Belize Integrated Coastal Zone Management Plan 2016

"Promoting the Wise, Planned Use of Belize's Coastal Resources."

Coastal Zone Management Authority & Institute
Ministry of Agriculture, Forestry, Fisheries, the Environment & Sustainable Development

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THE VISION FOR OUR COAST

A sustainable future where healthy ecosystems support, and are supported by, thriving local communities and a vibrant economy

FOREWORD

The coastal zone is one of Belize's greatest assets, and is vital to the Belizean way of life. Belize's highly productive coastal zone is the resource base that supports a broad range of economic activities and contributes significantly to the environmental, social and cultural fabric of our country. It is therefore imperative that we are able to identify and implement informed management solutions that will aid us as a people and a government to safeguard the wealth of coastal and marine resources from which we all benefit. The National Integrated Coastal Zone Management Plan for Belize is a comprehensive and cross-sectoral planning framework that offers robust strategic solutions that build on the national agenda for growth, sustainable development and improved resources management. It links the economic potential and ecological value of the coastal zone with a balanced mix of utilization and conservation, thereby promoting the long-term viability of the Belizean coastal zone. Equally important is that the Plan will ensure that we strengthen the governance of coastal resources by effectively facilitating the transition from sectoral management regimes to coordinated, cross-sectoral decision-making processes at local and national levels.

The Ministry of Agriculture, Fisheries, Forestry, the Environment, and Sustainable Development is very much aware of the efforts expended by the Coastal Zone Management Authority and Institute and its broad constituent base in developing this Plan. The policy options and management strategies formulated within the Plan's framework are founded on strong science and the shared vision and goals of the national community of stewards and stakeholders of the coastal zone.

This Plan is timely and reflective of not only the challenges my Ministry and this government faces in terms of how to best bolster the national economy and sustain a growing population, but it also presents many opportunities for progressive development that can result in desirable social, economic and environmental outcomes now and in the future.

As the Deputy Prime Minister, it is my pleasure to endorse this Plan, a first of its kind, which represents this government's commitment to continuously strive to meet Belize's human and economic development needs, while also ensuring that we leave behind a viable future for generations to come.

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HON. GASPAR VEGA
Deputy Prime Minister
Minister of Agriculture, Fisheries, Forestry,
the Environment and Sustainable Development

Almost two decades ago, Belize passed the Coastal Zone Management Act, a visionary legislation that recognized the deficiencies of sectoral management and established the institutional arrangements for integrated coastal zone management (ICZM). The ICZM approach is manifested throughout the National Integrated Coastal Zone Management Plan for Belize, which was developed to ensure that our coast remains a part of our future where healthy ecosystems, supported by effective cross-sectoral decision-making and technical coordination, maintain thriving coastal communities and a vibrant economy.

It is undeniable that the coastal zone of Belize is a national treasure. It supports a healthy national economy, innumerable ecosystem functions, and is home to approximately forty percent of the Belizean populace. Over the years, there have been numerous threats to the integrity and long-term viability of coastal resources and the delivery of ecosystem services from which Belizeans benefit. In recent times, the adverse effects of global climate change have only served to exacerbate the deleterious impacts of unplanned resource utilization on our resource base of the marine environs.

The Plan will allow the government to better respond to ICZM as a national cross-cutting issue, and to make defensible, enduring decisions for the sustainable development of Belize's marine resources. Specifically, it provides a strong framework to guide resource utilization, development and future investments, while ensuring the protection of livelihoods and the wealth of biodiversity of the coastal zone.

The Coastal Zone Management Authority is very pleased by the contributions made by its diverse group of stakeholders, whose knowledge base has significantly impacted the development of the Plan. The result is, unequivocally, a remarkable document of practical policies that are sure to engender confidence in the stewardship that the Authority will exercise in coordinating the implementation, monitoring and evaluation of this Plan. I encourage our partners in government, the private sector and civil society to join the Authority in ensuring the successful implementation of Belize's first ever National Integrated Coastal Zone Management Plan.

CHANTALLE CLARKE-SAMUELS
Chief Executive Officer
Coastal Zone Management Authority

ACKNOWLEDGMENTS

The Belize Integrated Coastal Zone Management Plan could not have been completed without the many interested stakeholders who supported this national planning initiative from its conception to its design, and throughout its development process to its finalization. Special thanks to Vincent Gillett, Colin Gillett, Janet Gibson, Imani Fairweather-Morrison and Leandra Cho-Ricketts, Ph.D., for their input on the framing and layout of the Plan document, and to Nicole Auil-Gomez for her thorough editorial review. Yamira Novelo and Monique Goldson were very helpful in researching and acquiring information on the human uses of the coastal zone.

The Coastal Zone Management Authority and Institute (CZMAI) is grateful to its partners from the Natural Capital Project at Stanford University for lending science support to the planning process through the use of its ecosystem-based decision making tool, "*InVEST*". This ecosystem-based approach formed the science basis for most of the coastal zone management recommendations presented in this Plan. Special recognition must be given to the Project's Managing Director, Mary Ruckelshaus, Ph.D., and the dedicated members of her team that worked closely with CZMAI to interpret and visualize the science outputs from InVEST. These team members are namely Katie Arkema, Ph.D., Amy Rosenthal, Gregg Verutes, Spencer Wood, Ph.D., Gregg Guannel, Ph.D., Anne Guerry, Ph.D., Jodie Toft, Ph.D., Jess Silver and Joe Faries. Thanks must also be given to Ian Gillett, Melanie McField, Ph.D., Nadia Bood and Julie Robinson for their contributions during the early phases of the application of InVEST in the capacity of participants of an advisory group.

CZMAI would like to especially thank all the government ministries, departments and non-governmental organizations that generously provided spatial data sets and non-spatial information utilized in the development of this Plan. These organizations included the Land Information Center, Lands and Surveys Department, Fisheries Department, Geology and Petroleum Department, Statistical Institute of Belize, Department of the Environment, Belize Trade and Investment Development Service, Belize Port Authority, ECOMAR, Belize Audubon Society, Wildlife Conservation Society, Wildtracks, The Nature Conservancy, Turneffe Atoll Trust, Healthy Reefs Initiative, World Wildlife Fund, The Oceanic Society, Toledo Institute for Development and Environment, and Southern Environmental Association.

Thanks to all the stakeholders that exercised their rights as Belizeans to have their voices heard during the consultation process. Your opinions and visions for the future of Belize's coastal zone have been invaluable. CZMAI commends those stakeholders that helped to drive the planning process, especially through their active participation in Coastal Advisory Committees. CZMAI would like to thank the Minister and Chief Executive Officer of the Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development, and the CZMA Board of Directors for their leadership and support. Finally, CZMAI is grateful to the Government of Belize, Oak Foundation and the Summit Foundation for financing the development of this Plan.

EXECUTIVE SUMMARY

Belize is home to the planet's second longest unbroken reef system and its coastal zone contains a rich diversity of habitats and attractions, including three atolls, several coastal lagoons, mangrove forests, and over 300 cayes. Over 40% of the Belizean population live and work in the coastal zone, which supports thriving fisheries, aquaculture and tourism industries. As a result of the multiple uses and increasing demand for coastal lands, the government of Belize passed the Coastal Zone Management (CZM) Act in 1998 to address issues such as rapid development, over-fishing, and population growth. The CZM Act mandates the Coastal Zone Management Authority and Institute (CZMAI) as the entity responsible to design a National Integrated Coastal Zone Management (ICZM) Plan. The goal of the ICZM Plan is to recommend actions that will ensure sustainable coastal resources use by balancing conservation ideals with the economic and social needs of the country.

Although national in scope, the Plan builds upon efforts at the local level to develop sustainable regional guidelines. These efforts are coordinated with Coastal Advisory Committees (CACs) for nine coastal planning regions along the coast and offshore cayes. As an important complement to written guidelines, the Plan includes a zoning scheme, which spatially designates permissible activities and uses. It was created in collaboration with the Natural Capital Project through the use of the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) modeling tool. The tool was used to examine the effects of human activities on the benefits people receive from coastal and marine ecosystems called 'ecosystems services'.

A flexible work plan was set that made knowledge-building, ecosystem services, and stakeholder engagement central to the process. CZMAI and the Natural Capital Project spent several months gathering existing data about biodiversity, habitats, and marine and coastal uses. This information was comprehensively mapped and shared with the public for review and feedback. CZMAI grouped marine and coastal uses into useful zoning categories and developed three possible zoning schemes at the local and countrywide scales. These three schemes emphasize different priorities of stakeholders: conservation, development and informed management. In order to understand the implications of each zoning scenario, CZMAI used InVEST to model several ecosystem services and to create final zoning schemes.

InVEST results indicate that in a "Development" future, the risk of habitat degradation would increase, and the delivery of ecosystem services would decrease. A "Conservation" future would improve the health of ecosystems but would reduce human use of the coastal zone. An "Informed Management" future embraces a combination of development and conservation priorities, and would minimize impacts on coastal and marine ecosystems. ***CZMAI endorses the informed management scenario as it represents the most sustainable future for Belize's coastal zone***. Belizeans will be ensured of a sustainable future where healthy ecosystems support, and is supported by, thriving local communities and a vibrant economy.

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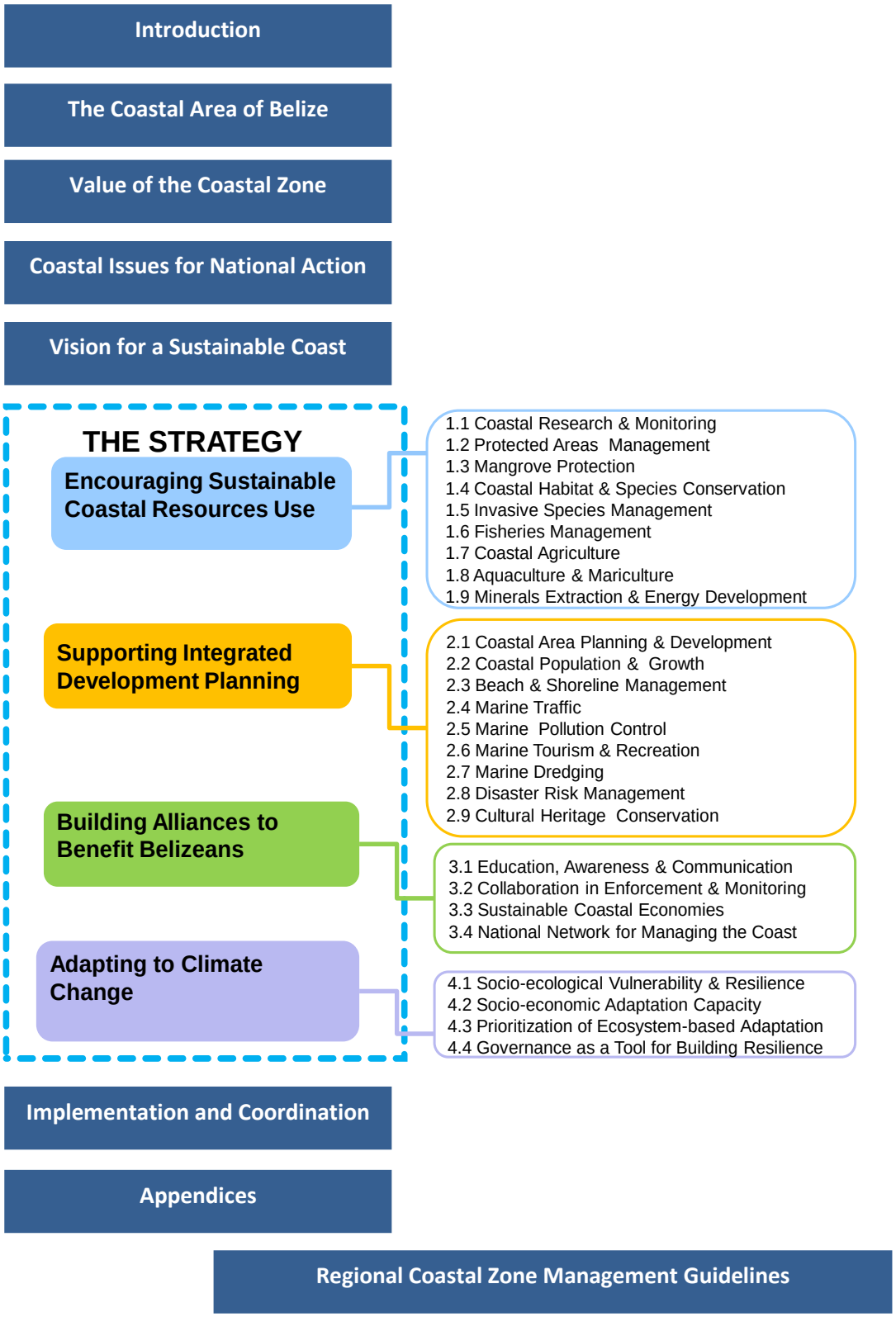
STRUCTURE OF PLAN



LAYOUT OF PLAN DOCUMENT

This Plan contains a combination of broad, strategic narratives and prescriptive, region-specific guidance that lays out proactive and adaptive strategies to facilitate the improved management of coastal and marine resources within a specified timeframe by all relevant agencies.

Introduction

This section provides historical context on the human use of the coastal and marine resources of Belize. It describes the events that led to the call for an integrated approach to coastal zone management and outlines the goals for integrated coastal zone management (ICZM) in Belize. The vision for a sustainable coast is also articulated that is in line with the country's national development framework. The legal framework, statutory responsibilities and planning processes for the development of Belize's ICZM Plan are also summarized.

Value of the Coastal Zone

This section defines the coastal zone and describes the ecological value of Belize's natural coastal and marine systems. The coastal resources base is highlighted as the central thrust for economic activities and the key to human well-being for the country.

Coastal Issues for National Action

This section specifies the key economic, social, cultural and environmental drivers that affect the current use of coastal resources, and which may affect their future sustainability of coastal and marine resources.

Vision for a Sustainable Coast

This section of the Plan details the strategic action steps required for Belize to attain its vision for a sustainable coast. Specifically, the strategic steps are discussed under four thematic areas: **Encouraging Sustainable Coastal Resources Use; Supporting Integrated Development Planning; Building Alliances to Benefit Belizeans; and Adapting to Climate Change**. For each thematic area, detailed topical issues and activities are addressed and corresponding guiding principles are presented that set the foundation for guiding ICZM.

Implementation and Coordination Plan

The implementation and coordination plan encapsulates the ideal action steps for making ICZM effective, that is, the coordination and integration of existing legislation, policies and management efforts of all organizations managing sectoral areas directly or indirectly related to the coastal and marine environment. The implementation plan identifies an issue, outlines the action that must be taken, identifies the relevant lead agency or agencies and sets a target timeframe for the completion of action items. The action plan also suggests a monitoring and evaluation mechanism by which organizations' performance can be measured. Key components of the implementation strategy are region-specific coastal zone management guideline for nine (9)

ACRONYMS

APAMO	Association of Protected Areas Management Organizations
BELTRAIDE	Belize Trade and Investment Development Service
BNE	Belize Natural Energy
BOD	Board of Directors
BTB	Belize Tourism Board
CAC	Coastal Advisory Committee
CATHALAC	Water Center for the Humid Tropics of Latin America and The Caribbean
COLA	Citizens Organized for Liberty through Action
COMPACT	Community Management of Protected Areas for Conservation
CZMAI	Coastal Zone Management Authority & Institute
DOE	Department of the Environment
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
GEF	Global Environment Facility
GOB	Government of Belize
HRA	Habitat Risk Assessment
ICZM	Integrated Coastal Zone Management
InSEAM	InVEST Scenario Modeller
IPCC	Intergovernmental Panel on Climate Change
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IUCN	International Union for the Conservation of Nature
MPA	Marine Protected Area
NCCC	National Climate Change Committee
NCRMN	National Coral Reef Monitoring Network
NEAC	National Environmental Appraisal Committee
NEMO	National Emergency Management Organization
NICH	National Institute of Culture and History
NGO	Non-governmental Organization
NPAPSP	National Protected Areas Policy and System Plan
NTUCB	National Trade Union Congress of Belize
REA	Rapid Ecological Assessment
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDA	Special Development Area
SIB	Statistical Institute of Belize
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNPEI	United Nations Poverty-Environment Initiative
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UNESCO	United Nations Scientific, Educational, and Cultural Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

GLOSSARY OF TERMS

"Climate Change" refers to a change in the state of the climate that can be identified, using statistical tests, by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer

"Coastal Zone" the area bounded by the shoreline up to the mean high-water mark on its landward side and by the outer limit of the territorial sea on its seaward side, including all coastal waters

"Conservation Scenario" refers to a vision of long-term ecosystem health through sustainable use and investment in conservation

"**Development Scenario**" refers to a vision that prioritizes immediate development needs over long-term sustainable use and future benefits from nature

"Ecosystem Services" are benefits nature provides to people that support human well being

"Informed Management Scenario" refers to a vision that blends strong conservation goals with current and future needs for coastal development and marine uses

"Integrated Coastal Zone Management" refers to an approach that brings together all decision-making agencies to resolve issues so as to ensure integration among their existing policies and plans to ultimately maintain, restore, and improve the quality of coastal ecosystems and communities they support

"Invasive species" any species (plant, animal or other organism) that is non-native to an ecosystem whose introduction causes or is likely to cause economic, social or environmental harm

"Marine Spatial Planning" refers to a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a political process

"Protected Area" an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means

"**Scenario**" refers to a vision or "snapshot" of what the future may look like and allow competing goal to be weighed and compared through narrative, quantitative and/or visual interface

"Sectoral" means pertaining to an economic sector

"Stakeholders" refers to individuals or groups within a region that have a vested interest in coastal and marine resources

"**Stressor**" refers to any human activity that utilizes coastal/marine resources and affects marine ecosystems

"Vessel" refers to any ship, tug or boat of any kind whatsoever whether it is propelled by steam or otherwise or is towed.

"Zone of Influence" refers to the geographic area, measuring 3 kilometers, where activities affect the properties and functions of the coastal ecosystem and the delivery of services

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INTRODUCTION

BACKGROUND

The coastal zone is one of Belize's greatest assets and its magnificent Barrier Reef Reserve System is a renowned World Heritage Site. It is the longest barrier reef in the Western Hemisphere, extending approximately 280 km from the northern to southern borders of the country (Cooper et al. 2009). Belize's coastal zone has complex and dynamic marine ecosystems that support innumerable ecological processes and a vast array of marine life and habitats. In addition to its important ecosystem functions, the coastal zone is vital to the Belizean way of life. The highly productive coastal zone is the resource base for a broad range of economic activities. In fact, approximately thirty-percent of the country's gross domestic product is directly linked to these commercial activities that take place within the coastal zone (Cho 2005). The coastal zone also has important social and cultural values to the Belizean people, especially to the approximately 40% of the population that reside on the coast and in offshore areas (SIB 2010).

Over the past decades, rapid economic development and population growth have taken place in the coastal zone and inland areas of Belize. World-renowned snorkeling and diving draw over 900,000 tourists to the region annually, driving the construction of new development (BTB 2008). These occurrences have led to increasing pressures on coastal and marine resources, with implications to the livelihoods of those that depend upon them. These anthropogenic threats stem from various developmental activities associated with tourism and recreational facilities, population growth and expansion, utility supply, dredging and mineral extraction, land clearance, pollution, waste disposal, fisheries and aquaculture. These threats are compounded by natural hazards, global warming and rising sea levels, and the vulnerability of sensitive ecological systems to climate change. Thus, it is imperative now more than ever to ensure that the coastal zone is utilized in a manner that will continue to support important ecological functions, as well as social, cultural and economic prosperity for current and future generations.

CIRCUMSTANCES AND NEEDS

Many countries, including Belize, have recognized the deficiencies of sectoral planning for coastal zone management and have identified the need for a national cooperative approach for achieving ecologically-sustainable development. The need for an integrated approach to optimally manage Belize's coastal resources was made resoundingly clear at a historic meeting in 1989 when a wide cross-section of stakeholders from various sectors, including scientists, marine managers, private sector, and coastal communities converged in San Pedro, Ambergris

Caye (Gibson 1989). The approach identified was integrated coastal zone management (ICZM) - an approach that brings together all decision-making agencies to resolve issues so as to ensure integration among their existing policies and plans to ultimately maintain, restore and improve the quality of coastal ecosystems and the communities they support (East Riding of Yorkshire Council 2002). The integrated approach also recognizes that many different players (i.e. government agencies, non-governmental organizations, industry, business, private sector, community groups, and indigenous communities can make a difference in the long-term management of the coastal zone and aims to gain commitment from these key players to a common vision. The lead in promoting the integrated approach to coastal area management has come from the European Union, the outcome of which has informed plans such as the East Riding ICZM Plan (East Riding of Yorkshire Council 2002). The small-island developing state of St. Lucia is among one of few countries in the Wider Caribbean region that developed and implemented a functional ICZM Plan (UNEP 2012). Costa Rica was the first developing country in Central America to take the lead in ICZM approaches when its program was established in 1977 (Isager 2008). Belize also began the process of preparing an ICZM Plan by way of The National Integrated Coastal Zone Management Strategy for Belize produced by the Coastal Zone Management Authority and Institute (CZMAI 2003). The Strategy was the first step of the ICZM Plan; which provides the framework to guide development and future investment, while ensuring the protection of important natural habitats and existing human uses of coastal resources.

Integrated Coastal Zone Management (ICZM) is "an approach that brings together all decision-making agencies to resolve issues so as to ensure integration among their existing policies and plans to ultimately maintain, restore and improve the quality of coastal ecosystems and the communities they support"

GOALS AND OBJECTIVES

The importance of the coastal zone is recognized by the everyday users of its resources, such as those people that live and work there, and by the multiple agencies tasked with managing different aspects of the coastal zone and its resources. These agencies primarily fall under two key ministries: Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development, and the Ministry of Natural Resources and Immigration. For many years, and even today, management of the Belizean coastal zone has been under the regime of sectoral planning. While sectoral planning and management are essential, the coastal zone is a highly dynamic area that is connected by ocean currents. Water connects all components of the coastal area, resulting in complex physical, chemical and biological interactions and the interdependency

of ecosystems over large and small spatial scales. Thus, under a sectoral planning and management regime, decisions made for one location can have significant impacts on the condition of the natural environment in that location and elsewhere.

Implementing integrated management is much harder than planning for it; it requires a combination of skills, and commitment from the people involved. Integrated management can only be achieved through a collaborative decision-making process that joins the interests, knowledge and experiences of all stakeholders from civil society, the private and public sectors. This is the core function of integrated coastal area management. The National ICZM Strategy spells out the goal of coastal area management in Belize:

> ***"To support the allocation, sustainable use and planned development of Belize's coastal resources through increased knowledge and building of alliances, for the benefit of all Belizeans and the global community"***

The fundamental goal of ICZM, then, is to facilitate the improved management of coastal and marine ecosystems so as to maintain their integrity while ensuring the delivery of ecosystem service benefits for present and future generations of Belizeans and the global community. A defining feature is that ICZM seeks to balance economic development needs with conservation in a spatially defined area within a specified timeframe. This feature also makes ICZM an ideal approach that can be applied to managing challenges that are national in scale and scope. Furthermore, for ICZM to be effective in Belize, the Plan must possess the following attributes:

- **A proactive and adaptive approach to address national marine and coastal issues that go beyond departmental mandates and jurisdictions;**
- **A specified year timeframe over which certain objectives and targets must be met; and**
- **A thorough and comprehensive means by which to track, monitor and evaluate progress**

INSTITUTIONAL ARRANGEMENTS FOR ICZM IN BELIZE

In 1990, based on recommendations from the historic Ambergris Caye meeting, a small Coastal Zone Management Unit was set up within the Fisheries Department to take a multi-sectoral management approach to coastal resources management. A Technical Committee was formed, and the need for expansion to truly carry out the functions of integrated coastal zone management became clear. Subsequently in 1993, the United Nations Development Programme/Global Environmental Facility (UNDP/GEF) supported the creation of the Coastal Zone Management Project for Belize. The Project focused on data acquisition, management, and coastal planning through several program areas.

Almost a decade after the Ambergris Caye meeting, Belize enacted the Coastal Zone Management Act (hereinafter referred to as the Act), the main function of which is to promote the sustainable development of coastal areas through coordination of existing legislation affecting coastal resources, and through building capacity and increased public participation to manage coastal resources. Through this visionary legislation (Statutory Instrument 52 of 1998), the Coastal Zone Management Authority and Institute (CZMAI) was created as the focal agency with responsibility for coordinating programs and activities for integrated coastal zone management.

Central to the mandate of the CZMAI, under the Act, is the preparation of a comprehensive coastal zone management plan. CZMAI established a coastal planning program as a strategy to ensure the attainment of this mandate. The process for the preparation of the National ICZM Plan is broadly defined in Section 23 (2) of the CZM Act. The process is relatively strict in respect of plan preparation, approval, implementation and monitoring (**Fig. 1**).

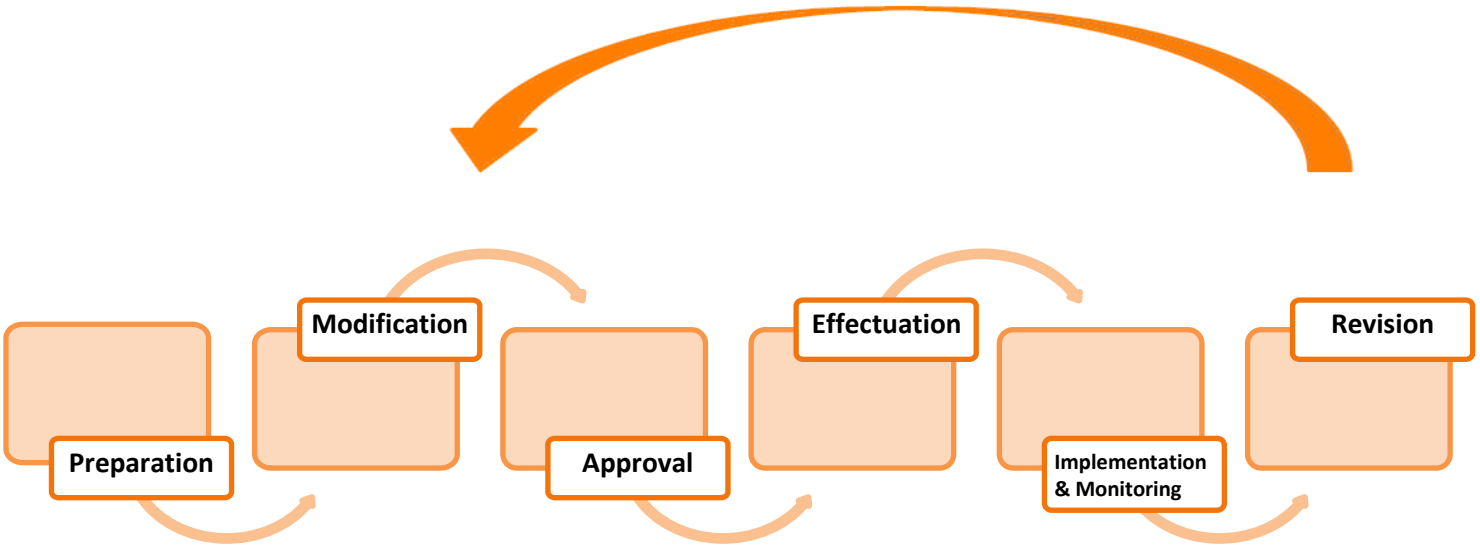


Figure 1: Planning Process for Development of Integrated Coastal Zone Management Plan

The planning process is continuous. The revision, as mandated by the Act, allows for the evaluation of the effectiveness of the proposed measures every four years, and for adjustments and additions to be made as new information comes to light. The process entails 17 clear steps, which are identified and summarized below:

Preparation

Step 1: Coastal Advisory Committees (CACs) for each coastal planning region prepare draft development guidelines, through public consultation.

Step 2: CACs forward guidelines with endorsements to the Chief Executive Officer (CEO) of the CZMAI.

Modification

Step 3: The CEO forwards guidelines to the CZM Advisory Council (CZMAC) for review, assessment, and evaluation within 30 days.

Step 4: While CZMAC is reviewing the guidelines, the CEO/CZMAI forwards the guidelines to other relevant government agencies, statutory bodies, NGOs, and members of the private sector that are not on the council for review and comments within 20 days.

Step 5: The CEO/CZMAI receives comments from relevant government agencies, statutory bodies, NGOs, and private sector and forwards them to the CZMAC.

Step 6: The CZMAC forwards comments on the guidelines to the CEO/CZMAI clearly indicating recommended changes which received full support of the council as well as areas of non-consensus.

Step 7: The CEO/CZMAI submits Plan (which is the compilation of all the guidelines with all comments received) to the Board of Directors (BOD) of the CZMAI for adoption (Section 23 (1)). As an attachment, the CEO will indicate the agency's technical/professional assessment of the guidelines and process for preparation.

Step 8: The BOD reviews the Plan within 60 days, makes modification, if any, and by Order publish in the *Government Gazette* a notice to the public that it is available for public inspection.

Step 9: The public has 60 days to review and submit comments, in writing, to the CZMAI from the date of notice of the availability of the Plan for inspection.

Step 10: At the end of the 60 days, the BOD may approve the Plan subject to such modifications it sees fit.

Step 11: The BOD submits the Plan to the Minister responsible for the CZMAI for approval (with any comments received from the public).

Approval

Step 12: After approving the Plan, the Minister tables it in the House of Representatives for approval of the House by affirmative resolution.

Step 13: Upon approval of the House, the Plan is published in three (3) consecutive issues of the *Government Gazette.*

Effectuation

Step 14: The Plan comes into effect on the last date published or on a later date, which may be specified within the Plan.

Implementation and Monitoring

Step 15: The Plan shall be implemented by government and non-governmental agencies responsible for certain aspects of the Plan.

Step 16: The CZMAI shall, in consultation with the affected GOB & NGO bodies, monitor implementation.

Revision

Step 17: Plan revision must occur within four years, commencing from the date the Plan comes into effect and must include steps 3-7 above.

COASTAL PLANNING INITIATIVES

The National Integrated Coastal Zone Management Strategy (CZMAI 2003) outlined a clear-cut strategy for improving the management of Belize's coastal area. The Strategy, which underwent extensive public consultation, was endorsed by the House of Representatives and adopted as a national policy document in 2003. In addition, using the framework of the Cayes Development Policy (CZMAI 2001), CZMAI prepared development guidelines for the country's more than 300 cayes, including the three atolls by 2004 for eight of nine coastal planning regions (**Fig.2**). Development guidelines for Ambergris Caye were not created as development planning for this region falls under the jurisdiction of the San Pedro Town Council and Ambergris Caye Planning Committee. Instead, a Master Development Plan was created for this region.

The development of both the National ICZM Strategy and site-specific development guidelines for the cayes were the preparatory phases for the development of the ICZM Plan. However, as a result of considerable scaling back of financial resources in 2005, the CZMAI had to limit its activities and the substantial coastal area planning activities embarked upon pre-2005 were effectively abandoned. As a consequence, coastal development projects and activities have been carried out in an ad hoc manner, in spite of the permitting powers several agencies have in respect of directing activities in the coastal zone. With the reinstitution of the CZMAI in 2008, and later the coastal planning program in 2010, the planning activities resumed, the main goal of which is to formulate the ICZM Plan.

It is noteworthy to mention that during the inactive years of CZMAI's coastal planning program, a key planning initiative was endorsed by Cabinet - the National Protected Areas Policy and Systems Plan (NPAPSP). The NPAPSP is a "*coherent approach to protected area establishment and management on a national scale that meets all obligations under international agreements to which Belize is a signatory*" (Meerman & Wilson 2005). Other recent Government-commissioned national planning initiatives with implications for improved resource management include the National Sustainable Tourism Master Plan (BTB 2011), the National Land Use Policy and Integrated Planning Framework (Meerman et al. 2011) and the Horizon 2030 National Development Planning Framework (Barnett et al. 2012).

The relationship between this Plan and the framework for Belize's national development is crucial. The development of the ICZM Plan represents a national planning strategy that is compatible with the consolidated national view for long-term sustainable development in Belize presented in the Horizon 2030 National Development Framework. Horizon 2030 charts a course through which citizens can live in harmony with the natural environment while enjoying a high quality of life. It also recognizes the natural resources base as the central thrust for economic growth as well the intimate connection between environmental quality and the quality of human life in Belize. Thus, embodied in the vision for Belize by the year 2030 is development planning that is based on the principles of environmental sustainability.

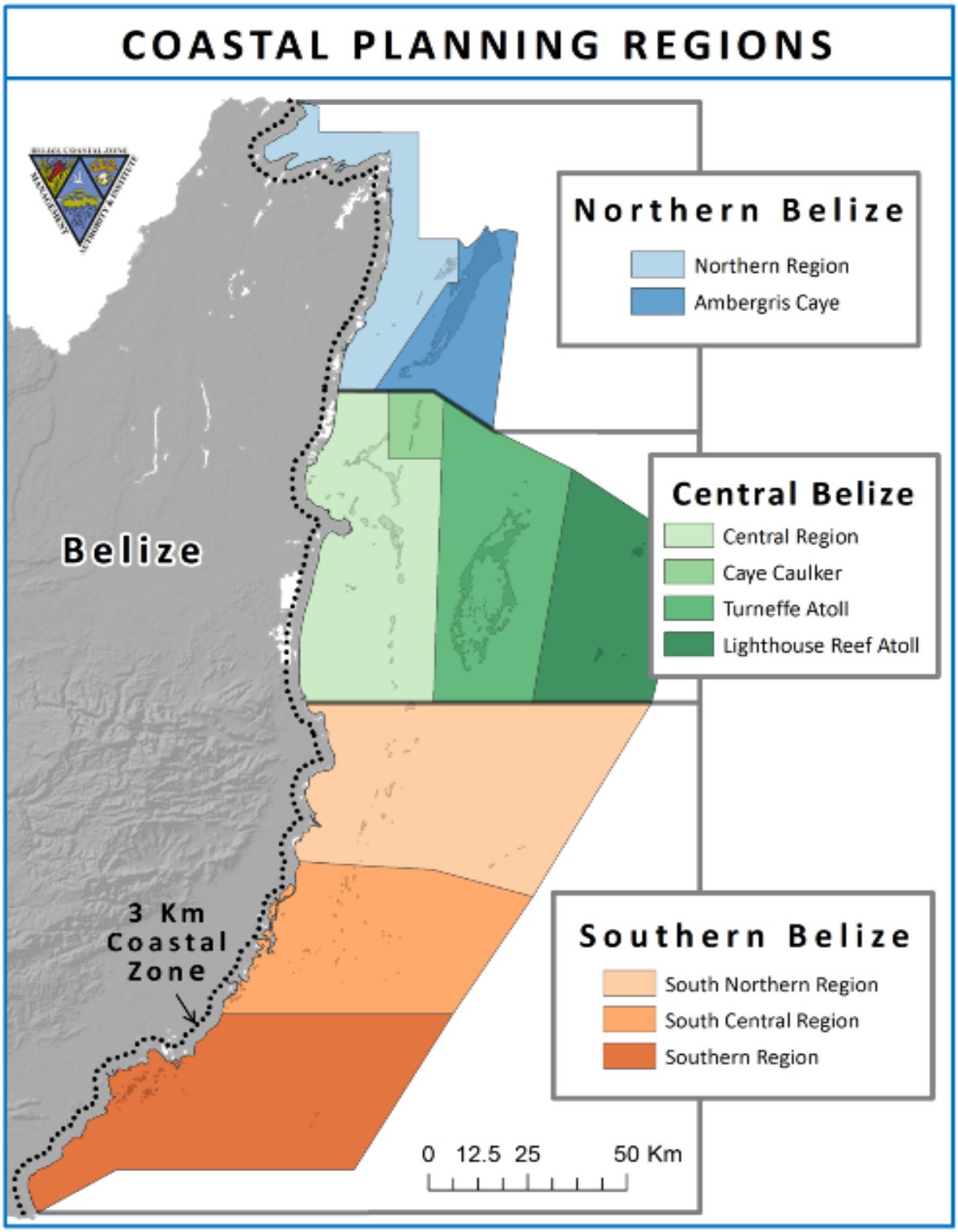


Figure 2: Coastal Planning Regions of Belize

CREATING AN INFORMED ICZM PLAN

The Belize Integrated Coastal Zone Management Plan is a planning framework that calls for national action to facilitate the improved management of coastal and marine resources, and to address the concerns of those people that visit, live in or work within the coastal zone. While the Act prescribes modifications to the Plan every four years, supporting the ideals of adaptive management, this Plan was prepared with a fifteen-year vision of sustainable marine & coastal resources use and management. The specific issues and themes addressed herein, and the proposed action steps, are the outcomes of stakeholder involvement throughout its development. Coastal and marine issues in Belize are wide ranging and cover social, economic, and environmental aspects. This is the heart of ICZM. The task of addressing some of these complex issues is not a light one, and CZMAI recognizes the importance of its partners and key stakeholders in implementing the plan. Thus, this Plan addresses and reflects people's real concerns and views, as much as possible.

CZMAI values the legislations, policies, plans, and strategies currently in place that are relevant to coastal zone management. The intention of CZMAI is to ensure that all existing plans with a relevance to the coast are integrated in this Plan. The ICZM Plan lays out policies for managing all aspects of the coastal zone. The aims of this Plan are twofold: (i) to focus management activities that are already being undertaken, ensuring these are integrated; and (ii) to highlight additional activities and actions that could be undertaken to help meet the challenge of ensuring a sustainable future. The result is a coastal zone where healthy ecosystems support and is supported by thriving local communities and a vibrant economy.

AIMS OF THE ICZM PLAN

Integrate Current Management Activities

Identify Management Gaps

Resolve conflicts over uses of the Coastal Zone

Support Multiple Human Use and Benefits

Ensure a Sustainable Future

APPROACHES

The approach taken by the CZMAI for the development of the Belize ICZM Plan involved four key steps: literature review, data acquisition, stakeholder engagement, ecosystem-based coastal and marine spatial planning:

Literature Review

A comprehensive review of peer-reviewed literature was undertaken for habitats and ecosystems, and existing and relevant planning documents. In particular, Belize planning legislation and initiatives were reviewed in addition to model ICZM plans from several geographic locations with applicability to the Belizean context.

Data Acquisition

Significant research was undertaken to acquire information on the coastal zone and to create a data base to manage data, in addition to data layers for use in a geographic information system (GIS). CZMAI collaborated with several partner agencies, both nationally and internationally, to collect physiographic, oceanographic, climatological, biological, infrastructural, geopolitical, economic, cultural and social data related to the coastal and marine area of Belize. Every effort was made to acquire the best available data and validating them with local experts.

Stakeholder Engagement

Meeting with members of the Southern Region CAC ***(CZMAI)***

In every step of the process, stakeholder participation has been critical, especially for the data acquisition, ecosystem assessments and marine spatial planning processes. The stakeholder engagement process was primarily coordinated with Coastal Advisory Committees (CACs) for the coastal planning regions along the coast and offshore cayes (**Fig. 2**), which convened representatives from multiple sectors and interest – from tourism to fishing to preservation – to make recommendations for development and conservation in their regions. Stakeholder consultations were held countrywide at strategic locations during the planning phase. These consultations included community level group meetings, and

interviews (face to face and telephone) with local experts in coastal zone management and key partners at the United States-based Natural Capital Project.

These consultations were crucial for identifying existing conflicts of interest with respect to resources use, and the vision of stakeholders as it pertains to maintaining a healthy coastal and marine environment that will continue to support livelihoods in the future.

To this end, CZMAI:

- Re-established 5 of 8 CACs
- Established working relationship with advisory committees in other 3 regions
- Hosted over 50 meetings in 9 planning regions with more than 500 stakeholders
- Completed 3 rounds of national stakeholder consultations

Ecosystem-based Coastal and Marine Spatial Planning

Belize's coastal and marine ecosystems provide a number of important benefits to its people. These benefits are sometimes referred to as "ecosystem services" (Daily 1997). For example, mangroves and corals provide protection from storms and critical habitat for lobster, a major source of revenue for Belizean fishing communities. However, they are increasingly at risk from coastal development and marine transportation. In order to address these kinds of conflicts among competing interests in a sound ICZM Plan, the CZMAI established a partnership with the World Wildlife Fund (WWF) and the Natural Capital Project to bring together critical information about the benefits coastal and marine ecosystems provide for people and the impacts human activities have on them. Starting with two major challenges, (i) **the lack of good information about the health of the coastal zone and the many existing uses it supports**; and (ii) **the competing interests among stakeholders for conflicting resource uses**, the team set up an advisory committee of regional experts to guide the process. Next, the team set out a flexible work plan that made knowledge-building, ecosystem services, and stakeholder engagement central to the process (**Fig. 3**). The team spent several months gathering existing data about biodiversity, habitats, and marine and coastal uses in collaboration with universities, government agencies, industry associations, citizens' groups, and non-governmental organizations.

Figure 3: Iterative coastal zone planning process

This information was mapped comprehensively for both the coastal and marine environs for the first time in Belize. Coastal Advisory Committees and other stakeholder groups in the nine planning regions communicated their values and goals for marine and coastal management through meeting minutes, surveys, and interviews. With this information, CZMAI determined how to group marine and coastal uses into useful zoning categories, which could be used by government agencies and stakeholders to guide implementation of the ICZM

Plan. Zones included locations set aside for marine protected areas, as well as areas prioritized for fishing, coastal development, marine tourism, aquaculture, and transportation, and other human uses (See **Figs. 7-16**). The team also began to develop three possible zoning scenarios, beginning at the local level and scaling up to countrywide. Each of these three schemes emphasizes different priorities of stakeholders (**Fig. 4**).

In order to understand the implications of each zoning scenario, the team used a decision-support tool for mapping and valuing ecosystem services called InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), developed by the Natural Capital Project. InVEST maps, measures and values benefits that humans obtain from natural systems. Based on available data and the key services of interest to stakeholders, the team modeled several ecosystem services, including catch and revenue from lobster fisheries, coastal and marine tourism and recreation, and coastal protection from inundations and storms, as well as risks to the habitats that provide these services (**Fig. 5**). Details on the methodology and InVEST models can be found in Appendices A and B respectively. InVEST results were then used to communicate options to stakeholders for a zoning scheme that would spatially locate permissible activities and human uses (**Figs. 7 - 16**). The results provided the science basis to support the ***Informed Management Zoning Scheme***, which optimally minimizes risks to critical habitats and the potential loss of important ecosystem services while also maintaining use of the coastal zone and its resources (**Fig. 6**).

Figure 4: Scenario Zoning Categories

WHY INFORMED MANAGEMENT?

The Informed Management Zoning Scheme, implemented through 2025, was preferentially selected over the Conservation and Development Zoning Schemes because this scenario represents a long-term vision of sustainable development of coastal resources that will ensure future economic benefit for Belizeans, through the minimization of environmental impacts and the maximization of ecosystem service returns. Informed Management especially acknowledges current and future needs for economic development and continued human use of the coastal zone. This zoning scheme was designed to reduce current user-conflicts, which supports the wise use and allocation of coastal and marine resources support. While the Conservation Zoning Scheme could enhance long-term ecological health through environmental preservation, it is largely anti-development and does not align with national economic

development goals for the people and country. It is intended to represent the narrow view of environmentalists who call for full preservation of existing ecosystems. The Development Zoning Scheme, on the other hand, lacks vision and is focused on maximizing economic returns from key coastal resources in the very short term. In other words, the Development Zoning Scheme embraces a vision of fast-paced economic development, based on natural resource utilization and urban expansion. It prioritizes immediate development needs over long-term sustainable use and future benefits from nature. Furthermore, the conflicts and overlapping coastal and marine uses by various industries and interests becomes increasingly greater compared to current conditions.

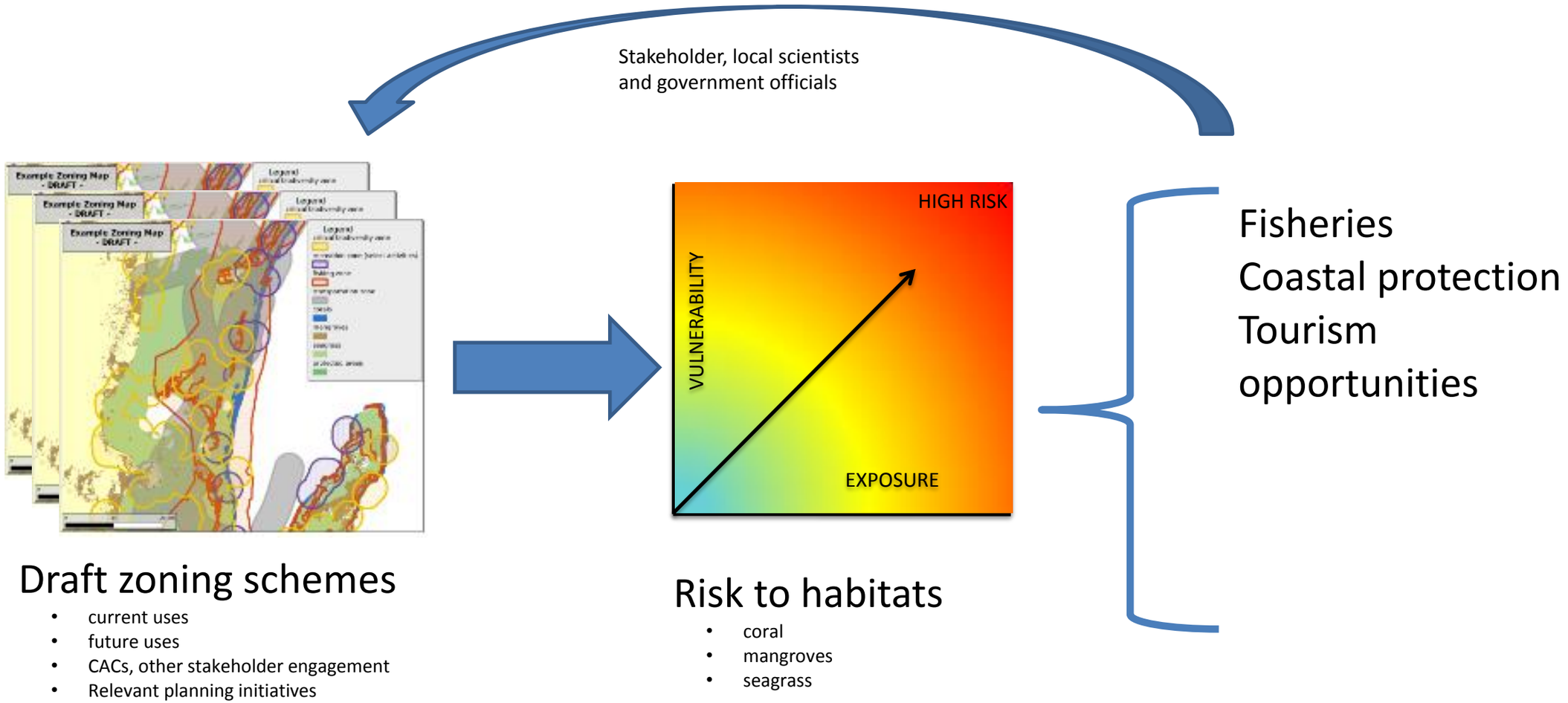


Figure 5: InVEST Approach for Modelling and Valuation of Ecosystem Services

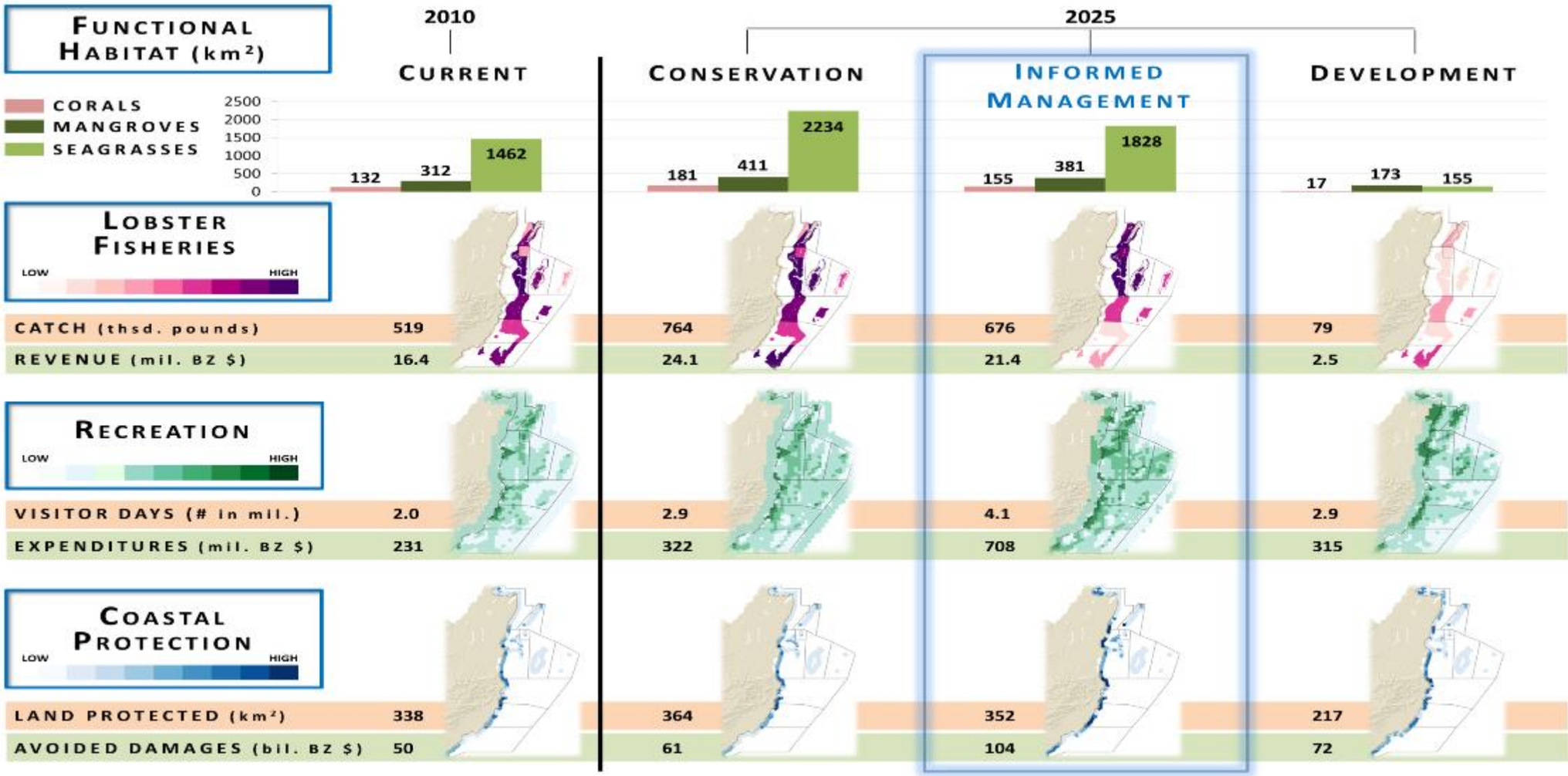


Figure 6: Functional Habitats and the Delivery of Ecosystem Services by Scenarios

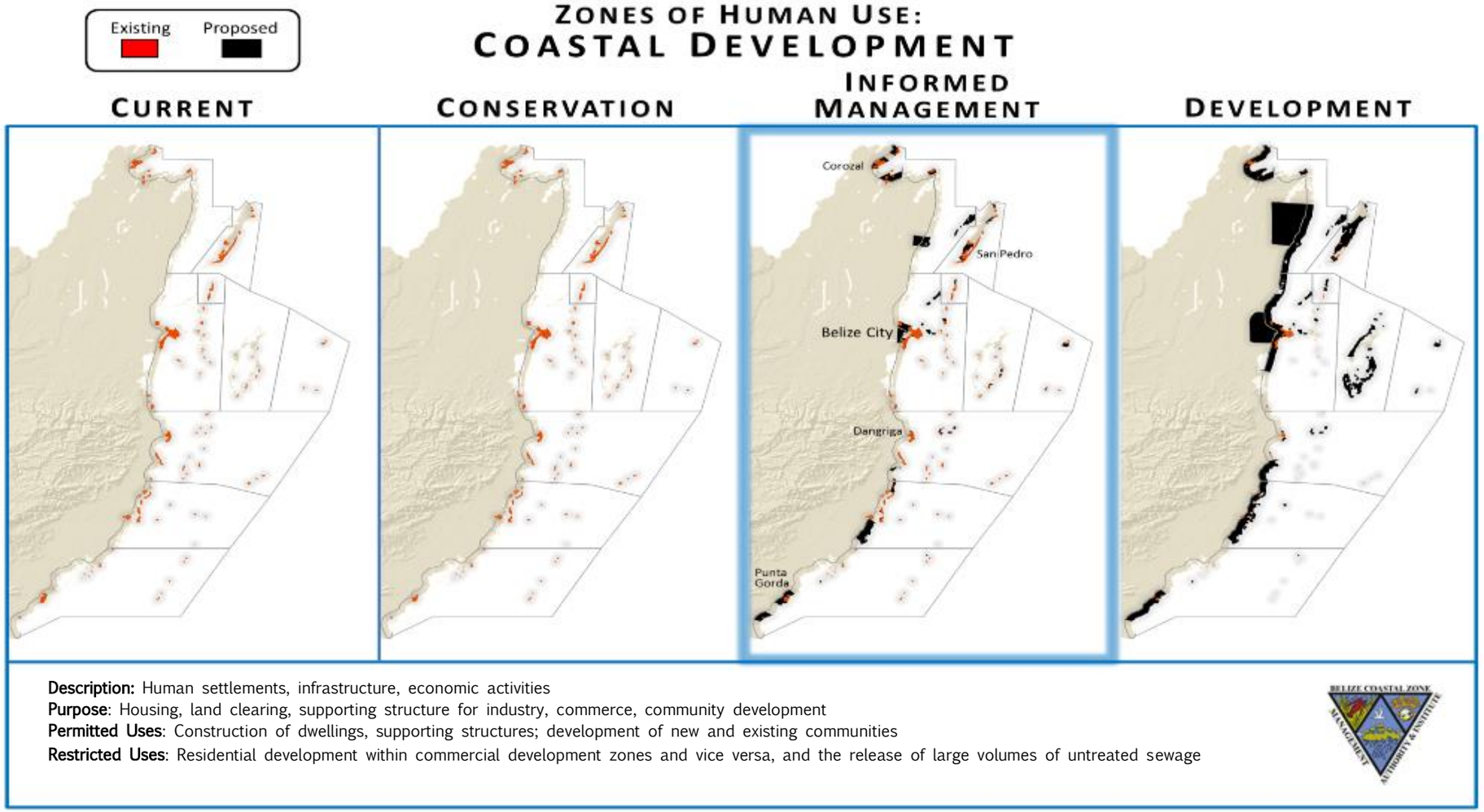


Figure 7: Coastal Development Zoning Scheme for the Current and Three Future Scenarios

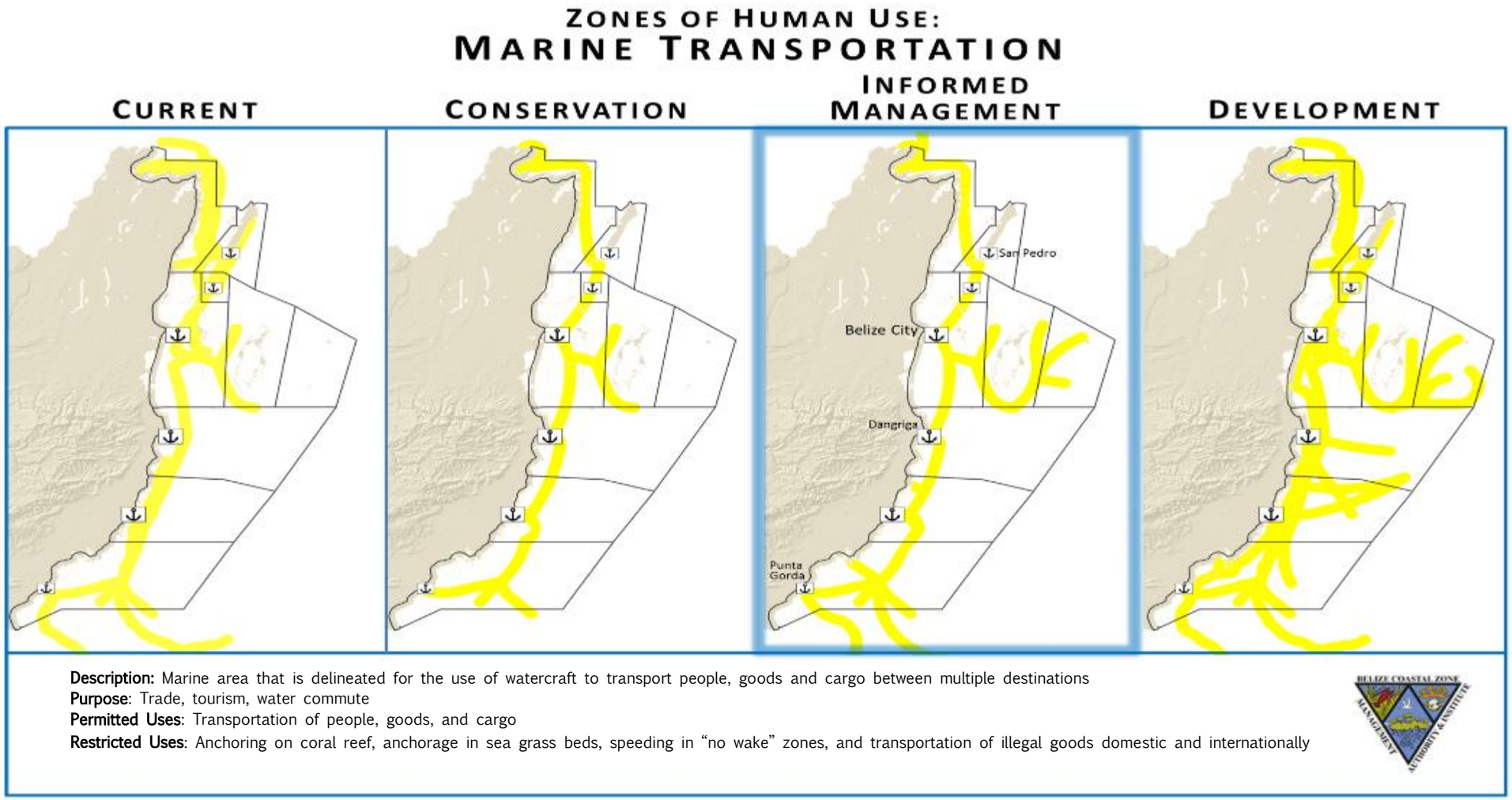


Figure 8: Marine Transportation Zoning Scheme for the Current and Three Future Scenario

