

The Economic Value of Seagrass Ecosystem in Trang Province, Thailand

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ABSTRACT

Thailand's sea grass ecosystem expanded over an area of 18,986 hectares in 2013, making it one of the main coastal ecosystems that provide both direct and indirect benefits. The objectives of this study was to analyze the benefits derived from sea grass ecosystems in Trang, the province recognized as being rich in diversity of sea grass species and an important habitat of the iconic marine endangered species, dugongs. Three types of economic values were estimated: (1) use values from fisheries and eco-tourism; (2) indirect use values from carbon sequestration and storage functions; and (3) non-use values of sea grass ecosystem which estimated by using Choice Experiment.

Use value from fishery and tourism was estimated to be USD 1.2 M and 5 M, respectively. The only indirect use value estimated, i.e. carbon sequestration, was valued at USD 65 M. Intangible and non-traded benefits of the sea grass ecosystems amounted to USD 275 M.

These numbers will not only be useful in understanding the economic benefits, but could also help in evaluating whether the cost of conserving sea grass ecosystem would generate a net benefit. Conservation prospects are positive. On the supply side, there is recognition of the direct link between the sustainability of the sea grass ecosystem and the flow of income from fisheries. On the demand side, apart from the tourism sector, the findings from the Choice Experiment Analysis also confirmed a demand for conservation measures from the general public who have neither present nor future benefits from sea grass ecosystems.

Keywords: Sea grass ecosystems services, Total Economic Value, Choice Experiment

INTRODUCTION

Sea grass ecosystem is one of the main coastal ecosystems that provide both direct and indirect benefits. Apart from the

direct benefits from fisheries and eco-tourism, there are also indirect benefits such as storing and sequestering carbon, water purification, and by reducing the strength of the current, coastal erosion protection (Wongsurirat 2007).

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Worldwide, there are 12 genera and 48 species of sea grasses (Philip and Menez 1988). In Thailand, there are 7 genera and 12 species of sea grass on the eastern coastline, on the Gulf of Thailand and west side of the Andaman coasts (Liewmanomond *et al.* 1993). According to the latest data set from the Department of Marine and Coastal Resources (DMCR), in 2013 the total area of sea grass beds was 18,986 hectares. Most of the sea grass beds ($> 70\%$ of the total area) are located on the Andaman coast, while the remaining are distributed along the coastlines of the Gulf of Thailand.

The study area, Trang Province, is located on the Andaman coast. Although the

sea grass beds of Trang span only 15% of the total area, the province is recognized as having a rich diversity of sea grass species (Figure 1 (a)). The conditions of sea grass beds in Trang have been classified by the DMCR as being moderate to good. Moderate refers to areas with 26-50% of sea grass coverage; good refers to areas with 51-75% of sea grass coverage, and degraded areas refer to those with less than 25% sea grass coverage (DMCR 2014). The distribution of seagrass beds along Trang's coastline are shown in Figure 1 (b). As yet, none in this province has been classified as degraded and the DMCR's concern is to maintain them in this condition. The coastline of Trang Province is also habitat for the largest group of dugongs



(a)



(b)

Figure 1. The location of Trang Province in the southern region of Thailand (a), and the distribution of seagrass in Trang Province (b).

in the country. Among marine endangered species, the dugong is perhaps one of the most charismatic and well known to the general public. This gentle mammal has been listed as one of Thailand's protected endangered species by the Wildlife Preservation and Protection Act 1992, the Fisheries Act 1947, the National Park Act 1947, and in Appendix I of the Convention of International Trade on Endangered Species (CITES), and it has recognized at least symbolically, having been used as the logo of Trang's province. Despite part of Trang's coastal areas being declared a Marine National Park, similar to other coastal areas, sea grass beds are threatened by continual wastewater discharge and increasing sediment loads from dredging for navigation and construction of ports. A Marine Protected Area is declared in areas where sea grasses are dispersed from the shore up to distances between 100-750 meters where the sands are either 'fine' or 'very fine', salinity between 28-31 ppt and sea temperature between 25-31°Celsius (Purinthewakul *et al.* 1999).

In addition, although local fishers acknowledge the importance of sea grass beds as fish spawning grounds and habitat, harmful fishing practices, such as the use of trawl push nets, is one of the major causes of degradation of this ecosystem.

The objectives of this study were to analyze the benefits derived from sea grass ecosystems in terms of direct and indirect use values, as well as the non-use value of sea grasses. These numbers will not only be useful in understanding economic contribution, but could also help in evaluating whether the cost of conserving sea grass ecosystem would generate a net benefit.

MATERIALS AND METHODS

Three types of economic values were estimated in this study: (1) use values from fisheries and eco-tourism; (2) indirect use values from carbon sequestration and storage functions; and (3) non-use values of sea grass ecosystem. The valuation methods used are discussed in the following sections for the different types of economic values.

