Practical for the course: Ecosystem Accounting, Manila.

Valuation of Coral Reef Degradation in St. Lucia

Introduction

In this practical, course participants will practice with the valuation of ecosystem services provided by a coral reef, in an accounting context. The practical will cover the flow of three different services, the capacity to generate these services, the value of the services, and the value of this capacity. A valuation approach consistent with accounting is to be applied.

The specific case study to be analyzed is coral reef degradation in St Lucia, an island located in the Eastern Caribbean. The case is partly built on data collected in the recent assessment 'Reefs at Risk in the Caribbean', conducted by the World Resources Institute, supplemented with other data where required. Hence, to a large extent, real data have been used for the case study.

Background data

St Lucia. St. Lucia is a small island developing state located in the Eastern Caribbean. It has a total area of around 600 km^2, with major land use types being agriculture (bananas, coconut, vegetables), forest, built up areas. It is mountainous, with the highest peak 950 m above sea level. The island has some 170,000 inhabitants. The capital is Castries, which has an excellent deep-water harbor. The key economic sectors are tourism and agriculture.

Coral Reefs. Fringing reefs and coral veneers are found along all of St. Lucia's coast line. Some small patch reefs are found on the southeast coast, but the majority are narrow fringing reefs lying close to shore. The spectacular reef communities along parts of the west coast are of great importance to fisheries, and the area is becoming increasingly popular as a diving destination.

Degradation of coral reefs in St. Lucia. The Reefs at Risk analysis identifies almost all the 90 sq km of reefs around St. Lucia as threatened by human activities. Almost all reefs were rated as threatened by overfishing, coastal development and sedimentation from land. Tourism and coastal development have increased around Soufriere, and the reefs are

under pressure from increasing populations along the coast. The analysis showed all the reefs to be threatened by sedimentation. About 40 percent of reefs were also rated as threatened by marine-based pollution. Degradation of reefs is accelerated by an increasing frequency of tropical storms and hurricanes in the Caribbean. Tropical Storm Debbie in 1994, one of the hardest to hit St. Lucia in recent decades, caused landslides and erosion that resulted in heavy siltation from runoff. There has been a high incidence of white band disease on reefs, in particular in the Soufriere Marine Management Area (SMMA), for instance in the years 1997-1998 a loss of living coral of over 3 percent was recorded.

Table 1. Coral reef degradation in St. Lucia

Status of the Reef	Share
Healthy, low threat	10%
Medium threat	50%
Highly degraded, high threat,	40%

Source: WRI, 2007

The following services have been selected for this case study: (i) fisheries; (ii) tourism; and (iii) coastal protection. A brief description of each service is provided below.

Fisheries. Fishing comprises recreational fishing, local artisinal fishing (in particular lobster and reef fish), and commercial large-scale fishing in territorial seas (the latter in particular from overseas trawlers). The reefs are especially important for supporting local fisheries. The protection of certain gradually declining marine species populations such as turtles, larger reef fish, conch, and sea urchins has promoted the imposition of marine protected areas with certain zones where no fishing is allowed.

Tourism. As in most Caribbean countries, Tourism is one of the key economic sectors of St. Lucia. Preliminary data indicate that gross tourism revenue was US$782.1 million in 2006. Key attractions are the beaches, coral reefs and natural parks. Castries also has one of the most easily accessible deep-water harbors, and cruise ships frequently arrive. Tourist arrivals in St. Lucia are shown in Table 2.

Table 2. Tourism arrivals in St. Lucia 2006 (Government Statistics)

Tourists staying overnight	320,510
Cruise Ship Arrivals	359,593
Yacht Passenger Arrivals	25,355
Total Visitor Arrivals	705,458

Coastal protection. Using data on shoreline and coral reef location, and identifying coastline within 2 km of a mapped coral reef as "protected" by the reef, the “Reefs at Risk study estimated that coral reefs protect about 21 percent of the 158 km coastline of St Lucia. The significance of the ecosystem service depends on the extent and depth of the coral reef, the risk of tropical storms and high energy wave action, and the amount of built-up capital available on shore.

As for St. Lucia, although the island is generally mountainous, there is a strong concentration of buildings and capital on the relatively narrow coastal strip, in particular in the northwest of the island. Coral reefs can provide coastal protection by mitigating wave action.

Biophysical assessment of ecosystem services

Question 1: Please identify indicators that can be used to describe, in physical terms, the three services provided by coral reefs, as well as indicators to describe the capacity of the coral reefs to generate these services.