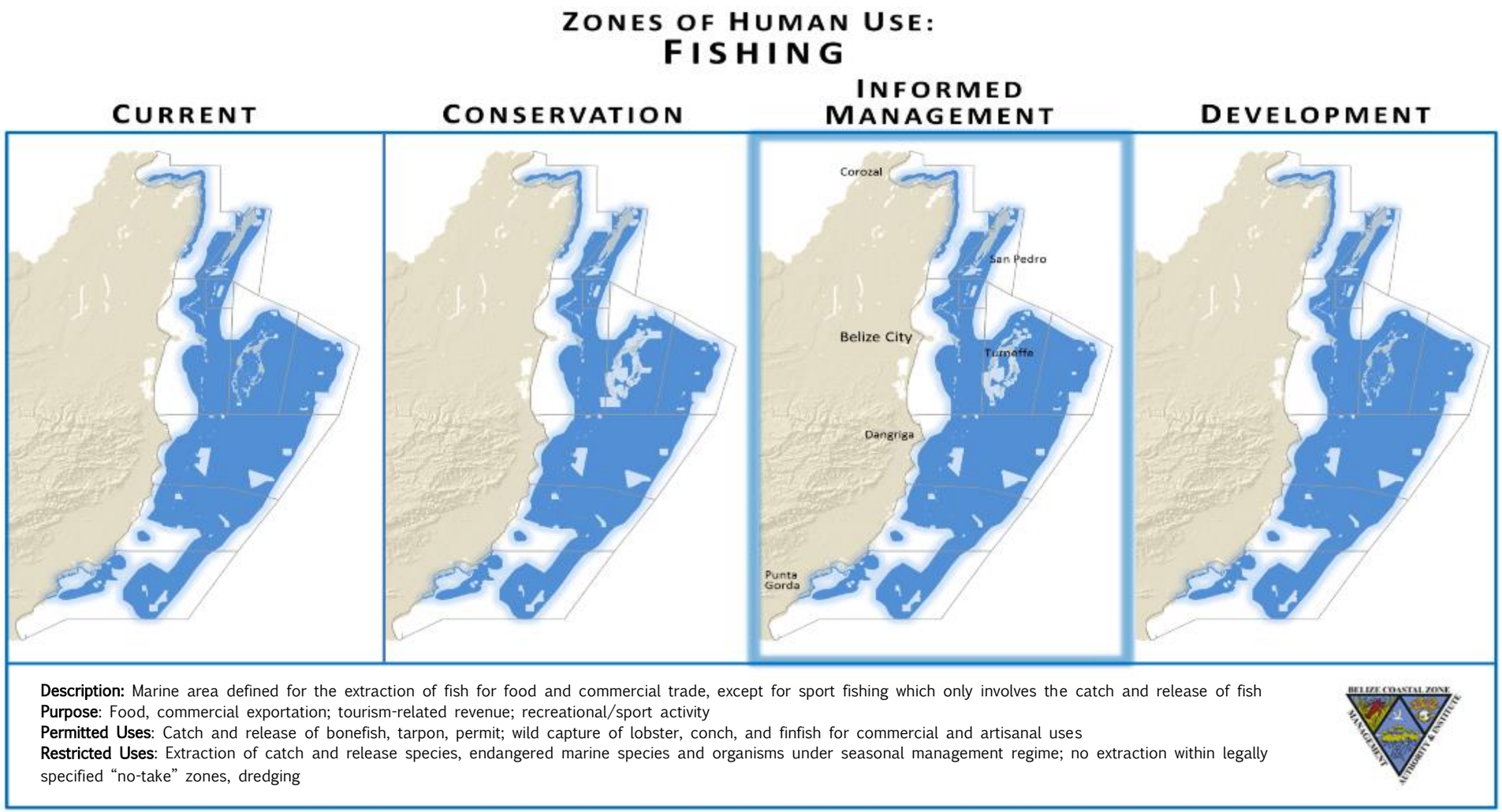


Figure 9: Fishing Zoning Scheme for the Current and Three Future Scenario

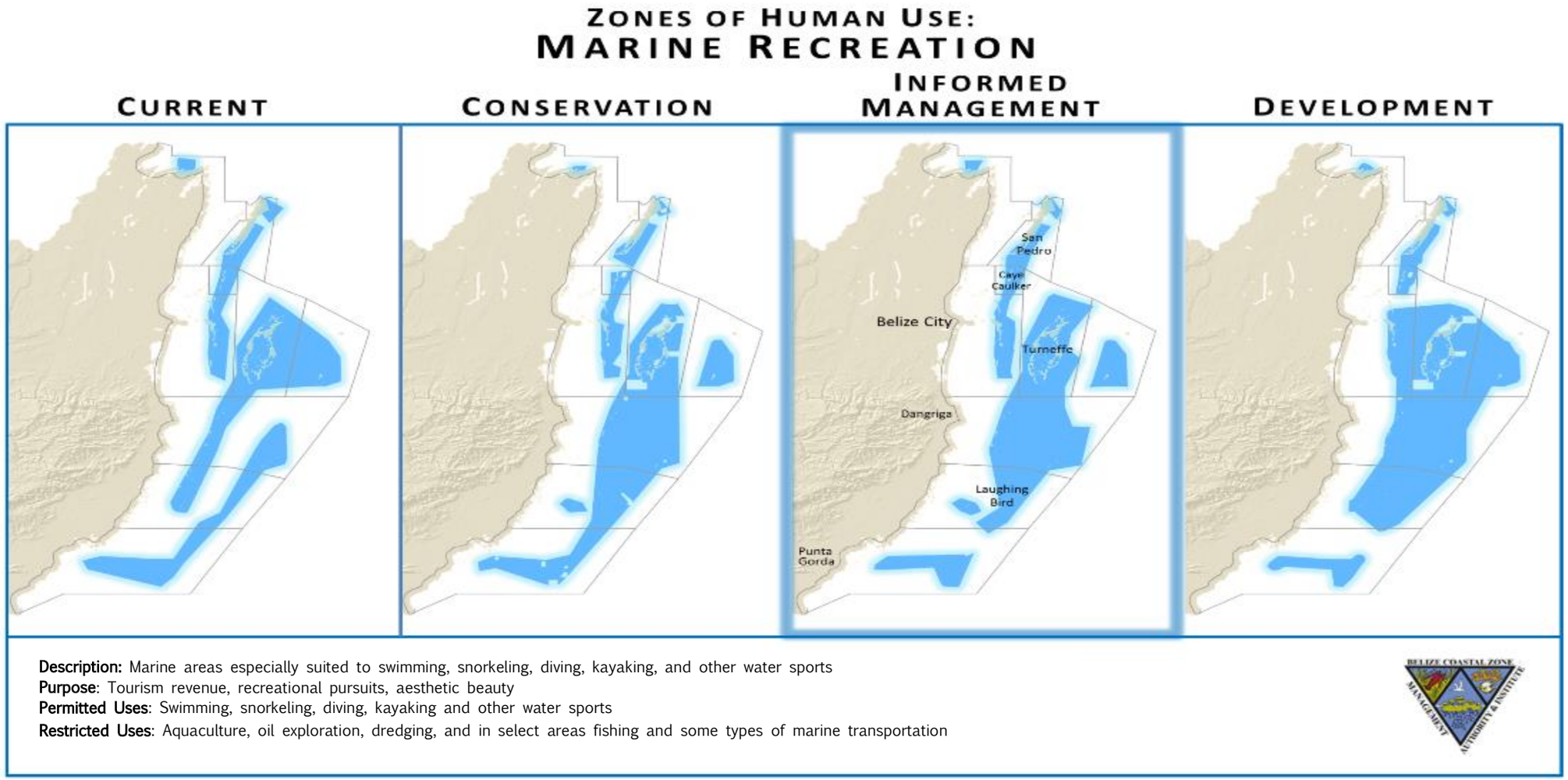


Figure 10: Marine Recreation Zoning Scheme for the Current and Three Future Scenarios

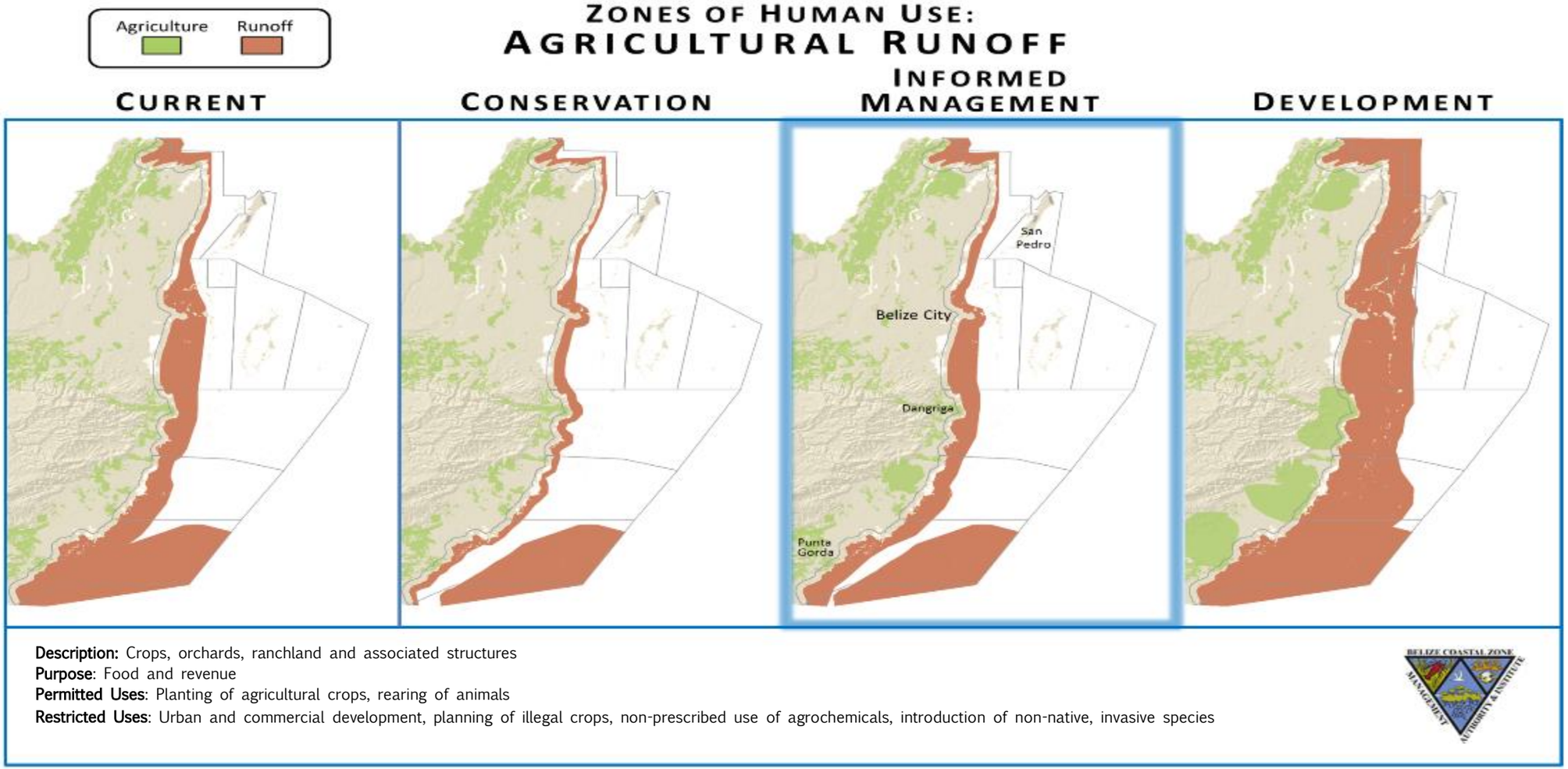


Figure 11: Agricultural Runoff Zoning Scheme for the Current and Three Future Scenarios

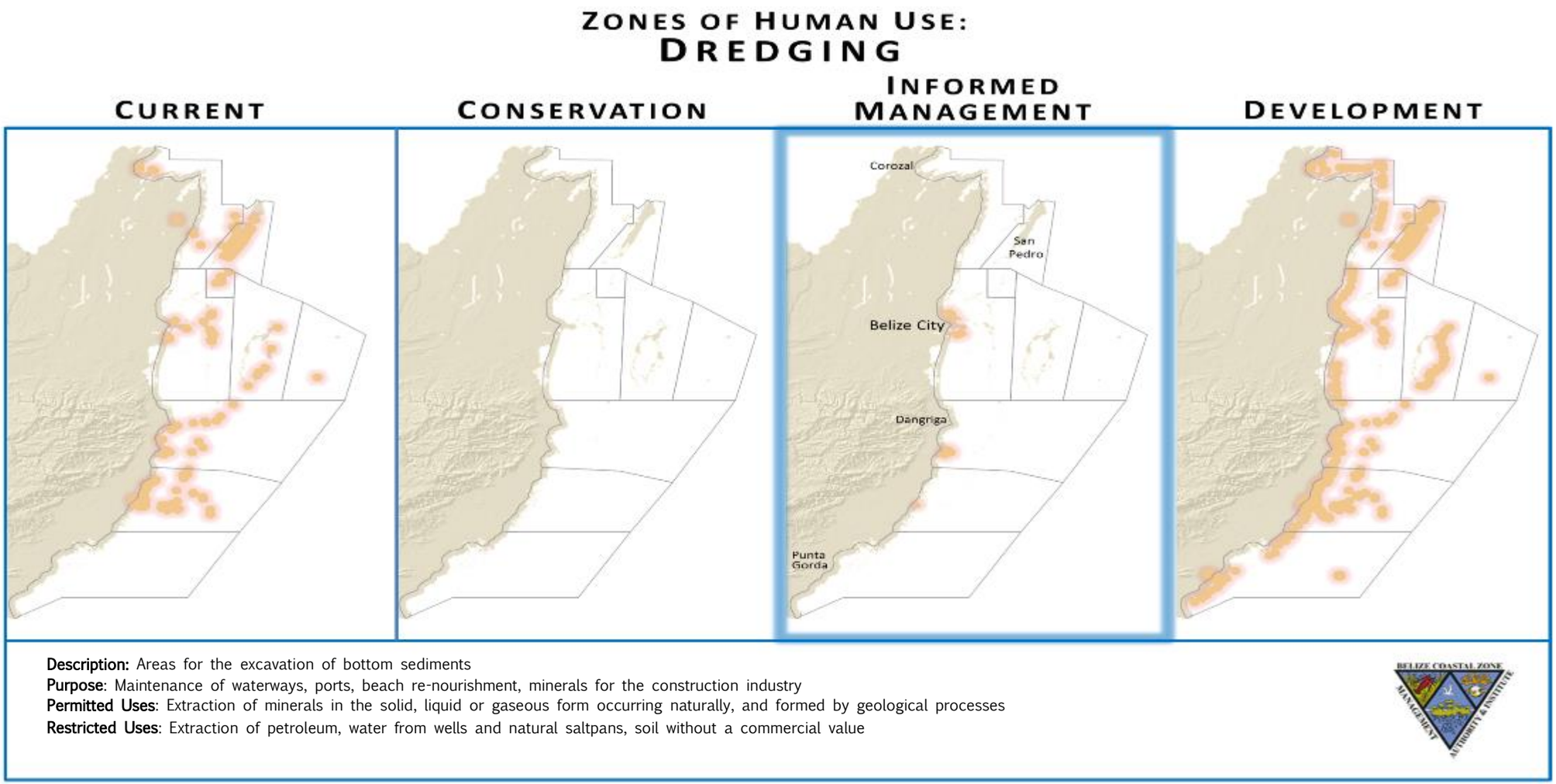


Figure 12: Dredging Zoning Scheme for the Current and Three Future Scenarios

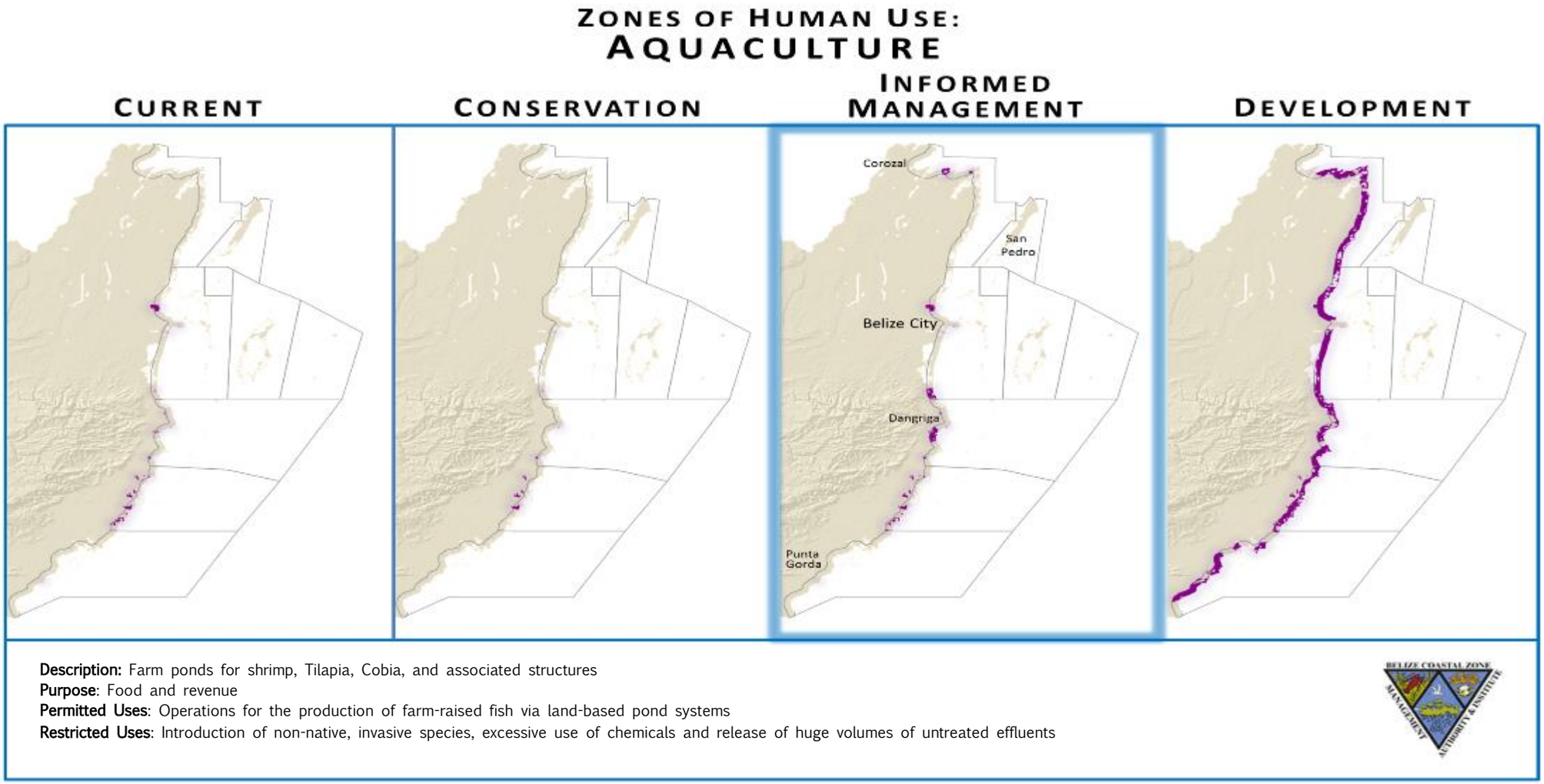


Figure 13: Aquaculture Zoning Scheme for the Current and Three Future Scenarios

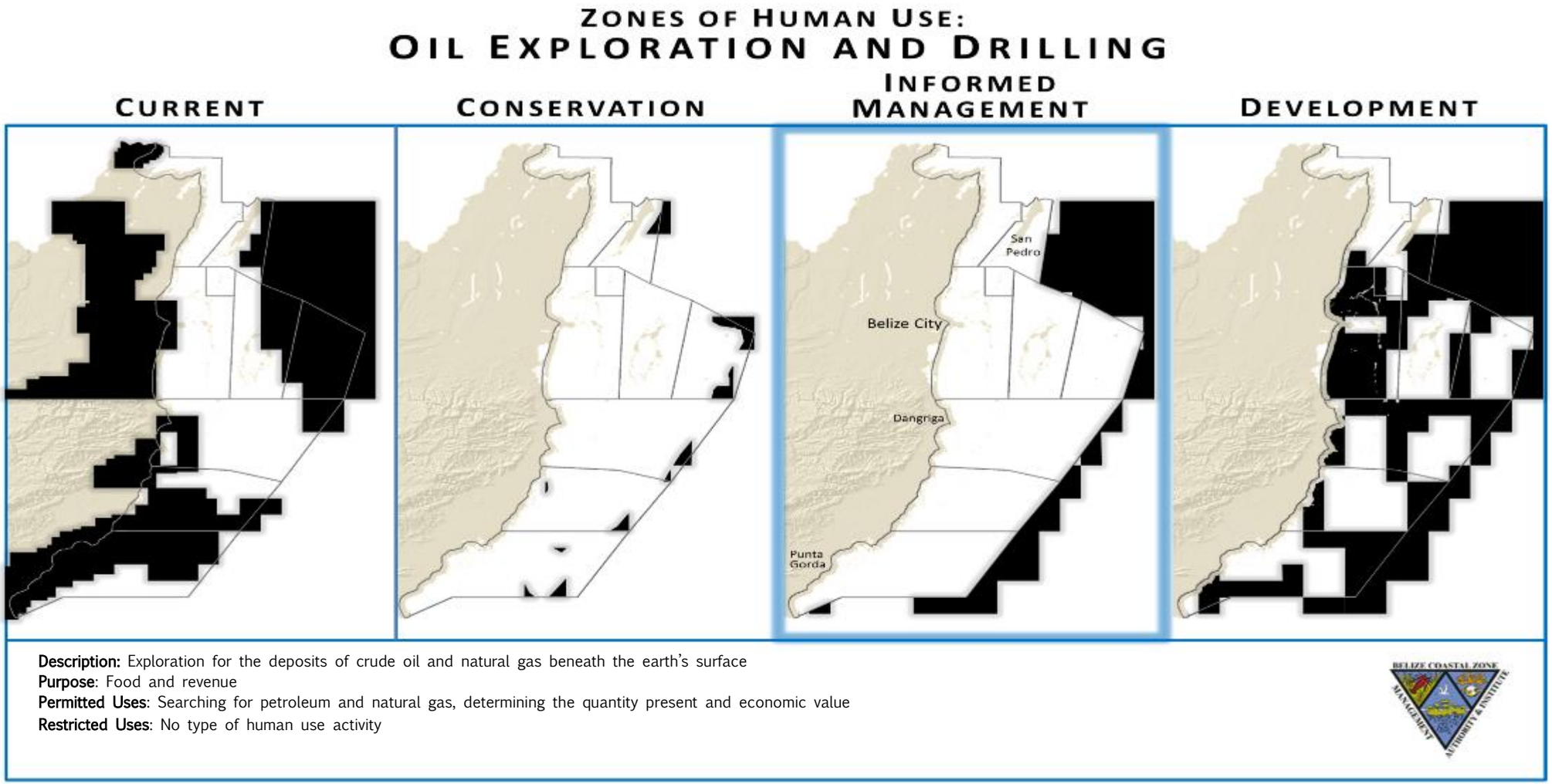


Figure 14: Oil Exploration and Drilling Zoning Scheme for the Current and Three Future Scenarios

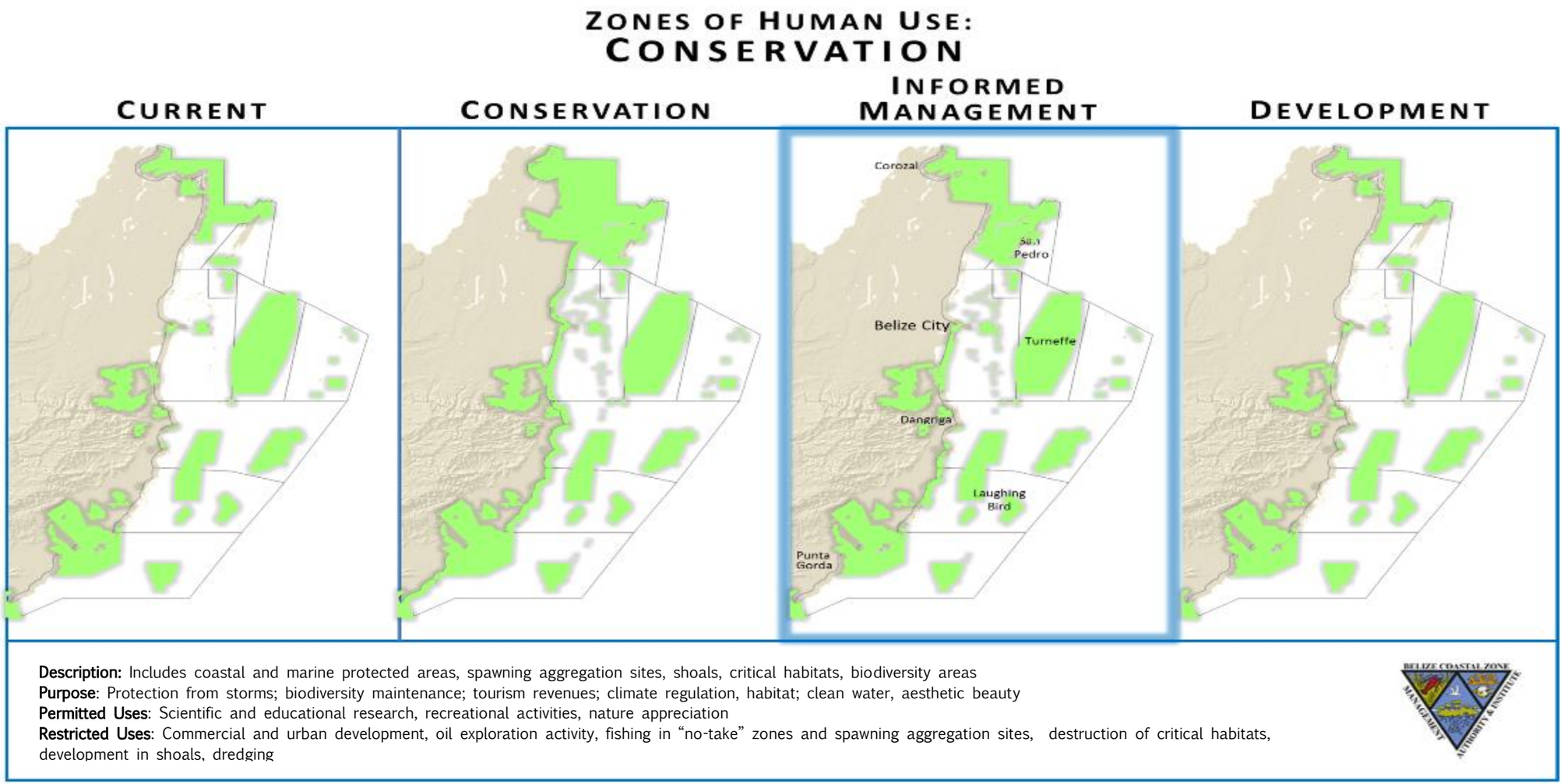


Figure 15: Conservation Zoning Scheme for the Current and Three Future Scenarios

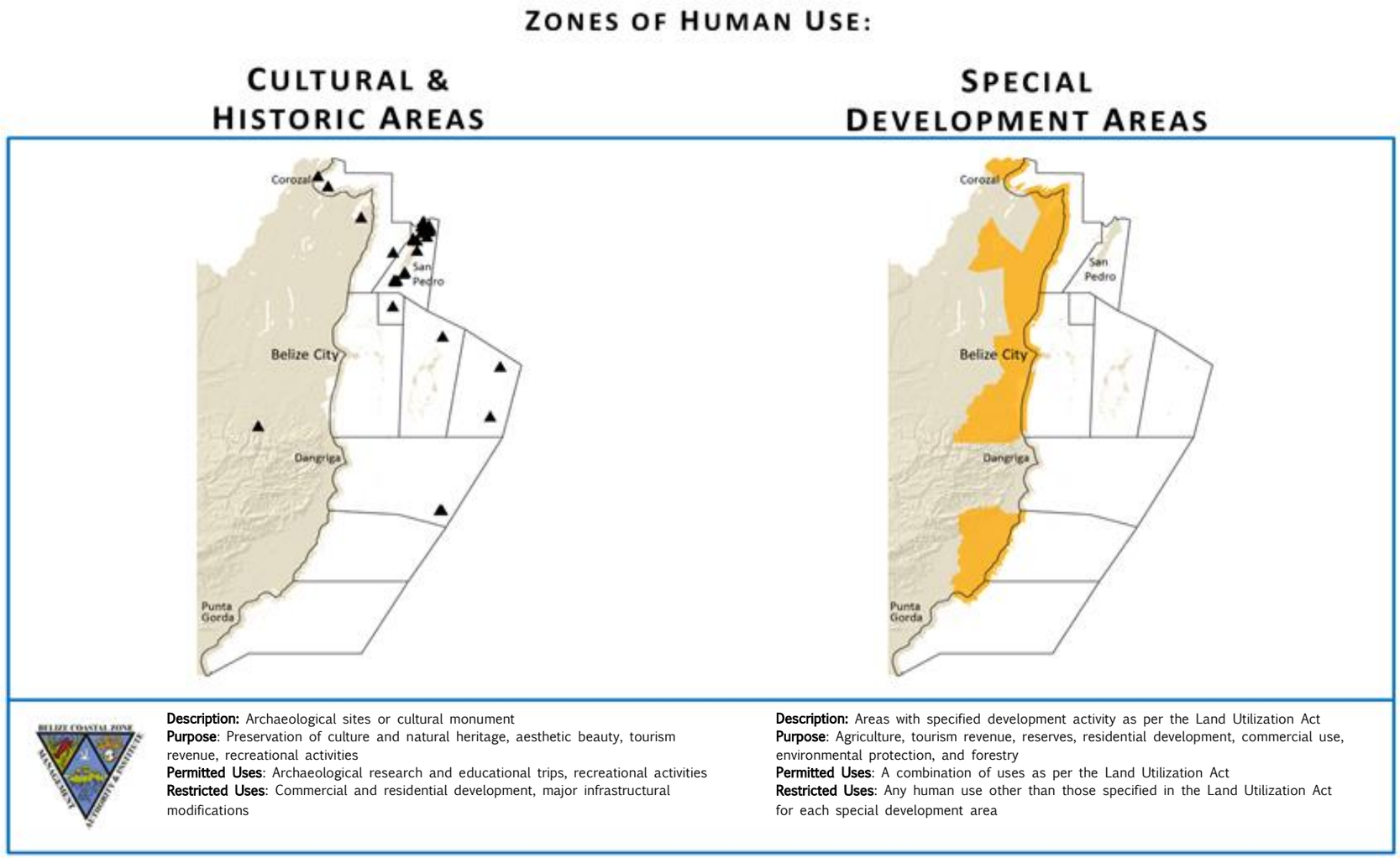


Figure 16: Cultural and Historic Areas and Special Development Zones

SECTION 1: THE COASTAL AREA OF BELIZE

THE COASTAL AREA OF BELIZE

DEFINITION OF THE COASTAL ZONE

The Belize Coastal Zone Management Act defines the coastal zone as "*the area bounded by the shoreline up to the mean high-water mark on its landward side and by the outer limit of the territorial sea on its seaward side, including all coastal waters*" (Coastal Zone Management Act, Chapter 329, Laws of Belize, Revised Edition 2000). This definition, however, limits the understanding of the coastal area as being comprised solely of the marine environment; it does not consider the influence from the terrestrial environment. Factors, including human activity, natural processes, and their interactions, greatly influence the condition and characteristics of the coast, thereby limiting or promoting ecosystem function (Kremer et al. 2005). The geographic area where activities affect the properties and functions of the coastal ecosystem and the delivery of services is referred to as the *zone of influence* (Merriam-Webster.com 2012). The use of a zone of influence in coastal planning is a common practice internationally (Naish & Warn 2001). Belize, like many other countries, is undergoing a period of growth and expansion in its economic, productive, and social sectors. Hence, there is an exponential change in the magnitude of the impacts associated with these developmental activities. This coupled with the threat of global climatic change increases the stress on the coastal ecosystem (Flood & Cahoon 2011).

MARINE BOUNDARIES

As defined in the Maritime Areas Act (Statutory Instrument 12 of 1992), the territorial sea of Belize (also the outer limits of the coastal zone) is the limit provided by law measured from the mean low water mark to 12 nautical miles outward in most places. In southern Belize from the Sarstoon River to Ranguana Caye, the outer limit is measured 3 nautical miles from the mean low water level to act as a compromise in consideration of Guatemala's proximity to Belize. Finally in areas where there are fringing reefs, the outer limit is measured using the mean low water level on the fringing reef itself. Therefore the three atolls (Turneffe, Lighthouse Reef and Glovers Reef) are included within the territorial waters of Belize. There are other specialized boundaries defined within territorial waters. These boundaries pertain to issues of conservation in which the specified areas have distinct ecological importance. Within these boundaries, activities can be regulated and extraction of any kind may be restricted.

TERRESTRIAL BOUNDARIES

All features found within three kilometers westward from the mean high water mark are considered in the Plan (**Fig. 2**). This is representative of the zone of influence, which immediately affects the coastal environment. The zone encompasses all coastal communities as well as the distribution of natural features and resources found in marine and coastal ecosystem where water levels (a) are influenced by tidal action, (b) are contiguous with sea-level, (c) have a saline influence, or (d) facilitate migration of fauna between fresh and saline water. This includes extensive riverine, estuary, and wetland systems of the coastal area.

COASTAL AND ESTUARINE WATERS

The coastal waters of Belize are the country's most important natural resource. There are many social and economic benefits attained due to its ecological richness and the many human activities supported. Estuaries, including mangrove estuaries, define the Belize coastal zone. They make up the central portion of the Mesoamerican Barrier Reef System drainage network, running from the karst hills of southern Mexico and eastern Guatemala and the Maya Mountains of southern Belize and discharging into the coastal lagoons and inner channel between the shoreline and the barrier reef (CZMAI 2012). The importance of coastal and estuarine waters to Belize can be summarized as follows:

- As the point of interaction between freshwater runoff and saline water from the Caribbean Sea, coastal waters contain many unique habitats such as estuaries, seagrass meadows, mangroves, and stromatolites. The distribution of these habitats throughout the ecosystem is the result of a variation in the level of tolerance to a salinity and sediment gradient (Mann 2000).

- The coastal waters of Belize supports a plethora of very unique and specialized fish species as well as some threatened and endangered species such as the manatees, sea turtles, and sperm whales (CZMAI 2012).

- It facilitates exchange across national and local boundaries transporting plankton, sediments, and other dissolved and suspended materials that are important to maintain ecosystem functions (Siegel et al. 2002).

- For humans, it provides and facilitates activities such as tourism and recreation, transportation, fisheries, and foreign trade. It also provides habitat for those flora and fauna that are economically important for Belize.

- Finally, coastal land is highly desirable and very valuable, with up to 40% of the population settling along the coast and parcels starting at $80,000 Belize dollars per parcel in some areas (Belize Real Estate and Auto Rental 2006).

Similar to the processes and components of the coastal ecosystem, the physical structure is equally as dynamic, shaped largely in part by the coastal waters. Through wave action and ocean currents, the seabed and shoreline are continuously being acted upon resulting in changes in position and composition (Natesan & Subramanian 1994). The constant disturbance and upheaval of the shoreline and seabed improves the resilience of the ecosystem and indirectly promotes healthy ecosystem function by unlocking nutrients that have been buried deep within the substrate. As a result, coastal waters are able to support many animals and plants that are essential for day-to-day community existence and cultural identity (Small & Nicholls 2003). Because of this interconnectivity between land, freshwater, brackish water, and marine ecosystems, effective management of watersheds and associated wetlands is essential to effectively manage the coastal and marine natural resources (CZMAI 2012).

BLUE WATER

In Belize, the extent of the sea bed is 280 kilometers long and between 15-40 kilometers wide (Purdy et al. 1975). Located within this underwater shelf extension are the atolls Glovers Reef, Turneffe, and Lighthouse Reef. Atolls are broadly defined as areas with large ring shaped coral reefs that surround a central lagoon. They were first recognized in the scientific community by Charles Darwin who postulated their origin, and linked reef formation and structure to environmental variables (Kohn 1961). Along the edge of the Belize continental shelf is the world's second longest barrier reef. The United Nations Scientific, Educational and Cultural Organization (UNESCO), in recognition of its status and importance at a global level, declared the Belize Barrier Reef Reserve System a World Heritage Site (Gibson 2011) – a serial nomination consisting of seven sites.

THE COASTLINE

Sixteen major watersheds and several coastal stream catchments drain into the continental coast of Belize (CZMAI 2012). Sediments carried by these rivers are redistributed by wave and current action along the shoreline forming numerous depositional features including beach ridges, sand bars, and deltas. These transported sediments and nutrients dictate the distribution of marine habitats such as seagrass bed, mangroves, and coral reefs by either promoting or inhibiting ecosystem functions. Habitat along the coastline act as nesting sites for many bird species and as nurseries for many juvenile marine and aquatic species. The wetlands, rivers, and lagoons are home to manatees, crocodiles, and many species of juvenile and adult

fish. The wetlands are efficient buffers against storm surge, are important in flood control, and can adapt to changing sea levels. They also thrive on nutrients and sediments derived from the land, and in so doing, help to trap them and limit transport to the sediment-sensitive reef systems of our blue water region.

THE SEA FLOOR

The rich seafloor of Belize acts as substrate for seagrass beds, one of the unique marine habitats that exist within our coastal waters. Seagrass beds in turn stabilize the substrate and act as a trap to prevent sediment build up from occurring on the reef. The most common type of sub-aquatic vegetation found in Belize is the turtle grass (*Thalassia testudinum*), which thrives in areas that receive protection from strong currents and high surf. Trapped sediments and other particulate organic matter attract many different species of fish, lobster, conch, turtles, and manatees. These organisms also take advantage of the vastness of the seagrass beds and utilize it for protection.

HABITATS

Corals Reefs

Belize's coral reef is a critical feature of the national economy, food security, and cultural traditions. The reef also provides critical "ecosystem services" that include: providing a habitat for commercially valuable fish, offering opportunities for recreation and tourism, and providing protection from coastal erosion and hurricanes (CZMAI 2012). Prior to 1998, Belize's reefs were thought to be in relatively "good" condition and were considered some of the healthiest in the Caribbean (McField et al. 1996; Kramer, et al. 2000). However, escalating threats, including coral bleaching, disease and a major hurricane in 1998, adversely affected Belize's reefs, which experienced a 48% reduction in the live coral cover along Belize's forereefs (McField 2002). As of 2005 there had been no sign of reef recovery based on the analysis of six reef sites (Bood 2006). The average coral cover and fish abundance was slightly below the Caribbean average (Marks & Lang 2006). In addition, the 2015 Report Card for the Mesoamerican Reef noted that of 94 sites assessed, 47% were in poor condition, 21% critical, 28% fair and 4% were found to be in good health (Healthy Reefs Initiative 2015). These observations were in reef health were attributed mainly due to reduced fish biomass and increased macroalgal cover.

This Plan presents an ecosystem-based assessment of potential threats to coral reef ecosystem in Belize. It draws on 9 environmental stressors (including fishing, marine transportation, coastal development, aquaculture, marine recreation, dredging, agriculture, and oil exploration), information on 9 coastal planning regions, and scientific expertise to model

areas where reef degradation is predicted to occur, given existing human pressures on these areas (**Fig.17**). Results are an indicator of potential threat (risk), not a measure of actual condition. In some places, particularly where good management is practiced, reefs may be at risk but remain relatively healthy. In others, this model may underestimate the degree to which reefs are threatened and degraded.

Results from the InVEST Habitat Risk Assessment (HRA) suggest that 81% of Belize's coral reefs, covering an area of 257 km ^{2}, are currently at medium risk by human activity (**Fig 17**). One percent of corals are currently at low risk, and almost 18% are currently under high threat from human activities. Coral reefs of the Southern Region, are the most threatened of any region under the current and 3 future scenarios; more than 90 percent are at risk (under medium and high potential threat), and over half are at high risk, primarily from fishing pressures and oil exploration. The South Northern Region, which houses more reef area than any other region, is also the least threatened currently and in the conservation, informed management and development zoning scheme.

InVEST Habitat Risk Assessment results also suggest that nationally, the Informed Management zoning scheme would reduce the area of corals at high risk to about 90% of the area currently at high risk (**Fig 17**). This reduction in high risk in the Informed Management zoning scheme was achieved by reducing the exposure of corals to the cumulative impacts of multiple stressors like fishing and oil exploration. Through this process of zoning areas for certain uses, CZMAI was able to minimize the number and overlap of human activities in sensitive ecosystems. It should be noted, however, that because the Informed Management scenario balances economic development and conservation, large expanses of these ecosystems are nevertheless still at medium risk to stressors. Dramatic increases in the area of the three habitats at low risk only occur in the Conservation scenario (**Fig. 17**). The results indicate that under the Development scenario, the area of corals at high risk is more than five times the area at high risk in the current scenario (**Fig. 17**). Additional information on how the Habitat Risk Assessment model works can be found in **Appendix B.1**.

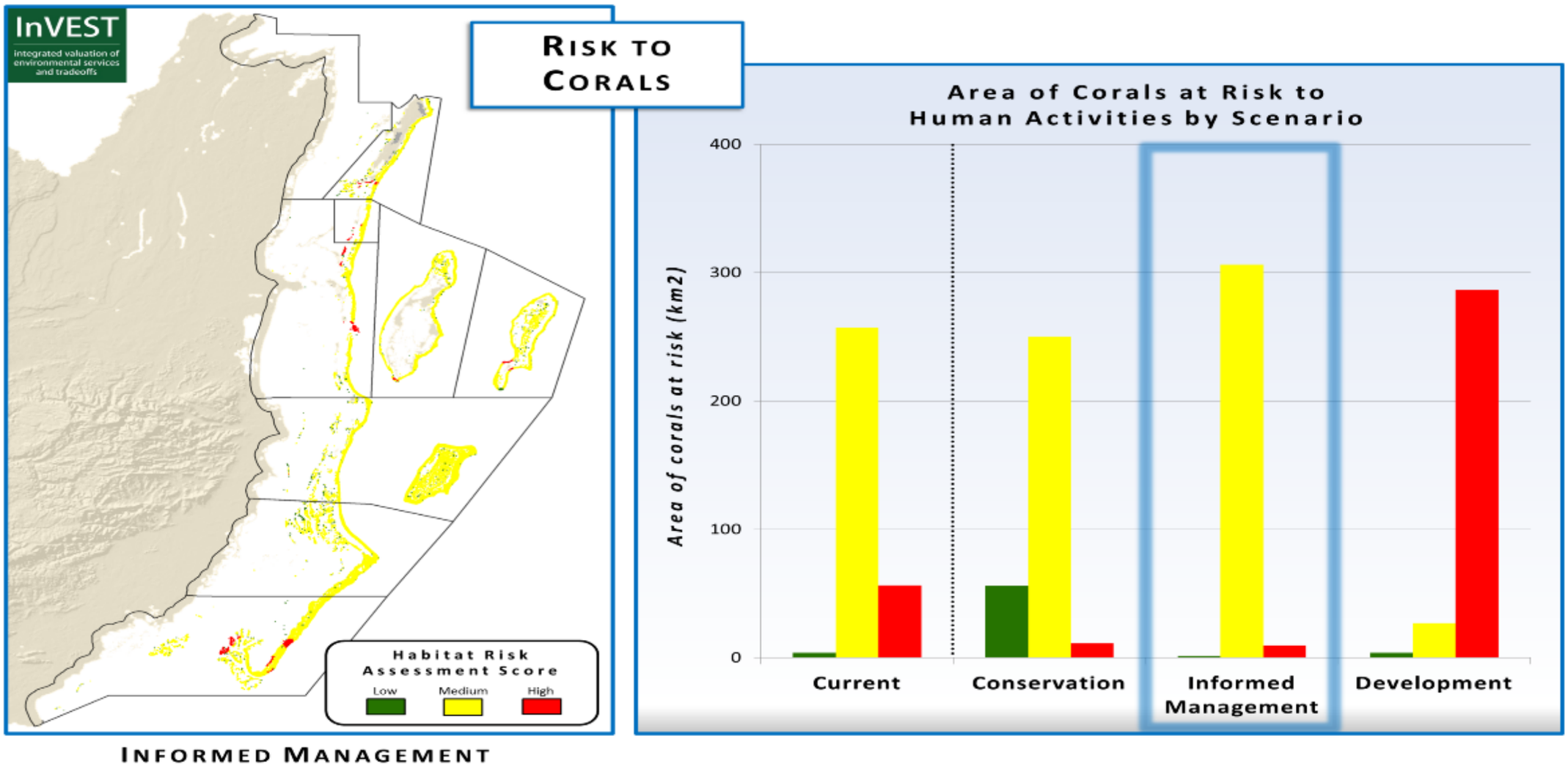


Figure 17: Area of Corals at Risk from Human Activities by Scenario

Seagrass

Seagrass in Belize is widespread and crucial to the health of the country's coastal oceans. Healthy seagrass supports both the fisheries resource (commercial, recreational and artisanal) and the clear marine waters that make Belize a tourist destination. Seagrass is an overall indicator of coastal ecosystem health and monitoring the seagrass status and trends is therefore important. Currently, seagrass are fairly stable and healthy, with only a few sites showing concerning negative trends. The major threats are coastal pollution (primarily nitrogen loading), sediment inputs from upland deforestation and mangrove removal, onshore coastal development, agriculture and aquaculture, and direct dredging and hardening in the coastal zone. Also, in some areas, there are tourist impacts from boating and trampling that may be an issue locally. With monitoring and careful management, along with increased awareness of the value of seagrass habitat to the country's economy, seagrass in Belize can persist and thrive (CZMAI 2012).

Results from the InVEST Habitat Risk Assessment (HRA) suggest that 78% of Belize's seagrass are currently at medium risk from human activity, the equivalent of 2869 km^2 (**Fig. 18**). One percent of seagrass are at low risk, and 21% are currently under high threat from human activities. Based on the InVEST Habitat Risk Assessment, the greatest area of seagrass currently at high risk of degradation from human activities is in the Central region, followed by Ambergris and Caye Caulker. Further analysis of the HRA results reveal that nationally, the Informed Management zoning scheme would reduce seagrass at high risk to about 75% of the area currently at high risk (**Fig. 18**). This reduction in high risk in the Informed Management zoning scheme was achieved by reducing the exposure of seagrass to the cumulative impacts of multiple stressors. In particular, by limiting the area allotted to dredging, oil exploration and agriculture in the Ambergris Caye, Caye Caulker and the Central regions, we were able to considerably reduce the risk to seagrass in these areas.

Through zoning areas of these areas for certain uses, it is possible to minimize the frequency and extent of overlap of human activities in sensitive ecosystems. Because the Informed Management scenario balances economic development and conservation, however, large expanses of these ecosystems are nevertheless still at medium risk to stressors. Dramatic increases in the area of the three habitats at low risk only occur in the Conservation scenario (**Fig. 18**). Under the Development scenario the area of seagrass at high risk is more than five times the area at high risk in the current scenario (**Fig. 18**). Additional information on how the Habitat Risk Assessment model works can be found in **Appendix B.1**.

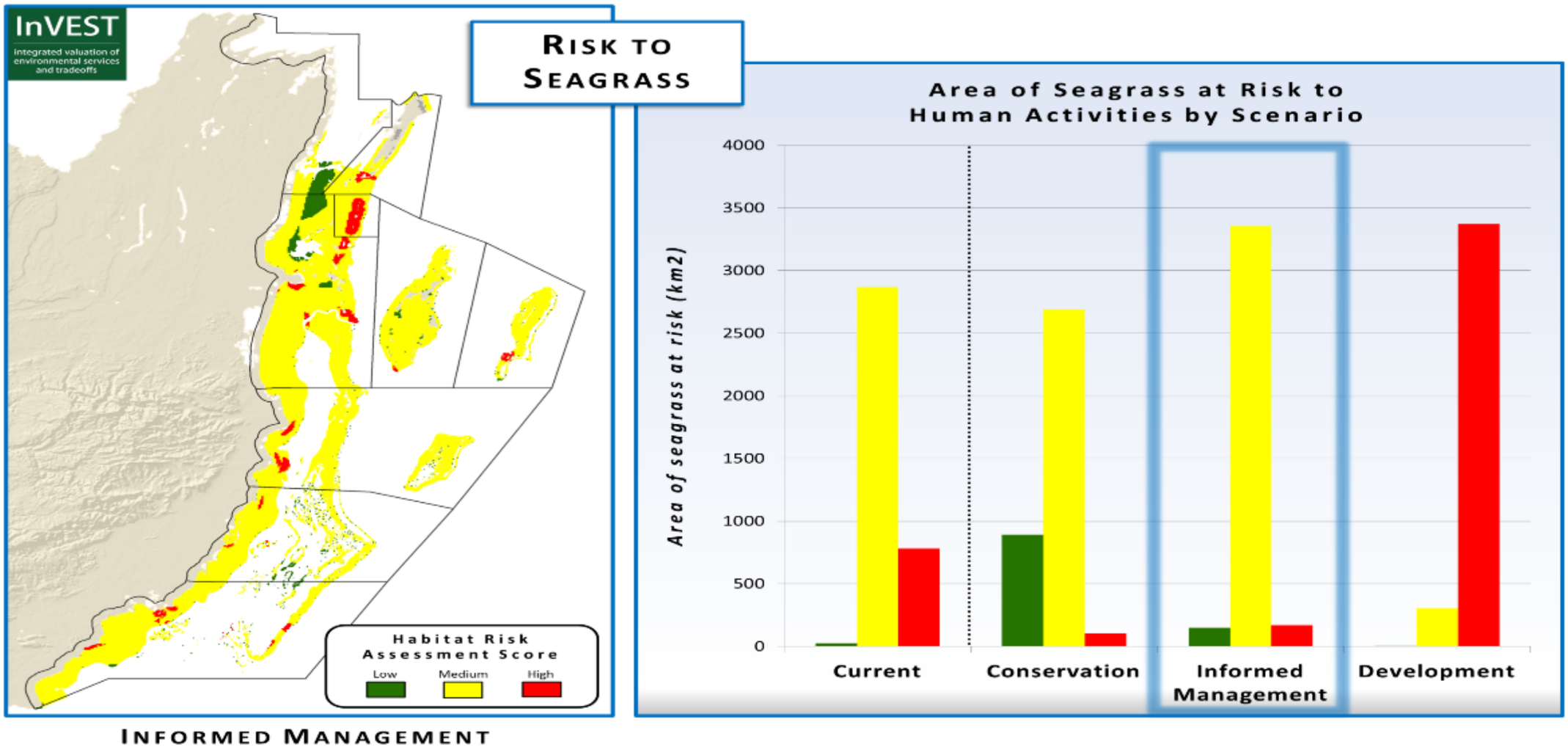


Figure 18: Area of Seagrass at Risk from Human Activities by Scenario

Mangroves

Mangroves play an important role in the cultural and economic livelihoods of coastal communities, and provide risk reduction measures in combating vulnerability to natural threats, for example storms (CZMAI 2012). A national economic valuation study carried out by World Resources Institute (WRI) found that Belize's mangroves annually contribute a value approximately equivalent to 25% of Belize's gross domestic product through the provision of nursery areas for fish and invertebrates, habitat for wildlife, and physical buffers against pollution, cyclonic storms and coastal erosion (Cooper et al. 2009). However, since mangroves grow along the mainland coast and on outer cayes, which are areas considered prime development locales, their domain has been greatly targeted for waterfront properties and other coastal development opportunities (WWF & Brooksmith Consulting 2011; HRI 2008; Boles et al. 2011). The coastal mangroves of Belize are also affected by a variety of other pressures, including logging for charcoal and construction material, pollution from urban, industrial and agricultural activities, direct destruction for urban growth, tourism infrastructure and coastal development, shrimp farms and agriculture as well as storm events (UNEP and CATHALAC 2010).

A key finding of the risk assessment for mangroves is that risks to this ecosystem do not occur uniformly across regions. Mangroves grow along the mainland coast and much of the area of the offshore cayes, which are areas considered prime development locales, have been greatly concentrated in housing and resort developments along the coast (World Wildlife Fund & Brooksmith Consulting 2011; HRI 2008; Boles et al. 2011). Therefore, mangroves being found in these prime areas will eventually be lost if no immediate management interventions are put in place. Results from the InVEST Habitat Risk Assessment (HRA) indicate that, currently, the greatest area of mangroves at high risk of degradation from human activities is occurring in four principal zones in the following order: (1) Ambergris Caye; (2) Central Region; (3) South Northern; and (4) South Central Region. Nationally, 34% of Belize's mangroves are currently at low risk from human activity, 60% are at medium risk, and 6% are under high threat from human activities (**Fig. 19**).

HRA results further suggest that the implementation of an Informed Management zoning scheme could reduce the area of mangroves at high risk nationally to about 95% of the area currently at high risk. This reduction in high risk was achieved by reducing the exposure of mangroves to the cumulative impacts of multiple human activities that overlap mangrove forests, such as coastal development, aquaculture and dredging. Since the Informed Management scenario balances economic development and conservation, large expanses of this ecosystem is still at medium risk to human stressors. Dramatic increases in the area of this habitat at low risk only occur in the Conservation scenario (**Fig. 19**). Under the Development scenario the area of mangroves at high risk nationally would more than triple the area at high risk currently (**Fig. 19**). Additional information on how the Habitat Risk Assessment model works can be found in **Appendix B.1**.

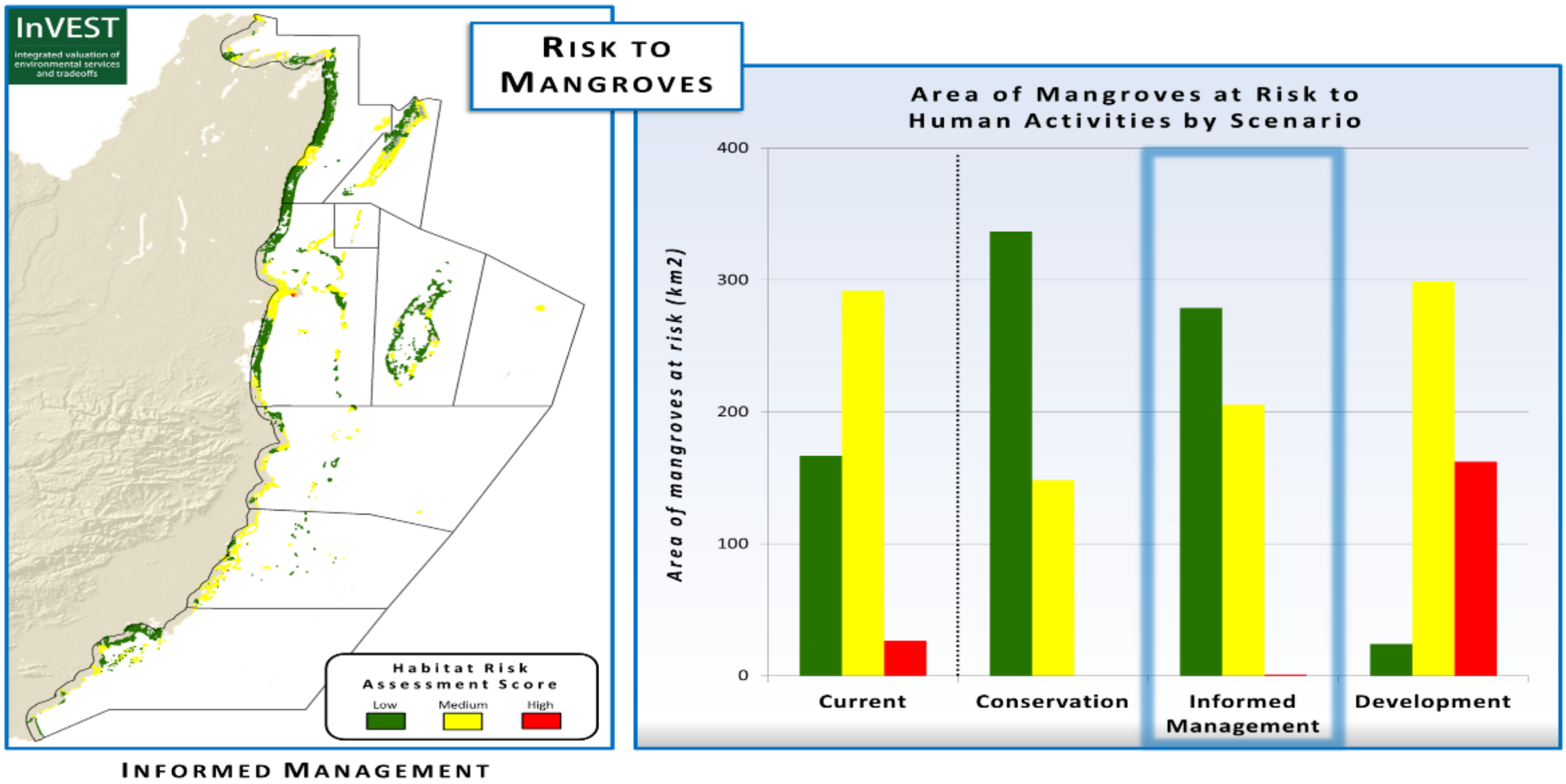


Figure 19: Area of Mangrove at Risk from Human Activities by Scenario

CURRENT CHALLENGES

Much of our daily activities are dependent on resources from the coastal environment. This in turn has its own consequences. We travel on and in the water, use it for recreation, fish in it for livelihoods, conduct oil exploration, and dump liquid and solid wastes within it, causing damage throughout the coastal area. With the expansion of human settlements and an increase in the population, large demands are made on freshwater from rivers, watersheds, and aquifer for public water supply, irrigation, hydropower, and aquaculture. There are documented concerns on impacts from development on this resource. For example:

- Reduced river flow by damming and water extraction is limiting supply of sediment to the coast, causing erosion that is threatening homes from Monkey River Village to as far south as Barranco Village.

- Friends of Placencia Lagoon, a local NGO, is greatly concerned about the quality of coastal water due to effluent disposal from shrimp farms located nearby.

- Citizens of Dangriga have repeatedly had their water supply contaminated by overflow of waste from the citrus industry into the North Stann Creek watershed, contamination that also affects the coastal environment and can impact food security.

- Tour guides in Punta Gorda Town have reported increased usage of the Sennis River for laundry and other related activities as a result of the growing settlement of Bella Vista located in the Toledo District.

- Residents of Sittee River Village have noted the changes in the erosion rate as a result of increased boat traffic in the area, also a local human-wildlife conflict regarding manatees.-

- Construction of a Norwegian Cruise line cruise ship docking facility at Harvest Caye.

- Significant increase in erosion along the southern coast from Monkey River to Hopkins.

By understanding our coastal waters we are able to effectively manage and plan for future usage. However, since this task is enormous, efforts must include input from local experts who utilize coastal resources on a day to day basis.

SECTION 2: VALUE OF THE COASTAL ZONE

VALUE OF THE COASTAL ZONE

The importance of the coastal zone in the productive sector of Belize is increasing rapidly. Most industries in Belize are either directly or indirectly reliant on some component of the coastal environment to function. Industries such as fishing and tourism are dependent on the organisms that inhabit the coastal area to sustain them. Other industries such as agriculture, aquaculture, and petroleum use the coastal waters to transport their products, thereby allowing them to engage in overseas trade. It is estimated that $350 to $400 million BZD is generated directly through resource-based economic activity in the coastal zone. Perhaps a further $450 to $500 million BZD are transported through the area in exports (sugar, citrus, bananas, timber, and other agricultural products). Approximately $650 million BZD worth of imports entered the country in 2010, more than half of this through the sea ports (CIA World Fact Book 2012). The following sections provide a brief overview of the contributing sectors.

