Ocean & Coastal Management 85 (2013) 177–185

Contents lists available at SciVerse ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Determining regionally applicable economic values for coastal habitats and their use in evaluating the cost effectiveness of regional conservation actions: the example of mangroves, in the South China Sea

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ARTICLE INFO

Article history:
Available online 31 May 2013

ABSTRACT

This paper outlines the process of: assembling an empirical data set relating to the values of resource 'goods and services[1]' derived from coastal habitats bordering the South China Sea; standardising these data as production values per hectare per annum; converting local currencies to US dollars; and converting these values to a standard year (2007) by means of the consumer price index. In order to address the problem of the wide variation in prices within one country, the data were weighted to determine a 'Weighted Mean National Value' that reflected ***both*** the prices for the same resource at each location and the 'stock' of that resource at the same locations. This results in a national value that reflects the totality of the national stock rather than being a simple arithmetic average of all values. The determination of weighted mean regional values was undertaken in a similar manner to the computation of weighted mean national values but using data and information concerning the total stock (or area) in each country and the weighted mean national values. These weighted regional mean values were subsequently used in a cost benefit analysis of actions to conserve regional coastal habitats.

What has resulted from this work is a standardised method for calculating national and regional weighted mean values of resource 'goods and services' that can be applied more widely in handling and manipulating economic valuation data from multiple locations across any time span. The method can be applied in any region where multiple currencies, varying exchange rates and widespread inter-location variations in farm gate prices are found. The specific targets of the revised Strategic Action Plan for the South China Sea have been valued or, more specifically, the incremental benefit derived from achieving the SAP target has been valued. The values saved by achieving the targets are then compared with the costs of implementing the actions defined in the regional SAP through a cost benefit analysis.

1. Introduction

The work reported in this paper represents an outcome from the project entitled "*Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand*" funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) in partnership with seven states bordering the South China Sea.[2] The Project was complex as it addressed three priority areas of concern identified in the

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[1] The term 'goods and services' is used in this paper to encompass all the elements normally evaluated as part of the process of determining total economic value.

[2] Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam.

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http://dx.doi.org/10.1016/j.ocecoaman.2013.04.001

Transboundary Diagnostic Analysis (TDA)[3] (Talaue-McManus, 2000), namely: the loss and degradation of coastal habitats; over-exploitation of fisheries in the Gulf of Thailand; and land-based pollution. Of these three substantive project components, the first, relating to habitat degradation and loss, was the largest and was sub-divided into four sub-components (mangroves, coral reefs, seagrass and coastal wetlands).

During the initial project development phase from 1996 to 1999, a framework Strategic Action Programme (SAP) was developed that not only formed the basis for the GEF approval of the project but was also somewhat innovative in including a cost benefit analysis of the benefits of conservation action compared with no-action scenarios (UNEP, 1999). The challenge facing the project in 1999 was that the only 'ecosystem values' readily available were those of Costanza et al. (1997) that were based on global data for ecosystem services. These estimates have subsequently been challenged on both economic and scientific grounds (Toman, 1998; Turner et al., 1998; Nunes and Jeroen, 2001). In approving the draft SAP and the SCS GEF project, the Project Steering Committee (PSC), composed solely of participating government representatives, insisted not only that the project activities include the revision of the SAP but also the determination of regionally applicable economic values for environmental goods and services.

2. Materials and methods

2.1. Assembling information on ecosystem 'goods and services'

Initially, the plan was for each national working group responsible for the project components to review the nationally available economic data and information relating to their areas of expertise (mangroves, coral reefs, seagrass, wetlands, fisheries and land-based pollution) and to assemble data sets that would enable some form of regional analysis of values to be undertaken by the regional working groups. By the end of 2002, it became apparent that the national working groups contained specialists in the subject matter, mainly ecologists and environmental managers with few or no economists amongst the members. The PSC therefore decided, (UNEP, 2002), to establish a Regional Task Force on Economic Valuation (RTF-E) consisting of nine economists from the region charged with providing economic assistance and advice to the national and regional working groups addressing habitat, fisheries and pollution issues and determining "*regionally applicable economic values for environmental goods and services*". In the context or the work of the regional task force, 'goods and services' were interpreted in their broadest sense to include all environmental resources subject to extractive or direct use; indirect uses of both resources and the ecosystem; and services provided either directly to society by the ecosystems (waste assimilation for example) or indirectly such as the nursery function of coastal habitats to commercial and subsistence fish stocks.