Now you will quantify these three services, for which you need additional data.

Fisheries. Previous studies of the productivity of coral reef fisheries in the Caribbean provide guidelines for determining productivity on healthy and degraded coral reefs. Fisheries productivity on Caribbean coral reefs overall ranged between 0.5 and 5.0 mt/sq km/yr. Degraded coral reefs produced much less, averaging between 17 percent and 44 percent of the productivity of healthy reefs. For your estimate, use the following productivity coefficients (Table 3). The actual fish production in St Lucia (excluding aquaculture) is 1625 metric ton (CREM[1], 2014). For the purpose of this practical, it is assumed that 10% of this is harvested on the coral reefs.

Table 3. Reef Productivity

Status of the Reef	Productivity metric tonne/sq km/yr.
Healthy, low threat	4
medium threat	2.3 – 2.9
high threat,	0.7 – 1.7

Source: WRI, 2007.

Question 2: What is the flow of the ecosystem service 'provisioning of fish', and what is the capacity of St Lucian coral reefs to support fisheries ?

Tourism. One of the key motivations for tourists to visit the country is the availability of coral reefs for diving and snorkeling. Scuba divers look for high-quality coral reef habitats (as indicated by live coral coverage), coral and fish diversity, and water clarity. Divers make up about 10 percent of all (overnight stay) visitors but contribute about 17 percent of all tourism revenue. Because of the interest of divers in seeing healthy coral reefs not affected by bleaching and with high biodiversity, coral reef degradation will impact the number of tourist arrivals. Relating coral reef conditions and divers is difficult, and a certain lag may occur between degradation and reduction of visitor numbers.

[1] http://www.caricom-fisheries.com/Members/MemberStates/StLucia/tabid/78/Default.aspx

Question 3: Calculate the flow of this service in physical terms, expressed as number of overnight stays that can be attributed to diving opportunities provided by coral reefs. Assume that Yacht passengers do not engage in diving, for the purpose of this practical. What would be the capacity to support diving tourism ?

Coastal Protection. Coral reefs protect around 21% of the total coastline of 158 km. In order to assess the benefits resulting from this service provided by coral reefs, it is necessary to link degraded reefs to development areas. In high development areas, the economic costs of reef degradation will be considerably higher. Table 4 shows a cross-tabulation for the whole Caribbean from WRI (2007), adjusted for St. Lucia.

Table 4. Shoreline Classified by Closest Coral Reef's Development and Threat Levels (percent)

		Status of Nearest Reef			
		Healthy	Medium	Highly degraded	TOTAL
Development level of shoreline	Low	14	9	16	39
	Med	2	7	28	37
	High	0	1	22	24
	TOTAL	16	18	67	100

Question 4. How can this service be expressed in physical terms ? How can the capacity - in physical terms - to provide this service be expressed ? Assume for this exercise that a degraded coral reef provides the same level of protection, in the short term, as a non-degraded coral reef. Also assume –for the purpose of this exercise - that there are no people living and that there is no infrastructure on coastal areas with a low level of development.

Monetary Valuation

Fisheries Revenue. Current market prices for reef-related fish in the Caribbean average about $6/kilogram (kg). This average can be used for all calculations of fish revenue for St. Lucia. Fishing costs – labor, fuel, depreciation of vessels and gear etc. – vary widely between countries within the region, ranging between 20 and 90 percent (WRI, 2007). For St. Lucia, use 50 percent of revenues as an average for the aggregated total costs.

Question 5. Calculate the monetary value of fisheries on coral reefs in St. Lucia. Use resource rent as indicator for monetary value. Note that resource rent (RR) equals: TR

(total revenue) - IC (intermediate consumption) – CE (labor costs) - CC (consumption of fix capita).

Question 6. Calculate the NPV of the capacity of the reefs to support fisheries. Use a market discount rate of 8% and a 20 years discount period. The formula for NPV is provided below (C are the net benefits in year t, r= the discount rate, T = the discounting period).

$$NPV = \sum_{t=0}^{T} \frac{Ct}{(1+r)^t} = C_0 + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \ldots$$

Question 7. Imagine that a large proportion (e.g. over 40%) of the St Lucian labor force would be working as fisherman. How does this influence the calculation of the resource rent ? And what would happen to the resource rent generated by fisheries in case it was managed as a pure open access, common pool resource where over time resource rents would be driven to zero ?

