reefs are included in 28 NDCs but are typically included as adaptation components (Gallo et al. 2017).

As mentioned in the previous sections, the ecosystem services afforded by seagrasses, mangroves, and coral reefs are important to sustain the negative impacts from climate change in terms of shoreline protection. The *blue carbon* mitigation contributions that are presented in the NDC encompass carbon storage and the protection, restoration, and management of seagrasses, mangroves, and salt marshes.

A recent study led by The High-Level Panel for a Sustainable Ocean Economy showed that ocean-based mitigation options (Figure 35) have the potential to reduce the emissions gap in 2050 by up to 21% on a 1.5°C pathway and by approximately 25% on a 2°C degree pathway (Hoegh-Guldberg et al. 2019a). Ocean-based opportunities could reduce approximately 4 billion tonnes of carbon dioxide equivalent by 2030, and more than 11 billion tonnes by 2050 (Hoegh-Guldberg et al. 2019b).

As highlighted in the report, there is substantial mitigation potential in nature based solutions that include the blue carbon services of seagrasses and mangroves. Protecting coastal areas will play a key role preserving the ecosystem services for shoreline protection from storms, nurseries for fish that increase food security provide biodiversity benefits for coastal communities. In the short term, it is imperative

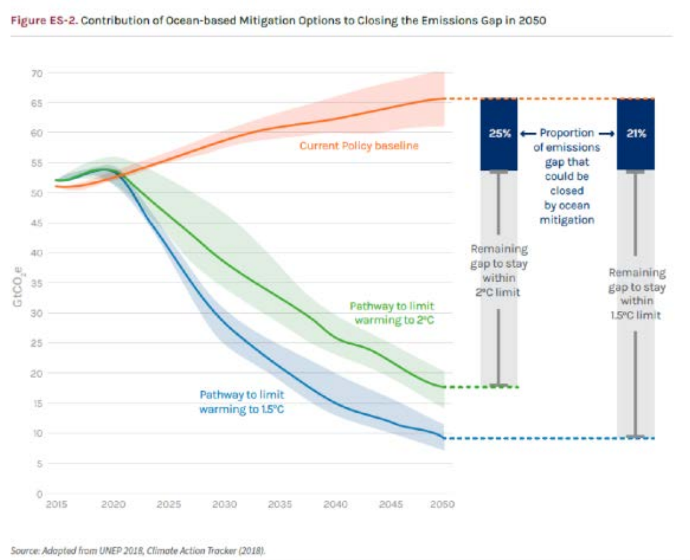


Fig. 35 | Contribution of Ocean-based Mitigation Options to Closing the Emissions Gap in 2050. Source: UNEP Climate Action Tracker (2018).

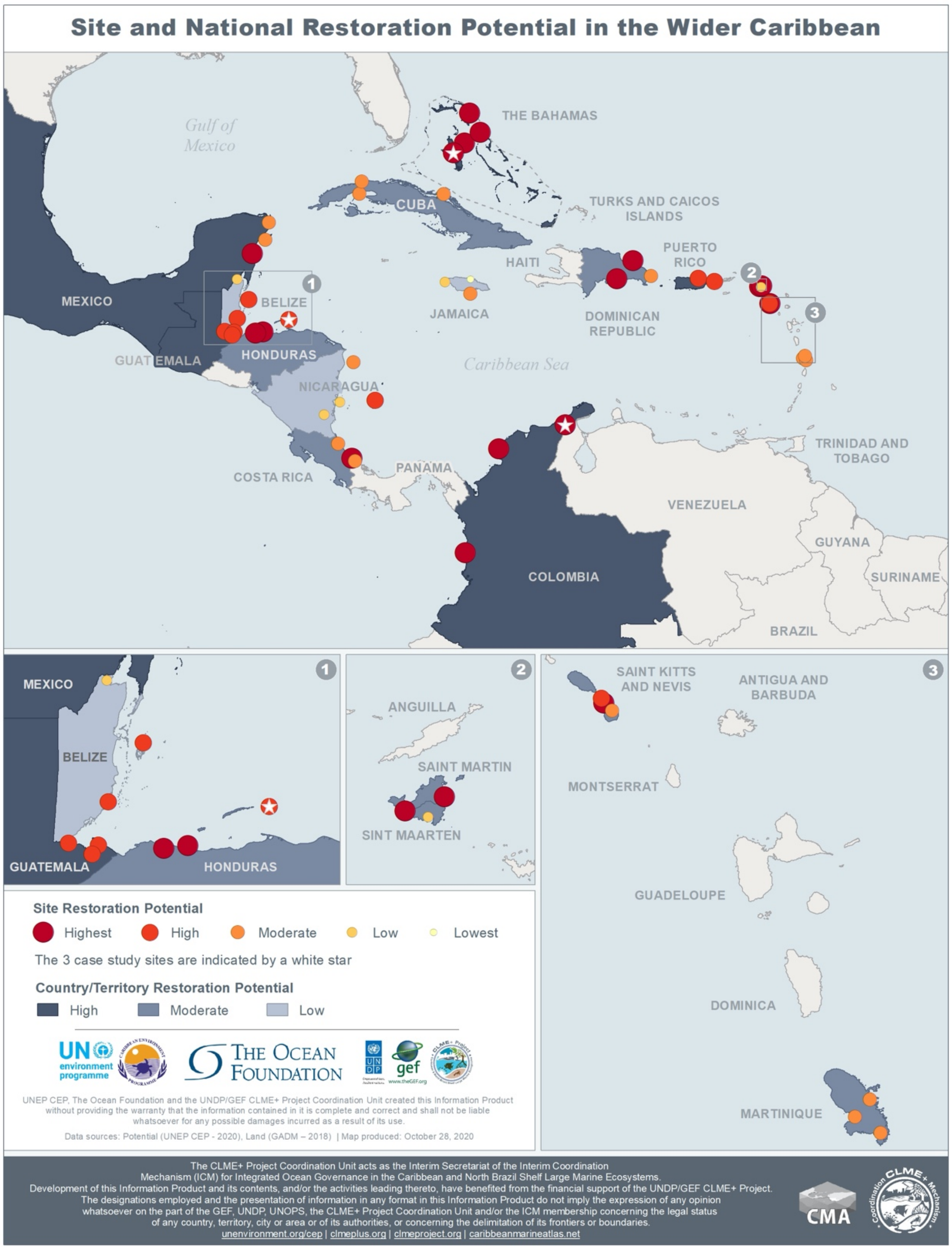
to focus on the conservation of marine ecosystems to prevent the release of the carbon that is sequestered and stored in the biomass and underlying sediments.

During COP 26, countries will have to submit and update their NDCs if we are to close the emissions gap by aligning the efforts to the Paris Agreement goals. Including these ocean-based actions as part of a county's NDCs is an opportunity to set quantifiable targets, including policies or measures to conserve and restore blue carbon ecosystems (including seagrasses and mangroves) and capture their climate change mitigation benefit in national GHG inventories.

These options have links with other global commitments and agreements that can capitalize on the co-benefits associated with these ecosystems, including new jobs in ocean-based industries, gains from innovation, increases in revenues and profits to firms, alternative livelihoods for local communities, improvements in human health, and contributions towards global food security targets--all of this with the potential to ensure greater gender parity as ocean-based industries expand. The key element of the strategy now is to ensure that NDCs are updated and expanded to take into consideration the ocean, both as a source of low-cost, high-efficiency mitigation options, and as a focus of adaptation investment. The multiple co-benefits for the Sustainable Development Goals need to be identified, quantified, and highlighted for local policy action. Research centers, private sector partnerships, and civil society organizations must form coalitions to help governments both identify and seize these opportunities.

Case Studies: Applying Blended Finance Models to Large Scale Habitat Restoration and Pollution Reduction Projects in the CLME+ Region

As discussed in Part I, our scorecard system allowed us to identify a number of “priority sites” throughout the CLME+ Region. The top sites for the countries we examined represent a balance of feasibility and need in the context of broader country and stakeholder-specific goals. In this final section, we explore three of the sites as case studies designed to illuminate different environmental and socio-political conditions and the respective blended finance strategies that could be employed in the development of new habitat restoration and pollution reduction projects. While these sites did not necessarily score the highest among all sites that we considered, we selected these three sites to serve as models for different types of interventions and make our analysis more representative of the region as a whole. Building on the ecosystem valuation literature cited previously, we provide a list of challenges, goals, key stakeholders, potential interventions, and corresponding blended finance elements that can support the design and implementation of seascape-focused habitat restoration and pollution reduction projects in these areas. The map below includes all prioritized sites with the case study sites indicated by “starred circles” (Appendix C).



Site #1: Guanaja, Honduras

Background
At over 1,000 km in length, the Mesoamerican Reef (MAR) system is the second largest barrier reef in the world. While not as large as the Great Barrier Reef, it runs the coastlines of four different countries, Mexico, Belize, Guatemala, and Honduras; and, as a result shares many jurisdictional challenges. In addition, the reef faces considerable natural and anthropogenic threats including hurricanes, mass tourism, overfishing, and pollution. Its corals have suffered considerably as evidenced by a recent overall reduction in its coral health score by the Healthy Reefs monitoring program.

The Bay Islands represent Honduras' segment of the MAR. Located under 50 km from the Honduran coastline, they host large populations of marine organisms and tracts of coral, mangrove and seagrass beds. Guanaja island is the bay island furthest from the mainland but also the most densely populated, leading to considerably more impacts on its coastal habitats.

Scores for Guanaja using the methodology presented in Part I of this report are as follows:

Guanaja, Bay Islands, Honduras
Structure: 13
Function: 14
Ecosystem Services: 16
Feasibility: 15
Threat Abatement: 12
TOTAL: 79

Status of Seagrasses
The seagrasses of Guanaja have received less monitoring and scientific studies than the mangroves and coral reefs, thus little is known about their current extent or condition. *Thalassia testudinum* and *Syringodium filiform* are the dominant species. Previous studies by USGS after Hurricane Mitch suggest some areas were affected by scouring due to wave action, particularly in the Northern part of the island near Mangrove Bight which was hit hard by the Hurricane. USGS estimated 923 ha of seagrass (See reports by USGS 2002), although a more recent habitat mapping effort by Purkis (2016) has more recent seagrass estimates.

Status of Mangroves
Mangrove forests are found in low-lying coastal areas of Guanaja, such as Mangrove Bight and North-east Bight on the north shore (~ 190 ha) (Cahoon et al. 2003) and Savannah Bight, El Pelican, Airport, and West End South. In October 1998, Hurricane Mitch, a Category 5 hurricane, devastated mangroves on the island, particularly on the North End. Prior to Hurricane Mitch, Guanaja had about 311 ha of mangrove forests of which only 11 ha (3%) survived post hurricane. Red mangroves (Rhizophora mangle) dominate, with some black mangrove (Avicennia germinans), and fewer white mangrove (Laguncularia racemosa), and buttonwood (Conocarpus erectus) (Cahoon et al. 2003). Recovery of mangroves has been studied by USGS (2002), Cahoon et al. (2003), and Fickert (2018). Some natural regeneration has occurred, but issues of regeneration may be due to several factors such as loss of sediment elevation when the initial 1998 tree mortality occurred. Fickert (2018) reviews natural mangrove regeneration and reasons behind low success of restoration efforts.

Fig. 36 | Guanaja Island. Coral reef habitat indicated in pink, mangrove habitat indicated in brown, and seagrass habitat indicated in green. Source: Patricia Kramer (2020).

Status of Coral Reefs
The Healthy Reefs Initiative has monitored the coral reefs in Honduras since 2006. In 2018, 23 sites were again monitored and revealed the overall Reef Health Index in Guanaja (combination of coral cover, fleshy macroalgae, herbivorous fish and commercial fish) was 2.5 or a grade of "Poor" overall health and has declined since 2016 (McField et al. 2020). Taking a closer look shows that corals, the major architects of reef structure and shoreline protection, were in "Good" condition with an average of 26% coral cover (range 14-45% cover) in 2018. Two of the reef survey sites had coral cover in "Very good" condition, 8 in "Good" condition, 3 in "Fair", and no reefs in "Poor" or "Critical" coral condition. However, overabundant fleshy macroalgae is a threat to corals as it can overgrow or kill corals and the overall score is "Poor" (avg. 23% fleshy macroalgal cover). No sites had scores of good or very good due to the high abundance of fleshy macroalgae, yet 5 reef sites had "Critical" scores, 4 had "Poor" and 3 had "Fair".

Fleshy macroalgae cover may be high partially because of poor nearshore water quality due to nutrient enriched water related to sewage or agricultural runoff or low abundance of herbivores such as urchins and fish. When abundant, herbivorous fish like parrotfish and surgeonfish graze fleshy macroalgae and keep it in check. Herbivorous fish populations scored “Fair” (2,381 g/100 m^2), with 1 reef site scoring “Very Good”, 2 “Good”, 3 “Fair”, 6 “Poor” and 1 “Critical”.

While there are management measures in place in the Bay Islands to protect herbivorous fish, illegal fishing and overfishing is a problem. Commercially important fish like groupers and snappers are being overharvested and scored “Critical” (281 g/100 m^2), with no reef sites scoring Very Good or Good, only 1 reef site scoring “Fair”, 2 Poor and 10 Critical. Commercial, industrial, and local fishermen have overfished Guanaja, a main port for industrial fishing boats, for decades without strict regulations. Fishing pressure and illegal fishing has increased, even within the no-take zones. There are 6 verified fish spawning aggregations (FSA) in Honduras, but only 4 are protected. One FSA in Caldera del Diablo, Guanaja has been reported with at least 4 grouper species (*E. striatus* and 3 species of *Myceroptera*), but it still may not still be viable. There is a fishing ban regulation on Nassau Grouper from December 1st to March 31st, although illegal fishing still occurs.

Recent Extreme Weather Events

In November 2020, two catastrophic, back-to-back Category 4 hurricanes, Eta and Iota, made landfall in Central America, likely causing greater devastation than Hurricane Mitch in 1998. The mainland of Honduras suffered some of the most severe damage in the region due to landslides and flooding created by intense rainfall when the hurricanes slowed over the country. The Bay Islands were less affected by hurricanes Eta and Iota, with only minor flooding and beach erosion along some coastal beaches. Earlier in the season, Honduras’ disaster agency, Comision Permanente de Contingencias (COPECO), reported Hurricane Nana (Sept. 2-3) passed along the Bay Islands causing some flooding and minor landslides on the island of Roatan. Healthy, intact mangrove and coral reef habitats are important in reducing wave energy and preventing coastal erosion from moderate and severe hurricanes.

Key Goals, Challenges, and Stakeholders for Guanaja, Honduras
A group of habitat restoration and pollution reduction experts identified key goals, challenges, and stakeholders for Guanaja in consultation with key local actors and organizations and through a review of relevant literature.

Key Goals, Challenges, and Stakeholders for Guanaja, Honduras
Key Goals
• Establish an urban wastewater treatment program to improve water quality • Improve enforcement of existing fishing regulations and education to help increase fish populations, particularly herbivorous and commercial important fish • Improve coastal zone management to reduce upland impacts (sedimentation, pollutants), continue community and education programs; and expand reef and water quality monitoring • Share knowledge, techniques and lessons learned with other Bay Islands (Utila, Roatan, Cayos Cochinos) • Restore the ecosystem in areas affected by hurricanes, habitat degradation, tourism, waste disposal and plastic pollution. • Promote protection, education and sustainable management of the seagrass, coral and mangrove ecosystems • Boost multi-stakeholder partnerships for biodiversity conservation
Key Challenges
• There is a large population and extensive urban development for the size of the island. • Diffuse environmental legislation. • Lack of a sector analysis. • Scattered information on habitat type and extent. • Lack of existing environmental indicators. • In 1998, Hurricane Mitch destroyed the extensive mangrove forests, which is critical in supporting fisheries and other wildlife, protecting nearshore seagrass and coral reefs, and providing shoreline protection to the island community. • Guanaja is an industrial fishing hub, which brings in a significant amount of income and livelihoods, but overfishing and unsustainable practices have caused a decline in fish populations and food for communities. Sustainable use of fisheries depends upon improving community knowledge, increasing compliance and implementing enforcement of regulations. • Lack of political support for implementing coastal zone management and sustainable fisheries.   ○ Outreach to the fishing community on sustainable management of resources**.** Specifically, **i**llegal fishing and aggressive practices in insular ecosystems lead to overexploitation and environmental deterioration • Implementation mangrove restoration actions that are NOT related to the construction or maintenance of nurseries. • Lack of sewage and solid waste treatment, thus there is an urgent need to install sewage treatment facilities and programs to minimize solid waste impacts. • Economy was impacted by Hurricane Mitch in 1998. Tourism exists, but is not as developed as Roatan or Utila, thus the economic situation in Guanaja has resulted in poverty and lack of commitment to infrastructure development.
Key Stakeholders
• National Water Authority (Autoridad Nacional de Agua) • SANAA (Servicio Autonomo Nacional de Acueductos y Alcantarillados) • CONASA (Consejo Nacional de Agua Potable y Saneamiento) • ERSAPS (Ente Regulador de los Servicios de Agua Potable y Saneamiento) • Bay Islands Conservation Association - Utila (BICA -Utila) • Islas de la Bahía Foundation (Iguana Station)

- Whale Shark & Oceanic Research Center
- Center for Marine Ecology (Utila Ecology)
- Utila Dive Safety & Environmental Council (UDSEC)
- The Nature Conservancy (TNC)
- Municipality of Utila
- Port Captain
- Civil Society
- Local communities
- Ex-patriots
- Tourists/visitors from Honduran mainland
- Tourists/visitors from outside of Honduras (tourism is based primarily on snorkel, dive and sailing community)
- Local municipalities and national government
- Local and international non-governmental organizations
  - Ministry of environment and sustainable development
  - Cuerpos de Conservación Omoa (NGO)
  - Secretaría de Recursos Naturales y Ambiente (SERNA)
  - ProTECTOR, an organization dedicated to protecting the turtle in Honduras
  - FAO, UNDP Fisheries Management with an ecosystem approach
  - Biodiversity Partnership Mesoamerica (BMP)

Historic and Current Work at Guanaja

There are several funders, organizations, programs, and financing mechanisms operating at the site.

Major Funders and Organizations:

- Islas de la Bahía Foundation (Iguana Station).
- Whale Shark & Oceanic Research Center, Center for Marine Ecology (Utila Ecology).
- Utila Dive Safety & Environmental Council (UDSEC).
- The Nature Conservancy (TNC).
- Municipality of Utila.
- Port Captain.
- Civil Society.
- Mesoamerican Reef Fund (which has various donors and partnerships) (MAR Fund) supports several Regional Networks including: Mangrove and Seagrass Network, Sustainable Fisheries Network of the MAR, the MAR Reef Restoration Network, and the Fish Spawning Aggregation Network, as well as the MAR Leadership program which provides leadership trainings for conservation in the MAR. They support several grant programs to improve conservation in the region.
- Healthy Reefs Initiative is a collaborative effort of over 70 groups dedicated to the scientific monitoring, reporting and conservation of the MAR and produces Coral Reef Report Cards and Eco Audits of management effectiveness. They have collected coral reef monitoring data since 2006.
- Integrated Ridge to Reef Management of the Mesoamerican Reef Ecoregion (MAR2R) Project.
- BICA - Guanaja Mangrove Restoration Project - The project is an initiative of the Bay Islands Conservation Association Guanaja (BICA Guanaja) and is a multi-year restoration effort to plant 400,000 mangroves to restore a self-sustaining healthy forest on Guanaja Island, Honduras (with funding historically from The Ocean Foundation). Activities include on-the-ground planting, monitoring, and education.
- The Coral Reef Alliance (CORAL) provides assistance to improve sustainable tourism as well as improving community livelihoods, such as the Association of Artisans of Roatán, Utila, and Guanaja.
- AGRRA (Atlantic & Gulf Rapid Reef Assessment Program) has collaborated with Healthy Reefs Initiative for >15 years to provide increased science and technical support to marine managers and develop new online education, management and communication tools.
- Department for International Development (DFID) through World Wildlife Fund (WWF - climate change study done for Utila/Cayos Cochinos available at http://awsassets.panda.org/downloads/honduras_cc_assesment_final.pdf.
- Fish for Change uses fly-fishing as a platform for education and community involvement including planting over 500,000 mangrove seeds and building a recycling/trash system for Mangrove Bight.
- Dunbar Rock is a resort on Guanaja that has supported installation of mooring systems and a hyperbaric dive chamber to support the community https://www.dunbarrock.com/portfolio/about-us/.
- Cuerpos de Conservación Omoa is an NGO dedicated to conservation and restoration of mangroves since 2011 with multiple low budget restoration projects.
- Fundación Chito y Nena Kafie initiative focuses on the restoration of corals.

