

Marine Integrated Decision Analysis System (MIDAS)

User Guide



Conservation International
Center for Applied Biodiversity Science (CABS)
Marine Management Area Science Program (MMAS)
2011 Crystal Drive, Suite 500
Arlington, VA 22202 USA

Phone: +1 703 341-2718

Fax: +1 703 979-0953

Web: www.conservation.org/MMAS

Contact:

Professor Suchi Gopal
Department of Geography, Center for Remote Sensing,
Center for Cognitive and Neural Systems
Center for Conservation Ecology
Boston University Boston, MA 02215
Phone: (617) 353-5744,
E-mail: suchi@bu.edu

Marine Integrated Decision Analysis System (MIDAS)

With marine conservation becoming increasingly important, there is a need for practical model-based decision tools to guide managers and decision makers working in coastal and marine environments. The MIDAS is a spatial decision support system software designed to support the process of decision-making for managers of marine management areas (MMAs) and policy makers. This tool is designed to assist the various users to understand the critical determining factors (CDFs) for the success of an MMA so that they can plan accordingly. The tool is designed to estimate the likely effects of MMAs based on ecological, socioeconomic and governance conditions. Figure 1 shows the MIDAS interface.

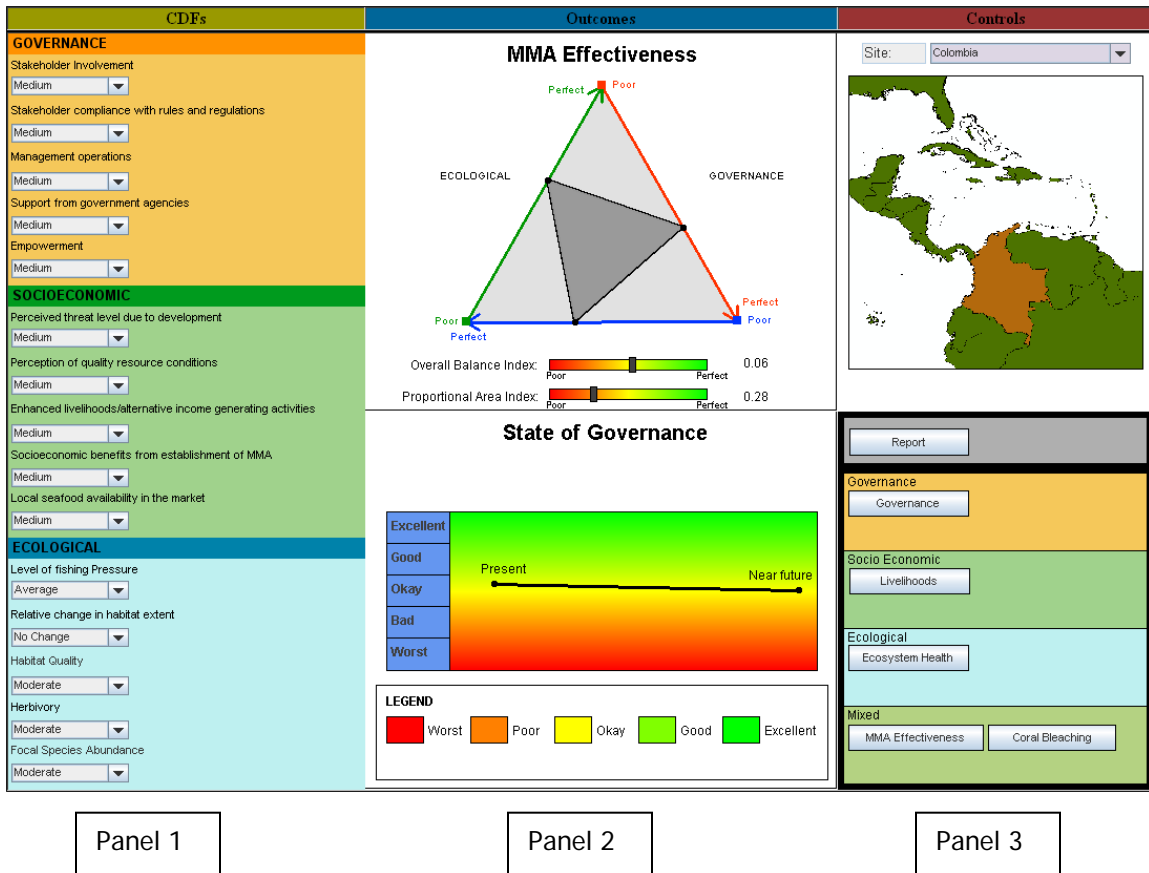


Figure 1 – MIDAS Interface consists of three panels

The user can input data for 15 CDFs, five for each of the following: socio-economic, governance and ecological factors. Panel 2 of MIDAS displays a series of Java applets representing outcomes (effects) of the interactions between the variable states that the user provides in Panel 1. As the user's input varies, Panel 2 with Java applets changes, giving the user an instant feedback on what would happen to key outcomes ("dependent" variables). The outcomes include state of governance, livelihoods, ecosystem health, as well as mixed interaction outcomes related to MMA effectiveness and coral bleaching. Any two outcomes can be displayed at a time and the user can toggle to display other outcomes. Panel 3 shows the country map while the lower half of Panel 3 shows the

outcome buttons. The user can also print the entire runtime session and obtain a report. The user can access a quick start guide, as well as MIDAS' help menu at any time.

The *governance CDFs* includes stakeholder involvement, stakeholder compliance with rules and regulations, management operations, support from government agencies and empowerment (e.g., training, education). *Socio-economic CDFs* include perceptions related to the following: threat level due to development, quality of resource conditions, enhanced livelihood and alternative income generating activities, socioeconomic benefits from establishment of MMAs, and local seafood availability in the market. *Ecological CDFs* include level of fishing pressure, relative change in habitat extent, habitat quality, herbivory, and focal species abundance.

At the start of the MIDAS session, the user can choose a particular level for each CDF. The default condition is set up at the medium level for each CDF. For example, participation of those affected can vary from very low to very high. The user has to point the mouse to the variable level (marked with a down arrow) and right click to see the options in the pull down menu.

Panel 2 displays five outcomes that inform the user the state of the system; the user can run a number of simulation exercises to investigate the relationships. Panel 2 displays two outcomes at a time. However, the user can toggle to display the remaining three. Panel 3 shows the general locations of the 15 countries, as well as navigation buttons for displaying outcomes in Panel 2.