During its first meeting in September 2003 (UNEP, 2003), the RTF-E reviewed the data and information assembled by the habitat and land-based pollution regional working groups and provided advice regarding the further elaboration and refinement of these data sets. Initially, each habitat regional working group was asked to prepare a listing of all the goods and services provided by each habitat of which they, as expert members, were aware. Such lists were prepared during 2003 and provided to the RTF-E that produced simple guidelines regarding what were the easiest methods to use for deriving an economic valuation of each of the identified goods and services (Annex 4 of UNEP, 2004) and the procedures for valuing the impacts of land-based pollution (UNEP, 2005).

The lists of goods and services for each coastal habitat were discussed and refined through a process of iteration between the regional working group concerned and the RTF-E. A final listing for each resource good or service for each habitat was agreed that comprised individual identified resources directly exploited and ecosystem 'services' as follows.

- Mangroves: 24 resources directly exploited and 9 identifiable 'services'.
- Seagrass: 9 resources directly exploited and 12 identifiable 'services'.
- Coral Reefs: 11 resources directly exploited and 7 identifiable 'services'.
- Coastal wetlands (estuaries & brackish lagoons): 10 resources directly exploited and 8 identifiable services.

2.2. Limitations of the available data

It should be noted at this point that the available data (economic values) are heavily biased towards extractive, direct uses, or, what the Millenium Ecosystem Assessment (MEA, 2003) defines as 'provisioning services'. Some of the 'services' identified in the present study, fall into the 'regulating' and 'cultural' categories of services defined in the Millenium Ecosystem Assessment whilst very few fall into the MEA category of 'supporting' services'.

The available data have severe limitations in that the vast majority of available economic valuations in Southeast Asia relate to the direct extractive use of resources supplied by coastal habitats and very few are available for ecosystem services, however these are defined. For example, although the nursery functions of mangrove and seagrass habitats are well documented in the ecological literature, this function has not been valued frequently by economists. Under such circumstances, many economists would apply some form of benefits transfer in order to substitute for missing values. The regional task force decided against such an approach as they were of the view that, first, this might inflate the regional values derived and second the economic conditions in each country encompassed such a range of development conditions that use of such an approach was inappropriate. The task force considered that a conservative approach to deriving regionally applicable economic values would be politically more acceptable to the participating countries.

In this context, it should be further noted that the calculation of Total Economic Value described below is clearly not 'Total' in the sense of environmental economics, because it is based only on **available** economic valuation data and many of the identified resource 'goods and services' that are known to be used or provided by coastal habitats have apparently not been valued by economists in this region.

A further limitation of the data will be apparent to readers with an ecological background, namely the fact that different kinds of mangrove forests provide different kinds of goods and services. Ewel et al. (1998) suggest that mangrove ecosystems can be divided into three types, fringing, riverine and basin with each type providing different kinds of ecological goods and services. Regrettably, the present data are too limited to permit separation of the data pertaining to each of these types. For the purposes of this analysis, therefore, all mangrove systems, regardless of hydrogeomorphic type and stage of succession, are considered as being equivalent from the perspective of the goods and services produced.

[3] All project related documents cited in this paper can be found on the project website at www.unepscs.org.

2.3. Quality control and standardisation of the data

During 2004, the RTF-E commenced assembling an empirical dataset of economic values of goods and services derived from the coastal habitats bordering the South China Sea. Data were taken from published sources in the international literature and from the 'grey' literature of government reports. Each focal point produced a synoptic report on the economic valuation data available in their country that was provided to the meetings of the task force. These data were then compiled into tables annexed to the various meeting reports (UNEP, 2006; UNEP, 2007a; UNEP, 2007b). The focus was on data derived from empirical studies along the coasts of the South China Sea although, in a few instances, data from elsewhere in the seven participating countries were included. Data for resource values represent market values at the point of production or 'Farm Gate Prices' and this is assumed to be equivalent to the value of natural production, *i.e.*, the value of the labour involved in harvesting is considered negligible in comparison with the 'value' of the natural production. Data derived from secondary markets have not been included because, in most cases, the value added cannot be reliably determined. Every attempt has been made to ensure that the data contained in the final tabulations are based on primary data collection and did not merely represent values derived elsewhere.

