WORLD RESOURCES INSTITUTE

Economic Valuation of Coastal Ecosystems in the Caribbean
Project Overview – January 2008

Project Purpose

The World Resources Institute (WRI) seeks to improve the management of coral reef ecosystems in the wider Caribbean by catalyzing the development and use of reliable information on the value of ecosystem goods and services derived from coral reefs.

Beginning in two pilot countries in the Eastern Caribbean, WRI has been developing an economic valuation method that can be applied across the region. The methodology focuses on producing detailed estimates of the value of coral reef related fisheries, tourism, and shoreline protection. The project is currently underway in Belize, and is beginning work in Jamaica and the Dominican Republic this year. WRI is also developing estimates of value for both healthy and degraded coral reefs, and is working closely with governments and non-governmental organizations (NGOs) within each of the countries to ensure that the study results support improved coastal policy and management planning.

The project is designed to:

- Increase the capacity to perform ecosystem valuation and to use these estimates in planning and decision-making;
- Make the economic case for better coastal and land management, as well as for increased investment in Marine Protected Areas, so that these are viewed as investments in the future of the country and their economic and societal benefits are maximized;
- Arm NGOs and marginalized resource users with powerful information, enabling them to achieve greater voice in local decision-making.

Problem Statement

Coral reefs are a critical component of the marine environment. Biologically rich coral reef habitats provide important ecosystem services to local and regional economies, including tourism, shoreline protection, and fisheries. As coral reefs degrade, these services are diminished, resulting in economic losses to coastal communities.

Despite their importance, nearly two-thirds of the Caribbean's coral reefs are threatened by human activities. Agricultural runoff, overfishing, dredging, sewage discharge, and the growing pace of coastal development have already degraded important reef systems, reducing their recreational appeal and decreasing fishery production in many places. As a result, fisheries and tourism sectors are not reaching their full potential. Over time, these local and national economic losses could lead to reductions in GDP.

Economic incentives for urgent action are needed

Economic valuation – the attempt to assign quantitative values to the goods and services provided by environmental resources – can provide an important tool to aid and improve the wise use and management of coral reefs. Although there have been several economic valuation studies conducted in the Caribbean within the last decade, these studies focused on relatively narrow geographic areas, dealt with a limited range of goods and services, and used divergent valuation methods. There is a clear need within the region for a publicly accessible, practical, standardized method to calculate coral reef ecosystem value under current and changing resource conditions.

WRI's Economic Valuation Project Strategy

Since 2005, WRI has been working closely with partners in three Caribbean countries to develop realistic estimates of the economic value of goods and services associated with coral reefs, and to share these results with local and national government officials and stakeholders. These efforts have resulted in the development of a consistent methodology which could then be applied in other countries across the region.

Outreach and capacity building are critical elements of the project. WRI is partnering with economists in the region, university and government scientists, resource managers, and both local and international conservation organizations. These partnerships enable us to draw on local knowledge and gain access to the local data required for coral reef valuations; formulate management recommendations with regional decision-makers and resource experts; and share our methodology with others to enable further evaluations of coral reefs in the region. The latter will enable valid comparisons among Caribbean countries.

Coral Reef Valuation Methodology

WRI's economic valuation methodology provides a simple and replicable method for estimating the value of coral reefs and mangroves in the Caribbean. The methodology uses the concept of "ecosystem services"– the tangible benefits ecosystems provide which sustain and fulfill human life—as the basis for measurement. The approach looks primarily at the direct economic benefits provided by these resources; it does not attempt to calculate the Total Economic Value (TEV) of coral reefs and mangroves, which would include non-use values (for instance, the 'existence value' non-users place on the presence of the reef). The methodology focuses instead on three important ecosystem goods and services associated with coral reefs: fisheries, tourism, and shoreline protection services. These services comprise an integral part of many Caribbean economies. The methodology also offers guidance on estimating the wider (indirect) impact on the economy of these resources, the consumer surplus associated with their use, and the potential losses or gains in value associated with changes in ecosystem condition. The method was developed based on literature review, coupled with examination of coral reef use and data availability in two Eastern Caribbean countries with fairly different coastal management and data richness situations.

A) Coral Reef-Associated Tourism

The value of coral reef-associated tourism is assessed using a financial analysis approach. This requires totaling the gross revenues (accommodation, reef recreation and tours, miscellaneous expenditures) captured by service providers and subtracting the costs of providing these services to arrive at a net benefit. Wages, taxes, and fees are counted as "pass-throughs" to the economy, and are included in total benefits. The methodology also uses a multiplier to estimate the wider economic impacts resulting from tourist expenditure.

