

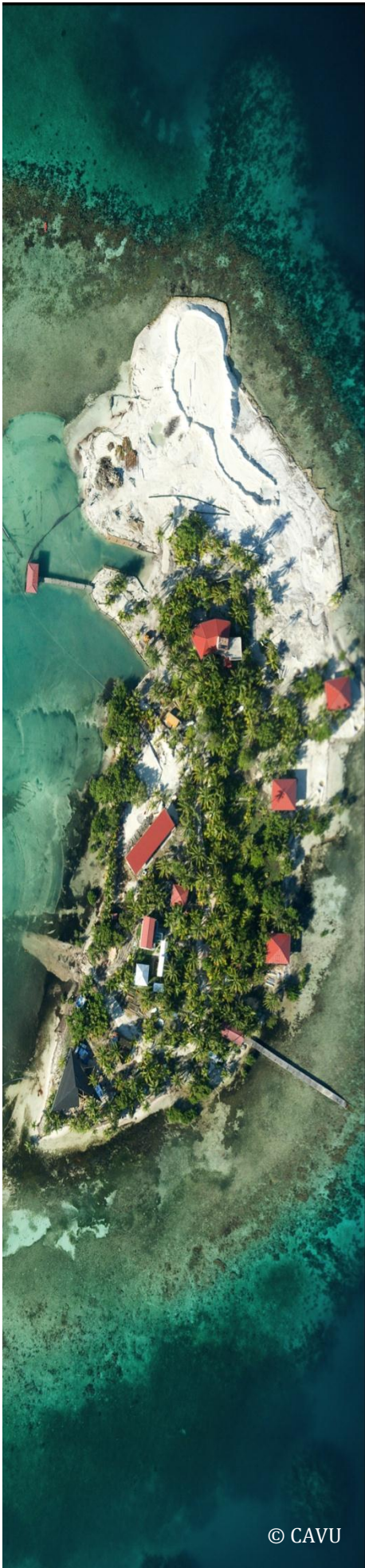
An aerial photograph of a coastal lagoon. The water is a deep, dark blue in the center, transitioning to lighter turquoise and green near the shore. A white boat is moving through the water, leaving a prominent white wake. The surrounding land is covered in dense green vegetation.

# InVEST Scenarios Case Study: Coastal Belize

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part of the series:

## Developing Scenarios to Assess Ecosystem Service Tradeoffs

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This case study highlights a real-world example of developing scenarios to inform coastal and marine spatial planning decisions. In this example, stakeholders engaged in an iterative process of scenario development, data were collected, ecosystem service impacts were assessed, and the results were used to inform national marine policy decisions in Belize. The case study offers background on the policy context and goals, and then delves into the experience with scenarios and draws lessons.

### Background

Belize is one of the jewels of the Caribbean, known for its Mayan temples, lush forests, and remarkable coastline. Its coastal zone contains a rich diversity of habitats and attractions, including three offshore atolls, coastal plains and lagoons, mangrove forests, seagrass beds, coral reefs, and over 300 cays. This highly productive coastal zone is home to 35% of the population of Belize as well as endangered species like the West Indian manatee, American crocodile, sea turtles, and several bird species.

With over 280 km of barrier reef, Belize is home to the planet's second longest unbroken reef system. World-renowned snorkelling and diving draw around 900,000 tourists to the region annually, driving construction of new coastal development, airports, urban areas, and cruise ship ports. The same coastal ecosystems also support several commercial, recreational, and subsistence fisheries.

Despite the importance of Belize's coast, little integrated planning was done to ensure that the existing uses of coastal resources did not trigger conflicts among industries and communities. In 1998, the government established the Coastal Zone Management Authority and Institute (CZMAI) and gave it the mandate to develop a national Integrated Coastal Zone Management Plan (ICZMP). Yet ten years later, no plan existed.