There are many low-budget projects that are in place in Honduras to protect the environment that could be subsidized:

- Mi Playa Limpia 2019.
- "Pro Rio Motagua" project in coordination with World Vision Honduras and the National Autonomous Service of Aqueducts and Sewers (SANAA).
- Sustainable Rational Use of Firewood to promote and articulate actions that promote the reduction of firewood consumption and deforestation.
- Motagua River, as part of the Playas Limpias Guatemala-Honduras program.

Alignment With Other Initiatives / Programs:

- Contracting Party to the Cartagena Convention and all of its protocols.
- In 2000, the Honduras national government signed the Millennium Declaration together with 189 nations.
- In 2000, the government adopted as a long-term commitment The Strategy for the Reduction of Poverty (ERP), an instrument for social and economic development with a gender perspective, which has the consensus of Civil Society and the Community International. In this strategy, goals are established to achieve 95% coverage in drinking water and sanitation by 2015.
- In 2003, the Framework Law for the Potable Water and Sanitation Sector was promulgated, an instrument that stipulates a new institutional framework with separation of the functions of planning, operation and regulation of services, consistent with the State's decentralization policies. The Law created the National Council of Water and Sanitation (CONASA).
- National Compliance Strategy for Environmental Legislation in Honduras within the framework of the Free Trade Agreement between Central America and the United States of America and the Dominican Republic (CAFTA).
- National Sustainable Tourism Strategy (ENTS).
- SINAPH Strategic Plan 2010-2020.
- National Biodiversity Strategy.
- National Forest, Protected Areas and Wildlife Program (PRONAFOR) Honduras 2010-2030.
- CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).
- Convention for the Conservation of Biodiversity and Protection of Priority Wilderness Areas in Central America.
- United Nations Framework Convention on Climate Change.
- Regional Agreement for the Management and Conservation of Natural Forest Ecosystems and the Development of Forest Plantations in Central America.
- United Nations Convention on the Law of the Sea.
- Framework Convention on Climate Change.
- RAMSAR Convention.
- Convention 169 on Indigenous and Tribal Peoples of Independent Countries.
- Convention for the Protection of the World Cultural and Natural Heritage.
- Honduras is part of the Tulum Agreement (1997), an agreement signed by the leaders of the four Mesoamerican countries of Mexico, Belize, Guatemala and Honduras to cooperatively manage and conserve the Mesoamerican Reef.
- Honduras is one of 197 member countries of the United Nations Framework Convention on Climate Change (UNFCCC), ratified by the National Congress on 29 July 1995, and has therefore made international commitments to the country's natural resources.

Financing Mechanisms Employed:

- The Program for the Modernization of the Water and Sanitation Sector (PROMOSAS) of the World Bank ran from 2008-2013 and it included investments of up to US$35,000,000. The main components of the program were to support national institutions, institutional reform and investments in intermediate cities, and the transfer of Tegucigalpa from SANAA to the Municipality.
- The Investment Program in Water and Sanitation in Honduras is a program in which the Inter-American Development Bank (IDB) supports 25 intermediate cities in the country by investing US$30,000,000. In the past, actions for the institutional strengthening of the operators were financed, through studies and designs of works, tariff and environmental studies, training and publicity campaigns, the elaboration of local policies for services. In this second stage, the focus is on the financing of urban works, which were designed in a previous phase of the project.
- Honduras is participating in the GEF Caribbean Regional Fund for Wastewater Management (CReW+) Project.

Water Quality Issues at La Guanaja

The service quality in Honduras is low compared to other countries in Latin America. In 2006, 75% of the drinking water in urban areas was disinfected and 10% of collected wastewater received treatment. In rural areas, it was estimated that one-third of the systems provided continual service and less than 14% of the systems delivered disinfected water in 2004. Only 3% of collected wastewater was treated.

Water losses, or more precisely non-revenue water is estimated at 50% in the capital Tegucigalpa and 43% in San Pedro Sula, well above an estimated efficient level.

According to the Honduran Ministry of Finance, US$262 million were invested in the sector between 1997 and 2006, which is on average US$4 per capita and year. The annual investment mostly ranged from US$1.1 and US$4.6 per capita. The Honduran water supply and sanitation sector receives significant support in terms of financing and technical assistance from a large variety of donors, including The World Bank, the IDB, USAID, the European Union, German KfW and Swiss SDC. Some channel their support through the FHIS (World Bank, IDB, KfW, USAID, COSUDE) and others through SANAA (USAID, European Union).

In 2019, Honduras became the second country in the MAR (besides Belize) to sign and ratify the Cartagena Convention's Land Based Sources of Marine Pollution Protocol, which has stricter effluent limits for areas near coral reefs. In 2011, Healthy Reefs Initiative, CORAL, BICA (and others) partnered with Inter-American Development Bank to install a wastewater treatment infrastructure in West End, Roatan. By 2018, 98% of households were hooked into the sewage treatment system. CORAL estimated over 23 million gallons of sewage per year were being treated, resulting in a 30% reduction in *Enterococcus* bacteria since 2013. The West End sewage treatment plant project provides a model for replicating the project in Guanaja.

Guanaja has a large population for the size of the island (Figure 37) and there is a lack of sewage and solid waste treatment. On Low Cay (or Bonacca Cay), a small cay (~100 acres) off the main island, is home to the majority of the island's population (>5500 people). Sewage is dumped directly into the marine environment. There is a need to reduce nutrients and pollution due to lack of proper sewage treatment in Guanaja, especially Low Cay.

Mismanagement of Solid Waste on the Island of Guanaja
The current management of solid waste in the municipality of Guanaja presents deficiencies that prevent providing a good service to the entire population. These deficiencies affect the population and the environment of the municipality.

Fig. 37 | Low Cay photo. Source: https://caribbeansealife.com/category/honduras/guanaja/bonacca/

- Deficient coverage of wastewater treatment on the Island of Guanaja. Currently, the municipal corporation does not have any model of solution to wastewater and each resident proposes his solution at his convenience, therefore, almost 70% of the homes discharge their wastewater directly into the sea and only 30% have a type of septic tank solution without a concrete bottom.
- Lack of implemented coastal zone management plans and regulations to keep native vegetation intact, minimize upland runoff, reduce erosion, or minimize upland pollutants from entering nearshore waters.

Interventions Needed at Guanaja, Honduras
A group of habitat restoration and pollution reduction experts identified interventions needed at Guanaja in consultation with key local actors and organizations and through a review of relevant literature.

Interventions Needed at Guanaja, Honduras
Improve Water Quality and Reduce Pollution
• Create a solid waste management program for Guanaja and implement strategies through public awareness and environmental education for management during collection and transfer to the final disposal site and have a final disposal site with the appropriate technology to reduce the impact of waste, resulting in a reduction of toxic pollutants and their associated effect on public health. • Address the poor wastewater treatment coverage by establishing a wastewater treatment plant to treat municipal and industrial wastewater and help avoid the contamination of natural bodies of water, while at the same time providing employment opportunities and an increase in overall ecosystem quality and health. • Install a centralized water treatment facility at the highest priority site. This will include several steps such as: a) conducting a site evaluation plan to determine priority site, b) community outreach to increase awareness and support, c) developing a management board to implement and manage treatment facilities, d) ensuring long term financial and management sustainability, and water quality monitoring. A first step should be consulting with the West End Sewage Treatment Project on Roatan (Healthy Reefs Initiative, CORAL, BICA).

- Reduce pollutants from septic tanks by improving decentralized wastewater systems. Leakage from older or poorly designed septic tanks can result in excess nutrients and pollutants seeping into nearby ground water and nearshore marine waters. Actions to minimize impacts from sewer systems include a) community and business outreach on proper septic tank maintenance, b) surveys to identify systems in need of repair/replacement, c) water quality monitoring and d) actions included in coastal zone building and management plans to ensure new developments.
- Develop an island wide water quality monitoring program with emphasis on nutrients and E.coli bacteria, especially around Low Cay.
- Evaluate fresh water use and availability and develop programs to improve water capture, retention, reuse and drinking water quality.
- Improvement of wastewater treatment plants. Include primary and secondary treatment. Invest in new wastewater treatment plants.
- Solid waste management improvement. Move solid waste collection sites to areas far from the coast.
- Use of constructed wetlands for tertiary treatment and water pollutants.
- Use of mangroves and seagrasses in a system built in series for the retention of pollutants and suspended solids that help the recovery of areas where there are coral reefs.

Preliminary Estimated Cost (USD):

- Wastewater treatment plant: $10,000,000 - $30,000,000 over 25 years, with initial building costs to be higher in the first 2-5 years, and costs subsiding as customers pay for services.
- Review, repair, installation, and maintenance of septic tanks: $1,000,000 - $5,000,000 for 25 years. The lifespan of a septic system varies widely depending on make, maintenance, efficiency etc., so the need for maintenance, repairs or replacement may vary widely and affect the amount of funding needed.[4]
- In addition to the actual cost of installing and maintaining the sewer facility and water facility, funding is needed for long term implementation and management including working with the community for monthly payments, etc.

TOTAL: $11,000,000 - $35,000,000 over 25 years

Blended Finance Model Elements:

- Multilateral / GCF / development bank lending to national governments for the larger infrastructure projects (blue bond debt-for-nature swap, conservation trust fund establishment, etc.).
- Municipal bonds and private investment to serve as matching support for development bank financing.
- Monthly service-based payments from customers.
- Establish a local water board to administer service payments and develop and maintain the wastewater treatment infrastructure.
- Provide potable water initially to transition customers to fee-based wastewater treatment.
- Revolving fund for micro-lending at household level to support nature-based solutions.
- Mitigation banking for coastal development permitting to support nature-based solutions for green infrastructure.
- Philanthropic support to support knowledge sharing, tech transfer, as well as water quality monitoring efforts and citizen science engagement.
- Access fees / user fees for visitors to MAR.
- Enabling municipalities to tap capital markets to fund infrastructure development through concessional loans and equity backing bond issuance in local currency.
- Multipurpose water infrastructure projects and landscape-based approaches (integrated projects within a given spatial area) deliver multiple water-related benefits across several sectors (to agriculture, energy production, fisheries, recreation, and tourism). Landscape-based approaches can capture additional revenues and returns across the value chain to raise further types of financing.
- Water Funds have proven to be scalable and replicable when adapted to the local context.
- Blended finance can potentially operate as a fit-for-purpose financing instrument as it brings together different stakeholders responding to their individual investment preferences.

[4] Key providers to engage: West End Sanitation Facility and the company that installed West End and the Carnival Cruise Ship sewer and solid waste facility – ACME Environmental Solutions https://www.facebook.com/AcmeEnvironmental. See also: https://www.onsiteinstaller.com/editorial/2014/06/installing_in_paradise. The Florida Keys Aqueduct Authorities Financial Plan and Budget may be referenced for sewage and water costs.

Restore / Rehabilitate / Conserve Seagrasses
Seagrasses occupy considerable areas in Guanaja. Almost all of the island's inland and barrier reefs are covered by seagrass. The aforementioned interventions to improve water quality and reduce pollution will inherently improve the conditions for seagrasses. ● There is limited data on seagrasses. USGS (2002) estimated 923 ha of seagrass. ● Produce detailed seagrass and species composition maps for the island. ● Educate the community and visitors on the importance of seagrasses and ways to minimize impacts especially related to boating, dredging and pollution. ● Develop a seagrass monitoring program to evaluate status and identify areas in need of restoration (which can include citizen scientists – see https://www.seagrasswatch.org/). ● Evaluate the seagrass areas in the north part of Guanaja near Mangrove Bight that were identified in USGS 2002 report as being affected by scouring and determine if restoration is needed and develop a restoration action plan. ● Evaluate if seagrass beds are being impacted by boat motors or dredging especially around Low Cay and if needed, install navigation markers, protected areas, and/or mooring buoys. ● Work to sensitize and educate the local communities about the need to protect seagrasses. ● Organization of routes to appreciate the coastal ecosystem. Training workshops on restoration and monitoring. Develop a long-term community-based monitoring program. ● Transplantation and expansion of areas of meadows affected by habitat degradation from fishing, tourism, hotels, solid waste and river pollutant discharge. Inventory and identify these areas relative to MPAs. **Preliminary Estimated Cost (USD):** *cost increases with project size / scope* ● Mapping and initial site surveys: $100,000 - $400,000 ● Seagrass monitoring program (with citizen science participation): $50,000 - $100,000 ● Restoration feasibility assessment and design: $150,000 - $650,000 ● Partner coordination, permitting/permissions, and logistics: $100,000 - $200,000 ● Training workshops and educational campaigns: $50,000 - $250,000 ● Restoration project implementation: $400,000 - $1,200,000 ● Mooring and navigation buoys (preventative): $100,000 - $500,000 **TOTAL: $950,000 - $3,300,000 over 5-10 years** ○ Approximately 10-50 hectares of restoration and improved management / conservation (site and methodology dependent) ○ In addition, long-term monitoring, maintenance, and carbon credit reporting: $50,000 - $150,000 per year post-project execution. **Potential Blended Finance Model Elements:** ● Multilateral / GCF / development bank lending to national governments for the larger infrastructure projects (blue bond debt-for-nature swap, conservation trust fund establishment etc.). ● Municipal bonds and private investment to serve as matching support for development bank financing. ● Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, water quality improvement, and natural infrastructure for storm protection and erosion prevention. ● Concessionary private capital in conjunction with philanthropic support to advance project certification to generate blue carbon credits. ● Additional value for biodiversity and climate resilience related certification (augments carbon credit value on voluntary market). ● Sale of blue carbon credits on the voluntary market post-certification (private capital). ● Volunteer engagement, specifically through ecotourism, recreational fishing, and diving industry, to provide in-kind support. ● Engage resorts, like Dunbar Rock, to seek support for mooring buoys and other preventative / conservation measures. ● Establish boater behavior change programs supported by marina user fees. ● Look at opportunities to use parametric insurance to protect seagrasses that protect human infrastructure.

Restore / Rehabilitate / Conserve Mangroves

The harvesting of mangrove forests and the deterioration of seagrass beds has reduced the sediment filtering capacity of the archipelago's coasts and could partially explain the problems of water turbidity. Job generation created by alternative livelihoods and a public awareness program can help drive local people away from logging and towards new employment opportunities thus preventing further deterioration of these ecosystems. The interventions to improve water quality and reduce pollution will inherently improve the conditions for mangroves and there should be a focus on water quality monitoring. An improvement in water quality will ensure that any restoration activities are sustainable in the long-term.

- Review previous studies on mangrove impacts from Hurricane Mitch and effectiveness of previous replanting restoration efforts to identify areas for restoration and develop suitable restoration actions. Investigate reasons why previous methods were not as effective including high loss of transplants, soil elevation and composition, and transition to other vegetation communities (e.g., salt marsh plain).
- Study effects of Hurricanes Eta and Iota on mangrove habitats and the potential for restoration considering those effects.
- Continue and expand education and outreach on the importance of mangrove ecosystems, protection from tree removal or burning trees, and importance of restoration efforts.
- Develop a long term mangrove restoration and monitoring plan, as well as work towards improving policies to protect mangroves. Restoration efforts should include community members and citizen scientists.
- Transplant and expand mangrove areas affected by deforestation, sedimentation, and solid waste. Implement exclusion zones, critical habitats and coastal modification if necessary to return hydrology to the system.
- Identify the local key stakeholders to strengthen their capacities in terms of ecosystem conservation and restoration through practical workshops.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*

- Mangrove post-hurricane studies, feasibility assessment, and restoration plan development: $150,000 - $800,000
- Partner coordination, permitting/permissions, and logistics: $100,000 - $200,000
- Training workshops and educational campaigns: $50,000 - $250,000
- Restoration project implementation (which may include soil elevation, increased flow, population enhancement): $500,000 - $2,500,000
- Mangrove management (monitoring, management, and policy enforcement): $100,000 - $500,000

  TOTAL: $900,000 - $4,250,000 over 4-7 years
  - Approximately 50-250 hectares of restoration and improved management / conservation (site and methodology dependent).
  - In addition, long-term monitoring, maintenance, and carbon credit reporting $50,000 - $100,000 per year post-project execution.

Potential Blended Finance Model Elements:

- Multilateral / GCF / development bank lending to national governments for the larger infrastructure projects (blue bond debt-for-nature swap, conservation trust fund establishment etc.).
- Municipal bonds and private investment to serve as matching support for development bank financing.
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, water quality improvement, and natural infrastructure for storm protection, flood mitigation, and erosion prevention.
- Government funding for mangrove restoration to support efforts to meet non-GHG NDC (afforestation / reforestation of 1 million hectares of forests by 2030. Moreover, through the NAMAs, efficient stoves are expected to reduce the consumption of firewood by families by 39%, helping in the fight against deforestation).
- Philanthropic capital and development bank support (complementing existing efforts) to advance project certification to generate blue carbon credits.
- Additional value for biodiversity and climate resilience related certification (augments carbon credit value on voluntary market).
- Sale of blue carbon credits on the voluntary market post-certification (private capital).
- Volunteer engagement, specifically through ecotourism, to provide in-kind support.
- Form public-private partnerships to advance projects that require a broad coalition of stakeholders.
- Collaboratively managing MPAs offers impact investors a strong opportunity to support the sustainable management of marine resources, improve coastal livelihoods, and generate financial returns.

Restore / Rehabilitate / Conserve Coral Reefs

The poor treatment of domestic, industrial, and wastewater has generated an abnormal development of macroalgae and has deteriorated the state of health and development of corals. Thus, the interventions to improve water quality and reduce pollution will inherently improve the conditions for coral reefs and there should be a focus on water quality monitoring. An improvement in water quality will ensure that any restoration activities are sustainable in the long-term.

In the Bay Islands, over 5,500 genetically diverse elkhorn and staghorn corals at five nurseries on Roatan and Utila are cared for by Bay Islands Reef Restoration, Roatan Marine Park, Roatan Institute for Marine Sciences and Utila Coral Restoration. An important part of these efforts has been the inclusion of volunteers and community support (Mcfield et al 2020).

- There is a need to increase the spatial and temporal scales of coral restoration in order to address restoring ecosystem structure and function. Coral restoration efforts in Guanaja should look beyond only population enhancement at a single or few coral nurseries and outplant sites and should consider addressing the restoration of structure and function on coral reefs.
- In addition, on September 25, Roatan Marine Park confirmed the presence of Stony Coral Tissue Loss Disease (SCTLD) had spread to Roatan Bay Islands, making it the 16th country/ territory in the Caribbean to report the presence of SCTLD. The likelihood of it continuing to spread to Guanaja is high given its contagious nature and ability to spread over 10-100 km spatial scales. The presence of SCTLD elevates the need for coral restoration, although restoration plans should be adaptable considering the presence of SCTLD.
- Monitor for presence of SCTLD, and develop response actions such as coral rescues (in situ, lab based), coral treatments, coral tissue histopathology, coral cryopreservation, etc.
- Work to sensitize local communities about the need to protect corals.
- Organize visits and tourism routes to build appreciation for the coral ecosystem.
- Work with fishing communities on sustainable fishing, connected with fair trade markets. Implement exclusion zones and critical habitats.
- Host solid waste and micro plastics workshops on the impact of plastic to the reef habitat.
- Develop Guanaja coral restoration goals.
- Improve water quality of marine waters to provide a conducive habitat to conduct coral restoration (including reducing nutrient, pollutants, and sediments).
- Use existing data and conduct new evaluations of priority areas for restoration and develop restoration plans.
- Support training of restoration personnel.
- Conduct outreach and education.
- Increase efforts to reduce impacts from global climate change such as ocean acidification, rising sea surface temperatures and sea level change (including reviewing literature on past coral bleaching impacts and future predictions of risk to coral bleaching).