Direct use value from coastal fisheries and from tourism

Fishing is an important source of revenue for coastal communities particularly for those who live in three islands in the study area, namely Muk, Libong, and Sukorn. Many small-scale fishers also earn income from other sources. For this analysis, revenue from fishing was calculated based on information collected through in-depth interviews with 50 small-scale fishers whose main source of income is from fishing in Trang. Only 50 fishers were interviewed because initially the study focused on indirect use and non-use values. Nevertheless, recognizing that revenue from fishing in seagrass areas could be significant and would demonstrate one of the benefits of seagrass beds, the researcher had decided to conduct in-depth interviews of fishers as an added component of the study. Since each respondent would make decision for 4 choice sets, thus there were 16 observations. Hence having 330 respondents was more than sufficient. The respondents live on the mainland in districts along the coast, such as Sigao, Kantang, Haad Samran and Palian, as well as on the three islands. The fishers were asked where they fished and how far from the shore, the number of days their boats were taken out to sea during

and outside the monsoon season, what types and volume of fish caught, as well as the prices they fetched.

For use value from tourism, two approaches were used to estimate income. The first was to gather secondary data from the Trang Province Tourism Office. The second used the Benefit Transfer of consumer surplus calculated from tourism in other similar seaside tourist destinations. Benefit Transfer is a method for estimating the economic value of nonmarket goods of ecosystems services by transferring values estimated by other studies with similar ecosystems and adjusting these to reflect differences in time, exchange rates and purchasing power parity (Nabangchang 2011).

Indirect use values

Although sea grass performs a number of ecological functions, the indirect use value was estimated for only one of the ecological functions of sea grass, namely carbon sequestration. The calculation is based on average rate of carbon sequestered by 1 kilometre² of sea grass (Fourqurean *et al.* (2012). This is converted into weight of CO₂ using a ratio of 1 ton of carbon to 3.66 tons of CO₂. As 1 ton of CO₂ is equal to 1 carbon credit, the number of carbon credits that could be generated was multiplied by the average 2010 carbon credit price, which was USD10.3/ carbon credit, and the average 2011 carbon credit price, USD7.6 USD/carbon credit (Ecosystems Market Place 2013). It should be noted that market prices of carbon credit should be considered as lower bound estimates; the indirect use value of the carbon sequestration function would be higher if the value of the social cost of carbon were included.

Measurement of intangible and non-traded benefits from the ecosystems services provided by sea grasses

In addition to the direct benefits to fisheries and tourism and the various indirect benefits of the ecological functions described earlier, sea grass beds serve as habitat and feeding grounds for many aquatic and marine organisms including the iconic species, the dugong (*Dugong dugon*). This ecosystem service was based on how much people were willing to pay to support conservation of the sea grass ecosystem. Since the objective is to determine which conservation measures are most important to the respondents, the Contingent Valuation methodology was used.

The attributes of the sea grass habitat and dugong population level were identified in consultation with experts from Haad Chao Mai Marine National Park, researchers from Prince of Songkhla University, and representatives of the Andaman Foundation, which is a local NGO. The program included sea grass replanting, improving water quality, tagging dugongs, and assigning prices. The attributes are measures aimed at reducing pressure on sea grass from various land- and sea-based activities. The first two are measures to replant and improve water quality. The third facilitates monitoring the effectiveness of sea grass conservation efforts by measuring the dugong population being protected.

Each attribute has 3 levels, as represented by the visuals shown in Figure 2. For the sea grass-replanting attribute, each green square represents 25 m²; under the status quo condition, 3 parcels of sea grass are planted each year. At level 1, the number of parcels for replanting increases from 3 to 6

Attributes	status quo	level 1	level 2	level 3
Replanting seagrass				
	3 parcels	6 parcels	9 parcels	12 parcels
Clarity of water				
	Not clear	Not clear	Clear	Very clear
Dugongs (numbers tagged)	None	 Trang has 130 dugongs	 Trang has 130 dugongs	 Trang has 130 dugongs
		4 tagged	8 tagged	16 tagged
Price	0	500 Baht	1,000 Baht	1,500 Baht

Figure 2. Attributes and levels in the Choice Experiment orthogonal design

parcels. The number of parcels to be planted continues to increase to 9 parcels in level 2 and 12 parcels in level 3.

For water quality improvement attribute, water quality is described in terms of clarity of the water, i.e. the clearer, the better. Water quality under the status quo condition and at level 1 is assumed to be the same, i.e. poor water quality with high concentration of sediments and wastewater run-offs from land. The proposed measures would reduce the discharge of land-based pollutants and sediments and result in improved water quality depicted by the picture of 'clearer' water at level 2. Stepping up those measures would improve the water

quality further still, and this improvement is represented by 'very clear' water at level 3.

