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by

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ABSTRACT

The ecological significance of mangroves has long been established by scientific studies. It is a well-accepted fact that these tropical trees provide many services that are important in sustaining livelihoods and protecting lives. These ecological functions include among others, support to offshore fishery, storm protection, soil erosion, flood control and carbon sequestration. Unfortunately, mangrove forests all over the world are rapidly disappearing due pollution, harvesting, and massive conversions to aquaculture and housing. Oil spills, in particular, was identified by the National Oceanic and Atmospheric Administration (NOAA) as one of the reasons for their degradation.

Last August 11, 2006, the tanker MT Solar I carrying two million litters of bunker fuel sank off the coasts of Guimaras Island, causing the biggest oil spill ever in the country's history. It severely affected the island's mangrove areas as the oil coated significant portions of the trees. The rapid assessment conducted by the local government of the island estimated a total of 648.98 hectares of mangroves areas were affected, 72% or 469.18 hectares were heavily oiled and 28% or 179.8 hectares were slightly oiled. In less than a year after the spill, actual area of dead mangroves has reached 0.947 hectares.

The Solar I Oil Spill did not only damage a natural resource that is highly valuable but also one that is difficult and takes a long time to re-establish. This study valued the costs foregone associated with the loss in Guimaras' mangrove cover resulting from the oil spill. Using benefit transfer approach and interviews with a mangrove expert, the costs were estimated based on four selected ecosystem functions deemed important by the affected communities.

A hectare of mangrove was valued in this study at Php 73,681.37/annum, when discounted for 25 years (based on the scientist's estimate of the age of the trees) at 8% rate, the present value is 762,023.80 pesos. The mangrove expert did not rule out the possibility of chronic effects manifesting in the future because according to NOAA, the effect of the oil spill on mangroves could last up to more than 10 years. In order to capture this uncertainty and anticipate future impacts, this study assumed the best and worst case scenarios of damage based on the expert's opinion. The present values were determined for each scenario using 8% and 15% discount rates.

Ideally, an original valuation study should have been "first-best" strategy but budgetary and time constraints would not allow it. In the absence of a primary research, benefit transfer can serve as the "second best" option. Considering the limitations of the study, it is recommended that an original valuation study will be conducted in the future. It is also recommended that such research/es be conducted on a broader scope to include more ecosystem functions so that the economic value of the resource will be captured better.

I. Introduction

The ecological importance of mangroves has long been established by scientific studies. It is a well-accepted fact that these tropical trees that thrive along coastal intertidal zones provide numerous services that are important to people and communities. They not only sustain livelihoods, they also protect life. Their ecological functions include support to offshore fisheries; storm protection; carbon sequestration; soil erosion and flood control, among others. At present, mangrove ecosystems all over the world face intense pressure as a result of pollution, logging/harvesting, increasing conversions to aquaculture and real estate projects (Bann, 1998).

For a long time, the communities in Guimaras enjoyed numerous benefits from the mangroves that cover their shorelines. Unfortunately the Solar I oil spill last August 11, 2006 severely damaged a substantial fraction of the island's mangrove areas including that of Taklong National Marine Reserve. The oil slick coated significant portions of the mangrove trees because the spill hit the shorelines during high tide (Rapid Assessment Report, 2006). The Rapid Assessment Report of Guimaras province indicates 648.98 hectares of the mangroves were affected, of which 468.18 ha (72%) are heavily affected and 179.8 (28%) are slightly affected. Three months after the spill actual tree deaths (in patches) has reached an aggregate of 0.96884 hectares. (Moscoso, 2006)

The National Oceanic and Atmospheric Administration (NOAA,) identified oil spills as one of the reasons for the rapid degradation of mangrove habitats worldwide. A NOAA report on oil spill in mangroves states that despite the high adaptability of mangroves to physical changes in their environments they are still very vulnerable to oil spill toxicity and could take more than 30 years to recover from severe impacts. (NOAA,2005)

The Solar I Oil spill did not only damage a natural resource that is highly valuable but also one that is difficult and takes a long time to re-establish. Unfortunately, many important benefits derived from mangroves do not directly translate to income (e.g. protection function) hence their values are often ignored in most studies. Society cannot fully appreciate what has been lost unless an estimate of its monetary value is provided.

This research is part of the economic assessment of the effects of Solar I Oil Spill in Guimaras. This study is focused particularly on the values of the selected ecosystem functions of mangroves damaged by the spill. Further, this study asks the question of how much has been lost to society in terms of indirect use values of dead mangrove trees.