In 2010, CZMAI began work on an ecosystem-based plan intended to sustainably develop coastal resources for the current and future benefit of all Belizeans. CZMAI partnered with WWF and the Natural Capital Project (NatCap) to help them use the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) software suite to form a management plan that was scientifically and economically sound. The aim of the collaboration was to:

- Understand and map how people currently use the coastal zone and marine waters of Belize,
- Map and value coastal and marine ecosystem services now and in the future,
- Create an ecosystem-based plan that provides guidance for spatially explicit management of coastal resources for multiple uses, including coastal development, conservation, and fishing.

### **What policy questions did the InVEST analysis set out to address?**

The ICZM Plan serves as a guideline for future permitting and development in the coastal zone. Once approved by the National Assembly, the plan must be revised every four years. The goal of the Plan is to recommend actions that ensure sustainable coastal development through a balanced mix of conservation and use. Permitted activities should support economic growth while promoting the long-term viability of the country’s treasured barrier reef and coastline, and bolster uses of the coast that provide enduring benefits to Belizeans.

The Plan includes two operational components: (1) a set of management guidelines; (2) a zoning scheme for national and regional jurisdictions, which pinpoints permissible activities and uses in specific areas. Zones include 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. The zoning scheme is intended to encourage management that will minimize conflicts arising from competing interests and uses of the coastal zone.

To develop the Plan, CZMAI, WWF and NatCap used InVEST to help answer several questions:

1. How are a diversity of human activities, e.g. coastal development and marine transportation, likely to affect key ecosystems and the services they provide for Belize?
2. How will alternative development and conservation strategies and management recommendations affect key ecosystem services for Belize?
3. Where should selected zones – or areas designated for a particular purpose or use – be located or prohibited to maximize economic benefits and also limit environmental degradation?

Using InVEST, the work team assessed the current distribution of key ecosystem services and calculated estimates of their value. Scenarios were developed to reflect possible future spatial plans and activities in coastal zones, and InVEST was used to assess changes to ecosystem service provisioning under these various conditions. The complete process took a team of seven scientists and planners about three years.