For the dugong-tagging attribute, under the status quo at the time of the survey, there was no effort to tag dugongs. Four dugongs would be tagged at level 1. The numbers tagged would increase to 8 at level 2, and 16 at level 3. The last attribute is price, expressed as voluntary donations to the program, which ranges from 0 THB (status quo), 500 THB at level 1, 1,500 THB at level 2, and 3,000 THB at level 3) (USD1 = 32 to 33 THB).

Using orthogonal design for the choice experiment (CE), the attributes and

levels were organized into 24 choice sets. Each choice set consisted of 4 options. For example, in Figure 2, the status quo condition is one in which 75 m² of sea grass are replanted each year, water quality is poor, no dugongs tagged, and people do not pay into the program. For the three other options, there is variation between the areas of sea grass planted, the investments for water quality improvement and the number of dugongs tagged. Each of these options would have varying prices (donations) that people would pay.

The survey was conducted with two groups of respondents. The first and larger group consisted of 330 respondents in Trang

(Figure 3) who come from the mainland and the islands. Trang is well known for having scenic seascapes in the southern region, as well as a dugong habitat. The second group for household surveys come from 8 districts in Bangkok (randomly selected from 50). It was assumed that awareness of the benefits and threats, as well as the perceptions of importance and motivations for sea grass conservation would differ between the two groups. Each respondent makes decisions for the 4 choice sets; a participant shown the images from Figure 2 chooses whether s/he would prefer the status quo option and pay nothing, or choose one of the other three options where s/he would have to pay some money for improvement of environmental quality.

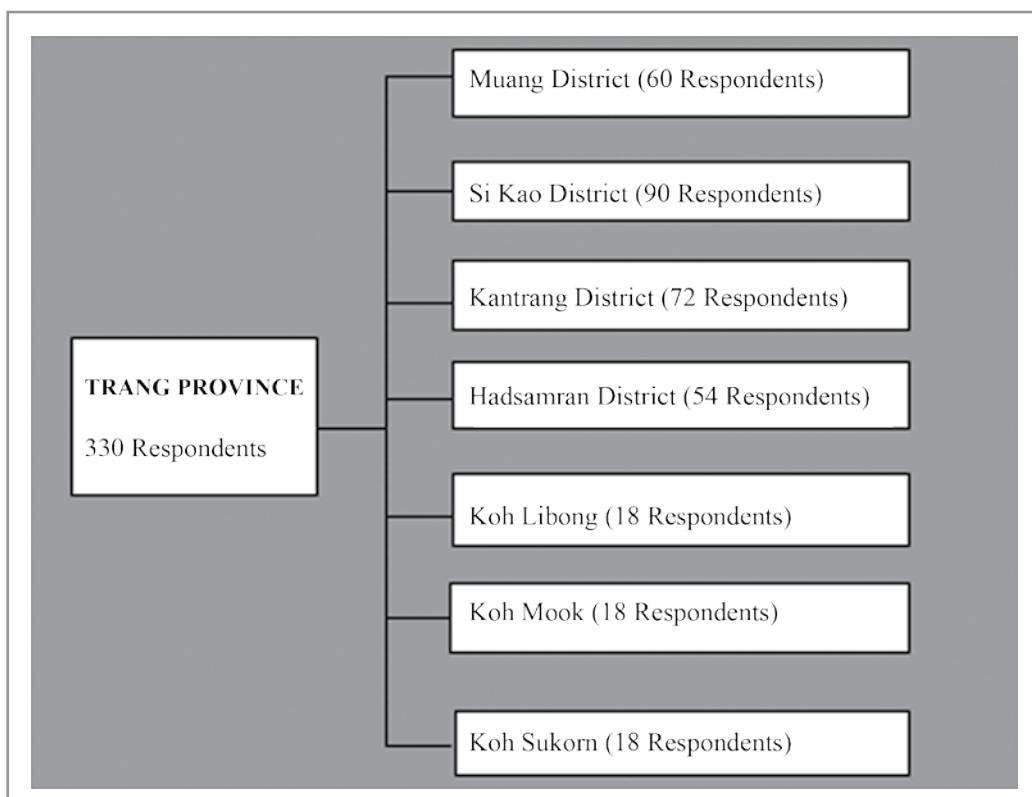


Figure 3. Distribution of samples in Trang Province

RESULTS AND DISCUSSION

Direct Use Value from Coastal Fisheries

Based on the information from in-depth interviews, local fishers fish in all locations, i.e. sea grass beds, mangroves, coral reefs, and open seas within 3 km of the coast. Moving around these locations, fisher folk can typically earn some money all year around. Among these, 28% said they fished in and near the sea grass beds.

Catches from sea grass beds include 4-5 common fish species, blue crabs, wing shells, and squid. At the time of the survey, the species that fetched high market prices were white pomfret (580 THB/kg) and mackerel (100 THB/kg). Jellyfish were also fetching a high price of 200 THB/kg. To estimate the annual revenue, the reported number of days they fished during and outside the monsoon season was multiplied by the income per trip. On average, fishers take their boats out 24 days/month during the 7 months of non-monsoon season. During the 5 months of monsoon season, fishers still

take their boats out, but poor weather means they fish at most 10 days/month. Based on this information, 218 days/year was multiplied by the income per day for each fisher.