Technical Specification: MIDAS is platform independent since it is written in Java SDK and Runtime Environment version 6 update 5. Java needs to be installed on your computer in order for MIDAS to run. If you already have an earlier version of Java installed on your computer, you must first remove it and then install version 6. To remove previously installed versions, select 'Add or remove programs' from the Control Panel on your computer.

- Install jre_.exe.
- MIDAS version 1 (midas.exe along with other files).

When installed, the MIDAS software will be on the C:\ directory on the hard disk of your computer. The default will create the directory C:\MIDAS and the files will all be stored under that directory. In the default case the "root" directory of the installation will be C:\MIDAS. If you wish to install to a different directory, please follow the instructions in the User Guide.

Install MIDAS.exe

You can launch the MIDAS by double clicking on the html icon.

1. Introduction

Despite the recent increase in the use of Marine Management Areas (MMAs) for marine resource management, we still know little about how different types of MMAs (e.g., fully protected vs. various levels of partial protection) perform under different circumstances, nor do we have a comprehensive understanding of how ecological, socioeconomic and governance factors interact to influence MMA performance. To address this need, Conservation International is conducting a MMAs Global Management Effectiveness Study to examine ecological, socioeconomic and governance in 15 global sites. The main objectives of this study are to:

1. determine the socioeconomic, governance and ecological *effects* (outcomes) of MMAs;
2. determine the *critical factors* (ecological, socioeconomic and governance) affecting MMA effects, as well as the impact of the *timing* of those factors on the effects of the MMA;
3. provide management tools for *predicting* MMA effects based on ecological, socioeconomic and governance variables as well as outputs showing results of various management actions.

The Marine Integrated Decision Analysis System (MIDAS) is a software tool that addresses the third objective. It was developed to assist the MMA users and managers understand the critical factors for success of MMA so that they can plan accordingly, and to estimate the likely effects of their MMA based on the ecological, socioeconomic and governance conditions and finally, revise plans to optimize outcomes and outputs. MIDAS will help conservationists demonstrate the likely effects of a new MMA, and will enable conservationists working in existing MMAs to determine the likely effects of alternative strategies and therefore, where they should most effectively focus resources. User groups (such as fishers, tourism operators) and the general public can use MIDAS to understand how and why various ecological, socioeconomic and governance conditions are so critical for positive outcomes. Users and policy makers are encouraged to use the tool in an exploratory way to identify interactions of variables and potential outcomes. MIDAS could also be used as a diagnostic tool to identify specific problems in MMAs that could be further addressed or examined.

MIDAS is not designed to replace the decision-making process, but to provide an interface to perform a series of thought experiments or game play. MIDAS does not provide a categorical single answer to a given question, nor does it provide a single solution to a problem. MIDAS provides an intuitive graphic interface that displays key outputs and outcomes. This enables the potential outcomes of different levels of key factors to be compared. For example, the user can visualize the likely impact of fishing and coastal development on ecological sustainability.

Source of Data: MIDAS is based on the primary and secondary data gathered by Bob Pomeroy and Tammy Campson (University of Connecticut), Burton Shank (Boston University) and Craig Dahlgren (Perry Institute of Marine Science); further details of these studies will be available in the project reports accompanying this software tool on the CD-ROM.

Guiding Principle: We model the complex dynamics of the three sets of factors using a general framework to capture commonalities across countries. However, there may be unique features to each site that have to be set up as a *de facto* standard for that country.

2. MIDAS Quick Start

Welcome to MIDAS (Marine Integrated Decision Analysis System version 5.1). Follow these steps to get familiar with MIDAS.

1. Choose a Country: In order to run MIDAS, choose a country (MMA) from Panel 3. For example, Ecuador. The default MIDAS country is Columbia.

2. Input Values at Panel 1: You can input values from drop down menus for each CDF (Critical Determining

Factor). There are 15 CDFs categorized into 3 groups - governance (in orange), socioeconomic (in green) and ecological (in blue). Each default CDF value is set to medium.

3. Results Shown in Panel 2 and 3:

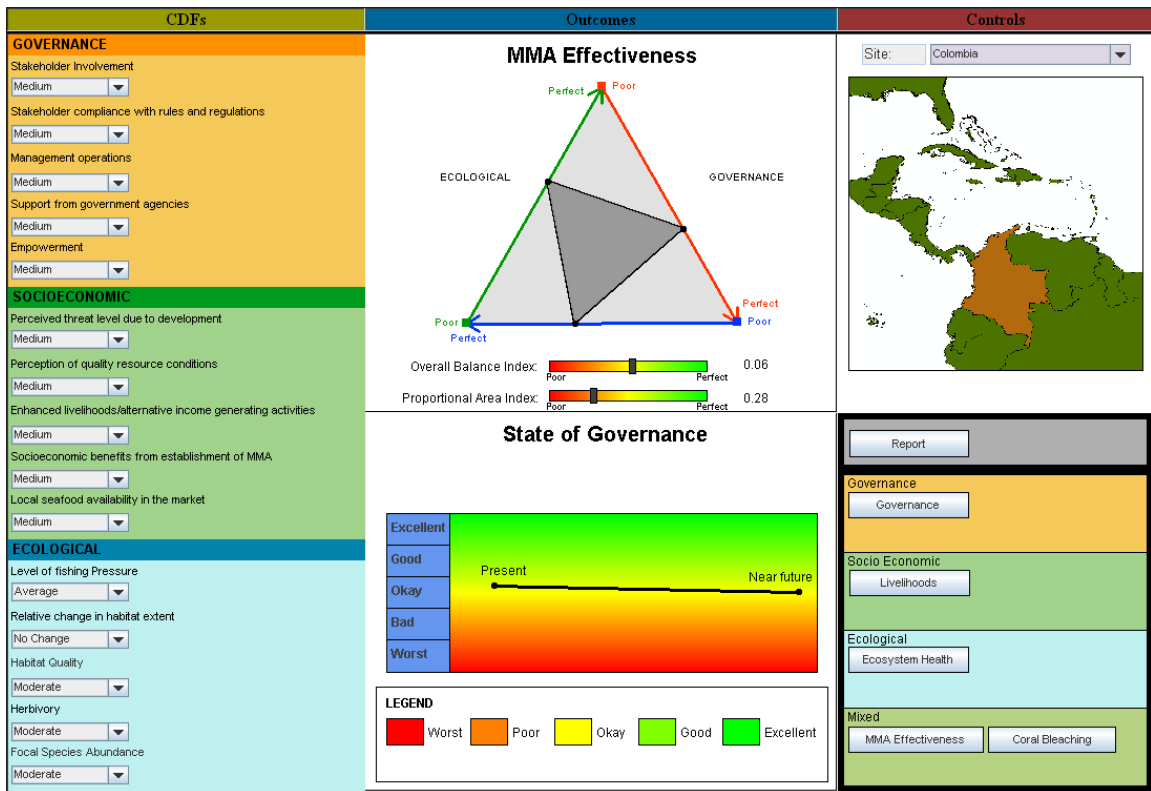
Once you have completed Step 1 and 2, you can display results as outcomes in Panel 2 or risk maps in Panel 3 for the selected country.