Preliminary Estimated Cost (USD): *cost increases with project size / scope*

- *Water quality – see estimated actions and budget above .*
- SCTLD Response Plan and actions, which depend on future impacts of SCTLD in Guanaja: $100,000 - $500,000 per year or more for 10 years depending on severity of disease--note SCTLD has caused a loss of 30-90% coral cover of highly susceptible species in some other areas.
- Coral restoration planning phase: $50,000 over 1 year .
- Project Phase 1 – Site preparation, coral restoration, grazer enhancement, monitoring, maintenance, adaptive management (cost to be determined, but in the Florida Keys the projected cost is $100,000,000 for 7 reefs over 5-7 year timeframe).
- Project Phase 2 – Site preparation, coral restoration, grazer enhancement, monitoring, maintenance, adaptive management to be determined.
- Training of restoration personnel: $100,000 in Year 1 and $25,000 per year for 5 years.
- Outreach and education: $100,000 per year for 10 years.

  TOTAL: $11,775,000 - $76,275,000 over 10 years

  - Approximately 50-350 hectares of restoration and improved management / conservation (site and methodology dependent)

Potential Blended Finance Model Elements:

- Multilateral / GCF / development bank lending to national governments for the larger infrastructure projects (blue bond debt-for-nature swap, conservation trust fund establishment etc.).
- Municipal bonds and private investment to serve as matching support for development bank financing.
- Global Fund for Coral Reefs, which may include a blend of traditional grant funding, development bank financing, and program related investments (PRIs).
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, and natural infrastructure for storm protection.
- Volunteer engagement, specifically through ecotourism, to provide in-kind support.
- Corporate sponsorship, in-kind support, and media promotion.
- Certification for biodiversity and resilience credits to be traded on voluntary markets.
- Parametric insurance product (in collaboration with local resorts per the model pioneered in Quintana Roo, Mexico by The Nature Conservancy) to support restoration and rehabilitation costs associated with extreme storm events and coral bleaching.
- Innovative management lease for MPAs with tangible revenue models, leveraged by blended finance and empowerment of local communities.
- Certification of small-scale fisheries improves the conservation of coral reef ecosystems by providing financial incentives to fishing communities to adopt sustainable fishing behaviors and rights-based management regimes. Formal Fisheries Improvement Projects (FIPs) are recommended.

Key Beneficiaries

In Guanaja, there are institutional stakeholders from the Municipality of Guanaja, the Honduran Institute of Tourism, Digepesca, the Harbor Master's Office, and civil society. The Honduran Institute of Tourism and the ICF have interests in the three islands because of the protected areas. All these institutional stakeholders play an important role in the socio-environmental dynamics in the Bay Islands, from the co-management of protected areas between Municipalities and NGOs (for example BICA), to more specific and localized organizations that carry out specific equality programs which support the conservation of marine and terrestrial biodiversity that exists in this region.

These pollution reduction, restoration, conservation, and management actions will benefit all residents and visitors, as well as nearshore habitats and their associated marine life. These ecosystems are important nursery areas for many species. Guanaja and the Bay Islands play an important role in larval connectivity of fish, coral, and other invertebrates to the rest of the MAR region, as well as provide habitat to migrating fauna like birds, turtles, and whale sharks.

The main beneficiaries are the population dispersed through the North Honduras (Chachaluala, Omoa, Rio Coto, Rio Montagua, Guanaja Islands) and many other populated areas. Pollution is a major problem and can be alleviated by the installation of a new wastewater treatment plant and a strong educational program on habitat conservation followed by restoration activities and a sound monitoring program.

Risk and Reward of Carrying Out Interventions

Experts estimated the “risk” (i.e. likelihood of success, longevity) on a scale from 1 to 10 (in which 10 represents extremely high risk) and “reward” (i.e. extent/nature of benefits) on a scale from 1 to 10 (in which 10 represents extremely high reward) taking into account the local environmental and political landscapes previously described.

<u>Risk Estimate</u>

Risk score: 5

The interventions mentioned above pose an overall positive net impact based on our analysis of the social, environmental, and economic conditions of the site. The risk is considered relatively medium-low given that the problems facing the site have been identified and the intervention alternatives are feasible to implement, but within a limited governance and socio-economic framework.

Regarding habitat restoration, there is a low risk to restoring seagrass because seagrasses are fairly intact and there is availability of proven restoration approaches. The main risk is from upland erosion due to poor coastal zone management and poor water quality from nutrients/pollutants. For mangrove restoration, the area to restore is relatively small and techniques exist, but there is a need to determine why some regeneration or restoration has not been effective. Stony Coral Tissue Loss Disease appeared in Roatan in November 2020, and there is a likelihood of it spreading to Guanaja, increasing the risk of coral restoration. All three ecosystems are at risk due to impacts associated with climate change, ocean acidification, and sea level rise. There is a high risk of improving water quality if there is a lack of financing and long-term maintenance and management of central sewer facilities. Water quality should be improved before conducting coral restoration.

<u>Reward Estimate</u>

Reward score: 9
Currently on the island of Guanaja, there is no municipal wastewater solution model and each inhabitant proposes their solution at their convenience, therefore almost 70% of the homes discharge their wastewater directly into the sea and only 30% have a type of bottomless septic tank solution of concrete. The population that benefits from a water supply with disinfection procedures does not exceed a coverage of 51% in urban areas and 14% in rural areas.

Regarding habitat restoration, mangrove restoration is critical for shoreline protection, habitat, and nursery areas. Also, Guanaja has some of the largest areas of mangroves in the Bay Islands. Coral reef restoration is critical for shoreline protection, habitat, and nursery areas, as well as providing larvae to the rest of MAR. Also, Guanaja relies on tourism and fisheries for their economy, so without reefs, there is an economic loss.

Protected Area(s) at Site
Honduras has ten marine protected areas covering an area of 9,572.8 km² with 482.1 km² designated as no-take zones (Mcfield et al. 2018). The largest MPA is 6,449 km² and the smallest 15 km². Over 19,564 km² of the Territorial Sea is protected or about 49% but only 2.5% of that is within fully protected replenishment zones. Guanaja is within Parque Nacional Marino Islas de la Bahia, which was established in 2010 and covers 47,152.49 ha. While the park includes the entire Bay Islands, management and enforcement need to be improved and the area of fully protected areas needs to be expanded.[5]

A total of 95 protected areas in Honduras are registered members of the SINAPH (Honduras National System of Protected Areas). Under REHDES leadership 8 North Coast NGOs such as (Aecopijol, BICA, Fundación Cayos Cochinos, Fucsa, Fupnand, Fucagua, Prolansate, Fupnapib) have signed protected areas management agreements with the government of Honduras since 1996.

In the context of the Mesoamerican Barrier Reef (MAR), the Bay Islands is defined as a high priority area for its rich biodiversity. The MAR is considered a Caribbean jewel in the Western Hemisphere. It is shared by four countries and extends 1000 km from the north in the Yucatan Peninsula to Belize, Guatemala and the Bay Islands reef system in the south.

BAY ISLANDS PROTECTED AREAS: The Bay Islands protected areas are important terrestrial and marine parks of local, national, regional and international significance. These islands are

- Guanaja: Half Moon Cay- South West Cay, Michael Rock.
- Utila: Raggedy Cay – South West Cay, Zona de Proteccion Especial Marina Turtle Harbour – Rock Harbour.
- Roatán Zona de Protección Especial Marina Santa Elena – Barbareta.
- Zona de Protección Especial Marina Sandy Bay West End or Sandy Bay – West End National Marine Park.

MARINE PROTECTED AREAS: The archipelago of the Bay Islands located 64 kms off the North Coast of Honduras supports coral reefs, seagrass flats, productive marine banks, flats and mangrove forest. This rich and vibrant biodiversity is ideal for conservation and economically important for the local population that depends on these resources for their livelihood and future development.

SANDY BAY - WEST END MARINE PARK: Located on the Northwest coast of the island of Roatan, Sandy Bay-West End Marine Park encompasses the communities of Sandy Bay, West End, West Bay, and Key Hole on the south side of the island, extending from the high water mark outward 3 km, encompassing 27 km of coastline and 27,000 km^2 of reef.

The terrestrial parks are: Port Royal National Park, Municipality of Santos Guardiola on Roatan; Utila Turtle Harbour Wildlife Refuge and on Guanaja the Zona Forestal Reservada #3 with Legislative Decree since 1960.

The following interventions could potentially establish new or improve existing protected areas:

- The amount of fully protected areas (i.e., not take zones) needs to be increased (e.g., to 10%), along with increased enforcement.
- Regulations to protect spawning aggregations need to be implemented.
- Overall fishing regulations need to be enforced, including the protection of parrotfish.
- Watershed (ridge to reef) management and coastal zone plans need to be implemented.
- Funding for the management and long-term sustainability of MPA parks is greatly needed.
- Informational/educative signage.
- Implementation of exclusion zones including use of navigation markers and mooring buoys.

[5] A review of MPAs in Roatan identified specific priority needs for improving MPA capacity that can be used as a guide for Guanaja. See Gombos et al. 2011 for the Roatan Honduras assessment. See: Gombos, M., A. Arrivillaga, D. Wusinich-Mendez, B. Glazer, S. Frew, G. Bustamante, E. Doyle, A. Vanzella-Khouri, A. Acosta, and B. Causey 2011. A Management Capacity Assessment of Selected Coral Reef Marine Protected Areas in the Caribbean. Commissioned by the National Oceanic and Atmospheric Administration (NOAA) Coral Reef Conservation Program (CRCP), the Gulf and Caribbean Fisheries Institute (GCFI) and by the UNEP-CEP Caribbean Marine Protected Area Management Network and Forum (CaMPAM). 252 pp. https://www.gcfi.org/pdf/MPAConnect/MPAManagementCapacity%20Assessment_2011_en.pdf

- Improve scientific monitoring efforts, training, and equipment.
- To improve or propose new protected areas, an analysis of the current ones and their programs is first required, as well as a regional study to complement the analysis. However, *a priori* we suggest improving the management of existing ones.

Approximate costs[6] of interventions to establish MPAs or improve existing MPAs:

- MPA park staff and management costs: US$500,000/year
- Enforcement: US$500,00/year
- Scientific research: US$200,000/year
- Outreach and education: US$200,000/year
- Developing private partnerships and support: US$50,000/year
- Watershed management: US$500,000/year
- Alternative livelihood opportunities: US$500,000/year
- Fishing and diving safety: US$100,000/year
- Informational/educative signage: US$2,000,000
- Implementation of exclusion zones. Aids to navigation markers, mooring buoys: US$20,000,000
- Scientific research, monitoring training workshops and monitoring program implication: US$10,000,000
- Analysis of the society-nature state of the current protected coastal areas: US$5,000,000
- Regional study of La Guajira to identify potential sites to propose them as a new protected coastal area: US$10,000,000

Local Training and Capacity Building at Site
The following is a list of capacity building needs at Guanaja:

- With the help of academia, provide participatory workshops aimed at raising awareness among young people in the municipality about the environmental and public health consequences associated with burning waste or clandestinely depositing it on land.
- Conduct training on the building of more efficient septic tanks.
- Conduct capacity building relating to water quality monitoring, citizen science, and wastewater as a resource.
- With the help of academia and civil associations, impart to the owners and workers of the micro, small and medium businesses present in the municipality of the environmental and public health consequences associated with the mismanagement of solid waste.

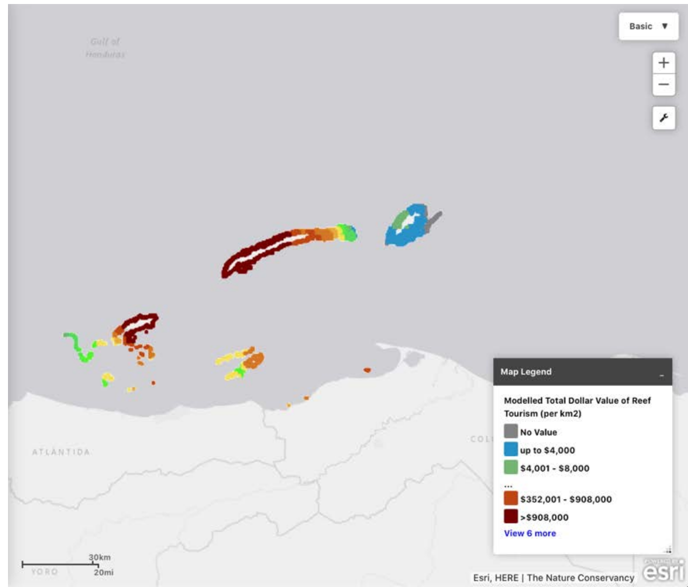


Fig. 38 | Modelled Total Dollar Value of Reef Tourism (per km^2) for the Bay Islands, Honduras. Guanaja is the far right island colored blue and green. Source: http://maps.oceanwealth.org (2020).

- Collaboration with academia, Civil Society Organizations and Non-Governmental Organizations to carry out participatory workshops for the generation of compost and vermicompost derived from garden waste.
- Training in MPA management is needed including enforcement, financial sustainability, scientific monitoring, leadership, alternative livelihoods, and resilience to climate change.
- Fisher and marine ranger training workshops. Maintenance of the park network.
- Train ecosystem monitoring teams.
- Restoration workshops series (at least 3).

Econometric Studies Specific to This Region
The Nature Conservancy's Mapping Ocean Wealth Program produced a "Modelled Total Dollar Value of Reef Tourism (per km²)" and valued between US$4,000 to US$8,000 / km² (Figure 38). TNC also calculated the Blue Carbon opportunity from mangroves to represent the Blue Carbon that can be gained on an annual basis through restoration efforts plus the Blue Carbon from annual avoided loss (based on mangrove extent estimates from Global Mangrove Watch). However, TNC did not calculate a metric for Natural Coastal Protection for Honduras. For more information see: http://maps.oceanwealth.org/

The Food and Agriculture Organization conducted a fisheries value analysis – see Claudia Stella Beltrán Turriago. 2011. "Value-Chain Analysis of International Fish Trade and Food Security in the Republic of Honduras."
Aspects to Consider When Developing Investment Plan

[6] These costs are estimates. See NOAA's Florida Keys Sanctuary Budget or speak with MARFUND on budget planning.

Honduras in recent years has had significant advances in environmental policy, which will contribute to the success Guanaja can achieve through conservation and restoration interventions. However, a few key challenges persist:

Challenge 1: Lack of donors. One aspect to consider is the long-standing challenge of procuring donor investments in the MAR region and Caribbean in general. However, donor support in the Mesoamerican region has increased over the past few years due to the establishment of the MAR Fund, which has resulted in an increase in the amount of funding and new partners supporting conservation in the MAR. With the new Global Fund for Coral Reefs starting up, there may be hope for increasing investments. Key to this will be collaborating with the MAR Fund for support and to help leverage investments. There will also be a need to investigate other funding options such as Environmental Funds, Conservation Trust Funds and Ocean-related development aid funding (ODA), as well as scaling up through global partnerships.

Challenge 2: Covid 19 pandemic. Covid-19 has had a tremendous impact on marine conservation due to the lockdown measures and has significantly impacted the economy due to the stoppage of major tourism and cruise ships (while simultaneously possibly reducing the impact on marine ecosystems). Fisheries markets in this region have been significantly impacted due to the inability to export fishery products to external markets. Fisheries catch prices have also been impacted negatively. Increased use of single-use plastic, food containers, and masks have created waste management issues in the region.

Challenge 3: Restoring coral reefs in a new era of coral disease. On September 25, Roatan Marine Park confirmed the presence of SCTLD had spread to Roatan Bay Islands, making it the 16th country/territory in the Caribbean to report the presence of SCTLD. There is a likelihood of SCTLD spreading to Guanaja given its contagious nature and ability to spread over 10-100 km spatial scales. The presence of SCTLD elevates the need for coral restoration, although it is important that restoration plans adapt to SCTLD.

The current outbreak of SCTLD throughout the Caribbean, including now Roatan, has changed the priorities and responses to coral restoration. For example, management efforts in the Florida Keys expanded from active coral restoration to also applying intervention actions for disease response. This has included focused monitoring of the disease outbreak, increased targeted science, and research on causes of the disease, as well as experimenting with applying antibiotics to high value corals. A new focus has been on doing an intensive rescue effort of remaining healthy corals in order to conserve and protect the genetic diversity of Caribbean coral species and increase the number of corals available for future outplantings on the Florida Reef Tract as well as cryopreservation efforts of coral sperm. Response efforts in the Caribbean vary but includes increased monitoring (Alvarez et al. 2019), experimenting with various natural treatments and antibiotics and increasing awareness about the disease to reduce human impacts, with much of these efforts limited by funding. Currently, there is not a framework to establish national or regional coral rescue efforts, although some localized efforts (e.g., Mexico) are trying to establish rescue for key species like pillar and brain corals.

Site #2: Central Andros, The Bahamas

Background
The Bahamas consists of over 700 islands and cays spread over 500 miles of the Atlantic Ocean along mostly shallow sand banks. Only 30 of these islands are inhabited meaning much of the country's famed seagrass banks and patch corals remain in relatively good condition, particularly the further one gets from Nassau, the capital city on New Providence island.

The Andros archipelago is the largest Bahamian island system and is as large as all of the other Bahamian islands combined. North Andros island alone is considered the sixth largest island in the Caribbean. Andros is so large and ecologically diverse that it is the only Bahamian island with its own freshwater supply. As with many Bahamian islands, it boasts a very low population density. However, this has not spared the island's habitats from threats seen elsewhere in the Caribbean including boat groundings, coral disease and bleaching, and altered water chemistry related to climate change and human extraction of raw materials.

Andros hosts five marine protected areas: Blue Holes National Park, Crab Replenishment Reserve, North & South Marine Parks, and the West Side National Park. See below for more information about these MPAs. Andros also hosts a 190-mile-long fringing barrier reef and with it an abundance of marine life, much of it spared the major tourism development seen in other Bahamian islands.

Scores for Central Andros using the methodology presented in Part I of this report are as follows:

Central Andros, Bahamas
Structure: 16
Function: 16
Ecosystem services: 15
Feasibility: 15
Threat abatement: 13
TOTAL: 75

Key Goals, Challenges, and Stakeholders for Central Andros, Bahamas
A group of habitat restoration and pollution reduction experts identified key goals, challenges, and stakeholders for Central Andros in consultation with key local actors and organizations and through a review of relevant literature.