As the data have been derived from diverse studies undertaken over the course of some twenty years, the methods used to undertake the valuations differ, as do the forms of the actual data and information contained in the publications and reports. In order to ensure that values are comparable, all data have been expressed as production or harvest values in US dollars per hectare per annum, including the values for 'ecosystem services'. Values have been converted to a standard year (2007) by means of the Consumer Price Index (UNEP, 2007a) and these values in local currency have been converted to US dollars using the 2007 exchange rate. Tables 1 to 8 of Annex 4 of the report of the seventh meeting of the RTF-E (UNEP, 2007b) present the empirical data and derived values for the goods and services provided by mangroves, coral reefs, seagrass and wetlands bordering the South China Sea.

The largest volume of data relates to the mangrove habitat and surprisingly few data were available for either coral reefs or coastal wetlands. This may be an artefact, as scientific data and information tend to be highly compartmentalised in the participating countries and it is often not easy to access data from sources outside an individual's own government department, institution or organisation. The lack of data for seagrass habitats is less surprising because the actual extent of this habitat in the region could not be accurately determined and the number of scientists currently involved in the study of seagrass ecosystems is quite limited, resulting in a comparatively small body of published literature.

The completed data sets were extensively discussed and reviewed by the RTF-E and, where anomalies or questions remained unresolved or unanswered, the data were excluded from further consideration. A number of values that were stated in the original reports as representing the capture of wild fish, crabs and prawns and the natural production of molluscs gleaned from mangroves were excluded from further analysis as the values were considered by the task force to be too high to represent natural production and, more likely, represented production from some form of simple mariculture.

In the case of 'services', data have been excluded from further consideration if they were deemed by the task force to represent unrealistically high, or unrealistically low, values. An extremely high value for ecotourism for Youstefa Bay, Indonesia, was excluded, for example, because this almost certainly represents the total annual value for all tourism at this location and not merely the value of tourism associated with the mangrove habitat in the bay. A number of the 'services', such as extensive mariculture for example, were deemed to have sufficient impact on the supporting ecosystem as to constitute a change in use rather than natural sustainable production and these values, although retained in the database, were not included in the calculation of the economic value of sustainable natural production.

2.4. Determination of weighted mean national values

As is well known, farm gate prices for environmental goods vary within countries, reflecting both the local supply and local demand. Where blood cockle beds (*Anadara granosa*), for example, are located in close proximity to a centre of population, the unit farm gate price is higher than when an equivalent sized resource is located further away.

In order to address this problem of the wide variation in farm gate prices within one country, the RTF-E decided to weight the data from each location and determine a 'Weighted Mean National Value' that reflected ***both*** the market prices for the same resource at each location and the 'stock' of that resource at the same locations. Hence, the price at location A was multiplied by the stock (or area where the stock could not be estimated) in area A, and this value was added to other values determined for locations B, C, etc. The summation was then divided by the total stock (or area of the habitat) for the country concerned, thus providing the ***Weighted Mean National Value***. This results in a national value that reflects the totality of the national stock and the range of farm gate prices rather than being a simple arithmetic average of all values for farm gate price. Full details of this method are contained in the various reports of the RTF-E.

The weighted mean national value is always lower that the farm gate price at any single location because the form of the weighting means that stocks for which farm gate prices were not available were treated as having zero value but the stock was included in the total national stock when calculating the "*Weighted Mean National Value*". The weighted mean national value is therefore a highly conservative value.

2.5. Determination of weighted mean regional values

The determination of weighted mean regional values (RV^{-ha}) was undertaken in a similar manner to the computation of weighted mean national values but using data and information concerning the total stock (or area) in each country and the weighted mean national values. Thus, the weighted mean national value for each resource was multiplied by the stock for each country and the resultant values summed, then divided by the total stock (or area) of the habitat bordering the South China Sea.

$$RV^{-ha} = \frac{[(S_{Ca}{*}MV_{Ca}) + (S_{Chi}{*}MV_{Chi}) + (S_{In}{*}MV_{In}) + (S_{Ma}{*}MV_{Ma}) + (S_{Ph}{*}MV_{Ph}) + (S_{Th}{*}MV_{Th}) + (S_{Vi}{*}MV_{Vi})]}{(S_{Ca} + S_{Chi} + S_{In} + S_{Ma} + S_{Ph} + S_{Th} + S_{Vi})}$$

RV = Weighted Mean Regional Value; S = stock of resource; MV = Weighted Mean National Value;

Ca = Cambodia; Chi = China; In = Indonesia; Ma; Malaysia; Ph = Philippines; Th = Thailand; Vi = Viet Nam.