In Table 1, income from fishing is shown for all of the areas of sea grass beds, coral reefs, mangroves, and open seas. According to information gleaned from the in-depth interviews, only 20% of the total number of fish catch came from sea grass beds, and an estimated 2,955 small-scale fishing boats operating in Trang. The number of small-scale fishing boats was estimated by the Andaman Foundation, which is an NGO based in Trang. The assumption that 20% of total number of fish catches came from seagrass beds is based on responses from the 50 small-scale fisher folk on where they fished. As such, it is assumed that 591 boats fish in the sea grass beds (20% of 2,955). Multiplying 591 by the mean income of 66,535 THB earned by fishing in sea grass beds gives an estimate of the economic value of Trang's sea grass beds at around 39 million THB/year.

Table 1. Estimated income from fisheries according to type of fishing area (USD 1 = 32 to 33 THB)

	Fishing location			
	Sea grass beds	Coral reefs	Mangroves	International
THB	998,030	5,869,890	615,275	22,927,480
Number of fishermen fishing in specified location	14	15	11	44
Mean	66,535	75,495	87,896	409,419
Max	261,000	218,000	225,000	3,750,000
min	6,000	3,780	24,525	8,720
Number of fishers fishing in and near sea grass beds				591
Estimated benefits from fishing in and near sea grass beds (THB)				39,322,185

Direct Use Value from Tourism

Estimation based on information of tourism revenue

Calculation of direct use value from tourism is based on tourism statistics from the Trang Provincial Tourism Office. According to this source, 993,615 tourists visited Trang in 2008, of which 993,615 (90%) were Thai. The Tourism Authority of Thailand estimates tourism revenue by multiplying average daily expenditures, which totaled about 3,328 THB/person/day, by the average number of days spent at the sites. By this approach,

total tourism revenue (approximately 3,307 million THB/year) is actually the value of total tourist expenditures.

In Table 2, varying assumptions have been made about the percentages of visitors who go diving and/or snorkeling. Based on statistics from the Tourism Authority of Thailand, around 40% of tourists who come to Trang spend time visiting beaches and caves, but not all of these would be eco-tourists who would visit sea grass beds to see dugongs. Moreover, the number of Thai eco-tourists is most likely fewer than international tourists. The calculation in Table 2, therefore, assumes

Table 2. Direct Use Value from Sea grass-related Tourism (financial information in THB)

	Thai	International
Number of tourists in 2008 (persons)	895,513	98,102
Number of tourists visiting beaches, waterfalls, and caves (40% of total number of tourists)	358,205	39,241
Number of tourists who are eco-tourists		
Assumed to be 5% of 40% of total number of tourists	17,910	1,962
Assumed to be 10% of 40% of total number of tourists	35,821	3,924
Assumed to be 20% of 40% of total number of tourists	71,641	7,848
Trang's provincial income from tourism	3,306.85 million	
Trang's provincial income per tourist	3,328	
Estimated revenue from tourists who are eco-tourists (assumed to be 5% for Thais, and 20% for international)*	59,605,345	26,118,144
Estimated revenue related to diving and snorkeling (Assuming 25% of tourist revenue is derived from diving and snorkeling activities)	14,901,336**	6,529,669***
Consumer surplus from tourism per trip (in 2008)****	6,638	
Total consumer surplus from tourism	118,888,306	52,095,024
Direct use value from tourism (sum of consumer surplus plus Estimated revenue from tourists who dive and snorkel assuming 25% of tourist revenue is derived from diving and snorkeling activities)	133,789,642	58,624,693

* For Thai tourists, this is assumed to be 5% of the 40% who said they visit beaches; for international tourists, this is assumed to be 20% of the 40% who said they visit beaches

**6,638 THB/person x 17,910 Thai tourists

***6,638 THB/person x 7,848 international tourists

**** Nabangchang-Srisawalak Orapan. 2011. The Study of Impact of Public Investment on Land Use in Koh Tao Island. A Study commissioned by the Thailand Research Fund. September 2011 (in Thai).

that only 5% of Thai tourists would spend part of their visit to Trang diving and snorkeling, while a higher proportion (20%) is assumed for international tourists. The 5% assumption is a conservative assumption based on general observation of behavior of Thai tourists. In relation to the assumption that only 5% of Thai tourists would spend part of their visit to Trang diving and snorkeling, the estimates we made reflect the lower bound value that could be generated. We could use this value as a base for doing sensitivity analysis but all this would amount to is to demonstrate that the value could be higher.