Accommodation – Identifying the "reef-associated" share of accommodation expenditures requires compiling standard information on hotel room rates, occupancy rates, operating costs, taxes and service charges, as well as determining whether a visitor is present at least in part due to the area's coral reefs. Depending upon data availability, information can be compiled by individual hotel, by accommodation type (hotel, guest house, etc.), or based on average values for the country, region, or study area. For each, an estimate of the "percent of visitors using the reef" is specified, which is used to pro-rate accommodation credited to the reef. In addition, foreign versus domestic ownership of hotels is used to estimate of the amount of net revenue that is likely to remain in the country.

Reef Recreation -- Reef recreation includes foreign and local use of the reef for snorkeling, diving and sport fishing. The value of reef-related activities is estimated by totaling gross revenues and subtracting the costs. This can be estimated based on company-level information, or based on the price of specific activities (dive or snorkel trips, etc.) coupled with the number or percent of visitors who engage in this activity.

Marine Protected Areas – MPAs are an important draw for tourists as well as an important tool for managing coastal resources and protecting coral reefs. Revenues from visitor fees and other relevant fees (mooring, diving, etc.) are totaled, and the cost of collecting fees is subtracted from the total. In places where MPAs have good reef recreation data, these can also be used as a starting point for estimating reef use.

Additional expenditures - Tourists typically spend additional money on restaurants and shopping as part of their visit. An estimate of these additional direct expenses by reef-related tourists is based on information on the tourism industry (e.g. for each dollar spent on accommodation, forty additional cents go towards expenditures such as food and entertainment).

Economy-wide effects

The values described above are considered direct economic impacts of coral reef associated tourism. Expenditures by tourists have additional economic benefits beyond these direct effects via the additional spending by hotels, restaurants, tour operators and the employees of these businesses. This additional "indirect" or "secondary" economic impacts can be estimated using a tourism multiplier. The multiplier attempts to capture the overall impact of direct tourist expenditure on the economy. The size of the multiplier is influenced by how much of the purchased goods is produced domestically and how much needs to be imported, such as fuel, linen, beverages, produce, dive equipment, construction materials, etc.).

The methodology also gives the option of using a multiplier to measure the wider (indirect) economic benefits associated with reef-related tourism. Users can choose to exclude the estimates of wider economic impact from the final value.

B) Coral Reef-Associated Fisheries

A financial analysis approach is also used for assessing the value of coral reef-associated fisheries. This approach involves totaling the revenues from the commercial fishing and fish processing industries, and subtracting the costs of theses activities, arriving at net financial benefits. Wages, taxes, and fees are treated as "pass-throughs" to the economy, and are included in total benefits. The value of local (non-commercial) fishing for consumption or for pleasure is also assessed. The methodology also assigns a multiplier to estimate the wider economic benefits associated with the fishing industry. Changes in coral reef health have an effect on total potential revenue available through changes in the fisheries productivity of the reef.

Commercial Fisheries – The revenue from commercial fisheries is based on reef-associated fish catch and sale price, by species. Annual catch can be estimated from data by landing site, based on a sample of fishermen, or using estimates of fisheries productivity per unit of reef area. Local expert opinion is used to estimate both labor and non-labor costs as a percent of gross revenue.

Fish Processing Industries – The value added from fish processing is estimated using the sale price minus purchase price of fish and the quantity purchased by facilities. Operating costs are subtracted to arrive at net benefits. Informal on-site cleaning is estimated based on earnings associated with cleaning at landing sites. (In the absence of information on fish processing, a fish processing multiplier can be used to approximate the added value from fish processing in an area.

Local Fishing – the values from local fishing for consumption and pleasure are calculated separately using estimates of the percent of the population engaging in these activities, the time spent fishing, and the market prices of reef fish. The value of leisure time, based on average local wages, is used to estimate the enjoyment value from local fishing.

C) Shoreline Protection Services

Evaluation of the shoreline protection services provided by coral reefs requires an understanding of the protection afforded by different types of coral reefs in different coastal settings, under different storm scenarios, coupled with information on property values in areas receiving at least some protection from coral reefs. A modified "avoided damages" approach is used to estimate the value of this service along coastal segments protected by coral reefs. This involves estimating the likely damage (and associated economic losses) to a coastal area from a given storm event, both with and without the reef present. The difference is the "avoided damages."

Essential elements of understanding the damages avoided due to the presence of coral reefs include:

1) understanding the storm regime for an area (expected storm frequency, intensity, and associated storm surge and wave height), as well as the historic damage caused by these storms (particularly due to wave damage);
2) identifying the land areas considered "vulnerable" to wave-induced erosion or storm damage (based on elevation and coastal proximity);
3) identifying coastal segments which are protected by coral reefs (and/or mangroves);
4) evaluating the share of coastal protection provided by coral reefs (and mangroves);
5) estimating the property values (land and structures) of land areas identified as both vulnerable and protected by coral reefs; (the estimate should also consider the revenues generated by businesses in these areas);
6) combining these individual elements to estimate the reduction in damages attributable to coral reefs.