TOURISM

Visitors at Goff's Caye Special Management Area ***(CZMAI)***

Tourism is the single largest contributor to the country's economic growth. Important attractors include natural features found within the coastal zone such as the barrier reef, atolls, and several hundred cayes. For this reason, Belize has become a major ecotourism destination. According to the Belize Tourism Board's 2008 Statistical Digest, the tourism sector generated $264.4 million USD and welcomed 842,396 visitors, 597,370 of which were from cruise tourism (BTB 2008). Total visitation continued to increase annually and in 2014 there were 1.2 million visitors, 321,220 of which were overnight tourists and 968,131 were cruise passengers. Major tourism activities in the coastal zone include diving and snorkeling with the most frequented sites being Hol Chan Marine Reserve, Blue Hole Natural Monument, and Goff's Caye Marine Managed Area (BTB 2008).

FISHING

Harvested conch and lobster ***(Belize Fisheries Department)***

Like most Caribbean countries, the fishing industry is a major part of the Belizean society and plays an important role in building the economy. The industry supports over 2,500 registered fishers and their families, and provides a source of protein for local consumption and exportation to foreign markets. In 2010 the fishing industry generated $23.2 million BZD with the exportation the three main marine products lobster, conch, and finfish. Table 2 is a summary of total catch and revenue generated from exportation in 2010 in Belize dollars. Although the lobster industry has been considered to be relatively stable over recent years there has been a decline in the production of lobster. In 2014 there was 484,891 lbs. of lobster caught which generated $15.2 million in revenue. Some 452,930 lbs. of lobster tail was exported generating $13.5 million. Other exports included 31,840 lbs. of head meat, 3,102 lbs. of lobster head, and 77,911 whole lobster.

Table 1: Amount of Marine Product Exported and Revenue Generated in 2010

Product	**Catch (lbs)**	**Revenue Generated (BZD)**
Lobster (Head and Tail Meat)	492,460	$13,325,300
Fin Fish	109,190	$265,878
Conch	726,050	$7,986,550
TOTAL	1,327,700	$21,577,729

Source: Belize Capture Fisheries Unit Annual Report 2011

AQUACULTURE

Aquaculture development in Belize dates back to the last thirty years, commencing with the commercial farming of the Pacific white shrimp *Litopenaeus vanammei* (CZMAI 2012). With the successful first commercial trials of shrimp aquaculture, the industry experienced rapid expansion with a total of 16 farms established by the end of 2005 and a total production area of 6,888 acres (CZMAI

Shrimp ponds in southern Belize ***(Southern Environmental Association)***

2012). Although the economic returns from shrimp aquaculture proved promising, significant declines in world market prices and the incidence of disease have resulted in economic losses that have depressed production and resulted in the closure of more than 60% of the production area. In 2013 the number of operational farms reduced to a total of 9 farms with a total production area of 2,673 acres. Currently there are eight active shrimp farms in Belize.

Besides shrimp, the aquaculture species portfolio also includes tilapia and cobia. In 2002 the first commercial tilapia operation, Fresh Catch Belize Limited, was established with the production of the grey tilapia (*Oreochromis niloticus*). Since its inception, the company expanded its tilapia production to 300 acres, and in 2008 produced 1863 million tons (CZMAI 2012). By 2010, however, the industry suffered significant economic losses resulting from Hurricane Richard and also experienced financial problems. The farm ceased operations and was taken into bank receivership. There is development of small scale tilapia productions, which includes 65 producers and an production area of approximately 20 acres (CZMAI 2012).

Cobia (*Rachycentron canadum*) was developed in 2006 by Marine Farms Belize Limited near Robinson Point Cayes. By 2009, the farm produced a total of 500 million tons, representing the highest production of cobia for the county. However, one year later the cage production infrastructure suffered severe damages resulting from Hurricane Richard. The cage site production by Robinson Point ceased in 2010, and the company has since dedicated its efforts in the hatchery production of cobia seedstocks near Dangriga in an effort to diversity the species portflio. Table 2 is a summary of aquaculture production of shimp, tilapia and cobia and revenue generated in 2010 in Belize dollars.

Table 2: Amount of Aquaculture Product Exported and the Revenue Generated in 2010

Product	**Production (lbs)**	**Revenue Generated (BZD)**
Farmed Fish (Tilapia & Cobia)	2,504,000	$1,300,000
Farmed Shrimp	11,264,000	$38,400,000
TOTAL	13,768,000	$39,700,000

Source: Belize Capture Fisheries Unit Annual Report 2011

More recently, other species of aquaculture interest have emerged, including hatchery trials of the Florida pompano (*Trachinotus carolinus*) by Marine Farms Belize Limited, the cultivation of seaweed (*Euchuma isoforme* and *Gracelaria* spp.) by fishermen of the Placencia Fishing Cooperative and the experimental grow-out trial of the red drum (*Sciaenops ocellatus*) near Stake Bank Caye. There has also been expressed interest in the cultivation of sea cucumber, common snook, oyster and octopus (CZMAI 2012).

AGRICULTURE

Banana plantation in southern Belize ***(Belize Trade and Investment Zone)***

Agricultural practices are common in Belize due to the country's historical past as a logging nation, and agriculturally productive soils. Although not all agricultural practices extend into the coastal zone, the effects of runoff from approximately 57,000 hectares of land being cultivated pose a direct threat to the health of the coastal ecosystem. Table 3 shows the revenue generated from the exportation of major crops in Belize in 2013 in Belize dollars.

Table 3: Amount of Produce Exported and the Revenue Generated in 2013

Produce	**Amount Exported**	**Revenue Generated (BZD)**
Sugar	**105,210 long tons**	**$107,360,000**
Molasses	9,760,000 Gal.	$7,810,000
Citrus (Orange & Grapefruit Conc.)	5,100,000 Gal.	$106,640,000
Banana	217,870,000 tons	$88,470,000
Papaya	56,510,000 lbs.	$20,6700,000
TOTAL		$330,950,000

Source: Central Bank of Belize Annual Report 2014

COASTAL DEVELOPMENT

Development near the famous Caye Caulker "Split" ***(Samir Rosado)***

Of the ten major residential centers in Belize, six are located on the coast. In spite of a stated policy to relocate housing inland due to sea level rise and hurricane vulnerability, all coastal centers are experiencing growth to varying degrees. Development is being undertaken by both the public and private sectors, with the latter involved primarily in sub-divisions in several coastal locations, often targeting foreign markets and retirees.

INDUSTRY AND COMMERCE

Marie Sharp's pepper sauce production line ***(Savour Belize)***

Belize still has a relatively small industrial base as compared to more traditional markets. In 2010, non-traditional exports such as orange oil, fresh orange, pepper sauce, red kidney beans, black eye peas, sawn woods, and grapefruit oil generated $47.2 million BZD (Central Bank of Belize 2010). The re-exportation of goods through the Corozal Free Zone, however, is continuing on its steadily increasing trend, and as sales in 2010 reached $350.8 million BZD. With the collapse of the Dickies Factory in the Belize District, there was also a collapse of the garment industry with no substantial exportation taking place (Central Bank of Belize 2010).

INFRASTRUCTURE

All the airstrips with regular, scheduled flights lie within the coastal area: Corozal, San Pedro, Caye Caulker, Belize City, Dangriga, Placencia and Punta Gorda. The Philip S. W. Goldson International Airport is within 5 km of the shoreline of Belize City. The construction of a second international airport is also proposed with the shoreline of the Placencia Peninsula.

Maxi-float arrival at low berth of the Belize City Port ***(Port of Belize Limited)***

Of the three main ports, Belize City acts as a main entry point and is currently upgrading facilities to recover and expand on losses in traffic experienced in recent years. This port received 251 container ships in 2007. The port at Big Creek, located west of Placencia village on the outskirts of Independence/Mango Creek in the Stann Creek District serves as a secondary port with 161 container vessels visiting in 2007. Activity at this port facility is expected to increase significantly due to the expected increase in visitation this area with the creation of the Norwegian Cruise Line Cruise Ship Docking facility at Harvest Caye. In anticipation of increased activity, port facilities should be expanded to accommodate.

There are several marinas and docking facilities are also found throughout Belize. More specifically they can be found in all major coastal communities including; San Pedro, Caye Caulker, Belize City, Placencia, New Haven, Punta Gorda, Turneffe Atoll, Sittee River and Corozal. Road access across the country has improved tremendously over the last decade and there exists four major two-lane, asphalt-paved highways, including the paving of several important segments important for tourism for example the Placencia and Maskall Roads. All of the major coastal settlements are accessible by paved roads along the network of highways. Additionally, roads leading to smaller coastal communities have also been upgraded and in most cases paved. Municipalities throughout Belize have also began initiatives to cement streets. This was made possible through an investment loan from the Petrocaribe Development Fund and grant monies under the World Bank Climate Resilience Project.

InVEST Coastal Vulnerability model results reveal that of the nine planning regions, five of them contain significant lengths of paved roads that lie within vulnerable coastline. These regions are namely: (1) Central; (2) Northern; (3) South Central; (4) South Northern; and (5) Southern **(Fig. 20**). The Central and Northern regions have the longest lengths of paved roads within vulnerable sections of coastline respectively (**Fig. 20**). While the results do not indicate that these roads will be any less vulnerable in any of the future scenarios (**Fig. 20**), they are helpful for identifying the two regions that may require significant investment in durable materials to avoid costly repairs over time. The results also have implications for community and economic development planning when considering the dependency of road infrastructure for transportation of goods and services and mobility of coastal communities. Additional information on how the InVEST Coastal Vulnerability model works can be found in **Appendix B.2**

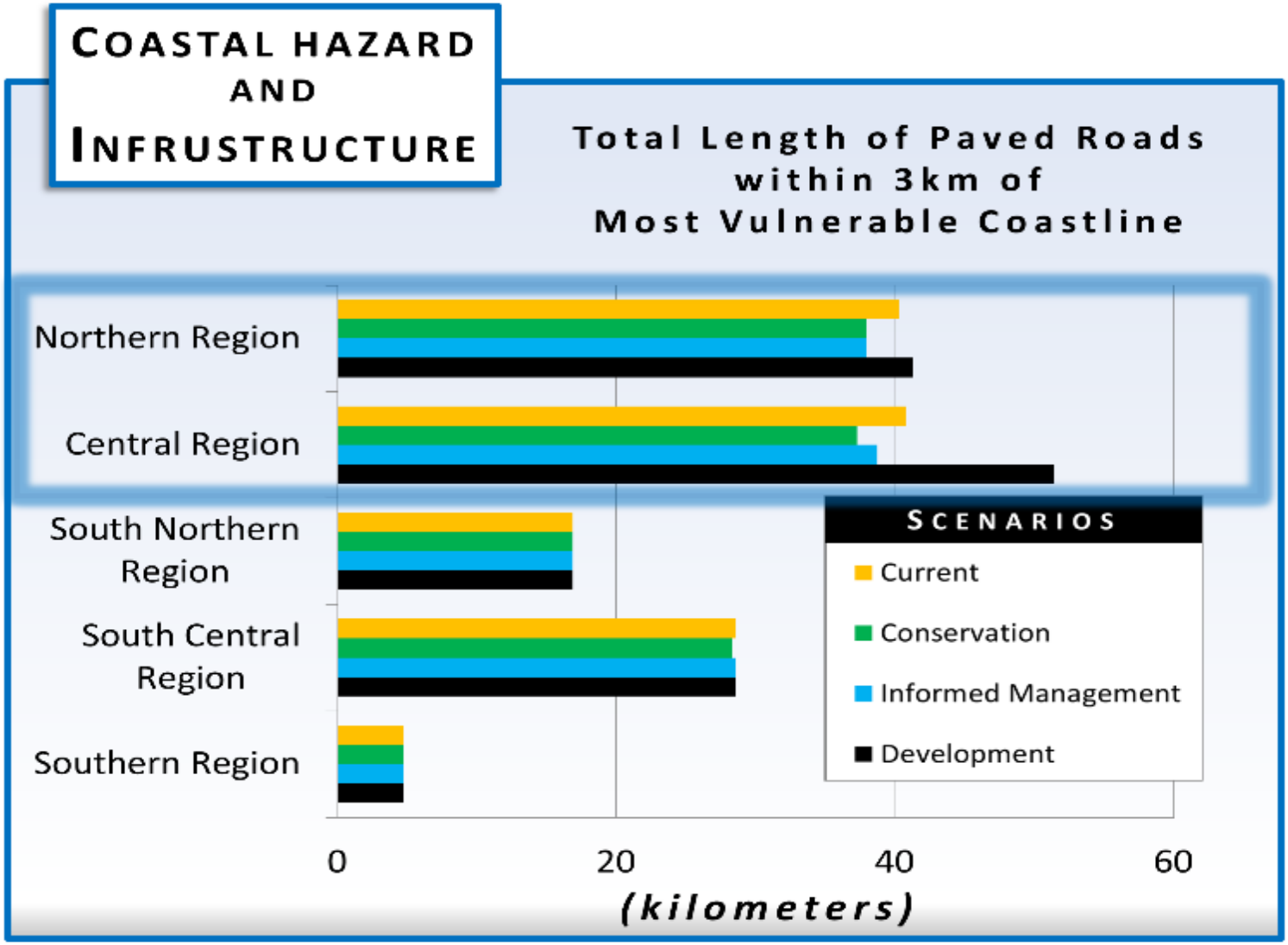


Figure 20: Total Length of Paved Roads within Vulnerable Coastline

OIL AND PETROLEUM

Background Information

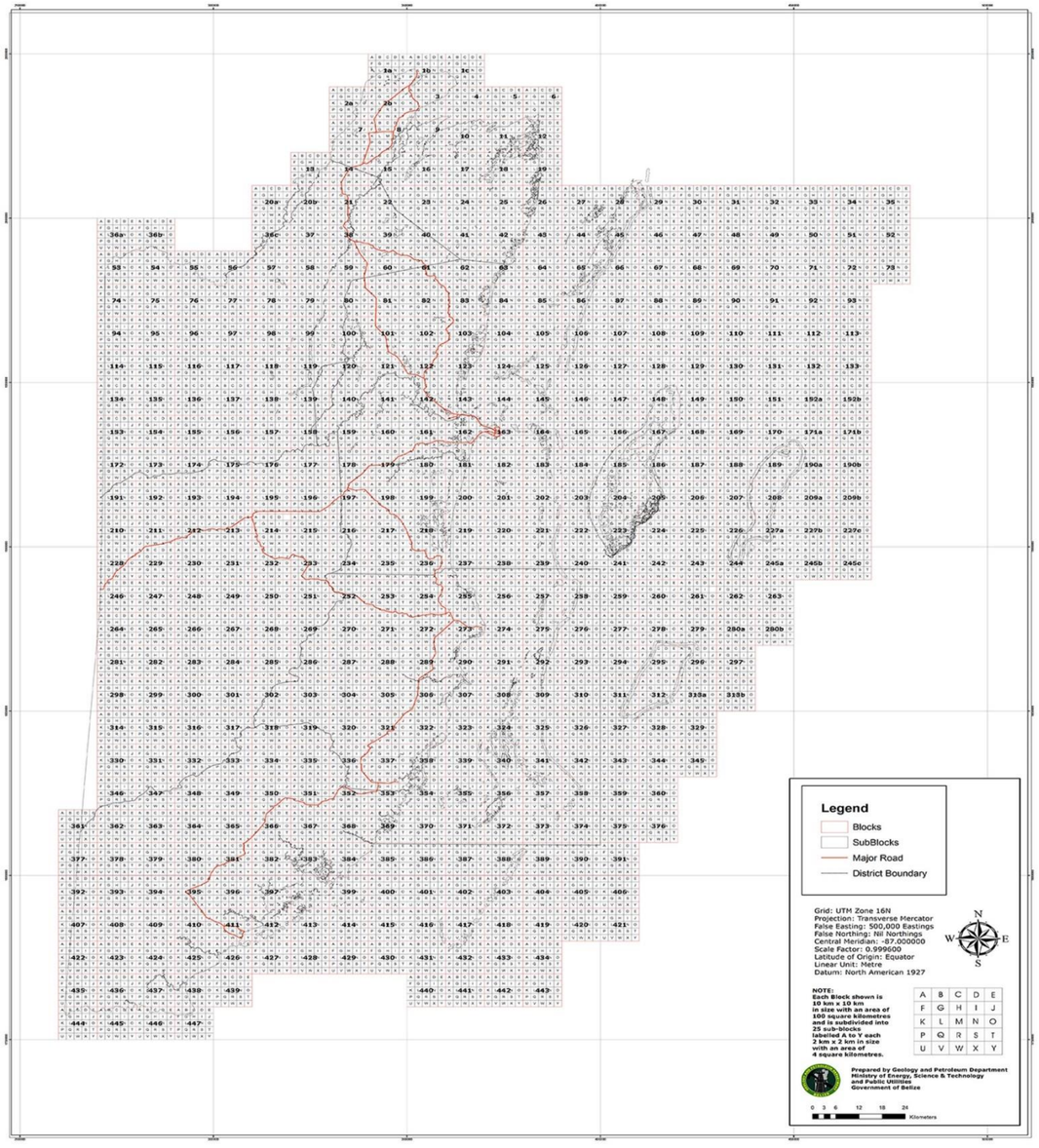
The petroleum industry in Belize is governed by the Petroleum Act and Regulations and the terms and conditions of the licenses. The Geology and Petroleum Department administrates the petroleum industry and supervises and monitors all exploration and production operations. Other Government agencies which regulate the petroleum industry are the Income Tax Department and the Department of the Environment.

The management of petroleum extraction/exploration activities in Belize is done using a block and sub-block system **(Figure 21a)**. Using this system the entire country of Belize, including territorial seas, has been divided into approximately 447 blocks which represents an area of 100 square kilometers. These blocks are further divided into 25 sub-block which are alphabetized A-Y and represents 4 square kilometers. Companies can apply to the Geology and Petroleum Department for licenses to conduct exploration activities in different Blocks and Sub-Blocks. In order to attain a license, prospective companies must undergo a thorough evaluation process which is conducted by the Geology and Petroleum Department. Once the company has received approval from Geology and Petroleum the Minister with responsibility for Petroleum Development will be responsible for issuing the license.

History of the Petroleum exploration in Belize

Petroleum exploration in Belize began in the 1930's. Oil exploration licenses were granted to the large oil companies such as Shell, Esso, Texaco, Gulf Oil, Anschutz and Chevron as well as smaller companies and small independent oil companies to explore for petroleum in both the onshore and offshore areas of Belize. By 2000, a total of 50 exploration wells were drilled, 34 onshore and 16 offshore, the first of which was the Yalbac #1 well located in the Yalbac Hills in the Cayo District drilled by Gulf Oil in 1956. No commercial discovery was made in any of these wells with the closest being the Eagle #1 well drilled in 1984 in Belmopan which recovered approximately 3 barrels of light crude oil. **(Figure 21b)**.

Belize Petroleum Exploration Blocks and Sub-blocks Base Map



Geophysical Surveys and Wells Drilled in Belize

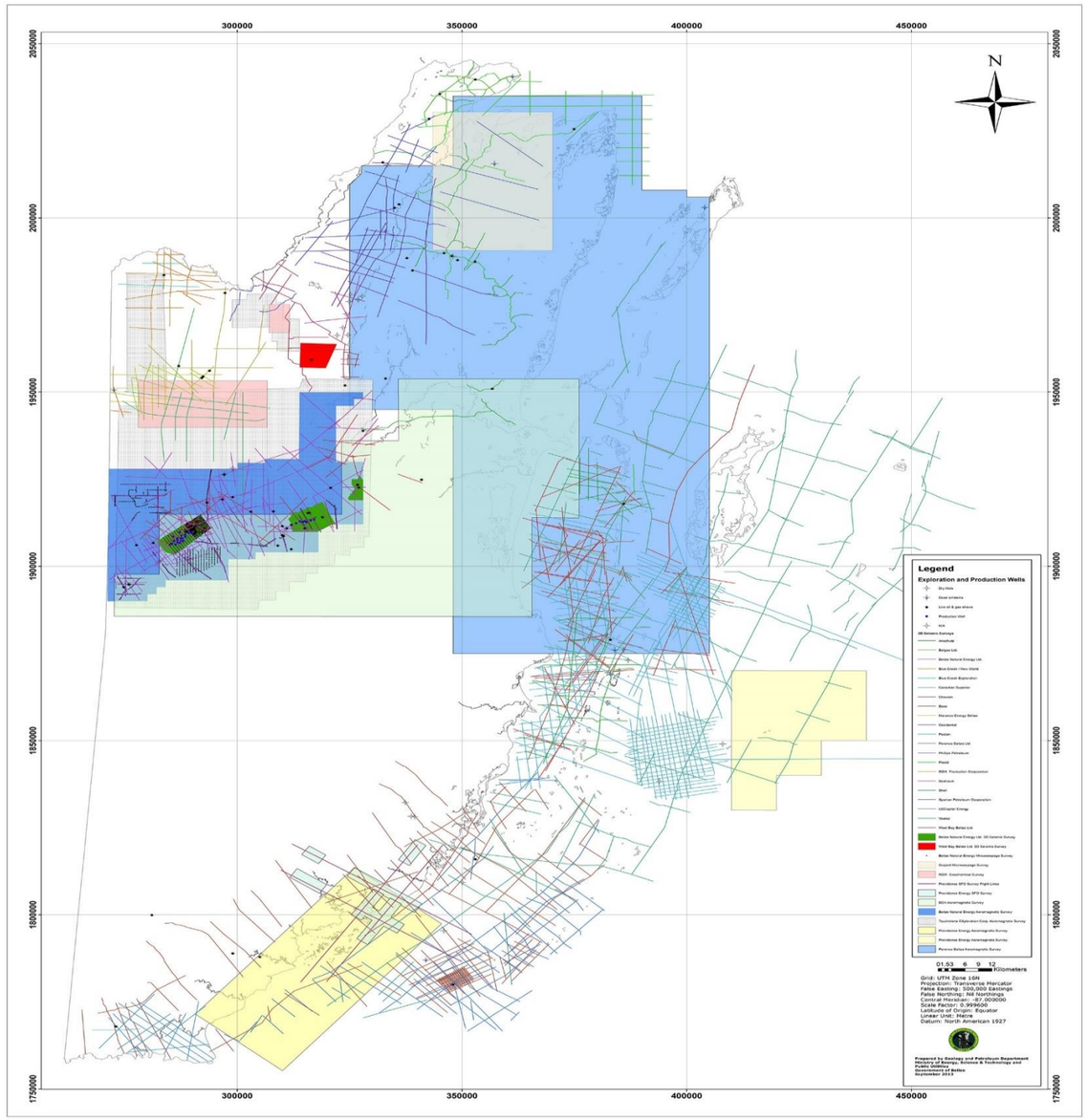


Figure 21: (a) Base map of the Block and Sub-block System used to manage Exploration in Belize. (b) Map of current and historical geophysical surveys and wells drilled in Belize

Discovery and First Production

In 2000 an oil seep was discovered at Calla Creek in the Cayo District sparked new interest of oil extraction in Belize. As a result, the Belize Natural Energy Ltd. (BNE) was granted an exploration license and subsequently made the first commercial discovery of petroleum in the Mike Usher #1 well in Spanish Lookout in July 2005. This discovery was developed by BNE into the Spanish Lookout Oilfield which is currently producing an average of 1,705 barrels of oil per day. BNE later made another commercial discovery in October 2008 in the Never Delay area in the Never Delay #1 well. The Spanish Lookout and Never Delay crude oils are trucked from the oilfields to BNE's export facility in Big Creek and shipped and sold to the US Gulf Coast. BNE is the only producer of crude oil in Belize.

Current Exploration

There are currently eight (8) companies with exploration licenses in Belize that can carry out seismic surveys and drilling of exploration wells. The Belize Petroleum Contracts Map shows these companies and their license areas (**Figure 22)**. However, by the end of January 2016 the exploration contracts for four of these companies will expire, thus leaving only four companies in operation which include:

1. BCH/Pacific Rubiales
2. Parenco
3. Maranco Energy
4. Belize Natural Energy Ltd.

In 2014 the Prime Minister of Belize issued a temporary moratorium on the issuing of parcels for offshore oil exploration/drilling activities. Additionally, many of the contracts that are soon to be expired include offshore areas. Therefore, for the near future, oil exploration/extraction activities will be conducted exclusively in onshore areas.

Current Production

The Belize Natural Energy Ltd. is the only company currently extracting oil in commercial quantities for exportation and sale. The Spanish Lookout Oil Field from its inception in 2005 has produced 9,866,232 barrels of oil up to 2014 and the Never Delay Oil Field has produced 151,646.43 barrels from 2008 to 2014. As a result, the total Petroleum revenue earned by the Government of Belize from 2006 to 2014 was $211,799,521.17 USD. However it is important to note that the price per barrel of oil on the international market has reduced significantly, therefore the revenue from oil production in Belize is decreasing. Also, there is evidence that oil levels are also declining leading to a reduction of barrels being produced.

Belize Petroleum Contracts Map

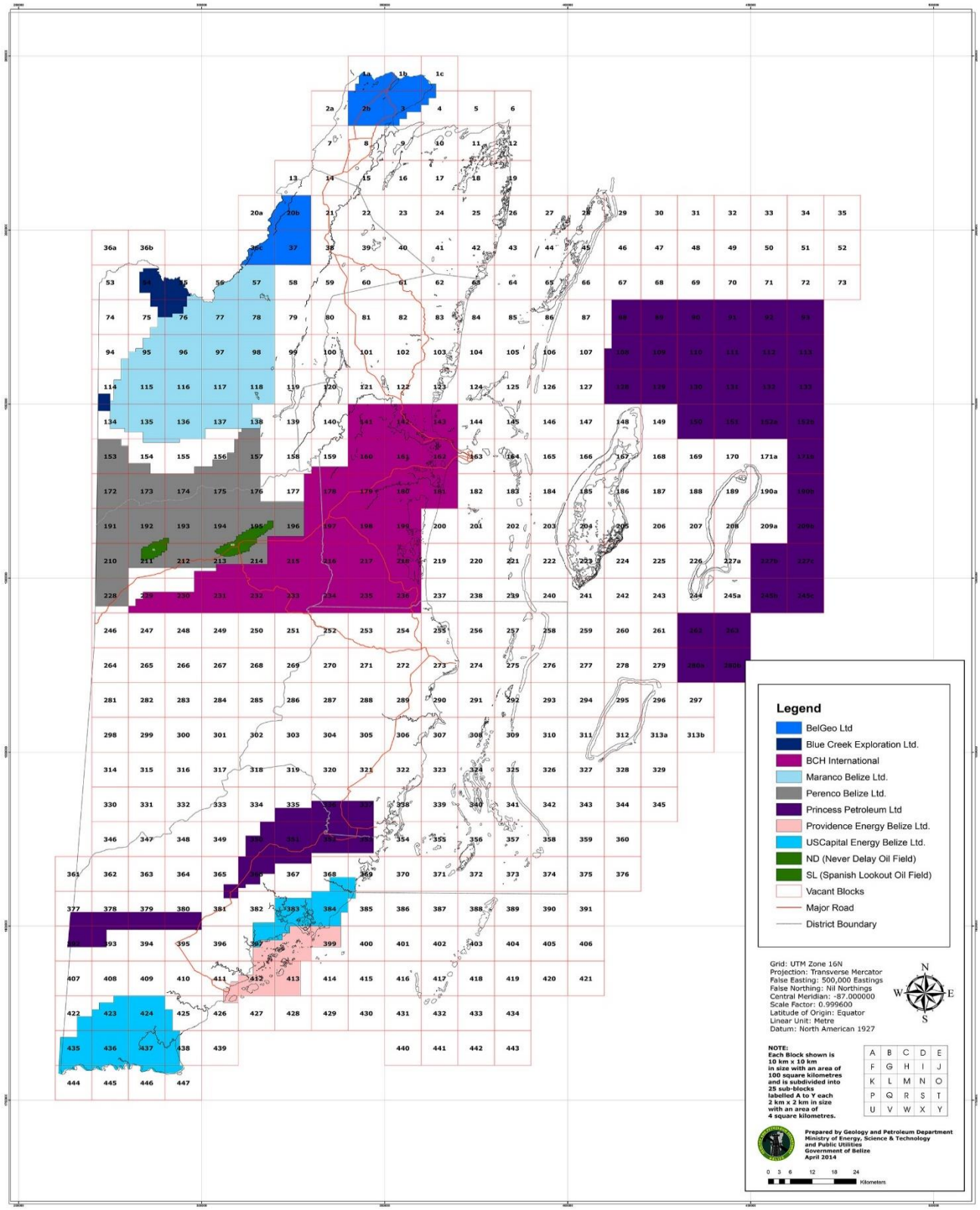


Figure 22: Map showing contract map with parcels up to 2015

THE FUTURE

There is a draft Petroleum Exploration Zones and Guidelines document (September 2013) that was shared by the Department with key stakeholder groups and agencies that identifies four zones for exploration activity based on the level of sensitivity and significance of the zones. Threshold values for the four zones were created being zone 1 – exploration restricted and zones 2 to 4 – exploration allowed with varying degree of restrictions and guidelines. However, this document is yet to be finalized. These guidelines will effectively steer future oil exploration activities in Belize.

SECTION 3:
COASTAL ISSUES FOR NATIONAL ACTION

COASTAL ISSUES FOR NATIONAL ACTION

Through consultations with its stakeholders, CZMAI has identified four key drivers, economic, social, cultural and environmental, which currently affect and may affect future sustainable use of coastal and marine resources. These drivers include:

COASTAL RESOURCE BASE PROTECTION

Undeniably, the protection and sustainable use of the coastal resources base is critical to the biological, economic, social and cultural values linked to the coastal zone. The National Development Framework for Belize, ***Horizon 2030***, notes the role of the natural environment as both the source and basis of economic and social progress (Barnett et al. 2012). Horizon 2030 also identifies the incorporation of environmental sustainability in development planning and the strengthening of protected areas management as a key strategy to achieve sustainable development goal while supporting the protection and management of the coastal resource base. Therefore, it is imperative that this resource base be protected and that certain measures are put in place to ensure the sustainable management of the resources that are highly valued by the Belizean populace and the global community. Equal important is the identification of sustainable, long-term alternative livelihood portfolios for resource-dependent communities as a means to reduce current pressures on the resource base. Alternative livelihood initiatives have been implemented across the country. However, these initiatives have been largely project-based and consequently, short-lived and not effective for reducing resource-dependency. This issue requires national action if it is to be effectively addressed as well as the integrated management of resources.

Photo by: ***Southern Environmental Association***

INDUSTRY AND COMMERCE

As noted previously, the coastal zone is a major focus of the country's economic development. Current industry trends for various productive sectors are indicating increased pressure on the coastal zone resources to meet the demands of economic and social progress. Since sustainable development is in the national interest, it is important that development planning takes a holistic, national approach that is rooted in environmental sustainability.

Sugar factory at Tower Hill, Orange Walk ***(Belize Trade and Investment Zone)***

COASTAL POPULATION GROWTH

Since the 1970s, Belize has been experiencing a steadily increasing growth rate. **Table 4** summarizes the historical population trends for the period 1970-2010, and the projected population for 2020 and 2030.

Table 4: Historical and Projected Population Trends

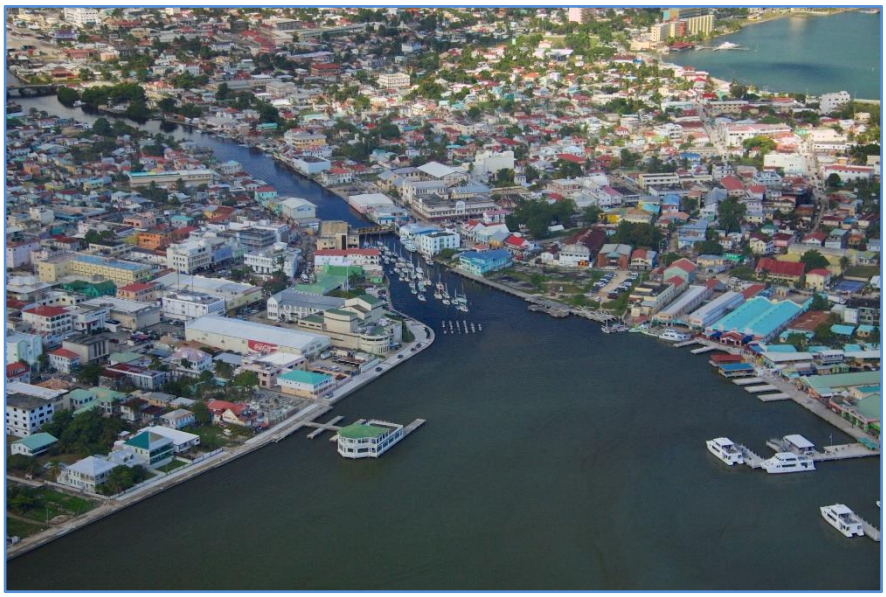
Total Enumerated Population by Census Years					Projected Population	
1970	*1980*	*1991*	*2000*	*2010*	*2020*	*2030*
119,645	145,353	189,392	240,204	312,698	368,693	423,093

Actual Population Inter-censal Change (%)				Projected Population Inter-censal Change (%)	
1970-1980	*1980-1991*	*1991-2000*	*2000-2010*	*2010-2020*	*2020-2030*
21.49	30.30	26.83	30.18	17.91	14.75

Source: Belize Population and Housing Census (2000, 2010), Statistical Institute of Belize

According to the Belize 2000 Population Census Report, the increase in population over the census period 1970-2000 can be attributed mainly to immigration. This finding is supported by the fact that overall fertility rate, which is the only other potential demographic that could contribute to positive population change, has been declining since the 1980s (Belize 2010 Population and Housing Census). The 2000 census also predicts a doubling in the population by the year 2026, should the trends in immigration and the fertility rate remain constant over time.

Another interesting feature is the urban-rural population dichotomy. Both in the 1970 and 1980, the urban population was relatively higher than the population in rural areas. Specifically, in 1970 the urban to rural population ratio was 54% to 46%. In 1980 the ratio was 51% to 49%. However, during the 1990s the situation reversed. Rather than experiencing urban sprawl, Belize experienced somewhat of a suburbanization of the rural areas. For instance, in both the 1991 and 2000 censuses, the urban to rural population ratio was 48% to 52%. In 2010, the trend continued with the urban population comprising 44% of the total population while the rural population was 56%. Of this 56%, approximately 73% live along the coast.



Coastal development in Belize City ***©Gustavo Giron www.astrumhelicopters.com***

By all accounts, the increase in the rural population over the years has also meant an increase in areas settled along the coast. As the 2000 census points out, the shift to rural areas, and by extension the coastal zone, is indicative of the need for national interventions and strategic national development planning to ensure that rural areas have necessary resources to ensure social well-being, supported by vibrant, diverse, and sustainable local economies. Such resources include access to technology and improved infrastructure, such as water supply, waste management and disposal, roads, drainage, and the provision of health, education, security, and emergency management services. There is also the need to factor in the carrying capacity of the various rural areas in future scenarios; this will ensure that the natural resources can support a growing population in perpetuity. The projected population for 2020 and 2030 predicts a growth rate of approximately 18% and 15% over the two respective decades. Thus, it will be necessary to plan for coastal population growth so as to minimize the unsustainable use of coastal resources, while also ensuring that communities in rural areas can enjoy a high quality of life.

CLIMATE CHANGE ADAPTATION

With burgeoning modernization worldwide, there is unforeseen pressure being placed on the environment. The activities of mankind throughout human history are having a rapid and profound effect on global climatic conditions. The result is a continued shift in climatic

Extreme flooding event in Belize City ***(Belize Meteorology Department)***

conditions all over the world. Climate Change is defined as "*a change in the state of the climate that can be identified, using statistical tests, by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer*" (IPCC 2012). Climate change may be due to natural processes or as a result of persistent anthropogenic changes in the composition of the atmosphere or in land use. Global climate change can fundamentally affect natural, economic and social systems that can result in significant changes to coastal resources availability and the way the coastal zone is managed or used. According to the Intergovernmental Panel on Climate Change (IPCC), anthropogenic effects are having a significant influence on the earth's changing climate. Projections have global mean sea surface temperatures rising 1.5 to 6.0 degrees Celsius within the next century and as a consequence, a rise in global mean sea level of 15 to 95 centimeters (NCCC 2008).

The exact changes to Belize and the region are unknown at this stage and this serves as a challenge for how to best develop adaptation strategies. However, the best scientific evidence is indicating that climate change could affect economic and social well-being, including major productive sectors of Belize. Geographically, Belize is located approximately six meters below sea level, thus the threat of rising seas is a major concern especially to the 40% of the population that is settled along the coast and the cayes. A national proactive and adaptive approach is necessary in order to coordinate appropriate responses to climate change across sectors. The Government of Belize, through its national policy on adaptation to global climate change, recognizes the need to adequately plan, as best as possible, appropriate national responses for managing the impacts of global climate change. The policy encourages agencies to "*explore and access the opportunities being developed by the climate change negotiation process*" and it also "*mandates relevant government agencies to prepare adaptation policy options for their sectors*" (NCCC 2008). It therefore calls for a national approach to address adaptation to climate change.

SECTION 4:
VISION FOR A SUSTAINABLE COAST

Encouraging Sustainable Coastal Resources Use

Supporting Integrated Development Planning

Building Alliances to Benefit Belizeans

Adapting to Climate Change

VISION FOR A SUSTAINABLE COAST

The Belize Integrated Coastal Zone Management Plan is a planning framework to focus management activities that are already being undertaken, ensuring these are integrated, and to highlight additional activities and actions that could be undertaken to help meet the challenge of ensuring a sustainable future for the coastal zone where healthy ecosystems support, and is supported by, thriving local communities and a vibrant economy. The framework includes recommendations, supported by a spatially explicit zoning plan. Outlined below are four strategic objectives for achieving this vision for sustainable coast.

1.0 ENCOURAGING SUSTAINABLE COASTAL RESOURCE USE

There is a growing need to advance the economic and resource attributes of the coastal and marine protected areas system, and to improve the management of natural habitats and wildlife. Scientific research and monitoring is central to the process.

1.01 COASTAL RESEARCH AND MONITORING

Coastal research has become an increasingly popular and important activity in Belize. However, this activity is still ill-defined and not well centralized. The purpose of research and monitoring is to provide insight into how events, processes, and activities, over larger spatial and temporal scales, influence the properties and functions of the coastal ecosystem (Nixon 1996). Conducting coastal research at the national level requires an integrated approach, which combines diverse efforts.

Benefits of research and monitoring can be summarized as follows:

- Improving forecasting of future uses of the coastal zone by knowing the effects of events, processes, and activities
- Maintaining ecosystem functions by understanding the relationships between and among its components
- Effectively planning for the future by monitoring the changes in use and interactions by coastal communities
- Providing sound data to incorporate into modelling programmes, thus improving management

Research efforts thus far in Belize have been distributed among government and non-governmental organizations. These organizations focus on components specific to the objectives of the organization, and are either funded locally, by government subvention, or have received

grants from international agencies. The University of Belize launched its Environmental Research Institute in 2010 responsible for the building of national capacity for research and monitoring to better inform natural resource management decisions. One of the major products from the institute is a National Environmental and Natural Resources Management Research Agenda. The purpose of the agenda is to prioritize the country's research needs at five year intervals.

In terms of government organizations, the Department of the Environment, Geology and Petroleum Department, Forest Department and Fisheries Department are the major agencies with mandates that include research or monitoring activities within the coastal areas of Belize. The Coastal Zone Management Authority and Institute (CZMAI) is a quasi-governmental organization mandated to conduct research within the coastal areas of Belize. It is tasked with performing coastal research, community outreach and coordinating data collection for the region. Current research and monitoring programmes being undertaken by the CZMAI include Endangered Species Research (Manatee), Coastal Planning and GIS/Data Analysis.

As a part of the implementation strategy for the Belize Integrated Coastal Zone Management Plan, CZMAI will focus its efforts on establishing a coastal health monitoring program that will include a national water quality monitoring program to be developed in coordination with key agencies. It is envisioned that this program will serve as a means to monitor the effectiveness of the Plan.

Furthermore, in 2008 the Government adopted the "National Integrated Water Resource Management Policy" and in 2011 it enacted the National Integrated Water Resources Act (NIWRA). In addition, the National Integrated Water Resources Management Policy calls for the development of a National Integrated Water Resources Plan and outlines strategic actions necessary to develop the plan.

Actions

- Develop a centralized data repository for Belize on ecosystem health and human use activities within the coastal zone
- Facilitate data accessibility among government agencies and non-governmental organizations for monitoring ecosystem health and human use impacts on the coastal area
- Establish a national water quality monitoring programme for Belize
- Develop a long-term national strategy for the scientific monitoring of the health of critical habitats, including but not limited to reef, seagrass, mangroves, and coastline dynamics
- Prepare annual State of the Coast Report to analyze trends and changes in the coastal zone

1.02 PROTECTED AREAS MANAGMENT

A "*Protected Area*" is defined by the IUCN as "*An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*" (Dudley 2008). In Belize, approximately 36% and 20% of the terrestrial and marine areas respectively are protected (Meerman & Wilson 2005). Belize's network of protected areas is comprised of national parks, nature reserves, wildlife sanctuaries, natural monuments, forest reserves, marine reserves, archaeological sites and archaeological reserves, as well as private reserves, strategic biological corridors and scenic landscapes of geomorphic significance. Although 20% of Belize's marine area is protected, less than 4% of these are zoned as 'no take' as most marine protected areas (MPAs) are zoned for general use (Gordon & Green 2011).

Belize is rich in biodiversity and natural resources. It is home to many threatened species as well as approximately 280 km of the largest barrier reef system in the northern hemisphere. As a result, there are many areas of ecological importance spread across the country that have received protective status. Recognizing its inability to effectively manage, monitor, enforce and maintain all protected areas, the government of Belize entered into co-management agreements with various NGOs to aid in the arduous task of managing these sites (APAMO 2012). The benefits of co-management are summarized as follows:

- NGOs can conduct hands-on management of protected areas, ensuring the sustainability of these areas that are of environmental, social, economic, and cultural importance to all Belizeans.
- NGOs can tap into resource pools not accessible by the government agencies. There are many reputable international organizations that support protected area management by NGOs through grant funding.

Currently, Belize has fourteen (14) marine protected areas in Belize (**Table 5**) with one proposed MPA being considered at Ambergris Caye that would cover three sites: Mexico Rocks, Bajos & Cayo Frances). Twelve of these MPAs are co-managed, leaving two under the complete management of the Fisheries Department.

Table 5: Belize MPAs and agencies with management responsibilities

*World Heritage Site

Marine Protected Area	Management Agency	Co-management Agency
Corozal Bay Wildlife Sanctuary	Forest Department	Sarteneja Alliance for Conservation & Development
*Laughing Bird Caye National Park	Forest Department	Southern Environmental Association
*Blue Hole Natural Monument	Forest Department	Belize Audubon Society
*Half Moon Caye Natural Monument	Forest Department	Belize Audubon Society
*Bacalar Chico Marine Reserve	Fisheries Department	-
Caye Caulker Marine Reserve	Fisheries Department	Forest and Marine Reserve Association of Caye Caulker
Gladden Spit Marine Reserve	Fisheries Department	Southern Environmental Association
*Glover's Reef Marine Reserve	Fisheries Department	World Conservation Society (Informal)
Hol Chan Marine Reserve	Fisheries Department	Hol Chan Trust Fund
Port Honduras Marine Reserve	Fisheries Department	Toledo Institute for Development & Environment
Swallow Caye Wildlife Sanctuary	Forest Department	Friends of Swallow Caye
*Sapodilla Caye Marine Reserve	Fisheries Department	Southern Environmental Association
*South Water Caye Marine Reserve	Fisheries Department	-
Turneffe Atoll Marine Reserve	Fisheries Department	Turneffe Atoll Sustainability Association

Source: Walker & Walker 2011

In 2005, the Task Force on Belize's Protected Areas Policy and Systems Plan was commissioned by the then Deputy Prime Minister and Minister of Natural Resources and the Environment, in collaboration with the then Minister of Agriculture and Fisheries and the Minister of Tourism. The Task Force created the Belize National Protected Areas System Plan. The objective of the plan was to provide guiding principles for managing protected areas in Belize in a way that promotes biodiversity and ensures sustainability for future generations. A summary of the provisions within the document are as follows:

The Protected Areas System:

- Will be established based on ecological and intrinsic value to present and future Belizeans.
- Will adhere to global conventions of conservation. Where needed biological corridors and private protected areas will be established and recognized provided that they are complementary to the national system.

Administration and Management:

- All protected areas will be integrated under the national system.
- Management of these areas must reflect stakeholder knowledge and expertise of the ecology of the environment and must be transparent.
- Thresholds must be established to ensure the social and economic benefit of Belizeans, while not undermining the integrity of ecosystems.
- Management effectiveness and integrity must be ensured through monitoring and evaluation mechanisms.
- Any change in protective status requires stakeholder consultation.

Socio-economic considerations:

- Appreciation of protected areas should be enhanced via public campaigns. The protected areas will in turn facilitate education, research and income for the general public.
- Collaborative management and other socio-economic enhancement mechanisms will be encouraged to maintain the cultural and ecological integrity of the protected areas.
- Equal access opportunities will be granted to all stakeholders.
- Sustainability of protected areas is paramount to the development of Belize and local communities.

At the 20th session of the World Heritage Committee held in Mexico in December 1996, seven of Belize's marine protected areas (**Table 5**), encompassing a total of 96,300 ha, became inscribed as World Heritage Sites. These areas were inscribed under the following natural criteria (Gibson 2011):

- Superlative natural phenomena and natural beauty
- Ongoing biological and ecological processes and biological diversity

In 2008, there was concern about the future integrity of the designated areas, as there was increased mangrove clearing and sale of lands within these areas. Under the conventions set by the World Heritage Committee, countries that host World Heritage Sites should:

- work to promote the prestige of the designated areas
- promote their importance both locally and internationally
- set systems in place that will protect their integrity

- not take any deliberate measures that directly or indirectly damage their heritage
- consider these areas of cultural and natural heritage as being priceless and irreplaceable assets

Consequently, in June 2009 the Belize Barrier Reef System was inscribed on the List of World Heritage Sites in Danger following reports of oil exploration concessions being issued, sale of lands within protected areas, such as South Water Caye Marine Reserve (Gibson 2011). Under the World Heritage Convention, when a property inscribed on the World Heritage List is threatened by serious and specific dangers, the Committee considers placing it on the List of World Heritage in Danger. When the Outstanding Universal Value of the property which justified its inscription on the World Heritage List is destroyed, the Committee considers removing the property from the World Heritage List (UNESCO 2011).

The issue of development within World Heritage Site is one that has caused much debate, and raised more questions yielding few concrete answers. The Coastal Zone Management Authority and Institute (CZMAI) believes that it is very important that development activities within World Heritage Sites are strictly controlled in order to protect their integrity. Through this Plan, recommendations regarding developing World Heritage Sites can only be made within the confines of the law and the World Heritage Convention. There are no clear-cut guidelines for development within World Heritage Sites. Thus any proposed development activity would require extraordinary scrutiny, attention, consultation and monitoring to ensure that the outstanding universal value for which the site was inscribed is kept intact.

The development of an in-country legislation and policy position on development within World Heritage Sites, such as a World Heritage Protection Bill, is recommended to provide guidance for managing proposed development activities. Given the fact that some of the lands within World Heritage Sites are privately-owned, it is inevitable that there will be changes to each site. As an organization that embraces the principles of sustainable use and management, CZMAI recommends that each World Heritage Site should have active, updated management plans that are fully implemented. The management plans should include strategies for promoting or improving community involvement in the management of the sites, and promoting economic development strategies while ensuring environmental sustainability. The management plans should also have a long term vision that is built upon short term action plans and policies. Through these plans, it is envisioned that developmental guidelines for each site will be provided that will allow for better decision-making during the environmental clearance process. To support this process, all development proposals within World Heritage Sites should be placed in Schedule 1 of the EIA regulations. All sites would be treated as "sensitive areas", and this action would therefore limit developmental activities.

The Belize Integrated Coastal Zone Management Plan recommends several areas in the Informed Management Zoning Scheme for Conservation (**Figure 15**), some of which includes privately-held lands. There are possible legal implications that could arise from recommending land use standards for the conservation and retention of natural features of title hold lands. When lands that provides important ecosystem services to the public, the precedent and common practice in other regions across the world is to incentivize the transfer of development rights and property-ownership. For example, The Nature Conservancy in the United States would privately negotiate to purchase land outright or development rights. The US federal government also acquires land for conservation as a public good using a variety of mechanisms.

One common mechanism for the acquisition of privately-held lands for national conservation purposes is a claim of ***eminent domain.*** ***Eminent domain*** is the right of a government or its agent to expropriate private property for public use, with payment or compensation. This mechanism is a viable option for the Government of Belize. Another mechanism that Belize's government can undertake to acquire privately-held lands for conservation is voluntary subsidies. For example, in the United States, the Farm Bill provides farmers within approximately $4 billion dollars a year if they engage in conservation practices on critical parcels of land. To ensure a good return on investment, the government uses an auction to get farmers to compete against each other to lower the cost of subsidizing this conservation, while simultaneously ranking parcels on their level of environmental quality.

Conservation covenants and financial incentives can undoubtedly facilitate the inclusion of private lands within the corridor routes. Conservation covenants can be an excellent tool to try to bring private lands covering threatened ecosystems or habitat vital for survival of particular threatened species. Belize's draft Conservation Covenant Act provides a mechanism to secure conservation management without a change of ownership. In most cases, however the commitment to implementing the Act if legislated will require some form of financial incentive for landowners. These incentives are more appropriate and economical for the Government than land-purchases in most instances. Incentives should be tied to legal commitments through conservation covenants with investigation of mechanisms, such as partially or wholly discounted land taxes for the portions of properties within the corridor footprint. Another is access to grant sources by landowners to offset conservation management costs and support compatible economic development activities, with mechanisms such as the sale of carbon credits through REDD / REDD+ with the potential to contribute to the financial sustainability of corridor maintenance.

Actions

- Increase the technical and management capacity of both management and co-management agencies in order to ensure sound management practices
- Support local and national initiatives to achieve the target of 20% full protection of the marine territory of Belize

1.03 MANGROVE PROTECTION

Next to littoral forests, mangroves are the most affected ecosystem as a result of coastal development (Polidoro et al. 2010). As noted in Section 1, InVEST Habitat Risk Assessment results for mangroves are suggesting that 34% of Belize's mangroves are currently at low risk from human stressors, while 60% are at medium risk and 6% are under high threat. Furthermore, the highest incidence of mangrove degradation is occurring in Ambergris Caye, followed by the Central, South Northern and South Central regions. This seemingly unimportant foliage that lines the riparian zones of rivers and coastlines of Belize are often completely removed to make way for more economic and aesthetically pleasing structures. However, mangroves play a very important role in both ecosystems. The government of Belize recognizes the ecological and social importance of mangroves as summarized in the Forest Act (Statutory Instrument 16 of 1965) as follows:

Mangroves:

- *Stabilize much of the coastline and cayes and form an important component of the natural vegetation;*
- *Have protective functions and mitigate the destructive forces of natural disasters;*
- *Provides habitat for a diverse community of plants and animals, including fish and other species of social, commercial or recreational importance;*
- *Play a crucial role in the ecology of the coastal ecosystem by producing essential organic matter which are used by marine organisms in coastal food webs;*
- *Act as natural filters of nutrients, sediments, agrochemicals, and other contaminants;*
- *Provide critical habitat for migratory and resident birds, wildlife, and aquatic life in Belize;*
- *Are aesthetically attractive and can be incorporated into the landscaping of waterfront residences and communities;*
- *Provide recreation and employment through eco-tourism and sport fishing;*
- *Protect coastal habitats, communities and infrastructure, and mitigate impacts from climate change*

Mangrove regulations (Statutory Instrument 52 of 1989) are provisioned under the Forest Act, and amendments were prepared in 2010 for the Cabinet's consideration and approval. To dates, the recommended amendments have not been approved by Cabinet. These regulations are monitored, administered, and enforced by the Forest Department. Broad provisions of the Act are as follows:

- *There will be no alteration of any mangrove on public or privately owned land unless a special permit is issued by the Forest Department. To obtain such permit a non-refundable fee must be paid which is dependent on the amount of mangrove desired to be*

altered. Also the Department is within its rights to impose restrictions on the percentage of mangrove that may be altered pending a site visit.

- *For larger extractions, the Forest Department may warrant a complete environmental assessment of impacts associated with removing mangrove. Pending a review of the results, the Forest Department may issue or deny the permit.*
- *Permits will be rarely issued or difficult to obtain in priority areas*
- *Removal of mangrove without a permit may result in fines not in excess of ten thousand dollars or imprisonment not exceeding twelve months.*

More recently, mangroves have been identified as an ecosystem that provides important benefits for people. They are a potential deterrent to the effects of climate change because they are carbon sinks for greenhouse gases, and they also provide protective services for Belize's vulnerable coastline against intense cyclonic activity. The results of the InVEST Coastal Protection model suggest that currently, 337 km^2 of land is protected by coastal habitats, such as mangrove forests, sea grass beds, and coral reefs. Additionally, the results suggest that in the Central region, mangroves and coral reefs currently protect the most land in the event of a Category 1 hurricane in the Central region, followed by the Northern, South Northern, Southern Regions and Turneffe Atoll (**Fig. 21**). These regions are large and encompass an extensive area of coastal habitats. These results suggest that if coastal habitats were destroyed, all coastal planning regions would suffer from erosion, with the most loss occurring in the Central region. The InVEST Coastal Protection model suggest that the Conservation scenario would have the greatest area of land protected, followed closely by the Informed Management Scenario. In many of the regions, the Development scenario may lead to less than half the area of land protected under the current scenario (**Fig. 21**).

Currently, mangroves, coral reefs and seagrass beds provide shoreline protection services with an average annual value of BZ $50.4 billion per year in potentially avoided damages as per InVEST Coastal Protection model results (**Fig. 22**). In a Conservation scenario, 364 km^2 of land will be protected by coastal habitats. Mangroves and coral will provide shoreline protection services with an average annual value of BZ $61.3 billion per year in potentially avoided damages. On the other hand, under a Development scenario, 217 km^2 of land will be protected by coastal habitats. Mangroves and coral will provide shoreline protection services with an average annual value of BZ $71.5 billion per year in potentially avoided damages.

InVEST Coastal Protection results also suggest that the Informed Management scenario would result in the highest coastal protection value because it combines both conservation of coral reefs, mangroves and seagrass, which provide protection, and increased development which leads to higher value property that these habitats would be protecting. A total of 352 km^2 of coastline would be protected by coastal habitats. Mangroves, coral and seagrass would provide shoreline protection services with an average annual value of BZ $104 billion per year in

potentially avoided damages through reduced erosion and storm damage. Furthermore, InVEST results suggest that the Central Region, South Northern Region and South Central Region are likely to have the highest coastal protection value in the Informed Management scenario. The Informed Management scenario blends strong conservation goals with national economic development needs, and these regions are places where habitats provide significant coastal protection services for high value coastal property. Additional information on how this model works can be found in **Appendix B.5**.