Given not all of tourist expenditures would be expenses related to ecotourism, one other necessary assumption to be made is what proportion of tourist expenditures would be related to ecotourism. In Table 2, to demonstrate how revenues can vary, two sets of estimates are shown for the assumption that 25% of tourist expenditure is spent on ecotourism and for the assumption ecotourism is 50% of the total. In the calculation of total use value from tourism, the more conservative assumption of 25% is used.

Estimation of consumer surplus using Benefit Transfer

Consumer surplus measures the difference between what tourists have to pay and what they are willing to pay; it is a measure of the net benefit of visiting the site. A number of Thai studies have used Travel Cost Method to estimate the consumer surplus tourists derive from visiting nature reserves and nature-based recreational sites. This study borrows a value of 6,638 THB/person/trip from Nabangchang (2011) who estimated consumer surplus from tourists visiting *Koh*

Tao, one of Thailand's top 10 diving sites. Multiplying 6,638 THB/person/trip by the number of Thai and international tourists to Trang that spend part of their vacation diving and snorkeling, gives a total of 118,894,428 THB. The value transferred from *Koh Tao* is low compared to other TCM studies undertaken (Nabangchang 2011).

The gross benefit from tourism is made up of two components: the amount tourists actually spend on tourism activities, and the consumer surplus. Using the assumption that only 25% of tourism expenditures (both Thai and international tourists) is related to ecotourism, the use value of tourism related to sea grass was estimated at 192,414,335 THB.

Indirect Use Value from Carbon Sequestration and Storage

The indirect use value is based only on calculation of carbon sequestration and storage functions. The total carbon stored in sea grass beds nationwide is estimated at 15.76 million tons, which is based on the country's estimated carbon storage capacity of 83,000 metric tons/km² (or equivalent to 132.8 tons/rai (Table 3), where the total area of sea grass beds in Thailand is 118,665 rai; 1 rai = 1600 m²) (Fourqurean *et al.* 2012). The volume of carbon stored is converted into weight of carbon dioxide using the relationship of 1 metric ton of carbon being equivalent to 3.66 metric tons of carbon dioxide. Since 1 ton of carbon dioxide equals 1 carbon credit, the carbon stored in the sea grass beds is worth an estimated 57.7 million carbon credits. Using the average 2012 carbon price in the Voluntary Carbon Market of 7.6 USD/ton CO₂ (247 THB), the value

carbon storage would be 14.027 million THB. More specifically, the carbon storage value of the sea grass beds in Trang province is 2,125.9 million THB.

Measurement of intangible and non-traded benefits from the ecosystem services provided by sea grasses.

Altogether 522 respondents were interviewed, of whom 192 were in Bangkok and 330 in Trang Province. The average age of both groups was 40 years. The average number of years of education for Bangkok respondents was higher than those from Trang. The majority in both respondent groups either had their own private business or were traders. The second largest occupation among the Bangkok respondents was as wage workers (22%), followed by people working in the private sector (16%). The second and third largest vocational groups among the Trang respondents earn their living from agriculture (26%) and wage work (16%).

Table 4 reveals that while most people in Bangkok (86%) agreed that there were more important problems than declining sea

grass beds, 90% also agreed that “everyone should take part in dugong conservation efforts.” When asked whether they agreed that all Thais should contribute some money toward sea grass and dugong conservation, 69% supported sea grass conservation and 64% supported dugong conservation. Similar responses were noted for Trang respondents: people felt there were more important problems to take care of but nevertheless agreed, in principle, that the general public should support conservation efforts for sea grasses and dugongs.

Responses to knowledge questions show differences in awareness and level of support for conservation between the two groups of respondents. As expected, respondents in Trang are more aware of the importance of Trang’s coastlines as an area with higher concentrations of sea grasses, including the importance of sea grass abundance to the survival of dugongs, and the dependence of their livelihoods on coastal fisheries (Table 5). This is consistent with the pattern of responses in Table 4 where Trang respondents were more aware and supportive of contribution to dugong conservation.

Table 3. Indirect use value of sea grass beds

Carbon sequestration (ton per rai*)	132.8
Sea grass areas of Thailand (rai)	118,665
Total volume of carbon sequestered by sea grass in Thailand (ton)	15,758,712
Carbon sequestered in terms of weight of carbon dioxide (1 ton carbon = 3.66 ton carbon dioxide)	57,676,886
Carbon credit available (1 ton carbon dioxide = 1 carbon credit)	57,676,886
Average value of carbon credit in Voluntary Carbon Market in 2011 (THB/ton CO ₂)	247
Value of Thailand’s carbon sequestering function of sea grass (million THB)	14.027
Value of carbon sequestering function of sea grass in Trang (million THB)	2,125.9