Application of this modified avoided damages approach for two pilot locations in the Eastern Caribbean used the following rules and assumptions:

1) **Storm Regime.** The analysis focused on storms likely to occur within a 25 year period for each area.

2) **Vulnerable Lands**. The definition of vulnerable lands is based on the sum of the average storm surge and wave heights associated with a 25 year storm event along a given coastline.[1]

3) **Reef Protected Shorelines**. Shoreline segments "protected" by coral reefs were defined as those within 100m of a fringing reef, or enclosed by a lagoon-forming reef.

4) **Coastal Protection and Coral Reefs.** The Institute of Marine Affairs in Trinidad developed a coastal protection classification scheme (index) which integrates ten physical characteristics to estimate the relative resistance of each coastal segment to wave-induced erosion and damage from storms. This scheme can also be used to evaluate the role coral reefs (and mangroves) play in reducing vulnerability to erosion and storm damage. The coastal protection index integrates data on coastal geomorphology (limestone cliff, beach, etc.); coastal geology (igneous, metamorphic, etc.); coastal exposure (protected by headland, seawall, or riprap, or exposed); wave energy (typical maximum wave height); storm frequency (frequency of tropical storms and hurricanes); coral reef characteristics (reef type, continuity, and distance from shore); coastal vegetation (mangroves, wetlands, etc.); coastal elevation (m); coastal slope (percent); and the presence of erosive anthropogenic activities, such as sand mining.

   The relative total coastal protection for a particular coastal segment is the average value for the ten factors combined. This integration of individual factors is done in a geographic information system

[1] Modeled storm surge and wave heights were obtained from *Atlas of Probable Storm Effects in the Caribbean Sea,* http://www.oas.org/CDMP/document/reglstrm/index.htm. Within our pilot implementation of the methodology for Tobago, for example, "vulnerable lands" were defined as any areas of 5m or less in elevation which are within 1 km of the coast, and all areas immediately adjacent to the coast (within 25 m resolution coastal grid cells.)

(GIS).The calculation can be repeated with the coral reef variable set to "no reef" to examine the change in this value due to the reef. In addition, the relative contribution of coral reefs to relative total coastal protection can be specifically evaluated based on the value of the coral reef variable relative to all other factors.

5) **Property Values.** Property values for land areas identified as both "vulnerable" and "protected by a coral reef" are required to estimate potential losses due to erosion and storm damage. Land value (to capture losses due to erosion) and value of built structures (to capture property damage) are required. Specific values are desirable, but average property values can be used. In addition, the revenues from businesses in vulnerable areas will be used to capture potential losses due to loss of use, based upon duration of expected loss of use.

6) **Damages Avoided Attributed to Coral Reefs.** The factors described above are integrated to estimate the value of shoreline protection provided by coral reefs through reducing erosion and mitigating wave-induced storm damage. The value of property on "vulnerable lands" "protected by a coral reef" is multiplied by the relative reef contribution to coastal protection (RRC) to arrive at an approximation of the value of this service.

Limitations and considerations

There are inevitably uncertainties associated with a multi-stage modeling approach designed to emulate complex physical processes. The analysis can be implemented using ranges to reflect some of these uncertainties. A range of values can be used to reflect estimates of property values In addition, the "relative reef contribution" values along coastal segments can be varied (by + and – 20%, for example) to develop an uncertainty range, rather than a single value. Results should be evaluated using available information on historic wave-induced storm damage in the study area or a similar area.

Next Steps

An Excel-based Economic Valuation Tool to guide implementation of this methodology is nearing completion. We are focusing on helping country partners apply the methodology and Tool to specific policy applications. Also, in response to feedback from project stakeholders, we are continuing to refine the existing valuation method while expanding its scope. Starting in Belize, we have begun testing additional components, and will be expanding this work into Jamaica and the Dominican Republic this year. Specifically:

1. **Mangroves** – A key intertidal habitat, mangroves provide an important nursery function for fish and shellfish, as well as providing vital shoreline protection services. They also trap sediments and nutrients, providing an environment that fosters coral reef development.
2. **Shoreline Protection** – Our current methodology includes an evaluation of shoreline protection services. However, this is a complex component, and in order to develop a more robust, replicable, and effective method, we would like to examine more complex examples of coral reef and mangrove loss, shoreline protection functions and economic losses from storm damage in additional locations.
3. **Climate Change** – Threats from climate change, such as warming seas, rising sea levels and ocean acidification are critical threats to coral reefs. To better incorporate these threats, we plan to run scenarios of climate change impacts on coral reefs and their associated economic effects, and adapt the findings and models into our methodology and tool as appropriate.

Your feedback and support is welcome!

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