Key Goals, Challenges, and Stakeholders for Central Andros, Bahamas
Key Goals
● Improve coverage and availability on climate change data and vulnerability to inform future risk-resilient coastal planning and decision-making in Andros. ● Address the diminishing freshwater supplies, degraded freshwater, and coastal water quality. ● Protect and restore coastal habitats (seagrasses, mangroves, and coral reefs) and pine forests, while connecting protected areas where possible . ● Develop a monitoring, evaluation, and reporting framework program to gauge restoration efforts and to provide future correction action. ● Strengthen Andros at the institutional level for coastal risk management and marine resource management and enforcement. ● Reduce large scale unsustainable development, harmful fishing practices, and poaching.
Key Challenges
● Low spatial and temporal seagrass data (Kramer 2007). ● Weak management plan for seagrasses. ● Invasive pine species in mangroves areas. ● Established MPAs lack management and oversight. ● Sensitization of economic sectors to better practices to diminish plastic pollution. ● MPAs are not large enough. ● Despite a wealth of natural resources, Andros lacks the essential infrastructure, social services, and educational opportunities to support sustainable and prosperous livelihoods. ● Current and emerging threats in Andros include unchecked development (involving pollution, dredging, and indiscriminate habitat clearing), overfishing, invasive species, sewage, climate change, and ocean acidification. ● People benefit directly in many ways from the flora and fauna, from the extraction of crabs, sponge, fish, wood,

and palm for crafts, medicine and fruits from the forest, as well as water from the ground. The population of approximately 10,000 depend heavily on a healthy environment and are therefore potentially vulnerable to environmental degradation. ● Out of all the threats identified for affecting biodiversity in The Bahamas, climate change is considered to have the greatest effect as 80% of The Bahamas' landmass is within 1.5 m of sea level rise and 90% of The Bahamas' freshwater lenses are within 1.5 m of the land surface, making the groundwater resource fragile and highly vulnerable to contamination. ● Invasive species in mangroves areas. Better measures are needed to control pine invasion within mangrove areas. ● Bridges showing significant deterioration and potential negative impacts on mangrove health.
Key Stakeholders
● ANCAT (Andros Conservancy and Trust Bahamas) ● BAMSI (The Bahamas Agriculture and Marine Science Institute) ● Agriculture and Marine Resources, Ministry of Andros (Government) ● Government forestry unit ● NGO Nature's Hope for Southern Andros ● Rotary International ● Central government ● Hotel industry ● Ecotourism/fishing ● NGO Bahama Creek and Wetland Restoration Foundation ● Department of Marine Resources ● Office of the Prime Minister ● Ministry of Health (MOH) ● The Department of Environmental Health Services (DEHS) ● Joint Water Quality and Pollution Control Unit (JWQPCU) ● The Bahamas Environment, Science, and Technology (BEST) ● The Natural Capital Project ● The University of The Bahamas ● SEV Consulting Group ● The Nature Conservancy ● Inter-American Development Bank ● Forfar Field Station ● NGO Waitt Foundation

Historic and Current Work at Andros Island

There are a number of funders, organization, programs, and financing mechanisms operating at the site.

Major Funders and Organizations:

- Ministry of Environment.
- BEST Commission.
- Forestry Unit: Led US$10,000,000 GEF-funding rehabilitation of the mangrove ecosystem in Davis Creek, Andros (50 acres) to restore ecosystem services and increase carbon sequestration up to 14,563 CO_2e.
- The National Creek and Wetlands Initiative (NCWI): Commenced in 1999. Forty creek systems countrywide were catalogued and inventoried for restoration--an important starting point for The Bahamas to effectively manage its creeks and wetlands. The findings of the initiative proved that creek fragmentation on the eastern side of Andros due to deforestation caused by human development has severely impacted the ecosystem functioning of the mangroves. One such example is Davis Creek, Central Andros. The connectivity and flow have been greatly reduced due to sedimentation and encroaching invasive species. The creek is now bisected by three roads with minimal amounts of culverts which does not meet the needs of the creek, and thus has been digressing in productivity over the last few decades. The areas immediately adjacent to Small Hope Bay Lodge area, providing significant potential for demonstration for both local and international visitors regarding the negative impacts of the absence of knowledge of mangrove ecosystem services, leading to un-informed land use planning decisions.
- European Outdoor Conservation Association (EOCA): Proposed a project to restore mangroves

at Love Hill, Andros. The mangroves in Andros have been affected by the installation of three roads over 50 years ago. Although culverts were installed to maintain water flow these are now broken or clogged and, where no culverts were installed, the mangroves are only nourished during high tides when the water floods the roads. As a result, the mangroves have degraded. Pine trees have also invaded. The project aims to restore 96 hectares of mangrove by cleaning out, repairing, and installing culverts on all three roads and by replacing the invasive pine trees with native species.

Alignment With Other Initiatives / Programs:

- The Bahamas is a party to approximately 20 international agreements that deal with environmental and public welfare issues. From a national perspective, The Bahamas is actively involved in the following Conventions: the Ramsar Convention, the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), The Convention of International Trade in Endangered Species (CITES), and the United Nations Convention on Laws of the Sea (UNCLOS).
- In 2015, the Office of the Prime Minister embarked on an effort to create a 25-year sustainable development plan for Andros as part of a national development planning process, Vision2040. The goal of the plan was to address Androsians' development needs while ensuring the sustainability of commercial and sportfishing industries, nature-based tourism activities, agriculture, and freshwater resources. In consultation with Androsians from each of the island's four districts, the Office of the Prime Minister, the Natural Capital Project, the University of The Bahamas, SEV Consulting Group, and the Nature Conservancy, with support from the Inter-American Development Bank, developed four future development scenarios and compared these scenarios by modeling ecosystem services (Government of The Bahamas 2017).

Financing Mechanisms Employed:

- Promising sources of funding include bonefishing fees, fines for environmental damage, grants from international organizations, a "Friends of Andros" fundraising program, cruise ship fees, and voluntary hotel surcharges.

Water Quality Issues at Andros

- Increased risk to freshwater as a result of expanded footprint of agriculture and development that coincides with critical water resources. The Government has invested heavily in the Bahamas Agriculture and Marine Sciences Institute (BAMSI) in the North District of Andros. In addition to the major agriculture investment in the north, Androsians throughout the island engage in smaller scale agriculture to supplement their income and nutrition as they face a high cost of living. However, there are worries that both BAMSI and other agricultural production could have negative impacts on the island's freshwater resources and other environmental services, through for instance unsustainable farming practices. Freshwater for drinking is plentiful in the north, but Androsians elsewhere (and especially in the south) frequently lack basic infrastructure to access freshwater to meet their most basic human needs and to support small business ventures. Given the permeability of the soils and parent rock and the close proximity of the freshwater aquifer to the land surface, these agrochemicals are readily leached into the freshwater lenses (U.S. Army Corps of Engineers 2004, Government of The Bahamas 2017).
- High vulnerability to climate change effects (sea level rise, flooding, erosion, extreme weather events, increased temperature) and to natural disasters due to geographic remoteness and lack of infrastructure and emergency response services.
- The nature of the geology and the lack of proper sewage collection and treatment are contributing to the contamination of groundwater. Natural disasters and severe weather, such as hurricanes, however, are probably the most threatening to the health of the freshwater reserves. Once polluted, groundwater is very expensive to clean up. Protecting the resource from contamination is preferable and more cost effective than remediation. Specific threats to the water supply quality include over-abstraction, physical disturbance, point-source pollution, solid waste disposal, disposal wells, underperforming septic tanks, abstraction wells, and diffuse pollution (U.S. Army Corps of Engineers 2004).
- For North Andros, the storm surge associated with Hurricane Frances increased chlorides in their trenches dramatically, from less than 400 mg/L about 3 months before Frances, to as much as 15,000 mg/L in some wellfields.
- Water is also subject to contamination with industrial and commercial effluents. The main pollutants from the agricultural industry are pesticides such as organochlorine pesticides and nicotinoids, metals, and agrochemicals such as nitrate, phosphate. Also, increasing soil erosion promotes run-off to the shores, affecting quality water in these areas. Urban sewage containing high amounts of organic matter along with self-care products, medicine and drugs represent a potential threat to water quality and directly affects mangroves and coral reefs.
- Only 3% of all sewage at Andros receives treatment. Urban solid wastes must be properly

managed to avoid the formation of lixiviats containing high amounts of elements and compounds that, given the geological context, could be transported to the aquifer and therefore polluting it.
- Tourism, a significant industry for the country, has serious impacts on the freshwater resources. The total number of visitors has been greater than 3 million annually for a number of years. Tourists consume an estimated 400 to 1,000 liters of water per person per day. This is in contrast to residential consumption of 150 to 200 liters per person.
- There are insufficient data and computer models of groundwater flows to account for the impact of sea-level rise on groundwater levels.
- Solid waste disposal and point source chemicals pollution are also becoming an increasingly serious issue. While some communities have lined landfill sites, the majority do not. The number of unlined dump sites and the frequency of indiscriminate dumping are increasing.
- The extent of freshwater resources is limited to very fragile freshwater 'lenses' in the shallow karstic limestone aquifers of Andros. The 'freshwater' is actually derived from precipitation, lying on top of the shallow saline water as a 'lens', less than 5 feet from the ground surface. Fresh surface water is basically non-existent. The country, therefore, relies on a single source of water. The need for regulating and protecting the water resources is essential. Regulating the resource through integrated groundwater management is recommended. Ignoring the over exploitation and protection will have severe repercussions, such as health issues from water-borne diseases and much greater water costs. The greatly increased cost of water will be due to treatment incurred as a result of groundwater contamination, from the necessity to use RO, and/or barging more water to meet demand. Failure to act will result in even higher costs being incurred. Proper land use planning and regulations, which are currently lacking, will play an important role in the protection of the resource. The formation of a new department, Department of Environmental Planning and Protection, is proposed by the Ministry of Health and the Environment, to regulate groundwater abstraction and pollution control. Regulation is justified in this case as the water situation in The Bahamas needs attention, and regulations and a regulatory body to address the situation do not currently exist. Current laws and regulations, particularly regarding land use and it's planning, governing the water lack clarity and are inadequate. Overall, groundwater should be treated as a strategic national resource (U.S. Army Corps of Engineers 2004).
- Saltwater intrusion due to over-extraction is already occurring on New Providence, the most populous island in The Bahamas, where the greatest water demands of the country exist. Sea level rise due to climate change will exacerbate the situation. The aquifers are very shallow, and are at great risk of becoming inundated with saline water even with a small rise in sea level. Less precipitation over the years in some islands due to climate change is also reducing freshwater availability
- Lack of wastewater treatment plants.
- Disposal of solid waste and plastic.
- Salinization of water.
- Increasing coastal development pollution due to sediment run-off.
- Harden seashore, artificial dikes, causeways, and poor road system.
- Non-native pine species invasion on mangrove habitats, impacting adjacent coastal ecosystems.
- Sedimentation of creek, which alters hydrology of mangrove areas.
- Roads affecting water flux.
- The tourism sector plan implemented pump out facilities for wastewater and containment facilities for hazardous and solid waste at marinas participating in the Blue Flag Programme, resulting in the protection of the coastal environment from pollution. An ecotourism plan for Andros was developed as an output of the Integrated Watershed and Coastal Areas Management Project (IWCAM). The Coastal Awareness Committee chaired by the Ministry of Tourism and Aviation assists in educating the public on the threats to the coastal environment and a manual for training birding guides is being developed.

Interventions Needed at Central Andros, Bahamas

A group of habitat restoration and pollution reduction experts identified interventions needed at Central Andros in consultation with key local actors and organizations and through a review of relevant literature.

Interventions Needed at Central Andros, Bahamas
Improve Water Quality and Reduce Pollution
• The need for regulating and protecting the water resources through integrated groundwater management is recommended.

- Develop an in-depth water quality monitoring program, particularly for non-registered private wells.
- Sustainable practices in agriculture, forestry, and fishing activities.
- Develop water conservation strategies and educational programs in coordination with local communities.
- Limit dredging and aggregate mining activities: Mining can become more environmentally sustainable by developing and integrating practices that reduce the environmental impact of mining operations. These practices include measures such as reducing water and energy consumption, minimizing land disturbance and waste production, preventing soil, water and air pollution at mine sites, and conducting successful mine closure and reclamation activities.
- Enforcement of protected area regulations.
- Investment in a wastewater treatment plant.
- Solid waste management improvement.
- Educational programming.
- Use of mangroves and seagrasses in a system built in series for the retention of pollutants and suspended solids that help the recovery of areas where there are coral reefs.

Preliminary Estimated Cost (USD):
- Groundwater and surface monitoring program: $1,500,000/year
- Tailings (by-product of mining) control and immobilization: $12,000,000 over 4 years
- Water pollution reduction: $10,000,000 over 3 years
- Wastewater treatment plant: $5,000,000 - $15,000,000 for 25 years, with initial building costs to be higher in the first 2-5 years, and costs subsiding as customers pay for services.
- In addition to the actual cost of installing and maintaining the sewer facility and water facility, funding is needed for long term implementation and management including working with the community for monthly payments, etc.

  TOTAL: $90,500,000 - $100,500,000 over 25 years

Blended Finance Model Elements:
- Municipal bonds and private investment to serve as matching support for development bank financing.
- Monthly service-based payments from customers.
- Mitigation banking associated with mining operations to support nature-based solutions to complement grey infrastructure.
- Reclamation funds from mining operations.
- Government support for monitoring and regulatory enforcement.
- Philanthropic support to support water quality monitoring efforts and citizen science engagement.

Restore / Rehabilitate / Conserve Seagrasses

- Work to sensitize and educate the local communities about the need to restore seagrass, mangroves, coral and better practices for activities.
- There is little to no data on seagrasses. In order to protect and conserve, we need to know what is present, which requires extensive seagrass mapping.
- Organization of routes to appreciate the coastal ecosystem.
- Conduct training workshops on restoration and monitoring.
- Develop a long-term monitoring program for the MPAs.
- Transplantation and expansion of areas of seagrass meadows affected by habitat degradation from fishing, tourism, hotels, and solid waste.
- Protect broader ecosystems by expanding and improving critical habitats.
- Install mooring fields to protect both seagrasses and corals, both in MPAs and adjacent to hotels that are located on the shoreline.
- Leverage ecotourism as an educational and public engagement tool for seagrass conservation.
- Improved fishing practices could ensure that seagrasses remain at low risk.
- Conservation and protection of key natural buffers such as coral reefs, seagrass, mangroves, wetlands, and coppice forests.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*

- Mapping and initial site surveys: $200,000 - $600,000
- Seagrass monitoring program (with citizen science participation): $50,000 - $100,000
- Restoration feasibility assessment and design: $200,000 - $550,000
- Partner coordination, permitting/permissions, and logistics: $100,000 - $250,000
- Training workshops and educational campaigns: $80,000 - $200,000
- Restoration project implementation: $600,000 - $2,800,000
- Mooring and navigation buoys (preventative): $60,000 - $300,000

  TOTAL: $1,290,000 - $4,800,000 over 5-10 years
  - Approximately 15-100 hectares of restoration and improved management / conservation (site and methodology dependent)
  - In addition, long-term monitoring, maintenance, and carbon credit reporting: $80,000 - $200,000 per year post-project execution.

Potential Blended Finance Model Elements:
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, water quality improvement, and natural infrastructure for storm protection and erosion prevention.
- Concessionary private capital in conjunction with philanthropic support to advance project certification to generate blue carbon credits.
- Additional value for biodiversity and climate resilience related certification (augments carbon credit value on voluntary market).
- Sale of blue carbon credits on the voluntary market post-certification (private capital).
- Volunteer engagement, specifically through ecotourism and diving industry, to provide in-kind support.
- Engage local resorts to seek support for mooring buoys and other preventative / conservation measures.
- Establish boater behavior change programs supported by marina user fees.

Restore / Rehabilitate / Conserve Mangroves

- Reduce the total area of mangroves at high risk from human activities.
- Work to sensitize local communities about the need to protect mangroves. Why these habitats are important for their food security, security of their properties, security of their health, and in general beneficial for their well-being.

- Organize tourism routes to build appreciation for the estuarine and coastal ecosystems.
- Remove exotic pine species.
- Create dispersion centers for mangroves, conduct hydrological restoration of areas affected by deforestation and sedimentation. Implement exclusion zones for critical habitats, and conduct coastal modification, if necessary, to return hydrology to the system.
- Identify the local key actors to strengthen their capacities in terms of ecosystem conservation and restoration through practical workshops.
- Leverage ecotourism as an educational and public engagement tool for mangrove conservation.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*
- Feasibility assessment and restoration plan development: $300,000 - $800,000
- Partner coordination, permitting/permissions, and logistics: $150,000 - $350,000
- Training workshops and educational campaigns: $80,000 - $400,000
- Restoration project implementation (which may include soil elevation, increased flow, population enhancement): $800,000 - $3,200,000
- Mangrove management (monitoring, management, and policy enforcement): $120,000 - $300,000

  TOTAL: $1,450,000 - $5,050,000 over 4-7 years
  - Approximately 80-320 hectares of restoration and improved management / conservation (site and methodology dependent). See Figure 39 below for the priority area.
  - In addition, long-term monitoring, maintenance, and carbon credit reporting of $50,000 - $150,000 per year post-project execution.

Potential Blended Finance Model Elements:

- Philanthropic capital and development bank support (complementing existing efforts) to advance project certification to generate blue carbon credits.
- Additional value for biodiversity and climate resilience related certification (augments carbon credit value on voluntary market).
- Sale of blue carbon credits on the voluntary market post-certification (private capital and potentially government support).
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, water quality improvement, and natural infrastructure for storm protection, flood mitigation, and erosion prevention.
- Mitigation banking associated with mining operations to support pollution remediation and hydrological improvements at restoration sites.
- Volunteer engagement, specifically through ecotourism, to provide in-kind support.

Restore / Rehabilitate / Conserve Coral Reefs

- Work to sensitize local communities about the need to protect corals.
- Work with fishing communities on sustainable fishing and connect with Fair Trade markets.
- Establish minimum fishing sizes, exclusion zones, observance of closures, and use of seasonal supply.
- Conduct coral restoration and gardening.
- Host solid waste and microplastics workshops on the impact to the reef habitat.
- Divert marine transportation routes from the coral reefs to reduce the risk of degradation from pollution and anchoring.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*

- *Water quality – see estimated actions and budget above .*
- Stony Coral Tissue Loss Disease Response Plan and actions, which depends on future impacts of SCTLD in Andros: $100,000 - $500,000 per year or more for 10 years depending on severity of disease--note SCTLD has caused a loss of 30-90% coral cover of highly susceptible species in some other areas.
- Coral restoration planning phase: $50,000 over 1 year.
    - Project Phase 1 – Site preparation, coral restoration, grazer enhancement, monitoring, maintenance, adaptive management (cost to be determined, but in the Florida Keys the projected cost is $100,000,000 for 7 reefs over 5-7 year timeframe).
    - Project Phase 2 – Site preparation, coral restoration, grazer enhancement, monitoring, maintenance, adaptive management to be determined.
- Training of restoration personnel: $100,000 in Year 1 and $25,000 per year for 5 years.
- Outreach and education, including workshops on microplastics: $150,000 per year for 10 years.

TOTAL: $12,225,000 - $76,775,000 over 10 years

- Approximately 60-700 hectares of restoration and improved management / conservation (site and methodology dependent)

Potential Blended Finance Model Elements:

- Global Fund for Coral Reefs, which may include a blend of traditional grant funding, development bank financing, and program related investments (PRIs).
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, and natural infrastructure for storm protection.
- Volunteer engagement, specifically through ecotourism, to provide in-kind support.
- Corporate sponsorship, in-kind support, and media promotion.
- Certification for biodiversity and resilience credits to be traded on voluntary markets.

Fig. 39 | Potential areas for mangrove restoration in Central Andros 120,000 ha, in Stainard Creek, 690 ha. Source: Source: Jorge A. Herrera-Silveira (2020).

Key Beneficiaries

- Considering the numerous sectors that operate in Andros, an important first step will be development of a marine spatial plan that will address future conflicts and encourage enhanced management of the space
- Andros Island has a very low population and the main key beneficiaries are the agriculture, tourism, fishing, and development sectors. Reduction of pollution and a wastewater treatment plant could benefit the health of the population and its ecosystem tremendously.
- Commercial fisheries in Andros (including crab, sponge, lobster, queen conch) generate US$70,000,000 in revenues each year, which provides food and income for many people and households.
- The ecosystems, species, and landscapes of Andros represent a huge ecological and economic endowment for the people of Andros, The Bahamas, and the Wider Caribbean Region.
- Tourism is recognized as one of the most economically important factors in Andros. Climate change will affect tourism directly and indirectly due to loss of beaches to erosion and inundation, increasing stress on coastal ecosystems, and damage to coastal infrastructure from storm events. Such impacts will threaten the long-term sustainability of the tourism industry.
- The largest community is Fresh Creek, in Central Andros. Human activities on the island are mainly related to agriculture, tourism, fishing, and general development, with some employment by the government, the Atlantic Undersea Test and Evaluation Center (part of the U.S. navy) and the water company. Options for employment are therefore relatively limited.
- The sustainable management of dumps/landfills and sewage will be key to the health of Andros. Best practices will be put in place for the sustainable management of landfill/dump sites and that illegal dumping be penalized and better enforced. The recycling of a greater number of types and volumes of waste should be introduced. It is also recommended that locations be designed and designated as solid waste disposal locations and pump trucks be available at all districts.
- A National Plan of Action for Pollution that documents major pollution sources would be a useful and important document to inform national pollution reduction strategies and action plans.