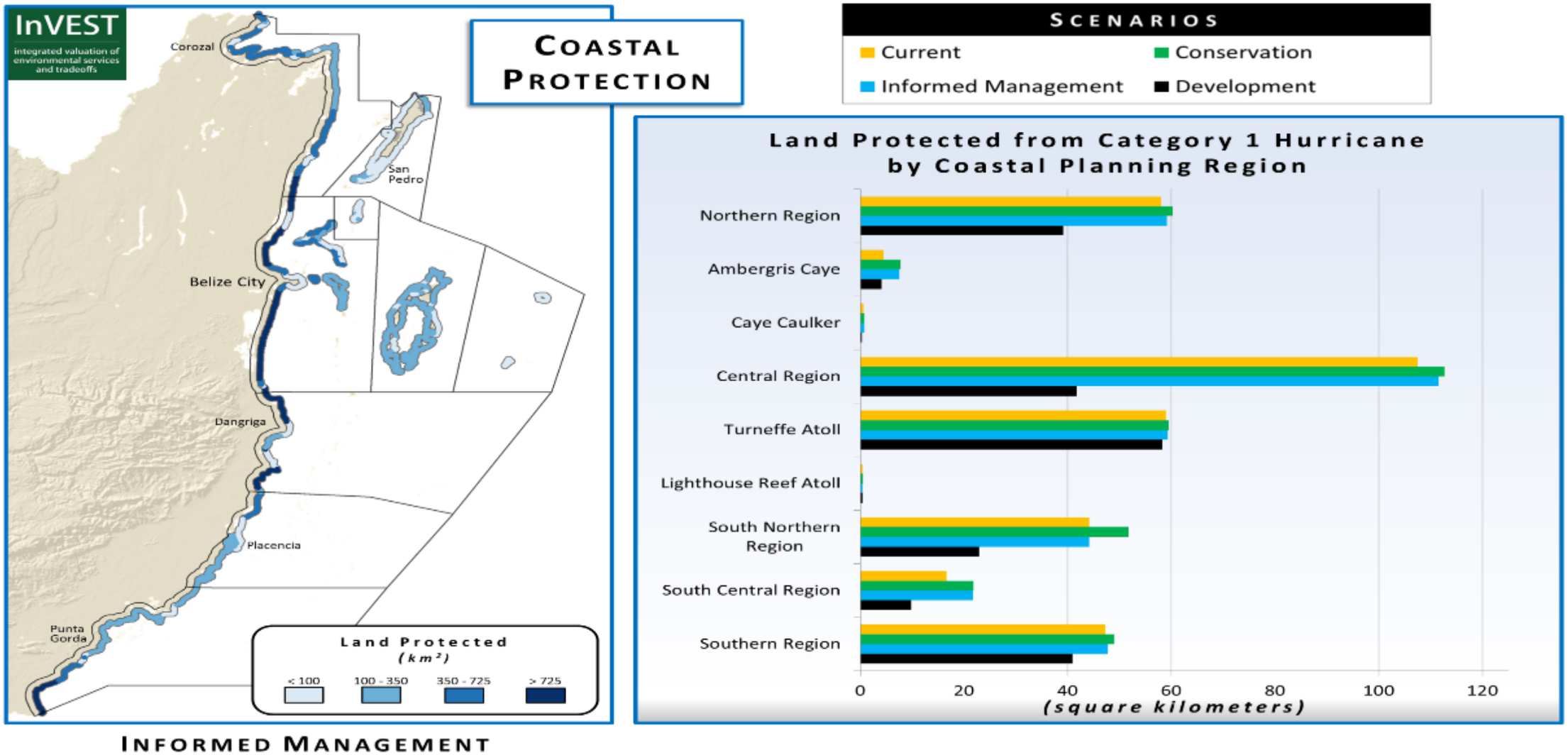


Figure 23: Protection of Coastal Lands from Category 1 Storms by Scenario

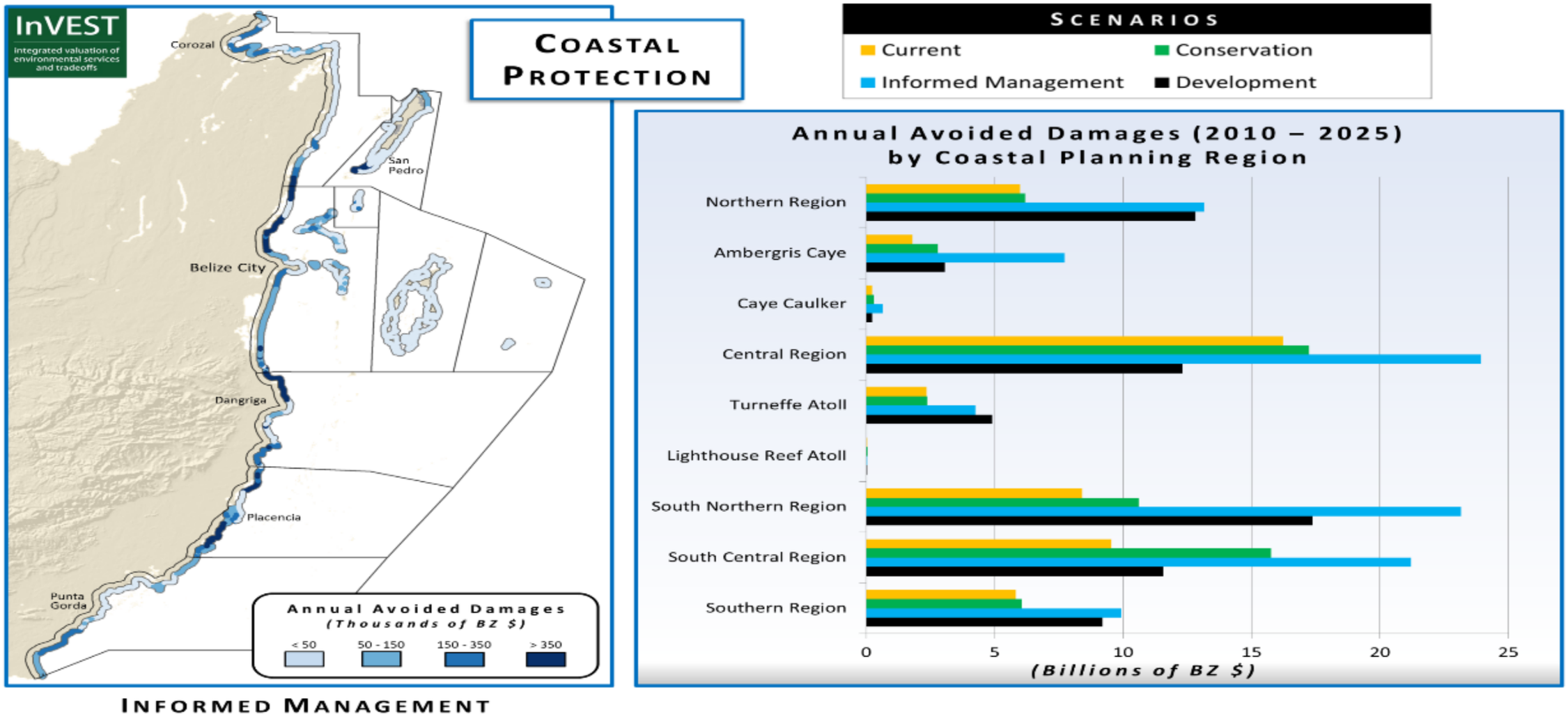


Figure 24: Annual Value of Avoided Damages to Coastal Lands by Scenario

Actions

- Advocate for adoption of revised Mangrove Regulations
- Implement mangrove restoration projects as a means to mitigate the effects of climate change, and to ensure the delivery of coastal protection services especially in areas, such as the Central and Southern region of Belize, which are highly prone to erosion and inundation
- Develop an inventory on Belize's mangrove cover and distribution, which should be updated on a bi-annual basis
- Identify areas for mangrove conservation
- Conduct research to better capture the biomass, coverage, spatial distribution and rates of change for mangroves in Belize, and make this information available to support decisions on the issuing of mangrove alteration permits

1.04 COASTAL HABITAT AND SPECIES CONSERVATION

Increased development activity and extreme weather events due to global climate change have led to increased loss or damage of coastal habitats in Belize. Habitats most at risk include mangroves, sea grass beds, wetlands, shorelines, and coral reefs. These ecosystems are affected directly by development through dredging, effluents, and sedimentation as well as natural events, through inundation, erosion and increased temperature. More recently, Belizeans have become proactive in their efforts to restore habitats at risk. For example, in 2011 the World Wildlife Fund (WWF) Belize Office launched a mangrove restoration project for Belize in which they identified areas in need of restoration. Another component of this project was to determine optimal growth conditions in order to ensure seedling success. Vernon Consultancy and WWF also successfully launched a mangrove restoration project for the Placencia Peninsula in 2011. Protecting habitats at risk is not limited to restoration activities. Often times, sound management principles can help to reduce risks to habitat before they become a cause for concern.

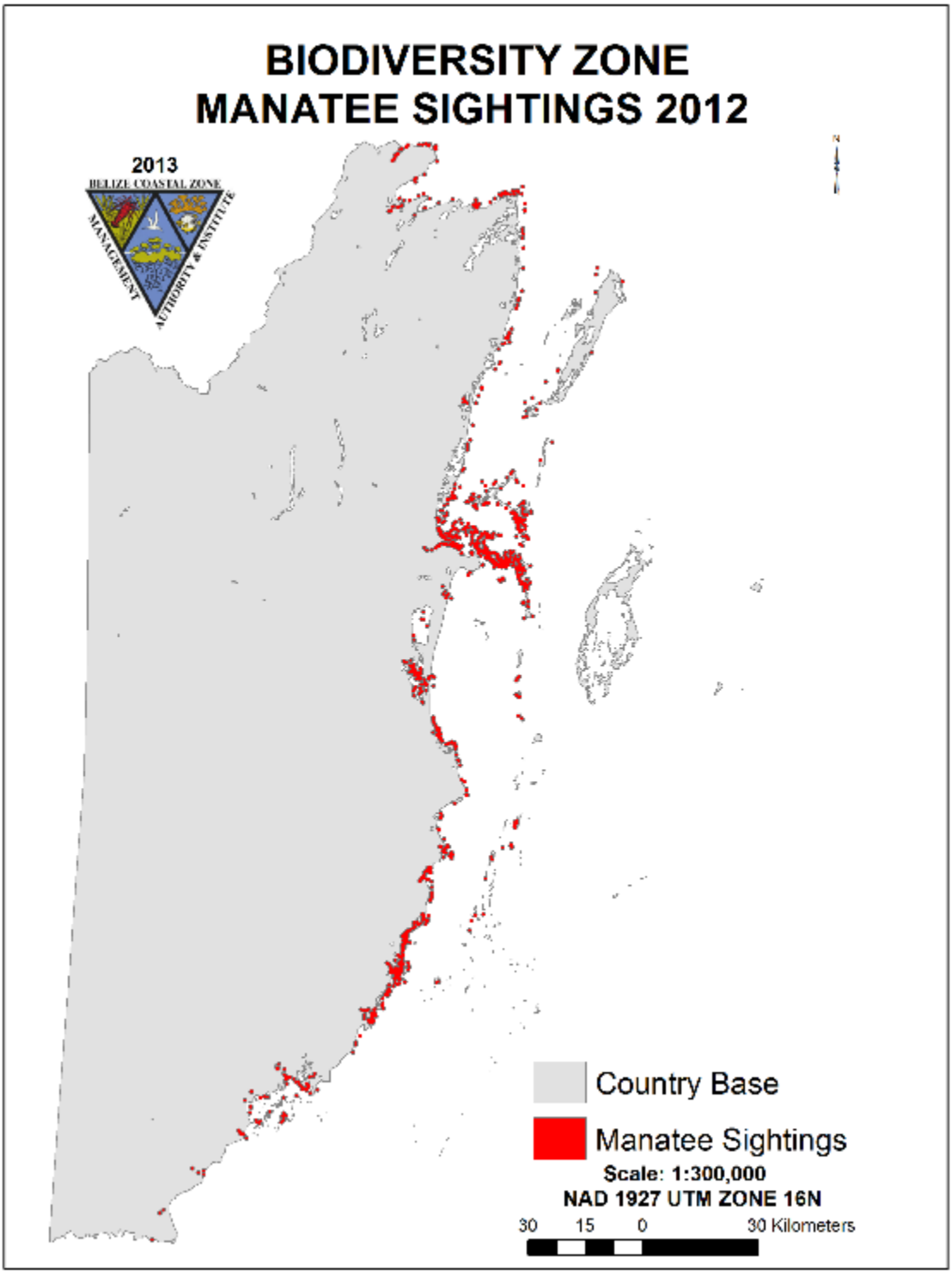
Although there is no way to prevent effects due to weather, the government should work towards identifying and penalizing individuals that contribute to the growing risk to habitats. Whether an offence is committed as a result of non-compliance or mere negligence, the government should impose harsh penalties on violators. Only in this manner will Belize ensure the sustainability of these habitats for future generations of Belizeans.

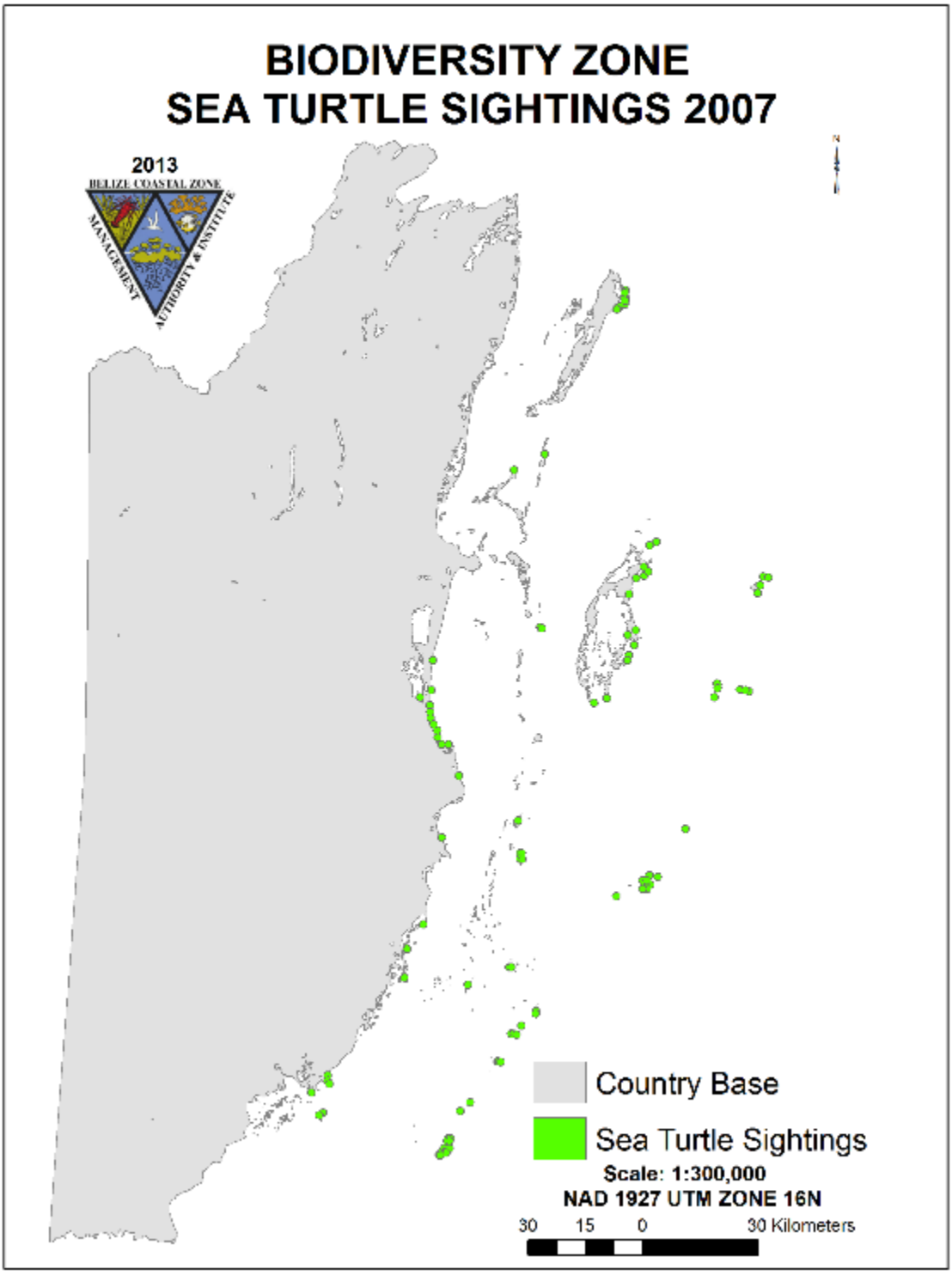
Reducing the loss of these habitats will ensure the survival of the many threatened and commercially important species present in Belize. Some of these species include manatees, crocodiles, marine turtles, and dolphins (**See distribution Maps 1-4**). These species are protected under the Fisheries Act, Chapter 210, Statutory Instrument 66 (2002), which is enforced by the Fisheries Department.

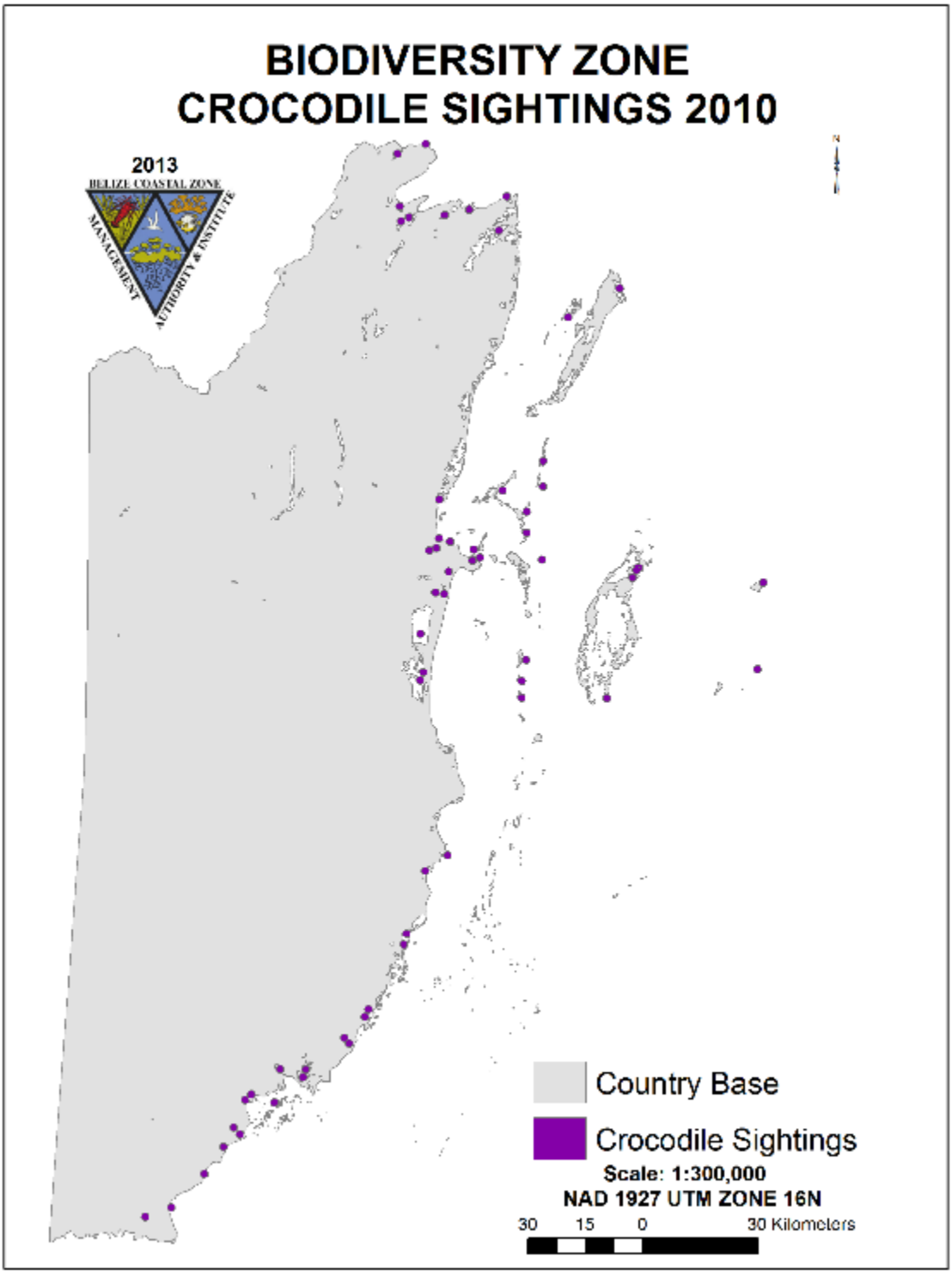
The following is a list of the primary organizations that monitors threatened or commercially important species in Belize:

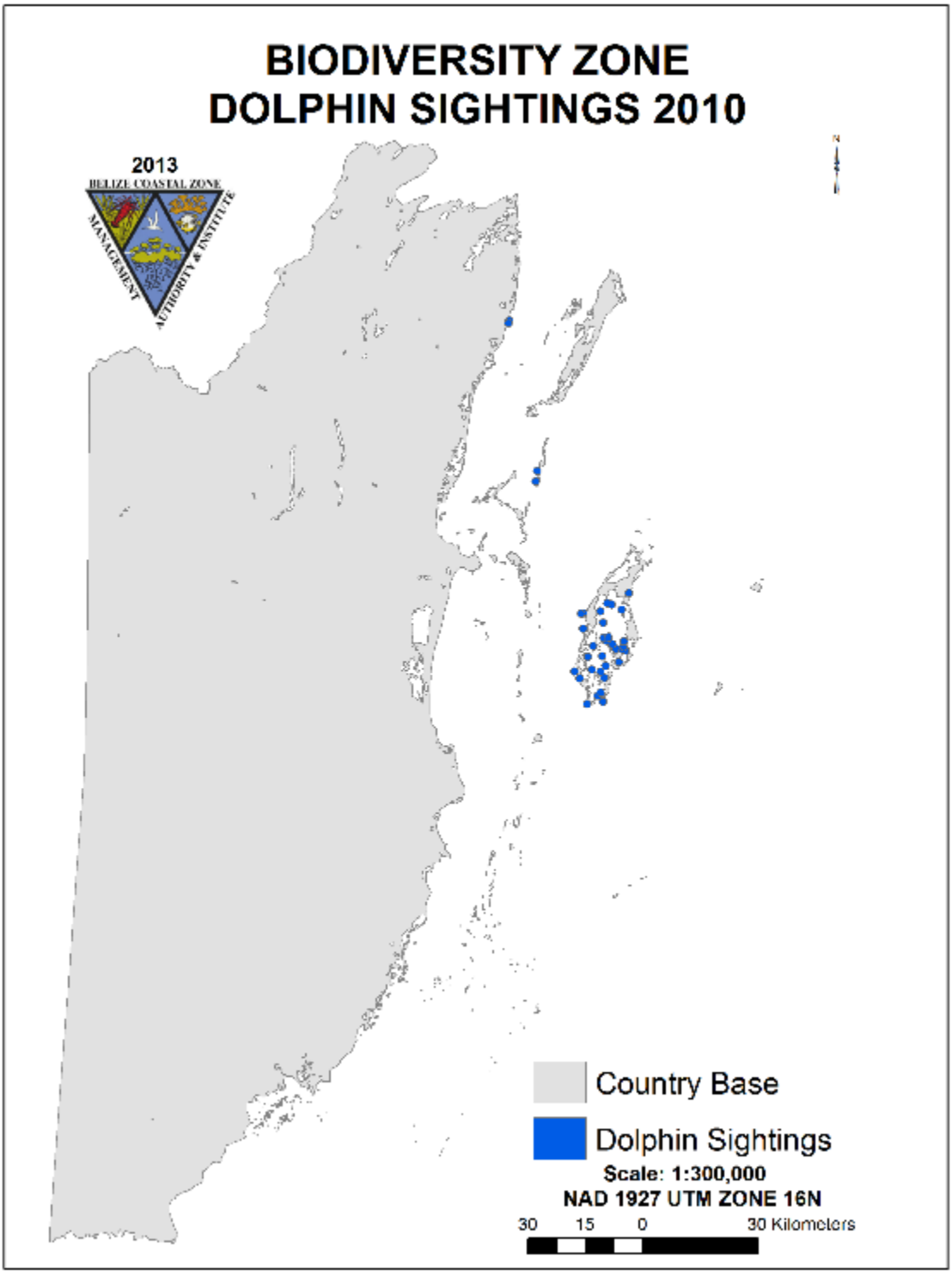
Agency	Species
Belize Fisheries Department	Fisheries resources
Belize Audubon Society	Migratory and Coastal Birds (Booby Bird, Jabiru Stork)
CZMAI/Sea to Shore Alliance	Manatee
Oceanic Society/MAR Alliance	Sharks, Crocodiles, Dolphins
ECOMAR	Marine Turtles
Wildlife Conservation Society	Sharks

These species all have demonstrated importance to the Belizean society, in terms of social, cultural and economic values. Belizeans take great ownership and pride in being the last stronghold for endangered species such as the West Indian manatee (Auil-Gomez 2012). Also, these species have contributed to Belize's international recognition as an ecotourism destination.


BIODIVERSITY ZONE
MANATEE SIGHTINGS 2012
2013
BELIZE COASTAL ZONE
MANAGEMENT AUTHORITY & INSTITUTE
Country Base
Manatee Sightings
Scale: 1:300,000
NAD 1927 UTM ZONE 16N
30 15 0 30 Kilometers


BIODIVERSITY ZONE
SEA TURTLE SIGHTINGS 2007
2013
BELIZE COASTAL ZONE
MANAGEMENT AUTHORITY & INSTITUTE
Country Base
Sea Turtle Sightings
Scale: 1:300,000
NAD 1927 UTM ZONE 16N
30 15 0 30 Kilometers


BIODIVERSITY ZONE
CROCODILE SIGHTINGS 2010
2013
BELIZE COASTAL ZONE
MANAGEMENT AUTHORITY & INSTITUTE
Country Base
Crocodile Sightings
Scale: 1:300,000
NAD 1927 UTM ZONE 16N
30 15 0 30 Kilometers


BIODIVERSITY ZONE
DOLPHIN SIGHTINGS 2010
2013
BELIZE COASTAL ZONE
MANAGEMENT AUTHORITY & INSTITUTE
Country Base
Dolphin Sightings
Scale: 1:300,000
NAD 1927 UTM ZONE 16N
30 15 0 30 Kilometers

Actions

- Conduct an inventory of potentially resilient critical habitats/areas that could benefit from restoration programs and long-term monitoring
- Preserve critical nesting sites and foraging areas
- Decrease development activities near fragile ecosystems
- Restore mangroves, especially in areas that are most vulnerable to erosion and inundation
- Replant sea grass in areas that have been dredged
- Establish a fund that is dedicated to national restoration projects.
- Increase public awareness about the importance of threatened species to Belize and Belizeans to encourage the promotion of the species within the coastal area of Belize

1.05 INVASIVE SPECIES MANAGEMENT

An invasive species is defined as "*any species (plant, animal or other organism) that is non-native to an ecosystem whose introduction causes or is likely to cause economic, social or environmental harm*" (USDA 2012). In Belize, several species have been introduced, either accidentally or deliberately, into the environment and have cause notable negative ecological effects. If left unmanaged, these species can also have severe economic and ecological implications.

Since the threats from invasive species are present within the environment, management options have to be low impact. Therefore, very sound decision-making is required, which can only be achieved by building a knowledge base on the species. Although there are many invasive species identified in Belize, only those of increasing concern for the coastal zone are mentioned in this section.

Lionfish

The introduction of lionfish (*Pterois miles* and *Pterois volitans*) to the temperate and tropical Atlantic region is considered as one of the greatest threats to current reef systems, and associated biodiversity. Lionfish were first observed in this region off the coast of Florida in 1985 (Morris & Atkins 2009). By 2012, lionfish have successfully colonized the south-eastern United States, the Caribbean and Gulf of Mexico (USGS 2012) and are expected to expand their spatial range to South America within the next few years (Morris 2012).

Their success in occupying a wide range of habitats is attributed to their:

- Very broad diet, consuming an array of smaller fish species
- Wide habitat preferences including reefs, mangroves (Barbour et al. 2010) and sea grass beds (Smith 2010)

As a result, lionfish have quickly become a top predator on most reef system due to its aggressive behavior and predation on the eggs of other predatory reef species. Impacts associated with the spread of lionfish include:

- Disruption of food web (Albins 2012)
- Reduction in stock-rebuilding efforts by economically important reef fish due to competition for food and space requirements (Morris & Atkins 2009)
- Increasing the mortality rate of species of conservation concern, such as Groupers (Albins 2012)
- Increasing the rate of degradation of reef systems due to additional stress (Côté and Green 2012)

In Belize, lionfish were first sighted and captured in December 2008. As a response to their existence in Belizean waters, a Lionfish Committee was established in early 2009. This

committee was a sub-committee of the Belize National Coral Reef Monitoring Network (NCRMN). Immediately after its formation, the Committee initiated a process to address and manage the problem. One year later, the Belize Lionfish Project was launched, an initiative to promote a nationwide public awareness campaign, and to increase the capacity of the NCRMN to better manage lionfish. The project is being implemented by ECOMAR, in close collaboration with the Belize Fisheries Department, and with grant finding from the UNDP/GEF Community Management of Protected Areas for Conservation (COMPACT) Programme. A lionfish management plan for 2009-2012 was prepared to help guide the management activities of the Belize Lionfish Project. Between 2009 and 2010 alone, a total of 2635 Lionfish were captured throughout the expanse of the elaborate reef system in Belize (Majil 2010). Many juvenile Lionfish have also been captured, which is an indication that they are successfully reproducing. It is believed that the extent of colonization of Belizean waters is much greater than is currently estimated as lionfish have been sighted at depths not originally believed to be occupied by the lionfish (Searle 2010). The lionfish management plan has been updated for the period 2013-2017. Additionally, new markets have been created with the restaurants in Ambergris Caye, Caye Caulker, Placencia and Belize City. Also there is an effort by the National Cooperative to buy Lionfish fillets and sell to the local markets. Finally, there has been a push by Blue Venture, an international NGO, to use the colorful fins and spines to make jewelry. This in effect has created another market using this species and is being targeted towards women in smaller communities.

Actions

- Update the Belize National Lionfish Management Plan on a regular basis (every 3-4 years), to include any new mechanism/protocol to monitor and suppress Lionfish populations in Belize. Mechanism must also be included to determine success.
- Expand the market for Lionfish consumption as a means to manage the lionfish population while providing an alternative
- Permanent removal of Coconut Trees near prominent Booby Bird nesting grounds on Half Moon Caye
- Conduct feasibility studies and eradicate invasive rat population at Half Moon Caye

Rats and Coconut Trees

Although considered a common social pest, the introduction of rats (*Rattus rattus spp.)* to Half Moon Caye Natural Monument has had a profound effect on the ecology of this World Heritage Site. Specifically, rats have been reported to consume the eggs of the endangered Red-footed Booby birds (*Sula sula).* Reports of rats at this site began as early as 1959, and the population has grown exponentially since that time (Waight & Lumb 1999). Although their introduction to Half Moon Caye is not definitively known, it is believed that rats were accidentally introduced to the island via cargo vessels during the 1800's. There have been several attempts to rid the island of rats, including a campaign using the poison "Warfarin" in 1969. However, all attempts to rid the island of rats have been unsuccessful.

The success of rats on Half Moon Caye can be attributed to the flora and fauna on the island. Their diet consists of the eggs of the Red-footed Booby birds, the Belize Atoll Gecko (*Phyllodactylus insularis*), and coconut fruits. In addition to providing food, the thick blanket of fallen dry fronds and leaves from coconut trees provide shelter. The increasing population of the non-native coconut trees at Half Moon Caye is also of great concern as they are rapidly replacing littoral forest that provides nesting sites for the Red-footed Booby. Due to their short reproductive periods and readily available food supply, complete eradication of rats is a fruitless management strategy. If not fully eradicated, rats are capable of re-colonizing an area very quickly. This, in addition to encroachment on nesting habitats by coconut trees, is placing the future of Boobies under continuous pressure. Currently, the Belize Audubon Society (Co-managers of Halfmoon Caye and Blue Hole) are conducting feasibility assessments and eradication efforts through a consultant. Their hope is to rid the island of these pests with minimal ecological damage.

1.06 FISHERIES MANAGEMENT

Fisheries resources in Belize are under pressure from unsustainable fishing practices, increased fishing effort and illegal poaching. The Fisheries Department is the regulatory body responsible for all aspects of marine resource utilization in Belize. Their powers extend from the regulation of licenses for fishing and aquaculture operation, to managing marine protected areas. Therefore their regulations encompass all aspects of aquatic and marine flora and fauna. A brief summary of the major constructs of the duties and responsibilities of the Fisheries Department as mandated within the Fisheries Act are as follows:

- *The Department is responsible for enforcing restrictions surrounding all flora and fauna within established marine reserves.*
- *A research permit issued by the Fisheries Administrator is required before any research activities can take place.*
- *Fines and penalties are levied on offenders who breach fisheries regulations pertaining to the size, season, amount, or type of specific, protected commercial fish species.*
- *Bio-research and bio-prospecting require a permit that is issued depending on the impacts of such activities.*

Since its passage in 1948, the latest amendment to the Fisheries Act and its Regulations was in 1989. In late 2010 the Fisheries Department, with support from the Wildlife Conservation Society, initiated the process to review and amend the existing Fisheries Act with the goal of long-term sustainable use and management of fisheries resources. The resulting *Aquatic Living Resources Bill 2012* (draft) now renamed *"Fisheries Resources"* Bill 2015 will incorporate modern conservation and management principles, compliant with international laws and conventions. Provisions within the proposed legislation include:

- Sustainable management of fish and fish stocks
- Promotion of inter-sectoral participation
- Elimination of overfishing and harmful fishing practices
- Data collection and management
- Effective enforcement of compliance with conservation ideals
- Improvement of the welfare of the fishing community

In terms of fisheries resources, the Spiny Lobster (*Panulirus argus*) is the most important fishery commodity fished in Belize (Gongora, 2012). However, there has been a decrease in lobster catch over the past twenty years resulting from overexploitation. Further decline in the production of this fishery commodity and the decrease in price for this product in the international markets could have dire effects on the fishing community and other sectors that depend on this fishery (Gongora 2012). One of the mechanisms through which the Belize

Fisheries Department hopes to increase the numbers of Spiny lobster (among other commercial species) is by increasing the percentage of "no take" zones through the marine protected areas mechanism and by implementing the managed access program in all MPAs. Prior to this the fishing industry worked within an open access fishery, which allows anyone with a commercial fishing license access to fish anywhere in territorial waters except for areas designated as "no take". With managed access in place, the number of fishermen allowed to fish within the marine reserves is limited to fishermen with their managed access license. The licenses are specific to a certain area and as a part of holding a license fishers are required to report catch data. This mechanism thereby controls the amount of fishers in a given MPA and also collects vital data to needed determine total catch, catch per effort, and diversity which contribute to determining quotas for various commercial species.

The total spiny lobster fishing area for the country is approximately 4,512 km^2 as calculated using GIS. The InVEST Spiny Lobster Fishery model estimates 0.52 million lbs of lobster tail are caught in the current scenario (2010) and that exports generated revenue of approximately BZ $16.4 million (**Fig. 23**). These modeled results align well with observed data reported by the Belize Fisheries Department of 0.61 million lbs of tail caught in 2011 and a total revenue of BZ$16.85 million (Gongora 2012). The results also suggest that the planning regions across the country contribute different amounts to this catch and revenue, with the greatest proportion of lobster currently caught in the Central Region (about 400 lbs annually) followed, by Turneffe Atoll, Ambergris Caye and the Northern Region.

The returns from lobster fishing also differ among future scenarios, with the model forecasting highest catch and revenue in a future similar to the conservation scenario and lowest for the development scenario. In the Conservation scenario, the catch is forecasted to increase to 0.76 million lbs and generate revenue of BZ $24 million by 2025 (**Fig. 23**). Under the Development scenario, the catch would decrease to 0.079 million lbs and generate an annual revenue of only BZ $2.5 million by 2025 (**Fig. 23**). However, InVEST results suggest that the Informed Management scheme would increase the catch to 0.68 million lbs, an increase of nearly 25% relative to the current scenario, and generate revenue of BZ$ 21.3 million by 2025 (**Fig. 23**). The increase in catch and revenue in the conservation and Informed Management scenario results from lower degradation of mangroves, corals and seagrass, which are essential for lobster nursery and adult habitat, through reduction in the area of these habitats at risk from multiple human uses. In particular, InVEST results suggest that through lowering risk to habitat degradation lobster catch and revenue could nearly double in Ambergris Caye under the Informed Management scenario. Additional information on how this model works can be found in **Appendix B.4**.

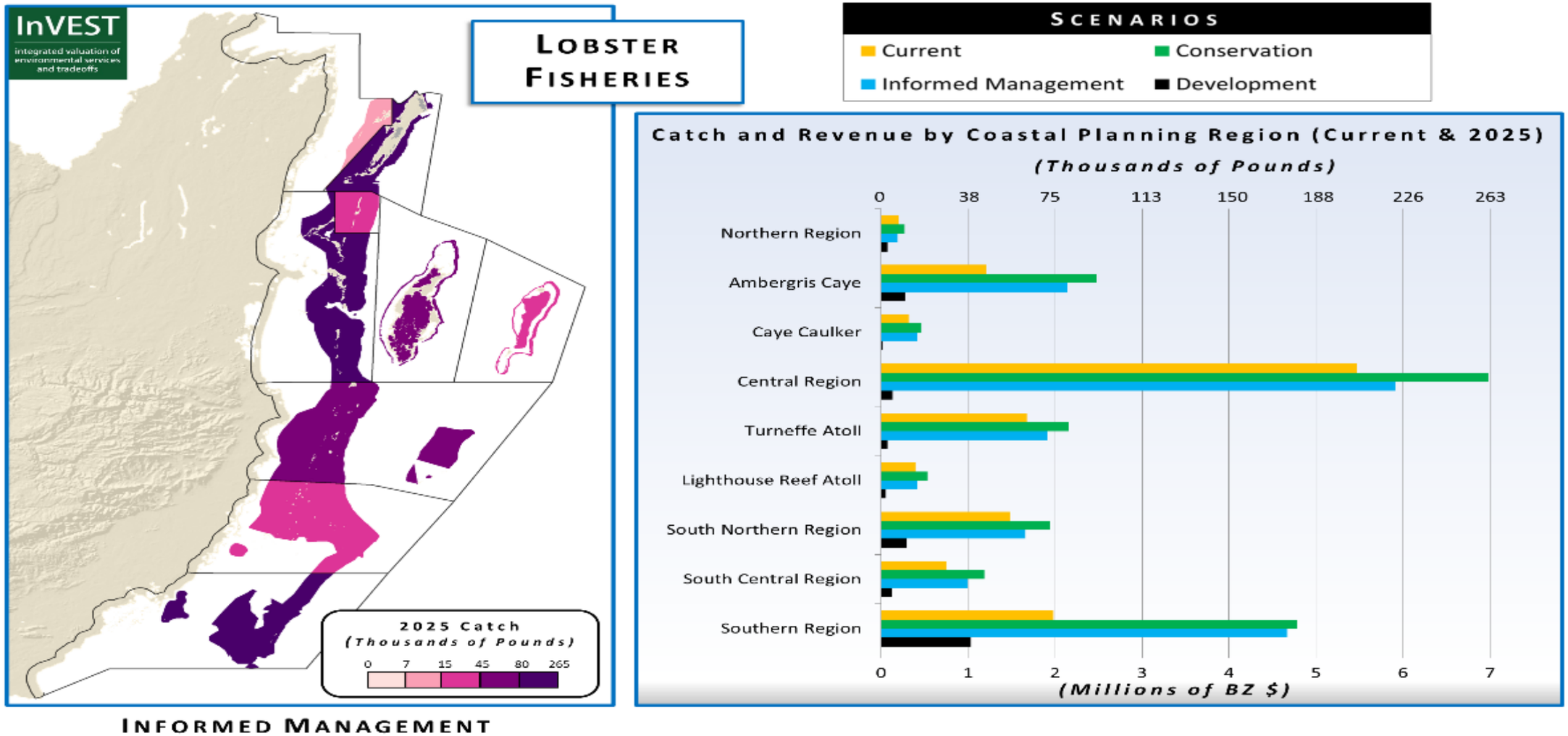


Figure 25: Lobster Fisheries Catch and Revenue by Scenario

Actions

- Strengthen the fisherfolk licensing system through the establishment of standards
- Implement national roll out of Managed Access Program in all Marine Protected Areas.
- Secure resources to permit increased monitoring and data collection at the various landing sites along the coast of Belize to help in the sustainability and conservation of commercially important species
- Monitor quotas to ensure full compliance

1.07 COASTAL AGRICULTURE

Agriculture in Belize accounts for over one third of the labour force in Belize. It is one of the country's leading contributors to the GDP. It is also one of the key terrestrial activities that are influencing coastal zone processes through siltation, eutrophication, and both point and non-point pollution with a growing number of pesticides, hydrocarbons, heavy metals and faecal material from livestock (CZMAI 2012). Cumulative water extraction and diversion to feed large-scale crop production such as banana farms are also affecting coastal sediment transport dynamics. This occurrence is being observed in southern Belize whereby the huge volumes of water being diverted away from the Monkey River have affected sediment transport to the extent that the shoreline from Monkey River Village to Barranco Village is experiencing severe erosion (Galen University 2007).

During the past 15 years, agricultural activities within the coastline have been steadily increasing. Meerman (2012) notes that agricultural expansion, and by extension deforestation, has been most prominent in Northern Belize during 1998 to 2012 specifically in the Rio Hondo River, New River, Shipstern Lagoon and Belize River watersheds. With increased global demand for agricultural commodities, it is projected that agricultural production across Belize will increase incrementally, thereby also increasing nutrient and pollutant load in major watersheds that interact with the coastal zone.

There are several legislations governing agricultural activities in Belize including:

- Banana Industry Act (Statutory Instrument 43 of 1997):
    - *Establishes the Banana Growers Association and Banana Control Board who work toward further enhancement of the Banana Industry in Belize and also ensures pricing and operating procedures.*
    - *Sets regulations and restrictions on the exportation processes of each farm.*
    - *Set penalties for operating without proper permits.*
- Belize Agricultural Health Authority Act (Statutory Instrument 47 of 1999):
    - *Establishes the Belize Agricultural Health Authority as the agency responsible for ensuring food safety, quarantine, plant and animal health to safeguard and facilitate trade.*
- Land Utilization Act (Chapter 188, Laws of Belize, Revised Edition 2000):
    - *Outlines the allowed usages and practices on land slated for agricultural activities.*
- Meat and Livestock Act (Chapter 214, Laws of Belize, Revised Edition 2000):
    - *Appoints a Commission responsible for ensuring quality of livestock and issuing or permits.*
    - *Set regulations for owning and operating a ranch.*

In 2015, the Government of Belize along with the United Nations Food and Agriculture Organization (FAO) in collaboration with the Inter-American Institute for Cooperation on Agriculture and the Task force established by the Ministry Natural Resources and Agriculture drafted the National Agriculture and Food Policy for Belize 2015 – 2030. The document presents the elements of a Policy Incentive Framework and related Good Governance System for the Agriculture and Food Sector of Belize. The objective of which is *"to provide an environment that is conducive to increasing production and productivity, promoting investment, and encouraging private sector involvement in agribusiness enterprises in a manner that ensures competitiveness, quality production, trade and sustainability".* The framework provides a platform to guide the development of actionable proposals to transform the agriculture and food sector into a modern pillar of economic growth and development in the country, with equity.

Actions

CZMAI recommends:

- Institute best management programs with agriculture and watershed stakeholders for the development and implementation of best management practices for agricultural land use in order to protect and maintain riparian forests
- Incorporate the prescription of minimum flow standard for major watersheds into the National Integrated Water Resources Act
- Monitor water quality for point and non-point pollution sources in the Rio Hondo River, New River, Shipstern Lagoon and Belize River watershed on a regular basis
- Finalize and implement the National Agriculture Food Policy for Belize

1.08 AQUACULTURE AND MARICULTURE DEVELOPMENT

The aquaculture industry made its humble beginnings with a shrimp farm project in southern Belize. Today the aquaculture industry has become one of the country's major foreign exchange earners and production has expanded to include Tilapia and Cobia farms in addition to the long-standing shrimp farms. The Fisheries Department, as provisioned in the Fisheries Subsidiary Act, was responsible for the issuing of licenses to developers wishing to own and operate shrimp farms in Belize. In order to obtain a license, an annual fee of $1,000 Belize dollars must be paid annually (Gillett & Myvett 2008). However, in 2012 the mandate for the management of aquaculture has been divided between the Department of Agriculture and the Fisheries Department. The Department of Agriculture has the responsibility for land-based aquaculture, with major focus on developing freshwater aquaculture in Belize. The Fisheries Department, on the other hand, has responsibility for mariculture and any other related activities within coastal waters.

In a 2002, CZMAI and the Fisheries Department collaborated to prepare a National Aquaculture Policy and Zoning Plan for Aquaculture in Belize. This document has the following principles regarding a national policy for aquaculture development:

- Management should encompass broad geographic areas and should cross institutional boundaries: including Enhanced Sector Management, Integrated Coastal Zone Management, and Water Shed Management
- Development options should be evaluated on the basis of the costs or consequences, as weighed against the benefits to be derived from undertaking a certain activity or sets of activities: Assessments must include financial, economic, social and environmental evaluations
- Impacts of developments should be within the absorptive or regenerative capacity of nature, and that this issue should be integrated into development decisions: carrying capacity is used interchangeably with environmental capacity;
  Best Management Principles should be exercised to assist the effective husbandry of aquatic stocks and conserve the environment.

From January 2014 to December 2015 shrimp farms in Belize worked towards attaining Aquaculture Stewardship Council (ASC) shrimp certification. This process was facilitated by the World Wildlife Fund and included Compete Caribbean and Belize Shrimp Growers Association. With ASC certification shrimp farms in Belize gain a competitive advantage in high-quality international markets since it demonstrates that shrimps were produced with minimal impact to the environment and communities where farms are located. Opportunities available from ASC shrimp certification include:

- Reduction of adverse environmental impacts through wetland and mangrove preservation, improved water and management, responsible use of feed, disease control and addressing biodiversity issues.

- Encourages improvements to coastal zone and fisheries management
- Future food security
- Improved social conditions
- Improved production methods and technology

With this certification, Belizean shrimp farms will set the standards for best practices in shrimp production and processing for this region. Enhancing the sustainability of the industry.

Actions

- Update draft aquaculture policy and regulations to reflect Aquaculture Stewardship Council guidelines
- Formulate an Aquaculture Steering Committee, comprising of government, non-government and private sector stakeholders, to advise and guide planning future aquaculture development in Belize
- Implement incentive programs to support small-scale producers to support local economies and reduce pressures on wild fisheries resources
- Report on the status and performance of both aquaculture and mariculture developments annually

1.09 MINERALS EXTRACTION AND ENERGY DEVELOPMENT

The Mineral Sector is governed by the Mines and Minerals Act, Chapter 226 of the Substantive Laws of Belize, Revised Edition 2000-2003, and the associated Regulations: the Mines and Minerals (General) Regulations, and the Mines and Minerals (Safety, Health and Environmental) Regulations. The Mining Unit of the Ministry Natural Resources is the lead agency with responsibility for enforcing the regulations. The scale and nature of the activity determines the type of Mineral Right the will be required. The most common Mineral Rights issued are as follows:

- *Quarry Permits (Renewed yearly)*
- *Mining Licenses (Maximum of 20 years or estimate life of deposit)*
- *Prospecting Licenses (Only granted for 3 years and has a 25 square kilometre limit)*
- *Reconnaissance Licenses (Only granted for 1 year and has a 50 square kilometre limit*)

In 2011, the Geology and Petroleum Department, in collaboration with the UNDP/GEF *Mainstreaming and Capacity Building for Sustainable Land Management in Belize Project* and the Forest Department under the pilot project *Rehabilitation of Scarred Landscapes* prepared the *Mineral Extraction Handbook.* The Handbook highlights procedures in the extraction process, the different methods that can be utilized, and steps to prepare an Extraction Management Plan.

The petroleum industry is relatively new in Belize with the first successful drilling operations commencing in June 2005 by the Belize Natural Energy. Since then, both terrestrial and marine areas have been parceled out to 18 companies under exploratory license agreements with the Government of Belize. These companies include:

BCH International Incorporated
BelGeo Limited
Belize Natural Energy
Blue Creek Exploration Limited
Island Oil Belize Limited
Miles Tropical Energy Limited
Northern Spirit Resources Incorporated
Perenco Limited
ZMT International Incorporated
PetroBelize Limited
Princess Petroleum Limited
Providence Energy Belize Limited
RSM Production Corporation
SOL Oil Belize Limited
Spartan Petroleum Corporation
US Capital Energy Belize Limited
West Bay Belize Limited
OPIC Resource Corporation (abandoned)

Companies are given an eight year exploratory license, and if oil is found during that period, a twenty-five year period for commercial exploitation. However, if no oil is discovered during the exploratory period the contract self-terminates and operations must cease. Importantly, it must also be noted that oil concessions may change with the ruling of the court.

In February 2010, an oil concession map was released by the Geology and Petroleum Department which confirmed that parcels were being issued throughout Belize, including marine reserves and national parks (Oceana 2010). This sparked a nation-wide campaign to ban drilling in these areas led by the Belize Coalition to Save Our Natural Heritage and OCEANA Belize. There was also strong support for the campaign from the tourism and fisheries sectors whose major concerns included:

- Risk from shipping and pipeline accidents
- Increase in marine traffic over sensitive marine ecosystems
- Legal framework is lacking and must be reviewed
- Effects on migratory fish stocks
- Effects on aesthetics of the coastal and marine areas
- Lack of assessments to determine the value of the coastal resources at risk
- The ability of government agencies to respond to oil spills.
- Lack of transparency and accountability in granting oil contracts
- Revenues from the current petroleum operation are being absorbed by the government contrary to government's commitment to its usage to alleviate poverty.
- Additional pressures on the Belize Barrier Reef System

To date, there exists no oil spill response legislation, however a response mechanism has been put in place to deal with a spill event at sea, whether from oil exploration activities or transportation of oil products via bunkers or hydrocarbon cargoes. The Department of the Environment has conducted numerous oil spill drills and have included other government agencies to participate and receive training. . The Petroleum Act governs activities within the country of Belize and its main provisions are as follows:

- *The appointment of an Inspector of Petroleum who is authorized to issue or revoke contracts for the exploration of oil.*
- *Strict penalties for parties that conduct exploration activities without a permit.*
- *Designates the area in which exploration can be undertaken.*

The Geology and Petroleum Department is currently finalizing a National Petroleum Exploration Zoning Framework. This framework will guide exploration activities by establishing various zones based on environmental sensitivity. For each zone the type and extent of exploration activities is outlined. This includes type and scope of testing and requirements for permits. The higher the sensitivity of the area, the more stringent is the requirements. These zones will not include marine protected areas or the reef system as per a decision made by the Cabinet in December 2015.

Actions

- Prepare a sound National Emergency Preparation Plan for Oil Spills and Waste Oil Management
- Conduct cost-benefit analyses of developing a petroleum-based energy sector ,
- Identify viable alternatives to crude oil for energy generation
- Develop the scientific capacity and technical expertise to understand hydrocarbon behavior in the marine environment to assess spill behavior and patterns in order to inform practical spill response.

2.0 SUPPORTING INTEGRATED DEVELOPMENT PLANNING

Integrated resource use and development planning, both on land and in the sea, is a critical issue. This can be achieved by tightening the control on unplanned development through improved planning, co-ordination, legislation and regulations to reduce the impact of both marine and terrestrial development in coastal Belize.

2.01 COASTAL AREA PLANNING AND DEVELOPMENT

The coastal area of Belize has been targeted by local and foreign investors for the development of the public and private sectors. A majority of Belizean livelihoods are linked to coastal resources, which makes the task or managing and allocating its usage much harder. With the introduction of environmental legislation in the 1990's, the government of Belize began making strides toward sustainable use. The major provisions of the laws passed in the 1990's included the following:

- *Enforcement of the Environmental Assessment Process*
- *Establishment of the National Environmental Appraisal Committee, a body which reviews development proposals and determines whether environmental clearance should be granted based on the projected impacts.*

Most areas within the Belizean coastal zone are considered to be sensitive, and as a consequence, all development project proposals should be screened for their impacts on the environment. The Environmental Impact Assessment (EIA) process allows for proper screening of development proposals and project management during the implementation phases. **This process also helps to define specific development standards and limits of acceptable change for proposed developments.** These activities are accomplished through the active participation of the National Environmental Appraisal Committee (NEAC) that examines all possible scenarios of environmental impacts to the environment arising from proposed developments as well as assess the feasibility of the development for the developer. The EIA process also allows for project proposals to be viewed through many angles. For instance, a project may be small in size but its impacts may be great in scale. The overall cumulative impact of an additional structure to an area may have significant implications of that area's capacity to support additional footprints. The Environmental Compliance Plan prepared for projects that have received environmental clearance is legally-binding contact between a developer(s) and the government that lends itself to accountability and mitigation of undesired negative environmental impacts. The informed management zoning scheme for coastal development in this Plan, identifies suitable areas that could be developed by potential interested parties. Investment in these areas should be transparent, giving the investor all the proper information needed to sustainably develop his/her land in an informed manner. The region specific coastal zone management

guidelines contain development standards and are intended to support the NEAC who oversees the EIA process.

Recently, the government has sanctioned several projects geared towards ensuring sustainable development and usage of Belize's land resources. Included in these efforts are coastal lands, cayes, and atolls. The three main planning initiatives include The Belize Land Use Policy Framework, National Sustainable Tourism Master Plan for Belize 2030 and the Belize Integrated Coastal Zone Management Plan. The purpose and anticipated outcomes of the Belize land Use Policy Framework and National Sustainable Tourism Master Plan for Belize 2030 are highlighted below:

Belize Land Use Policy Framework

In November 2011, the cabinet endorsed the Belize Land Use Policy and Integrated Planning Framework during a regular cabinet session. The Land Use Policy Framework is the response by government to the growing demand for access and usage of land throughout the country. The three main components that were approved by Cabinet include:

- *National Land Use Policy – sets out the principles on which land development should be undertaken*
- *Integrated Planning Framework – sets out the process in which the policy will be implemented through interagency cooperation.*
- *Land Suitability Mapping System – a dynamic GIS toolkit containing information that makes resource data layers available that reflect the provisions of the Policy. Intended usage is for national and community level development planning.*

National Sustainable Tourism Master Plan for Belize 2030

The National Sustainable Tourism Master Plan for Belize 2030 is government's actions to ensure the sustainable development of the tourism sector. This Plan consists of several major components, which include a diagnostic of the tourism sector, destination-level planning and associated implementation programs. Destination-specific planning for major tourism destinations in Belize are as follows:

- Belize City – Urban Renovation
- San Ignacio – Promoted Tourism Growth
- Placencia Peninsula – Contain Development and Consolidate
- Stann Creek – New Development
- Ambergris Caye – Contain Development and Consolidate
- Northern Belize – Promote Tourism Growth
- Southern Belize – Promote Tourism Growth
- Belize Reef – Contain Development and Consolidate

Actions

- Implement the spatially-explicit Informed Management integrated planning zoning presented in this Plan. This zoning scheme is in tandem to other existing land-use planning initiatives

- Support the continued partnership and liaison with coastal advisory committees (CACs) and relevant planning agencies as a basis for regional coastal area management planning

- Undertake revisions of regional coastal area management guidelines on a regular basis in consultation with CAC's, Technical advisory Council, and relevant planning agencies.

2.02 COASTAL POPULATION AND GROWTH

Across the globe, coastal regions are quickly becoming home to a large proportion of the world's population. Studies have shown that almost 50% of the world's population resides within 100 km of the coast, and researchers predict an increase of about 35% from 1993 to 2025 (Small & Nichols 2003). Similarly, almost 40% of the population of Belize is concentrated in population centers along the coast or on the cayes. The InVEST Coastal Vulnerability model results indicate that currently, the Corozal and Belize Districts are the coastal areas of highest vulnerability to flooding and erosion from storms, which are also the most concentrated population centers along the coast (**Fig. 23, Fig 24**). InVEST results also suggest that under each of the three future scenarios of Conservation, Development and Informed Management, these vulnerability of communities will remain relatively high (**Fig.23, 24**). Additional information on how the Coastal Vulnerability model works can be found in **Appendix B.2**.

The vulnerability of communities to coastal hazards has severe social and economic implications such as:

- Increased exposure to the effects of sea level rise increases, putting a large proportion of the population at risk
- Higher population densities increases the pressure placed on the marine/coastal environment through sewage and waste disposal
- Urbanization of coastal areas introduces extensive development, which has associated negative effects on marine and coastal ecosystems
- Tourism can lead to unsustainable coastal development such as infrastructure built on the shoreline. In Belize City, cruise ships discharge waste water into the marine and coastal environments, causing eutrophication of sensitive habitats marine ecosystems
- Decrease in fish stocks as a result of over fishing

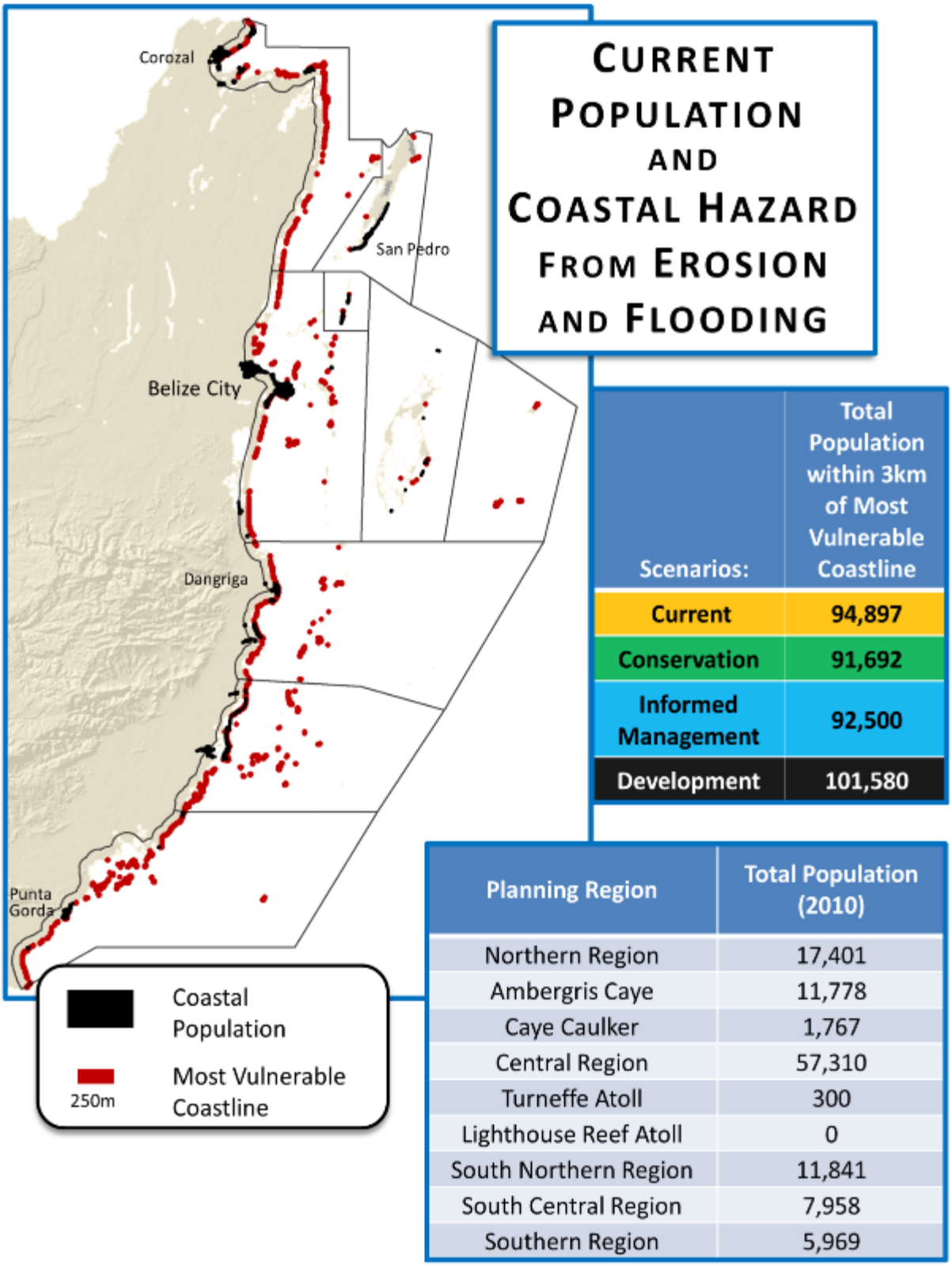


Figure 26: Vulnerability of Communities to Coastal Hazards by Scenario

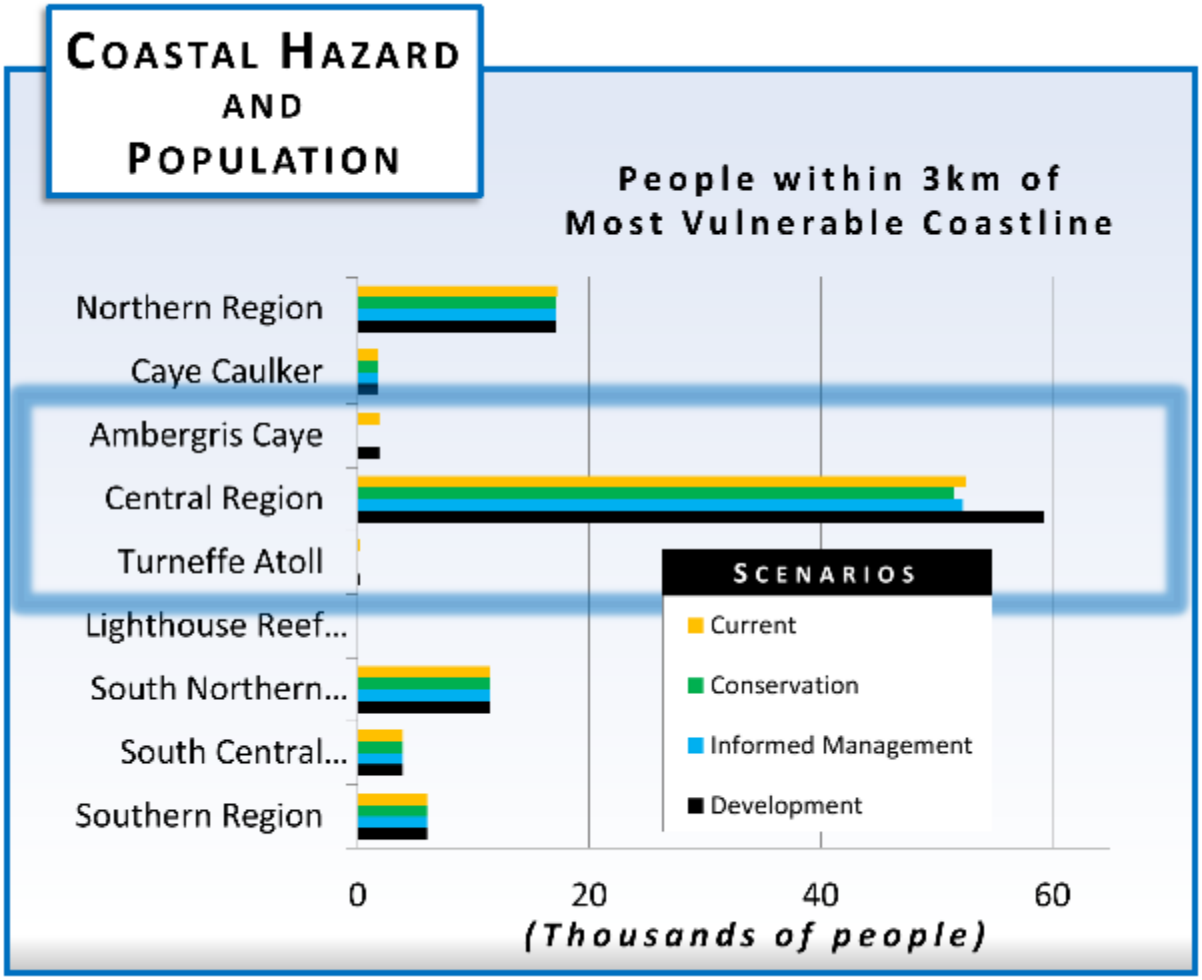


Figure 27: Coastal Regions within Most Vulnerable Coastline by Scenario

The Government of Belize has recognized that the growing threat of climate change to the future of Belize is looming and has taken steps to encourage preparation for anticipated effects. Through the forthcoming amendments to the existing National Climate Change Adaptation Policy (2008), the government will take steps to ensure that all sectors incorporate adaptation planning into their management plans. Also, through the continued strengthening of the protected areas management system, the government is promoting ecosystem-based adaptation, which is the most cost-effective and reliable approach for climate change adaptation since the country possesses resilient ecosystems.