Tourism. The average diver spends about US$2,100 in St Lucia per holiday trip, compared to US$1,200 for tourists in general (WRI, 2007). Also for tourism, a resource rent approach can be used to assess the monetary value of the service. Expenditures relate to costs such as labor costs, intermediate inputs for the diving recreational sector (e.g. food supplied to restaurants and hotels), depreciation of tourism infrastructure (hotels, restaurants) and equipment rented to divers, etc. These costs can be assumed to be 65 percent of total expenditure (WRI, 2007).

Question 8: Calculate the value of the tourism service provided by St Lucian coral reefs and the NPV of the capacity of the reefs to support tourism. Use the same assumptions as in question 6 above. Note that multipliers are not considered in monetary valuation consistent with SNA.

Coastal Protection. To estimate the economic value of the shoreline protection services provided along a coastline, benefit transfer can be applied. In several studies, benefits of coastal protection from coral reefs have been calculated. Methods applied in these studies included (i) comparison of flood losses in areas protected and not protected by coral reefs; and (ii) assessments of costs of artificial protection of shorelines. These estimates ranged from about US$2,000 to US$800,000 or more for each kilometer of coastline protected by coral reefs. The value of the coastal protection service varies with the level of development along the shoreline, population density, and presence of a tourism industry. In your case study, use the following figures, see the Table below.

Table 5. Benefits of coastal protection by coral reefs

Status	Annual Benefits based on avoided damage costs (US$ per km of coastline).
Low-development areas (fewer than 100 people within a 5-km radius)	US$2,000 to US$20,000
Medium-development areas (100 to 600 people within a 5-km radius or located within 5 km of a dive center)	between US$30,000 and US$60,000
High-development areas (more than 600 people within a 5-km radius) used	between US$100,000 to US$500,000

Source: WRI, 2007

To estimate the loss in coastal protection function, assume that shorelines adjacent to reefs under low threat retain 100 percent of their current coastal protection service; shoreline's near reefs under medium threat retain 90 percent of their current coastal protection function; and shorelines near reefs under high threat retain 80 percent of current service (WRI, 2007).

Question 9. What is the monetary value of the coastal protection service as expressed through an avoided damage cost approach ? Consider both flow and capacity for this service as well. Note that an alternative approach would be the replacement cost approach, which would estimate the value of this service on the basis of the costs of constructing alternative coastal protection structures. A critical consideration here is if it can realistically be expected that such structures would indeed be constructed. This will generally be the case if: (i) this is technically feasible, and (ii) if damage costs exceed replacement costs. For reasons of simplicity this practical uses the avoided damage costs only.

Question 10. Prepare an accounting table for the LCEU (Land Cover/Ecosystem Unit) 'Coral reefs' in St. Lucia. Note that a comparable table can be produced to record the capacity of coral reefs to provide these services. Is the accounting table complete ? (i.e. does it over all benefits provided by coral reefs?). Which service may be missing ?

Table 6. Partial Physical Ecosystem Accounting table (1 LCEU only)

LCEU	Area (ha)	Fisheries (ton/year)	Diving recreation (divers/year)	Coastal protection (km developed coast line protected)
Coral reefs, of which				
- Healthy reefs				
- Medium degraded reefs				
- Highly degraded reefs				

Table 7. Partial Monetary Ecosystem Accounting table (1 LCEU only)

LCEU	Area (ha)	Fisheries ($/year)	Diving recreation ($/year)	Coastal protection ($/year)	Total ($/year)
Coral reefs, of which					
- Healthy reefs					
- Medium degraded reefs					
- Highly degraded reefs					

In order to analyze the effects of ecosystem degradation, the accounting table can also be expressed on a per hectare basis.

With limited additional analyses, this information can also be used to calculate the economic losses resulting from coral reef degradation in St. Lucia as a consequence of a loss in the supply of the three different ecosystem services.

To estimate losses in tourism revenue due to coral reef degradation, a relation needs to be established between the condition of the reefs and the amount of divers interested in visiting the site. For your calculations assume the relation between reef conditions and divers' interest presented in the Table below. Assume that all international divers experience the quality of reefs in St. Lucia as 'Medium Degraded' (i.e. assume that they change their diving practices in such a way that they mostly dive on reefs that are Medium Degraded).

Table 8. Relation between reef condition and divers' interest.

Status	Decrease in number of divers
Healthy, low threat	0%
Medium threat	10%
Highly degraded, high threat	25%

Source: WRI, 2007

Question 11. What are the total costs of coral reef degradation that has taken place in St. Lucia ?