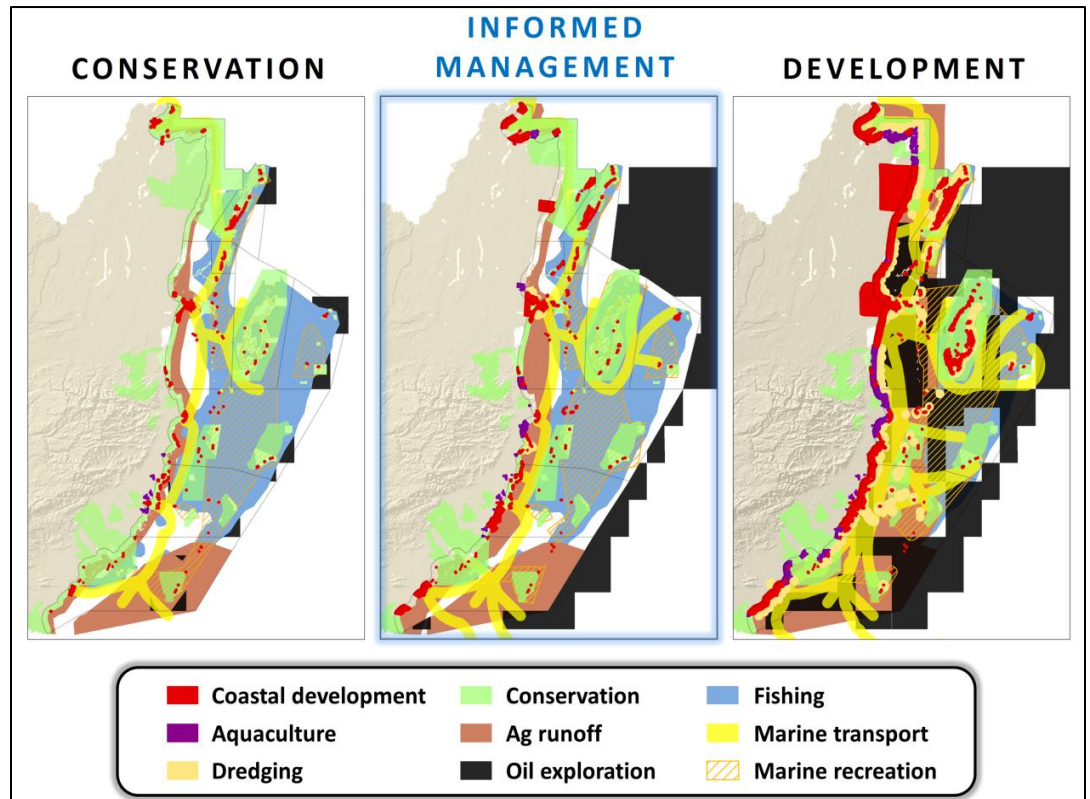
### **What scenarios were selected?**

Scenarios were developed to investigate the consequences of alternative planning policies and inform the Belize ICZM Plan. Scenarios were envisioned as possible

alternative zoning schemes that emphasized different conservation and development strategies.

The iterative process involving policymakers, stakeholders and scientists meant that scenario objectives and composition changed over time to reflect improved data sources, local knowledge, and outputs from InVEST models. At the end of the process, three contrasting scenarios were developed (see figure 1).

**Figure 1.** Alternative future scenarios used to design the ICZM Plan



**Conservation:** This scenario prioritizes a vision of long-term ecological health through environmental preservation of existing ecosystems through 2025. It is intended to represent the view of environmentalists.

**Development:** This scenario presents a vision of rapid economic development based on natural resource utilization and urban expansion through 2025. It prioritizes immediate development needs and the interests of coastal developers and extractive industries over the proactive preservation of ecosystem services. As the scenario was developed over time, it came to represent possible construction and development that could occur without zoning guidelines. This plan illustrates the many conflicting and overlapping coastal and marine uses proposed by various industries and interests.

**Informed management:** This scenario represents a policy supporting sustainable development of coastal resources to ensure future economic benefit for Belizeans, implemented through 2025. Informed management blends environmental conservation goals with current needs for coastal development and marine uses that relate to Belize’s top industries. This scenario was originally called “middle-of-the-road,” and then “compromise scenario,” to reflect a compromise between conflicting viewpoints of environmental preservationists



and economic development interests. Eventually, it was developed into a science-based zoning scheme for maximizing economic returns from key coastal resources while minimizing environmental impact and, where possible, enhancing ecological health. Importantly, this scenario integrated the views of a broad range of stakeholders and was refined using ecosystem service information from InVEST. It became the final zoning scheme incorporated into the coastal zone management plan.

### How were scenarios developed?

CZMAI defined the goals of the scenario development process based on existing policies, such as the Coastal Zone Management Act, and stakeholder interests. Planning required addressing multiple sectors, ecosystem benefits, and spatial consideration of activities.

Scenarios were developed as part of a science-policy process with substantial stakeholder engagement and input. Over two years, three distinct work streams were cultivated to develop and refine scenarios. These work streams occurred in parallel, each drawing on the advances of the other two.

#### 1. Data and information gathering

To begin, the team compiled the first comprehensive map of human activities and coastal and marine ecosystems for Belize. Spatial data were acquired through government agencies, research centers and universities, trade associations and environmental organizations. This information was used to create a map of the coastal zone and its current uses, which provided a starting point for creating future scenarios. CZMAI consolidated this information into broad categories of human use for zoning. For example, the marine transportation zone included cruise ship lanes, commercial shipping lanes, and water taxi routes. In total, CZMAI identified 9 coastal planning zones (figure 2). Local data about the location and intensity of human uses was continuously incorporated in the scenario development process through stakeholder engagement.



Figure 2

#### 2. Stakeholder engagement and review

After an initial round of stakeholder meetings in the nine coastal planning regions (figure 3), CZMAI designed three possible future zoning schemes to identify tradeoffs among alternative stakeholder visions and values. Given the contrast between stakeholders advocating for expansive environmental protection and those pushing for expanded economic and development options, the team developed visions that depicted:

1. A “conservation heavy” future, in which preservation of ecosystems and biodiversity were heavily favored over development of the coastline and other economic activities;
2. A “development heavy” future, in which all economic activities expanded without regard for natural capital and conservation;
3. A “middle of the road” scenario, which combined elements of the other scenarios in a compromise between the two extremes. After an extensive process of stakeholder review and ecosystem service modeling, this scenario was revised and renamed the “informed management” scenario (see figure 1).