As in the case of the weighted mean national values, the weighted mean regional value is a highly conservative estimate of the actual value.

2.6. Determination of Total Economic Value (TEV)[4]

The RTF-E agreed that for the purposes of the South China Sea Project Total Economic Value would be considered to be the sum of all available economic values for the annual production from habitats bordering the South China Sea; estimated as the summation of the available values of all resource 'goods and services' produced by each habitat on an annual basis. The summation of the regionally weighted values, therefore, represents the Total (available) Economic Value of the annual production and service functions per hectare, whilst the Total Economic Value for the entire extent of each habitat in the South China Sea is derived from the product of this value multiplied by the total area of the habitat bordering the South China Sea.

Including values as part of a figure for annual production for products whose harvest results in habitat change such as mangrove timber, which might take years or decades replenish, was done on the basis of the time taken to replace the resource removed. Thus, for example, it is known from the sustainable harvest of mangrove timber in Matang, Malaysia,[5] that rotation takes approximately 30 years. In this case, therefore, the timber values were simply divided by the replenishment time and this was taken as an approximation of the annual value of timber production. Harvest of mangrove poles for charcoal in Thailand is undertaken on a 15 year cycle, although for most charcoal values assembled by the Task Force the total production per annum was deemed sufficiently low as to constitute actual annual sustainable production.

2.7. Current management regimes of mangroves and proposed targets in the South China Sea Strategic Action Programme[6]

The Regional Working Group on Mangroves assembled the information contained in Table 1 that relates to the current management of mangrove areas in six of the seven countries bordering the South China Sea. Five categories of mangrove forest are recognised in the region: production forest, used on a sustainable basis for timber and wood chip production; conversion forest, a category in Indonesia representing areas of mangrove land designated for alternative land use under current development plans; parks and protected areas; and areas in which timber extraction is not permitted but extractive use of other resources is permitted. In the case of Thailand, a further category is recognised namely 'private land, unregulated use', which accounts for 10 000 ha.

Table 1 illustrates the complexity of management regimes in six of the seven countries concerned but does not provide a mechanism for objectively determining the effectiveness of that management regime. For example, in Cambodia, 13 558 ha of mangrove are contained within parks and protected areas for which there is no legal extractive use of either the mangrove trees or other resources. This area is also listed as being under a management regime regulated in law and similarly within the areas listed as being sustainably managed. The assumption is that, because access to and use of this area is restricted, the management is sustainable. In contrast, 58 792 ha in Cambodia are currently not regulated under the law and are subject to extractive resource use other than the mangroves themselves. Of this area, only 8 820 ha are considered as being exploited in a sustainable manner. The target for Cambodia is therefore to ensure that all 49 972 ha of mangrove outside the legally protected parks and protected areas are used in a sustainable manner by 2012. Targets for the six countries are presented in Table 2 below.

2.8. Cost-benefit analysis of action versus no-action in the strategic action programme

An economic cost benefit analysis unlike a financial analysis attempts to consider all aspects of a project's costs and benefits including the environmental consequences and the costs and benefits to society as a whole rather than simply the financial benefits to a specific investor.

The benefits derived from the actions, as outlined in the SAP, reflect, in reality, the anticipated change (decline) in the rate of loss or degradation of the habitat under consideration. Each regional working group provided up-to-date estimates of the rates of loss and degradation of important coastal habitats in order that the costs associated with a no-action scenario could be estimated. These are then compared with the costs of the actions proposed in the SAP and an analysis of the costs and benefits of action compared with non-action is presented. The data and information used include:

1) time-series data of the rates of habitat loss and degradation;
2) estimated rates of loss and degradation in high-pressure (no-action scenario) and low-pressured scenarios (action scenario); and
3) investments and costs needed to undertake the actions and achieve the targets as estimated by the regional working groups and included in the SAP.

2.9. Costs and benefits of Mangrove interventions

The targets in the SAP are of four types, each of which is discussed below:

2.9.1. Areas to be transferred from various categories of use to protected area status

In this case, the rate of mangrove loss in the region over the preceding decade of 1.61% per annum is used to ascertain the proportion of the mangrove currently not accorded protection status that will be saved by achieving this target. It is further assumed that the proportion accorded protection status is equally spread across the first five years of SAP implementation. The cumulative benefit is therefore the value of the annual production saved through such a change in designated status.