Risk and Reward of Carrying Out Interventions

Experts estimated the “risk” (i.e. likelihood of success, longevity) on a scale from 1 to 10 (in which 10 represents extremely high risk) and “reward” (i.e. extent/nature of benefits) on a scale from 1 to 10 (in which 10 represents extremely high reward).

<u>Risk Estimate</u>

Risk score: 5/10

The importance of this island to the country of The Bahamas and to the WCR, in particular when it comes to the nation’s water resources, creates widespread attention and concern for the health of its ecosystems and protection of natural resources. For this reason, a great number of NGOs, local and national government agencies, and private stakeholders have taken significant interest in the preservation, restoration, and sustainable management of this island. The poor coordination between local and national government, however, is a concern as is the continued reactive planning resulting in continued loss of infrastructure and natural resources from the effects of climate change (Hurricane Frances and Jeanne in 2004, for example). The risk is medium-low given that the problems facing the site have been identified and the intervention alternatives are feasible to implement.

<u>Reward Estimate</u>

Reward score: 9/10

Andros’ natural resources generate millions in direct revenues each year and employ the vast majority of the population either full or part-time. Natural resources such as marine resources, forests, and land appropriate for agriculture are relatively vast in comparison with other islands in The Bahamas. There are many development opportunities in areas of forestry, high end and boutique hotels, fisheries, agriculture, and more. However, policies must be put into place that ensure the local communities are able to directly benefit from projects. Environmental degradation in the Caribbean means that natural resources on Andros are likely to become more valuable if they are properly protected. Conversely, the potential losses in values and the loss in income, jobs and welfare could be enormous, if effective conservation actions are not implemented. Current and emerging threats in Andros include unchecked development (involving pollution, dredging, and indiscriminate habitat clearing), overfishing, invasive species, sewage, climate change, and ocean acidification. Conservation projects are urgently needed to avoid this outcome and even to increase the value of the island's natural resources.

Protected Area(s) at Site

The Bahamian archipelago and its surrounding waters encompass more than 2000 km² of seagrass and 700 km² of mangroves. The habitats on and around Andros are home to 37% and 14% of the country's mangrove and seagrass habitat, respectively. Approximately 60% of the total Andros mangroves are located in protected areas. Five protected areas on Andros Island are listed below in Table 32 (also see Figure 40).

Protected area name	***Size in ha***	***IUCN category***	***Type***
Blue Holes National Park	16,187	II (National Park)	Terrestrial with freshwater
Crab Replenishment Reserve	1,619	VI (Protected Area with Sustainable Use of Natural Resources)	Marine & Terrestrial
North Marine Park	2,023	VI (Protected Area with Sustainable Use of Natural Resources)	Marine & Terrestrial
South Marine Park	1,416	VI (Protected Area with Sustainable Use of Natural Resources)	Marine
West Side National Park	607,028	II (National Park)	Marine & Terrestrial

Table 32 | *Protected areas on Andros Island, Bahamas. Source: Marine Conservation Insitute: Marine Protected Atlas (2020).*

There is a need to protect more areas to ensure the resilience of the system and the connectivity between them. As Andros tourism and population increases over time, many of its protected areas would benefit from improvements in management. About 60% of Andros mangroves are protected, but this is the most preserved mangrove island in the Caribbean. However, there is a need to protect more areas to ensure the connectivity of the area. It is possible a RAMSAR site could be proposed.

Fig. 40 | Map of Andros National Parks. Source: Agnessa Lundy (2020).

The following interventions could help establish new or improve existing protected areas:

- Work with local authorities and universities to select new protected areas to ensure the longevity of the project after the restoration is completed.
- Improve scientific monitoring efforts, training, and availability of equipment.
- Improve or propose new MPAs, an analysis of the current ones and their programs is required first, as well as a regional study to complement the analysis. However, *a priori* we suggest improving the management of existing ones.

Costs associated with these interventions include:

- Informational/educative signage: US$2,000,000
- Administrative Implementation of exclusion zones. Aids to navigation markers, mooring buoys: US$20,000,000
- Scientific research, characterization diagnosis selection of indicators including analysis of the

society-nature state of the current protected coastal areas: US$16,000,000

- Scientific: Regional study of central Andros and mangrove kay to identify potential sites to propose them as a new protected coastal area: US $10,000,000

Local Training and Capacity Building at Site

The following is a list of capacity building needs and costs at Andros:

- Fishermen training workshops, training of Marine Rangers (US$20,000,000)
- Maintenance of park network
- Ecotourism workshops (US$5,000,000)
- Improve technology and equipment expanded laboratory access (US$15,000,000)

Econometric Studies Specific to This Region

The Nature Conservancy's Mapping Ocean Wealth Program produced a "Modelled Total Dollar Value of Reef Tourism (per km²)" and valued between up to US$4,000 and greater than US$492,000/ km² for Central Andros (Figure 41). The value of coral reefs per year for Bahamas is $516,478,000. Other relevant econometric studies include:

- An Economic Valuation of the Natural Resources of Andros Islands, Bahamas. By Venetia Hargreaves-Allen (PhD) of the Conservation Strategy Fund for The Nature Conservancy, August 2010. http://www.globalislands.net/userfiles/bahamas_4.pdf

<<"*Andros generated $155.6 million in direct economic revenue (2015 dollars), including $52,000 from fishing and roughly $25,000 from crabbing and sponging (Hargreaves-Allen 2010). The habitats on Andros provide an estimated mean of $46,000 per km² per year in ecosystem services, such as carbon storage, water supply, and recreation. Commercial fisheries in Andros (including crabbing and sponging) generate $70 million in revenues each year, which provides food and income for many people and households. Nature based tourism activities (including accommodation, bone fishing, and diving) constitute $43.6 million in revenues each year in Andros.*

Environmental degradation in the Caribbean means that natural resources on Andros are likely to become more valuable if they are properly protected. Conversely, the potential losses in values and the loss in income, jobs and welfare could be enormous, if effective conservation actions are not implemented. To establish a basic level of sustainable management of these habitats, initial funding of $1.62 million is needed, which is equivalent to 0.6% of the economic benefits and 1% of the gross revenues this island's ecosystems produce each year.">>

- Arkema, Katie & Rogers, Lauren & Toft, Jodie & Mesher, Alex & Wyatt, Katherine & Albury-Smith, Shenique & Wells-Moultrie, Stacey & Ruckelshaus, Mary & Samhouri, Jameal. (2019). Integrating

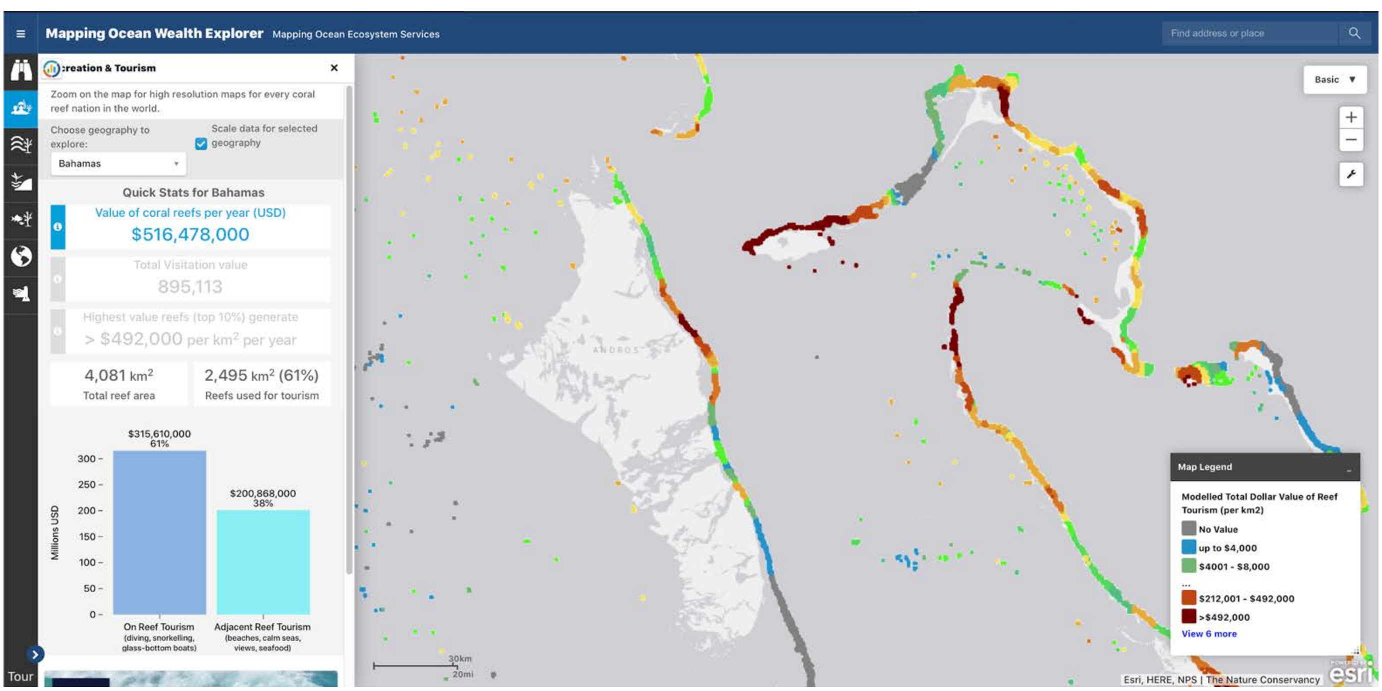


Fig. 41 | Modelled Total Dollar Value of Reef Tourism (per km²) for Bahamas with a close-up view of Andros. Source: http://maps.oceanwealth.org (2020).

fisheries management into sustainable development planning. Ecology and Society. 24. 10.5751/ES-10630-240201.

Aspects to Consider When Developing Investment Plan
The Government of The Bahamas has endorsed biodiversity conservation. It has recognized that the environment is critically important to the economy and well-being of all generations of Bahamians. As a result of this policy, the Government has begun to incorporate the protection and enhancement of the environment and biodiversity into the national planning process. To facilitate this process, the Government created the Bahamas Environment, Science, and Technology (BEST) Commission in 1995, passed important environmental legislation, and is actively reviewing international agreements on environment and natural resources.

The government of The Bahamas is collaborating with coastal communities and various public and private sector stakeholders. The goal was to design a master plan for Andros that identifies investments in development and zoning guidelines that harness the island's natural assets without harming ecosystems that underlie its economy and sustain human well-being. One of the pillars of the plan is to leverage the protective capacity of ecosystems to enhance coastal resilience and climate adaptation (Government of The Bahamas 2017).

The complex structural conditions associated with old-growth forests results in enhanced provision of ecosystem services such as clean water, clean air, and sequestration of carbon, relative to those provided by younger, less complex forests. The old-growth pine forests on South Andros are also apt to be more resilient in the face of disturbances, such as hurricanes, because of the presence of a range of age classes of pines. In contrast, the second-growth pine forests supported relatively few young individuals, and thus they will be slow to recover from any widespread loss of canopy trees. Clearing for agricultural development will not only eliminate large areas of this globally unique forest, but it will fragment and degrade even those remaining stands of old-growth pine that are left untouched. Sustainable agriculture development that does not negatively affect freshwater supply and existing economic activities while reducing the use of pesticides and fertilizer should be considered.

Hurricanes and pollution are the major problem that could affect the investment plan. If damaged mangrove habitats are not restored both the seagrass and mangrove communities will suffer and the ecological services will be diminished, especially in tropical ecosystems with high connectivity.

Andros Island has four airports with paved runways: San Andros Airport at Nicholls Town, Andros Town International Airport located at Fresh Creek, the Clarence A. Bain Airport at Mangrove Cay and Congo Town Airport in South Andros. Andros Town International is an international port of entry for private pilots.

The existing port at Morgan's Bluff, the main port for North Andros. The only well-developed area is around Nicholl's Town and Lowe Sound (the fishing center). The area around BAMSI is somewhat developed for agriculture. It should be limited in development with a bus service providing access to the nearby area of Nicholl's Town. The master plan indicates that development should be limited to the expansion of BAMSI and essential areas for farmers. The area at Red Bays Road and the Queens Highway Junction should be developed as an industrial area with packing houses etc. There is already a packing house at this location which is ideal given that it is located in between the airport and the port at Morgan's Bluff and close to the main town, agricultural center, and fishing center. Expansion of this area should incorporate agri-tourism that can be captured thanks to tourists visiting the Red Bays Heritage Centre/Village. There are only septic tanks and they could pollute the nearby water. From Nicholls Town in the north to Little Creek in the south are 35–40 hotels, motels, resorts, guest houses and lodges (the number varies), with a total of approximately 400 rooms.

Andros Town and Cargill Creek are the main administrative and residential areas. We expect that future developments should be focused on high ground and away from the coast. Consideration should also be given to reviewing the width of the right of way for Andros' main roads and bridges, in particular to accommodate multi-lane traffic, central reserves with lighting, drainage, bus stops, cycle paths and sidewalks in the future. The existing port facilities at Fresh Creek should be improved and a recreational marina created to offer a better experience to tourists and boaters. Fresh Creek should become the maritime port of entry to the district and its tourism center, providing easy access and day-trips to all the protected areas to be visited, and to all nature-based activities available. The harbor should provide a Tourist Information Center, some grocery shops and restaurants. It should be easily linked with Andros Town. Andros Town and Cargill Creek centers should be planned to focus shops into a single area such as a mini mall with parking and adequate space for future expansion and to locate a main grocery store. Plans should be such that green spaces are incorporated and clearing of sites limited. A bus service should be developed to link the town centers of Cargill Creek and Andros Town with Fresh Creek and the different protected areas. All the infrastructure above mentioned is and will be compromised during flood, hurricane, and climate change impacts. Mangrove and seagrass restoration will reduce the risk of losing these assets.

Site #3: La Guajira, Colombia

Background
Colombia's Caribbean coastline is long and diverse, stretching from the wild, rainforest covered border with Panama to the arid La Guajira Peninsula on the border with Venezuela. Home to ten million people, the Colombian Caribbean is made up of sandy beach and coastal dunes but also hosts many inlets where seagrass beds and mangrove wetlands abound.

La Guajira Peninsula is 250 km long and characterized by high peaks along the littoral zone and large expanses of tropical desert landscape along the coastal plain. Due to its location just south of the Atlantic trade winds it receives very little precipitation and sees extremely high heat year-round. The peninsula's isolation and low population density has spared many of its coastal habitats to date. However, the Colombian coastal region is one of the fastest growing in the country. The established indigenous Wayuu population is feeling the effects of this growth and is demanding protection of its delicate coastal habitats.

La Guajira is home to El Cerrejón, the largest open-pit mine in Latin America. The mining company, Cerrejón, is independently operated and belongs in equal parts to subsidiaries of the international mining companies BHP, Anglo American and Glencore. The Cerrejón extracts coal from open pits in the region of La Guajira and is considered a "giant which does not stop working," due to the fact that the mine operates 24 hours a day, 364 days a year, in order to comply with a daily production of 100,000 tonnes of coal, producing more than 32 million tons of coal per year.
Mining and transportation along railroads also owned by the company emit fine particles called PM 2.5, invisible to the human eye. This pollutant can cause asthma, respiratory illnesses, heart disease, hypertension and cancer, skin and eye damage, miscarriages and premature births. These pollutants however have only been measured since 2018, after the mine had already been operating for 35 years. The Cerrejón mine is also the largest water polluter in the region. The company not only diverts and uses a large number of streams and tributaries, but also pours back water contaminated with heavy metals and chemicals such as Ni, Zn, Sr, Ba, Cu, Mn, Se, Ba, and Sr.

Scores for La Guajira using the methodology presented in Part I of this report are as follows:

La Guajira, Colombia
Structure: 16
Function: 16
Ecosystem Services: 16
Feasibility: 16
Threat Abatement: 15
TOTAL: 79

Key Goals, Challenges, and Stakeholders for La Guajira, Colombia
A group of habitat restoration and pollution reduction experts identified key goals, challenges, and stakeholders for La Guajira in consultation with key local actors and organizations and through a review of relevant literature.

Key Goals, Challenges, and Stakeholders for La Guajira, Colombia
Key Goals
• Restore the ecosystem in areas affected by habitat degradation, tourism, and solid waste disposal. • Implement better management practices for handling and disposing pollutants from the Cerrejón Mine. • Improve basic infrastructure such as sewage systems, wastewater treatment, and sanitation.
Key Challenges
• Interaction with the Wayuu community on the importance of protecting the ecosystem. • Sensitization and limited awareness by the fishing community regarding the sustainable management of resources. Illegal fishing and aggressive practices in insular ecosystems lead to overexploitation and environmental deterioration. • Alignment of local, national and international efforts in conservation with the uses and customs of local indigenous communities. • Implement mangrove restoration actions that are NOT related to the construction or maintenance of nurseries. • The department of La Guajira is suffering greatly as a result of large mining operations, the altering of rivers and streams, and the damming of major sources of water leading to the aquifers drying up. These more recent changes are causing scarcity and food security issues for the population, leading to severe cases of malnutrition, affecting mainly children and gestating mothers.

- The main issue with Colombia's governance feasibility is often the translation of (national) policies into concrete (regional and local) action, namely the execution of prevailing laws.
- The deterioration and destruction of mangroves have been accelerated due to the increase in industrialization through the expansion of the Cerrejón Mine and overall urbanization.

Key Stakeholders
• The Departmental Environmental Authority (Corporación Autónoma de la Guajira) • Ministry of Environment and Sustainable Development • Municipalities of Dibulla, Riohacha, Manaure, and Uribia • La Guajira Department • Local Indigenous Associations • Association of Artisanal Fishermen • Indigenous community in general • INVEMAR • Conservation International • Although the industrial exploitation of the Cerrejón mines was initially a business managed by the Colombian State, at present, the Government is not part of the shareholder structure of either of the two companies that comprise it. The state participation (represented through Carbocol with 50% of the company) lasted until 2001 when its components were sold to Sociedad Cerrejón Zona Norte S.A. Cerrejón currently includes two operations: Carbones del Cerrejón Limited and Cerrejón Zona Norte S.A. • The multinationals BHP Billinton, Anglo American, and Xtrata • RICO (Network for Community Initiatives) • Colombia Solidarity Campaign • TerraJusta

Historic and Current Work at La Guajira

There are a number of funders, organization, programs, and financing mechanisms operating at the site:

- At an international level, Conservation International supports work in terrestrial ecosystems, as it is an area susceptible to desertification.
- Since 2019, the German Agency for International Cooperation (GIZ) with the regional environmental corporation Corpoguajira has been carrying out a project for education and sustainability of the Bahía Portete natural reserve area, Bahía Honda y Hondita.
- The regional environmental corporation Corpoguajira initiated a seagrass management plan (not implemented) and there is an exclusive regulated area for artisanal fishing.
- The pilot project, "Restoration of mangrove ecosystems in La Guajira" led by INVEMAR aims to define the ecological restoration guidelines in two mangrove sectors: the Musichi Integrated Management District, and the Los Flamencos Fauna and Flora Sanctuary. This project is supported by PETROBRAS.
- Different experimental studies and pilot projects for the restoration of mangroves have been developed, as well as analysis of the perception of the inhabitants and the role of environmental education in the conservation of the mangroves of the Guajira region.
- The Cerrejón Company is one of the companies that are assisting in the development of the United Nations' guiding principles about companies and human rights (Cerrejón 2014); however, these guiding principles have been insufficiently enforced in the Guajira region to date.

Financing mechanisms employed:

- There is payment for environmental services (PES) for regional terrestrial ecosystems, but it has not yet been implemented for marine ecosystems.
- The La Guajira Water and Sanitation Infrastructure and Service Management Project sought to strengthen the institutional performance of municipal public companies by involving the private sector in service delivery. The integration of specialized operators (SOs) in service provision is an approach the World Bank had previously supported in Colombia. The capital investment financed by the World Bank created an enabling environment that attracted private SOs which, in turn, facilitated their engagement in developing infrastructure and improving utilities' institutional performance. The World Bank, through the International Bank for Reconstruction and Development (IBRD), provided US$71.4 million

toward the total project costs of US$139.6 million. The Bank's contribution of international expertise, best practices, and relevant lessons learned supplied critical support to Colombia's government for delivering the project and achieving the desired results in the Department of La Guajira's complicated operating environment. The project contributed to leveraging an additional US$68.2 million in counterpart financing, drawn from a mix of national and local resources.