4. Help Button: Help is available for each CDF and outcome option. For example, select a CDF and press Help button. Another screen pops up and explains what the CDF means and how it is being measured in MIDAS.

5. Print Button: Once you have completed Steps 1 and 2, you can print at any time.

3. How MIDAS is organized

When the MIDAS is launched, the user is presented with an interface screen, which enables the user to enter values relating to governance, socio-economic, and ecological variables and the outputs or outcomes to be visualized. Before describing how to enter values and interpret output, a brief description is provided here of how MIDAS is structured.



Panel 1

Panel 2

Panel 3

Figure 1 – MIDAS consists of Three Panels

Panel 1 is a graphic interface that is written in JAVA code (programming) that allows a MMA user to change parameters or conditions as a thought experiment and see what happens; this part of the model is called MIDAS-JIM (Java Interface for Managers) is shown in Figure 1; the user can input data for 15 variables, five for each of the following: socio-economic, governance and ecological. Panel 2 displays five Java applets representing outcomes of the interactions between the variable states that the user input in Panel 1. As the user's input varies, the middle panel with Java applets dynamically changes, giving the user an instant feedback on what would happen to key outcomes ("dependent" variables). These outcomes are shown for user selected MMA in Belize. Panel 3 shows country maps for reference and the navigation buttons (see Figure 1). The three panels together provide the state of the system in terms of CDFs and outcomes.

At the bottom part Panel 2, shown in Figure 2, the user can access *Quick start* and *Help* as well as report function in Panel 3. The quick start guides the user to run a simulation or thought experiment using MIDAS. The online help defines the CDFs as well as outcomes. For example, population and tourism can impact the coastal livelihoods, which in turn, affect the management effectiveness. These can help the user with his/her choices in Panel 1.



Figure 2 – Quick start, Help and Report Screens

We have designed the screen to use 1280 and 800 pixels and therefore the best view is obtained at this screen resolution. The user may have to scroll left to right or top to bottom if the screen resolution is smaller than 1280 x 800.

Panel 1 - MIDAS - Users Input for Key CDFs

Based on GME workshops and meetings, 15 CDFs relevant across all MMA sites are used in MIDAS. There are multiple levels for each attribute with accompanying explanations and references. To select a level, the user has to point the mouse to the variable level (marked with a down arrow) and right click to see the options in the pull down menu.

I. Governance: Governance is the process through which diverse elements in a society wielding power and authority ultimately influence and enact economic and social development policies and decisions. Multiple players including the state, the private sector and civil society can carry out governance. In the context of MMA, governance refers to the structures and processes used to govern behavior, both public and private, in the coastal area and the resources and activities it contains. While the coastal area governance system can apply to the execution of a single activity (e.g., control of coastal development), in a MMA, there is a need to create a governance system capable of managing multiple uses in an integrated way through the cooperation and coordination of government agencies at different level of authority and of different economic sectors. MMAs have to emphasize local participation and governance at all levels for effective management. There are five CDFs.

1. Stakeholder involvement
2. Stakeholder compliance with rules and regulations
3. Management operations
4. Support from government agencies
5. Empowerment (e.g., training, education)

GOVERNANCE

Stakeholder Involvement
Medium

Stakeholder compliance with rules and regulations
Medium

Management operations
Medium

Support from government agencies
Medium

Empowerment
Medium

GOVERNANCE

Stakeholder Involvement
Medium

Very Low
Low
Medium
High
Very High

Stakeholder compliance with rules and regulations
Medium

Support from government agencies
Medium

Empowerment
Medium

**Figure 3a – Choosing CDFs: Governance;
Figure 3b: Levels of Stakeholder involvement**

The application of community-based natural resource management is widespread in Belize, but it is critical to understand the impacts of local governance, knowledge and practices on MMA and conservation programs. Hence the design of MIDAS solicits the input of five governance CDFs from the MMA users, stakeholders and managers.

1. Stakeholder involvement:

This variable defines the level of stakeholder involvement that results in a positive impact on the MMA. Level of stakeholder involvement in surveillance, monitoring and enforcement is a useful measure of how successful a MMA would be in the present as well as in the future. (Cho, 2005;Pomeroy et al., 2000). Stakeholder involvement can be effective in controlling non-compliance behavior through social and peer pressure. Increased participation of stakeholders provides them with more ownership over the MMA which should result in overall improvement as well as decrease violations. Active involvement in stakeholder activities is highly beneficial to overall MMA governance. (See Figure 3B)

Very low: The level of participation is almost non-existent and hence MMA may not be well patrolled or managed.

Low: Low level of participation may lead to negative impacts.

Moderate: Moderate stakeholder participation levels resulting in a slightly higher positive impact for the MMA.

High: Involves high level of involvement from a relatively large proportion of stakeholders

Very High: Surveillance, monitoring and enforcement leads to improvement in overall community compliance and enforcement.

2. Stakeholder compliance with rules and regulations:

This variable defines the existence and adoption of a management plan and the level of compliance by the community or people to the rules enforced by federal government or agency. Compliance to rules is linked to local input capability and socio economic circumstances included in decision-making. Comprehensive federal regulations and the participation of a wide range of stakeholders are beneficial for MPA management and increase the level of compliance to the rules by the local community.

Not at all: The community doesn't at all comply with the rules and regulations.

Somewhat: There is some level of compliance, but not high enough to have any positive impact.

Medium: Moderate level of compliance creates some positive impact on the MMA management.

High: High compliance results in positive relationship between the government and the community.
Very High: Very high levels of compliance make marine management highly effective thus increasing the pace for marine conservation and the room for implementation of newer policies.

3. Management operations:

This variable measures the user's awareness and perception of management operations including g people, infrastructure, equipment and funds available for enforcement, monitoring, outreach/education, field presence (also based on funding) and management plan.

Very low: There is very little management operation.

Low: There is some level of management operation.

Medium: Moderate level of operation creates some positive impact on the MPA management and effectiveness.