Stakeholder engagement was conducted region by region, and was primarily coordinated through Coastal Advisory Committees (CACs). These CACs represented multiple sectors and interests – from tourism to fishing to conservation – and convened regular meetings to offer recommendations to CZMAI for their respective regions.

CZMAI gathered information on stakeholder values and needs through regular meetings and presentations. Participants in public forums discussed preferences for coastal development, conservation, and their desires for spatially explicit information about different human uses of the Belizean coast. CZMAI and NatCap then combined the input from stakeholders with data and maps on current distribution and types of uses, economic forecasts, and existing government plans (e.g. the National Sustainable Tourism Master Plan for Belize). The result was an initial set of maps and descriptions for each of the nine planning regions, and three possible future scenarios (see figure 1).

At a second round of stakeholder engagement through CAC meetings, InVEST training and public consultations, CZMAI presented the scenarios and requested feedback. Stakeholders provided local information about possible human uses and more specific preferences for the future, including the intensity and location of human uses. They also asked for specific changes to test alternative development plans or natural resource uses. For example, in two regions stakeholders debated whether to build or expand ports. These infrastructure changes were included in the “development” scenario but not in the “conservation” one.

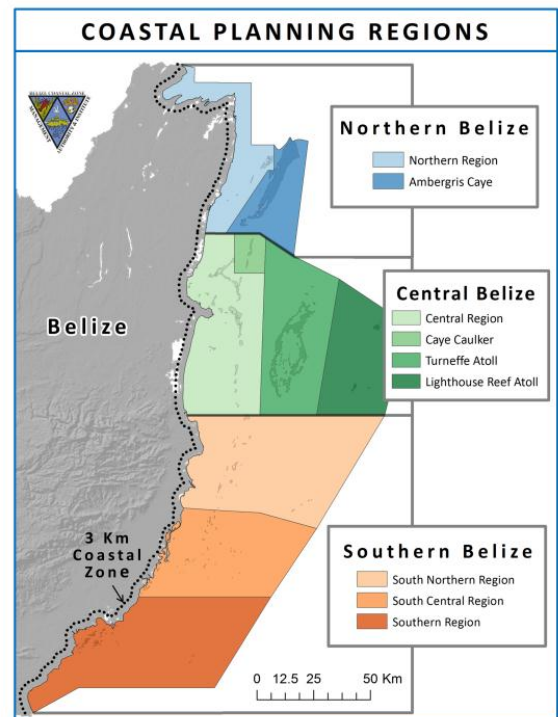


Figure 3 Belize’s nine coastal planning regions.

In many planning regions, developing the first version of scenarios was challenging; policymakers and stakeholders were afraid that their suggestions or visions were unrealistic or controversial. Many stakeholders also found it difficult to think about the future in terms of mapped spatial changes.

To overcome these challenges, the team initially developed very simple scenarios to “put something on paper” and then encouraged an iterative process of refining them. NatCap developed a game called “Best Coast Belize” to help stakeholders understand what scenarios are and how alternative spatial development decisions can affect natural capital. In addition, NatCap created an online mapping tool, InSEAM, to help stakeholders map and discuss possible future changes to the coast. InSEAM's code is freely available and NatCap is planning future improvements to the software (<http://code.google.com/p/invest-natcap/>).



CZMAI staff on a panel at an InVEST training

In some regions, CACs conducted additional interviews or field trips in order to tailor scenarios to answer realistic questions about future development and restoration options. CZMAI also worked with stakeholders to investigate where conflicts among uses might occur. For example, in the Northern Region, CZMAI sought to understand where coastal resort development would increase erosion rates from mangrove removal and impact recreational areas like beaches.