2.9.2. Areas to be transferred from status defined as "conversion" to sustainable use

In this second case, it is assumed that mangrove forest designated for conversion to alternate uses will have a change in designation to sustainable use (including sustainable timber extraction) and that such change in designation will impact areas in equal proportion over the first five years of SAP implementation. The cumulative benefit is therefore the value of the annual production saved.

[4] As noted in section 2.2 this is not TEV in the sense of environmental economics which is a theoretical construct in which all values both present and future are encompassed. In the present context TEV is total **available** economic value.

[5] Although on the Andaman Sea coast of Malaysia, the environment and ecology of the mangrove habitat in this location is considered to be sufficiently similar to that of the South China Sea such that the replenishment rate can be used as a proxy in the South China Sea.

[6] These targets were accepted by the sixth meeting of the Regional Scientific and Technical Committee.

Table 1
Areas of Mangrove currently under different forms of land-use designation and management. (Areas derived from national statistical and forestry records that are based on ground truthed satellite imagery. The degree of significance of these numbers is unknown).

	Cambodia	China	Indonesia	Philippines	Thailand	Viet Nam	Total	%
Total area (ha)	72 350	23 446	934 000	28 014	62 616	156 608	1 277 034	**100**
Production forest	0	0	610 800	0	1 600	18 000	630 400	**49**
Conversion	0	0	165 000	0	0	0	165 000	**13**
Parks & Protected Areas (Conservation) non-extractive use	13 558	15 772	158 200	27 072	11 520	20 000	246 122	**19**
Non-use of mangrove but extractive resource use (fish, crabs etc.)	58 792	7 674	0	942	39 496	118 608	225 512	**18**
Private land, unregulated use	0	0	0	0	10 000	0	10 000	**1**
Area currently under management Regulated in laws/regulations	13 558	15 772	768 800	27 072	11 520	155 000	987 793	**77**
Areas estimated as currently under sustainable management[a]	13 558 8 820[b]	15 772 1 000	158 200 100 000	26 010	11 520 1 600	20 000 18 000 46 608	432 078	**33**

[a] Areas considered as being currently sustainably managed include all lands designated as production forest as it is a legal requirement that these be replanted; all mangrove lands contained within National Parks and Protected Areas; and a proportion of the mangrove area subject to extractive use of non-timber resources.
[b] Area outside the protected area for which some form of management plans exist – estimated.

2.9.3. Areas in which management is to be improved

In this third case, a modest 5% per annum improvement in annual production is projected over the first five years of SAP implementation.

2.9.4. Areas of deforested mangrove land to be replanted

In the case of areas of degraded mangrove forest that are replanted, no cumulative benefits are anticipated over the first four years. The first year in which a return is likely to be seen is in year five. In this year, the annual production of the area planted in the first year is assumed to reach one sixth of the Total Economic Value. This proportion was selected based on the harvest cycle of mangroves under sustainable forestry management, namely a thirty year rotation in the only known example of sustainable forest management of mangroves at Matang, Malaysia.

2.9.5. Areas of degraded mangrove to be subject to enrichment planting to increase the species diversity

As in the case of the fourth target, it is assumed that no benefit accrues until the final year of the first phase of SAP implementation. Benefit is calculated in a similar manner to that calculated for the fourth target.

The costs of the actions contained in the SAP were determined by the Regional Working Group for mangroves on the basis of experience in implementing the first phase of the UNEP/GEF project entitled "*Reversing Environmental Degradation trends in the South China Sea and Gulf of Thailand*" and are expressed as 2006 costs.

2.10. Results

Table 3 presents the summary weighted mean national values for each resource good and service provided by mangrove ecosystems bordering the South China Sea. These derived values represent 164 market values for goods, together with 41 service values taken from the published literature and informally published government reports. It will be seen from this table that numerous cells contain no data, reflecting one of two conditions: n/a, when a resource is known to be used or a service provided but no published values could be found in the literature and n/u where a resource is not utilised in the country concerned. An example of the latter is the case of sipunculid worms that are highly prized in China and also eaten to a lesser extent in the Philippines and Viet Nam but which are not consumed in the other countries of the region. Consequently, there are no market values from Cambodia, Indonesia, Malaysia and Thailand reflecting the fact that these worms are not eaten and do not enter the market in these countries. Although the worms are consumed in Viet Nam, no market prices were found in either the published or unpublished literature. These deficiencies in data will further contribute to the highly conservative nature of the estimated total economic values both nationally and regionally.

Table 4 present presents a comparison of the weighted mean national, and weighted mean regional values in US dollars for mangroves, coral reefs and seagrass respectively.