High: High level of operation ensures effective stakeholder participation and representation.

Very High: Very high levels of operation make marine management highly effective thus increasing the pace for marine conservation and the room for implementation of newer policies.

4. Support from government agencies:

This variable defines the level of input or feedback received from the federal government in support of the MMA. This may come in the form of enacted legislation, supporting existing and creating new policies that result in positive impact on the MMA. Before any marine conservation act is put into action, input is created for the community to address its own concerns. A strong two-way relationship between the Community and the Federal Government is vital for good long-term results. It also affects other complimentary variables, such as compliance to rules and stakeholder involvement.

Very Low: Government has no input mechanism in place to support the MMA.

Low: Government gives low level of input to local community groups or the local government in support of the MMA.

Medium: Moderate level of input from the federal government is still not that effective but better than

High: High level of input improves the relationship with the community thus affecting compliance and community involvement.

Very High: Government has aggressive campaigns in support of the MPA. Strong and effective input and/or policies are in place for the better management of the MPA.

5. Empowerment:

An essential element of MMA is the empowerment of local people and communities through self-governance by local communities and conservation education (Beger et al., 2004). A community's willingness to participate in management is heavily influenced by this understanding of reef ecology and the anthropogenic impacts on reef health (Russell 1997).

Very Low: Low empowerment leads to lack of community participation and ultimately, the failure of a MMA.

Low: Low empowerment of local community groups results in lack of support of the MMA.

Medium: Moderate level of empowerment is still not that effective but better than none at all

High: High-level community empowerment affects compliance and community involvement.

Very High: Very high empowerment is desirable since it ensures the continued success of a MMA.

II Socio-Economic: Prior studies have demonstrated the importance of understanding the socioeconomic context of factors such as occupational structure, and levels of dependence for the conservation of marine

resources in MMAs (Cinner, 2007, Roman et al., 2007). MIDAS includes five socio-economic factors in terms of response from the user to examine their impacts on MMAs (See Figure 4).

SOCIOECONOMIC

Perceived threat level due to development
Medium

Perception of quality resource conditions
Medium

Enhanced livelihoods/alternative income generating activities
Medium

Socioeconomic benefits from establishment of MMA
Medium

Local seafood availability in the market
Medium

Figure 4 – MIDAS Socio-economic Inputs

6. Perceived threat level due to development

This variable defines the level of development including urban expansion, pollution, hotels, cruise ships, and other tourism activities near the MMA. Coral damage due to boat anchors, physical contact by divers with the corals and waste generated via development are major concerns that may also affect the protected areas. For example, in Belize, the level of development is increasing over time and thus more damage is being done to the marine areas. If further development is limited, best practice strategies such as limiting access from sensitive habitats and resource components would create a more positive impact on the MPA.

None/Low: Low level of development has a positive impact on the MPA since it has led to increased job and employment opportunities for the local community.

Low: Low level of development along coast can have a positive impact on MMA.

Medium: Moderate development level with best practices creates a positive impact on the MMA.

High: Higher level of development activities is a bigger threat to coastal and marine ecosystems.

Very High: Higher development levels have an adverse impact on the MMA.

7. Perception of quality of resource conditions

This variable defines the threat perception to local marine resource use patterns that reflects whether or not management strategies are impacting income and livelihood patterns and cultural traditions in the near term (immediately) or far term (within five years). Level and type of marine related activity including local and commercial fishing, diving, and cruise shipping are included in this input.

Very Low: Current use of local marine resources poses a very low threat to MMA.

Low: Current use of local marine resources poses a low threat to MMA

Medium: Current use poses moderate level of threat.

High: High level of threat is perceived given the aggressive marine resource pattern.

Very High: Very High level of threat is perceived given the aggressive marine resource patterns. (high levels of tourism, cruise activity, commercial and local fishing, tourism, urban and rural land use patterns, non-point source discharge).

8. Enhanced livelihoods / alternative income generating activities

Alternative income-generating activities are considered necessary to provide substitute and supplementing income sources for fishing communities in MMAs (Rivera and Newkirk 1997; Pollnac and others 2001a).

Alternative

income is judged to be an important component of MMA as other jobs such as those in the tourist, service and agricultural sector provide local people with the time to gain skills and knowledge for more sustainable alternative employment to fishing.

Very Low: There are no other jobs and people are dissatisfied; needs to be addressed immediately.

Low: Some jobs are available but not sufficient enough to serve the needs of the whole community.

Medium: Alternative jobs such as tour guides and hospitality service jobs are moderately available.

High: Jobs are abundant. Local needs are served.

Very High: Many alternative jobs for both men and women satisfy and provide livelihoods leading to better MMA management and local participation.

9. Socioeconomic benefits from establishment of MMA

Socioeconomic benefits from establishment of MMAs include food security; and income generating activities.

This results in general nutrition and health, quality of life and relative wealth for people in the community.

This is an important indicator that helps to check if the MMA is providing improvements.

Very poor/Poor: Poor conditions reflect comparative lack of wealth and poor quality of life in the community.

Medium: Medium level indicates a minimum access and distribution of basic resources.

High: High level leads to better quality of life as well as human development.

10. Seafood availability in the market:

Perception of seafood availability is a measure of what the primary household member in the household thinks about the local availability of seafood for the household. This indicator is important for understanding the contribution of MMA to food security and economic well being of the community. This indicator is useful in addressing the negative perceptions from the local community about the MMA.

Very Low: Seafood is insufficient and unavailable to the local community (for most of the days of the week) and needs to be addressed immediately. Commercial fishing may be prevalent leading to dissatisfaction.

Low: Seafood is available in small quantities and is not enough to serve the needs of the whole community.

Medium: Seafood is moderately available.

High: Seafood is abundant. Local needs are served.

Very High: Very High availability of seafood in the local markets completely satisfies the local demand and provides adequate sustenance.

III. Ecological. MMAs are vital tools for managing food webs, ecosystem function and the resilience of reefs, in a seascape setting that extends far beyond the boundaries of the reefs themselves. Figure 5 shows ecological CDFs of MIDAS.

ECOLOGICAL

Level of fishing Pressure
Average

Relative change in habitat extent
No Change

Habitat Quality
Moderate

Herbivory
Moderate

Focal Species Abundance
Moderate

Figure 5 – MIDAS Ecological Inputs

11. Level of fishing pressure

A significant issue for fisheries in Belize and elsewhere is to ensure the ecological sustainability of wild fish stocks in the long term so that ecosystems that are fished remain diverse and healthy. Fishing also has impacts on the marine environment beyond the species it targets. This variable describes if the area is overfished. The type and level of fishing is a measure of the total labor and time used during a fishing activity as well as the total amount of fish landed. There are four levels to this variable.