With a population growth rate of 2.011%, Belize can expect that in the near future more than half of the population of Belize will be settled along the coast of Belize. The following are potential steps that CZMAI recommends as worth developing in order to minimize the exposure of coastal communities and the fragile ecosystems that support them to coastal hazards in the future:

Actions

- Undertake initiatives to relocate people who are settled in vulnerable areas, as a precaution against the effects of climate change
- Diversify income generation options to reduce the number of people who rely on the coastal resource base to support their income
- Implement proper building standards set and setback distances
- Limit exponential growth and expansion of communities within 3km of the coastline with high vulnerability to coastal hazards, such as the Central region, which includes Belize City ,and the Northern region
- Conduct regular vulnerability assessments of the coastal area in order to understand and to assess the effectiveness of climate adaptation strategies

2.03 BEACH AND SHORELINE MANAGEMENT

Next to the reef and lush tropical forests, the beaches and shoreline of Belize are one of the most iconic features that characterize Belize. They embellish the notion of life in the tropics, and serve as an attraction for tourists around the world. As a result of its multiple uses and prestige, beach and shoreline property have become highly coveted. Consequently, many conflicts and competing interests have resulted between and among stakeholders regarding the use of beaches and shoreline property. Examples of such conflicts include:

- Public access to beaches
- Sale of shoreline and beach properties to foreigners
- Pier construction
- Development in shoals
- Unnatural impacts to beach dynamics and processes, such as dredging and coastal erosion

Setbacks

Setbacks are transitional zones that buffer the effects of human activity from the natural processes of the coastal area. They are important for maintaining the integrity and stability of the shoreline in its natural state. The Government of Belize, through the National Lands Act, has prescribed a vegetative buffer of 66 ft on all national lands that adjoins water bodies outside of a city town or village. However, even though this standard is set, a look at development today suggests that it is not enforced as many structures have been constructed up to the shoreline. Inclusion of setbacks in construction would allow for natural resilience to the effects of global climate change, and also allow public access to the beach.

Pier Construction

In 1999, the Physical Planning Section of the Lands and Survey Department produced a set of guidelines to standardize the construction of piers in coastal areas. The guidelines included provisions for the length, minimum separation between piers, and design as well as emphasized the need for proper illumination and public access. However, the guidelines were not adopted by cabinet therefore there is currently no legal policy to guide pier construction in Belize.

Pier construction requires a permit from the Lands Department. This must be distinguished from the environmental clearance process that must also be conducted by DEO prior to the issuance of the permit. Even if environmental clearance is granted, developers must receive permission from the Lands Department in order to use the sea bed. Additionally, the Belize Port Authority must also be consulted during this process in order to determine whether or not the proposed pier would disrupt the flow of marine traffic and/or obstruct turning bases.

Development within Shoals

Shoals are linear landforms within or extending into a body of water, typically composed of sand, silt or small pebbles. They are characteristically long and narrow, and develop where a stream or ocean current promotes deposition of granular material (Wikipedia.com 2012). In 2010, the Department of the Environment submitted a paper to cabinet recommending that development in shoals be banned. This recommendation was made on the basis that development in shoals poses the following environmental impacts:

- Impact to nursery grounds of commercial species
- Impact to the sport fishing industry
- Waste management concerns associated with development due to the porous nature of the shoal areas.
- Dynamic nature of shoal areas not suitable to support construction
- Increased footprint associated with obtaining materials to fill shoal areas

Subsequently, in 2011, Cabinet endorsed the recommendations by the DOE and has banned development in shoal areas. Specific recommended actions by DOE regarding shoals development are as follows:

- All processing of shoals applications be stopped immediately
- Caution to stop leasing or titling shoals
- A list of all shoals issued either as lease or title be complied.
- The leases/titles of shoals identified within protected areas should be cancelled
- All sites outside of protected areas are assessed to determine feasibility for development
- For those sites, outside protected areas under processing, a committee be established to review all shoal applications prior to issuance of title or lease
- A rapid ecological assessment (REA) for existing shoals that have been leased or titled will be conducted at GOB's expense
- All new applications sites should be assessed at the investor's expense and MUST go through the committee

While the DOE has developed guidelines for over the water structures, the mandate for permitting the construction of these structures does not only fall under the DOE. The seabed is considered national lands under the National Lands Act. Thus, permission to build on the seabed must come from the Lands Department. Other key agencies such as the Belize Port Authority and the Central Building Authority must also be included to ensure construction is in line with their respective mandates/guidelines.

Shoreline Stabilization

Perhaps the most efficient and cost effective method of shoreline stabilization in Belize is by natural methods, via mangrove protection. It has been shown that mangroves stabilize shorelines with its intricate root system that holds soil together and buffers it against the effects of storm surge and other natural processes. Mangroves are among the ecosystems that are directly affected by development and therefore restoration projects should be encouraged in order to fully utilize their stabilization functions. Other methods of "soft" stabilization includes replanting native plants, creating an artificial slope, constructing armaments using natural features such as logs and digging trenches. The construction of manmade structures such as sea walls can also be used, but are discouraged because they cause isolation of the two environments - there are many negative impacts associated with the construction of such features on the marine environment.

Actions

- Implement restoration projects in Belize with increased investment by developers whose projects will remove vegetation that aid in shoreline stabilization
- Enforce and update national policy to govern the construction of piers, sea walls, jetties, groynes, harbor arms and other hard structures. This policy should encourage the use of soft shoreline stabilization methods
- Strengthen regulatory requirements for the full enforcement for setbacks governing activities related to commercial and/or residential development within the coast that considers the threat of global climate change and coastal hazards

2.04 MARINE TRAFFIC

Due to its location in both Central America and the Caribbean, Belizean waters have become a site for a host of maritime activities, including shipping and cruise tourism. With almost 1000 cayes within territorial waters, leisure boating and travel to and from the cayes is also an integral part of Belizean life. Water taxi routes, shipping and cruise ship lanes traverse almost the entire expanse of the coastal waters of Belize. These marine transportation activities sometimes overlap with other important activities, such as fishing, marine tourism and recreational activities like snorkeling. Increased boat traffic is also contributing to human-wildlife conflicts, especially in the instance of the endangered West Indian manatee (*Trichechus manatus*). Reports of 76 manatee strandings between 2005 and 2010 show the main verifiable cause of death of Belize's manatees was as a result of watercraft collision (Galves 2011).From 2010 – 2014, that number has risen to 114 deaths (Galves 2015) and currently there has been 24 stranding up to the end of April 2015. The regulation of marine transportation routes is done by the Belize Port Authority (BPA). However, there is no policy in place that outlines specific routes for each type of activity or zones the marine area according to activity. To accomplish this Hydrographic surveys/mapping of the seabed are required to inform this process. Additionally, the current nautical charts for Belize are outdated and need to be revised to reduce the growing number of groundings occurring throughout Belize. In the interim clear identification of "sensitive" zones that should not be heavily trafficked has been identified as a temporary solution until more advanced surveys/mapping is possible. Also, setting navigational standards for depth in relation to the vessels draft as well as implementing buffer zones for pleasure vessels can also be used as tools for improving marine traffic in Belizean Waters. For example, setting a buffer zone of approximately 1000 feet around pleasure vessels that frequent the Cayes where there are known sensitive habitats would safeguard these areas and prohibiting vessels from travelling in water less than one foot (0.3m) over the draft of the vessel would prevent groundings and damage to sensitive coral reefs. In order to accomplish this in a cost effective way, joint compliance monitoring of these areas will be necessary to ensure compatible marine traffic.

Marine traffic, particularly oil tankers and cruise ships traveling through our coastal waters, presents the risk of oil pollution from accidents at sea. This poses a threat to the Belize Barrier Reef Reserve System (BBRRS) and biodiversity. Additionally, oil tankers, which transport fuel to inland towns and villages, can threaten water bodies, forest areas and other infrastructure including towns. The cleaning of international vessels in Belizean waters, hull washing, structural maintenance of ships, and the offloading of wastes and garbage is particularly problematic. The "staging areas' for ships are requirements as part of international agreements. The MARPOL Convention, of which Belize is a signatory, provides alternatives to dumping at sea. In regards to the transportation of "dangerous goods" in our water, attention must be given to domestic and international transport of these materials due to the associate risk.

Although the CZMAI is offering a spatially explicit marine transportation zone, this zone and associated routes must be approved by the Ministry of Transport via the BPA. Also, If there is need for revision prior to the four year revision of the National ICZM Plan, as mandated by the CZM Act, the Ministry of Transport/BPA reserves the right to do so as well.

Actions

- Develop a national policy on marine transportation in support of the Informed Management zoning scheme to minimize user-conflicts
- Develop and implement a national policy and supporting standards for the safe transport of hazardous chemicals in the sea.
- Conduct Hydrographic surveys/mapping of the sea bed in order to better inform marine transportation routes.
- Update the navigational charts for Belize to ensure boating safety by vessels.

2.05 MARINE POLLUTION CONTROL

The major cause of marine pollution in coastal areas is the waste products produced from human activities on land. These waste products include municipal, industrial, and agricultural run-off and by-products that enter into the coastal and marine environment through the many waterways that drain into the coast. Once in the coastal zone, it can no longer be controlled and then threatens the survival of highly sensitive and highly productive coastal and estuarine ecosystems.

The following are the major concerns that contribute to marine pollution in Belize:

- Population centers in Belize have very poor sewerage systems, and public awareness about the effects of open latrines is low to non-existent
- Cruise tourism makes up the majority of the tourism sector in Belize (BTB 2008). It facilitates the visitation of a large number of people to coastal areas in short bouts. This leads to increased sewerage production, development activity, and solid waste.
- Belize is a historically agrarian society, with the agriculture industry contributing a large portion to GDP. Land use in this industry is widespread, and cultivating practices includes the increasing use of fertilizer and pesticides to increase crop yield (Fernandez 2002). The use of such agrochemicals consequently leads to nutrient and sediment loading in the coastal environment.

In response to the devastating implications of marine pollution from land-based sources, the Government of Belize joined the global effort to mitigate this threat. In doing so, Belize became a signatory to the Cartagena Convention in 2003, ratifying the Land Based Sources of Pollution Protocol, and designing the Belize National Program for Action for the Control of Land Based Sources of Pollution (NPA LBS) in 2008. The outcome of the NPA LBS development process is a national strategy for the reduction and mitigation of land based sources of marine pollution created and enforced through the Department of Environment (Table 6).

Actions

- Implement the NPA LBS to effectively manage and mitigate the growing problem of marine pollution in Belize
- Design and implement public awareness campaigns to inform the public about the hazards resulting from improper waste disposal

Table 6: Action for the Control of Land-based Marine Pollution

Source: Belize National Program for Action for the Control of Land-based Sources of Pollution (2008)

Issue	Primary Source	Objective	Priority Actions
Sewage	Commercial sewage systems, septic tanks, latrines, service trucks, marine vessels	Improve efficiency of the existing sewage treatment facilities within 5 years to meet existing standards	• Assess sewage facilities • Preparation of guidelines for waste management for hotels, including the treatment, re-cycling and disposal of wastewater
		Provide waste water treatment facility for coastal communities within five years	• Conduct a feasibility study • Acquire appropriate land for systems • Identify sources of funding • Design and construction of facility
		Increase residential connectivity to existing & future sewage treatment facilities	• Educate general public on proper disposal of sewage waste • Subsidize cost for connection • Existing waste treatment facility
		Strengthen building codes for septic tanks and latrines	• Develop and implement an educational program for builders, contractors, city, town and village councils • Increase capacity of institutions for monitoring and enforcement • Coordinate the Standardization Guidelines for designs
		Reduce bilge and sewage discharge into the marine environment	• Assessment of waste disposal from marine vessels (commercial and recreational) • Develop disposal guidelines and safety standards • Establish a public awareness program for relevant interest groups, including but not limited to, for cruise ship agents hoteliers, and operators • Develop a ship registry

Issue	Primary Source	Objective	Priority Actions
Nutrients	Agriculture / aquaculture (sugar, citrus, banana, livestock, shrimp, tilapia),residential and commercial sewage, and marine vessel effluents (bilge)	Develop one coordinated national water quality monitoring (WQM) network to measure nutrient loads in rivers, lagoons, and coastal areas to reduce nutrient pollution Harmonize water quality monitoring standards and coordinate current and future efforts	• Hold two national workshops with government., NGOs, and private sector • Establish one protocol for freshwater and one protocol for marine water monitoring. • Conduct a legislative review of existing WQM issues • Recommend legal responsibilities for continued implementation of the National Water Quality Monitoring Program. • Mechanisms to enforce the Riparian Buffer Zone (66 feet) alongside all water bodies and increase this requirement to 200 feet. • Revisit the 2 WQM Protocols to agree on their joint implementation from a national perspective. • Develop guidelines for the treatment and discharge of point and non-point sources of wastewater
		Identification and Implementation of best management practices (BMPs) from agricultural and aquaculture systems (small to large farms).	• Training of farmers in agricultural BMPs • Implement land-use planning and zoning, alongside land distribution policies • Minimize or avoid use of marginal lands for agriculture.

Issue	Primary Source	Objective	Priority Actions
Physical Alteration & Destruction of Habitat	Urbanization & development, deforestation, agriculture & aquaculture.	Development and implementation of a Land Use Plan, zoning scheme forurban areas, zoning scheme for tourism development along the coastal areas. Harmonize land development and existing laws as they relate to coastal areas, e.g., develop amoratorium on mangrove clearance.	• Utilize GIS and other technology as part of land use planning • Establishment of baseline data to monitor long term. • Assess ownership of mangrove cayes • Revise and promote the use of existing land use plan (SDAs). • Assess agricultural irrigation practices & develop of best practices • Compare and coordinate existing legislation so that they relate to each other. • Implement and enforce existing law (SDA, 66 ft buffer, etc). • Implement a moratorium on sale of mangrove cayes. • Enforce and Strengthen legislation in regard to riparian forest and steep slope. • Inventory vegetation along riverbanks. • Revive planning bill initiative.
		Updating and legislating a Coastal Development Policy.	• Review and revised both documents • Implement policies • Strengthen the legal coordinating capacity of the CZMA.

Issue	Primary Source	Objective	Priority Actions
Solid Waste Management (SWM)	Household and commercial, agro-industries (citrus, sugar, banana), and meat andseafood processing.	Implement the National Solid Waste Management Plan. Develop norms and specifications for collection, transportation, storage, treatment, and disposal of solidwastes in collaboration with Departments of Environment and Health.	• Review status of the Board of Directors to reflect the primary stakeholders in the Authority • Establish the SWM Authority • Establish the secretariat with qualified Staffing • Review and Strengthen Act (Chap 224) • Review and Update Management Plan

2.06 MARINE TOURISM AND RECREATION

The tourism sector in Belize is dependent upon the pristine natural resources, since it is ranked among the top ecotourism destinations in the world (Planet Green.com 2009). Thousands of tourists flock to Belize all year round, with the peak season occurring late November to late April. This causes significant stress to the fragile, interconnected ecosystems of the coastal zone. Consequently, this situation emphasizes the need for sustainable methods of conducting tourism and recreational activities to ensure the viability of the tourism industry. As a step towards this, in 2001 the CZMAI published the *Tourism and Recreation: Best Practices for Coastal Areas in Belize* (CZMAI 2001). It highlights the social and economic benefits to implementing best practices into business plans. The guiding principles for tourism and recreation, as included in the best practice guide are:

- Adequate tourism planning
- Responsible promotion and marketing
- Compliance with legislation, tourism and coastal zone management strategies and related CZM policies
- Reducing tourism impact
- Investigating and investing in appropriate technologies
- Local community involvement
- Working and supporting coastal and marine protected areas

Impacts to the coastal areas originate from external areas and many times result in irreversible damage. Any loss or degradation of habitat that does occur has a direct effect on the amount of tourism dollars that can be generated. Through careful planning and sound operational practices, tourism operators and enthusiasts can ensure the sustainability of the tourism industry in Belize.

The results from the InVEST Recreation and Tourism model suggest that a greater proportion of tourism days are spent in some planning regions than others. By combining these results with the Belize Tourism Board's estimates for total annual number of tourists to Belize, our analysis suggests that tourists spend the greatest total number of days in the Central region followed by the South Northern, South Central and Ambergris regions. The results suggest a similar pattern for expenditures. As per the InVEST Recreation and Tourism model results, currently annual visitation is approximately 1.98 million (**Fig. 26**) generating revenue of approximately BZ $231 million (**Fig. 27**).

According to the National Sustainable Tourism Master Plan for Belize 2030, and our modeled results, annual visitation will more than double under all future scenarios in all planning regions. However, expenditures are likely to be highest under the Informed Management scenario – more than double expenditures in the Development and Conservation scenarios. In a Conservation zoning scheme, annual visitation is expected to increase to 2.9 million (**Fig. 26**),

and generate revenue of BZ $322 million by 2025 (**Fig. 27**). A Development zoning scheme is also expected to increase annual visitation to 2.8 million (**Fig. 26**), and generate revenue of BZ $315 million by 2025 (**Fig. 27**). In the proposed Informed Management zoning scheme for Belize, annual visitation increases significantly to 4.1 million generating revenue of BZ $708 million by 2025.

Under the Informed Management scenario, the Central region will likely continue to experience the highest tourism days and expenditures. However, results suggest the largest percent increase in expenditures will be experienced in the Lighthouse Reef Atoll and Southern regions. This is largely because people are drawn to areas with both high quality coral reefs and infrastructure to support tourism – a combination that is best enhanced through the informed management scenario. Overall, the results from the InVEST tourism model suggest that the proposed Informed Management zoning scheme for Belize will increase tourism in all regions, with greater number of visitors to regions where new coastal development preserves coral and seagrass habitats. Additional information on how the Recreation model works can be found in **Appendix B.3**.

Actions

- Implement the National Sustainable Tourism Master Plan (STP) for Belize 2030 in conjunction with the recommended Informed Management zoning scheme for sustainable marine recreation and tourism
- Develop and support further sustainable tourism management through products from the STP II Project

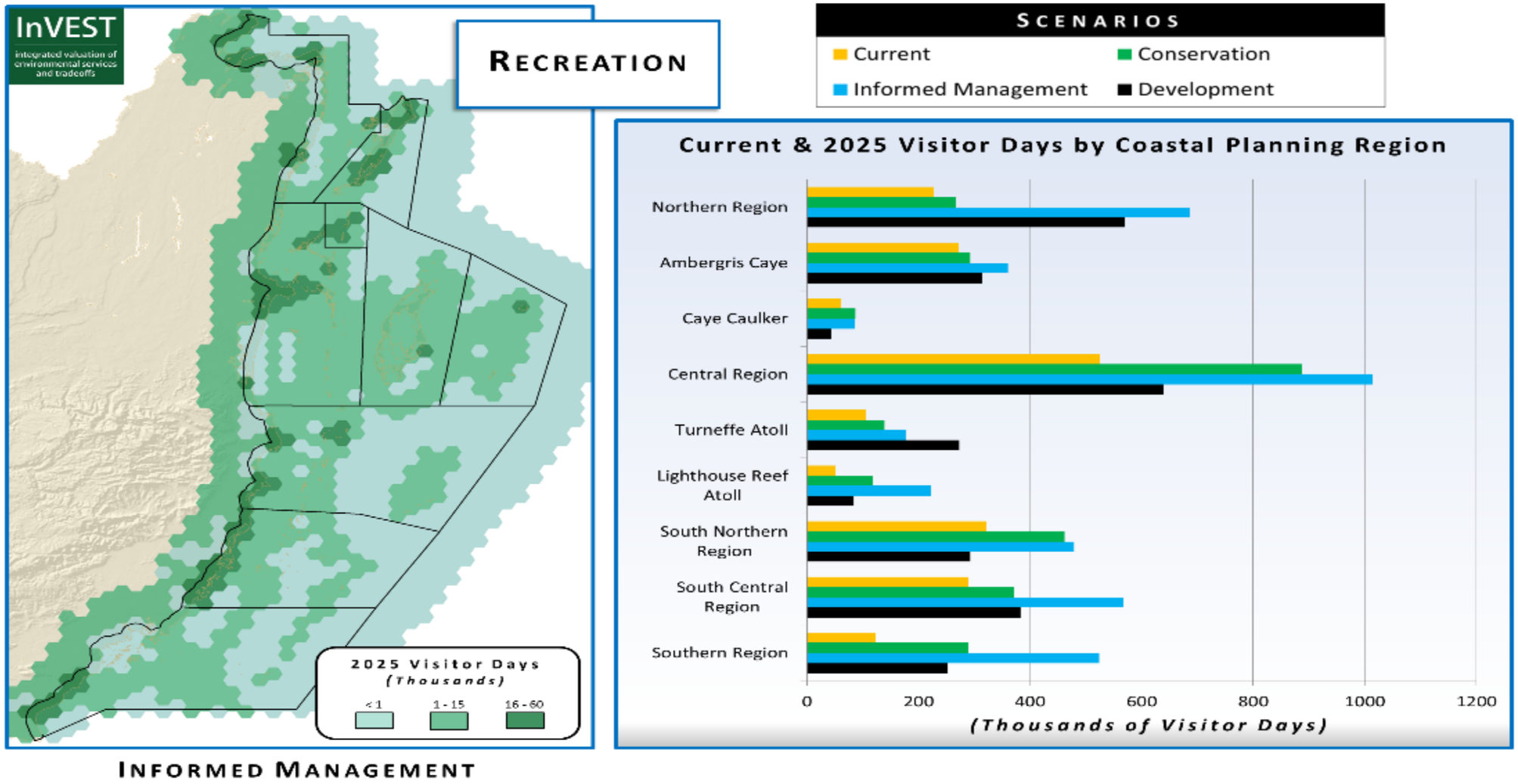


Figure 28: Annual Visitation for Marine Tourism and Recreation by Scenario

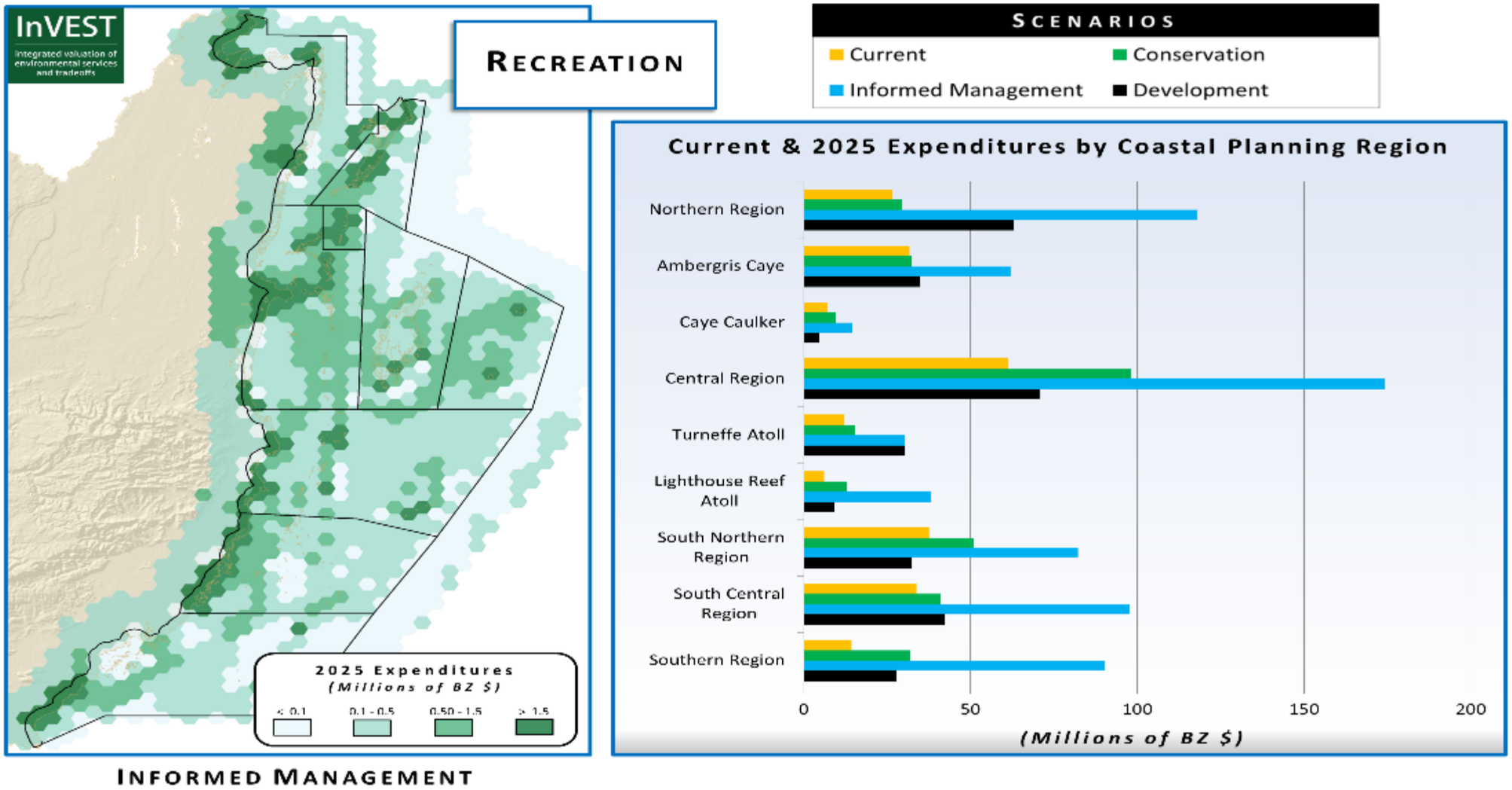


Figure 29: Annual Expenditures for Marine Tourism and Recreation by Scenario

2.07 MARINE DREDGING

Dredging is considered one of the main stressors to marine ecosystems associated with development in the coastal areas. The activity usually involves the extraction of bottom sediments from one area for disposal in another and its usage ranges from opening navigational channels to beach reclamation. It has been shown that once sediment is removed, it takes on average 10 – 15 years for the area to recover and regain its biological complexity (Newell et al. 2008). Although this activity is considered highly disruptive to coastal and marine ecosystems, it is necessary for certain activities to take place within the coastal zone. These activities include the maintenance of port facilities, and navigational lanes. Additionally, in some areas it is necessary to fill or reclaim land in order for development to occur. In these instances relevant authorities should take the proper precautions and follow best practices in order to minimize the effects to the environment.

To date there is no policy implemented to deal with marine dredging in Belize. As it stands, authorization for dredging is issued through the Mining Unit of the Ministry of Natural Resources. The Ministry is taking the lead in preparing the Marine Dredging Policy that will aid in the management of dredging within the coastal environment. Some recommendations from the Mining Unit in regards to this includes include:

- Developers must identify alternative sources of dredged materials and access routes prior to issuance of license and mandatory NEAC approval (through an EIA) for granting permits.
- Mineral Rights may be either a permit of a license and the type of Mineral Right issued is dependent on the scope of the development requirements.
- All mineral rights issued within the coastal zone require Environmental Clearance from DOE.
- Projects that are reviewed by the NEAC are considerably larger in scope and thereby requires and EIA.
- Smaller projects may require a Limited Level Study (LLES) which is reviewed by a NEAC subgroup.
- Heavy scrutiny of dredging within MPAs and permits only granted after completion of a definitive environmental assessment.
- Developers are to undertake and finance the replanting of seagrass, mangroves and coral through the environmental clearing process, in areas that have been dredged.

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Actions

- Finalize and implement a National Marine Dredging Policy
- Identify alternative sources of dredged material and access routes prior to issuance of licenses and permits for obtaining dredged spoils
- Scrutinize applications for dredging activities within protected areas (MPAs, Natural Monuments, World Heritage Sites)

2.08 DISASTER RISK MANAGEMENT

Disasters are globally imminent and occur as a result of both natural and man-made perturbations. The Atlantic hurricane basin is always experiencing a state of heightened activity. This heightened activity makes Belize particularly vulnerable each hurricane season. Tropical cyclones and flooding events alone pose the greatest threat of natural devastation in Belize. During the last ten years alone, Belize has experienced a few strong hurricanes and several tropical storms that have had devastating impacts. Despite the fact that there lies some uncertainty in the potential changes in intensity and tracks of tropical cyclones in the future, evidence indicates that they are likely to become more intense under a warmer climate as a result of rising sea surface temperatures (McSweeney et al. 2004). Thus, the ability to prepare, respond to and manage the incidence of disasters is a critical component of everyday life in Belize. For example:

- Located along the Atlantic Hurricane Belt, Belize is under constant threat and tropical cyclone activity, and historically has lost many lives as result (UN 2000).
- Land topography and building practices in the interior portions of Belize has led to loss of life during landslide events (Richardson 2009).
- The historical colonial style method of constructing wooden structures increases the risk of loss of life due to fires. But building on stilts has been one way to mitigate flooding.

Disaster preparedness and response in Belize is carried out by the National Emergency Management Organization (NEMO), which was established under the Disaster Preparedness Act (2000). NEMO is chaired by the Prime Minister. NEMO is mandated to implement measures, in a disaster preparedness and response decision-context, which will preserve life and property in the event of an emergency and will mitigate associated impacts. It has ten committees that handle all aspects of emergency response including: NEMO is the organization mandated to coordinate the mitigation, preparedness, response and recovery from emergency and disasters.

- Education
- Communication and Warning
- Medical and Relief Measures
- Housing and Shelter
- Search, Rescue, and Initial Clearance
- Collection, Control, and Distribution of Food and Material
- Assessment and Evaluation of Damage
- Foreign Assistance
- Transport
- Environment and Utilities

NEMO has permanent members from a cross section of sectors as well as local committees in every district. In 2000, the Government of Belize also passed the Disaster Preparedness and Response Act Commencement Order, which mandates that in the event of disaster alert the provisions of the National Disaster Preparedness Act are to be immediately implemented. Also, it sets guidelines for response by the different committees; for example the opening of shelters and evacuation procedures.

In order to minimize the impacts of natural disasters and improve sustainable development there needs to be the exchange of information and tools among agencies focused on disaster risk management, climate change, and human development. Impacts associated with climate change will intensify the existing effects of natural disasters. When including climate change effects in disaster risk management, planning must begin using the current vulnerability status of an area. Understanding how to deal with current vulnerability is a step toward building the capacity of government and communities. As changes occur due to climate change, the existing approach could be adjusted accordingly.

The process of including climate change effects into disaster risk management is only slowly being implemented as the government acknowledges that climate change is a valid threat to Belize. Although there are policies in place that promote disaster risk management, there needs to be a thorough review in order to fill gaps, and to ensure the mainstreaming of disaster risk management in relevant policies, such as:

- Belize National Hazard Mitigation Policy (2004)
- Belize Building Act 2003 (Amended in 2005)
- The Coastal Zone Management Act (1989)
- The Environmental Protection Act (1992)
- Insurance Act (1976)

Actions

- Develop a comprehensive inventory of people and property located within vulnerable coastline

2.09 CULTURAL HERITAGE CONSERVATION

In addition to the high species biodiversity, Belize is also home to a very diverse human population. Today, Belize boasts many different cultures, the evidence of which can be seen in Belizean way of life. The major ethnicities resident in Belize include the following:

- Maya (Kechi, Mopan, Yucatan)
- Creole
- Garifuna
- Mestizo
- East Indian

Others include Syrian, Lebanese, Chinese, Taiwanese, Korean and Mennonites.

The Mayas are the indigenous people of Belize, evidence of which can be seen around the country in the form of archaeological ruins that were once a part of a greater Mayan civilization known as the southern Maya Lowlands during the Preclassic period (2000 BCE – 200 CE). Today, all the ethnic groups make up the Belizean identity, and therefore their cultural must be conserved to maintain the country's uniqueness. In response to this need for cultural heritage conservation, the Government of Belize established the National Institute of Culture and History (NICH) in 2003. The goals of NICH are to ensure and encourage a better understanding of Belize's historical and ethnic roots, and to instill a sense of pride in the country's cultural heritage and shared national identity. NICH falls under the Ministry of Tourism, Culture and Civil Aviation, and is governed by a board appointed by the Minister of Culture. The objective of NICH is to:

- Encourage creativity and freedom of expression within the law
- Foster cross-cultural understanding and mutual respect
- Ensure that the several districts of Belize are beneficiaries and contributors to cultural policies and programmes
- Promote effective integration of culture and arts as part of school curriculums
- Ensure participation of civil society in the making of policies and programmes
- Ensure the participation of youth
- Take full advantage of the latest technological advances to ensure that the mass media contributes effectively to cultural development
- Ensure that cultural promotions stress the values of national and regional community.
- Conduct international relations and exchanges to safeguard and enhance national sovereignty and dignity
- Allow free and democratic access to information within the framework of the law
- Preserve Belize's diverse culture and heritage

There are economic as well as social benefits to conserving our cultural heritage. Belize attracts a large number of archaeological enthusiasts from around the world. During the ten year period from 1998 to 2008, Belize experienced a 160% increase in visitation to archaeological sites, which equates 215,000 visitors in 2008.

Actions

- Implement existing policies for the preservation of culture and the integrity of cultural monument and archaeological sites for the benefit of current and future generations

3.0 BUILDING ALLIANCES TO BENEFIT BELIZEANS

It is essential to build bridges between and among various interest groups as a mechanism to improve public education, and form functional linkages for effective coastal area management. Such linkages will strengthen the capacity for monitoring and enforcement for a large coastal area, especially where institutional resources are stretched to achieve their mandates.

3.01 EDUCATION, AWARENESS AND COMMUNICATION

Environmental education and public awareness are among the core activities of the Coastal Zone Management Authority and Institute. In the creation of this Plan, several iterations of stakeholder consultations were undertaken. This was done to gather ideas and support from coastal communities, and to inform them of the current issues and foreseeable concerns of coastal planning. Other methods utilized by CZMAI to make information available to the public and provide updates include:

- Social Media i.e. Facebook, Instagram, Twitter
- CZMAI Website (www.coastalzonebelize.org)
- Mass media (Radio, Newspaper, Television)

All conservation NGOs carry out some form of public awareness and/or advocacy initiatives in Belize. Some notable ones include the Belize Audubon Society, Toledo Institute for Environment and Development, Belize Tourism Board, Healthy Reefs Initiative, and Oceana in Belize. These agencies, in some cases, target local communities while others embark on country-wide campaigns with the overarching message being the protection of our coastal and marine resources (Williams 2012).

Actions

- Target efforts to ensure that the future generations of Belize are aware of problems that may occur throughout their lifetimes
- Sustain aggressive public education and awareness campaigns in order to continue information sharing to key stakeholder groups

3.02 COLLABORATION IN ENFORCEMENT AND MONITORING

The task of holistically managing the coastal areas of Belize cannot be effectively done by government departments alone. As a means to accomplish this, government departments responsible for protected areas have entered into co-management agreements with NGOs (CZMAI 2012). This form of management not only benefits the agencies involved, but also the country of Belize since it widens the resources available to make monitoring and policing of these areas a success. On November 22, 2012, co-management agreements between the Ministry of Forestry, Fisheries and Sustainable Development and local conservation NGOs were signed into law. The co-management agreements were signed by four NGOs for the following protected areas:

Non-Governmental Organization	Protected Area
Sarteneja Alliance for Conservation and Development	Corozal Bay Wildlife Sanctuary
Friends for Conservation and Development	Chiquibul National Park
Ya'axché Conservation Trust	Bladen Nature Reserve
Toledo Institute for Development and Environment	Port Honduras Marine Reserve

The co-management framework establishes improved standards for the agreement between the Government and the NGOs that manage protected areas. The signing of the agreement signals the government's recognition of the key role of co-management agencies in the management and sustainable development of Belize's natural resources. Although the effectiveness of these agreements has been proven, there is still the need to strengthen the capacities of both parties in order to ensure the continued protection of marine flora and fauna (APAMO 2012).

A means to improve the effectiveness of MPAs would include enlisting the aid of agencies outside co-management agreements. Particularly, involving the surrounding communities and stakeholders in research, education and enforcement efforts, and offering incentives for them to do so. Also, providing special training for other agencies such as the Geology and Petroleum Department, Police Department, Customs Department and the National Coast Guard on the issues concerning MPAs would improve vigilance. Continued inter-agency collaboration is key for sustaining MPA functions.

Actions

- Conduct a comprehensive review of the capacity in Government , NGOs and stakeholder communities to identify available options for optimal resource use
- Enlist the aid of agencies and groups, in addition to those in co-management agreements, such as communities and stakeholders in research, education and enforcement effort as a means to improve the effectiveness of protected area management
- Provide special training for enforcement officers and partner stakeholder groups to improve vigilance

3.03 SUPPORTING SUSTAINABLE COASTAL ECONOMIES

The coastal area of Belize has been long targeted for its investment potential. Over the years there have been many project proposals, both national and international, that have been funneled through agencies such as the Belize Trade and Investment Development Service (BELTRAIDE), which promotes the use of the coastal areas for economic activities. These agencies offer information such as national requirements and investment procedures, advice on development, and pre-feasibility studies. However, they do not provide the environmental sustainability direction for these projects. The DoE does provide the mechanism for environmental clearance though the EIA process, but would benefit from approaching development recommendations in a holistic point of view.

Actions

- Establish a direct liaison with BELTRAIDE to streamline development applications and extend to other investment agencies as appropriate
- Implement an Informed Management zoning scheme for the integrated management of activities of the coat to ensure that the coastal resource base yield returns on the benefits from nature to communities in the short, medium and long-terms

3.04 NATIONAL NETWORK FOR THE MANAGEMENT OF THE COAST

Coastal Advisory Committees (CACs) played a key role in the development of the Belize Integrated Coastal Zone Management Plan. The CACs are made up a very diverse, cross-sectoral group for each of the nine planning regions (Fig 2). Members represented include, and are not limited, to educational institutions, NGOs, government departments, business sector, civil society and the private sector (**Fig. 28**). The diversity of the CACs ensures representation of all major stakeholders groups within each region. CACs will then play a dual role in assisting in the drafting of legislations and working along with relevant government departments in implementing such legislations.

In the drafting of legislation, the government must do its part to ensure that the input of stakeholders is incorporated within the document. Striking a balance between the opinions of stakeholders and governmental objectives levies support by CACs, and the public at large. The establishment of a network such as this will also requires transparency and proven sound management practices in order for it to function as a single unit. However, if such a network is established, the task of managing the coastal area is not solely in the hands of the government, but also in the public's, thus heightening their sense of ownership and pride in the management of Belize's coastal and marine areas.

Actions

- Seek formal means for all application impacting the coastal zone to be submitted to the Coastal Zone Advisory Council by the relevant permitting agencies

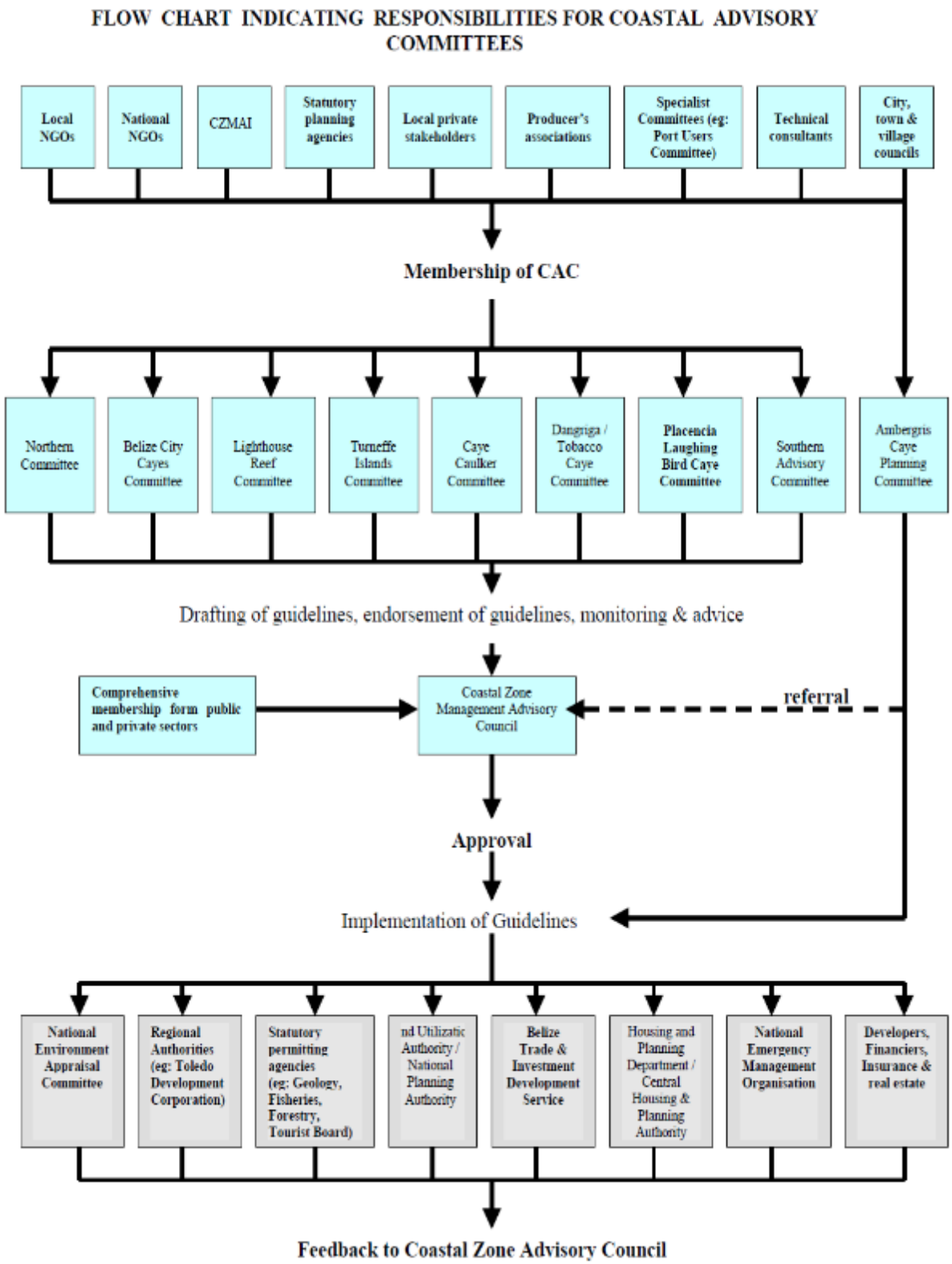


Figure 30: Flow Chart of the Coastal Advisory Committees in Coastal Planning in Belize

4.0 ADAPTING TO CLIMATE CHANGE

4.01 SOCIO-ECOLOGICAL VULNERABILITY AND RESILIENCE

Exposure and Sensitivity to Climate Conditions

Climate Data

Located between latitude 16^{o} – 18^{o}, Belize is located along the north eastern edge of Central America. Subsequent to the geographic location, Belize experiences sub-tropical climate conditions, seasonal variation alternating between a "wet" and "dry" seasons. Mean temperature is approximately 79^{0}F with average relative humidity around 80%. A temperature gradient exists across the country as the low lying coastal areas experiencing warmer temperature than the mountainous interior. Annual rainfall varies across the country; the north experiencing 60 inches of rainfall annually and the south 150 inches. Belize is located within the Atlantic Hurricane Belt and has had a history of encounters with tropical cyclones events. A brief summary of major cyclonic events are listed below.

Year	Name of Storm
1931	Storm #5
1955	Hurricane Janet
1961	Hurricane Hattie
1971	Hurricane Edith
1974	Hurricane Fifi
1978	Hurricane Greta
2000	Hurricane Keith
2001	Hurricane Iris
2007	Hurricane Dean

The coastal area of Belize is comprised of about 386 km of coastline, 3 atolls, 220 km of the world's second largest barrier reef system and over 300 small mangrove cayes scattered across 23,660 km^2 of territorial seas. Generally, the coastal areas are low lying with many of the small cayes and large sections of the coastline being less than one meter below sea level. As a result these areas are very vulnerable to the effects of global climate change (McSweeney et al. 2004).

Recent Trends (McSweeney et al. 2004)

Temperature

- Increased by 0.45^{o}C since 1960 at an average of 0.10^{o}C per decade with the most rapid rate of increase during the wet season.
- Average number of "hot" days has increased by 67 or 18.3% from 1960 to 2003, majority of which occur most strongly during the summer months
- Average number of cold days decreased by 5.7% from 1960 to 2003

Precipitation

- There is no statistically significant change in precipitation from 1960 to 2003 with decrease at an average rate of 3.1mm per decade.
- The percentage of 'Heavy' rain has not increased, consistent with rainfall pattern.
- Maximum 5 day rainfall has increased by 5.4 mm per decade since 1960.

Future Climate Predictions (McSweeney et al. 2004)

Temperature

- Mean annual temperature is projected to increase by 0.8^{o}C – 2.9^{o}C by 2060 and 1.3^{o}C – 4.6^{o}C by 2090 with the rate increasing during the summer months.
- Projections indicate substantial increases in frequency of 'hot' days and nights and 'cold' nights will become rare, decreasing to less than 10% by 2090.

Precipitation

- Projections of mean annual rainfall by various models indicate a decrease in rainfall by about 11% - 22% by 2090
- 'Heavy' rainfall will decrease consistent with precipitation predictions.
- Projections may vary as tropical cyclone activity was not included in models as there are too many uncertainties associated.

Tropical Cyclone Activity

- While tropical cyclones are expected to be more intense as a result of warmer sea surface temperatures, it is uncertain whether the frequency and track will change, especially with influence from other features such as El Niño and La Niña oscillations.

Projected Impacts on Natural Resources (Richardson 2009)

Coastal Zone

The area most susceptible to the effects of climate change is the coastal ecosystem. Anticipated increases in sea surface temperatures, salinity, pH, sea level, and intensity of tropical cyclone events have direct implications on the future state of the coastal zone and the ability of Belizean to utilize the resources it provides. Belize's coastal ecosystems and rich biodiversity will also be affected by global climate change. Delicate marine ecosystems such as sea grass beds, mangroves and coral reefs are directly dependent on climatic conditions for distribution, function and growth. Change in climatic conditions can lead to degradation of these already threatened ecosystems (Bueno et al. 2008).

Coral Reefs

Perhaps the most sensitive components of the coastal area of Belize, coral reefs require a very specific range of environmental conditions for it to function optimally. Therefore, slight variations in environmental conditions can affect the viability of coral reef systems. The following are the expected effects of climate change on coral reef ecosystems:

- It has been shown that an increase in sea temperature of about $1^{o} – 2^{o}C$ has triggered massive coral bleaching events.
- Increased temperature has been shown to magnify the effects of infectious diseases since stress lowers the functionality of the immune system.
- Decrease in ocean pH by an average of 0.1units has been shown to decrease coral growth rate. This has competition implications as corals often compete with species such as sponges and seaweeds for resources.

Although it is suggested that healthy corals will be resilient to effects of global climate change, it has been shown that corals that do recover are more brittle and less efficient. Therefore, under the most conservative IPCC scenarios, models indicate that coral growth will decrease by 50% by 2050.

Mangroves

The major threat to mangrove ecosystems has been shown to be human development since many projects involve mangrove removal. However mangroves are still vulnerable to the effects of global climate change but, unlike other marine ecosystems, they are more tolerant of changing environmental conditions. Negative effects are as a result of the expected direct physical effects of climate change. The projected effects on mangroves are as follows:

- Increased intensity of tropical cyclones is expected to increase the removal of mangroves along the coastline, especially in areas that are vulnerable to erosion and inundation.

- Distribution will change relative to sea level rise. Increased sea level will alter the concentration of salt in the soil thereby altering mangrove growth in the area. It is expected that mangroves will retreat in response.

Seagrass Beds

Seagrass beds are the most widely dispersed marine ecosystem within the coastal area of Belize. This suggests that they are able to survive under a wide range of environmental conditions. Therefore is suggested that the effects of climate change will vary between positive and negative. The following are the predicted effects of climate on sea grass:

- Increased ocean temperature is expected to cause a shift in distribution as a result of stress and resulting changes in reproductive patterns.
- Increased intensity of tropical cyclones and possible increase in frequency is expected to increase sedimentation and turbidity which will affect growth rates.
- Some communities of sea grass are carbon limited; therefore increased atmospheric carbon dioxide will promote growth in new areas.

Impact on Important Economic Sectors in Belize

Agriculture

Agriculture accounts for 35% of GDP and is one of the country's largest contributors to GDP next to Petroleum exports. Approximately 41% of the population relies on the agriculture industry for employment. Currently, approximately 265,000 acres of land is being used for agricultural activity. These activities are spread out across the country with sugarcane and papaya being cultivated in the north (Orange Walk and Corozal), banana and citrus products in the south (Stann Creek) and rice in the Toledo district. The distribution of these crops is a function of conditions necessary for optimal growth. This includes soil composition, soil type, temperature, precipitation, topography etc. Therefore the sustainability of the agriculture industry is directly linked to climatic conditions. This further emphasizes the implications of global climate change on the industry.

Depending on the growth conditions of the crop, the effects of climate change may differ. Generally, higher temperature and lower precipitation is expected to be amongst the major changes associated with climate change projections for Belize. Therefore, crops that favor warmer temperatures such as rice will thrive under climate change conditions. However, for more economically important crops such as sugar cane and citrus, decrease in precipitation will decrease yield leading to a decrease in export income.

Fisheries

The Fisheries sector in Belize is comprised of three main industries; capture fisheries, aquaculture and inland subsistence fishing. This sector is particularly vulnerable to the effects of climate change since they rely on resources from coastal waters, inland coastal lands and major rivers respectively. The following is a summary of predicted impacts of climate change:

- An increased sea surface temperature has been shown to trigger large scale coral bleaching events and mortality. Many economically important fish species such as the spiny lobster, snappers, Queen Conch, and several other important fin fish species rely on nutrients and protection from coral reefs. Loss of this habitat can lead to lowered fish stock.
- Ocean acidification affects the growth and stability of coral reefs; therefore it will contribute to bleaching and mortality and ultimately decreases in fish stock due to loss of habitat. Also decreased ocean pH has been shown to reduce the ability of species with exoskeletons to form shells sine the amount of available calcium carbonate will decrease.
- Sea level rise threatens sensitive ecosystems such as mangroves, sea grass beds and coral reefs which act as nursery habitats for many commercial fish species.
- Degradation of mangroves and loss of coastal lands as a result of sea level rise will directly reduce the total area of coastal lands available for aquaculture activities. Subsequent loss of mangroves also leaves areas exposed / vulnerable to impacts from tropical cyclone events.
- Increased temperatures and decreased precipitation associated with climate change is expected to increase stratification in ponds and decrease water levels of inland aquatic systems.

Tourism

Belize is ranked among the top eco-tourism destinations in the world offering some the world's most unique natural attractions. Therefore, the future of tourism in Belize is particularly vulnerable to the effects of climate change since it is largely resources dependent. The general consensus is that climate change will dictate the type and quality of tourist attractions. Tourism in Belize generated US$429.4 million in 2007 and projections show, at a growth rate of 3.8% per year, an increase to US$791.1 million by 2017. However, this projection is based solely on trends and does not factor in climate change.

The susceptibility of the nature-based tourism sector of Belize to the effects of climate change is very high. The two most critical resources utilized in the tourism sector are the barrier reef and coastal areas. According to the Belize Tourism Board over 70% of tourists visit the cayes and an additional 12% visits Placencia. Also 80% participates in reef based activities such as snorkeling and diving. However it has been suggested that the effects of climate change will reduce the appeal of the coastal areas because of heat stress, erosion and declining reef health

(Mather et al. 2005). In addition, the following are other expected effects of global climate change:

- Increase in sea level will lead to flooding, inundation, saltwater intrusion and erosion which affect the sustainability of the industry.
- Warmer seas threaten the coral reef which attracts thousands of tourists yearly and is also associated with an increase in the frequency and intensity of tropical cyclones.

Very generally, climate change is expected to affect the availability, overall comfort and enjoyment of outdoor activities. Also there is expected loss in function of ecological systems that are the attractants for tourists. Using linear interpolation the following are projected impacts of climate change on the tourism sector:

Economic Impact	2025	2050	2075	2100
Tourism	BZ$11.0 Million	BZ$27.0 Million	BZ$43.2 Million	BZ$59.3 Million

Coastal Communities

Almost 50% of the population has settled along the coastline of Belize. This has severe implications since almost half of the population is vulnerable to the effects of climate change. There are many direct and indirect effects that are being projected which are as follows:

- Sea level rise, flooding, erosion, increased storm intensity and salinization of ground water are amongst the main threats to coastal communities and their economies, infrastructure, households and ways of life.
- Remote coastal communities are particularly vulnerable since their access points can be affected by sea level rise and tropical cyclone activity.
- Climate change can bring about an increase in food, water and vector borne diseases as well as diseases related to heat stress.

If predictions at either extreme materialize, Belize will be increasingly vulnerable to the effects of climate change.

Actions

- Increase and strengthen the capacity of the Coastal Zone Management Authority and Institute to ensure developments within the coastal areas of Belize include a climate change adaptation strategy

- Improve and encourage inter-agency cooperation on matters pertaining to climate change adaptation

4.02 SOCIO-ECONOMIC ADAPTATION CAPACITY

The potential effects of climate change will affect both the economic and social sectors of Belize. Recognizing this, the Government of Belize (GOB) has developed the Belize Climate Change Adaptation Policy, the main objectives of which are to promote, prepare and develop adaptation strategies in all sectors. In doing so GOB has appointed the Chief Meteorologist at the National Meteorological Service as the focal point for issues pertaining to climate change in Belize. He is therefore tasked with bridging the gap between climate change science and policy and also to disseminate information to the public. As focal point the Chief Meteorologist has the responsibility to regularly convene the National Climate Change Committee (NCCC 2008).

The Belize Climate Change Adaptation Policy sets adaptation strategies for all sectors. These strategies are as follows:

Agriculture
The Ministry of Agriculture should:

- Undertake climate change vulnerability studies on all the major crops in Belize.
- Prepare adaptation options for those crops, which are threatened. These may include the introduction of varieties, which are more tolerant to the new climatic regime, diversification, and the introduction of new agronomic practices.
- Promote the use of new cultivars and practices in the agricultural community.
- Include a report on climate change related activities in the Ministry's Annual Report
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Coastal Zone
Coastal Zone Management Authority & Institute should:

- Undertake climate change vulnerability studies of the coastal zone.
- Prepare adaptation plans for the coastal zone to address the impacts of climate change.
- Maintain the inventory of coastal zone resources developed through the Caribbean Planning for Adaptation to Climate Change (CPACC) project.
- Include climate change in its Annual Report on the State of the Coastal Zone.
- Provide a report to the National Climate Change Committee and the Chief Meteorologist on its climate change activities.

Education
The Ministry of Education should:

- Promote the inclusion of climate change in the school curricula at all levels.
- Prepare educational material on climate change for use at all levels.

- Provide a report to the National Climate Change Committee and the Chief Meteorologist on its climate change activities.

Energy

The Ministry of Energy should:

- Convene an Interdisciplinary Energy Committee comprised of energy producers, distributors and the major users to formulate a national energy plan and provide the Government with advice on energy.
- Seek opportunities for Belize to participate to the fullest extent possible in energy projects which meet the needs of the country and which can be accommodated within the opportunities being developed through the climate change negotiation process.
- Undertake climate change vulnerability studies of the energy sector.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Environment

The Department of the Environment should:

- Undertake climate change vulnerability studies of the environment.
- Prepare adaptation options to meet the threats of climate change.
- Invite project proponents to address climate change in their Environmental Impact Assessments.
- Include a report on climate change in their Annual Reports
- Provide the National Climate Change Committee and the Chief Meteorologist with reports on their climate change activities

Fisheries

The Fisheries Department should:

- Undertake climate change vulnerability studies of the fish species resident in Belizean waters.
- Sensitize the fishing community to opportunities that may arise as new species become more abundant in Belizean waters.
- Monitor and protect the nation's reefs and mangroves to preserve these important fisheries habitats.
- Include a report on climate change related activities in the Ministry's Annual Report
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Forestry
The Forest Department should:

- Undertake climate change vulnerability studies on Belize's forests.
- Explore and promote the opportunities being developed for forestry projects, which will enable the country to participate fully in the emerging carbon markets.
- Monitor and protect the nation's forests and watersheds, including our mangroves.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Health
The Ministry of Health should:

- Undertake climate change vulnerability studies in the health sector.
- Prepare options to address the potential threats.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Housing
Municipal Authorities, Department of Lands and Surveys and Housing and Planning Department should:

- Undertake climate change vulnerability studies of residential areas along the coast of Belize.
- Prepare adaptation options to meet the threat of sea level rise.
- Enforce existing regulations and develop new regulations, which promote good building practices to meet the threat of sea level rise and dangerous storms and hurricanes.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Information
Ministry of Information should:

- Develop a public awareness campaign on climate change.
- Encourage the media to publicize the issues associated with climate change.
- Provide a report to the National Climate Change Committee and the Chief Meteorologist on its climate change activities.