Scenarios were mapped by CZMAI and NatCap scientists using ArcGIS and reviewed by stakeholders over several iterations. Over the course of a year, the scenarios were honed to focus on particular options or problems. Final feedback from stakeholders was gathered during a 60-day public comment period for the ICZM Plan.

### **3. Ecosystem service modeling and mapping**

The third and final work stream was ecosystem service modeling and mapping. This process helped the team to understand the impacts of alternative scenarios and, ultimately, to hone the “informed management” scenario to develop an ecosystem-based zoning scheme. InVEST models for habitat risk, coastal protection, spiny lobster fishery, and tourism and recreation were used to identify places in the “informed management” scenario where the location, extent and intensity of human activities could be adjusted to improve ecosystem service outcomes. These changes were made continuously to inform the management decisions in the zoning scheme and achieve CZMAI’s objectives of sustainable development for the ICZM Plan.

#### **How were scenarios translated into coastal and marine use maps?**

In the first stage of data gathering, the team used digitized satellite imagery of the Belizean coast in a geographic information system (in this case, software

programs QGIS and ArcGIS) to map data layers provided by government agencies, university researchers, and environmental organizations, which illustrated existing coastal and marine ecosystems and uses. These layers were then grouped by zoning category (see figure 2) to create a map of implied coastal zones that was easier to analyze and use for spatial planning decisions than individual layers. For example, commercial fishing, subsistence fishing, and recreational fishing for species such as tarpon, permit, spiny lobster, and conch were grouped into a “fishing” zone; data about snorkeling, scuba diving, and swimming were incorporated into a single “marine recreation” zone.

The three future scenarios (conservation, development, and informed management) were created by demarcating these zones in different ways and overlaying the data layers. In particular, the team worked with stakeholders to change the location and size of zones (e.g. where fishing is permitted and how much catch is allowed or expected) from the original “current” map (circa 2010). This “current” map was used as a baseline for comparison when modeling future changes.

Because of the nature of the Coastal Zone Management Act – which included requirements for regional management recommendations and stakeholder engagement in planning – and the inputs, these alternative scenarios were mapped for each of the nine planning regions. These maps were shared with regional stakeholders for review and feedback and then “stitched” together into national scenario maps to run models and compare ecosystem service outcomes for the entire Belizean coastline. Ecosystem service results (e.g., catch and revenue from lobster fisheries) were eventually provided for both the national and regional levels (figure 4).

Stakeholder inputs were gathered through Coastal Advisory Committees (CACs) and public consultations. They were mapped using a variety of methods: digitizing paper drawings, incorporating input layers drawn using InSEAM and translating oral inputs into a GIS or into ecosystem service models. In early regional meetings, CZMAI shared maps of the regions with stakeholders to draw locations of fishing camps or mangrove removal. These maps were scanned and converted to .jpg files, and then used to create new layers or shapes in ArcGIS. The team also used Google Earth to create data layers (e.g., a coastal development layer).

To help incorporate extensive stakeholder knowledge and preferences accurately, NatCap created InSEAM – an online mapping tool based on Google Maps that enables people to collaborate virtually to add and categorize shapes, lines, and points to a base map. InSEAM will be available online in 2014. Although some data were collected through InSEAM, few stakeholder groups continued to use the tool beyond initial meetings. This was attributed to the newness of the tool, a lack of follow-up by the team, and time constraints on stakeholders. In addition, CZMAI opted to develop maps with GIS specialists directly inputting stakeholder comments into a GIS as points, lines, and shapes.



The final method was the one most often used by the team: translating inputs directly into ArcGIS. CZMAI held three rounds of stakeholder meetings related to the coastal zone planning process, and received inputs to incorporate into scenarios during each round. At each CAC meeting and public consultation, meeting minutes and notes were taken, which were later mined by the team to modify the scenarios by changing the location, size, and definition of zones. At many of these meetings, CZMAI asked stakeholders for specific comments and questions about the placement of particular activities in the scenarios.