Under/Ecologically underfished: Fish stock that has the potential to sustain catches higher than those currently taken.

MSY/Maximum Level of Ecologically Sustainable: Fishing at maximum sustainable yield (MSY) levels means catching the maximum proportion of a fish stock, that can safely be removed from the stock while, at the same time, maintaining its capacity to produce maximum sustainable returns, in the long term.

OY/Optimum Level of Ecological Sustainability: Adjusting fishing effort to some optimum level determined usually by an indicator level of fishing (or stock size).

OVER/Over Maximum Level of Ecological Sustainable: Over MSY leads to dangerous depletion of spawning biomass below optimum levels and catches below the maximum sustainable yield.

12. Relative change in habitat extent:

Habitat is defined as the living space of an organism, population or community, and is characterized by both its biotic and physical properties. Habit types are distinguished from each other by both biotic and abiotic composition and structure. Extent in the form of total area (in Km²), configuration and physical location are important in describing extent. Disturbance events in the community, (whether anthropogenic or natural) can lead to changes in habit extent, structures and declines in complexity. MMAs are used to prevent or reduce the frequency and intensity of man-made disturbances in an area so as to prevent major changes in the habitat within. This variable refers to relative changes in reef, mangrove and sea grass habitats inside and outside the MMA following the establishment of the MMA.

None: No observable change in the habitat.

Somewhat: Change in coral, sea grass and mangrove is moderate.

High: Great change in habit extent of coral, sea grass and mangrove

13. Habitat Quality:

This variable evaluates how intact are near reef habitats such as mangroves, corals, and sea grass. Is the system perfectly intact, or not intact? Thus this concept will include habitat loss, disturbance frequency and intensity, nutrient/sediment/pollution inputs into the system, intact trophic linkages etc. (Halpern et al., 2008).

Pristine: Intact system with near reef habitats such as mangrove and sea grass.

Very Good: Moderate and good reef habitats.

Moderate: Moderate quality

Poor: Poor reef habitat affecting system health and resilience

Unrecognizable: Worst condition signaling major impacts.

14. Herbivory:

Herbivores are an important part of coral reef ecosystems. They maintain the balance between corals and macroalgae on reefs, which potentially out compete the corals, in both diversity and composition. Both invertebrate herbivores (including urchins, crabs, limpets, etc). and vertebrate herbivores (including reef fishes, sea turtles, and dugongs) are extremely important to the health of coral reefs. This variable measures the level of herbivory present.

Excellent: Excellent herbivory

Very Good: Moderate and good reef herbivory

Moderate: Moderate herbivory missing one or two key species

Poor: Poor reef habitat due to poor herbivory

Very Poor: Poor reef habitat due to lack of key herbivores

15. Focal species abundance:

This variable refers to the number of individuals of specific species found to occur within and outside the MMA. This CDF is a commonly used proxy for population size and can be used as a biological success measure of MMA effectiveness. In this context, it refers to the following species - conch, lobster, manatees, crocodile, shark, and commercial fish species (primarily snappers and groupers).

How effective is the MMA in building populations of manatees, crocs, green sea turtles, whales, whale sharks and others. Focal species abundance is vital for MMA functioning and operations. A complete inventory of habitat types/zones around the MMA, and organisms in each habitat is required for understanding species composition, species richness, relative species abundance, species evenness, and habitat diversity. There are three levels of the category.

Excellent: Excellent focal species

Very Good: Moderate and good focal species distribution

Moderate: Moderate distribution missing one or two key species

Poor: Poor distribution and number of focal species

Very Poor: Will have major impacts in habitat health

MIDAS Panel 2 – What is happening in your MMA?

Panel 2 of the MIDAS interface shows key outcomes. The user has the ability to choose or toggle between 5 applets. The applets below show outcomes that dynamically change, when the user inputs the ecological, socio-economic and governance variables in Panel 1, and press one of the five buttons. The toggle map button is explained later.

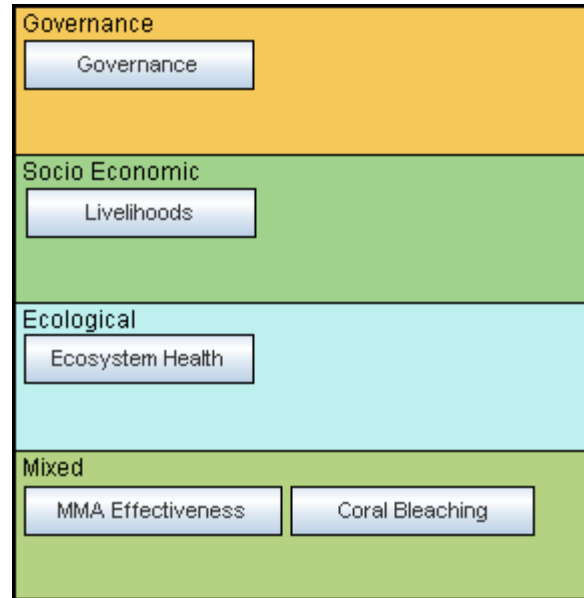


Figure 6 –MIDAS Applets Menu

Applet 1 – Governance Index or State of Governance: The five governance variables and two socioeconomic variables, (alternative livelihoods and direct benefits from MMA establishment), and the ecological variable (relating to focal species abundance) interact to influence this key outcome. Stakeholders would use this outcome to know the state of governance in their MMA.

These variables are weighted to estimate a general index called *state of governance* modeled after a traffic light, ranging from red to green, with many levels between (instead of just 3). The exact form of the equation uses a simple additive multi-attribute model (Keeney and Raiffa, 1993).

Equation 1

$$V(\mathbf{x}_i) = \sum_{j=1}^n w_j v_j(x_{ij})$$

Where V is the overall value, $0 \leq V \leq 1$,

X_i is the vector of attribute values $x_{i1}, x_{i2}, \dots, x_{in}$

$v_j(x_{ij})$ is a single attribute function $0 \leq v_j(x_{ij}) \leq 1$,

w_{ij} are weights reflecting the relative importance of the range of values of attributes j

Equation 2

$$\sum_{j=1}^n w_j = 1$$

We have selected a set of arbitrary weights for attributes based on existing literature and consultation with experts to determine the initial value of this governance index. The user provided values in Panel 1 determine where this index is located. This visually represents to the user the perceived weighted governance. Figure 7 shows a green line that is improving towards a better state in the near future.