Tourism

Ministry of Tourism should:

- Undertake climate change vulnerability studies of the tourism industry.
- Prepare adaptation options for those sectors threatened by climate change
- Promote projects within the tourism industry, which could benefit from the opportunities being developed by the flexibility mechanisms of the climate change negotiation process. These include renewable energy production, energy efficiency and waste disposal projects.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Transportation

Ministry of Works and Port Authority should:

- Undertake climate change vulnerability studies of the nation's roads, bridges and waterways.
- Prepare adaptation options to meet these threats.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Water Resources

Ministry of Natural Resources should:

- Convene an interdisciplinary Water Commission to coordinate, monitor and regulate the use of the nation's water resources.
- Undertake climate change vulnerability studies of the nation's water resources.
- Advise the relevant sectors of threats on their supplies of water as a result of climate change and recommend that they prepare adaptation options.
- Include a report on climate change related activities in the Ministry's Annual Report.
- Provide a report on its climate change activities to the National Climate Change Committee and the Chief Meteorologist.

Actions

- Update the National Climate Change Policy, Strategy and Action Plan on a periodic basis, and as new climate change data/information becomes available

4.03 PRIORITIZATION OF ECOSYSTEM-BASED ADAPTATION

The effects of climate change are being accelerated by biodiversity loss and ecosystem degradation in addition to increase greenhouse gas emissions. Healthy ecosystems, such as mangrove forests, act as carbon reservoirs and regulate global climate conditions. The continued degradation of these ecosystems threatens to accelerate and intensify the negative effects of climate change in the future. In order to buffer the effects of climate change on human populations, these ecosystems must be sustained since it these natural ecosystems are thought to be more resilient to climate change effects (UNDP 2012).

Ecosystem-based Adaptation is thought to be an approach that builds resilience and reduces the vulnerability of local communities to climate change. Furthermore it integrates sustainable use of biodiversity and ecosystem services in a comprehensive manner. One way in which Ecosystem-based Adaptation is achieved is through the establishment of protected areas. The following are the benefits of protected areas to adaptation and mitigation (Mercer et al. 2012):

- Contribute to climate change mitigation through carbon sequestration.
- Act as important barriers for land conversion.
- Provide ideal delivery mechanisms for both sequestration and ecosystem based adaptation.
- Natural carbon sinks
- Prevent carbon emission caused by land conversion and degradation.

In Belize, protected areas are the pillars of conservation. They house very important sources of natural capital as well as a wealth of benefits and services that ensure the livelihoods of many Belizeans. Of the total area of Belize, approximately 62.7% is forested and of that 43% is under conservation legislation. Forests in Belize are protected as national parks, forests reserves, nature reserves, and private reserves each having varying degrees of regulation.

Terrestrial protected areas provide erosion and flood control, sediment retention, and carbon storage. Marine protected areas which include coral reef, sea grass and mangrove offer a variety of coastal and marine services such as protection against erosion, reduction of damages from storm surge, and protection from sea level rise.

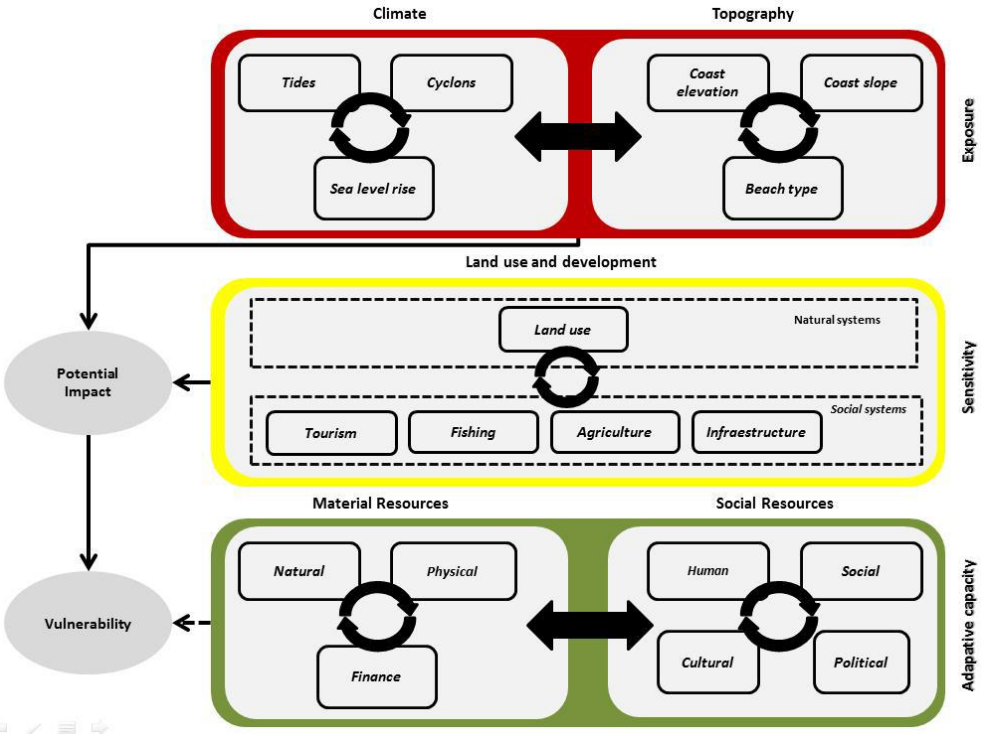
Coral reefs and mangroves provide the most cost effective means of protection against the effects of climate change. The value of mangroves as a function of coastal protection estimated to be US$231–$347 million per year. The Belize Barrier Reef can mitigate over ¾ of wave energy and provide an estimated US$120–$180 million in avoided damages per year while coastal mangroves offer protection worth an additional US$111–$167 million per year. The

Belize Barrier reef has also been estimated to generate US$150 – 196 million per year in tourism dollars and US$14 – 16 million per year in fisheries products.

Perhaps the biggest threat to coastal communities is the expected rise in sea level. The IPCC predict a sea level rise of 40 cm by 2080. This is expected to cause the following:

- Permanent flooding of coastal zones and loss of coastal ecosystems and infrastructure.
- Changes in estuarine salinization levels and tidal residence times.
- Changes in flooding levels and patters.
- Coastal erosion and loss of beaches.
- Saltwater intrusion in the coastal aquifers.

Expected rises in sea level has been attributed mainly to the exchange of water between the ocean and reservoirs including permafrost and the atmosphere as a result of global warming. The way in which sea level rise affects vulnerability and adaptation is summarized in the following conceptual diagram (UNPEI 2012):



In this model, exposure to sea level rise is driven by the interaction between the topography of the coastal area and the climatic conditions to which it is exposed. This interaction determines the potential impacts that are possible. Sensitivity is derived from considering ecosystems, activities and infrastructure present in the coastal area. This gives an indication of the degree to which the area is affected negatively by climate change and contributes to overall potential impacts. The potential impact can be translated into the vulnerability of an area since it expresses the potential for adverse effects. In order to reduce vulnerability, adaptive capacity

must be determined and introduced. The adaptive capacity is a function of resources used to address potential impacts and vulnerability of an area.

It has been determined that, in Belize, the Corozal and Belize districts are highly vulnerable to the effects of sea level rise. These districts which have been determined to be, on average, less than 1 meter above sea level are highly exposed to flooding and erosion due to tides, extreme rains, and storms of all categories. Adding to this is the fact that the population and infrastructure in these areas are located within 1km of the coastline.

Actions

- Avoidance of further development of the coastline in areas particularly vulnerable to natural hazards and climate change, such as the Belize and Corozal districts.
- Incorporate adaptation strategies in management planning in all coastal and marine sectors

4.04 GOVERNANCE AS A TOOL FOR RESILIENCE BUILDING

Despite the many uncertainties surrounding the effects of climate change, there is a wealth of scientific evidence that suggests that climate change will alter the way in which mankind is able to utilize natural resources. As a result of years of increased Green House gas emissions our planet is faced with an unprecedented change in our global climate conditions. Since these events are a manifestation of forces beyond our control, mankind must adapt to the rapidly changing environmental conditions that we will continue to face in the future. In doing so, government and policymakers must ensure that adaptation strategies be included in development plans for all sectors. Also, they must ensure that regular vulnerability assessments be carried out on order to continuously monitor the effects of climate change.

In order to effectively plan adaptive strategies, the adaptive capacity of communities must be analyzed. The adaptive capacity is an assessment of a community's ability to respond to climate change. It aids in identifying communities that are relatively more at risk than others. Table 7 outlines suggested criteria for analyzing adaptive capacity at regional and local level, scores ranging from 1 – 5 can be assigned once information is collected (UNDP-UNEP 2011):

Belize, as a developing third world country, is not a major contributor to greenhouse gas emissions. Consequently mitigation measures are very minimal. However, given climate change projections, it is increasingly important that the government of Belize enforce and implement adaptation planning in all sectors of Belize. Included in this is a review of all relevant laws and agency mandates so that they can be amended to include preparations for the effects of climate change.

Carbon credits and carbon market are feasible initiatives that Belize can participate in. Carbon credits are certificates that represent reduction of greenhouse gases in the atmosphere. They are earned via projects or initiatives that remove greenhouse gases or reduce emissions. Acquired credits can then be traded or sold to companies, developers, and individuals etc. to offset the emissions they generate. Each carbon credit is representative of one metric tonne of carbon that can be emitted. The overarching goal is to encourage low emission standards in the industrial and commercial sectors of developed countries and to finance emission reduction projects.

The system of carbon credits is based on the idea that developed countries, through the purchasing of carbon credit, will encourage developing countries to responsibly promote conservation, sustainable management of forests and enhancement of forest carbon stocks. With its rich coastal/marine ecosystems and dense tropical forests, Belize is in a position to benefit greatly from the sale of carbon credits. Through initiatives such as REDD+, established under the Kyoto Protocol in accordance with resolutions made at the sixteenth session of the United Nations Framework Convention on Climate Change Conference of Parties (UNFCCC COP 16), and Blue Carbon, Belize can benefit financially from protecting ecosystems that act as carbon sinks.

Source: UNDP-UNEP 2011

Criteria	Indicator	Use of information
Demographic vulnerable groups	% of the population in poverty and extreme poverty	Identify groups with higher risks associated to CC and require most support.
Dependence on the resources and services vulnerable to the impacts of CC	% of the population whose principal livelihoods (more than 50% of their income) depend on de natural resources: tourism, fishing and agriculture	Predict impacts of CC in livelihoods, the economy and food security, points out the livelihoods that are highly sensitive to particular climate threats.
Actual livelihoods and home income diversity	Number of local productive activities.	Identify the economic sensitivity of the communities to CC and other external threats. Identify necessary options for livelihood diversification.
Perception of alternative and complementary livelihoods	Quantity of existing skills in key activities (fishing, agriculture and tourism)	Identify possibilities necessary re-sources for livelihoods adaptation to CC and other external threats
Access and use of available knowledge related to the weather	% illiteracy.	Capacity of communities to under-stand the impacts of CC and the need to educate, identify actual and potential uses of information on CC
Formal and informal support networks for the adaptation and risk reduction to the climate	Number and type of existing networks.	Adjust extension and education programs to face CC, fill gaps in information networks.
Capacity of the community to organize	Number and type of community organizations.	Identify potential networks that can transfer information related to CC and give support, collaborate with existing networks that can support adaptation and planning.
Leadership and governance	Number of coordination platforms with impacts on resources or territories to CC.	Assessing whether a community is able to restructure itself after suffering an impact, determine the level of confidence within a community, identify areas that should be strengthened for adaptation work, understand the level of stakeholder participation in management and decision-making.
Access to basic healthcare	Life expectancy at birth	Identify vulnerable segments of the population that could be less capable of adapting to CC
Access to basic infrastructure.	Kilometres of roads (in relation to the surface with 99% of population) % population with access to drinking water	Identify the access to basic infra-structure because more access is expected to be more adaptive.

Table 7: Criteria for Analyzing the Adaptive Capacity of Communities to Climate Change

The REDD+ initiative focuses on the sequestering of atmospheric Carbon Dioxide (CO_2) by tropical forests. Belize has 3,376,197 acres of forest cover (Cherrington et al. 2012) accounting for 61.64% of the country. With the optimal pricing for carbon credits suggested at $30 USD and prices currently fluctuating between $5 and $24 USD per credit (Hodes & Kamel 2007), protecting even a small subset can translate to considerable returns for Belize from sale of carbon credits. The money can then be used to further manage forest resources.

However, it has been shown that mangroves, salt marshes and sea grasses are more efficient at removing atmospheric CO_2 and can sequester up to five times more carbon than tropical forests. Therefore the Blue Carbon Initiative, a program developed by Conservation International, the International Union for Conservation of Nature (IUCN) and the Intergovernmental Oceanic Commission of UNESCO, focuses on the sequestration of CO_2 through the development of management approaches and mechanisms to protect coastal and marine ecosystems internationally. The program supports research and has implemented an incentive mechanism, i.e. carbon payment scheme, which facilitates the sale of carbon credits similar to REDD+. Belize has an estimated 74,684 hectares (184,549 Acres) of mangrove cover (2010 estimates). Using the conservative voluntary market price of $5 USD per carbon credit, Belize can potentially earn $217,901.60 USD/yr. in carbon stocks (Belize Forest Department 2011).

There are a lot of factors that must be considered by the government of Belize before adopting any of these initiatives such as cost benefit analyses comparing the totals received through carbon payment schemes and those that would be lost from not developing. However, with a large majority of Belizean industries and societies dependent upon the sustainability of these ecosystems, receiving money to ensure the stability of the economic and social sectors of Belize, while simultaneously contributing to a global cause should make adopting these initiatives an easy decision.

From preliminary investigations into the potential income from the carbon markets, CZMAI recommends that the government of Belize explore carbon market initiatives as a source of added yearly income for Belize.

Actions

- Accurate stock-taking of tropical forest and mangrove cover to pinpoint fragmentation and rates of carbon sequestration.
- Explore options for the sale or trading of carbon credits on international markets
- Passage of legislation in support of REDD+ and Blue Carbon initiatives

SECTION 5:
IMPLEMENTATION AND COORDINATION PLAN

IMPLEMENTATION AND COORDINATION PLAN

Integrated Coastal Zone Management (ICZM) in Belize is a process in continuous evolution and includes a wide range of sectors, actors and agencies. This Implementation and Coordination Plan (ICP) proposes to outline the strategic objectives, strategic level actions, key activities, timeframe, lead and partner agencies, and required budget for implementation. The ICP embraces the mandatory 4-year review period as defined by law, and as such, it recognizes that many of the strategic level objectives will likely consist of long term processes which may very well span over multiple review periods. This clearly requires and demands that performance indicators used to monitor the ICP be drafted to permit measurement of intermediary steps in the delivery of the ultimate objectives planned. Additionally, the prioritization of those one time or punctual activities geared at addressing existing threats within a given 4-year implementation period must be given due consideration in the process to identify management interventions in the coastal zone which can produce meaningful and or replicable results in the short term, without requiring long term processes spanning over multiple implementation periods. The proposed balance between short term high impact interventions and long term processes is key in attaining sustained and effective ICZM results. To strengthen the prioritization process of the ICP, the CZMAI and partner agencies can further refine the prioritization of activities in their Annual Work Plans, in support of ICP implementation.

The ICP has been developed with due consideration of the fact that a substantial part of the implementation process will require leadership by many agencies other than the CZMAI, who have the legal mandate and responsibility to address many of the challenges in the coastal zone. The need for functional and operational partnerships under coordination by the CZMAI in the execution of the ICP cannot be overemphasized, and especially the need for joint resource identification and allocation for ICP execution. It is clear that budget sources cannot be restricted to local sources and a specially defined effort to fund ICP implementation is an utmost priority.

To allow for periodic measurement and evaluation of ICP implementation efforts, a Monitoring Protocol has also been developed with focus on indicators, metrics, and data collection methods. The collaborative and multi-agency approach is also required for the implementation of the Monitoring Protocol, with the imminent competition for budget resources between the ICP and the Monitoring Protocol reemphasizing the vulnerability and risks of successful ICP and Monitoring Protocol implementation, unless there is a structured and coordinated approach to resource mobilization among all agencies concerned.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
Strategy 1.0: Encouraging Sustainable Coastal Resources Use									
1.1 Coastal Research and Monitoring	1. Develop a centralized data repository for Belize on ecosystem health and human use activities within the coastal zone	Structural design of repository and definition of equipment needs Develop data submission and access protocols Establish repository and Publicize existence and use of repository	**Lead:** Coastal Zone Management Authority and Institute **Partner(s):** All data generating entities					30,000	CZMAI is able to secure partnerships to source resources Data generating agencies value the establishment of a repository
	2. Facilitate data accessibility among government agencies and non-governmental organizations for monitoring ecosystem health and human use impacts on the coastal area	Implement data submission and access protocols developed for repository	**Lead:** Coastal Zone Management Authority and Institute **Partner(s):** All data generating entities					0.00	CZMAI is able to secure partnerships to source resources for establishing repository Partners are receptive to repository

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	3. Establish a national water quality monitoring program for Belize	Create a National Water Quality Monitoring Working Group to secure a multi-agency and coordinated water quality monitoring program Conduct joint procurement of equipment based on coordinated and shared needs among relevant agencies. Initiate and sustain multi-agency water quality monitoring	**Lead:** Coastal Zone Management Authority and Institute, with the National Integrated Water Resources Management Authority **Partner(s):** Fisheries Department; Department of Environment Ministry of Health					500,000	Partnership is given fair chance to function in the best interest of proper and comprehensive water quality monitoring.
	4. Develop a long-term, national strategy for the scientific monitoring of the health of critical habitats, including but not limited to reef, seagrass, mangroves	Create Scientific Working Group Terms of Reference for strategy developed and vetted by Scientific Working Group	**Lead:** Coastal Zone Management Authority and Institute					50,000	Funding is secured Partners see value of strategy

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
		Strategy developed through outsourcing of technical expertise	**Partner(s):** Forest Department; Fisheries Department UB and NGOs						
	5. Prepare annual State of the Coast Report to analyze trends and change in the coastal zone	Data analysis and interpretation Generation of technical, economic and policy recommendations Preparation and publication of report	**Lead:** Coastal Zone Management Authority and Institute **Partner(s):** All data generating entities					25,000	Meaningful CZM occurs worthy on data analysis and interpretation
1.2 Protected Areas Management	1. Increase the technical and management capacity of both management and co-management agencies in order to ensure sound management practices	Capacity Needs assessment Capacity building strategy developed and implemented in key agencies	**Lead:** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					90,000	Priority is given to capacity building in budget allocation exercises and in grant approval criteria

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Partner(s): Co-management agencies						
	2. Support local and national initiatives to achieve the target of 20% full protection of the marine territory of Belize	Sustained public awareness campaign on the role of protected areas in the country's national development.	**Lead:** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development. **Partner(s):** CZMAI and co-managers					Budgeted elsewhere	Campaign efforts underway are sustained to ensure protected areas are permanently reflected in national planning
1.3 Mangrove Protection	1. Advocate for adoption of revised Mangrove Regulations	Cabinet Paper Develop and publicize	**Lead:** Forest Department **Partner(s):** Department of Environment NEAC					20,000	Forest Department shares urgency and priority of preparing Cabinet Paper for regulations.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
		promotional materials specific to the revised mangrove regulations	CZMAI						
	2. Develop an inventory on Belize's mangrove cover and distribution, which should be updated on a bi-annual basis	Terms of Reference prepared and inventory outsourced	**Lead:** Forest Department Partner: Biodiversity Monitoring program					40,000	Forest Department shares urgency and priority of inventory and secures funding. Imagery accessible and affordable
	3. Identify areas for mangrove conservation	Assessment conducted as part of exercise to produce mangrove inventory Land Tenure Assessment relative to mangrove habitat with conservation potential	**Lead:** Forest Department and **Partner(s):** Non-Governmental					Budgeted elsewhere 40,000	Forest Department shares urgency and priority of inventory and secures funding with NGOs.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Organizations						
	4. Conduct research to capture the biomass, coverage, spatial distribution and rates of change for mangroves in Belize, and use this information available to support decisions on the issuing of mangrove alteration permits	Secure partnership with competent university Develop research proposal Implement research (partially covered in inventory) Develop mangrove permitting guidelines	**Lead:** Forest Department and **Partner(s):** Universities; Non-Governmental Organizations CZMAI					50,000 Partly budgeted elsewhere	Forest Department shares urgency and priority of inventory and secures funding with University/NGOs.
	5. Implement mangrove restoration projects as a means to mitigate the effects of climate change, and to ensure the delivery of coastal protection services especially in areas, such as the Central and Southern region of Belize, which are highly prone to erosion and	Develop proposals for mangrove restoration Implement projects and monitor restoration success	**Lead:** Forest Department **Partner(s):** Lands Department; Coastal Zone Management Authority and Institute and Non-					100,000	Forest Department shares importance of restoration and leads initiative

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	inundation		Governmental Organizations						
1.4 Coastal Habitat and Species Conservation	1. Conducting an inventory of potentially resilient critical habitats/areas that could benefit from restoration programs and long-term monitoring	Secure partnership with competent university or NGOs Develop research proposal Implement research	**Lead:** Forest Department, **Partner(s):** Fisheries Department, Coastal Zone Management Authority and Institute, Non-Governmental Organization					80,000	Forest Department shares urgency and priority of inventory and secures funding with University/NGOs/CZMAI.
	2. Preserving critical nesting sites and foraging areas	Assessment of protection of nesting sites and foraging areas in and out of protected areas and incorporate findings into management effectiveness exercises	**Lead:** Forest Department, **Partner(s):** Fisheries Department					40,000	Forest Department shares importance of this activity and leads initiative with identification of required funding.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	3. Decrease development activities near fragile ecosystems	Prepare policy paper on zonation near fragile ecosystem Cabinet Paper on zonation near fragile ecosystems	**Lead:** Lands Department **Partner(s):** Department of the Environment					0.00	Lands Department leads and engages DOE in this process
	4. Replant sea grass in areas that have been dredged	Develop proposals for seagrass restoration Implement projects and monitor restoration success	**Lead:** Coastal Zone Management Authority and Institute					100,000	CZMAI leads restoration initiative
	5. Establish a fund that is dedicated to national restoration projects	Conduct fund feasibility assessment Define institutional structure of fund	**Lead:** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					30,000	Ministry of Forestry, Fisheries and Sustainable Development shares priority and interest in this action
	6. Increase public awareness about the importance of threatened species to Belize and	Integrate with public awareness campaign on protected areas	**Lead:** NPAS, CZMAI					Budgeted elsewhere	Resources are identified to sustain campaign

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	Belizeans to encourage the promotion of the species within the coastal area of Belize		**Partner(s):** Forest Department, Fisheries Department Non-Governmental Organizations						
1.5 Invasive Species Management	1. Update the Belize National Lionfish Management Plan on a regular basis (every 3 -4 yrs.), to include any new mechanism/protocol to monitor and suppress Lionfish populations in Belize. Mechanism must also be included to determine success.	Outsource assignment to update plan inclusive of monitoring and evaluation framework Institute plan implementation	**Lead:** Fisheries Department, **Partner(s):** Non-Governmental Organizations					30,000	Fisheries Department agrees to build on existing efforts and formalize management plan structure and implementation.
	2. Expand the market for lionfish consumption as a means to manage the lionfish population while providing an alternative	Conduct market analysis Promote Lion Fish consumption through	**Lead:** Fisheries Department,					30,000	Fisheries Department agrees to build on existing efforts and formalize management plan structure and implementation, inclusive of marketing.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
		targeted market campaign	**Partner(s):** BELTRAIDE, Non-Governmental Organizations						
	3. Permanent removal of coconut trees near prominent Booby bird nesting grounds	Assessment of logistics and costs of removal Secure budget Execute removal	**Lead:** Forest Department with Belize Audubon Society					20,000	Agencies concerned give this priority and allocate the required funding
	4. Conduct feasibility studies and eradicate invasive rat population at Half Moon Caye.	Prepare Terms of Reference for feasibility Develop Rat Eradication Plan Execute Eradication Plan	**Lead:** Health Department with Belize Audubon Society **Partner(s):** Coastal Zone Management Authority and Institute					30,000	Agencies concerned give this priority and allocate the required funding

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
1.6. Fisheries Management	1. Strengthen the fisherfolk licensing system through the establishment of standards	Feasibility Assessment of standards introduction, training requirements, and cost of implementation Implement the revised licensing system	**Lead:** Fisheries Department **Partner(s):** Fishermen Cooperatives					50,000	Fisheries Department is convinced that revised system will bring added value and efficiency to fisherfolk licensing.
	2. Implement national roll out of Managed Access Program in all marine protected areas	Develop roll out schedule Develop and implement roll out plan inclusive of public consultations	**Lead:** Fisheries Department **Partner(s):** Fishermen Cooperatives MPA Managers					30,000	Fisheries Department asserts leadership in this initiative
	3. Monitor quotas to ensure full compliance	Develop and implement monitoring and enforcement system	**Lead:** Fisheries Department					40,000	Fisheries Department agrees with this activity as a priority, as opposed to other initiatives such as Managed Access.
	4. Secure resources to permit increased monitoring and data collection for finfish at	Funding proposal developed	**Lead:** Ministry of Agriculture, Fisheries, Forestry,					60,000	Fisheries Department agrees with this activity as a priority, as opposed to other initiatives such as Managed Access.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	the various landing sites	Hire additional personnel for data collection	the Environment and Sustainable Development.						
1.7 Coastal Agriculture	1. Institute best management programs with agriculture and watershed stakeholders for agricultural land use in order to protect and maintain riparian forests	Develop Strategy for Best Practice Agriculture in Watersheds using consultative process	**Lead:** Agriculture Department, National Water Resources Authority **Partner(s):** Coastal Zone Management Authority & Institute, Planning Unit, Lands Dept.					30,000	Policy-level leadership at Agriculture Department and Water Resources Management Authority
	2. Incorporate the prescription of minimum flow standard for major watersheds into the National Water Policy	Assessment to determine minimum flow standards for major watersheds Prepare Policy Paper	**Lead:** Department of Environment with Water Resources Management Authority					50,000	Policy-level leadership at Department of Environment and Water Resources Management Authority

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Partner(s): Agriculture Stakeholders						
	3. Monitor water quality for point and non-point pollution sources in the Rio Hondo River, New River, Shipstern Lagoon and Belize River watershed on a regular basis	To be addressed as part of National Water Quality Monitoring Program (Section 1.1.3), but retained to specify key monitoring locations	**Lead:** Department of Environment with Water Resources Management Authority **Partner(s):** Belize Agricultural Health Authority, Coastal Zone Management Authority and Institute					Budgeted elsewhere	Partnership is given fair chance to function in the best interest of proper and comprehensive water quality monitoring.
	4. Finalize and implement the National Agriculture and Food Policy for Belize 2015 – 2030	Prepare and submit Cabinet Paper on Food Policy	**Lead:** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					0.00	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development and political will are in support of this action

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
1.8 Aquaculture	1. Update aquaculture policy and regulations to reflect Aquaculture Stewardship Council guidelines	Develop proposed updates Conduct sector consultations Prepare and submit Cabinet Paper	**Lead:** Cabinet with Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					30,000	Executive leadership and political will are in support of this action. Support from Aquaculture Sector
	2. Report on the status and performance of both aquaculture and mariculture developments annually	Conduct field data collection, analysis and interpretation Prepare and Publish Report	**Lead:** Cabinet with Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					25,000	Executive and management leadership see value in annual reporting.
	3. Formulate an Aquaculture Steering Committee, comprising of government, non-government and private	Prepare Terms of Reference and Member Profiles for the Steering Committee	**Lead:** Fisheries Department					20,000	Fisheries Department agrees to need/value of this committee and secures executive support for its creation.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	sector stakeholders, to advise and guide planning future aquaculture development in Belize	Determine institutional framework for Steering committee Appoint committee members	**Partner(s):** BELTRAIDE and Ministry of Economic Development						
	4. Implement incentive programs to support small-scale aquaculture producers, and reduce pressures on wild fisheries resources	Develop National Aquaculture Strategy, inclusive of incentives for small farmers	**Lead:** Fisheries Department **Partner(s):** BAHA Ministry of Trade Aquaculture Sector					30,000	Fisheries Department agrees to need/value of this committee and secures executive support for the development of the strategy.
1.9 Minerals Extraction and Energy Development	1. Prepare a sound National Emergency Preparation Plan for Oil Spills and Waste Oil Management	Terms of Reference Outsource Plan Preparation	**Lead:** Department of Environment, Geology and Petroleum					50,000	Department of Environment agrees to need/value of this plan and secures executive support for its development.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
		Prepare and Submit Cabinet	Department, **Partner(s):** National Emergency Management Organization						
	2. Conduct cost-benefit analyses of developing a petroleum-based energy sector	Terms of Reference Outsource Preparation of Cost-Benefit Analysis	**Lead:** Geology and Petroleum Department **Partner(s):** Ministry of Science, Energy and Technology, Ministry of Economic Development					50,000	Geology and Petroleum Department agrees to need/value of this analysis and secures executive support for its development.
	3. Identify viable alternatives to crude oil for energy generation	To be included as part of Cost-Benefit Analysis in Section 1.9.2. Retained here to ensure inclusion in analysis.	**Lead:** Geology and Petroleum Department					Budgeted Elsewhere	Geology and Petroleum Department agrees to need/value of this analysis and secures executive support for its development.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Partner(s): Ministry of Science, Energy and Technology, Ministry of Economic Development						
	4. Develop the scientific capacity and technical expertise to understand hydrocarbon behavior in the marine environment, and to assess spill behavior and patterns in order to inform practical spill response	Capacity Needs Assessment Develop Training Program Implement Training Program	**Lead:** Geology and Petroleum Department with Ministry of Science, Energy and Technology,					100,000	Geology and Petroleum Department agrees to need/value of this capacity building initiative and secures executive support for its development.
Strategy 2.0: Supporting Integrated Development Planning									
2.1 Coastal Area Planning and Development	1. Implement the spatially-explicit Informed Management zoning scheme in tandem to other existing land-use planning initiatives	Prepare policy jointly with Physical Planning unit of Lands Department for executive level decree to integrate informed management zoning scheme and land use planning initiatives	**Lead:** Coastal Zone Management Authority and Institute, Physical Planning Unit					0.00	Executive Leadership at both agencies value the need for integrated police relative to zoning and land use.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	2. Support the continued partnership and liaison with coastal advisory committees (CACs), the Coastal Advisory Council, and relevant planning agencies as a basis for regional coastal area management planning	Constantly revise and update TORs for CACs and the Coastal Advisory Council, as appropriate and as is feasible Provide constant opportunity for participation and feedback to the CACs and the Coastal Advisory Council Regular CAC and the Coastal Advisory Council meetings	**Lead:** Coastal Zone Management Authority and Institute					20,000	Coastal Zone Management Authority and Institute continue to prioritize CAC and the Coastal Advisory Council meetings and secure funding for same Sustained interest and participation by CAC and the Coastal Advisory Council members
	3. Undertake revisions of regional coastal area management guidelines on a regular basis in consultation with CACs, Technical Advisory Council, and relevant planning agencies	Consultation Meetings Revision, circulation and publication of Coastal Area Management Guidelines	**Lead:** Coastal Zone Management Authority and Institute and regional CACs **Partner(s):** Relevant planning agencies					30,000	Coastal Zone Management Authority and Institute continue to prioritize CAC meetings and secure funding for same Sustained interest and participation by CAC and Technical Advisory Council members and partner agencies

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
2.2 Coastal Population and Growth	1. Undertake initiatives to relocate people who are settled in vulnerable areas	Map and quantify settlement in vulnerable areas and assess legal, social and economic implications of resettlement Prepare Resettlement Plan, compensation package, and timeline Define source of compensation funding	**Lead:** Coastal Zone Management Authority and Institute **Partner(s):** Ministry of Human Development and Social Transformation, Ministry of Housing and Planning					200,000	Coastal Zone Management Authority and Institute is able to demonstrate and justify why resettlement is warranted, and secure political support to actually effect the resettlement.
	2. Diversify income generation options to reduce the number of people who rely on the coastal resource base to support their income	Quantify the demand for goods and services which can be met through alternatives to coastal resource use Assess number of employed persons to be impacted from alternative livelihood activities	**Lead:** BELTRAIDE **Partner(s):** Ministry of Economic Development					75,000	BELTRAIDE or other agency recognizes the value of this and give due attention to lessons learned in other attempts to introduce alternative livelihoods to coastal resource use.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
		Develop turn-key business plans for Small and Medium Enterprises to diversify into identified alternatives							
	3. Implement proper building standards and setback distances	Revise and Update Building Standards through consultative process Prepare and submit Cabinet Paper	**Lead:** Physical Planning Section, Lands and Surveys Department Central Building Authority					30,000	Physical Planning Section, Lands and Surveys Department and Central Building Authority give this the priority attention it deserves. Political will is secured
	4. Limit exponential growth and expansion of communities within highly vulnerability to coastline	Revise and Update National Zoning Policy through consultative process Prepare and submit Cabinet Paper	**Lead:** Physical Planning Section, Lands and Surveys Department **Partner(s):** Ministry of Human Development and Social Transformation Central and Municipal Governing					30,000	Physical Planning Section, Lands and Surveys Department and Municipal bodies give this the priority attention it deserves. Political will is secured

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Bodies						
	5. Conduct regular vulnerability assessments of the coastal area in order to understand and to assess the effectiveness of climate adaptation strategies	Develop Vulnerability Assessment Protocol Conduct Assessment every 2 years	**Lead:** Coastal Zone Management Authority and Institute, National Climate Change Office **Partner(s):** Other relevant Government Departments					60,000	Protocol is developed and sanctioned by relevant parties. Funding for assessments secured.
2.3 Beach and Shoreline Management	1. Implement restoration projects in Belize with increased investment by developers whose projects will remove vegetation that aid in shoreline stabilization	Develop proposals for vegetation restoration through Public-Private Partnerships Implement projects and monitor restoration success	**Lead:** Department of Environment **Partners:** Coastal Zone Management Authority and					100,000	NEAC and the DOE are able to secure private sector compliance through whatever means possible.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Institute; Private Sector						
	2. Enforce and update national policy governing the construction of piers, sea walls, jetties, groynes, harbor arms and other hard structures, and the use of soft shoreline stabilization methods	Update Policy through consultative process Prepare and submit Cabinet Paper	**Lead:** Physical Planning Section, Lands and Surveys Department					20,000	Physical Planning Section, Lands and Surveys Department prioritizes this activity. Political will secured.
	3. Strengthen regulatory requirements for the full enforcement of setbacks that considers the threat of global climate change and coastal hazards related to commercial and/or residential development within the coast	Review of Relevant Regulatory Framework and Prepare necessary Draft S.I. and Cabinet Paper Conduct inter-agency consultation process	**Lead:** Physical Planning Section, Lands and Surveys Department, **Partner(s):** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development. National Climate Change Office					30,000	Physical Planning Section, Lands and Surveys Department prioritizes this activity. Political will secured.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
2.4 Marine Traffic	1. Develop a national policy on marine transportation in support of the Informed Management zoning scheme to minimize user-conflicts	Terms of Reference Outsource Preparation of policy Prepare and submit Cabinet Paper	**Lead:** Belize Port Authority **Partner(s):** Coastal Zone Management Authority and Institute and other relevant parties					25,000	Belize Port Authority agrees to take this on as matter of priority and secures funding for same.
	2. Develop and implement a national policy and supporting standards for the safe transport of hazardous chemicals in the sea	Terms of Reference Outsource Preparation of policy Prepare and submit Cabinet Paper	**Lead:** Belize Port Authority					25,000	Belize Port Authority agrees to take this on as matter of priority and secures funding for same.
	3. Conduct Hydrographic surveys/mapping of the sea bed to better inform marine transportation routes.	Develop propose methodology, timeline and implementation plan for hydrographic mapping	**Lead:** Belize Port Authority					100,000	Belize Port Authority asserts leadership in proposal development and in seeking partnership with competent agency.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
		Develop MOU with competent hydrographic agency to implement proposal							
	4. Update navigational charts for Belize to improve boating safety.	Outsource production of navigational charts based on results of hydrographic mapping	**Lead:** Belize Port Authority					30,000	Belize Port Authority asserts leadership in developing the charts and securing the necessary funding.
2.5 Marine Tourism and Recreation	1. Implement the National Sustainable Tourism Master Plan for Belize 2030 in conjunction with the recommended Informed Management zoning scheme for sustainable marine recreation and tourism	Develop National Tourism Act, which reflects the principles and vision of the National Sustainable Tourism Master Plan for Belize 2030 Conduct broad sector consultations on draft Act.	**Lead:** Ministry of Tourism & Civil Aviation, **Partner(s):** Belize Tourism Board, NICH					20,000	Ministry of Tourism & Civil Aviation exercises leadership in the required processes and in garnering necessary political support.
	2. Develop and support further sustainable tourism management through products from	Define, prioritize, and implement activities under STP to build on policy priorities defined in National Sustainable Tourism	**Lead:** Ministry of Tourism and Civil Aviation					0.00	Ministry of Tourism & Civil Aviation exercises leadership in defining activities and obtaining the IDB support.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	the STP 2 Project	Master Plan	**Partner(s):** Belize Tourism Board, NICH, IDB						
2.6 Marine Dredging	1. Finalize and implement a National Marine Dredging Policy	Finalize Policy Public Consultations Prepare and submit Cabinet Paper	**Lead:** Ministry of Science, Energy and Technology, Geology Department					20,000	
	2. Identify alternative sources of dredged material and access routes prior to the issuance of licenses and permits for obtaining dredged spoils	Prepare National Source Document on Alternative Dredge Material	**Lead:** Geology Department					30,000	Geology Department shares importance of this need and asserts leadership in sourcing the funds needed.
	3. Scrutinize applications for dredging activities within protected areas (MPAs, Natural Monuments) and World	Develop Dredging Application Evaluation Checklist	**Lead:** Mining Unit, Ministry of Natural Resources and Agriculture					0.00	Mining Unit, Ministry of Natural Resources and Agriculture see the value of checklist

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	Heritage Sites								
2.7 Disaster Risk Management	1. Develop a comprehensive inventory of people and property located within vulnerable coastline	Terms of Reference Outsource inventory	**Lead:** NEMO **Partner(s):** Statistical Institute of Belize					30,000	Funding can be sourced and NEMO takes lead.
Strategy 3.0: Building Alliances to Benefit Belizeans									
3.1 Collaboration in Enforcement and Monitoring	1. A comprehensive review of the capacity in Government, NGOs and stakeholder communities to identify available options for optimal resource management	Capacity Assessment and Recommendations for Optimal Resource Management Consultation with partners on recommendations	**Lead:** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					25,000	Agriculture, Forestry, Fisheries, Environment and Sustainable Development sees value in this exercise and embraces it.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	2. Enlist the aid of agencies and groups, in addition to those in co-management agreements, such a communities and stakeholders in research, education and enforcement effort as a means to improve the effectiveness of protected area management	Create National Protected Areas Effectiveness Working Group Develop Terms of Reference and member profiles Appoint members Meet twice per year	**Lead:** Forest Department, Fisheries Department, **Partner(s):** Non-Governmental Organization, Private Sector					18,000	Forest Department and Fisheries Department see value in this working group and lead the process for its creation and operations
	3. Provide special training for enforcement officers and partner stakeholder groups to improve vigilance	Develop Training Manual and Schedule Execute Training	**Lead:** Forest Department, Fisheries Department, **Partner(s):** Non-Governmental Organization, Private Sector					60,000	Forest Department and Fisheries Department see value in this training process and lead its development.

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
3.2 National Network for Managing the Coast	1. Seek formal means for all application impacting the coastal zone to be submitted to the Coastal Zone Advisory Council by the relevant permitting agencies	Feasibility Assessment of creating legal instrument under the CZMA Act Consultations with partner agencies	**Lead:** Coastal Zone Management Authority and Institute with the Solicitor General's office					20,000.00	Reception and support by partner agencies and Solicitor General's office
Strategy 4.0: Adapting to Climate Change									
4.1 Socio-ecological Vulnerability and Resilience	1. Increase and strengthen the capacity of the Coastal Zone Management Authority and Institute to ensure developments within the coastal areas of Belize include an adaptation strategy to mitigate the effects of climate change	Training to CZMAI staff in Climate Change Adaptation Strategies	**Lead:** Coastal Zone Management Authority and Institute, National Climate Change Office					20,000	Board of Directors of the CZMAI supports this need and identify funding
	2. Improve and encourage inter-agency cooperation on matters pertaining to climate change adaptation	Develop MOUs to formalize interagency cooperation	**Lead:** Coastal Zone Management Authority and Institute, National Climate Change					0.00	Agencies see the benefit of formalizing cooperation

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
			Office						
4.2 Socio-economic Adaptation Capacity	1. Update the Belize National Climate Change Adaptation Policy on a periodic basis, and as new climate change science becomes available	Conduct consultative process to update policy	National Climate Change Office					20,000	National Climate Change Office gives this priority and follows through
4.3 Prioritization of Ecosystem-based Adaptation	1. Further development of the coastline should be avoided, especially in vulnerable areas such as the Belize and Corozal districts	Develop and legislate zoning plans for coastal areas consistent with EBA Conduct required public consultations Prepare and submit Cabinet Paper and Draft S.I.	**Lead:** Physical Planning Section, Lands and Surveys Department, **Partner(s):** Coastal Zone Management Authority and Institute					30,000	Physical Planning Section, Lands and Surveys Department and Coastal Zone Management Authority and Institute can garner executive leadership support for this to occur.
	2. Incorporate ecosystem-based adaptation strategies in management planning in	Develop White Paper on Ecosystem Based Approach in Management	**Lead:** Coastal Zone Management					30,000	Coastal Zone Management Authority and Institute can garner executive leadership

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	all coastal and marine sectors	Planning Technical consultations with productive sectors in the coastal zone Develop Ecosystem Based Guidelines for Coastal Planning Policy and Cabinet Paper on Ecosystem Based Guidelines for Coastal Planning	Authority and Institute with all relevant planning agencies						support for this to occur.
4.4 Governance as a tool for Building Resilience	1. Accurate stock-taking of tropical forest and mangrove cover to pinpoint fragmentation and rates of carbon sequestration	Terms of Reference Outsource assessment	**Lead:** Forest Department					80,000	Forest Department can secure funding through partnerships
	2. Explore options for the sale or trading of carbon credits on the	Feasibility Study of Carbon Credit Markets	**Lead:** National Climate					40,000	National Climate Change Committee gives this priority

Topic	Actions Required	Key Activities	Implementing Agency(ies)	Timeframe				Estimated Budget (BZD)	Risk and Assumptions
				YR1	YR2	YR3	YR4		
	international markets		Change Committee **Partner(s):** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.						and secures required funding
	3. The passage of legislation in support of REDD+ and Blue Carbon initiatives	Cabinet Paper Draft Legislation Public Consultations	**Lead:** National Climate Change Committee **Partner(s):** Ministry of Agriculture, Fisheries, Forestry, the Environment and Sustainable Development.					30,000	National Climate Change Committee gives this priority and secures required funding
TOTAL ESTIMATED BUDGET REQUIRED								**$3,118,000**	

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APPENDICES

A. Detailed Zoning Scheme Methodology

Introduction

Belize currently has no blueprint for the sustainable allocation and management of its coastal and marine environment. Although designated zones for meeting conservation objectives exist, such as marine reserves, Belize has not designated zones within its coastal and marine spaces for the wide variety of human activities. This should occur in order to meet cultural, social, economic and environmental priorities. Nonetheless, the coastal and marine areas continue to be used in a variety of ways. Throughout Belize, human activities are increasing in scope and intensity. Without an informed, spatially-explicit zoning plan, there is no integrated assessment of ecosystems and the varied risks posed by human activities. The resulting situation is one of two major types of conflicts:

1) Conflicts among human activities (i.e. user-user conflicts); and
2) Conflicts between human activities and the coastal and marine environs (i.e. user-environment conflicts)

These conflicts are often the result of poor planning and management of resources use. As a result, responses to management issues are typically addressed on an ad-hoc basis. This management regime limits the ability of managers to better control the flow of resources in a manner that would lead to desirable future outcomes. If the conflicts continue without planned, sound management, they could reduce the provision of natural services from which humans benefit, otherwise known as ecosystem services. This is where an ecosystem-based approach to marine spatial planning (MSP) can help to fill gaps in management and offer an approach for developing informed, future-oriented management strategies.

Marine spatial planning (MSP) is "*a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a political process*" (Ehler & Douvere 2009). The MSP process can allow for:

- organization of the use of marine space
- interactions between uses
- balancing demands for development with the need to protect marine ecosystems
- achieving social and economic objectives in an open and planned way
- allocating human activities to specific marine areas based on objectives for human use zones,
- analyzing current and anticipated uses
- providing a clear process to better determine how oceans can be sustainably used and protected

- identifying of suitable use areas in an effort to (1) reduce conflicts (user-user) and (user-environment); (2) reduce environmental impacts; and (3) preserve critical ecosystem services

There are also certain principles that must be in place in order to ensure that the MSP process is effective for meeting management needs. These principles, which are compatible with CZMAI's vision of a sustainable coast for Belize, must be inherent in the MSP process and include:

- ***ecosystem-based***: balancing ecological, economic and social goals and objectives for sustainable development
- ***integrated***: across sectors and agencies, and among levels of government
- ***adaptive***: capable of learning from experience
- ***strategic and anticipatory***: focused on the long-term
- ***participatory***: stakeholders actively involved in the process

Thus, in an effort to reduce the conflicts resulting from the ad-hoc resources use, CZMAI recommends a spatially-explicit coastal and marine zoning scheme that is informed by the principles of ecosystem-based management, which is integrated, adaptive, participatory and strategic and anticipatory. To this end, the coastal and marine spatial plan that uses an ecosystem-based approached to marine spatial planning should support the sustainable, planned allocation of resources as well as the provision of ecosystem services and maintenance of the integrity of coastal and marine ecosystems.

Methods

CZMAI, in collaboration with the Natural Capital Project, developed a science-based coastal and marine spatial plan that allows for the continuous delivery of environmental benefits to Belize by creating a zoning scheme to resolve conflicts in resource use and negotiate competing interests for management of the Belizean coastal zone. The approach undertaken to create the Plan consisted of multiple steps, which are described below. These steps included:

- **Process design**, whereby the process for developing the Plan was established and refined;
- **Stakeholder engagement**, whereby representatives from relevant sectors of government, industry, and civil society, as well as members of the public, were involved in each of the following steps of the planning process;
- **Establishment of zoning categories and creation of use zones**, whereby the current uses and values Belizeans have for the coastal zone were identified and mapped;
- **Data collection**, whereby quantitative and spatial information about the ecosystems and uses of coastal and marine areas were gathered into a database and catalogued in maps;
- **Development of alternative zoning options and scenarios**, whereby scenarios for possible future configurations of use and development were designed and mapped;
- **Cost and benefit assessment**, whereby the options were analyzed to compare the costs and benefits to ecosystems and society with an ecosystem service assessment tool, InVEST;
- **Review and iteration**, whereby all maps and analyses were reviewed by experts and stakeholders and thereby improved to ensure broad participation and the highest quality results;
- **Elaboration of the written Plan**, whereby results were translated into a comprehensive zoning scheme and recommended actions.

The following sub-sections describe the methods used in many of these steps to produce a comprehensive, science-based coastal and marine spatial plan.

Identification of Human Use Zones and Important Habitats

In creating an informed coastal and marine zoning scheme for Belize, one of the first steps that had to be taken was the identification of the variety of uses of the coastal and marine areas. CZMAI accomplished this task by first creating a list of known uses of the coastal and marine environment and then consulting with key stakeholders, such as regional coastal advisory committees (CACs) and multiple government agencies, to verify and validate the list. This panoply of activities was then consolidated into useful zoning categories, grouping some like activities into a single zone. The resulting list of use zones is below:

1. **Coastal Agriculture**
2. **Coastal Aquaculture**
3. **Coastal Development** (including human settlements)
4. **Conservation**(including coastal & marine management areas, spawning aggregation sites, biodiversity areas, critical sport fishing habitats, shoals)
5. **Cultural and Historical Sites**
6. **Marine Dredging**
7. **Fishing** (including commercial, sport fishing, subsistence, recreational non-sport fishing)
8. **Marine Transportation**
9. **Marine Recreation**
10. **Oil Exploration**

Existing zoning of Special Development Areas inland as per the Land Utilization Subsidiary Act was also recognized.

A second but equally important step that was taken following the identification of uses was the identification of important habitats in the coastal and marine environment. In the coastal zone mangrove forest, seagrass beds and coral reefs were identified as three important habitats for consideration in the zoning scheme; there is evidence that these habitats are affected by the variety of uses of the coastal zone and are critical for an abundance of human uses. The identification of these habitats as being of utmost importance was validated through the CAC process. CAC members highlighted the three habitats for their important role in ecosystem functions and the provisioning of ecosystem services from which Belizeans benefit. These recommendations from CAC groups were collected and recorded at regular, scheduled meetings.

Data Requirements and Acquisition

The goal of data collection was to establish the first comprehensive map of the natural features and human uses of Belize's coastal zone. Such information is a critical foundation for developing a plan for natural resource use and economic growth. The data gathering process commenced with the compilation of existing spatial and quantitative data that could be mapped using a geographic information system (GIS). Particular attention was paid to inputs necessary for the ecosystem service tool, InVEST, designed by the Natural Capital Project.

Since many data layers were not publicly available for download, the team spent several months gathering existing data about biodiversity, habitats, and human uses of the marine and coastal area in collaboration with universities, government agencies, industry associations, citizens' groups and non-governmental organizations. Organizations from which data were requested were asked to provide data in its simplest form to ensure that these data were raw, rather than aggregated, to improve resolution detail. Some of this information was provided to CZMAI as written reports and thus needed to be digitized. All data created in this manner were compared and verified using a combination of Google Earth, local surveys, and then confirmed by local scientists though in-person consultations or social media. All this information was used to build a central repository of data about the coastal and marine areas of Belize. The repository

includes raw data and aggregate spatial information (i.e. layers) that depict habitat types, human uses, and characteristics of the coastal and marine environment (see Table A for a full listing). For example, layers indicating the geomorphology (make-up) and slope of the coastline allowed the team to identify potentially vulnerable areas to flooding and erosion from a major event like hurricanes.

Table A: Belize Central Repository of Environmental Service Data

CATEGORY	DATA GOUP	DESCRIPTION	SOURCE	RESOLUTION	SPATIAL EXTENT	TEMPORAL EXTENT	SHAPE
Physiographic (Land)	Land topography	digital elevation model	NASA / US Geological Survey, The Natural Capital Project	30m	country	2011	raster
	Hydrology	rivers	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies)	1:800,000	country	2011	polyline
	Watersheds	outlines of major watersheds	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies)	1:800,000	country	2011	polygon
	Coastline	outline of any land above sea level	CZMAI	1:800,000	country	2011	polygon
	Coastal geomorphology	dune, beach, grass, seawall, rip-rap, etc	Selva Maya Consortium	1:250,000	country	2011	polygon
	Coastal lagoons	lagoons	CZMAI	1:800,000	country	2011	polygon
Oceanographic	Water temperature	time series data	TIDE		country	2010	point
	Salinity	time series data	TIDE		country	2010	point
	Tides	time series data	MET Department		country	2010	point
	Wave height	Wave Watch 3 model output - time series data	The Natural Capital Project		country	2010	point
Climatological	Precipitation	time series data	Met Service		country:	7-35 yr average	point
	Wind speed	time series data	Met Service		country	2010	point
	Wind direction	time series data	Met Service		country	2010	point
	Air temperature	time series data	Met Service		country	2010	point
	Hurricane wind speed	time series or event average	The Natural Capital Project		country	2010	point
	Hurricane wind direction	time series or event average	The Natural Capital Project		country	2010	point
	Hurricane wave height	time series or event average	The Natural Capital Project		country	2010	point

Biological	Fish distributions	ranges of fished species	GreenReef, Mito Paz	1:800,000	country	2010	polygon
	Fish abundances	abundances in fished and unfished areas	WCS, TIDE, Hol Chan, SEA	1:800,000	country	2010	polygon
	Marine habitat	coral, seagrass, and mangrove	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies), Peter Mumby, WRI, WWF, Cathalac, and MAR Millennium Study & CZMAI	multiple sources: 20m-1:100,000	Mesoamerica and country	2007 - 2010	polygon
	Terrestrial habitat	Land use/Land cover	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies)	1:100,000	country	2010	polygon
	Biodiversity	West Indian Manatee (Trichechus manatus) sightings, sea turtles nesting, American saltwater crocodiles (Crocodylus acutus) sightings and dolphin sightings.	TNC & CZMAI	1:800,000	country	2010	polygon
	Shoals	location and number of marine structures that are of ecological importance to the coastline	DOE & CZMAI	1:800,000	country	2010	polygon
	Marine/coastal reserves	location of marine reserves including spawning aggregation sites & special development areas	Land Information Centre & Land Utilization Authority & CZMAI	1:800,000	country	2011	polygon
Infrastructure	Roads	Major road network	Belize Land Information Centre & Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies)	1:50,000	country	2011	polyline
	Shipping ports	major shipping centers	Belize Port Authority & CZMAI	1:50,000	country	2011	point
	Shipping lanes	major shipping lanes	Belize Port Authority & CZMAI	1:50,000	country	2011	point
	Water Taxi	Major water taxi terminals	Belize Port Authority & CZMAI	1:50,000	country	2011	point
	Marinas	areas with permanent structures (docks, pilings, etc) for boat moorage	CZMAI	1:50,000	country	2011	point
	Airports	location of airports and airstrips	Belize Department of Civil Aviation & CZMAI	1:50,000	country	2011	point

Geopolitical	Regional boundaries	Toledo, Stann Creek, etc	Land Information Centre and CZMAI	1:800,000	country	2010	polygon
	Municipalities	names of cities and villages	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies) and CZMAI	1:800,000	country	2010	point
	Populations	number of people in cities and villages	Statistical Institute of Belize & Election & Boundaries & CZMAI	1:800,000	country	2000	excel format
	Populations	number of people per administrative district	WWF, Statistical Institute of Belize	1:800,000	mesoamerica	2010	polygon
	Urban areas	outlines of urbanized land	Belize Land Information Centre	1:800,000	country	2010	polygon
	Park boundaries	outlines of terrestrial parks, reserves, archaeological sites, etc; including data on level of protection	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies)	1:800,000	country	2005 data	polygon
	Population Census	including data on level of protection	Statistical Institute of Belize & CZMAI	1:800,000	country	2004	polygon
Human Use	Aquaculture boundaries	farm locations and species being raised, farming practices	Fisheries Department, Department of Economics and CZMAI	1:800,000	country	2011	polygon
	Commercial fisheries	places, species, number being fished commercially. This included only Caribbean spiny lobster (Panulirus argus)	BTB, BAS, AFT, APAMO,SEA and TIDE	1:800,000	country	2010	polygon
	Recreational fisheries	places, species, number being fished recreationally. This includes: bonefish, tarpon, and permit	Ecoworks and Green Reef Environmental Institute and CZMAI and The Natural Capital	1:800,000	country	2010-2012	polygon
	Oil/petroleum lease boundaries	areas of oil/petroleum leases	Geology and Petroleum Department and CZMAI	1:800,000	country	2011	polygon
	Tourist visits	number of visitors entering Belize (per month, origin, entry port, overnight vs cruise)	BTB		country	2011	excel format
	Tourist visits	number of visitors (per month and originating country) to defined marine locations within Belize (marine reserve, blue hole. Hol Chan)	BTB, BAS, AFT, APAMO,SEA and TIDE		country	2010 - 2011	excel format
	Tourist expenditures	expenses by tourists	BTB		country	2011	excel format
	Hotels	locations of hotels and number of beds/rooms	World Wildlife Fund Belize, TNC and BTB	1:800,000	country	2005 data	point

	Marine recreation	recreational activities by tourists in Belize. number of tourist diving, jet skiing, kayaking, snorkeling, swimming and wind surfing-days per month at popular sites.	BTB and CZMAI	1:800,000	country	2011	points and polygon
	Marine transportation	major shipping route, water taxi routes, and ports	Belize Port Authority and CZMAI	1:800,000	country	2011	points, polylines and polygon
	Marine dredging	any cleared land for development	Mining Department and CZMAI	1:800,000	country	2011	polygon
	Coastal development	This layer highlights and cleared land with and without structures	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies), DOE & Economic development Department, The Natural Capital Project and CZMAI	1:800,000	country	2011	polygon
	Agriculture runoff	Effects from pesticide and herbicides	WRI, The Natural Capital Project and CZMAI	1:800,000	country	2011	polygon
	Fishing	fishing for commercial fisheries but not permitted within the wilderness, preservation, and conservation zones within marine reserves	TIDE (PHMR), SEA (GSSCMR, LBCNP), Healthy Reefs and CZMAI	1:800,000	country	2011	polygon
	Cultural & historical sites	locations of coastal cultural & historical sites	NICH website: http://www.nichbelize.org/ and CZMAI	1:800,000	country	2011	points
	Schools (preschools, primary, secondary, tertiary& vocational institutions)	locations of coastal schools	Ministry of Education and CZMAI	1:800,000	country	2011	points
	Medical facilities	locations of coastal medical facilities	Ministry of Health website: http://health.gov.bz/www/ and CZMAI	1:800,000	country	2011	points
	Fire stations	locations of coastal fires stations	Fire Department website: http://www.nationalfireservice.gov.bz/ and CZMAI	1:800,000	country	2011	points
	Police stations	locations of police stations	Belize Police Department website: www.police.gov.bz and CZMAI	1:800,000	country	2011	points

This information was mapped comprehensively for the first time in Belize (Figs. A.1and A.2). The mapping process began by revising existing maps and layers provided by several organizations to ensure accuracy, precision and appropriate projection. Basic geoprocessing tools were used which includes: buffer, clip, intersect, union, merge, and dissolve. Some maps were scanned, georeferenced and digitized in ArcMap. Data presented in Excel files were converted into shapefiles as points, polylines, and polygons. In addition, a Google Map-based designed by the Natural Capital Project, InSEAM (**In**VEST **S**c**E**n**A**rio **M**odeler), was used to highlight biophysical changes, or recent management and development activities in particular places.