II. Methodology

This study used benefit transfer method to calculate economic values for ecosystem services of mangroves. This approach involves the adaptation of available information from studies already completed in another location and/or context. Benefit transfer is appropriate if primary research takes long to implement and/or when it is too expensive to conduct (Champ, et.al, 2003). This is true for primary research on the indirect use values of mangroves since it would require several studies and collaboration of experts from different fields. Due to lack of both time and resources, benefit transfer was the chosen approach for this assessment.

Benefit transfer is the practice of applying non-market values obtained from primary studies of resource or environmental changes undertaken elsewhere (Freeman as cited by Rosenberger and Loomis, 2003). It is based on the idea that we can learn about something vicariously through the experiences of others (Rosenberger and Loomis, 2003). Benefit transfer is done by adopting available information from studies already completed in another location and/or context (http://www.ecosystemvaluation.org/benefit_transfer.html).

There are two ways of doing benefit transfer, one is value transfer or the direct application of original research summary statistics; the other is function transfer or the adoption of statistical models that define relationships between vectors of data collected at a study site. This research makes use of value transfer method specifically point estimate transfer which employs a single measure from an original study to be applied in the policy site. Following Rosenberger and Loomis, the context of the original research is referred to as the study site while the context for which we need the estimates is called the policy site. Point estimate transfer uses measure(s) of V_{Si} given the context of the study site i (Q_{Si}), to estimate the needed measure for policy (V_{Pj}) site j, given the context of the policy site (Q_{Pj}):

$$V_{Pj}(Q_{Pj}) = V_{Si}(Q_{Si})$$

A thorough search on mangrove valuation literature was conducted to gather original research outcomes. More than 30 studies implemented all over the world were reviewed for relevance and similarity to the context in Guimaras. Results from Asian studies (particularly low and low middle income countries) were chosen as candidate estimates because of their likeness to Philippine characteristics. This was further trimmed down to two researches that best fit the Guimaras situation. These studies were selected for the appropriateness of the values they provided. Finally, the values were adjusted in real terms and then applied to the Guimaras context.

This research included four ecosystem services of mangroves. These are erosion control, storm protection, nursery and litterfall function. These were selected based on the opinions shared by the participants in nine focus group discussions conducted in the Island. Most of them viewed that the significant benefits that they get from the mangroves are storm protection, erosion control and support to fishery.

Oil spill impacts on mangroves could last up to more than 10 years (NOAA). Its effects in the future is uncertain, the mangrove ecosystem in the island could either improve or worsen. Taking into account this uncertainty, the study assumes two probable scenarios, the condition of optimism and pessimism. In order to have a sound basis for the scenarios and other assumptions, key informant interviews were conducted. The experts provided information relevant on mangroves and the possible impacts of the oil spill in the future.

III. Results

Destruction of the natural environment is very costly when the loss for the future generation is considered. Thus proper valuation of natural resources like mangroves is important because it provides significant information for policymaking specifically in formulating appropriate and efficient management strategies.

The total economic value of natural resources includes indirect use values. This is in cognizant of the fact that each ecosystem is characterized by spatial dimensions, species compositions, functions and processes that it carries out, and the services it provides to people (Whigham, as cited by Freeman, 2002). Ecosystem services are results of these functions and processes that accrue to people and sustain and fulfil human life. (Dailay, as cited by Freeman, 2002). The term indirect use values generally refer to the value of these ecosystem functions and processes. Examples of these services are organic material decomposition or crop and natural vegetation pollination. (Champ,et.al, 2003).

This study valued four mangrove services deemed significant by the residents of Guimaras. One is the support it provides to fishing as a nursery and shelter to valuable marine stock that populate both the forest interior and the adjacent coastal waters. Some of these animals depend on the mangrove environment for their whole life cycle while others utilize mangroves only during specific life stages, usually reproductive and juvenile stages. (Yañez-Arancibia et al. 1988, as cited by NOAA, 2005) Another important benefit considered is served by mangrove litterfall biomass essential for plant growth, soil nourishment and marine food chain enrichment. (De Los Angeles, et al. 1995) Protective functions were also thought by the Guimarasnons as another vital role that mangroves offer. Mangroves protect

coastlines from erosion and destructions during typhoons preventing the loss of valuable agricultural land and property (Bann, 1998). These services help governments and private individuals avoid the costs of constructing protective barriers such as dikes to limit storm and erosion damage. (NOAA, 2005)

The estimated values of these functions based on two studies are as follows:

Table 1: Values of Mangrove Indirect Uses by Function and the Researches

Mangrove Indirect Uses	**Values/ha/yr. (Php in 2005 prices)**
Litterfall function	13515.47
Nursery function	36,955.16
Soil erosion and storm protection	23210.74
Total	**73,681.37**

The values used for each function were taken from the studies of De Los Angeles, et.al, and Gunawardena, M. and J.S. Rowan in 1995 and 2005 respectively. These are primary researches which utilized market methods as valuation technique. The market price method estimates the economic value products or services that are traded in commercial markets (http://www.ecosystemvaluation.org/benefit_transfer.htm). The total indirect use values amounts to Php **73,681.37**per hectare of mangroves per year adjusted in real terms. The amount was then applied to the situation in Guimaras.

Table 2: Selected Mangrove Indirect Uses and Studies Utilized as bases for their Values by Country and Valuation Technique.

Mangrove Indirect Uses	**Studies**	**Country**	**Valuation Technique**
Litterfall function	De Los Angeles, et.al, 1995	Philippines	Actual expenditure /market price of output
Nursery function	De Los Angeles, et.al, 1995	Philippines	Actual expenditure /market price of output
Soil erosion and storm protection	Gunawardena, M. and J.S. Rowan, 2005	Sri Lanka	Replacement cost

The actual damage resulting from the 0.96884-ha of tree deaths (Moscoso, 2006) was computed to reach Php 71,385.46 for the initial year. Since mangroves take a long time to grow, the loss is expected to last for a number of years until the replacement reaches the same age to perform the functions at the same level of efficiency. The mangrove expert estimates that the dead mangrove trees were about 25 years of age (Interview with Sadaba, 2006). Discounting the loss for 25 years at 8% and 15% we get the present value of Php 786,532.13 and Php 476,287.36 respectively.

Table 3: Estimated Social Loss Resulting from Actual Mangrove Deaths
By Time Periods and Discount Rates (in pesos)

	Social Cost of the 0.96884 ha of Mangroves (PhP)
Initial Year	71,385.46
25 Years at 8% discount rate	786,532.13
25 years at 15% discount rate	476,287.36

Estimates of future losses were also done to give a full picture of the possible value of the damage of the oil spill on mangroves. Due lack of data on future effect of oil on the mangroves, the expert's opinion was sought through key informant interview. Information on possible damages was provided to create the scenario of extreme settings of optimism and pessimism. The best case scenario adopted 5% likelihood of tree deaths and worst case of 15% of the 648.98 ha oiled mangrove area (Interview with Sadaba, 2006). Total losses under these two conditions are as follows:

Table 3: Estimated Social Loss Resulting from Possible Mangrove Deaths
By Scenario, Time Period and Discount Rates (in pesos)

	Best Case – 5% loss in mangrove cover	**Worst case – 15% loss in mangrove cover**
Time Period	**(32.399 ha)**	**(97.197 ha)**
Initial Year (Php)	2,387,202.71	7,161,608.12
25 Years at 8% discount rate (Php)	25,482,854.58	76,448,563.75
25 years at 15% discount rate(Php)	15,431,234.16	46,293,702.48

Assuming 25 years of loss, the lowest estimate is Php 15,431,234.16 at 15% discount rate under the best case scenario and the highest is Php 76,448,563.75 at 8% discount rate under the worst case scenario.

IV. Conclusion

Ideally, original valuation study is the "first best" strategy because it provides content and context specific information regarding the policy site (Rosenberger and Loomis, 2003) while benefit transfer provides only content and context relevant information. However, it would require several studies that would take a large amount of resources and longer time to conduct. Due to budgetary and time constraints, benefit transfer was the most feasible approach for this research. When primary valuation is not possible, benefit transfer is the "second best" strategy. As pointed out by Loomis, the "worst-best" strategy in economic valuation is not to account for ecosystem services implying that they have zero value in an assessment model.

Since estimates from benefit transfer lack the precision inherent in original researchers, the figures presented are approximations and should not be taken as exact values of the ecosystem services of mangroves. They should be viewed as indicative figures of the social loss arising from the damaged mangroves caused by the oil spill and should be appreciated in terms of the insight they provide as to the extent of this loss.

In view of the preceding discussion, two opportunities of research are recommended. First, the monitoring of actual mangrove damage and its extent should be conducted to serve as basis for original valuation studies. Second, if possible perform original valuation studies on a wider range of ecosystem services of mangroves to provide a fuller picture of their true and specific value.

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