*1 rai = 1600 m²

Table 4. Attitudes related to environmental issues

Attitudes	Strongly agree	
	Bangkok	Trang
1. Thailand has other environmental problems that are more important than degradation of sea grass beds, such as wastewater and forest fires.	166 (86%)	251 (76%)
2. All Thais should donate personal money to protect and restore sea grass beds for future generations.	133 (69%)	245 (74%)
3. All Thais should donate personal money to protect and restore dugongs for future generations.	123 (64%)	250 (76%)
4. Everyone should take part in dugong conservation efforts to guard them from extinction, even if you never have the opportunity to see them in person	171 (89%)	325 (98%)
5. Both central (national) and local government budgets should be used to solve the basic livelihood problems of the Thai people before using it for protection and restoration of sea grass beds	123 (64%)	214 (65%)
6. Both national and local government budgets should be used to solve the basic livelihood problems of the Thai people before using it for dugong conservation	118 (61%)	203 (62%)
7. Investing in dugong conservation should be the responsibility of the government and the general public should not need to be involved	66 (34%)	79 (24%)
8. Investing in conservation of sea grass beds should be the responsibility of the government and the general public should not need to be involved.	57 (30%)	73 (22%)
9. The problems of degradation of sea grass beds in Trang are the responsibility of Trang people.	28 (15%)	87 (26%)

Note: Figures in parenthesis are percentage of the total

Table 5. Number and percentage of respondents who have knowledge and awareness about dugongs and sea grass

Areas of knowledge and awareness	Bangkok	Trang
The coastal area of Trang is major dugong habitat	92 (48%)	302 (92%)
Have seen a live dugong	29 (15%)	206 (62%)
The coastal area of Trang is one of the areas with high concentrations of sea grass in Thailand	52 (27%)	234 (71%)
Survival of dugongs depend on the abundance of sea grasses	90 (47%)	292 (89%)
Sustainability of income from coastal fisheries depends on the abundance of sea grasses	71 (37%)	248 (75%)
Total	192 (100%)	330 (100%)

Respondents were also asked about their preference on who should receive the voluntary payments (Table 6). The majority from both respondent groups preferred to donate directly to the Sea Grass and Dugong Trust Fund, which is to be set up for this purpose. The next most popular channel is as an income tax surcharge, and last, collection as a surcharge on electricity bills.

Factors Determining Decision-Making in Support of Restoration and Conservation of Sea Grass Ecosystems

Three groups of variables were included in the conditional logit model, namely, the attributes, the respondent demographics, and attitudinal variables. Variable definitions and their expected coefficient signs are described in Table 7.

The results of the conditional logit model are shown in Table 8. The coefficient signs of both *sea grass* and *dugong* are positive confirming respondents are willing to pay more for sea grasses to be planted and more dugongs to be tagged. As expected, the coefficient sign for the cost variable is negative, indicating respondents would be less willing to pay for higher costs. Water quality improvement, unlike the other explanatory variables, is a qualitative variable.

Therefore, an additional step is taken to calculate the implicit prices of this attribute* (*see section 3.2 Implicit Prices of Attributes and Consumer Surplus.)

All demographic variables were significant at a 99% level of confidence with the exception of income, which is significant at 90%. The coefficient signs of both income and education are positive, indicating the probability that respondents from higher income households and those with more education would be willing to pay more, as would male respondents and those respondents with children. The coefficient signs of the age variable are negative, which implies that younger people would likely be more willing to pay than older people.

The 2 attitudinal variables that were statistically significant, both at the 99% level of confidence, were *aatt1* and *attt4*. The coefficient sign of *att1* conforms to the *a priori* expectation that respondents who strongly agree Thai people should contribute to sea grass conservation for the benefit of the younger generation were more likely to be willing to pay. Interestingly, the coefficient sign of *aatt4* is negative, suggesting respondents who have not seen dugongs are more likely to be willing to pay, suggesting this is the non-use value that motivates this decision.

Table 6. Preferred payment channels for voluntary payments

	Payment channels	% of respondents	
		Bangkok	Trang
Rank 1	Direct transfer to the Sea Grass and Dugong Trust Fund	43.2	43.9
Rank 2	Pay as additional sum to income tax	27.6	20.9
Rank 3	Pay as surcharge to the electricity bill	8.9	12.1