Water Quality Issues at La Guajira

Mining presents a major threat to water quality in the region. Toxic substances from the Cerrejón mine expel as a result of the washing of its tanks and vehicles that flow into the rivers when it rains. These are inorganic chemical substances such as acids and toxic metal compounds (including mercury and lead) poison the water, while sediments or suspended matter such as insoluble soil particles create more turbid conditions.

Mining also represents a serious problem for the permanence of the aquifers: the flows of water to the mining pits--coming to the surface and being extracted by pumping from the mining front--produce abatement of the levels of the water table at the local level and, depending on the scale of mining, also at the regional level. In addition, there is contamination by mixing with poor quality water, re-direction of flows and drying of aquifers, and the disappearance of springs due to excavations carried out in underground mining.

Additional water quality issues include:

- Discharge of wastewater from the main urban centers: Riohacha, Manaure and Dibulla.
- Disposal of solid waste.
- Seasonal incidence of upwelling.
- Inadequate management of runoff and rainwater from the coal mine dumps.
- Contamination of surface and groundwaters by wastewater from mineral deposits, dumps, and coal storage yards.

Interventions Needed at La Guajira, Colombia

A group of habitat restoration and pollution reduction experts identified interventions needed at La Guajira in consultation with key local actors and organizations and through a review of relevant literature.

Interventions Needed at La Guajira, Colombia

Improve Water Quality and Reduce Pollution

- Improve basic infrastructure such as sewage systems, wastewater treatment and sanitation.
- Solid waste management improvement. Move solid waste collection sites to areas far from the coast.
- Integrated solid waste management, including waste sorting and recycling.
- Use of constructed wetlands for tertiary treatment and water pollutants.
- Use of mangroves and seagrasses in a system built in series for the retention of pollutants and suspended solids that help the recovery of areas where there are coral reefs.
- Create better management practices during each stage of mining operations to reduce environmental pollution and improve overall water quality in the area.
- Dispose of the liquid waste generated in the mining project in an adequate and sanitary manner.
- Establish a sensor system for monitoring the quality and quantity of surface water.
- Implement procedures inside the facilities where industrial liquid waste is generated, within the concepts of cleaner production.
- Optimize liquid waste management processes in workshops, powder magazines and fuel stations in order to reduce polluting loads and maximize the use of water wherever it can be reused.

Preliminary Estimated Cost (USD):

- Groundwater and surface monitoring program: $1,000,000-$2,000,000/year for 10 years
- Tailings control and immobilization, improved: $12,000,000-$24,000,000
- Water pollution reduction: $5,000,000-$20,000,000
- Greywater recycling and water conservation measures: $1,000,000-$10,000,000
- Deploy nature-based solutions at margins of contaminated sites (like bio-retention ponds, riparian vegetation, wetlands for nutrient cycling, etc.): $500,000-$4,500,000

TOTAL: $28,500,000 - $78,500,000 over 10 years

Blended Finance Model Elements:

- Mitigation banking associated with mining operations to support nature-based solutions to complement existing grey infrastructure.
- Reclamation funds from mining operations.
- Philanthropic and government support for pollution remediating nature-based solutions.
- Government support for monitoring and regulatory enforcement.
- Philanthropic support to support water quality monitoring efforts and citizen science engagement.

Restore / Rehabilitate / Conserve Seagrasses

- Work to sensitize and educate the local communities about the need to protect seagrasses
- Organization of routes to appreciate the seagrass ecosystem. Training workshops on restoration and monitoring. Develop a long-term monitoring program.
- Transplantation and expansion of areas of meadows affected by habitat degradation from fishing, tourism and solid waste. Implementation of exclusion zones, critical habitats and coastal modification if necessary.
- The monitoring of surface water and rehabilitation of river ecosystems that transport pollutants from the mine to the most extensive meadows of seagrass in the country, along the 340 kilometers of coastline, will help protect many species of marine invertebrates and vertebrates.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*

- Initial site surveys and review of management plan: $50,000 - $250,000
- Seagrass monitoring program (with citizen science participation): $50,000 - $100,000
- Restoration feasibility assessment and design: $150,000 - $400,000
- Partner coordination, permitting/permissions, and logistics: $60,000 - $180,000
- Training workshops and educational campaigns: $50,000 - $150,000
- Restoration project implementation: $300,000 - $1,500,000
- Mooring and navigation buoys (preventative): $30,000 - $200,000

  TOTAL: $690,000 - $2,780,000 over 5-10 years
  - Approximately 5-40 hectares of restoration and improved management / conservation (site and methodology dependent).
  - Plus long-term monitoring, maintenance, and carbon credit reporting: $40,000 - $120,000 per year post-project execution.

Potential Blended Finance Model Elements:

- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, water quality improvement, and natural infrastructure for storm protection and erosion prevention.
- Concessionary private capital in conjunction with philanthropic support to advance project certification to generate blue carbon credits.
- Additional value for biodiversity and climate resilience related certification (augments carbon credit value on voluntary market).
- Sale of blue carbon credits on the voluntary market post-certification (private capital).
- Adapt payment for environmental services (PES) program for coastal ecosystems (building on existing terrestrial program).
- Volunteer engagement, specifically through ecotourism and diving industry, to provide in-kind support.
- Engage local resorts to seek support for mooring buoys and other preventative / conservation measures.

Restore / Rehabilitate / Conserve Mangroves

- Work to sensitize local communities about the need to protect mangroves. Why mangroves are important for their food security, security of their properties, security of their health, and in general beneficial for their well-being.
- Organization of tourism routes to appreciate the mangrove ecosystem.
- Transplantation and expansion of mangrove areas affected by logging, sedimentation, and solid waste. Implementation of exclusion zones, critical habitats and coastal modification if necessary, to return hydrology to the

system.
- Works to protect the seedlings from goats.
- Identify the local key actors to strengthen their capacities in terms of mangrove conservation and restoration, this through practical workshops.
- Promote alternative livelihoods and conduct a public awareness program that can help drive local people away from logging and towards new employment opportunities thus preventing further deterioration of mangrove ecosystems.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*
- Public awareness campaign: $100,000 - $400,000
- Feasibility assessment and restoration plan development: $500,000 - $900,000
- Partner coordination, permitting/permissions, and logistics: $100,000 - $200,000
- Restoration training workshops: $40,000 - $120,000
- Restoration project implementation (which may include soil elevation, increased flow, population enhancement): $1,500,000 - $4,500,000
- Mangrove management (monitoring, management, and policy enforcement): $250,000 - $500,000

TOTAL: $2,490,000 - $6,620,000 over 5-8 years
  - Approximately 150-450 hectares of restoration and improved management / conservation (site and methodology dependent).
  - Plus long-term monitoring, maintenance, and carbon credit reporting $80,000 - $160,000 per year post-project execution.

Potential Blended Finance Model Elements:
- Philanthropic capital and development bank support (complementing existing efforts) to advance project certification to generate blue carbon credits.
- Additional value for biodiversity and climate resilience related certification (augments carbon credit value on voluntary market).
- Sale of blue carbon credits on the voluntary market post-certification (private capital and potentially government support).
- Adapt payment for environmental services (PES) program for coastal ecosystems (building on existing terrestrial program).
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, water quality improvement, and natural infrastructure for storm protection, flood mitigation, and erosion prevention.
- Mitigation banking associated with mining operations to support pollution remediation and hydrological improvements at restoration sites.
- Volunteer engagement, specifically through ecotourism, to provide in-kind support.

Restore / Rehabilitate / Conserve Coral Reefs

- Outreach with local communities about the need to protect corals.
- Work with fishing communities on sustainable fishing and connect with Fair Trade markets.
- Establish minimum fishing sizes, observance of closures and use of seasonal supply. Create exclusion zones for critical habitats.
- Conduct coral restoration and underwater coral farming.
- Address the toxic substances that the Cerrejón mine expels as a result of the washing of its tanks and vehicles that flow into the rivers when it rains. These include inorganic chemical substances such as acids, toxic metal compounds (mercury, lead), poisoning the water, sediments or suspended matter such as insoluble soil particles that cloud the water, and that are the major source of contamination. The interventions done at the source of these toxic substances, during mining operations, will help rehabilitate and conserve corals.

Preliminary Estimated Cost (USD): *cost increases with project size / scope*
- *Water quality – see estimated actions and budget above.*
- Coral restoration planning phase: $50,000 over 1 year.
- Project Phase 1 – Site preparation, coral restoration, grazer enhancement, monitoring, maintenance, adaptive management (cost to be determined, but in the Florida Keys the projected cost is $100,000,000 for 7 reefs over 5-

7 year timeframe).
- Project Phase 2 – Site preparation, coral restoration, grazer enhancement, monitoring, maintenance, adaptive management to be determined.
- Training of restoration personnel: $100,000 in Year 1 and $25,000 per year for 5 years.
- Outreach and education: $100,000 per year for 10 years.

TOTAL: $11,275,000 - $51,275,000 over 10 years
- Approximately 50-250 hectares of restoration and improved management / conservation (site and methodology dependent)

Potential Blended Finance Model Elements:
- Global Fund for Coral Reefs, which may include a blend of traditional grant funding, development bank financing, and program related investments (PRIs).
- Philanthropic support to fund habitat restoration, conservation, and enhancement for fisheries, ecotourism, and natural infrastructure for storm protection.
- Mitigation banking associated with mining operations to support coral restoration.
- Volunteer engagement, specifically through ecotourism, to provide in-kind support.
- Corporate sponsorship, in-kind support, and media promotion.
- Certification for biodiversity and resilience credits to be traded on voluntary markets.

Key Beneficiaries
The most direct beneficiary of the interventions is the Cerrejón mine itself because the interventions will not only improve the public perception of the mine, but the interventions will also improve its overall operation by adapting better practices designed to avoid further water quality degradation. The local population of the Guajira department will also be benefiting from this as well as the Caribbean at large since many of the rivers found carrying the pollutants from the mine discharge directly into the sea.

The Wayuu Aboriginal Community is dispersed throughout the Middle and Upper Guajira, forming family groups known as Rancherías found in the municipalities of Dibulla, Riohacha, Manaure and Uribia (Figure 42). The main focus is the coastal ranches and their economic activity is fishing.

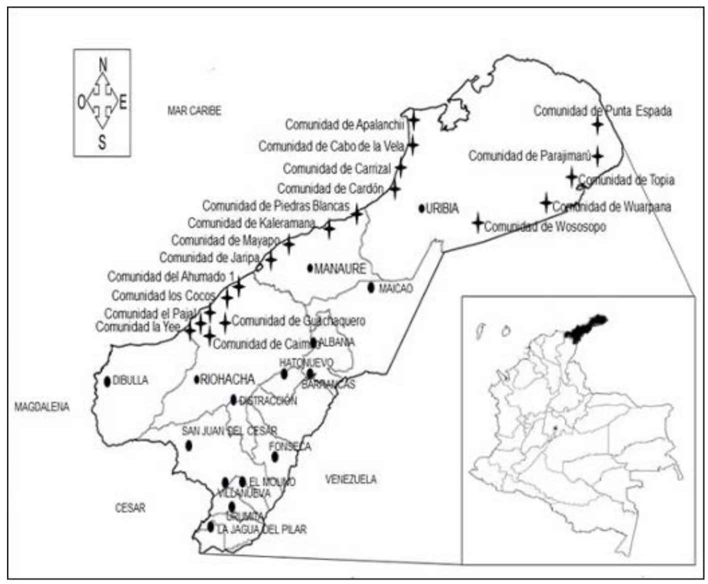


Fig. 42 | Main communities in the coastal zone of La Guajira. Source: Daza-daza et al. (2018)

Risk and Reward of Carrying Out Interventions
Experts estimated the "risk" (i.e. likelihood of success, longevity) on a scale from 1 to 10 (in which 10 represents extremely high risk) and "reward" (i.e. extent/nature of benefits) on a scale from 1 to 10 (in which 10 represents extremely high reward).

Risk Estimate
Risk score: 6/10
La Guajira region includes areas of dry tropical forest in an already water-stressed ecosystem. Precarious access to water is made even worse by the lack of basic infrastructure such as water and sanitation and the presence of the coal mine. Mining activities have affected the socio-cultural fabric of the communities through the eviction and resettlement of nearby populations. The political tension in the region has led to civil unrest in recent times. Longevity of the interventions will depend on the presence of the government agency in the region and the involvement by community members.

Reward Estimate
Reward score: 9/10
Having better management practices and a significantly lower environmental impact will allow the mine to continue expanding their operations in a more ecologically responsible way, while at the same time greatly improving the social and economic conditions of the public and easing the tensions between the two. The interventions would generate high benefits to a vulnerable social group. These benefits are in the sustainability of ecosystem services, protection of the coastline, food security (fishing) and the possibility of beneficial fixation through blue carbon.

Protected Area(s) at Site
La Guajira is home to 80.2% of Colombia's seagrass beds, 3,131 hectares of mangroves, and 151.8 km² of coral reefs and protected areas in the region aim to protect these ecosystems (Table 33).

Protected Area	Total Hectares	Ecosystem
Sawäirü (área de manejo especial)	66,000	Praderas Pastos-Octocorales
Parque Nacional Bahia Portete-Kaurrele	14,080	Paraderas, Corales, manglares
Distrito de Manejo Integrado del Delta del Río Ranchería	3,600	Manglares
Santuario de Flora y Fauna Los Flamencos	7,700	Manglares

Table 33 | *Protected areas in the La Guajira region, total hectares of the area, and the ecosystems protected. Source: University of La Guajira (2020).*

While an increase in area protected is important, perhaps more important is to develop a regional management plan (master plan) for coastal habitats and a specific plan according to the activities carried out in each locality, following the approach relationship between the ecosystem functions and the environmental services. The following activities could help improve existing protected areas:

- Post informational signs: US$2,000,000
- Implement exclusion zones with navigation markers and mooring buoys: US$20,000,000
- Analyze the society-nature state of the current protected coastal areas: US$5,000,000
- Regional study of La Guajira to identify potential sites to propose them as a new protected coastal area: US$10,000,000

Local Training and Capacity Building at Site
The following is a list of capacity building needs at La Guajira:

- Conduct fisher and marne ranger training workshops.
- Establish an ecosystem monitoring program with autonomous monitoring teams and a Marine Research Center for La Guajira.
- Involve restoration experts and international advisers.
- Conduct restoration workshops series (at least 3).
- Improve technology for the mine such as treatment by bioremediation of contaminated effluents and drainage control of leaching systems.
- Establish a network of water quality monitoring stations and collect data to promote research and ways to improve operations.
- Implement early warning systems to prevent pollution directly linked to mining operations.

Econometric Studies Specific to This Region
The Nature Conservancy's Mapping Ocean Wealth Program produced a "Modelled Total Dollar Value of Reef Tourism (per km²)" and valued between US$4,000 and greater than US$492,000/ km² for La Guajira (Figure 43).

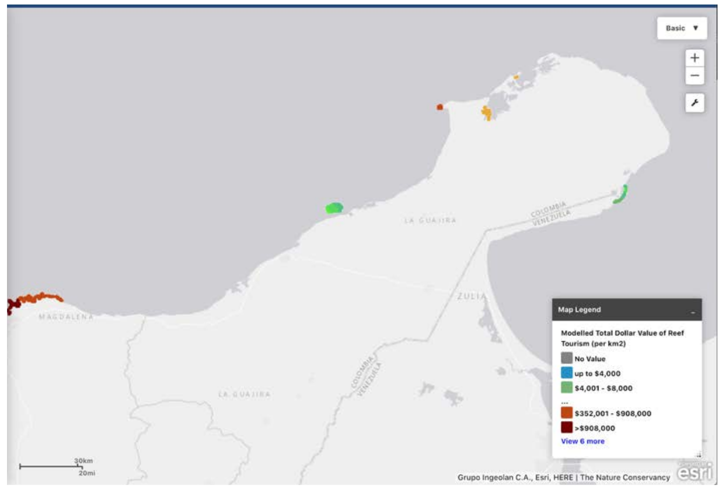


Fig. 43 | Modelled Total Dollar Value of Reef Tourism (per km^2) for La Guajira, Colombia. Source: http://maps.oceanwealth.org (2020).

To date, efforts have been made by the Alexander von Humboldt Institute for the economic valuation of ecosystem services (Comprehensive Valuation of Biodiversity and Ecosystem Services-VIBSE), conceptual and methodological aspects. However, to date there has not been an evaluation of the marine ecosystems in the Colombian Caribbean.

The Diagnosis of Erosion in the Colombian Caribbean Coastal Zone was carried out by the Marine Research Institute. The study shows the serious problems associated with erosion in La Guajira. With the improvement of the conditions of the marine ecosystems, the present erosion problem can be improved, in addition to the services of fishing provision for the coastal communities.

Aspects to Consider When Developing Investment Plan
Resident indigenous communities depend on the maintenance and sustainability of the ecosystem services of marine ecosystems, mainly seagrass beds. The work with the communities should consider connecting the local economy with strategies that allow their economic development through mechanisms such as payment for environmental services and CO_2 bonds. In 1999, an agreement was signed to extend the last phase of the mine for another 25 years to the year 2034. Then, in 2000, under

the government's privatization policy, Colombia sold the Carbocol Company to the Billiton Plc UK mining group, South African Anglo American Plc and Swiss Glencore International AG; these companies comprise the Cerrejón North Zone consortium. After the contract was signed, necessary preparations, such as the conduction of studies and the completion of construction, were carried out to allow for the mining to begin. Among the works constructed during this time were a 150-km railway through the entire Wayuu territory, and Puerto Bolívar, Latin America's foremost coal harbour. Today, the Cerrejón Company is one of Colombia's largest companies and a major driver of the nation's economy.

CONCLUSION

As one of the most biologically rich marine environments in the world, the CLME+ region is highly dependent on its marine and coastal resources. The growing impacts of unsustainable coastal development, climate change, overfishing, and land and marine-based sources of sediment and pollution threaten the viability of the region's marine and coastal ecosystems. Hence, protecting marine ecosystems in the Caribbean is vital to safeguarding the future of countries and territories in the region. Moreover, restoring ecosystems increases the supply and quality of ecosystem services over time towards desired outcomes supporting national sustainable development priorities

In this report, we have created tools that will enhance efforts on the international agenda, such as, the Decade of Restoration (2021-2030), which calls for the restoration of degraded and destroyed ecosystems to combat the climate crisis and improve food security, water supply, and biodiversity; the Sustainable Development Goals (SDGs), specially SGDs 6, 13, 14, 15; the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets; SPAW and LBS Protocols of the Cartagena Convention; and the CLME+ SAP.

It is noted that all these instruments are mutually supportive and reinforcing, and the implementation of one contributes to the achievement of the others. Furthermore, the results support the objectives of the SPAW Protocol which has pointed out the need for habitat restoration and the LBS Protocol on the importance of the control, reduction, and prevention of marine pollution.

Our methodology for large-scale habitat restoration and pollution reduction projects utilizes a four-part scorecard that starts at the country-level and narrows its focus down to specific large-scale habitat restoration sites. Through this process, we produced a total of 17 scorecards for 16 countries in the CLME+ region. A total of 48 unique large-scale habitat restoration sites were identified through this process--all of which present compelling reasons for investment in the coming years.

This list of high-priority sites is guiding our focus as we develop replicable models for investment plans that utilize a blended finance approach to pollution prevention, habitat restoration, and conservation. By mapping beneficiaries, including private, social, and public, we can link blended finance and the economic valuation of ecosystem services. This allows us to integrate public, private, and philanthropic capital not only to support the design and implementation of restoration and pollution prevention projects, but also the long-term monitoring needed to measure success.