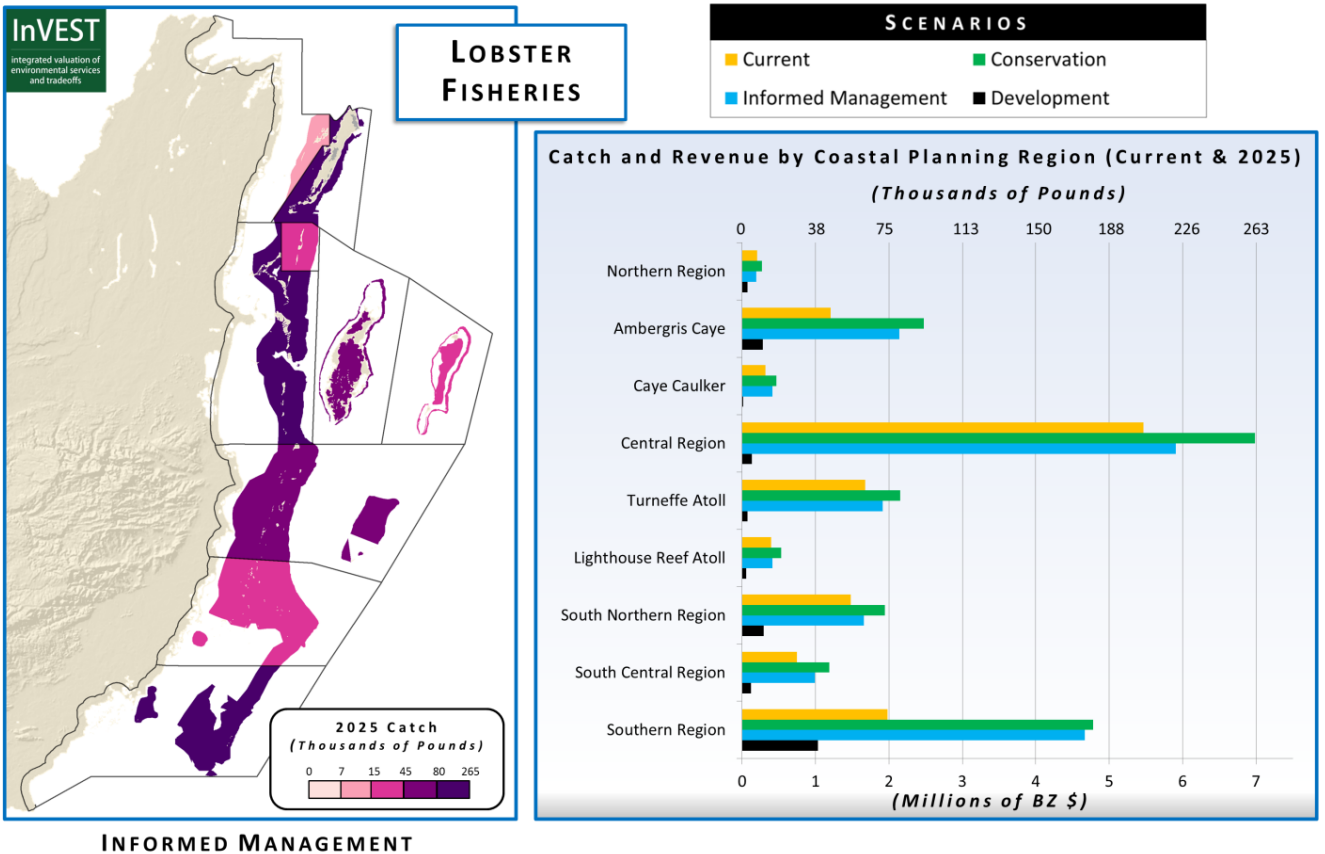


Figure 4 InVEST outputs for lobster fisheries

The above national map illustrates the expected distribution of spiny lobster catch in 2025 under the “informed management” scenario. The bar chart shows how spiny lobster catch and resulting revenue are likely to differ by region under alternative zoning scenarios. Informed management is represented in turquoise, which indicates an increase in revenue from the “current” map and better returns than the “development” scenario.