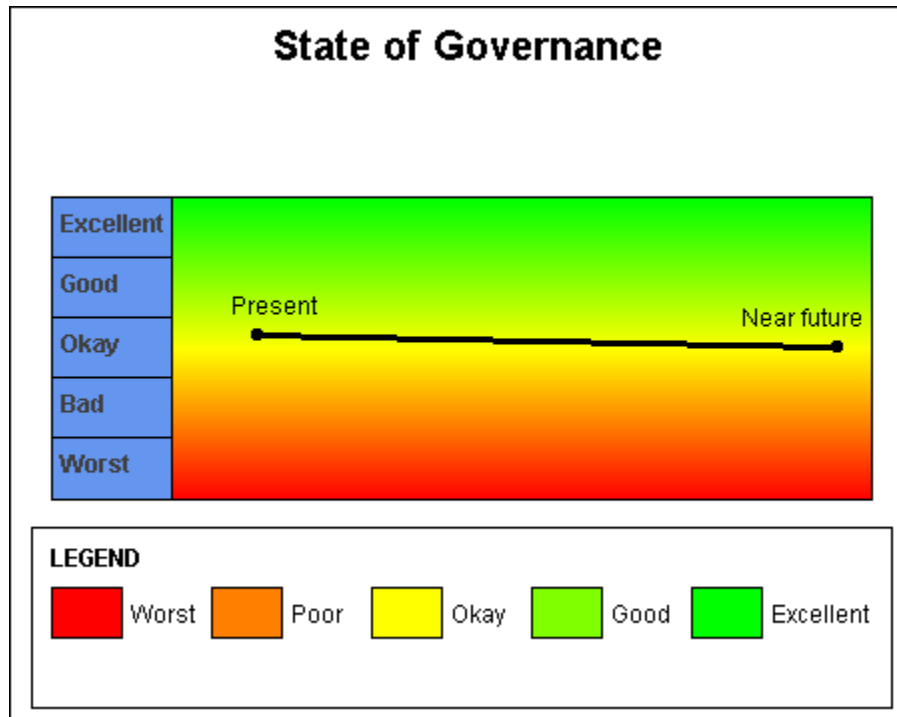


Figure 7 –MIDAS State of Governance Outcome

Applet 2 – Livelihood Index: This applet shows the viewer current livelihood structure in the MMA based on all socioeconomic CDFs, ecological CDFs related to level fishing pressure, habitat quality, and focal species abundance, and governance CDFs related to stakeholder involvement and empowerment (community education, training). This index shown in Figure 8 shows the selected CDFs values as histograms; the black line connecting the present (determined empirically from field work) and the perceived conditions (Panel 1 input) displays the perceived socioeconomic outcome called livelihoods.

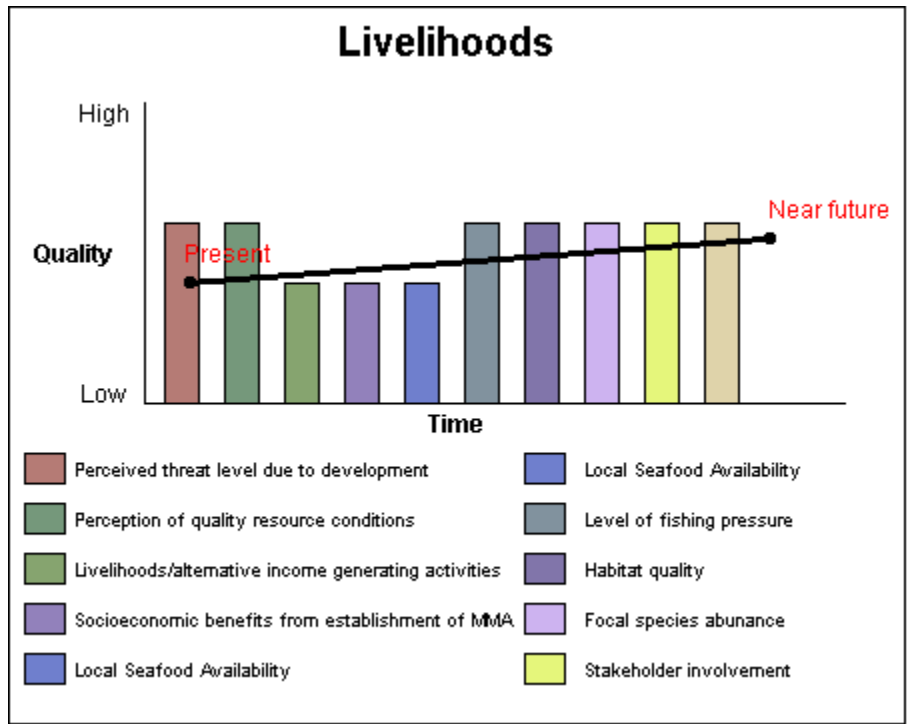


Figure 8a –MIDAS Livelihood Index

The index provides a lens for viewing human progress and the complex relationship between key CDFs and may be used to examine differences between the MMAs. Figure 8a shows that there is not much difference between what is being observed currently and what the stakeholder or user is perceiving in the near term; all CDFs are set at medium levels.

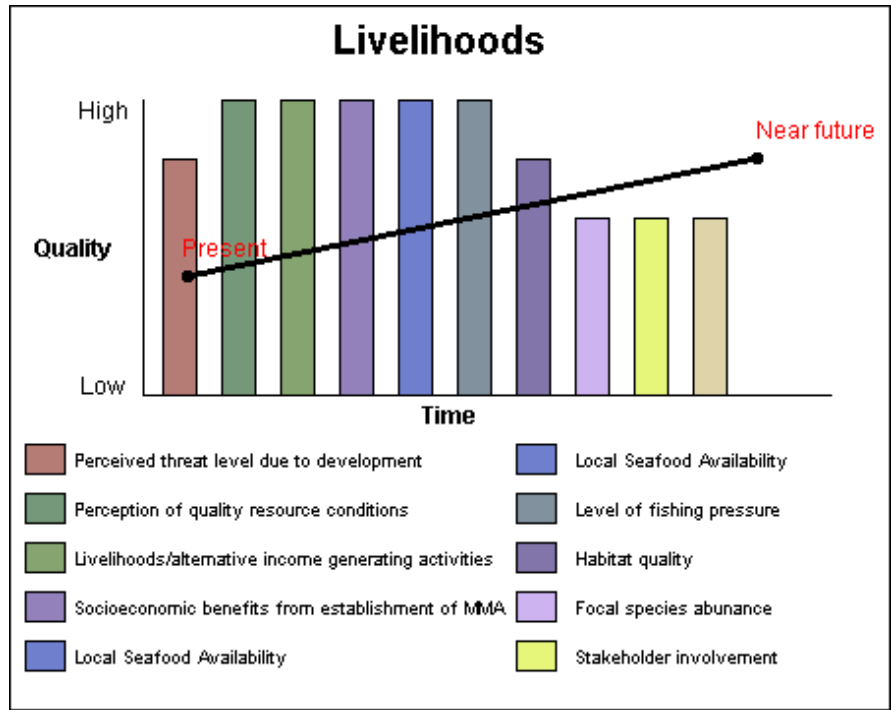


Figure 8b –MIDAS Livelihood Index

Figure 8b is interesting in that it shows that the user's perception of this outcome is bleak as the key CDFs are perceived to be declining.