In our three case studies--Guanaja Island, Honduras; Central Andros, The Bahamas; and, La Guijara, Colombia--we highlight various interventions that will help restore and protect critical coastal ecosystems, including mangroves, seagrasses, and coral reefs. All of these habitats will benefit immensely from pollution reduction initiatives, both nature-based and “grey infrastructure,” which will reduce sources of land-based pollution like wastewater, solid waste, and nutrient and sediment runoff. Efforts to improve water quality will enhance the effectiveness of habitat restoration, and vice versa.

However, it is important to emphasize that capital alone will not move these efforts forward. There needs to be concerted effort between international, national, and subnational stakeholders. And, much more attention should be given to capacity building efforts, including training in restoration techniques and long-term monitoring. Equipping local actors with the skills and equipment to carry-out large-scale projects is essential.

We all recognize the urgency of addressing climate change while promoting sustainable economic development. With this prioritization methodology, we are helping pave the way for strategic action that helps stakeholders in the Wider Caribbean Region to rally private investors, nonprofit organizations, and government actors to restore and protect coastal ecosystems that increase our climate resilience, reduce pollution, and promote a sustainable blue economy.

APPENDIX A: Score for Level of Need and Feasibility Potential by Country

	LEVEL OF NEED				FEASIBILITY POTENTIAL				
COUNTRY	Seascapes are present (both functioning reference and impaired states in need of restoration)	Impaired seascape condition/ intervention needed	Several important areas will benefit by seascape restoration	Numerous communities will benefit from seascape restoration	High support and motivation for restoration likely	Legislative frameworks or policies in place	Sufficient funding and capacity can likely be secured	Scalability of restoration approach to other areas	TOTAL SCORE
Bahamas	5	5	5	5	5	5	3	5	38
Belize	4	3	4	3	4	3	3	3	27
Colombia	5	4	5	5	5	4	3	5	36
Costa Rica	5	4	4	5	4	3	3	3	31
Cuba	4	3	5	5	4	5	2	3	31
Dominican Republic	4	4	4	4	3	4	3	5	31
Guatemala	5	5	4	5	5	5	5	4	38
Honduras	5	5	5	5	4	3	4	4	35
Jamaica	3	4	5	4	3	2	2	1	24
Mexico	5	4	5	5	5	5	4	5	38
Martinique	5	5	4	4	5	3	4	5	35
Nicaragua	4	3	4	4	3	2	2	3	25
Puerto Rico	5	5	5	5	5	5	3	4	37
St. Kitts & Nevis	5	4	4	5	3	4	4	5	34
Sint Maarten	5	4	5	3	5	4	4	5	35

APPENDIX B: Scorecards for Sites

	Priority Seascape Restoration Score Card
Enter results from step 1	**CENTRAL ANDROS, BAHAMAS**
Need & Feasibility	Score
Need Score	16
Feasibility Score	17
Restoration Score	33
Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)
Restoration Potential	Score
Structure	16
Function	16
Ecosystem Services	15
Feasibility	15
Threat abatement	13
Total	75
Restoration Success Potential *(enter results from SWOT Analysis)*	
Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health, biodiversity, resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources Goal 5: Design restoration project with local community involvement to improve social, cultural, natural and economic benefits; With both active and passive restoration. via protection, aids to navigation, mooring fields and an a aggressive educational component. The restoration could be the flagship for other projects. Develop a monitoring, evaluation and reporting frame work program to gauge restoration efforts and to provide future correction action and better management. Goal 6: Design restoration project using SFM/REDD+ principles of community co-management, which can increase potential for carbon sequestration.
Potential restoration actions:	Improve coverage and availability on climate change data and vulnerability to inform future risk-resilient coastal planning and decision-making in Andros; Conservation and protection of key natural buffers such as coral reefs, seagrass, mangroves, wetlands and coppice forests; Address the diminishing freshwater supplies, degraded freshwater and coastal water quality The GEF project identified several proposed rehabilitation objectives: •Conduct specific site assessment and determine baseline analysis •Develop and commence implementation of Participatory based Site Specific Management Plans based on the SFM principles for restoring/rehabilitating degraded mangroves •Develop and implement a community based monitoring of the rehabilitated mangrove site. •Research and monitoring program established for indicator species •Design and implement a comprehensive monitoring program that involves the community A rehabilitation analysis for the Davis Creek area should focus on the tidal flow/hydrodynamics of Davis Creek, how the three causeways and culverts affect flow, and potential opportunities to increase and restore flow and rehabilitate flora and fauna, with a focus on increasing mangrove populations. Restoration/enhancement could include the entire Davis Creek mangrove tidal system or focus on one of the causeway/culvert systems as a pilot. Studies should include lidar data, hydrodynamics/flow, sedimentation/ siltation, and flora and fauna. Data should guide identifying potential sites for pilot projects which could include restoration efforts such as increasing/restoring natural water flows, mangrove population enhancement, improving benthic habitat by removing deep siltation/sediment pockets and restabilizing bottom, remove upland/nearshore exotics like Casurina/Melaleuca, remove trash and large debris, identify potential sources of sewage/septic tank pollution, monitor water quality and reduce sewage impacts, conduct navigational aid study to identify areas at risk and places to install navigational aids to reduce boat impacts especially on corals and seagrasses, support coral population enhancement efforts, develop community programs for job, ecotourism and educational opportunities. The main focus is on improving mangrove habitats, which will benefit nearby seagrass and coral populations. Improve water flow and topography management. Improve fish recruitment mainly species characteristics from coral reefs and sport fisheries. Reduce vulnerability to sea level rise, improve management or protection, increase social benefits. Restoration of seagrass using the modified compresses succession technique, Placement of mooring fields to prevent further damage and stablish protection zones . Use the SAFE-Island methodology for mangrove restoration and direct mangrove forest reforestation , The use of living shorelines as a tool to protect the shoreline from erosion/ and to provide substrate for restoration activity (Such as mangrove planting. Enhancement of existing coral restoration projects , improve management of the MPA's.
Strengths	Andros is the largest island in The Bahamas and one of the least developed. Flanked by the third-largest barrier reef in the world to the east and the Great Bahama Bank to the west, the island supports much of the country's commercial and sport-fishing industries, nature-based tourism activities, and agriculture. The greatest strength is that there is an existing GEF proposal for this area. The proposal includes enhancing connectivity and tidal flow for the rehabilitation of mangrove ecosystems in Davis Creek comprising 50 ha. Another strengths is it is adjacent to Small Hope Bay Lodge, which is a popular ecotourist destination which allows for increased ecotourism and ecoeducation as well as the Small Hope Bay Foundation which supports conservation efforts. The Andros Master Plan also highlights importance of restoring flow to mangrove tidal creeks.. Coordinating with the local community is a high priority to ensure success in developing restoration goals and actions. The recent focus on replacing bridges and increasing water flow will contribute to habitat enhancement success. This area is adacent or near existing protected/managed areas such as Blue Holes National Park, Andros North and South Marine Park, Westside National Park, Maiden Hair Coppice Conservation Forest, and Crab Replenishment Reserve. Existing mangrove and coral enhancement projects nearby. Established Marine Protected Area. Fishing community involvement , Tourism and political support. Bahamas National Multiple NGO's and other entities with great interest in protecting and conserving area . Trust and Bahamas Department of Marine Resources. Great potential to promote ecotourism as a venue to protect the ecosystem and educate both the local community and the tourist on the importance of the ecosystem for its longevity.
Weaknesses	Despite a wealth of natural resources, Andros lacks the essential infrastructure, social services, and educational opportunities to support sustainable and prosperous livelihoods. Funding will need to be secured to support enhancement. Coordinating with local community is a high priority to ensure success in developing restoration goals and actions. There is a lack of local capacity to conduct studies/restoration project. Research is needed to develop a formal restoration project. The impacts of hurricanes and land use conflicts are also weaknesses.
Opportunities	It retains some of the most intact and least developed natural areas in the Bahamas and has high levels of biodiversity, some of the most extensive wetlands in the region and the largest source of freshwater in the Bahamas. In 2015, the Office of the Prime Minister embarked on an effort to create a 25-year sustainable development plan for Andros as part of a national development planning process, Vision2040. The goal of the plan was to address Androsians' development needs while ensuring the sustainability of commercial and sport-fishing industries, nature-based tourism activities, agriculture, and freshwater resources. Coordinating with local community is a high priority to help develop restoration goals and actions. Several local efforts support conservation such as Small Hope Bay Foundation, Bahamas Sportsfishing and Conservation Group, Fore Far Field Station, The Nature Conservancy, Reef Rescue Network (for coral restoration), Bahamas National Trust (BNT) and Bahamas Reef Environment Educational Foundation (BREEF). GEF funded Forestry project with Bahamas Forestry Unit will contribute to management and conservation efforts of forests. Collaborate with The Bahamas Agriculture and Marine Science Institute (BAMSI) to develop educational and research opportunities. Private partnerships with local hotels and tour operators may be possible. Enhancement project could provide local jobs and educational opportunities for community. Multiple partnerships, NGO's. Link to ongoing management priorities.
Threats	Current and emerging threats in Andros include unchecked development (involving pollution, dredging and indiscriminate habitat clearing), over-fishing, invasive species, sewage, climate change and ocean acidification. The Davis Creek mangrove system runs parallel to the coast and is affected by three causeways that bisect it greatly reducing flow and impacting flora and fauna and nursery habitats. Lack of infrastructure for solid and sewage waste disposal and indiscriminate dumping has impacted the environment. Lack of funding and support in the past has prevented progress. Land tenure may be an issue.
Score (from above Step 2)	75

	Priority Seascape Restoration Score Card
Enter results from step 1	**Golfo de Batabanó, Cuba**
Need & Feasibility	Score
Need Score	17
Feasibility Score	14
Restoration Score	31
Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)
Restoration Potential	Score
Structure	12
Function	13
Ecosystem Services	11
Feasibility	14
Threat abatement	11
Total	61
Restoration Success Potential *(enter results from SWOT Analysis)*	
Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health, biodiversity, resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources
Potential restoration actions:	Much of Cuba's terrestrial forests have been deforested since colonial times. Mangrove systems have been spared much of the deforestation given their isolation and the fact that Cubans do not rely particularly heavily on charcoal from mangrove forests. Also Cuba has been spared much of the coastal development seen in other Caribbean countries due to a low population (11M residents) and relatively low tourism pressure
Strengths	Guira de Melena is close to decision makers in Havana yet far enough to be spared any of the urban pressures from that city. Located on the southern coast of Cuba, it is more isolated and its proximity to the Gulf of Batabano brings it in close proximity to healthy coral and seagrass beds.
Weaknesses	Practices from local farming have compromised water quality reaching the mangrove areas. It is difficult to delineate human pressures given the low population in the area. Invasive plant species such as casuarina pose a problem in terms of restoration
Opportunities	Improve water quality and flow. Tap into local communities for assistance in carrying out restoration plans. Cuban population is highly literate meaning campaigns to preserve restored areas can be more effective.
Threats	Overfishing, water quality, increasing droughts due to climate change, increased prevalence of hurricanes, particularly on the southern coast of Cuba.
Score (from above Step 2)	61

Priority Seascape Restoration Score Card

Enter results from step 1	**Tela, Honduras (Bahía de Tela Marine Wildlife Refuge (Refúgio de Vida Silvestre Marino, Sistema Arrecifal de Tela))**

Need & Feasibility	Score	Comments
Need Score	**20**	
Feasibility Score	**15**	
Restoration Score	**35**	

Enter results from step 2 — Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	**16**	**High Overall score related to community support for protection, existing conservation efforts and uniqueness of coral reef habitats, lower than site 2 because mangrove restoration would be new.**
Function	**16**	
Ecosystem Services	**16**	
Feasibility	**13**	
Threat abatement	**12**	
Total	**73**	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	**Implement new efforts to restore mangrove systems, improve water quality and enhance/protect significant adjacent coral reefs**
	Goal 1. Enhance management of this new protected area. Develop a mangrove restoration program (identify extent of mangroves and issues threatening systems, build mangrove nursery and community programs. Protect/enhance the coral reef which is unique and extensive
	Goal 2. Improve enforcement of existing fishing regulations and rebuild fish populations
	Goal 3. Improve coastal zone management, increase community and education programs; expand reef and water quality monitoring
	Goal 4. Install sewage treatment system and program similar to the successful program on West End Roatan and improve solid waste programs in order to improve water quality
	Goal 5. Reduce agricultural and upland contaminants
Potential restoration actions:	**Enhance management of this new protected area. Develop a mangrove restoration program (identify extent of mangroves and issues threatening systems, build mangrove nursery and community programs. Protect/enhance the coral reef which is unique and extensive**
Strengths	**New protected area supported by community. Can build upon existing efforts and partnerships such as Tela Marine Research Centre (TMRC) , Healthy Reefs Initiative and CORAL.**
Weaknesses	**Funding to start new programs will be needed, but potential co-financing potential. See SWOT by MARFund on mangrove restoration in general**
Opportunities	**See above about partnership opportunities. Potential to replicate in other coastal areas of Honduras**
Threats	**Population and tourism increasing as is land conversion and agricultural practices.**
Score (from above Step 2)	**73**

Priority Seascape Restoration Score Card

Enter results from step 1	**The Narrows (between St. Kitts & Nevis)**
Need & Feasibility	Score
Need Score	**18**
Feasibility Score	**16**
Restoration Score	**34**
Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)
Restoration Potential	Score
Structure	**16**
Function	**15**
Ecosystem Services	**16**
Feasibility	**14**
Threat abatement	**13**
Total	**74**
Restoration Success Potential *(enter results from SWOT Analysis)*	
Potential for success	**Comments**
Restoration Objectives:	Improve management of coastal seagrass, mangrove, reef and beach habitats and enhance populations in degraded areas (mangrove shorelines, dredged/damaged seagrass beds, and structure and function of coral reefs). The Narrows, a 3 km shallow channel between the two islands, has a vast seagrass meadow dominated by dense turtle and manatee grass. The Narrows is unique in the Eastern Caribbean as it is the only sizeable seagrass meadow linking two large islands and adjacent reefs together.
Potential restoration actions:	Goal 1. Restore and enhance mangrove populations along shorelines of The Narrows. Establish coral nurseries and enhance adjacent coral reefs, particularly Acropora corals to NE side of Nevis. Restore damaged seagrass areas. Install navigational aids and/or buoys to reduce damage to seagrass beds and popular dive locations. Reduce upland erosion and sedimentation. Protect beaches and continue/increaase protection of nesting sea turtles. Goals 2 and 4. Implement sustainable development controls such as set backs and zoning. Prohibit removal or destruction of mangroves and other coastal vegetation, the mining of beach sand, or the filling of coastal wetlands. Implement/support sustainable fisheries policies. Goal 3. Strengthen policies to protect mangroves/seagrasses and reefs and increase partnerships with local land owners, businesses and communities to sustainably use mangrove, reef and seagrass areas. Encourage soft or 'living shorelines' as alternatives to hard structures in order to reduce erosion, stabilize shorelines and reduce flooding. Goal 5: Improve water quality and reduce contaminants
Strengths	Proposed restoration is withing boundaries of The Narrows Marine Managed Area (NMMA), restoration feasible and not too cost prohibitive, assistance available to increase restoration capacity
Weaknesses	Sufficient funding may not be available, lack of community or governmennt support
Opportunities	Opportunity to introduce restoration techniques, interested partners. Important seagrass area. Can collaborate with other islands in Eastern Caribbean and regional programs
Threats	Highly used area and continued coastal development and use are expected.
Score (from above Step 2)	**74**

	Priority Seascape Restoration Score Card	
Enter results from step 1	**Bay of Fort-de-France- Cohé du Lamentin (west coast), Martinique**	

Need & Feasibility	Score	Comments
Need Score	18	Mangrove area may be small as it is a small island nation, but mangroves are highly important. Need to address contaminants and coastal degradation of mangroves as well as degraded coral reef state
Feasibility Score	17	Capacity, community support and government interest. High likelihood to scale up to other SIDS
Restoration Score	35	

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)	

Restoration Potential	Score	Comments
Structure	13	Largest mangrove area in country
Function	11	
Ecosystem Services	15	
Feasibility	12	
Threat abatement	11	
Total	62	Lower score due to high contaminants and potentially high cost to restore

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	Goals 1, 4 and 5. Main focus is to protect largest mangrove ecosystem which will benefit nearby seagrass and reef habitats and improve overall water qualiy
Potential restoration actions:	Bay supports ~65% of all Martinqiue's mangrove forest: actions needed are to reduce contaminants, particularly Chlordecone, an organochlorine pesticide used to control banana weevil (1972-1993); reduce erosion and sedimentation; restore flow/connectivity of mangroves; reduce impacts from boat traffic/use; repopulate mangroves and corals
Strengths	French territories have a focus on restoration actions for the 3 habitats. Largest mangrove area, Near a Key Biodiversity Area (KBA-Mangrove de Fort de France), Community/tourist interest in protecting, adjacent to wildlife reserve, support/interest from IFRECOR; available historic environmental data; existing coral restoration efforts in country and mangrove, seagrass, mangrove capacity in other French territories
Weaknesses	Area heavily affected by urban, agricultural and industrial use, restoration efforts to reduce contaminants and sedimentation and to restore water flow may be costly;
Opportunities	Restoration efforts implemented here are likely able to be adapted to other French islands and other small island nations
Threats	Majority of population is concentrated as an urbanized zone of Fort-de-France and Schoelcher cities; houses/buildings built along coast at sea level; history of agricultural and industrial use and contaminants. An invasive seagrass, Halophila stipulacea, has been found; impact on native habitat unknown.
Score (from above Step 2)	62

Priority Seascape Restoration Score Card

Laguna Grande, Guatemala

Enter results from step 1

Need & Feasibility	Score	Comments
Need Score	19	Seascapes are present (both functioning reference and impaired states in need of restoration) Impaired seascape condition/ intervention needed Several important areas (e.g., protected areas) will benefit by seascape restoration
Feasibility Score	19	High support and motivation for restoration Legislative frameworks or policies in place Scalability of restoration approach to other areas. Seed funding for restoration, community support
Restoration Score	38	Highest level of need and feasibility

Enter results from step 2 — Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	13	unknown but the restoration implemented
Function	10	unknwn but the restoration implemented is possible
Ecosystem Services	16	Laguna Grande Reserve encompasses a unique system of lagoons, mangroves, inundated forests, lowland forests, and karstic mountain forests between sea level and 385m. Located within the Río Sarstún Multiple Use Reserve, which is a vital link in the Caribbean Rainforest Corridor of Guatemala.Improve coastal protection and livelihoods, improve biodiversity and connectivity with seagrasses and coral reefs. The mangroves' economic value only for fisheries in this area is around US$41,298 per year in shrimp production and US$48 mil in robalo production, this is according to Fundación para el Ecodesarrollo y la Conservación (FUNDAECO) (Guillermo Gálvez).
Feasibility	15	Government and international support. Private sector could be part of the donors.
Threat abatement	15	The area is large and requires more financing and that the flow of resources when necessary is on time. There may be conflicts over land tenure.
Total	69	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	Comments
Restoration Objectives:	Goals 1, 3, 4 Goal 5: The restoration strategy including the monitoring program can be applied in any mangrove condition, so it can be scaled to other countries
Potential restoration actions:	Improve fish recruitment mainly species characteristics from coral reefs and sport fisheries. Reduce vulnerability to sea level rise and floodings. In general healty ecosistem, mangrove density 1,320 trees/Ha. Mangrove mortality is around
Strengths	Community and political support, is part of a protected area which includes seagrasses. Adjacent to areas of high biodiversity. High interest as a mitigation/adaptation program through the blue carbon initiative at country level, reforestition efforts have been documented in the area.
Weaknesses	This constitute a natrual protected area of multiple use. Expansion of palm oil plantations and cattle ranching
Opportunities	Multiple partnerships with federal and local agencies, NOG's. Fundacion para el ecodesarrollo y la conservacion; international conservation found Canada Trained local community, strong technical group. Link to ongoing management. Potential private sector partnerships.
Threats	The area is large and requires more financing and that the flow of resources when necessary is on time. There may be conflicts over land tenure.
Score (from above Step 2)	69

	Priority Seascape Restoration Score Card
Enter results from step 1	**COMPLEJO DE SIAN KA'AN**

Need & Feasibility	Score
Need Score	**20**
Feasibility Score	**17**
Restoration Score	**37**

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score
Structure	**16**
Function	**16**
Ecosystem Services	**16**
Feasibility	**15**
Threat abatement	**14**
Total	**77**

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	**Goal 1. Strengthen ecosystem health, biodiversity, resilience**
	Goal 2. Sustainably use coastal and nearshore marine resources
	Goal 3. Strengthen restoration governance & partnerships
	Goal 4. Effectively manage the marine/coastal resources
Potential restoration actions:	**Promote participatory restoration of seagrasses, mangroves, and reefs.**
Strengths	**It has a 120 coral reef barrier, an area of sea grasses, seasonal creeks,**
Weaknesses	**Contains species such as the jaguar, the manatee, the migratory birds -**
Opportunities	**It contains the most important and significant habitats for in situ**
Threats	**There are activities that can be considered threats such as the illegal**
Score (from above Step 2)	**77**

Enter results from step 1	Priority Seascape Restoration Score Card **Simpson Bay, St. Martin (transboundary)**	
Need & Feasibility	Score	Comments
Need Score	17	Seascapes are present (both functioning reference and impaired states in need of restoration) Impaired seascape condition/ intervention needed the area will be benefit by seascape restoration
Feasibility Score	19	High support and motivation for restoration Legislative frameworks or policies in place Scalability of restoration approach to other areas. Seed funding for restoration, community support
Restoration Score	36	There are previous restoration efforts.