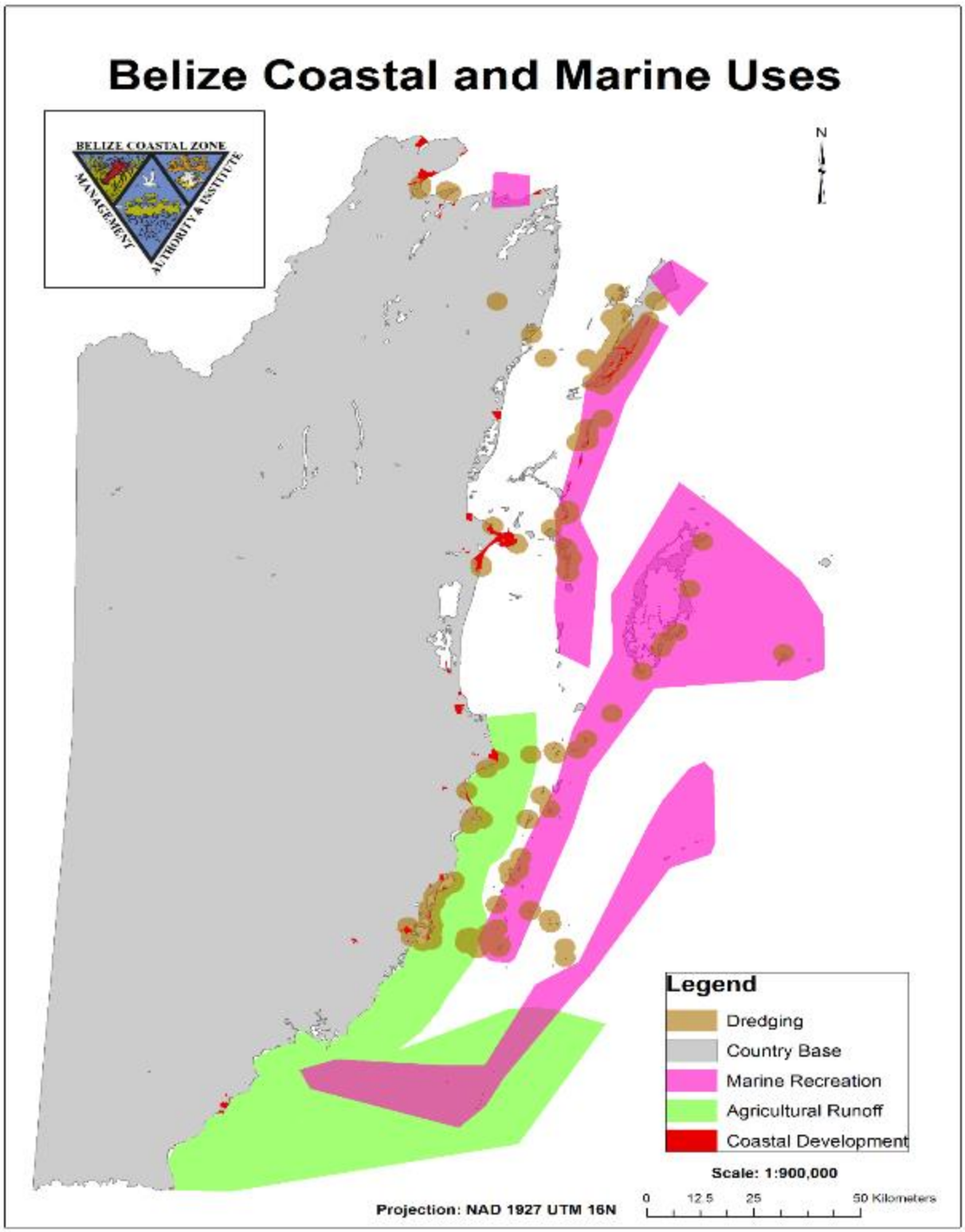

Figure A.1: Belize Coastal and Marine Zones

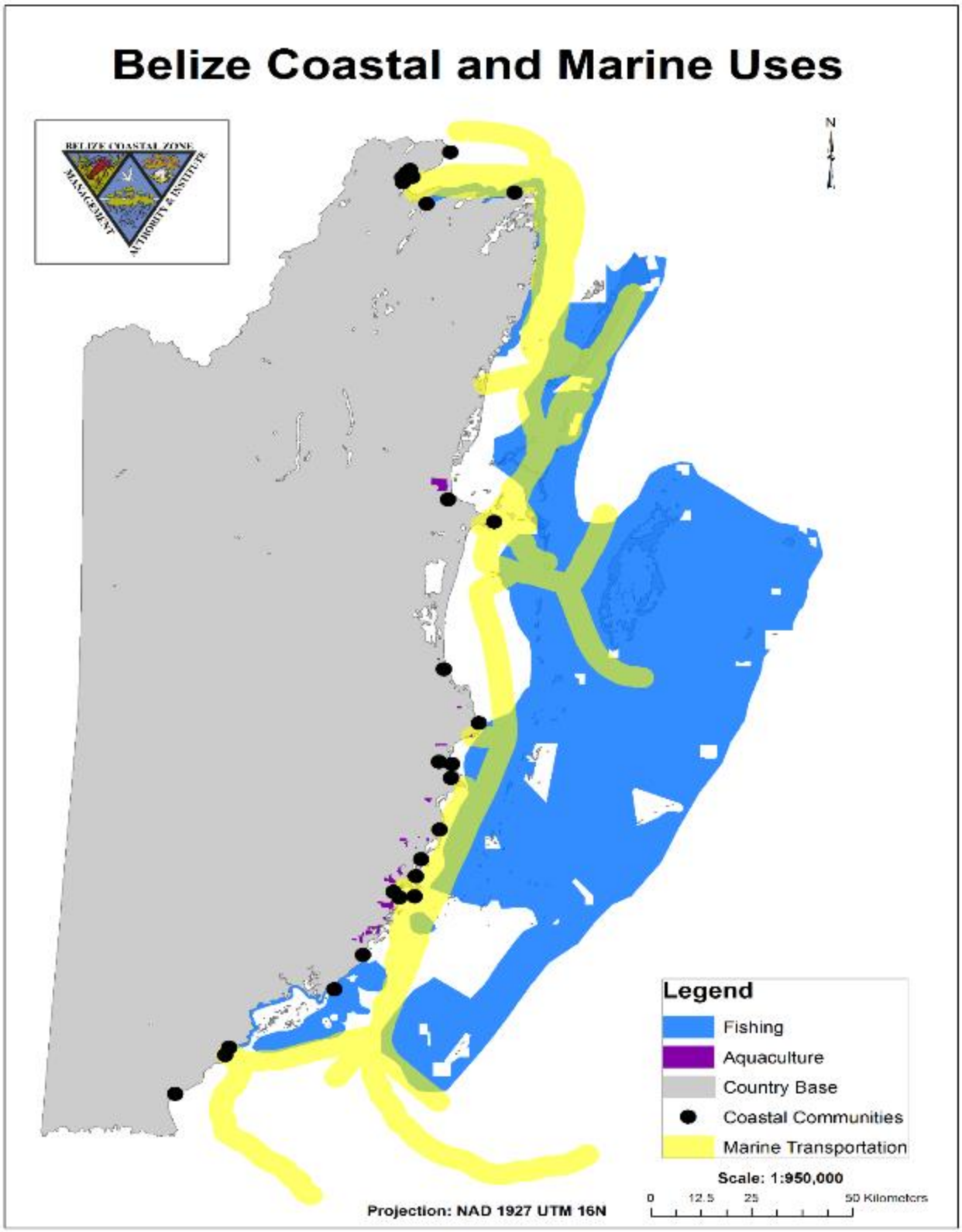

Figure A.2: Belize Coastal and Marine Zones

Delineation of Zones of Current Uses

The information contained within Figures A.1 and A.2 includes locations where mangroves, seagrass and corals exist, as well as the current distribution of human uses, including marine protected areas, fishing, coastal development, marine recreation, aquaculture and marine transportation. As the map indicates, these zones overlap in many areas and create a complicated, haphazard, and often incompatible mix of human uses and activities. With a more robust current knowledge of current uses, planning and delineation the "current" zones was possible.

First, a 3 kilometer zone of influence was created to encompass all coastal communities and capture their activities. Once known, human uses in the zone of influence were mapped, they were grouped into 'use zones' by aggregating data (e.g. multiple species into one 'biodiversity layer') and buffering of points and lines (e.g. surveyed manatee sightings) to facilitate planning purposes. The nine use zones include coastal agriculture, aquaculture, coastal development, dredging, fishing, oil exploration, marine recreation, marine transportation and conservation. Diving, jet skiing, kayaking, snorkeling, swimming and wind surfing were grouped into the marine recreation zone, while ports, water taxi, and shipping lanes were grouped into the marine transportation zone. Crocodile sites, dolphin sites, manatee sightings, and sea turtles were grouped into a 'biodiversity layer' and bonefish, permit and tarpon habitats were aggregated into a 'critical habitat layer'. These two layers, plus coastal and marine protected areas and shoals, were grouped into the conservation zone. An advisory group of experts was convened to provide feedback on zoning categories, delineation and mapping and analysis.

These zones were validated with regional experts and stakeholders through Coastal Advisory Committee (CAC) meetings and public consultations. The mapped layers were shared with the CACs and other stakeholder groups in nine planning regions, which through meeting minutes, surveys and interviews communicated their local and scientific knowledge about the locations, types and intensity of fisheries, habitat types, marine recreation, marine transportation, oil exploration and coastal development. This knowledge was incorporated into the placement of the zone-type location and size based on the current coastal and marine uses in Belize.

Independent research on zoning scenarios using InVEST was accomplished using the best available central repository of environmental service data. The first iteration of model runs also allowed the team to identify data gaps by comparing the results to prior studies done in the area. This process allowed for calibration of the models and informed the team as to which areas to focus on with regard to future data collection efforts. Based on expert and stakeholder review, all the zones were revised for accuracy and consistency. For instance, land mass was removed from marine use zones with the exception of the aquaculture areas, coastal development and dredging zones using the country base layer. Oil exploration was removed from the habitat cover, biodiversity zone and future conservation zones.

Stakeholder Engagement

Part of CZMAI's mandate is to integrate stakeholder input into the national plan. Stakeholders provide input through coastal advisory committees in nine regional planning regions, with representation from government, business, fishing cooperatives, and local communities. To draw out recommendations from the coastal advisory committees and the general citizenry, CZMAI took several actions (Clarke et al. 2012).

First, CZMAI participated in multiple committee meetings to establish the most critical issues for coastal zoning. Many of the issues identified were local or regional in scope, such as subsistence and commercial fishing, tourism, coastal development, and risks of inundation from tropical storms. To better understand stakeholder expectations and goals for the future, CZMAI disseminated a short survey at committee meetings. Respondents identified multiple drivers of future change: climate change, real estate speculation, expansion of tourism, and declining fisheries. The outcome of the survey established that many stakeholders wished to limit development, particularly on barrier islands. It also confirmed that most stakeholders relied on tourism and fishing for their livelihood (Clarke et al. 2012).

The data retrieved from CAC members helped CZMAI to revise the development guidelines and development of scenarios. For instance, a working book was created which identified sensitive areas, as well as areas of importance based on recommendations and knowledge level of stakeholders. The minutes compiled after meetings were revised and used to create zoning maps. Where necessary, InSEAM was used to digitally highlight these areas identified by stakeholders and to avoid the time consuming and often error-laden steps of digitizing paper maps and meeting minutes. The engagement process was necessary as it identified conflict among current uses and data requirements. In some instances, it provided data needed to run the ecosystem service mode suite, InVEST, model and validated some of the InVEST model results and scenarios developed.

Development of Alternative Future Use Zoning Options

Developing scenarios is an effective, participatory way to compare alternative zoning options and identify a preferred future plan. Scenarios are stories about what the future might look like, and allow competing goals to be weighed and compared through a narrative, quantitative, and/or visual interface (McKenzie et al. 2012). For coastal zone management, developing scenarios of possible human uses of the coast and marine areas made it possible to select and refine a feasible zoning scheme that fosters sustainable development of the Belizean coast. These options were compared in the form of maps for each of the nine planning regions, which were "stitched together" into national maps of coastal resources and uses.

Over the course of several months, three scenarios were developed based on alternative visions for Belize's coastal zone. The first scenario depicted a "conservation" future, in which preservation of ecosystems and biodiversity were heavily favored over development of the coastline and other economic activities. The second scenario illustrated a balanced approach to

planning for economic development and conservation of critical resources, called "informed management". The third scenario visualized a "development heavy" future for Belize, in multiple, competing economic activities were permitted without central coordination and planning and were prioritized over preservation of coastal natural resources. These alternative options were established using existing coastal plans, policy documents, and future forecasts for Belize.

The scenarios were developed using a map compiled by CZMAI of current human uses and coastal and marine resources, which were organized into zones. The map was modified in a geographic information system (GIS) by increasing or decreasing the location, extension, and intensity of particular zones, according to spatial and quantitative rules and possible changes to the coastal zone through 2025. These rules were developed to ensure that changes to existing uses were feasible and accorded with the 'vision' of each scenario. Once draft scenarios were created, they were shared in public meetings and CAC meetings in the nine planning regions, where stakeholders provided input to the scenarios, refined the rules and zones, and validated the approach through local knowledge and existing data. The scenarios were then revised with GIS and iteratively reviewed by stakeholders and experts.

To examine the consequences of each future scenario, InVEST models were run to map and quantify the resulting changes in ecosystem services, in particular the changes in benefits from tourism and recreation, spiny lobster fishing, and coastal protection from storms and inundations. Scenarios were measured against the current conditions (aka baseline) and to each other to establish which vision provided the greatest benefits to Belizean society and economy. Using these InVEST results and stakeholder preferences documented across the nation, the "informed management" option was selected as preferred for a national zoning scheme. This scenario was then iteratively revised – i.e., the zones were modified – to improve the potential economic and environmental benefits it provided. When the scenario had been manually optimized to meet the vision, it was again reviewed as the recommended zoning scheme by expert, the public, and CZMAI's advisory council and board of directors.

Results

InVEST is currently available as a set of tools for the GIS mapping software called ArcGIS (Environmental Systems Research Institute 2012). Therefore, demarcation and visualization of zones for each scenario was also undertaken using this software. The process of using InVEST, or any decision supporting tool, is also most effective when used in an iterative fashion (Guerry et al. 2012). Therefore, after synthesizing model outputs from various iterations of InVEST model runs, stakeholders were presented with the map outputs for the current and the 3 future scenarios where they decided to rearrange some uses, to emphasize some and deemphasize others, and to generally revise and reassess their plan for uses of their region. In this case, they had the opportunity to visualize the results first hand and to see the effects of each human use especially on the marine habitat: mangroves, seagrass and corals. Using these map outputs, these stakeholders made informed recommendations for each zone based on each

scenario. A diverse number of stakeholders (developers, fisher folk, tourism stakeholder, community resident etc.) were involved in this process to ensure there was a balance in development and conservation. With this information, CZMAI selected the Informed Management Scenario as the preferred marine and coastal zoning plan that will provide for the current and future needs of Belizeans.

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B. InVEST MODEL SUMMARIES

B.1 HABITAT RISK ASSESSMENT

Summary

The condition of coastal habitats is a key determinant of the ecosystem services they can provide. Human activities, such as fishing, climate change, and coastal development, may degrade coastal habitats and hamper the provisioning of valuable goods and services that people want and need. As human activities continue to intensify, so too does the need for quick, clear and repeatable ways of assessing the risks posed by human activities under various management plans. The InVEST habitat risk assessment (HRA) model allows users to assess the risk posed to coastal and marine habitats by human activities and the potential consequences for delivery of ecosystem services. Risk is a function of the exposure of each habitat to each activity and the consequences for each particular habitat type. Exposure to stressors can arise through overlap in space and time. Consequence depends on the effects of activities on habitat area and density, and the ability of habitats to recover from these effects. Outputs from the model are useful for understanding the relative risk of human activities and climate change to habitats within a study region and among alternative future scenarios. Model outputs can help identify areas on the seascape where human activities may create trade-offs among environmental services by posing risk high enough to compromise habitat structure and function. The model can help to prioritize areas for conservation and inform the design and configuration of spatial plans.

How the model works

The HRA model combines information about the exposure of habitats to each human activity with information about the consequence of that exposure to produce maps of risk to habitats and habitat quality for provisioning of each service. Exposure depends on the extent of geographic overlap between habitats and human activities, the duration of time that the activity and habitat overlap, the intensity of the stressor and the degree to which management strategies mitigate impact. The consequence depends on the degree of habitat loss, change in habitat structure and the ability of habitats to recover from these effects (i.e., through life history traits such as recruitment and regeneration rates). The first step in the model

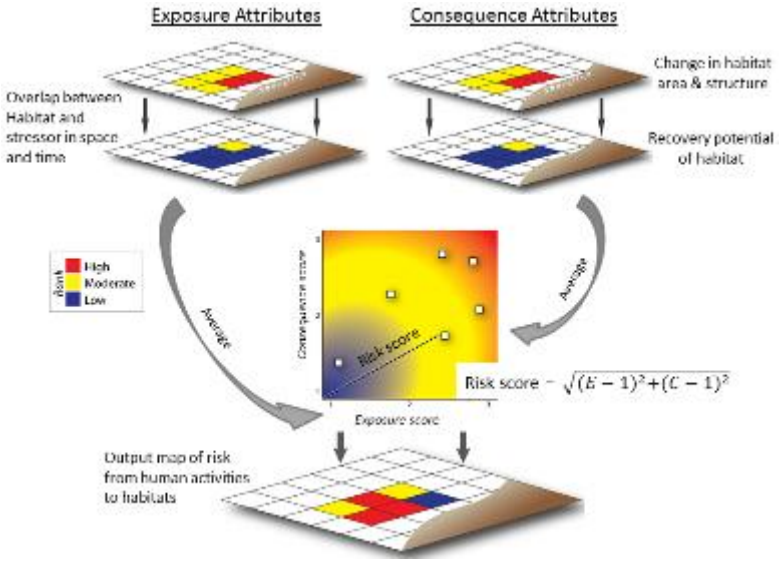

Figure B1.1 Conceptual diagram of habitat risk assessment model

Criteria	High (3)	Medium (2)	Low (1)	Description of criteria
Exposure				
Spatial overlap	>30% of habitat	10%-30% of habitat	0-10% of habitat type	The model uses the maps of habitat and stressor distributions to calculate the percentage of each habitat type that overlaps with each human activity and its zone of influence.
Temporal overlap	Habitat and stressor co-occur for 8-12 months of the year	Habitat and stressor co-occur for 4-8 months of the year	Habitat and stressor co-occur for 0-4 months of the year	The duration of time that the habitat and the stressor experience spatial overlap.
Intensity	High	Medium	Low	The exposure of a habitat to a human activity depends not only on whether the habitat and activity overlap in space and time, but also on the intensity of the activity, for example, number of cruise ship trips per year.
Management effectiveness	Poorly managed	Somewhat effective	Very effective	Management can limit the negative impacts of human activities on habitats, thus reducing exposure even where and when the activities interact with habitats.
Consequence				
Change in area	High loss in area (50-100%)	Medium loss in area (20-50%)	Low loss in area (0-20%)	The percent change in areal extent of a habitat when exposed to a given activity. Habitats that lose a high percentage of their areal extent when exposed to a given stressor are highly sensitive, while those habitats that lose little area are less sensitive and more resistant.
Change in structure	High loss in structure (e.g., 50-100% loss in density)	Medium loss in structure (e.g., 20-50% loss in density)	Low loss in structure (e.g., 0-20% loss in density)	The percentage change in structural density of the habitat when exposed to a given stressor
Frequency of disturbance	Annually or less often	Several times per year	Daily to weekly	If a habitat is naturally frequently perturbed in a way similar to the anthropogenic stressor, it may be more resistant to additional anthropogenic stress.
Natural mortality	Low mortality (e.g. 0-20%)	Moderate mortality (e.g. 20-50%)	High mortality (e.g.80% or higher)	Habitats with high natural mortality rates are generally more productive and more capable of recovery.
Recruitment	Every 2+ years	Every 1-2 years	Annual or more often	Frequent recruitment increases recovery potential by increasing the chance that incoming propagules can re-establish a population in a disturbed area.
Recovery time	More than 10 years	1-10 years	Less than 1 year	Habitats that reach maturity earlier are likely to be able to recover more quickly from disturbance than those that take longer to reach maturity. Here we refer to maturity of the habitat as a whole (i.e., a mature reef) rather than reproductive maturity of individuals.
Connectivity	Low dispersal (less than 10km)	Medium dispersal (10-100km)	High dispersal (>100km)	Larval dispersal and close spacing of habitat patches increases the recovery potential of a habitat by increasing the chance that incoming propagules can re-establish a population in a disturbed area.

Table B1.1 Description of outputs from Habitat Risk Assessment

assigns a score of HIGH = 3, MEDIUM = 2 or LOW = 1 to a set of exposure and consequence criteria (Table B1.1) for each habitat-human activity combination (Tallis et al 2012). The model automatically assigns the scores for spatial overlap using input data layers on the location and extent of habitats and human activities (B1.2). To ensure transparency, the other scores are determined based on readily available data from the scientific literature and published reports (B1.3). Methods for scoring each criterion are expanded upon in the InVEST User Guide (Tallis et al 2012). The second step in the model combines the exposure criteria and the consequence criteria for each grid cell to generate an average exposure and average consequence score for each habitat-human activity combination. In the third step, the model calculates risk for each habitat-human activity combination using average exposure and average consequence scores. Risk to habitat in each grid cell of the area of interest is calculated as the Euclidean distance from the origin in the exposure-consequence space (Fig. 1, Tallis et al 2012). In the fourth step, the model quantifies the cumulative risk of all stressors on the habitats, assigns a qualitative risk (High, Medium and Low) to each grid cell of habitat and then calculates a total ecosystem risk score of all stressors on all habitats combined. In the fifth and final step, the qualitative risk scores are translated into habitat quality scores which are then used as inputs into the ecosystem service models. In general, the higher the risk, the more fragmented the habitat and the lower the risk the more intact the habitat (but see individual model descriptions of habitat quality inputs).

INPUT	SOURCE	HOW THE DATA WERE USED IN THE MODEL
Coral	CZMAI and Peter Mumby	These data were used to determine the location and extent of coral exposed to human activities
Mangroves	World Wildlife Fund	These data were used to determine the location and extent of mangroves exposed to human activities
Seagrass	CZMAI	These data were used to determine the location and extent of seagrass exposed to human activities
Aquaculture zone	Fisheries Department, Department of Economics and CZMAI	These data were used to determine the spatial overlap between aquaculture and coastal habitats.
Agriculture run-off zone	World Research Institute and CZMAI	These data were used to determine the spatial overlap between agricultural run-off and coastal habitats.
Coastal development zone	Natural Capital Project – The InSEAM Annotation Tool, Department of Environment, Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies) and CZMAI	These data were used to determine the spatial overlap between coastal development and coastal habitats.
Dredging zone	Mining Department and CZMAI	These data were used to determine the spatial overlap between dredging and coastal habitats.
Fishing zone	Fisheries Department and CZMAI	These data were used to determine the spatial overlap between fishing and coastal habitats.
Marine transportation zone	Belize Port Authority and CZMAI	These data were used to determine the spatial overlap between marine transportation and coastal habitats.
Oil exploration/drilling zone	Department of Geology and Petroleum and CZMAI	These data were used to determine the spatial overlap between oil exploration/drilling and coastal habitats.
Effects of human activities on coastal habitats	Habitat-stressor ratings table with scores based on review of the scientific literature.	These data are used to assess additional attributes of habitat exposure to human activities (e.g., in time and based on management effectiveness). They are also used to assess the consequences of that exposure for change in habitat structure and area and the ability of the habitat to recovery from stress based on life history characteristics such as natural mortality, recruitment and connectivity.

Table B1.2 Description of input data for the Habitat Risk Assessment in Belize

LEGEND

	LOW HABITAT RISK	MODERATE HABITAT RISK	HIGH HABITAT RISK	DATA QUALITY
EXPOSURE	Limited Exposure	Moderate Exposure	Extensive Exposure	Best Data ***
CONSEQUENCE	Limited Impact	Limited Exposure	Extensive Impact	Adequate data **
RECOVERY	High Resilience	Moderate Resilience	Limited Resilience	Limited Data *
	No Score	No Score	No Score	N/A

EXPOSURE

EXPOSURE	CORALS	MANGROVE	SEA GRASS
SPATIAL OVERLAP	Calculated in GIS	Calculated in GIS	Calculated in GIS
TEMPORAL OVERLAP	High Temporal Overlap	High Temporal Overlap	High Temporal Overlap
STRESSOR INTENSITY	Edited By Sector**	Edited By Sector**	Edited By Sector**
MANAGEMENT EFFECTIVENESS	Edited By Sector**	Edited By Sector**	Edited By Sector**

RECOVERY

RECOVERY	CORALS	MANGROVE	SEA GRASS
NATURAL MORTALITY RATE	High	Low	Moderate
NATURAL RECRUITMENT RATE	Moderate	Low	Low
RECOVERY TIME	Moderate Recovery Time	Moderate Recovery Time	Low Recovery Time
CONNECTIVITY	Medium Dispersal	Medium Dispersal	Low Dispersal

CONSEQUENCE

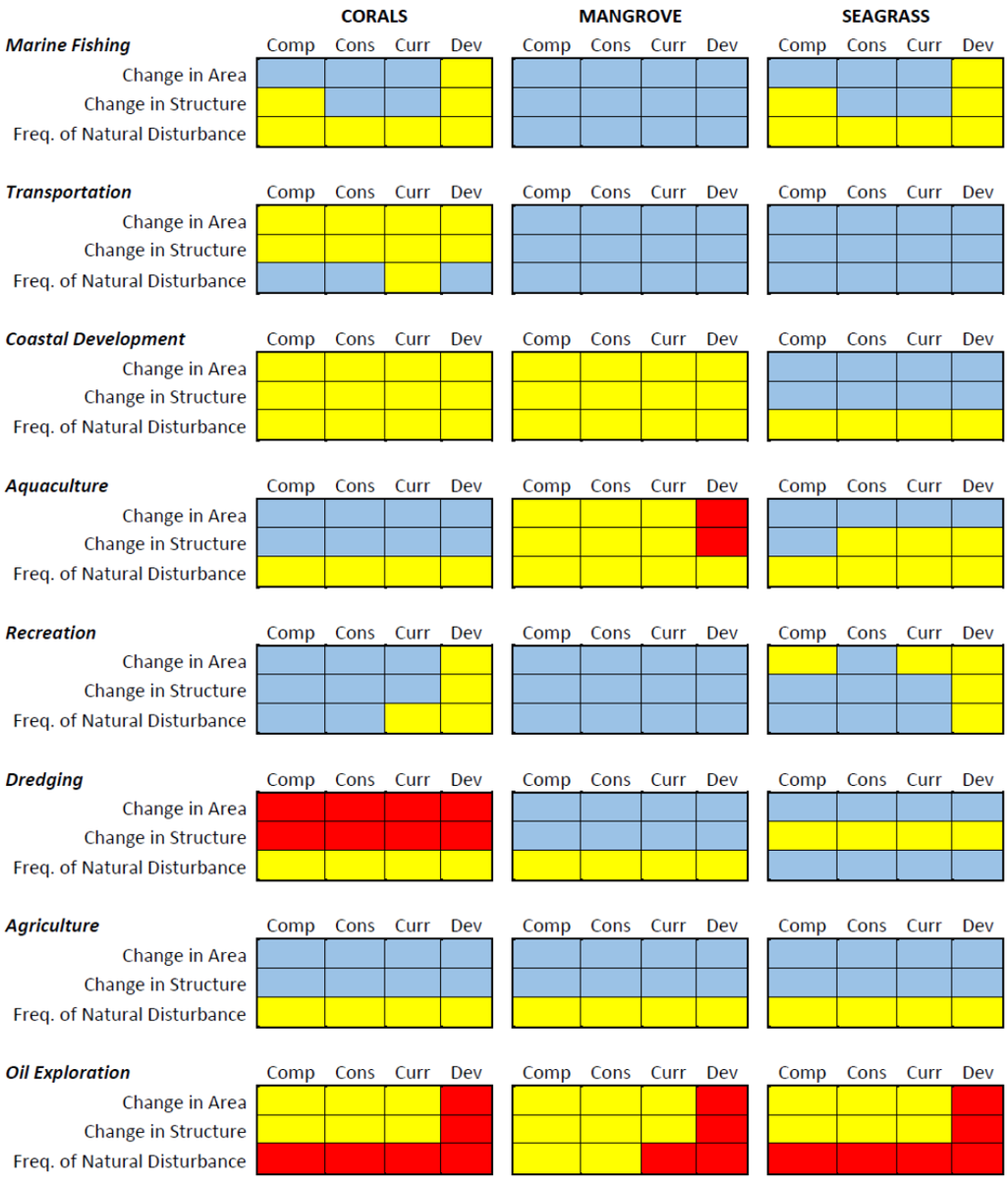

Table B1.3 Exposure, consequence and recovery scores for habitat-stressor interactions based on literature

In Belize we used the HRA model to assess risk to habitats posed by both current and potential future uses of the coastal and marine environment. We quantified the risk to three main habitat types - coral, mangrove and seagrass – based on nine different human activities (Table B1.2) at a 500 m resolution. The nine activities align with the zones for the Belize Integrated Coastal Zone Management Plan (Figs. 7-14). We used the HRA model to evaluate risk to habitats under the three alternative future zoning scenarios (i.e., Conservation, Informed Management, and Development). The model inputs were the same for all scenario runs; however, the location and extent of human activities varied depending on zoning scenario (See Section 1 in the Plan) and in a few cases the effect of activities on habitats changed depending on management strategies within each zoning scheme.

OUTPUT	DESCRIPTION
Qualitative habitat risk	Locations where each habitat type (e.g., coral, mangroves, seagrass) is at High, Medium and Low risk to all human activities included in the model
Ecosystem risk	The sum of all cumulative risk scores for all habitats in each grid cell. For example, in a nearshore grid cell that contains some coral reef, mangrove and seagrass, the ecosystem risk value reflects the risk to all three habitats in the cell. The ecosystem risk value increases as the number of habitats in a cell exposed to stressors increases.

Table B1.4 Description of outputs from Habitat Risk Assessment

Model validation

We tested the ability of the HRA model to capture observed habitat degradation by comparing our results for mangrove risk hotspots to observed data on mangrove fragmentation along the entire coast of Belize. The HRA model produces three categories of risk (High, Medium and Low) and the observed data categorize mangroves in five fragmentation categories (from Highest to Lowest). We found that the HRA model identified as high risk those areas where mangrove fragmentation is highest (e.g., Ambergris Caye, Belize City, Placencia) and identified as low risk much of the coastline where mangrove fragmentation is qualitatively lower (e.g., Northern Region and east coast of Turneffe Atoll). While we have not tested the ability of the model to accurately forecast risk of human activities to coral and seagrass, the qualitatively similar results for modeled risk to mangroves and observed fragmentation suggests the utility of the model for other habitats.

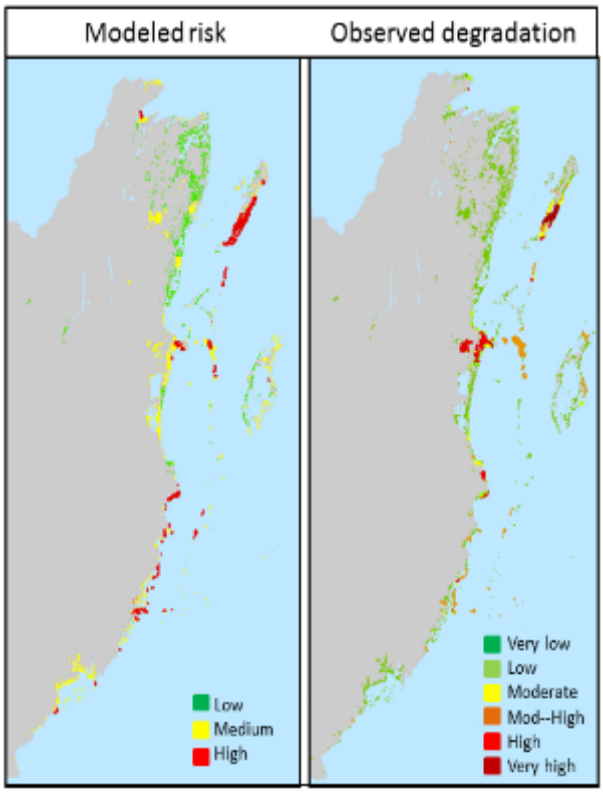

Figure B1.2 Comparison of modeled mangrove risk to observed mangrove degradation.

Limitations and assumptions

- Results are should be interpreted on a relative scale within a study region and across habitats and stressors, but not to results from separate analyses.
- Results do not reflect the effects of past human activities.
- Results are based on equal weighting of criteria unless the user weights the criteria by importance or data quality.
- Cumulative risk is additive (rather than synergistic or antagonistic).
- Climate change impacts are not directly accounted for in model

B.2 COASTAL VULNERABILITY INDEX

Summary

Faced with a changing climate and a growing intensity of human activities, coastal communities must better understand how modifications of the biological and physical environment can affect their exposure to storm-induced erosion and flooding. The InVEST Coastal Vulnerability Index estimates exposure based on the distribution of coastal habitats, such as mangroves, seagrass and coral reefs, geomorphology, elevation, wind and wave characteristics, sea level rise, and surge potential. By coupling an index of coastal hazard to data on population demographics, property values, emergency services, access and infrastructure, the model highlights where human populations and critical infrastructure are most vulnerable to storm waves and surge. Outputs can be used to quantify and value the protective services offered by natural habitats to coastal communities. This information can help coastal managers, planners, landowners and other stakeholders to identify regions of greater risk to coastal hazards and design ecosystem based approaches and strategies, such as conservation and restoration of coastal habitats, for reducing risk to coastal hazards.

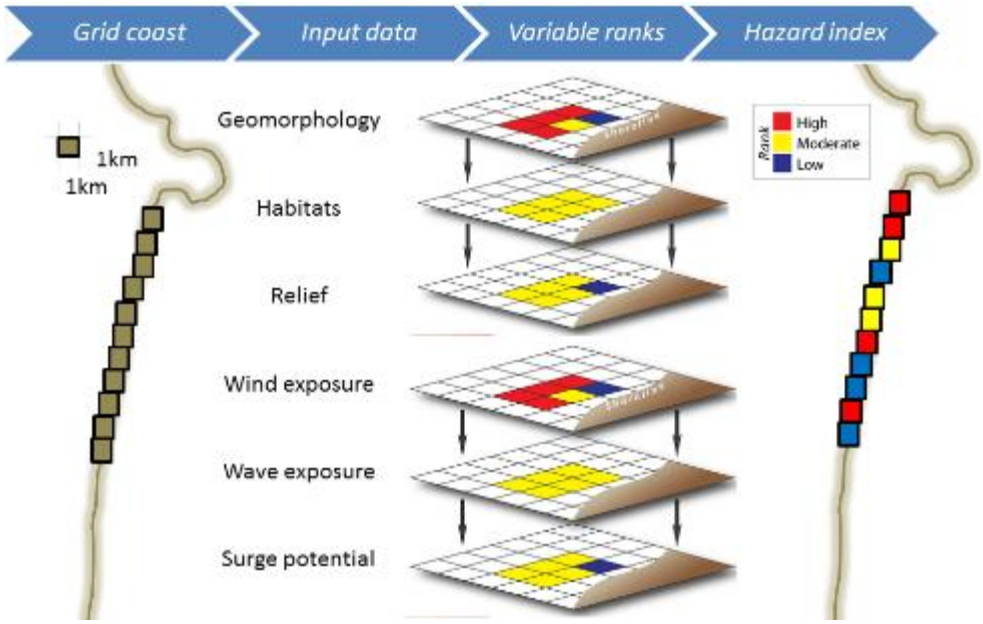

Figure B2.1 Conceptual diagram of coastal vulnerability model

How the model works

We estimated the current and future vulnerability of the Belize coastline by comparing vulnerability of people and emergency infrastructure to coastal hazards now and under three future coastal zone planning scenarios that vary in the risk posed to habitats from human activities.

To estimate the relative current and future vulnerability of each 1 km^2 segment of the Belize coastline (for a total of 8,190 segments), we calculated an index that incorporates seven variables representing the biological and geomorphic characteristics of the region: habitat types (coral reefs, mangroves and seagrass), geomorphology, relief, wind exposure, wave exposure, and surge potential (Table B2.1, see Tallis et al 2012 for more information). We used the same data for the physical inputs for all scenarios, but the habitat inputs differed based on spatial variation in risk from human activities we quantified using the HRA model for the current and three possible future scenarios (Figs. 17-19). Habitats at low risk were capable of providing normal amounts of protection. Where risk to the three habitats was high, we assumed they were too degraded to provide protection and removed them from the run of the model. Where risk was medium, the habitats provided an intermediate amount of protection. The habitat data for each scenario were then combined with data on all the other input variables.

$$VI = \sqrt[2]{\frac{R_{Habitats}R_{Geomorphology}R_{Relief}R_{SLR}R_{WindExposure}R_{WaveExposure}R_{SurgePotential}}{7}}$$

INPUT	SOURCE	HOW THE DATA WERE USED IN THE MODEL
Coastal Geomorphology	Emil Cherrington (CATALAC) and the Natural Capital Project	Geomorphology is one of six variables in coastal hazard index that determines exposure to erosion and flooding. The data layer included 13 unique classifications for shoreline type (sandy beach, barrier beach, mud flat, etc.) and the model assigned each shoreline segment a relative geomorphology ranking from 1 to 5 based on these classifications.
Relief	ASTER GDEM v2 – 30 meter resolution	Relief is one of six variables in coastal hazard index that determines exposure to erosion and flooding. The tool determines the average elevation (height in meters) of all DEM cells on land within this 1,500 meter search window. The resulting distribution is classified using percentile breaks (20, 40, 60, and 80) to produce relative ranks of 5 through 1 respectively.
Fringe coral reefs	CZMAI and Peter Mumby	Fringe coral reefs are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 1 and protective distance 2,000 meters.
Barrier coral reefs	CZMAI and Peter Mumby	Barrier coral reefs are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 2 and protective distance 30 kilometers.
Mangrove	World Wildlife Fund	Mangrove forests are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 1 and protective distance 500 meters.
Seagrass	CZMAI	Seagrass beds are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 4 and protective distance 500 meters.
Wind and Wave exposure	Wave Watch III (National Weather Service)	Wind and wave characteristics are two of six variables in coastal hazard index that determine exposure to erosion and flooding. The model computes relative wind and wave exposure for each coastline segment using time series data (2005-2010) of wind speeds and associated direction, above the 90th percentile value, and fetch distance.
Surge Potential	Continental Margins Ecosystem (COMARGE)	Surge potential is one of six variables in coastal hazard index that determines exposure to erosion and flooding. To estimate surge potential the tool calculates the distance between a segment of coastline and the edge of the continental shelf and assigns a relative ranking for each segment from 1 to 5.
Human population	Statistical Institute of Belize; Biodiversity and Environmental Resource Data System of Belize (BERDS)	These data allow us to assess where habitats are most critical for protecting people and how the vulnerability of coastal communities and people with different demographics varies among zoning scenarios.
Schools and emergency services	CZMAI	These data include the location and number of schools, police and fire stations, and medical facilities. They allow us to assess where habitats are most critical for protecting emergency services related infrastructure and how the vulnerability varies among zoning scenarios.
Access/ Infrastructure	Biodiversity and Environmental Resource Data System of Belize (BERDS); Natural Capital Project	These data allow us to assess where habitats are most critical for protecting important access points and infrastructure people depend on for mobility during storms. Access points include ports, marinas, ferry, bus and taxi stations, airstrips.

Table B2.1 Coastal vulnerability input data, source and use in model

To map coastal hazard we classified the distribution of values from the vulnerability index for all segments and scenarios into quantiles that indicate areas of highest hazard (>3.54 = top 25% of the distribution), intermediate hazard (1.44-3.54 = central 50% of the distribution) and lowest hazard (<1.44= bottom 25% of the distribution).

The hazard index quantifies physical risk. In order to convert this to imperiled infrastructure, property and human life, we combined it with mapped data on information about coastal populations and emergency infrastructure and services (Table B2.2). To assess the vulnerability of the people and important coastal infrastructure, we identified where these were within 1 km of coastal segments with the highest exposure to hazards.

OUTPUT	DESCRIPTION
Coastal hazard index value	A dimensionless number that represents the relative vulnerability of coastline segments to flooding and erosion from storms and SLR.
Coastal hazard index category (Highest, Intermediate, Lowest)	Coastline segments were categorized as highest, intermediate or lowest exposure to coastal hazards based on the distribution of index values across the whole country.
Vulnerability of people to highest coastal hazard	Number of people within 1 km of the highest coastal hazard areas.
Vulnerability infrastructure to highest coastal hazard	Number of different types of infrastructure within 1 km of the highest coastal hazard areas.
Property value most vulnerable to coastal hazards	Value of property within 1 km of the highest coastal hazard areas.
Coastal protection for people	Number of people within 1 km of the highest coastal hazard areas protected by mangroves, corals and seagrass.
Coastal protection for infrastructure	Number of different types of infrastructure within 1 km of the highest coastal hazard areas protected by mangroves, corals and seagrass.
Coastal protection for property values	Value of property within 1 km of the highest coastal hazard areas protected by mangroves, corals and seagrass.

Table B2.2 Description of output data from coastal vulnerability model

Model validation

We tested the ability of the coastal vulnerability index to capture risk to people by running the model for the entire coast of the United States and comparing the results to observed data from the Spatial Hazards Events and Losses Database for the U.S. Using state as a unit of analysis and data from 1995-2010, we found a significant relationship between modeled estimates of total population exposed to the greatest coastal hazard and observed number of coastal hazard-related fatalities (N = 21 states, R^2 = 0.71 P<0.0001, Arkema et al. 2013). This analysis suggests that the number of fatalities in a region each year is proportional to the number of people most exposed to coastal hazards as estimated by our hazard index and population mapping. While we have not validated this model in Belize, this analysis enhances our confidence in using the model in Belize to forecast coastal vulnerability under alternative planning scenarios.

Limitations and assumptions

- The model does not account for processes that are unique to a region, nor for interactions between the seven variables.
- The model does not predict changes in shoreline position or configuration.
- The model does not consider any hydrodynamic or sediment transport processes.
- The model assumes that the habitat data reflect the current distribution of coastal habitats, and that habitat distribution and abundance are constant.

B.3 RECREATION

Summary

People's decisions about where to recreate are influenced by the environment. Recreational divers need suitable water quality; birders seek out sites with high biodiversity. Through its contribution to outdoor recreation, the environment provides services to people. To quantify this value of natural environments, the InVEST recreation model predicts the spread of person-days of recreation by tourists in the coastal zone. The spread is based on the locations of marine habitats and human activities, such as fishing or transportation, that factor into decisions people make about where to recreate. Behind the scenes, the tool estimates the contribution of activities and environment (e.g., mangroves, fishing) to visitation rate using a simple linear regression analysis. Because we lack empirical data on visitation to most locations, we parameterize the model using a proxy for visitation: geo-tagged photographs posted to the website flickr. Using these estimates, the model can predict how future changes to habitats and patterns of human use will alter visitation rates. Outputs from tool are maps showing current patterns of recreational use and future patterns of use under alternate scenarios.

How the model works

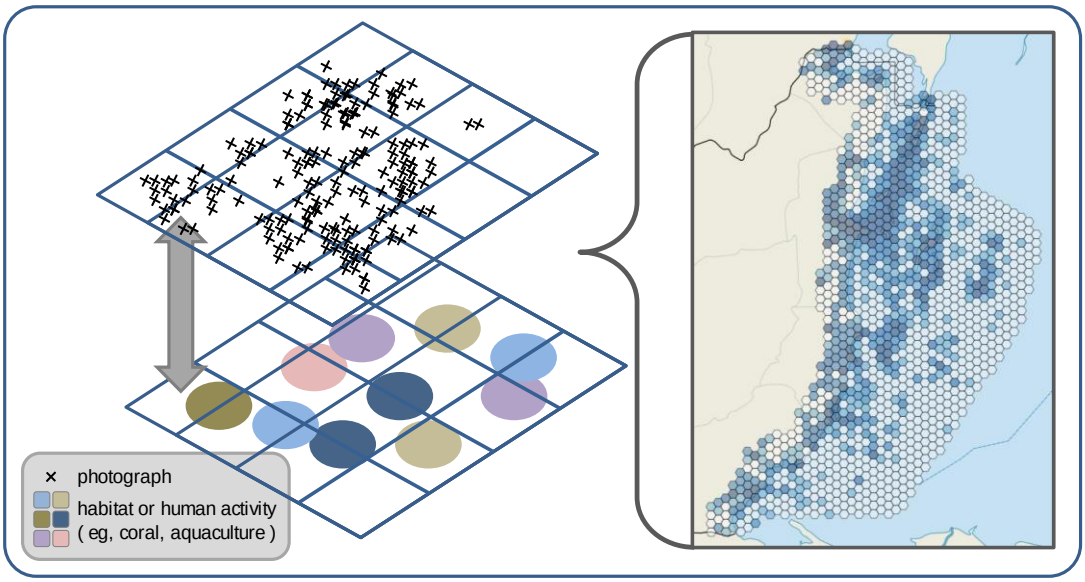

Figure B3.1 The model uses the relationships between locations of geo-tagged photographs and coverage of natural habitats and human activities to predict where in Belize tourists will visit. Darker polygons indicate more visitors.

First we conducted an initial run of the model to estimate the degree to which each attribute (e.g., coral habitat, mangrove habitat, transportation corridors; see below) relates to current visitation in the coastal zone of Belize, which we divided into 1268 hexagonal grid cells (width of 5 km between edges). Since fine-scale data on numbers of visitors is limited to a few locations (e.g.,

archaeological sites and marine reserves), we assumed that current visitation can be approximated by the total number of annual person-days of photographs uploaded to the photo-sharing website flickr. Many of the photographs in flickr have been assigned to a specific latitude/longitude. Using this location, along with the photographer's user name and date that the image was taken, the tool can compute the total annual days that a user took at least one photograph within each cell. The values of photo-person-days across all cells are regressed against the percent coverage of all attributes within each grid cell (current visitation rates and attribute coverage data are log transformed). The model estimates the extent to which visitation depends on all the input variables. For example, the model estimated that coral reefs and coastal development tend to draw visitors, as reefs are desirable to visit and tourists need infrastructure for lodging and to facilitate travel.

In subsequent model runs, the tool employs the regression coefficients (beta values) computed in the initial model run to predict visitation, given a spatial configuration of the predictors (e.g., coral reefs, coastal development etc., see Table B3.1 for input data). We used outputs from the Habitat Risk Assessment for the current and three possible future zoning schemes to determine where coral reef, mangrove and seagrass habitats were high enough quality to support tourism. We assumed that areas of habitat at high risk were too degraded to provide tourism and recreation opportunities and so removed these areas from the input maps to the recreation model. Areas of low risk were treated as fully functional habitats. Where habitats were at medium risk, we assumed only 50 % of the habitat area in each grid cell was capable of drawing visitors. We then ran the model to predict visitation to each grid cell under the current and three future scenarios.

INPUT	SOURCE	HOW THE DATA WERE USED IN THE MODEL
Photo-user-days	Total number of annual person-days of photographs uploaded to the photo-sharing website flickr from 2005—2012 Natural Capital Project	These data are used to parameterize the model. They allow us to estimate the significance and effect of each of the human use activities (see list of zones below) on visitation.
Land vs. ocean	CZMAI	These data were used to estimate the effect of land and ocean on current visitation and to predict future visitation.
Coral	CZMAI and Peter Mumby	These data were used to estimate the effect of coral reefs on current visitation and to predict future visitation.
Mangroves	World Wildlife Fund	These data were used to estimate the effect of mangroves on current visitation and to predict future visitation.
Seagrass	CZMAI	These data were used to estimate the effect of seagrass on current visitation and to predict future visitation.
Aquaculture zone	Fisheries Department, Department of Economics and CZMAI	These data were used to estimate the effect of aquaculture on current visitation and to predict future visitation.
Agriculture zone	Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies) and CZMAI	These data were used to estimate the effect of agriculture on current visitation and to predict future visitation.
Agriculture run-off zone	World Research Institute and CZMAI	These data were used to estimate the effect of agricultural run-off on current visitation and to predict future visitation.
Coastal development zone	NATCAP Project – The InSEAM Annotation Tool, Department of Environment , Jan Meerman (Biodiversity and Environmental Resource Data System of Belize - Belize Tropical Forest Studies) and CZMAI	These data were used to estimate the effect of coastal development on current visitation and to predict future visitation.
Dredging zone	Mining Department and CZMAI	These data were used to estimate the effect of dredging on current visitation and to predict future visitation.
Fishing zone	Fisheries Department and CZMAI	These data were used to estimate the effect of fishing on current visitation and to predict future visitation.
Marine transportation zone	Belize Port Authority and CZMAI	These data were used to estimate the effect of marine transportation on current visitation and to predict future visitation.
Oil exploration/drilling zone	Department of Geology and Petroleum and CZMAI	These data were used to estimate the effect of oil exploration/drilling on current visitation and to predict future visitation.

Table B3.1 Description of input data for the recreation model in Belize

We normalized the predicted visitation to each cell by dividing the total number of person-days across all cells. To estimate the total number of person-days to each cell for the current situation, we multiplied the proportion of person-days by 3,013,010. This value is based on the total number of incoming cruise (640,734) and overnight (277,135) visitors reported by the Belize Tourism Bureau in 2012 and the assumption that overnight visitors spend 8.56 days and cruise tourists spend 1 day in the country (APAMO, Kwan et al. 2010, National Sustainable Tourism Master Plan for Belize 2030, UNCTAD Handbook of Statistics). A multiplier of 0.74 was also included to discount total visitation to Belize by the proportion of person-days that tourists spend in the coastal zone (based on the proportion of all photo-person-days in the flickr database that fall within the coastal zone), such that

Total person-day = (annual overnight visitors * 8.56) + (annual cruise visitors*1)]*0.74 (Eq. 1)

To estimate the total number of person-days to each cell for the Informed Management scenario, we used a similar approach. Since the configuration of human uses in the Informed Management scenario follows the recommendation by the National Sustainable Tourism Master Plan for Belize, we calculated the total number of person-days per cell using estimates for future visitation to Belize from this plan. According to the National Sustainable Tourism Master Plan, Belize can expect to receive 1,500,000 cruise tourists and 556,000 overnight tourists if the Plan is implemented. The average length of a stay will also increase to 10.6 days per trip. Substituting these values into Eq. 1, the National Sustainable Tourism Master Plan for Belize predicts a total of 7,393,600 person-days by tourists in 2030. If visitation increases linearly between 2012-2030 there will be 6,176,769 total person-days in 2025. Thus, we calculated the total number of person-days to each cell for the Integrated Management scenario by multiplying 6,176,769 by the proportional visitation rate.

For the Conservation and Development scenarios, we estimated total person-days using a similar approach which assumes that 4,585,196 tourists will visit Belize in the year 2025. This is based on the long-term trend in visitation from 1995-2012 (BTB pers. comm. 2012), and the value corresponds with the prediction by the National Sustainable Tourism Master Plan for 3,935,961 person-days in 2020 if the Plan is not implemented.

OUTPUT	DESCRIPTION
Percent of visitors	Proportion of annual person-days of recreation by tourists in 5 km grid-cells spanning the entire coastal and marine zone of Belize. Total annual person-days is defined as the number of days of recreation by any person in a location each year.
Total number of visitors	The total number of person-days in a 5 km grid cell based on percent of visitors to that grid cell and total number of visitors to Belize.
Revenue from visitors	The revenue from visitors to a grid cell based on the total number of person-days in a 5 km grid cell and estimates of expenditures per-person per-day in Belize.

Table B3.2 Description of output data for the recreation model in Belize.

To estimate expenditures by tourists, for each cell we first apportioned total person-days into overnight and cruise visitors, then multiplied each value by the average daily expenditure rates provided by the National Sustainable Tourism Master Plan. Current (2008) expenditures are reportedly USD $133/day and $57/day for overnight and cruise visitors, respectively. Assuming that expenditures increase linearly until 2030, the National Sustainable Tourism Master Plan predicts tourists will spend USD $195/day and $83/day in 2025 under the Informed Management scenario. For the Conservation and Development scenarios, expenditures were determined using

the same method as visitation by projecting expenditures provided by the National Sustainable Tourism Master Plan (from 2000-2008) ahead to the year 2025.

Model validation

The number of tourists who visit a location is related to the number of photographs taken in the same area and uploaded to the online database flickr. This relationship, between the proportion of actual user-days and the proportion of photo-user-days, has been validated using data from 835 tourist attractions worldwide (Wood et al. in review). Note, because the model does not presuppose that any predictor variable has an effect on visitation, it is not necessary to validate their effects. Instead, the tool estimates the magnitude of each predictor's effect based on its spatial correspondence with current visitation in Belize.

Limitations and assumptions

- The model assumes that people will respond similarly in the future to the attributes that serve as predictors in the model. In other words, the assumption is that people in the future will continue to be drawn to or repelled by a given attributes to the same degree as currently.
- Some of the attributes that are used as predictors of visitation are representations of areas managed for particular human use (e.g. transportation). The model assumes that future management of the zones and the type of activities that they represent are similar to current.
- Since there are no fine-scale data on the distribution of visitors to Belize, we use photo-person-days as a proxy for the relative density of actual person-days of recreation across the coastal zone.
- Climate change impacts are not directly accounted for in model

B.4 LOBSTER FISHERY

Summary of model

Caribbean spiny lobster (*Panulirus argus*) are a heavily harvested, commercially important and widespread species that is found from Bermuda to Brazil. The model described here represents the Belizean population and can be used to explore how it responds to changes in amount of lobster habitat (i.e., seagrass, mangrove, coral reef) or in fishing pressure. Primary model outputs are gross export revenue and harvest of lobster tail.

How the model works

The population is modeled as 9 regional, linked subpopulations (one per Belize Coastal Zone Management Planning Region) connected via immigration as lobster move from mangroves and seagrasses to coral reefs.

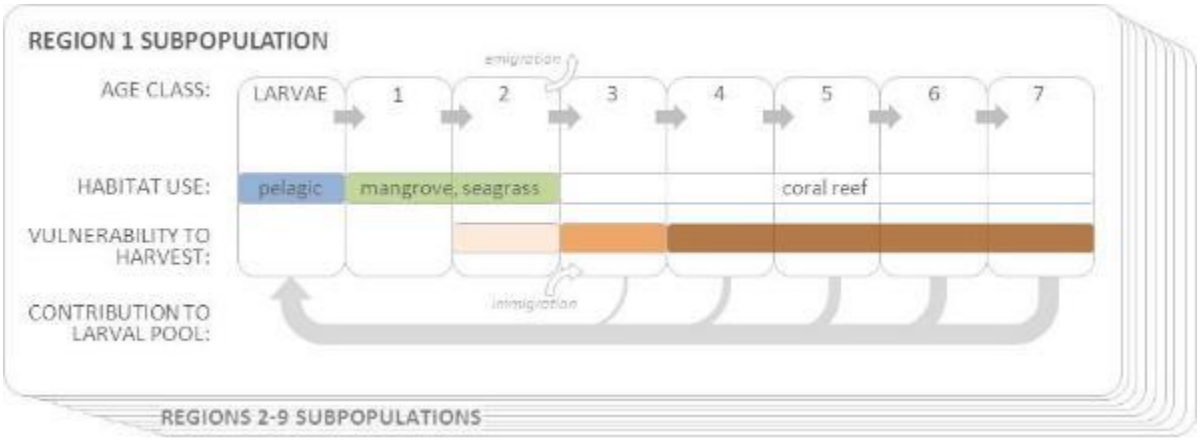

Figure B4. 1 Conceptual diagram of lobster model.

An age-structured model with Beverton-Holt recruitment is used to model the population from 2011-2050 on an annual time-step. Initial conditions are based on the amounts of mangrove and seagrass (for larvae and juveniles), and coral reef (for adults) in each planning region. Population dynamics are given by:

$$N_{a,x,y+1} = \begin{cases} \frac{\sum_x SB_{x,y}}{SB_0}\left(\alpha + \beta\frac{\sum_x SB_{x,y}}{SB_0}\right)\frac{H_{h,x,SCEN}}{\sum_x H_{h,x,SCEN}} S_{a,x} & \text{if } a = 0 \\ \left(N_{a-1,x,y} - C_{a-1,x,y}\right)S_{a,x} & \text{if } 1 \le a \le A-1 \\ \left(N_{A-1,x,y} - C_{A-1,x,y}\right)S_{A,x} + \left(N_{A,x,y} - C_{A,x,y}\right)S_{A,x} & \text{if } a = A \end{cases}$$

Where $N_{a,x,y}$ is the number of lobster of age a (A = maximum age = 7) in planning region x at the start of year y, $C_{a,x,y}$ is lobster catch (numbers). Spawner biomass, $SB_{x,y}$, is a function of numbers of lobster in each region, maturity (using a maturity ogive), and weight at age (using von Bertalanffy growth). α, β are stock-recruitment relationship parameters. $S_{a,x}$ is survival

from natural mortality from a-1 to a (note: $S_{0,x}$ is settlement survival from the larval, pelagic stage):

$$S_{a,x} = s_a \frac{T_a \sum_{H_z} \left(1 + \frac{H_{h,x,SCEN} - H_{h,x,BL}}{H_{h,x,BL}}\right)^{d_{a,h}\gamma}}{n_h}$$

Where $s_a$is baseline survival from a-1 to a: $s_0 = 1$, and $s_a = \exp(-M_a)$ if a>0; M_a is the natural mortality rate from a-1 to a. T_a indicates if a transition to a new habitat happens from a-1 to a, which is used so that changes in habitat coverage only affect lobster survival during transition to that habitat, but not once settled in the habitat. $H_{h,x}$ is the amount of habitat h (e.g., coral, mangrove, seagrass) in the region in the baseline (*BL;* i.e., status quo) system or under the scenario being evaluated (*SCEN)*. $d_{a,h}$ is the degree to which survival during the transition from a-1 to a depends upon availability of h, γ is a shape parameter, and $n_h$is the number of habitats with a $d_{a,h}$ parameter.

The harvest in numbers for each age are removed from biomass vulnerable to harvest as: $C_{a,x,y} = V_{a-1} N_{a-1,x,y-1} Ex_x$; where exploitation rate is: $Ex_x = \frac{hc_{y=2010}}{HHB_{y=2010}}(1 + E_x)$. $hc_{y=2010}$ is year 2010 harvest in pounds, $HHB_{y=2010}$ is harvestable year 2010 biomass , E_x is % change in fishing effort from baseline, and V_a is vulnerability to harvest. Harvest in pounds is the exploitation rate applied to biomass vulnerable to harvest.

Gross export revenue in a region in year 2025 is based on proportion of harvest that is exported, the product stream (tail or head meat) and price per pound of each product stream as:

$$G_{x,y=2025} = P \frac{C_{x,y=2025}}{Z}(PPP_{tail} T + PPP_{head}(1 - T))$$

where P is the proportion of harvest that is exported, Z is the conversion factor to scale a whole lobster to a processed one (sum of tail and head meat), $PPP_{tail\ or\ head}$ is price per pound of tail or head meat, and T is proportion of processed harvest that is tail meat.

To inform the design of the Belize ICZM plan, we quantified national catch and revenue in 2010 (current scenario) and for the three possible future (2025) zoning schemes. All inputs into the model remained constant for each scenario except for the amount of adult and nursery habitat (i.e., coral reefs, mangroves and seagrass) for lobster and the location where fishing for lobster occurs (see maps of human use zones for fishing Fig. 9). We used outputs from the Habitat Risk Assessment model (Figs. 17-19) for the current and three future scenarios as inputs into the lobster fishery model. Where habitats were at high risk, we assumed they were too degraded to provide nursery and adult habitat for lobster. In contrast, we assumed that 100% of low risk habitat and 50% of medium risk habitat was capable of supporting lobster, respectively. We then quantified the area of coral, mangroves and seagrass capable of providing nursery and adult habitat in each planning region and used this as inputs into the model described above.