Applet 3 – Ecological Health and Resilience Applet

The index provides a measure of ecological health and resilience and includes all the ecological CDFs, and governance CDFs relating to compliance, enforcement and zoning.

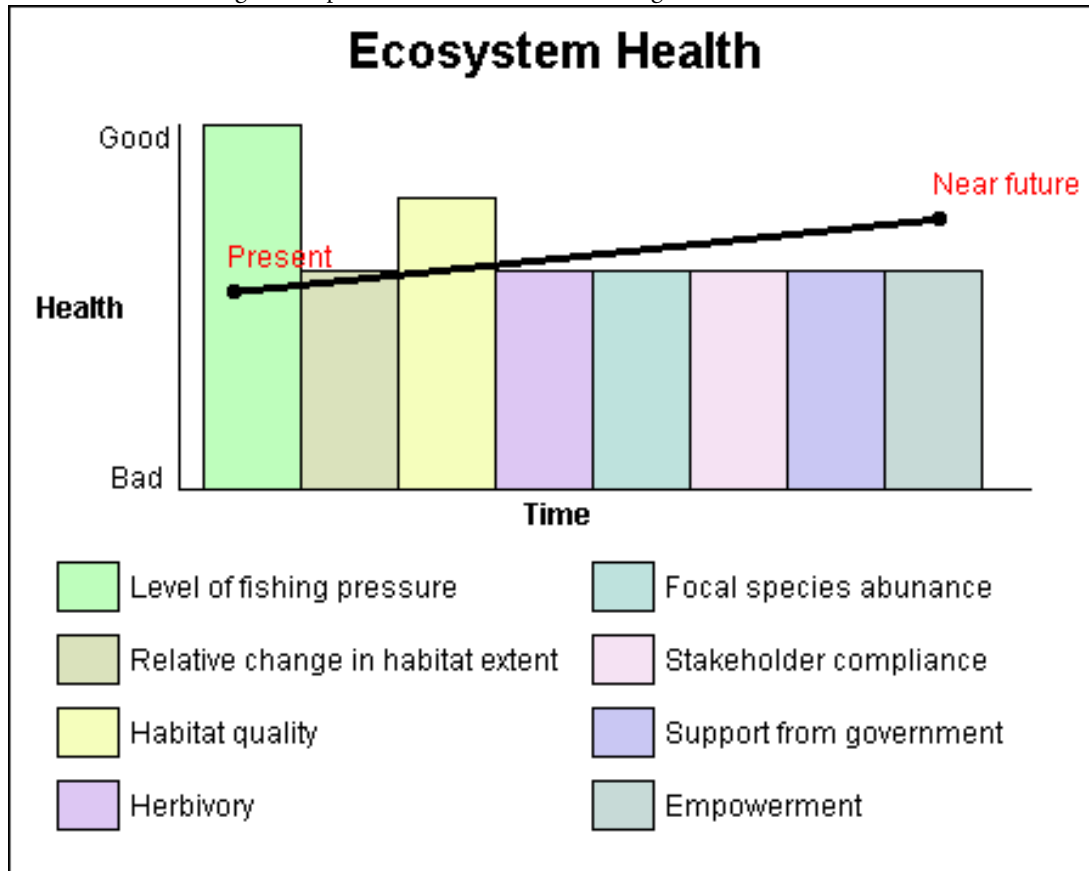


Figure 9 –MIDAS Ecosystem Health and Resilience Applet

The different colored histograms in Figure 9 represent empirical values for each CDF determined by experts based on their field knowledge of each MMA. They inform the user of the expert opinion. This applet results in an outcome called *system resilience* which is a snapshot of the complex interplay of mainly ecological variables.

Mixed Outcomes Applets

1. Coral Bleaching

Managers and users of the MMA have intimate knowledge of coral bleaching since there have been significant increases in the frequency and severity of bleaching events in Belize since 1995 onwards. Scientific research (Wilkenson et al., 2002; Berkelmans, 2002) in this context has demonstrated that sea surface temperature anomalies, number of degree days and heating may in some combination, help explain coral bleaching. This applet may be useful in informing the public about the potential signals that accompany such an event shown in Figure 10.

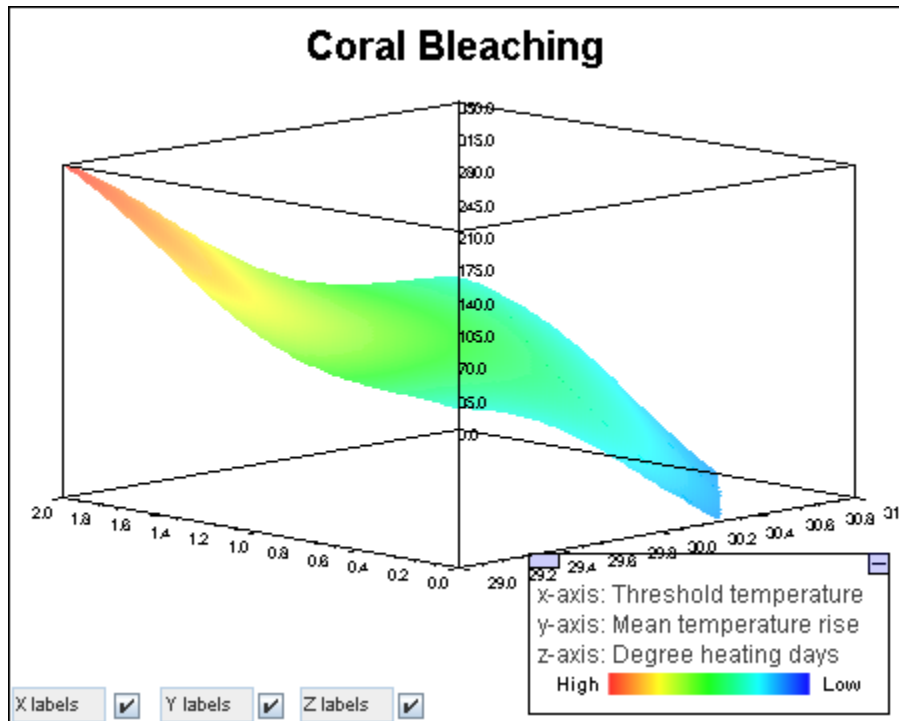


Figure 10 – Bleaching Events over 1995-2005

We have adopted bleaching curve equation proposed by Berkelmans (2002) and modified it for Belize. Predicted bleaching curve, bc , is estimated using measurements of temperature the following way.
Equation 3