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)	
Restoration Potential	Score	Comments
Structure	16	Impaired but the restoration implemented could help.
Function	14	Impaired but the restoration implemented could improve it.
Ecosystem Services	16	Improve coastal protection and livelihoods, improve biodiversity and connectivity with seagrasses and coral reefs
Feasibility	15	Community and government support. Private sector could be part of the financial strategy.
Threat abatement	15	The area may be conflictive due to land tenure and the transboundary issue.
Total	76	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources, Goal 5: The area has a high potential to recover mangrove areas. Some restoration efforts have been documented for the area. The site constitute a protected area and RAMSAR site.
Potential restoration actions:	Improve water flow and topography management. Improve fish recruitment mainly species characteristics from coral reefs and sport fisheries. Reduce vulnerability to sea level rise, improve management or protection, increase social
Strengths	This constitute a protected area and RAMSAR site, healthy adjacent habiat. Efforts to restore this site and some attempts to make a trasboundary protected area have been documented.
Weaknesses	The trasboundary issue could be limitant.
Opportunities	Multiple partnerships, NGO's. Trained local community, strong technical group. Link to ongoing management o restoration programs.
Threats	There may be conflicts over land tenure. Hurricane events.Pollution from debris.Nutrient inputs from town.Quarries.Free-roaming cattle
Score (from above Step 2)	76

Priority Seascape Restoration Score Card

Enter results from step 1	CAHUITA NATIONAL PARK, Costa Rica
Need & Feasibility	Score
Need Score	18
Feasibility Score	13
Restoration Score	31

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)
Restoration Potential	Score
Structure	15
Function	16
Ecosystem Services	15
Feasibility	15
Threat abatement	12
Total	73

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health, biodiversity, resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources
Potential restoration actions:	The reserve has a Solid Waste Plan, Cahuita National Park Load Capacity Studies and Aqueduct Construction There is a sustainable tourism plan for the reserve to regulate zoning activities. They have management of drinking water and wastewater; He is in charge of the certification of the Ecological Blue Flag (PBAE) program.
Strengths	The reserve has a solid community organization that carries out conservation and management activities in addition to a waste management plan that mitigates contamination and excess nutrients from anthropogenic activities.
Weaknesses	There are coral reefs of great regional importance. The reef has an extension of 600 hectares and is the best developed in the Costa Rican Caribbean. Since there is no control of some tour operators, the respect of the protection and load capacity regulations is not ensured, which can cause negative affections to the reef.
Opportunities	The Local Council of the protected area, has an interest in conserving, participating, promoting, collaborating and serving in the management of the protected area, it is the security they offered to the visitor, the support in the improvement of the infrastructure of the park, support in control activities and protection, as well as training, volunteer actions and donations that were channeled to benefit the wilderness and the community.
Threats	The localities located in the reserve and in the area of influence are mainly dedicated to the tertiary sector such as tourism and carry out some agricultural activities, many linked to banana cultivation. They depend largely on the natural resources of the area.
Score (from above Step 2)	73

	Priority Seascape Restoration Score Card
Enter results from step 1	**Portland Bight Protected Area (PBPA), Jamaica**

Need & Feasibility	Score
Need Score	16
Feasibility Score	8
Restoration Score	24

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score
Structure	13
Function	9
Ecosystem Services	12
Feasibility	14
Threat abatement	8
Total	56

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health, biodiversity, resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources
Potential restoration actions:	Reports indicate that as much of 30 percent of the island's original coastal vegetation has been lost. Most of the 1,240 square kilometers of coral reefs, with an estimated 111 species of coral, is mostly dead from a combination of human activities and disease. Of the remaining coral, about 60 percent are at risk, the World Resources Institute noted in a 2010 report.
Strengths	The PBPA is one of high biological importance. The site is a habitat for more than 15 globally threatened species. Its mangroves are home to waterfowl and crocodiles as well as a nursery for fish and other marine wildlife
Weaknesses	Fishing has been severely degraded as the majority of fishers' fish outside the PBA. In addition, the fisher folk place greater reliance on other –income earning activities. Fishing therefore provides mainly supplemental income to other activities in which the fishers are engaged.
Opportunities	To lessen the impact and repair some of the damage, the island is undertaking a broad-based climate change adaptation and risk reduction programmed, replanting hardwood and mangrove forests as well as sea grass beds
Threats	The climate of the PBPA is warming, with rainfall extremes (including droughts) and the frequency of intense storms and/or hurricane have increased in recent years. There is historical evidence of damage to coral reefs, mangroves and coastal infrastructure, with storm surge and flooding being particularly devastating.
Score (from above Step 2)	**56**

Priority Seascape Restoration Score Card

CAYOS MISKITOS, Nicaragua

Enter results from step 1

Need & Feasibility	Score
Need Score	**15**
Feasibility Score	**10**
Restoration Score	**25**

Enter results from step 2 — Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score
Structure	**14**
Function	**13**
Ecosystem Services	**14**
Feasibility	**10**
Threat abatement	**10**
Total	**61**

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	Comments
Restoration Objectives:	Goal 1. Strengthen ecosystem health, biodiversity, resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources
Potential restoration actions:	Restoration may not be successful if there is not an adequate investment framework before, with clear rules on incentives, facilities and taxes, defining tenure of the land, controlling invasions, establishing a legal regime that is really applied to control the destruction of gallery forests, soil, burning, hunting, etc., and where corruption does not discourage or increase the risk of investing.
Strengths	There are large extensions of mangroves, seagrasses, and coral reefs, which are strongly connected, maintaining species such as fish, crustaceans, and molluscs. It is one of the most productive fisheries in the Caribbean.
Weaknesses	The area has a low population density, yet completely dependent on fishing, which generates pressure on resources. Commercial fishing of lobster, conch, sharks, and turtles is still practiced even if those species are protected and in danger. There are few economic alternatives in the area.
Opportunities	Promote the conservation of existing ecosystems in the area of influence of the Cayos Miskitos Reserve, to guarantee the interconnection between natural areas and guarantee a natural corridor for migratory fauna.
Threats	The coastal marine ecosystems of Cayos Mistikos and littoral fringe are between the most conserved in the Caribbean, due to its remoteness. Yet human stressors are increasing in these ecosystems, mostly linked with land pollution and overfishing, which can fragilize their connectivity and their resilience to face natural stressors. It is key to improve the resilience by empowering communities to protect and develop sustainable practices.
Score (from above Step 2)	**61**

Priority Seascape Restoration Score Card

Enter results from step 1	**Bone Fish Pond National Park, Bahamas (4,998,677.05 sq meters)**	
Need & Feasibility	Score	Comments
Need Score	20	Seascapes are present (both functioning reference and impaired states in need of restoration)
Feasibility Score	18	Lack of funding , community support
Restoration Score	38	High level of need and feasibility, protected

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)	
Restoration Potential	Score	Comments
Structure	16	impaired but restoration is possible from donor
Function	16	impaired but restoration is possible from donor
Ecosystem Services	15	Improve coastal protection and livelihoods
Feasibility	13	Community and government support
Threat abatement	13	Land based threats
Total	73	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen local and regional restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources, Goal 5: Active and active restoration via protection, aid to navigation, restoration could be the flagship for other projects . Develop a monitoring program . Enhance and protect fish habitat for commercial and non commercial species
Potential restoration actions:	Re-forest damage areas using the modified compresses succession technique. Water quality improvements ,
Strengths	Existing capacity, community support, adjacent to biodiversity areas, management
Weaknesses	No funding
Opportunities	Link to existing capacity and projects
Threats	Pollution , water quality , turtle grazing , hurricanes
Score (from above Step 2)	73

Priority Seascape Restoration Score Card

Palencia, Belize

Enter results from step 1

Need & Feasibility	Score	Comments
Need Score	14	Seascapes are present (both functioning reference and impaired states in need of restoration)
Feasibility Score	13	Lack of funding , community support
Restoration Score	27	High level of need and feasibility

Enter results from step 2 — Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	14	Mostly intact, close to MPA's
Function	11	Most intact but restoration is possible from donor
Ecosystem Services	16	Improve coastal protection and livelihoods
Feasibility	14	Community and government support
Threat abatement	11	Land based threats, water quality seagrass die-off
Total	66	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	Comments
Restoration Objectives:	Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen local and regional restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources, Goal 5: With emphasis on Improving water quality and restoration could be the flagship for other projects
Potential restoration actions:	Re-forest damage seagrass areas using the modified compresses succession technique. Sediment bags for topographical restoration , seagrass planting units, fertilization via bridstakes , water quality improvements , navigational buoys and informational signage
Strengths	Existing capacity, community support, adjacent to biodiversity areas, management
Weaknesses	No funding
Opportunities	Link to existing capacity and projects
Threats	Pollution , vessels activities, water quality ,
Score (from above Step 2)	66

	Priority Seascape Restoration Score Card	
Enter results from step 1	**LA GUAJIRA, Colombia (4,661,978.6 hectares)**	

Need & Feasibility	Score	Comments
Need Score	19	Seascapes are present (both functioning reference and impaired states in need of restoration)
Feasibility Score	17	Lack of funding , community support
Restoration Score	36	High level of need and feasibility, protected

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	16	impaired but restoration is possible
Function	14	impaired but restoration is possible
Ecosystem Services	16	Improve coastal protection and livelihoods
Feasibility	14	Community and government support
Threat abatement	15	Land based threats
Total	79	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience
	Goal 2. Sustainably use coastal and nearshore marine resources
	Goal 3. Strengthen local and regional restoration governance & partnerships
	Goal 4. Effectively manage the marine/coastal resources,
	Goal 5: Active and active restoration via protection, aid to navigation, signage, restoration could be the flagship for other projects . Develop a monitoring program . Enhance and protect fish habitat for commercial and non commercial species. Seagrass , mangrove and coral restoration needs. Improve water quality and conduct educational workshops on pollution and restoration techniques
Potential restoration actions:	Improve water quality , flow, restore habitat via reforestation , enhance existing population. Enhance and protect fish habitat for commercial and non commercial species .Increase social benefits
Strengths	Community, tourism and political support. BEM and INVEMAR govern support , high biodiversity. government habitats within the surrounding areas
Weaknesses	No funding
Opportunities	Link to existing capacity and projects
Threats	Pollution , water quality, hurricanes earthquakes
Score (from above Step 2)	79

Priority Seascape Restoration Score Card

Enter results from step 1	**Punta Cana, Dominican Republic (475,262,812.25 sq meters)**

Need & Feasibility	Score	Comments
Need Score	17	Seascapes are present (both functioning reference and impaired states in need of restoration)
Feasibility Score	15	Lack of funding , community support
Restoration Score	32	High level of need and feasibility

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	15	impaired but restoration is possible from donor
Function	15	impaired but restoration is possible from donor
Ecosystem Services	16	Improve coastal protection and livelihoods
Feasibility	15	Community and government support
Threat abatement	16	Land based threats, lack of enforcement
Total	77	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	Comments
Restoration Objectives:	Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen local and regional restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources, Goal 5: Non active and active restoration via protection, aids to navigation, restoration via transplant, this project could be the flagship for other projects. Long term monitoring program essential to acquire needed data for the protection and restoration efforts.
Potential restoration actions:	Re-forest damage seagrass areas using the modified compresses succession technique. Sediment bags for topographical restoration , seagrass planting units, fertilization via bridstakes , water quality improvements , navigational aid buoys, exclusion zones and informational signage
Strengths	Existing capacity, community support, adjacent to biodiversity areas, management
Weaknesses	No funding
Opportunities	Link to existing capacity and projects
Threats	Pollution , vessels activities, water quality ,
Score (from above Step 2)	77

Priority Seascape Restoration Score Card

Enter results from step 1	**Laguna Nichupte, Mexico (47. 449,023 sq meters)**	

Need & Feasibility	Score	Comments
Need Score	**18**	**Seascapes are present (both functioning reference and impaired states in need of restoration)**
Feasibility Score	**19**	**Lack of funding , community support**
Restoration Score	**37**	**High level of need and feasibility**

Enter results from step 2	Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	**11**	**impaired but restoration is possible from donor sites**
Function	**15**	**impaired but restoration is possible from donor sites**
Ecosystem Services	**16**	**Improve coastal protection and livelihoods**
Feasibility	**15**	**Community and government support**
Threat abatement	**15**	**Land based threats, lack of enforcement**
Total	**72**	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	**Comments**
Restoration Objectives:	**Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience** **Goal 2. Sustainably use coastal and nearshore marine resources** **Goal 3. Strengthen local and regional restoration governance & partnerships** **Goal 4. Effectively manage the marine/coastal resources,** **Goal 5: Non active and active restoration via protection, aids to navigation, restoration via transplant, this project could be the flagship for other projects. Long term monitoring program essential to acquire needed data for the protection and restoration efforts.**
Potential restoration actions:	**Re-forest damage seagrass areas using the modified compresses succession technique. Sediment bags for topographical restoration , seagrass planting units, fertilization via bridstakes , water quality improvements , navigational aid buoys, exclusion zones and informational signage**
Strengths	**Existing capacity, community support, adjacent to biodiversity areas, management**
Weaknesses	**No funding**
Opportunities	**Link to existing capacity and projects**
Threats	**Pollution , vessels activities, water quality ,**
Score (from above Step 2)	**72**

	Priority Seascape Restoration Score Card	
Enter results from step 1	**LAGUNA CONDADO (374, 023 sq meters), San Juan Bay, Puerto Rico**	

Need & Feasibility	Score	Comments
Need Score	20	Seascapes are present (both functioning reference and impaired states in need of restoration)
Feasibility Score	17	Lack of funding , community support
Restoration Score	37	High level of need and feasibility

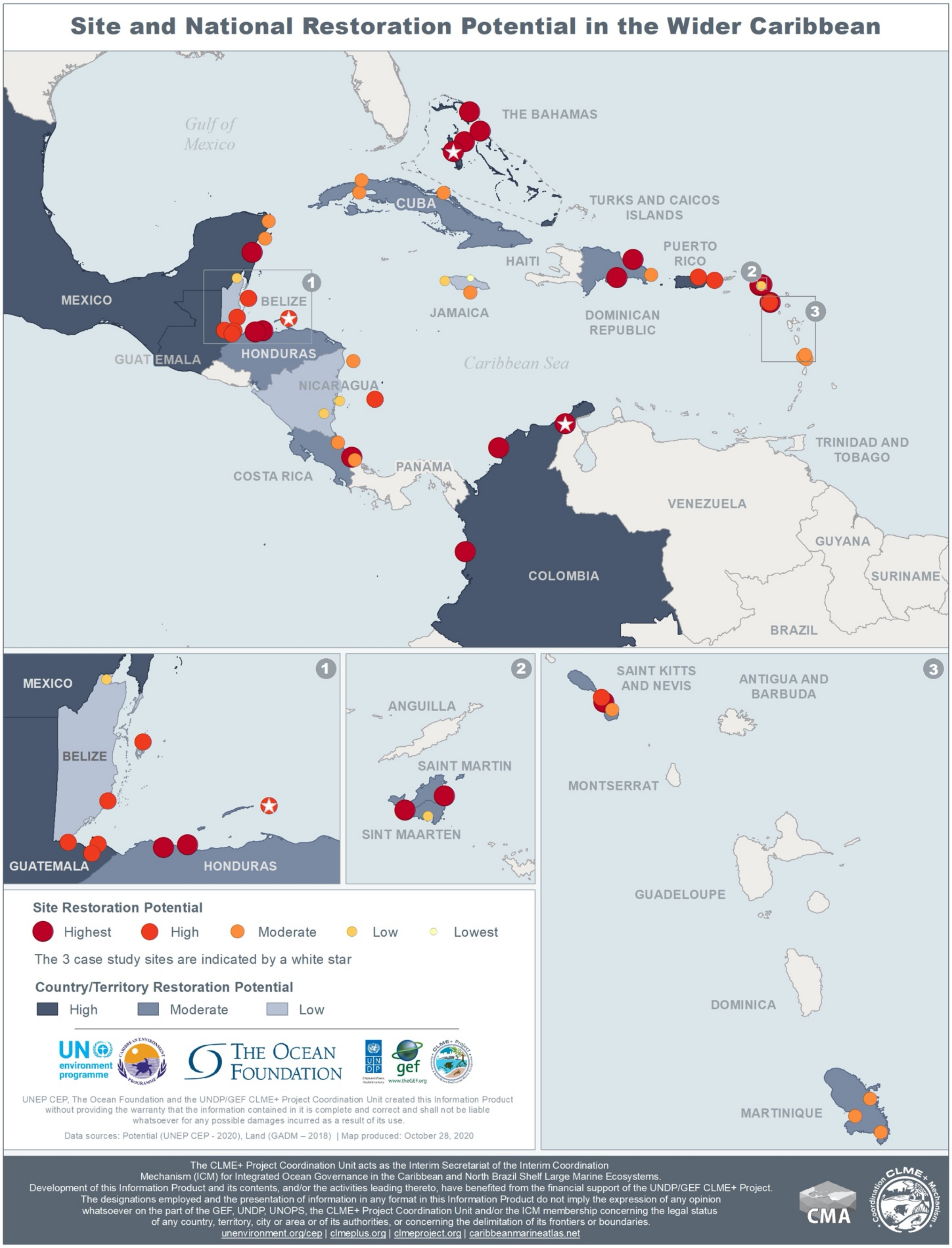
Enter results from step 2 — Score from final site selection (1 site out of the 3 sites you selected)

Restoration Potential	Score	Comments
Structure	12	impaired but restoration is possible from donor sites
Function	8	impaired but restoration is possible from donor sites
Ecosystem Services	15	Improve coastal protection and livelihoods
Feasibility	15	Community and government support
Threat abatement	14	Land based threats, water quality
Total	64	

Restoration Success Potential *(enter results from SWOT Analysis)*

Potential for success	Comments
Restoration Objectives:	Goal 1. Strengthen ecosystem health of mangroves, increase reef resilience Goal 2. Sustainably use coastal and nearshore marine resources Goal 3. Strengthen local and regional restoration governance & partnerships Goal 4. Effectively manage the marine/coastal resources, Goal 5: With emphasis on Improving water quality and restoration could be the flagship for other projects
Potential restoration actions:	Re-forest damage seagrass areas using the modified compresses succession technique. Sediment bags for topographical restoration , seagrass planting units, fertilization via bridstakes , water quality improvements , buoys and informational signage
Strengths	Existing capacity, community support, adjacent to biodiversity areas, management
Weaknesses	No funding
Opportunities	Link to existing capacity and projects
Threats	Pollution , vessels activities, water quality ,
Score (from above Step 2)	64

APPENDIX C: Map of Prioritized Sites With Case Studies Indicated



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