INPUT	SOURCE	HOW THE DATA WERE USED IN THE MODEL
Lobster growth parameters	Literature values (Refs* 1-3) and fitting (e.g., stock-recruit parameters fit to steepness and initial recruitment).	A variety of parameters are used in the population dynamics model to determine the rate of growth of the lobster population. Parameters include those for: natural mortality rate, the maturity function, stock-recruit relationship, von Bertalanffy growth function, weight-length relationship, initial recruitment.
Lobster-habitat associations	User-defined based on literature values	Parameters are used to identify which ages are linked to which habitat types, the strength of those dependencies, and when a transition to a new habitat occurs.
Habitat coverage	Calculated in ArcGIS	Areal extent of mangroves, seagrasses and coral reefs in each planning region is used to determine amount of larval and juvenile settlement in each region, and immigration between planning regions. Change in habitat coverage (via scenarios) affects lobster survival.
Fishery operations	User-defined, legal harvest requirements (e.g., minimum harvestable size)	Parameters that define fishing effort, age-specific vulnerability to and selectivity of harvest are used to calculate the volume and amount of lobster harvest.
Market operations	Belize Fisheries Dept. Annual Reports (2007&2008): http://www.agriculture.gov.bz/Document_Center.html	Market operation parameters are used to determine the product stream that the harvested lobster enters and express harvest in monetary terms, as gross export revenue. Parameters include: proportion of harvest that is tail or head meat, proportion of harvest that is exported, a conversion factor between whole and processed lobster weight, prices per pound (tail and head meat).

Table B4.1 Description of input data for lobster model in Belize. References: 1) M.E. de Leon González, R.G. Carrasco and R.A. Carcamo. 2008. A Cohort Analysis of Spiny Lobster from Belize; 2) Little, S.A. and W.H. Watson III. 2005. Differences in the size at maturity of female american lobsters, *Homarus americanus*, captured throughout the range of the offshore fishery. J. Crust. Biol. 25(4): 585-592; 3) Puga, R., Hernández S., López J and León M.E. de. 2005. Bioeconomic modeling and risk assessment of the Cuban fishery for spiny lobster *Panulirus argus*, Fisheries Research 75: 149–163.

Validation or model testing

Appropriate estimates of the 2 stock-recruit parameters and the initial, pre-exploitation recruitment are critical for use of a model of this type. All 3 were estimated using by fitting to 3 time series of local catch-per-unit-effort (CPUE; model fit shown in Figure 2). Data sources for other model parameters were taken from regional literature values to ensure that the model best represents the Belizean population. A reasonable estimate of current population size (year 2010 in this model) is an important starting point for modeling future population size. The pre-2010 population was modeled using a catch time series of 1932-2010 landings, generated by inflating annual lobster tail landings (sources: Ministry of Agriculture and Fisheries', 2008 Annual Report; Fisheries Department statistics) to account for head meat, and converting from processed to whole lobster weight.

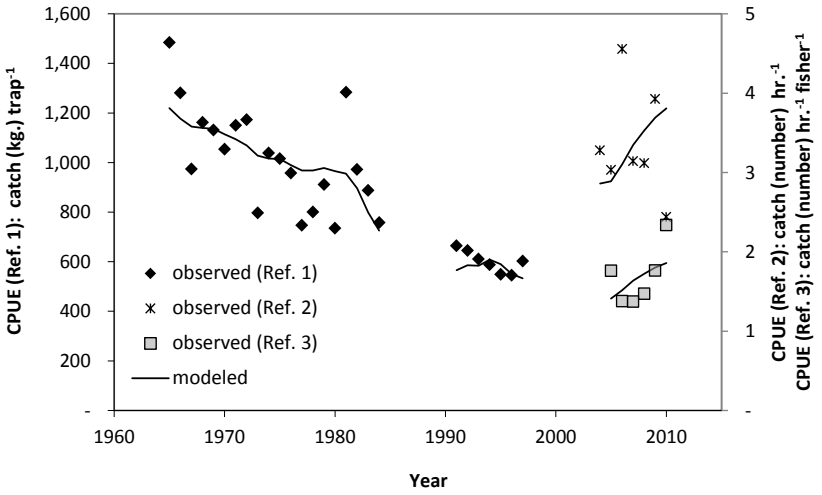

Figure B4.2 Model fit to 3 time series of catch-per-unit-effort (CPUE).

Ref.1: A. Carcamo, Jr, R.A. 2002. Report on the spiny lobster fisheries of Belize. in: Second Workshop on the Management of Caribbean Spiny Lobster Fisheries in the WECAFC Area. FAO Fisheries Report No. 715.; Ref. 2: Long Term Atoll Monitoring Program (LAMP) fishery independent surveys at SCMR, Glover's, GSSCMR and LBCNP.; Ref. 3. Glover's Reef Atoll Fisheries Catch Data Collection Program, described in "Glover's Reef Marine Reserve Fisheries Catch Data Collection Program Report for the period January 2005 to June 2010. Belize Marine Program. Wildlife Conservation Society".

OUTPUT	DESCRIPTION
Harvest (pounds)	This output is the total pounds of the tail portion of lobster harvested for each planning region in the year 2025
Gross export revenue (BZ$)	This output is the gross export revenue generated from lobster harvest (see previous output) for each planning region in the year 2025. The revenue is for the tail meat only.

Table B4.2 Description of outputs from lobster model. Outputs can be produced for any year in the model run, but default outputs are for the end of the model run (i.e., year 2050), after the model has had time to equilibrate.

Limitations and assumptions

- Population growth parameters are nationwide, not region-specific
- Habitat dependencies are obligatory (e.g., habitat substitutability is not explicit represented).
- The population responds to change in habitat quantity (i.e., areal extent of mangrove, seagrass, and coral reef), not quality of those habitats.
- The fishery is assumed to take place at the start of the year, before natural mortality
- The model assumes near knife-edge selectivity in harvest function
- Harvest selectivity (and catchabilitiy) is invariant, such that technological improvements to gear or changes in fishing practices are not modeled.
- Market operations are fixed, such that they do not vary in response to amount of harvest, shifts in market or consumer preference, or technological changes.
- Climate change impacts are not directly accounted for in model

B.5 COASTAL PROTECTION

Summary

The InVEST Coastal Protection model produces an estimate of wave attenuation and reduction in shoreline erosion provided by coastal and marine habitats. By running the model in the presence and absence of habitats or changing various characteristics of these ecosystems, such as fragmentation or areal extent, users can value coastal protection for people and property from storms and understand how coastal protection will change under different management and scenarios. For sandy beaches, the model computes the difference in shoreline retreat before and after habitat modification. For muddy beds, the model computes the volume of sediment loss and the distance inland from the shoreline where sediments losses occur. Using predicted values for erosion, the length of the shoreline, and property values, the model calculates the area and value of land protected by habitats during a single storm event. By incorporating the return period of the storm and these avoided damages, the model quantifies the value of coastal protection provided over a user-defined time horizon and the average annual value of habitats for protection.

How the model works

Assuming that waves have a deep water height of, H_0, and a period, T, it is possible to compute the evolution of wave height from offshore to the shoreline following the well-established wave equation:

$$\frac{1}{8}\rho g \frac{\partial C_g H^2}{\partial x} = -D_{break} - D_{bottom} - D_{veg}$$

where ρ=1,024 kg/m^3 is the density of seawater, g=9.81 m/s^2 is the gravitational acceleration, H is the wave height, C_g is the speed at which wave energy travels. D_{break}, D_{bottom}, and D_{veg} represent the dissipation of wave energy due to wave breaking, bottom friction, and the presence of vegetation, respectively.

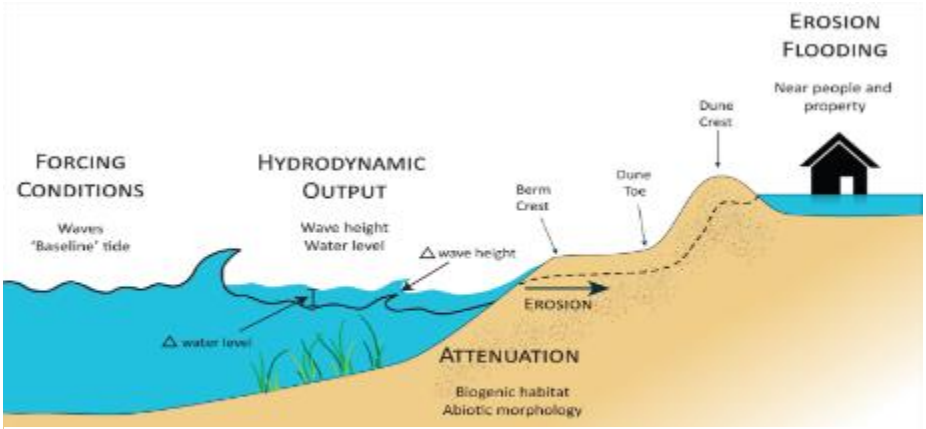

Figure B5.1 Physical processes captured in the wave and erosion model. By dissipating wave energy, or reducing wave height, and by reducing the water level in the nearshore region, the presence of healthy natural habitats leads to

Wave energy dissipation due to vegetation is

directly proportional to habitat density, submerged height and stem diameter. Coral reefs dissipate incoming wave energy in two different ways: the reef structure breaks large waves coming from deep water, and the high roughness of live coral dissipate an additional amount of energy via bottom friction. If coral reefs die, the roughness of the reef decreases and bottom friction along the reef top is reduced, leading to less wave dissipation.

The model of erosion for muddy consolidated beds assumes that the mobilization of sediment occurs above a fixed threshold of wave-induced stress on the seabed. Since this bed stress is proportional to wave height, greater volumes of sediment are expected to be eroded in the absence of protective habitat. Similarly, the distance inland from the shoreline where erosion occurs will be greater for larger wave heights propagating over land. These erosion volumes and inland distances where erosion occurs have been combined to approximate the distance over which mud sediment is mobilized and potentially entrained by wave and surge-induced currents.. The model for sandy beaches estimates shoreline retreat in the absence of habitat using published approaches (see Coastal Protection chapter in Tallis et al 2012 for review of these approaches). To estimate the difference in erosion owing to the presence of habitat, the model computes the average ratio of wave-induced water level and wave dissipation with and without habitat; these ratios are multiplied by the computed beach retreat to estimate the reduction in retreat due to the presence of natural habitat.

The model values the protection provided by habitats in terms of the avoided damages to property due to erosion from waves. The model estimates damages due to loss of land from a single storm event as:

$$D_x = E_x V$$

where E is area eroded under each scenario, x={1,2} and V is the total property value (land and structures). Because storms occur at irregular intervals over time (and vary in strength and probability of occurrence), the model allows the user to assess these benefits across a defined time horizon for a given strength of storm with an expected frequency. As changes in land use need to be considered against other possible investments and time preferences, the model considers the expected present value, *EPV*, of services provided by habitat. The calculation employs a discount rate, i, over a user-defined time horizon, τ, expressed in years. It reflects the value of the stream of avoided storm damages over time due to a change in habitat and discounts the value of those avoided damages in distant periods when the discount rate is greater than zero. *EPV* for a given storm class is calculated as:

$$EPV = \sum_{t=1}^{\tau} \frac{pD_A}{(1+i)^t}$$

where D_A is the avoided damage for a given storm class with an expected return time of T.

In Belize we used the InVEST coastal protection model to quantify and value the protection provided by coral reefs, mangroves and seagrass beds currently, and under the three possible

future zoning schemes. We modeled wave attenuation and erosion for the mainland and large atolls and cayes by dividing the coastline into over 400 segments ranging in length from a few hundred to a few thousand meters. The shoreline was segmented when the extent of mangroves, corals and seagrass defending the coastline, exposure to storms, and development varied along the coast. The Storm Hazard Assessment for Belize provided estimates of wave height and surge caused by a Category 1 or 2 hurricane, which have a return period of less than 10 years in Belize. For each coastline segment we modeled wave attenuation and erosion for the largest of the two types of hurricane. Such hurricanes have a 72% chance of occurring at least once within the next decade, so we believe that our analysis is relevant to the 2025 time horizon of the planning process). . We valued coral reefs, mangroves and seagrass for protection from a storm (i.e., avoided damages) by multiplying the areas of land protected for each segment by the average property value of developed and undeveloped land in each planning region. To quantify coastal protection provided between now and 2025, we used the avoided damages per storm event and the probability of a storm of that size occurring each year during this time horizon (see equation for EPV above).

We estimated the land protected and avoided damages provided by corals, mangroves and seagrasses currently, and under the three possible future zoning schemes. All physical and oceanographic data were the same in the four scenarios, but the biological information and amount of coastal development differed between the Current, Conservation, Informed Management and Development scenarios. We used the outputs from the Habitat Risk Assessment model for the four scenarios to identify areas of vegetative habitat that were too degraded to provide protection. We assumed that habitats at high risk were unable to attenuate waves, and that habitats at low risk were fully functional. Where mangroves and seagrass were at medium risk, we halved the density of trunks and shoots. Where coral reefs were at medium risk and high risk, we halved the friction factor of the reef and used a friction factor associated with a sandy bed, respectively; the friction factor influences wave attenuation over the reef top. We then fed the habitat information into the model as described above to produce outputs for the current and four possible future zoning schemes.

An additional protective role that habitats provide is the reduction of overland storm surge elevations and inundation owing to mangroves. Because of a lack of reliable topography data and modeling limitation, we omitted this reduction in our analysis. However, a modeling investigation of the surge protection capacity of mangroves on Florida, USA for a Category 3 hurricane found that continuous coastal mangroves reduced surge elevations at a rate of 0.4-0.5 m per km of mangrove forest (Zhang et al., 2012). Where mangroves were segmented by inland water bodies, the rate was about 0.2 m per km of mangrove forest. For the surge values applied, this corresponds to a reduction in the inland inundation limits by roughly 54-306 m or a ~23% reduction. Further, the reduction in surge depth would also lead to lower wave heights propagating inland owing to increased breaking and bottom dissipation. Consequently, we over-estimate the amount of erosion in the presence of vegetation: mangroves are likely to provide more protection than what we estimated in our analysis.

INPUT	SOURCE	HOW THE DATA WERE USED IN THE MODEL
Bathymetry	ASTER GDEM v2 – 30 meter resolution	Water depths were used in the wave model to quantify the effect of coastal habitats on wave attenuation and thus their ability to provide protection for coastal communities from storms.
Coral	CZMAI and Peter Mumby	Barrier coral reefs are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 2 and protective distance 30 kilometers.
Mangrove	World Wildlife Fund	Mangrove forests are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 1 and protective distance 500 meters.
Seagrass	CZMAI	Seagrass beds are one of the four habitat types in the coastal hazard index that determines exposure to erosion and flooding. Rank 4 and protective distance 500 meters.
Seagrass and Mangrove Physical Parameters	Literature survey (see InVEST User Guide)	These physical parameters (diameter, height, and density of seagrass stems and mangrove trunks, roots and canopy) determine the resistance of these habitats to waves and in turn quantify the ability of seagrass and mangroves to provide protection for coastal communities from storms.
Coral reef geometry	Extracted for discrete locations from Belizean coral reef profiles (Burke 1982).	The reef geometry (reef face slope, rim angle, depth at offshore edge, depth over reef top, and width of reef top) all determine how much wave energy is dissipated by the reef and in turn the amount of protection provided by the reef for coastal communities from storms.
Category hurricane and surge elevation for each region	Storm Hazard Assessment for Belize strongest category storm within a 10 year return period	The increase in coastal water level due to wind and pressure gradients associated with storms allows waves to propagate further inland before breaking due to decreasing depth.
Starting wave conditions	Storm Hazard Assessment for Belize; Coastal Engineering Manual (2008); measured fetch lengths; average depths.	Offshore Wave Height and Period....This is the starting wave which is propagated over the vegetated bathymetry profile to compute the wave height profile and erosion estimates.
Human population	Statistical Institute of Belize; Biodiversity and Environmental Resource Data System of Belize (BERDS)	These data allow us to assess where habitats are most critical for protecting people.
Property value	World Resources Institute; Natural Capital Project	These data are used to quantify damages from storms and hurricanes and to value coastal protection services provided by habitats.

Table B5.1 Description of coastal protection input data for Belize

Model validation

The wave and erosion models in absence of vegetation have been validated by their respective authors, and have been used, for the most part, in standard engineering textbooks and guidance documents (USACE, 2002; Whitehouse 2000; Dean and Dalrymple, 2002; FEMA 2004). Although the inclusion of vegetation in the wave model has been validated by various studies (see, e.g., Pinsky et al. 2013), we were not able to validate the erosion models because of a lack of observations.

OUTPUT	DESCRIPTION
Wave attenuation (m)	The reduction in wave height caused by the presence of coral reefs, mangroves and seagrass
Erosion for sandy areas (m)	Distance inland of shoreline retreat, estimated using model formulation for beaches
Erosion for muddy areas (m)	Distance inland of areas where sediment loss occurs, estimated using model formulation for muddy areas
Area of erosion (m^2)	Distance inland of erosion for muddy and sandy areas in each coastline segment multiplied by length of each segment
Avoided erosion (m)	The reduction in distance of erosion inland because of the ability of coral reefs, mangroves and seagrass to reduce waves and water level.
Land protected (m^2)	Reduction in area of land eroded because of ability of coral reefs, mangroves and seagrass to reduce waves and water level.
Avoided damages ($)	Value of property protected by coral reefs, mangroves and seagrass.

Table B5.2 Description of coastal protection output data for Belize

Limitations and assumptions

- The 1-D model assumes that vegetation and bathymetry features are uniform in the alongshore direction and any 2-D scattering is ignored.
- The model uses linear approximations and ignores any non-linear interactions due to phenomena such as wave-current interactions or the swaying of vegetation under wave forcing
- The retreat of the sandy beaches is computed using a heuristic model rather than computing direct erosional forcing including complex interaction such as feedback between the waves and the eroding sea bed.
- Surge-induced currents are neglected in estimating the amount of sediment loss for muddy beds.
- The stress threshold for mud sediment mobilization does not take into account the impact of the roots and biota: we might over-estimates sediment loss in the presence of vegetation.
- Mud sediment that is mobilized by waves is assumed to be entrained by wave and surge-induced currents. In reality some of this sediment will re-deposit on the mud bed.
- Storm surge reduction by mangroves has not been included.

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C. Monitoring Protocol for Periodic Evaluation of Implementation & Coordination Plan (ICP)

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
1.1 Coastal Research and Monitoring	1. Develop a centralized data repository for Belize on ecosystem health and human use activities within the coastal zone	Coastal Zone Management Authority and Institute	Repository established and operational by March 2017 Monitored for functionality quarterly.	Number of Data Nodes Number of data providers and users Number of documents in repository	Internet based repository linked to multiple data nodes, structured on commercial off the shelf database and operating system.	Repository accessible online Copies of signed acceptance of protocols by data providers and users
	2. Facilitate data accessibility among government agencies and non-governmental organizations for monitoring ecosystem health and human use impacts on the coastal area	Coastal Zone Management Authority and Institute with the National Integrated Water Resources Management Authority	At least 6 agencies accessing data used in monitoring ecosystem health and human use impacts on the coastal area as of March 2017; Monitored yearly.	Number of government agencies Number of non-governmental organizations	Invitation to become contributor or user of data from repository and Publication and presentation of Repository Protocols at technical events	Invitation Letters Annual Reports of the CZMAI State of the Coast Reports Program of Events

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	3. Establish a national water quality monitoring program for Belize	Coastal Zone Management Authority and Institute	National Water Quality Monitoring Program established and being implemented as of September 2017, monitoring at least 10 key parameters, at not less than 12 monitoring sites. Results monitored yearly.	Number of agencies participating Parameters: Nitrates, Nitrites, Phosphates, dissolved oxygen, salinity, temperature, pH, turbidity, *E.coli*, hardness, sedimentation, pesticide residues, chlorophyll A	MBRS-SMP CZMAI WQM Protocol	Water quality sampling schedule Physical samples in laboratory Data sheets from the field with records of physical parameters Spreadsheets and reports of processed data Map with geo-referenced sampling sites Water Quality Reports
	4. Develop a long-term, national strategy for the scientific monitoring of the health of critical habitats, including but not limited to reef, seagrass, mangroves	Coastal Zone Management Authority and Institute	Strategy which builds on existing approaches for reef, seagrass, and mangrove monitoring developed by January 2018 and jointly implemented by at least 3	Number of agencies participating in development of new strategy and its implementation.	Status Assessment SWOT Analysis Problem Tree Strategic Planning	Final strategy document List of Participants at Stakeholder Consultations

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			agencies as of June 2018.	Parameters: coral cover; algal cover; seagrass density; mangrove reforestation rate; redox potential in mangrove peat; biomass accumulation in mangrove trunks; photosynthesis (chlorophyll A); physical water parameters. Number of new monitoring parameters added.	CZMAI WQM Protocol MBRS-SMP AGRRA	Data sheets from the field with records of monitoring Spreadsheets and reports of processed data Map with geo-referenced sampling sites Critical Habitats Monitoring Reports
	6. Prepare annual State of the Coast Report to analyze trends and change in the coastal zone	Coastal Zone Management Authority and Institute	One (1) State of the Coast Report produced at least 2 times in every 5 year period	Number of State of the Coast Reports	Management-driven Data analysis and interpretation Healthy Reefs Report Card	Preparation and publication of report

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
1.2 Protected Areas Management	1. Increase the technical and management capacity of both management and co-management agencies in order to ensure sound management practices	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	One (1) Capacity Needs Assessment produced every 4 years At least two (2) capacity building exercises per year as of 2017 At least twenty (20) persons and at least five (5) agencies benefitting each year.	Number of capacity needs assessments Number of capacity building exercises and accompanying manuals or tools Number of technical and management staff benefitting Number of protected areas management and regulatory agencies benefitting	Purpose-driven Needs Assessment SWOT Analysis Problem Tree Classroom type delivery Field practical exercises Exchange programs among protected areas and among agencies International Exposure	Assessment Report Participants Registration Forms to Capacity Building Exercises Capacity building manuals and tools Evaluation Sheets of Capacity Building Exercises
	2. Support local and national initiatives to achieve the target of 20% full protection of the marine territory of	Ministry of Forestry, Fisheries, the Environment, and Sustainable Development	One (1) Public Awareness Campaign emphasizing role of protected areas in the country's national	Number of Public Awareness Campaign Number of target	Constituency Analysis/Mapping	Public Awareness Campaign Document Constituency Analysis

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	Belize		development formulated and under implementation by September 2016 At least three (3) target audiences, at least one (1) message per target audience, being delivered by at least two (2) delivery methods (medium) in at least two (2) languages each year as of 2016.	audience identified Number of targeted messages which justify 20% full protection of marine territory Number of delivery methods Number of languages in which messages are delivered.	SWOT Analysis Message Effectiveness Surveys	Report Copies of video spots, radio spots, Press Releases, documentaries, newsletters, technical reports Message Effectiveness Reports
1.3 Mangrove Protection	1. Advocate for adoption of revised Mangrove Regulations	Forest Department	Public Campaign on Adoption of Revised Mangrove Regulations containing at least three (3) target audiences, at least one (1) message per target audience, being delivered by at least two (2) delivery methods (medium) in at least two (2) languages between April and December 2016.	Number of target audience identified Number of targeted messages on adoption of revised mangrove regulations Number of delivery methods	Constituency Analysis/Mapping Message Effectiveness Surveys	Copies of video spots, radio spots, Press Releases, documentaries, newsletters, technical reports Message Effectiveness Reports Copy of Cabinet Paper

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			One (1) Cabinet Paper on Adoption of Revised Mangrove Regulations prepared and submitted to Cabinet by October 2016.	Number of languages in which messages are delivered. Date by when Cabinet Paper is prepared and submitted.		
	2. Develop an inventory on Belize's mangrove cover and distribution, which should be updated on a bi-annual basis	Forest Department	One (1) inventory with at least 90% of Belize mangrove coverage prepared by December 2017 and updated by December 2019.	Percent (%) of mangrove coverage in inventory Dates by when inventories are done	Satellite Remote Sensing of mangrove forest cover/GIS Map production	Data layers of mangrove coverage data Maps of mangrove coverage
	3. Identify areas for mangrove conservation	Forest Department	One (1) general map illustrating publicly owned mangrove coverage land worthy of conservation produced by October 2017.	Percent (%) of mangrove coverage in inventory with conservation potential Acreage of public land with mangrove coverage worthy of conservation Dates by when	Satellite Remote Sensing of mangrove forest cover/GIS Map production	Data layers of mangrove coverage data Maps of mangrove coverage

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
				inventories are done		
	4. Conduct research to capture the biomass, coverage, spatial distribution and rates of change for mangroves in Belize, and use this information available to support decisions on the issuing of mangrove alteration permits	Forest Department	One (1) map illustrating mangrove coverage for the northern, central and southern coastal regions of Belize produced by September 2019 One (1) Revised Guidelines for Mangrove Permitting produced by October 2019.	Number partnerships secured to conduct research Develop research proposal Increase or decrease in % mangrove coverage over time plotted against geographical space; Number of revised guidelines produced for the permitting of mangroves	Satellite Remote Sensing of mangrove forest cover/GIS Aerial Photography Physical Field Observations (Ground trothing)	Data layers of mangrove coverage data Maps of mangrove coverage Photographs from physical field observations Photographs from aerial photography
	5. Implement mangrove restoration projects as a means to mitigate the effects of climate change, and to ensure the delivery of coastal protection services especially in areas, such as the Central and Southern region of Belize, which are highly prone to erosion and	Forest Department	One (1) baseline established by September 2016, to substantiate mangrove coverage in central and southern Belize in 1992. At least two (2)	Percent (%) mangrove coverage in 1992 Number of restoration project proposals developed and funded	Satellite Remote Sensing of mangrove forest cover/GIS Aerial Photography of 1992	Data layers of mangrove coverage data Maps of mangrove coverage Photographs from aerial

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	inundation		restoration project proposals developed and under implementation by March 2017, which seek to restore at least 2% of the 1992 mangrove coverage baseline each year starting April of 2017.	Percent (%) mangrove coverage restored annually starting 2017, as measured against 1992 baseline	Replanting on Mangroves	photography Project proposal documents Photographs and videos of restoration activities in the field
1.4 Coastal Habitat and Species Conservation	1. Conducting an inventory of potentially resilient critical habitats/areas that could benefit from restoration programs and long-term monitoring	Forest Department,	One (1) map illustrating potentially resilient critical habitats/areas that could benefit from restoration programs and long-term monitoring produced by December 2016.	Acreage of potentially resilient critical habitats	Satellite Remote Sensing of mangrove forest cover/GIS Aerial Photography	Data layers of critical habitat data Maps of critical habitat coverage in acres Photographs from Aerial Photography
	2. Preserving critical nesting sites and foraging areas	Forest Department,	One (1) Assessment of Baseline of nesting and foraging sites conducted by June 2018 At least one (1)	Number of baselines substantiating number of nesting and foraging sites Number of management effectiveness tools using	Field observation survey On-site photography	Completed survey data Baseline Assessment Report

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			management effectiveness tool reflects findings of nesting and forging assessment	data from assessment	Management Effectiveness Tool (e.g. World Bank-WWF Site Tracking Tool	Management Effectiveness Report
	3. Decrease development activities near fragile ecosystems	Lands Department	One (1) Policy Paper prepared by June 2019 One (1) Cabinet Paper prepared and submitted by September 2019	Number of stakeholders consulted in policy formulation process Number of Policy Papers Number of Cabinet Papers Dates by when policy paper and cabinet paper are prepared	Public consultations 6-step policy formulation process	Stakeholder registrations at consultation sessions Copy of policy paper Copy of Cabinet Paper
	4. Replant sea grass in areas that have been dredged	Coastal Zone Management Authority and Institute	One (1) baseline established by December 2016, to substantiate current area requiring replanting of sea grass.	Acreage requiring replanting (baseline) Percent (%) of baseline replanted	Field Topographical Surveys Quadrats (SMP)	Reports of topographical surveys Quadrat data

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			At least two (2) seagrass restoration project proposals developed and under implementation by March 2017, which seek to restore at least 2% annually of area requiring replanting as defined in baseline.		Seagrass Replantation	Results of data analysis Photographs and detail numbers of replantation efforts as evidenced in project reports
	6. Establish a fund that is dedicated to national restoration projects	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	One (1) Fund feasibility assessment conducted by June 2018 Institutional structure of fund created by September 2018	Start-up amount of fund Number of contributors Amount per contributor Fund administration and use parameters	Cost Benefit Analysis Donor Prospect Research	Copy of Feasibility Assessment Copy of Institutional Arrangements Document
	7. Increase public awareness about the importance of threatened species to Belize and Belizeans to encourage the promotion of the species within the coastal area of	NPAS, CZMAI	Addressed under 1.3.1 Should be integrated under broader public awareness campaign in	Addressed under 1.3.1 Should be integrated under broader public awareness campaign in	Addressed under 1.3.1 Should be integrated under broader public awareness campaign in	Addressed under 1.3.1 Should be integrated under broader public awareness campaign in

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	Belize		1.3.1	1.3.1	1.3.1	1.3.1
1.5 Invasive Species Management	1. Update the Belize National Lionfish Management Plan on a regular basis (every 3 -4 yrs.), to include any new mechanism/protocol to monitor and suppress Lionfish populations in Belize. Mechanism must also be included to determine success.	Fisheries Department,	One (1) update to Lion Fish Management inclusive of evaluation framework completed by 2019 and every 4 years thereafter.	Distribution of Lion Fish Population in Belize (occurrence per geographic unit) Density of Lion Fish Population in Belize (No. of Individuals/square meter) Abundance of Lion Fish Population in Belize (density x geographic unit) Displacement of local species by Lion Fish (Ratio of Lion Fish to Local Species)	Mark and Recapture Frequency of Occurrence Linear Regression Analysis of Variance	Field Data substantiating the need to update the management plan Copy of the Updated Lion Fish Management Plan
	2. Expand the market for lionfish consumption as a means to manage the	Fisheries Department,	Market analysis conducted by September	Number of markets identified	Market prospect research	Market Analysis Report

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	lionfish population while providing an alternative		2017. Targeted campaign to promote Lion Fish consumption under continuous implementation as of December 2017, and targeting at least three markets identified in market analysis.	Number of campaign strategies defined	Survey on Lion Fish acceptability as a food source Survey of Lion Fish preference as compared to other locally available fish	Results of survey on acceptability Results of survey on preference Copies of promotional materials
	3. Permanent removal of coconut trees near prominent Booby bird nesting grounds	Forest Department with Belize Audubon Society	Feasibility and cost implications of removal determined by June 2017 At least 95% of coconut trees removed at no less than 80% of all nesting grounds	Number of nesting grounds defined Number of coconut trees removed	Survey using aerial fly overs and aerial photography Physical removal	Photographs of plant occurrence and distribution around nesting sites Survey calculations Photographs of removal
	4. Conduct feasibility studies and eradicate invasive rat population at Half Moon Caye.	Health Department with Belize Audubon Society	Baseline of current rat population established by April 2017 At least 90% of all rat eliminated by December	Number of rats occurring before eradication attempt Number of rats occurring	Trapping at randomly determined sampling sites, covering at least 80% of the Caye.	Report of baseline numbers Photograph of installed traps with trapped animal

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			2017	after eradication attempt	Descriptive statistics Correlation of number of trapped individuals between sampled sites.	Report of rat population after eradication attempt.
1.6. Fisheries Management	1. Strengthen the fisherfolk licensing system through the establishment of standards	Fisheries Department	Feasibility Assessment of standards introduction, training requirements, and cost of implementation conducted by June 2018 At least 70% of identified training needs addressed at the onset of introducing new system Continuous Implementation of the revised licensing system underway as of October 2018	Number of licensing standards introduced Number of persons trained to implement the new system Date by when new system is introduced	SWOT Analysis Critical Review of Licensing System Best Practices Stakeholder Consultations	Assessment Report Results of SWOT Analysis Results of best practice review Training Certificates of trainees
	2. Implement national roll out of Managed Access	Fisheries Department	Public consultations through-out country on	Number of stakeholder	Stakeholder	Stakeholder consultation

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	Program in all marine protected areas		roll out conducted by June 2017 Managed Access Program initiated by September 2017, in 50% of Protected Areas by June 2019 and 80% of all protected areas by December 2020	consultations held Number of fishing communities consulted Number of traditional fishermen consulted Percent (%) protected areas under Managed Access Program	Consultations Definition of catch limits within protected areas Biological response to fishing stock	reports Catch Data Analysis Reports Reports on Biological Response of Targeted fished Species
	3. Monitor quotas to ensure full compliance	Fisheries Department	Monitoring and Enforcement System established by April 2018 with quarterly reports on levels of compliance	Number of in-situ patrols Number of violations reported Number of prosecutions obtained Number of repeat offenders recorded	In-situ patrols by protected areas staff Multi-agency patrols	Quarterly Patrol Reports Quarterly TAC Compliance Reports

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	4. Secure resources to permit increased monitoring and data collection for finfish at the various landing sites	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	At least three (3) additional staff hired At least 75% of all landing sites covered in data collection Data collectors at landing sites at least 90% of the time dung fish landings	Number of staff hired Percentage (%) of landing sites monitored Frequency of presence of data collectors at landing sites during landing	Fisheries Management proposals for external funding Biometrical and Sex Data of finfish landed	Copy of proposals Contracts of new staff Completed data sheets from landing sites Descriptive Statistical and assessment of finfish Morphometric Report
1.7 Coastal Agriculture	1. Institute best management programs with agriculture and watershed stakeholders for agricultural land use in order to protect and maintain riparian forests	Agriculture Department, National Water Resources Authority	Strategy for Best Practice Agriculture in Watersheds developed and under implementation by June 2018 and revised every 3 years Agriculture in Watersheds Policy Developed by January 2018	Number of consultations held Number of farmers consulted in watersheds Number of best practices defined	Baseline Assessment SWOT Analysis Problem Tree	Copy of Baseline Assessment Results of SWOT Analysis Strategy Document Farmers Consultation Reports

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
						Copy of Policy Paper
	2. Incorporate the prescription of minimum flow standard for major watersheds into the National Water Policy	Department of Environment with Water Resources Management Authority	Assessment to determine minimum flow standards for at least 50% of all major watersheds completed by June 2017 and 100% by June 2019. Policy Paper prepared by September 2017	Number of cubic centimetres per second Percentage (%) of watershed for which minimum flow determined Date by when Policy Paper submitted	Digital/Computerized Hydrological Stations	Assessment Report Copy of Policy Paper
	3. Monitor water quality for point and non-point pollution sources in the Rio Hondo River, New River, Shipstern Lagoon and Belize River watershed on a regular basis	Department of Environment with Water Resources Management Authority	To be addressed as part of National Water Quality Monitoring Program (Section 1.1.3)), but retained to specify key monitoring locations	To be addressed as part of National Water Quality Monitoring Program (Section 1.1.3)), but retained to specify key monitoring locations	To be addressed as part of National Water Quality Monitoring Program (Section 1.1.3)), but retained to specify key monitoring locations	To be addressed as part of National Water Quality Monitoring Program (Section 1.1.3)), but retained to specify key monitoring locations
	4. Finalize and implement the National Agriculture and Food Policy for Belize 2015 – 2030	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	National Agriculture Food Policy prepared and relevant Cabinet Paper submitted by September 2016	Number of essential agricultural food products addressed in policy Date by when policy and Cabinet Paper are	Public Consultations Assessment of Agriculture and Food Best Practices	Consultation participants list and report Assessment Report

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
				submitted		Copy of Policy and Cabinet Paper
1.8 Aquaculture	1. Update aquaculture policy and regulations to reflect Aquaculture Stewardship Council guidelines	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	Proposed updates developed by June 2016 At least 80% of shrimp sector consulted in process by end of June 2016 Prepare and submit Cabinet Paper for updated policy by September 2016	Number of shrimp farming protocols proposed for standardization Percentage (%) of sector consulted Date by when Cabinet Paper is submitted	Assessment of ASC standards Public consultations	ASC Standards Copy of Revised Policy Consultation Participants List and Reports Copy of Cabinet Paper
	2. Report on the status and performance of both aquaculture and mariculture developments annually	Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	Field data collection, analysis and interpretation conducted by February in following for year last ended, and is done annually for at least 98% of all operations. Report prepared and	Number of aquaculture operations addressed in report Number of aquaculture products addressed Percentage (%) of total	On site observations Customs Export Entries Central Bank Statistics	Status and Performance Report

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			published by April of each year.	aquaculture production assessed.	SIB Data GST Records Farm Production Sheets	
	3. Formulate an Aquaculture Steering Committee, comprising of government, non-government and private sector stakeholders, to advise and guide planning future aquaculture development in Belize	Fisheries Department	Prepare Terms of Reference and Member Profiles for the Steering Committee by June 2016 Determine institutional framework for Steering committee by September 2016 Appoint committee members by October 2016 First meeting of committee by December 2016, and every 4 months thereafter	Number of profiles defined for members Number of objectives and responsibilities defined for committee Number of members appointed Number of meetings held per year	Review of Governance Best Practice for Sector Committees Review of operational procedures for sector committees	Copy of profiles Copy of institutional arrangement document Copy of appointment letters Minutes of meetings

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	4. Implement incentive programs to support small-scale aquaculture producers, and reduce pressures on wild fisheries resources	Fisheries Department	Develop National Aquaculture Strategy, inclusive of incentives for small farmers y April 2016 and updated every 4 years	Number of strategic objectives defined Number of targeted interventions defined Number of incentives defined Number of small farmers to be affected by strategy	SWOT Analysis Problem Tree Public Consultations Cost-Benefit Analysis SME Cluster Analysis	Results of SWOT Results of Problem Tree Strategy Document
1.9 Minerals Extraction and Energy Development	1. Prepare a sound National Emergency Preparation Plan for Oil Spills and Waste Oil Management	Department of Environment, Geology and Petroleum Department	Emergency Preparation Plan completed by September 2017 Prepare and Submit Cabinet Paper by December 2017	Number of management interventions for oil and waste spill defined in plan Number of international best practices used Number of stakeholders consulted	Assessment of International best practices Stakeholder consultations	Copy of Assessment report Participants list to consultations Copy of National Emergency Preparation Plan for Oil Spills and Waste Oil Management

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
				Date by when Cabinet Paper is submitted		
	2. Conduct cost-benefit analyses of developing a petroleum-based energy sector	Geology and Petroleum Department	Cost-Benefit Analysis conducted by June 2018	Number of Risks identified Number of benefits identified Number of required inputs to achieve profitability Number of alternatives identified	Standard Cost-Benefit Analysis approach Comparative Analysis of crude oil with alternatives	Report of Cost-Benefit Analysis Report of Comparative Analysis
	3. Identify viable alternatives to crude oil for energy generation	Geology and Petroleum Department	To be included as part of Cost-Benefit Analysis in Section 1.9.2. Retained here to ensure inclusion in analysis.	To be included as part of Cost-Benefit Analysis in Section 1.9.2. Retained here to ensure inclusion in analysis.	To be included as part of Cost-Benefit Analysis in Section 1.9.2. Retained here to ensure inclusion in analysis.	To be included as part of Cost-Benefit Analysis in Section 1.9.2. Retained here to ensure inclusion in analysis.
	4. Develop the scientific capacity and technical expertise to understand hydrocarbon behavior in the marine environment, and to assess spill behavior and	Geology and Petroleum Department with Ministry of Science, Energy and Technology,	Capacity Needs Assessment conducted by June 2017 Training Program	Number of needs identified Level of skills required	SWOT Analysis Problem Tree Analysis	Results of SWOT Results of Problem Tree

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	patterns in order to inform practical spill response		developed by September 2017 At least four (4) technical persons trained annually starting 2018	Number of training opportunities identified Number of persons trained on an annual basis.	MARPOL Response Training	Training Program Document Certificates of training by trainees
Strategy 2.0: Supporting Integrated Development Planning						
2.1 Coastal Area Planning and Development	1. Implement the spatially-explicit Informed Management zoning scheme in tandem to other existing land-use planning initiatives	Coastal Zone Management Authority and Institute, Physical Planning Unit	Prepare policy jointly with Physical Planning unit of Lands Department for executive level decree to integrate informed management zoning scheme and land use planning initiatives by June 2017	Number of elements of Informed Management zoning schemes integrated with existing land-use planning initiatives Number of potential overlaps eliminated Date by when Policy is prepared and adopted	Technical consultations Legal Consultations Public Consultations	Reports from Technical consultations Reports from Legal Consultations Reports from Public Consultations Policy Document
	2. Support the continued partnership and liaison with	Coastal Zone Management Authority	Revise and updated TORs for CACs and the	Number of recommendations and	CAC and Technical Advisory Council	Feedback emails

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	coastal advisory committees (CACs), the Coastal Advisory Council, and relevant planning agencies as a basis for regional coastal area management planning	and Institute	Technical Advisory Council every 2 years, or as is allowed under the CZMA Act Provide opportunity for participation and feedback to the CACs in quarterly meetings At least four (4) Regular CAC meetings per year	suggestions for updating TORs Number of opportunities that exist for CAC and Technical Advisory Council Feedback Number of CAC meetings	Performance Reviews Regular meetings	Minutes of meetings Copies of revised or updated TORs
	3. Undertake revisions of regional coastal area management guidelines on a regular basis in consultation with CACs, the Technical Advisory Council and relevant planning agencies	Coastal Zone Management Authority and Institute, Technical Advisory Council, and regional CACs **Partner(s):** Relevant planning agencies	Consultation Meetings held at least once per year to review guidelines CACs meet at least three (3) times per year Technical Advisory Council meets at least four (4) times per year Revision, circulation and	Number of consultation meetings Number of stakeholders consulted Number of CACs and Technical Advisory Council Meetings Number of suggestions and recommendations for updates	Stakeholder and partner agency consultations Assessment of lessons learned Brainstorming and agreement on suggested changes	Stakeholder participation lists Reports of stakeholder consultations with recommendations of updates Minutes of CACs and Technical Advisory Council meetings

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			publication of Coastal Area Management Guidelines done at least every two (2) years			
2.2 Coastal Population and Growth	1. Undertake initiatives to relocate people who are settled in vulnerable areas	Coastal Zone Management Authority and Institute	Map and quantify settlement in vulnerable areas and assess legal, social and economic implications of resettlement by December 2016, and continuously update the data. Prepare Resettlement Plan, compensation package, and timeline by March 2017, and update as new settlement data becomes available Define compensation target by March 2017, and update in March of every year.	Area of coastal habitats affected Number of settlements Number or persons to be affected Possible relocation options Number of risks associated with relocation Cost of relocation	Census Data Analysis Overlay of habitat satellite imagery with coastal settlements Cost-Benefit Analysis	Report of Census Data Analysis Map of over-laid data Report of Cost-Benefit analysis

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	2. Diversify income generation options to reduce the number of people who rely on the coastal resource base to support their income	BELTRAIDE	Quantify the demand for goods and services which can be met through alternatives to coastal resource use by March 2019 Assess number of employed persons to be impacted from alternative livelihood activities by June 2019 Develop turn-key business plans for Small and Medium Enterprises to diversify into identified alternatives, meeting the needs of at least 10% of the persons identified on an annual basis.	Number of goods and services that are potential alternatives Rate of consumption Number of persons Rate of availability of alternatives through SME business plans	Census Data Analysis Marketing Study Socio-economic Assessments SME Business Model	Report of Census Data Analysis Report of Marketing Study Report of Socio-economic Assessments Copies of SME Business Plans
	3. Implement proper building standards and setback distances	Physical Planning Section, Lands and Surveys Department Central Building Authority	Revise and Update Building Standards through consultative process by June 2017 Prepare and submit	Number of consultations held Number of stakeholders consulted	Public consultations Assessment of Best Practice Building Standards	Stakeholder participation lists Reports of stakeholder consultations with recommendations of

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			Cabinet Paper by September 2017	Number of standards revised and updated Date by when Cabinet Paper is submitted		updates Lessons learned from Best Practice Building Standards Cabinet Paper
	4. Limit exponential growth and expansion of communities within highly vulnerability to coastline	Physical Planning Section, Lands and Surveys Department	Revise and Update National Zoning Policy through consultative process by September 2017 Prepare and submit Cabinet Paper by December 2017	Number of consultations held Number of stakeholders consulted Number of recommendations and suggestions to revise and update policy Date by when Cabinet Paper is submitted	Public consultations Assessment of Zoning Best Practice and extraction of lessons learned.	Stakeholder participation lists Reports of stakeholder consultations with recommendations of updates Cabinet Paper
	5. Conduct regular vulnerability assessments of	Coastal Zone Management Authority	Develop Vulnerability Assessment Protocol by	Shoreline stabilization	Core sampling	Sampling data

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	the coastal area in order to understand and to assess the effectiveness of climate adaptation strategies	and Institute, National Climate Change Office	September 2016 Conduct Assessment every 2 years, covering monitoring sites in at least 60% of the coastal area	Mangrove cover Coral cover Rate of coastal erosion Rate of removal or overall coastal vegetation	Satellite imagery Aerial photography SMP	Maps of mangrove cover Aerial photographs SMP results
2.3 Beach and Shoreline Management	1. Implement restoration projects in Belize with increased investment by developers whose projects will remove vegetation that aid in shoreline stabilization	Department of Environment, Private Sector	One (1) baseline established by September 2016, to substantiate coverage of vegetation removed by development projects. At least two (2) restoration project proposals developed and under implementation by March 2017, which seek to restore at least 2% of the 2016 'removed	Percent (%) vegetation coverage determined in 2016 Number of restoration project proposals developed and funded Percent (%) vegetation coverage restored annually starting 2017, as measured against 2016	Satellite Remote Sensing of mangrove forest cover/GIS Aerial Photography Replanting on vegetation	Data layers of vegetation coverage data Maps of vegetation coverage Photographs from aerial photography Project proposal documents

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			vegetation' baseline each year starting April of 2017.	baseline		Photographs and videos of restoration activities in the field
	2. Enforce and update national policy governing the construction of piers, sea walls, jetties, groynes, harbor arms and other hard structures, and the use of soft shoreline stabilization methods	Physical Planning Section, Lands and Surveys Department	Update Policy through consultative process by September 2017 Prepare and submit Cabinet Paper by December 2017	Number of new and strengthened guidelines included in new policy Date by when Cabinet Paper is submitted	Public consultations Assessment of coastal construction best practices	Stakeholder participation lists Reports of stakeholder consultations with recommendations of updates Cabinet Paper
	3. Strengthen regulatory requirements for the full enforcement of setbacks that considers the threat of global climate change and coastal hazards related to commercial and/or residential development within the coast	Physical Planning Section, Lands and Surveys Department,	Review of Relevant Regulatory Framework by June 2017 Conduct inter-agency consultation process Prepare necessary Draft S.I. and Cabinet Paper by September 2017	Number of consultations held Number of stakeholders consulted Number of recommendations and suggestions to revise and update regulatory requirements	Public consultations Assessment of regulations Best Practice that considers impact of climate change	Stakeholder participation lists Reports of stakeholder consultations with recommendations of updates Cabinet Paper

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
				Date by when Cabinet Paper is submitted		
2.4 Marine Traffic	1. Develop a national policy on marine transportation in support of the Informed Management zoning scheme to minimize user-conflicts	Belize Port Authority	National Policy developed by June 2018 Prepare and submit Cabinet Paper by September 2018	Number of consultations held Number of stakeholders consulted Number of recommendations and suggestions to develop policy Date by when Cabinet Paper is submitted	Public consultations Assessment of Marine Policy Best Practice that considers principles of informed management zoning scheme	Stakeholder participation lists Reports of stakeholder consultations with recommendations of updates Cabinet Paper
	2. Develop and implement a national policy and supporting standards for the safe transport of hazardous	Belize Port Authority	National Policy developed by June 2018	Number of consultations held	Public consultations Assessment of Best	Stakeholder participation lists

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	chemicals in the sea		Prepare and submit Cabinet Paper by September 2018	Number of stakeholders consulted Number of recommendations and suggestions to develop policy Date by when Cabinet Paper is submitted	Practice standards for the safe transport of hazardous chemicals in the sea	Reports of stakeholder consultations with recommendations of updates Cabinet Paper
	3. Conduct Hydrographic surveys/mapping of the sea bed to better inform marine transportation routes.	Belize Port Authority	Develop proposed methodology, timeline and implementation plan for hydrographic mapping by June 2017 Develop MOU with at least two (2) competent hydrographic agencies to implement proposal by December 2017, and initiate implementation by March 2018	Bathymetric profile of sea floor in meters Number of channels Number of shoals Direction and strength of current patterns in feet per second	Depth Sonar Maritime topography and contouring GPS Request for Partnerships	Data from sonar, topography, GPS Navigation Map/charts MOU between partners

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			Update navigational charts by March 2019	Number of partnerships Number of charts updated		
	4. Update navigational charts for Belize to improve boating safety.	Belize Port Authority	At least three (3) new navigational charts produced by March 2019	Number of new charts produced	Technical cartography	Physical copies of navigational charts
2.5 Marine Tourism and Recreation	1. Implement the National Sustainable Tourism Master Plan for Belize 2030 in conjunction with the recommended Informed Management zoning scheme for sustainable marine recreation and tourism	Ministry of Tourism & Civil Aviation,	Develop National Tourism Act, which reflects the principles and vision of the National Sustainable Tourism Master Plan for Belize 2030 by June 2016 Conduct broad sector consultations on draft Act between April and June 2016	Number of consultations held Number of stakeholders consulted Number of recommendations and suggestions on Draft Bill Date by when Cabinet Paper is submitted	Public consultations Assessment of Best Practice of Sustainable Tourism Acts regionally and globally	Stakeholder participation lists Reports of stakeholder consultations with recommendations for Draft Tourism Bill Cabinet Paper
	2. Develop and support further sustainable tourism	Ministry of Tourism and	Define, prioritize, and implement activities	Number of direct linkages between NSTMP and	Direct comparison of	STP Loan Agreement

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	management through products from the STP 2 Project	Civil Aviation	under STP to build on policy priorities defined in National Sustainable Tourism Master Plan at the level of Project document and Loan Contract by January 2016.	STP 2.	content and outputs	STP Project Progress Reports
2.6 Marine Dredging	1. Finalize and implement a National Marine Dredging Policy	Ministry of Science, Energy and Technology, Geology Department	Finalize Policy by June 2016 Public Consultations held between January and June 2016 Prepare and submit Cabinet Paper	Number of consultations held Number of stakeholders consulted Number of recommendations and suggestions on policy Date by when Cabinet Paper is submitted	Public consultations Assessment of Best Practice of Marine Dredging regionally and globally	Stakeholder participation lists Reports of stakeholder consultations with recommendations for Draft Policy Cabinet Paper
	2. Identify alternative sources of dredged material and access routes prior to	Geology Department	Prepare National Source Document on Alternative Dredge Material by June	Number of sources	Inventory based on Geological Analyses	Inventory Report

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	the issuance of licenses and permits for obtaining dredged spoils		2017	Coordinates of sources Cost of sources Risks of alternative sources	Comparative Cost Analysis Collateral Risks associated with movement of alternatives	Report Comparative Cost Analysis Risk Assessment Report
	3. Scrutinize applications for dredging activities within protected areas (MPAs, Natural Monuments) and World Heritage Sites	Mining Unit, Ministry of Natural Resources and Agriculture	Dredging Application Evaluation Checklist developed by June 2017 Consultations held between January and June 2017	Number of consultations held Number of stakeholders consulted Number of recommendations and suggestions on Checklist	Public consultations Assessment of Best Practice of Dredging within protected areas and World Heritage Sites	Stakeholder participation lists Reports of stakeholder consultations with recommendations for Checklist Best Practice Assessment Report
2.7 Disaster Risk Management	1. Develop a comprehensive inventory of people and property located within vulnerable coastline	NEMO	Inventory developed by June 2018	Number of people Number of properties	Population Census Data Analysis	Report on Population Census Data Analysis Report on Land Use Data

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
				Number of critical coastal habitats affected	Land Use Data Analysis Satellite Imagery	Analysis Map of Satellite Imagery
Strategy 3.0: Building Alliances to Benefit Belizeans						
3.1 Collaboration in Enforcement and Monitoring	1. A comprehensive review of the capacity in Government, NGOs and stakeholder communities to identify available options for optimal resource management	**Lead:** Ministry of Agriculture, Forestry, Fisheries, Environment and Sustainable Development	Capacity Assessment and Recommendations for Optimal Resource Management conducted by June 2017 Consultation with partners on recommendations conducted between October 2016 and June 2017	Number of areas where capacity building is needed Number of Government and NGO agencies to benefit Number of persons to benefit Number of stakeholders consulted	Needs Surveys Stakeholder Consultations Assessment of Optimal Resource Management best practice	Survey results Stakeholder participation lists Reports of stakeholder consultations with recommendations for capacity building Best Practice Assessment Report
	2. Enlist the aid of agencies and groups, in addition to those in co-management agreements, such a communities and	**Lead:** Forest Department, Fisheries Department,	National Protected Areas Effectiveness Working Group created by December 2017	Number of profiles defined for members	Best Practice for Sector Working Groups	Copy of profiles Copy of institutional

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	stakeholders in research, education and enforcement effort as a means to improve the effectiveness of protected area management		Terms of Reference and member profiles created by June 2017 Appointment of members by September 2017 Meetings twice per year	Number of objectives and responsibilities defined for the Working Group Number of members appointed Number of meetings held per year	Review of operational procedures for sector working groups	arrangement document Copy of appointment letters Minutes of meetings
	3. Provide special training for enforcement officers and partner stakeholder groups to improve vigilance	**Lead:** Forest Department, Fisheries Department,	Develop Training Manual and Schedule by June 2017 Execute Training as of September 2016, with at least 10 trainees in each session, and at least one (1) session per year	Number of enforcement topics Number of training sessions Number of trainees	Classroom delivery Practical in the field Take home reading and assignment	Copy of manual Training program Certificates of trainees
3.2 National Network for Managing the Coast	1. Seek formal means for all application impacting the coastal zone to be submitted to the Coastal Zone Advisory Council by the relevant	Coastal Zone Management Authority and Institute with the Solicitor General's office	Feasibility Assessment of creating legal instrument under the CZMA Act conducted by June 2016	Number of legal options identified Number of consultations	Legal SWOT Analysis Public consultations	Report on Legal SWOT Analysis Report on Public

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	permitting agencies		Consultations with at least 10 key partner agencies between July and September 2016 Draft S.I. and Cabinet Paper submitted by March 2017	Number of partners Date of S.I. and Cabinet Paper	Assessment of legal best practice in coastal zone management	consultations and recommendations Report on Assessment of legal best practice Draft S.I. and Cabinet Paper
Strategy 4.0: Adapting to Climate Change						
4.1 Socio-ecological Vulnerability and Resilience	1. Increase and strengthen the capacity of the Coastal Zone Management Authority and Institute to ensure developments within the coastal areas of Belize include an adaptation strategy to mitigate the effects of climate change	**Lead:** Coastal Zone Management Authority and Institute, National Climate Change Office	Training priorities to CZMAI staff in Climate Change Mitigation and Adaptation Strategies defined by June 2016 At least 80% of the CZMAI staff trained in at least three (3) climate change mitigation and adaptation strategies by December 2016	Number of training areas Number of staff trained Date for training to be complete	Classroom delivery Practical in the field Take home reading and assignment	Copy of training materials Training program Certificates of trainees
	2. Improve and encourage inter-agency cooperation on matters pertaining to climate	Coastal Zone Management Authority and Institute, National	At least three (3) MOUs developed to formalize interagency cooperation	Number of partners	Direct invitation	Letters of invitation

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	change adaptation	Climate Change Office	on an annual basis starting 2016	Number of MOUs Number of areas of collaboration	Expression of interest Inquiry of shared interest	Exploratory emails Signed MOUs
4.2 Socio-economic Adaptation Capacity	1. Update the Belize National Climate Change Adaptation Policy on a periodic basis, and as new climate change science becomes available	National Climate Change Office	Conduct consultative process to update policy between June 2017 and March 2018 Cabinet Paper submitted by June 2018 the Belize National Climate Change Adaptation Policy updated by December 2018	Number of technical and legal opinions on policy Number of consultations Number of stakeholders Date of Cabinet Paper and final update	Public consultations Assessment of regional and global trend in Climate Change Adaptation Policy	Report on Public consultations and recommendations Report on Assessment of climate change trend Cabinet Paper Updated policy
4.3 Prioritization of Ecosystem-based Adaptation	1. Further development of the coastline should be avoided, especially in vulnerable areas such as the	Physical Planning Section, Lands and Surveys Department,	Develop and legislate zoning plans for coastal areas consistent with EBA by September 2018	Number of legal options identified	Legal SWOT analysis	Report on Legal SWOT Analysis

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
	Belize and Corozal districts		Conduct required public consultations between January 2017 and June 2018 Prepare and submit Cabinet Paper and Draft S.I. by August 2018	Number of consultations Number of partners Date of S.I. and Cabinet Paper	Public consultations Assessment of legal best practice regarding developments in the coastal zone	Report on Public consultations and recommendations Report on Assessment of legal best practice Draft S.I. and Cabinet Paper
	2. Incorporate ecosystem-based adaptation strategies in management planning in all coastal and marine sectors	Coastal Zone Management Authority and Institute with all relevant planning agencies	Develop White Paper on Ecosystem Based Approach in Management Planning produced by June 2018 Technical consultations with productive sectors in the coastal zone conducted between 2016-2018 with participation of at least 5 productive sectors Develop Ecosystem Based Guidelines for Coastal Planning by	Number of White Papers produced Number of consultations Number of partners Number of guidelines produced Date of Policy and	Policy and Legal SWOT analysis Public consultations Assessment of legal best practice regarding the integration of ecosystem based approach in to coastal management	Report on Policy and Legal SWOT Analysis Report on Public consultations and recommendations Report on Assessment of legal best practice Draft Policy and Cabinet Paper

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
			September 2018 Policy and Cabinet Paper on Ecosystem Based Guidelines for Coastal Planning produced and submitted by March 2019	Cabinet Paper		
4.4 Governance as a tool for Building Resilience	1. Accurate stock-taking of tropical forest and mangrove cover to pinpoint fragmentation and rates of carbon sequestration	Forest Department	Stock-taking of tropical forest and mangrove cover conducted by June 2018	Percent (%) Mangrove cover Rate of photosynthesis Chlorophyll A	Satellite Imagery Aerial photography	Maps of Satellite Imagery Photograph from Aerial photography Stock-taking report
	2. Explore options for the sale or trading of carbon credits on the international markets	National Climate Change Committee	Feasibility Study of Carbon Credit Markets conducted by September 2018	Number of markets Size of market Value of market	Market Prospect Research Market Penetration Research	Report of Market Prospect Research Report of Market Penetration Research Cost-Benefit Analysis

Topic	Actions Required	Lead Agency(ies)	Indicator/Target(s)	Metric(s)	Suggested Method	Means of verification
				Accessibility of market Vulnerability of markets	Cost-Benefit Analysis	Report
	3. The passage of legislation in support of REDD+ and Blue Carbon initiatives	National Climate Change Committee	Public Consultations held by June 2018 Cabinet Paper submitted by September 2018 Draft Legislation tabbed at House of Representatives by December 2018	Number of legal options identified Number of consultations Number of partners Date of Cabinet Paper Date Draft Bill tabled to the House	Legal SWOT analysis Public consultations Assessment of legal best practice regarding REDD and Blue Carbon initiatives	Report on Legal SWOT Analysis Report on Public consultations and recommendations Report on Assessment of legal best practice Cabinet Paper and Draft Bill