Table 7. Definition of explanatory variables in the regression model

Variable	Definition	Expected coefficient sign
Attributes		
Grass	Number of parcels to plant: status quo = 3 level 1 = 6 parcels level 2 = 9 level 3 = 12	+
w1	improvement from unclear to clear if yes = 1 ; 0 if otherwise	+
w2	improvement from clear to very clear if yes = 1 ; 0 if otherwise	+
Dugong	number of dugongs tagged status quo = 0 level 1 = 4 level 2 = 8 level 3 = 16	+
cost	sum to pay status quo = 0 level 1 = 500 THB level 2 = 1,750 THB level 3 = 3,000 THB	-
Demographic		
aage	Age (years)	+
aedu	Years of education (years)	+
aincomemem	income (THB)	+
ahhexp	Household expenditure	+
agender	Male = 1 Female = 0	-
Attitudes		
aatt1	Reaction to statement "All Thais should support personal money to protect and restore the sea grass beds for future generations" 1= Strong agree or somewhat agree; 0 if otherwise	+
aatt2	Reaction to statement "All Thais should support personal money to support dugongs conservation for the benefit of future generations" 1= Strong agree or somewhat agree; 0 if otherwise	+
aatt3	Reaction to statement "All Thais should support personal money to support dugongs conservation even if they will never get a chance to see dugongs" 1= Strong agree or somewhat agree; 0 if otherwise	+
aatt4	Have seen dugongs = 1; 0 if otherwise	+
aatt5	Know that the survival of dugongs depend on the abundance of sea grasses = 1; 0 if otherwise	+
aatt6	Know that sustainability of revenue from fisheries depend on the abundance of sea grasses = 1; 0 if otherwise	+

Note: W1 + and W2 + : expected coefficient sign is "+" because the assumption is that respondents would prefer better water quality

Table 8. Result of conditional logit model: Pooled samples

choice	Coef.	Std. Err.	Z	P> Z	[95% Conf.	Interval]
asc	-3.058828	.3096136	-9.88	0.000	-3.66566	-2.451996
seagrass	.1076144	.01146655	7.34	0.000	.0788706	.1363582
w1	-.8202743	.0579392	-14.16	0.000	.933833	.7067157
w2	.2752386	.0484334	5.68	0.000	.1803109	.3701663
dugong	.0397596	.0069804	5.70	0.000	.0260782	.0534409
cost	-.0005384	.0000361	-14.93	0.000	-.0006091	-.0004677
province	-.0280293	.0582594	-0.48	0.630	-.1422156	.086157
aage	-.009757	.0033825	-2.88	0.004	-.0163867	-.0031274
agender	.2208608	.070949	3.11	0.002	.0818032	.3599183
achild	.0785561	.0258946	3.03	0.002	.0278036	.1293086
aedu	.1594083	.0320977	4.97	0.000	.0964979	.2223186
aincome	.0049943	.0030459	1.64	0.101	-.0009756	.0109642
aatt1	.2320476	.0405635	5.72	0.000	.1525446	.3115506
aatt4	-.102271	.0342912	-2.98	0.003	-.1694804	-.0350616

Number of observations = 8352; LR chi2(13)=1129.40; Prob > chi2 = 0.0000;
 Log likelihood = -4116.3054; Pseudo R2 = 0.1206.

Implicit Prices of Attributes and Consumer Surplus

The information above was used to calculate the implicit prices of the attributes and the consumer surplus shown in Table 9. For planting 25 m² of sea grass, respondents are willing to pay 199 THB. They are willing to pay 2,035 THB to improve the water quality from the 'unclear' to 'clear' level, and 501 THB to improve water quality from the 'clear' to 'very clear' level. For tagging

dugongs, respondents are willing to pay 74 THB/dugong tagged. Consumer surplus is calculated using Equation (1) at an estimated 3,508 THB/household.

$$\text{Equation } CS = -\frac{l}{\beta_t} (V_0 - V_1) \quad (1)$$

Where,

CS : Consumer surplus

β_t : Coefficient

$V_0 - V_1$: The change in the water quality

Table 9. Implicit Prices of Attributes and Consumer Surplus

Unit: THB

	Pooled Bangkok+Trang
Sea grass planting (per 25 m ²)	199.09
Improving water quality from unclear to clear	2,034.8
Improving water quality from clear to very clear	501.1
Per dugong tagged	73.8
Consumer surplus*	3,508

*Consumer surplus base on Equation 1

Multiplying the consumer surplus by the number of households in the 4 districts of Trang and Bangkok gives a total of 8,956 million THB. Given that the willingness of some respondents (particularly those in Trang Province) to pay may be motivated by current or future uses, while for others (primarily the Bangkok respondents) the motivation to conserve sea grass is related

to neither current or future use, this value estimate reflects a combination of both use and non-use values (Table 10).

Combining direct and indirect use values and intangible non-traded attributes (shown in Tables 1, 2, 3 and 10 respectively) of the sea grass ecosystem gives a total economic value of sea grass in Trang of 11,313 million THB (Table 11).