$$bc = Tb - s/5(Tb - Tn), \text{ for } Tb > Tt$$

In equation 3, s is the bleaching severity score (integer between 1 and 4), Tb is the temperature distribution curve for the coolest bleaching year (if the temperature data include more than 1 bleaching year), Tn is the temperature distribution curve for the warmest non-bleaching year, and Tt is the threshold temperature ($^{\circ}\text{C}$). The threshold temperature is the highest temperature at which no bleaching is predicted to occur irrespective of exposure time and is taken as the point where the bleaching and non-bleaching temperature curves overlap (i.e. when $Tn > Tb$). A bleaching curve, therefore, represents a profile of average daily exposure temperatures and durations at which coral bleaching is thermally sensitive

2 MMA Effectiveness

The overall effectiveness can be visualized as a triangle, whose three vertices show the overall index for each CDF compiled based on user inputs.

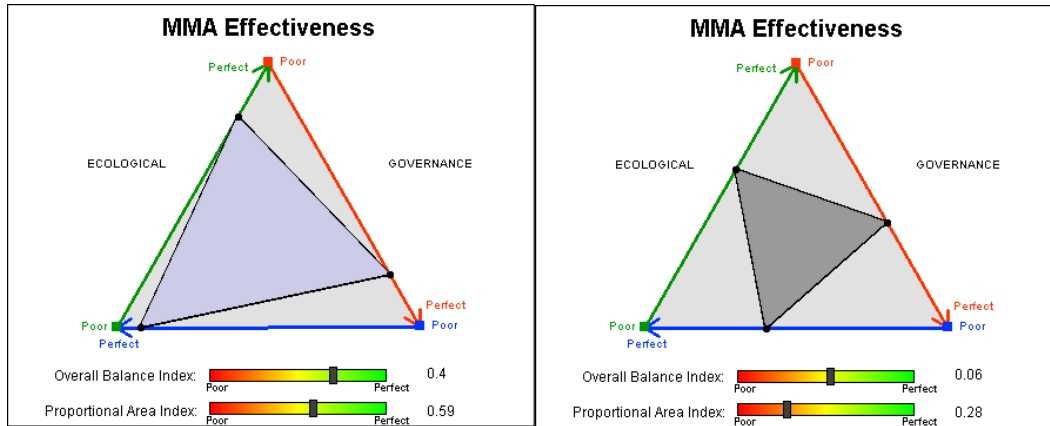


Figure 14 A – High Effectiveness and 14b Low Effectiveness of MMA

When overall conditions for all CDFs are near perfect, the area of the triangle would almost be equal to the theoretical limit, and hence the proportional area index and overall balance index would be high. However, if the 3 overall CDFs are low, then the overall index as well as proportional area index would be low. The shape and area of the triangle provide two metrics to describe the overall effectiveness index as well as the ratio of present condition to theoretical maximum.

Panel 3: Selecting the Country

Panel 3 represents the MIDAS map display options and other buttons that the user can toggle. The user can choose any country in the list. (See Figure 13).

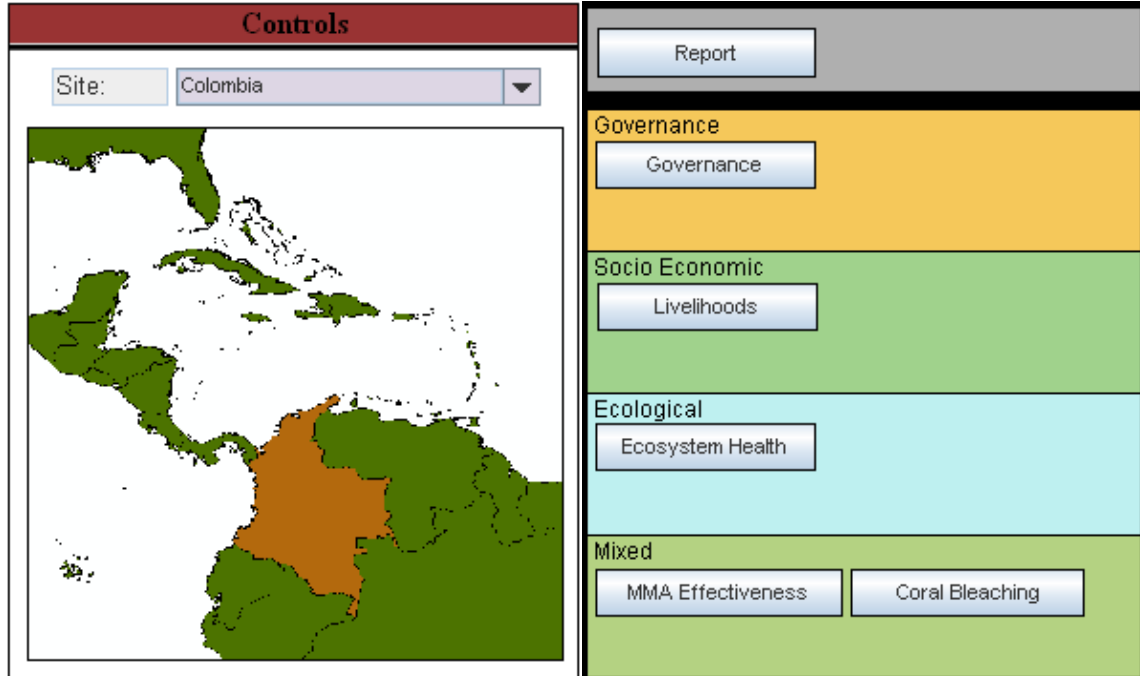


Figure 13: Panel 3 Components

The user can choose any button to display an output in Panel 2.

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