Changes to existing zones were made to visualize input from stakeholders and government planning and policies, using spatial and quantitative data where possible. These changes were made on the national map according to “rules” – e.g., which stakeholder preferences were incorporated when there were conflicts – that helped define change from the baseline to 2025 (about 15 years). Additional rules were developed to ensure that changes to existing uses were feasible and consistent with the vision of each scenario. One resource that assisted in this process was a matrix of planning zones that identified compatible

activities that could overlap (e.g. marine transportation and fishing), and zones that generated conflicts, and could not overlap (e.g. dredging and conservation). Science and policy advisors also reviewed changes to ensure that they were feasible futures for Belize.

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, helped refine the rules and zones, and provided better data and information for planning. After each review, scenarios were revised in ArcGIS by the team. Maps were also reviewed and commented on via a CZMAI Facebook page used by some stakeholders. Scenarios were refined with the following goals in mind:

- The scenarios need to represent changes in natural resource use that can be incorporated into InVEST models for the services being assessed
- The scenarios should be distinct and contrasting to compare different possible futures for the coast
- The scenarios should test alternative options for specific decisions being made (e.g. whether or not to build a port)
- The scenarios should be feasible, realistic representations of a future that could actually occur;
- The “informed management” scenario would serve as the base for a balanced zoning scheme.

Once stakeholder feedback rendered three scenarios that met the criteria above, the “informed management” scenario was further refined. The team ran four InVEST models to see how the proposed zoning scheme affected ecosystems and ecosystem services. The models included: habitat risk assessment, coastal protection, tourism and recreation, and spiny lobster fishery. Using the mapped and quantitative results, as well as information from stakeholders, the team modified the zone locations to improve the potential economic and environmental outcomes. Some zones were moved to less environmentally sensitive areas, while others were expanded to increase the ecosystem service returns. This process allowed the team to manually optimize ecosystem service returns to meet the goals of the ICZM Plan.

In a final iteration, the “informed management” scenario was released for public comment and reviewed by CZMAI’s advisory council. These written and oral comments were incorporated into the zoning scheme by changing the location and extent of zones into ArcGIS, where necessary.

### **How did the scenarios shape the final results for policy makers?**

The scenarios were used in a number of ways to enhance the ecosystem service assessment:

1. Scenarios helped policymakers, stakeholders and scientists understand how a variety of different human activities affect ecosystems and ecosystem services now and in the future.

2. Scenarios helped policymakers compare alternative planning options for the Belizean coast.
3. Scenario development was a method for policymakers to engage stakeholders, providing a concrete way for them to inform the planning process and to learn from the results.
4. Scenarios were used as evidence by CZMAI that “informed management” better achieved the goals of the ICZM mandate than either “conservation” or “development.”
5. The iterative process of scenario creation made it possible to manually optimize the resulting zoning scheme, achieving improved environmental and economic outcomes of the ICZM Plan.
6. In addition, the scenarios will provide a foundation for future planning and monitoring changes against goals, alternatives, and a baseline.

The planning team is using the scenarios – at national and regional scales – to



determine how alternative zoning schemes and use recommendations affect ecosystem services. This will enable configuration of a zoning scheme that limits impacts on habitats and the services they provide, while improving economic returns from sustainable uses. The resulting Plan will be submitted to the Ministry of Forestry, Fisheries and Sustainable Development for approval and then go to the National Assembly for a vote in late 2013 or early 2014. This will be Belize’s first national Integrated Coastal Zone Management Plan for the sustainable use of critical marine resources and ecosystems.

### Key assumptions

- Stakeholder input increases the accuracy and credibility of scenarios.
- Multiple opportunities for input and review increase stakeholder support for the planning approach and can improve scenarios. Iterative development of scenarios improves the quality and validity of scenarios for testing policy options.
- Feasible and relevant national scenarios can be developed by creating regional scenarios and stitching them together at broader scales.
- Manual optimization methods are well suited to create future scenarios and can significantly improve environmental and economic outcomes.
- Plausible spatial representations of the future are useful information in spatial planning.