Table 10. Estimation of Non-use Value of Sea Grass Ecosystem

Areas	Non-use value of sea grass ecosystem (THB)	Number of households*	Estimated Willingness to Pay (THB)
Muang District		54,058	189,635,464
Kantang		24,035	84,314,780
Sigao		11,314	39,689,512
Haad Samran	3,508	3,964	13,905,712
Bangkok**		2,459,679	8,628,553,932
Total			8,956,099,400

* Population Figures from the Department of Local Administration, Ministry of Interior.
Total population for Bangkok from the Bangkok Metropolitan Administration

** Bangkok is selected on a site base on assumption that the majority would not have seen dugong and the values would therefore represent non-use value

Table 11. Economic benefits of sea grass ecosystem in Trang

Type of economic value	Estimate in million THB
Direct use value:	
Fishery	39
Tourism	192
Indirect use value (carbon sequestration)	2,126
Intangible and non-traded benefits of the sea grass ecosystem	8,956
Total Economic Value of sea grass beds in Trang (including contribution from households in Bangkok)	11,313
Total Economic Value of sea grass beds in Trang (excluding contribution from households in Bangkok)	2,685

Note: Information of non-use value from Table 10 excluding the non-use value of households in Bangkok of 8,628.6 Million Baht

The cost of restoring sea grass beds

One way of determining whether to invest in restoration and conservation measures is to compare the economic value of the benefits with the costs. In this study, only 2 types of costs have been estimated, namely the cost of replanting sea grass and the cost of tagging dugongs. Information on the cost of replanting sea grass was obtained from the Chairman of Aquaculture Group in Sigao District. Replanting cost is divided into 3 stages, namely planting, monitoring, and replanting saplings that do not survive. According to data in Table 12 below, costs for replanting a 25 m² parcel (5 x 5 m) is 163,500 THB and a cost of 6,540 THB/m².

If 300 m²/year were planted, which is the maximum area that has been proposed

in the CE scenario, the annual cost would amount to 1,962,000 THB. The cost of tagging dugongs, based on the maximum number of dugongs to be tagged under the CE Scenario, which is 16 dugongs/year, would at most be 1,600,000 THB. Combining these two costs, the annual expenditures would amount to 3,562,000 THB, a considerably lower sum than the Total Economic Value of the sea grass ecosystem estimate of 11,314 million THB. The implication is clear: invest 3.56 million THB per year to maintain the flow of benefits. Even if the willingness to pay estimates of the Bangkok households were excluded, the economic value of the non-tradable benefits for households in Trang alone, as presented in Table 11, would still be 327.5 million THB. The total economic benefits of 2,685 million THB would still exceed the estimate of 3.56 million THB/year needed for restoration and conservation.

Table 12. Estimated cost of replanting sea grass

Unit: THB

Stage 1: Planting	
1. Sapling @ 30 THB/sapling *100/m ² * 25 m ²	75,000
2. Planting cost @300 THB/day* 10 people*7 trips	21,000
3. Boat @ 1,500 THB/trip* 7 trips	10,500
Stage 2: Monitoring	
4. Monitoring sea grass parcels replanted	
4.1 Boat @ 1,500 THB/trip* 3 trips	4,500
4.2 Labour cost @ 300 THB/person*10 people* 3 trips	9,000
Stage 3: Replanting saplings that did not survive	
5. Replanting costs (assuming survival rate is 60%)	
5.1 Replacement saplings @1,000 sapling* 30 THB/ sapling	30,000
5.2 Labour cost @300 THB/person* 10 people*3 trips	9,000
5.3 Boat @ 1,500 THB/trip* 3 trips	4,500
Cost per 1 parcel (25 m ²)	163,500
Cost per m ²	6,540

CONCLUSION AND RECOMMENDATION

The coastline of Trang, similar to other provinces is under pressure from both land- and sea-based activities. The estimation of the different types of economic values should at least provide a clear indication of the economic losses incurred should any development efforts harm or further degrade coastal ecosystems.

On the demand side, the tourism sector is a direct beneficiary. The findings from the Choice Experiment Analysis also confirm demand for conservation measures from the general public who have gleaned neither present nor future benefits from sea grass ecosystems.

On the supply side, interviews with the households in Trang, indicate local communities recognize the direct link between the sustainability of the sea grass ecosystem and the flow of income from fisheries—now an estimate of some 39 million THB/year. These fishing communities therefore have a direct interest in ensuring that the sea grass beds remain intact.

As for the conservation measures that need to be prioritized, the starting point is to focus on the attributes with the highest implicit prices, namely improvement of water quality, by reducing land-based pollution. This will require further investigation of cost-effective measures to reduce land-based pollution. The second priority is replanting of sea grass. Trang's advantage is the existence of local initiatives, and their local experiences can be tapped.

The third ecosystem attribute, tagging of dugongs, has the lowest estimated implicit price. Note, however, that undertaking the 2 other measures produces a positive benefit to the dugong population in terms of both habitat and food supplies of dugongs. Thus, including the benefits to dugong as a byproduct benefit may be a more strategic fundraising approach since this will protect this iconic species to which many respondents may feel sympathetic.

To raise funds for the conservation project of sea grass in Trang, the most suitable mechanism according to household surveys is to set up the Trang Sea Grass and Dugong Conservation Trust Fund. This would allow potential donors to contribute directly to the Trust Fund without having to go through a third party. A majority of the respondents also indicated that the main implementing agency of this program should be the Department of Marine and Coastal Resources (DMCR), and indeed this activity falls within the DMCR mandate.

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