## Strengths

- Scenarios were developed through deep and broad stakeholder engagement. Stakeholders provided data sources, shared local knowledge, shaped regional scenarios, and reviewed scenario drafts and InVEST outputs. This ensured that the scenarios were feasible, credible and relevant to real challenges and conflicts faced in Belize's nine planning regions.
- Multiple methods were used to incorporate local knowledge and preferences into the scenarios, which supported participation by stakeholders and increased the credibility of the scenarios.
- Extensive review of national and regional legislation and planning documents ensured that future scenarios were grounded in existing policies and informed by data from a diversity of sources.
- Relationship-building between NatCap, WWF and CZMAI, and between CZMAI and key ministries, was critical to accessing the best available data, getting participation from stakeholders, and forming scenarios that could be useful to the policy process.
- Initial thematic scenario maps presented to policymakers and stakeholders helped stakeholders consider discrete options for the future of the coast and grapple with long-term projections of change. The "current" map was presented first, which familiarized stakeholders with developing spatial assumptions and the kinds of information needed to develop scenarios.
- The "informed management" scenario was developed through multiple rounds of review, which included inputs from stakeholders, the scientific literature, existing policy, and outputs from InVEST. Where InVEST showed that ecosystem service returns could be improved by changes in zoning, the "informed management" scenario was adjusted to enhance environmental and economic outcomes in a process of "manual optimization."

## Challenges and areas for future improvement

- Marine environments are complicated when developing scenarios. There is no single equivalent of a land-use/land-cover map for the marine realm.
- No one agency has jurisdiction over the full seascape. Thus, the development and implementation of a marine spatial plan required coordination among many stakeholder groups and government agencies.
- Extensive stakeholder engagement was time and resource intensive. The scenario development process took almost 2 years, in part because policymakers and stakeholders had few models, resources, and expertise to rely on to design a clear, efficient scenario development process. Training and tools like case studies and guides could help reduce the amount of resources and time needed for scenario development.
- The scenarios did not include expected impacts of climate change, changes in technology, or changes in market prices.
- Due to constraints on data sharing among agencies and groups, some relevant data were not incorporated into the scenarios, affecting their precision and comprehensiveness.
- Poor accountability of stakeholders reduced uptake of certain scenario input methods such as InSEAM and increased the duration of the process.

## SNAPSHOT | Coastal Belize

### POLICY CONTEXT

#### Policy level

National and regional

#### Policy goals

- Identify best strategy for conservation and development
- Design zoning plan for sustainable use of coastal zone
- Inform and support recommended actions for resource management

#### Ecosystem services included

Tourism & recreation, spiny lobster fishery, coastal protection, and habitat risk

### SCENARIO PRODUCT AND PROCESS

#### Scenario format

Maps produced with ArcGIS

Maps depict coastal and marine ecosystems, uses, developments and activities

#### Number of scenarios

3 (with multiple iterations)

#### Time frame for scenarios

Study undertaken in 2010-2012; scenario reference of 2025

#### Time frame for ES assessments

15 years

#### Spatial extent of scenarios

National coastal zone and atolls of Belize

#### Spatial extent of policy recommendations

National coastal zone and coastal regions of Belize

#### Stakeholder participation in scenarios

High

#### Consideration of exogenous drivers

Low

#### Consideration of endogenous drivers

High

#### Capacity and time required

High

## Case Study References

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**Developing Scenarios to Assess Ecosystem Service Tradeoffs: Guidance and Case Studies for InVEST Users** is a resource for practitioners who want to assess the provision of ecosystem services under alternative future scenarios. The guide draws on case experiences where InVEST was used to compare ecosystem service tradeoffs under different scenarios. It can help InVEST users choose appropriate types of scenarios and methods, engage stakeholders, and create scenario maps. The guide highlights key issues and questions for reflection, along with tools, case studies, references and resources for those who want to learn more.

InVEST is a suite of ecosystem service models, developed by the Natural Capital Project, for mapping, quantifying and valuing ecosystem services under different scenarios. InVEST helps decision makers incorporate ecosystem services into policy and planning at different scales in terrestrial, freshwater and marine environments. Further materials are available on the scenarios page at [naturalcapitalproject.org](http://naturalcapitalproject.org)