In the case of mangrove 'fruit', or propagules, the value from China represents the price of *Avicennia marina* propagules that are used in soup and other dishes in southern China and are apparently only eaten elsewhere in the region in Indonesia (where no market values are available for this resource). Propagules of other species are processed as sweets and eaten in Thailand but no farm gate price is available from that country. What is interesting is the apparent absence of a market for mangrove propagules in countries where propagules are regularly purchased from local villagers for use in re-forestation and re-planting schemes. During the sixth meeting of the regional Working Group on Mangroves (UNEP, 2006), there was a discussion regarding the value and sale of propagules during which it was noted that propagules from the Batu Ampur demonstration site in Indonesia were being sold for

Table 2
Targets *[Proposed areas in hectares to be subject to changes in designation and/or management regime]* for Future Mangrove Management (All of these numbers are those provided by national authorities. Their degree of significance is unknown.).

	Cambodia	China	Indonesia	Philippines	Thailand	Viet Nam	Total	% of total area of mangrove
Area to be transferred to National Parks and Protected Area status	0	5 330	20 000	631	1 400	30 000	57 361	**4**
Non-conversion of mangrove but sustainable use	0	0	165 000	0	1 600	0	166 600	**13**
Improved management relating to sustainable use	49 972	0	490 800	2 000	10 000	50 000	602 772	**47**
Replanting of deforested mangrove land	2 500	500	0	2 000	8 000	8 000	21 000	**2**
Enrichment planting to increase mangrove biodiversity	0	5 000	0	1 000	3 200	2 000	11 200	**1**

Table 3
Weighted mean national and regional values (US$) for the per hectare annual production of resource goods and services by mangroves bordering the South China Sea. (Values of goods and services have been rounded to 3 significant figures; + = values less than 1 dollar ha^{-1}; Total values of annual production by country and region US$ × 10^6).

Mangrove goods	Cambodia	China	Indonesia	Malaysia	Philippines	Thailand	Viet Nam	Regional
Timber	780	137	74	10	203	0	11	73
Firewood	17	0	65	0	84	107	243	2
Poles	0	0	0	0	2	0	0	0
Charcoal	71	0	16	0	1	2	0	0
Leaves/palm fronds (Thatch, fodder)	14	0	0	0	2	0	0	0
Fruit/propagules	0	101	0	0	0	0	0	1
Medicine	0	0	238	0	0	0	0	173
Fish capture	0	186	282	0	161	207	200	231
Fish fry	0	0	47	0	0	51	0	37
Eels	0	0	41	0	0	0	0	30
Crab capture	0	200	267	0	13	22	0	199
Prawn capture	0	135	272	0	11	150	0	210
Shellfish collection	0	1 150	19	0	2	386	0	55
All Fisheries resources	0	0	0	3 630	0	0	0	514
Worms	0	2 580	0	0	+	0	0	41
Wildlife	0	0	25	0	0	0	0	18
Total value of goods US$ per Ha	**882**	**4 500**	**1 350**	**3 640**	**479**	**926**	**454**	**1 590**
Mangrove services								
Ecotourism	0	0	60	0	0	0	0	43
Nursery Function	0	1 270	782	0	0	0	0	573
Sediment retention	0	11 350	0	0	0	0	0	66
Coastal Protection	0	1 040	422	0	0	2 200	0	444
Windbreak	0	1 200	0	0	0	0	0	7
Carbon Sequestration	0	326	116	0	0	60	0	89
Oxygen Production	0	435	0	0	0	0	0	3
Option Value	0	0	70	0	0	0	0	51
Aesthetic Value	0	1 870	0	0	0	0	0	11
Total value of services US$ per Ha	**0**	**17 491**	**1 450**	0	**0**	**2 260**	**0**	**1 290**
Grand Total Goods and Services	**882**	**22 000**	**2 800**	**3 640**	**479**	**3 180**	**454**	**2 870**
Total Area of Mangrove Ha	72 400	23 400	934 000	532 000	28 000	62 600	157 000	1 810 000
Value of Total Annual Production US$ millions	63.8	515	2 610	1 940	13.4	199	71.1	5 200

replanting elsewhere in West Kalimantan at a price for *Rhizophora* of 1$ for 200 propagules. In Thailand and Viet Nam, the price was cited at around 1$ for 100 propagules, whilst in the Philippines the price was higher at 1$ for 50 propagules. Markets thus do exist for these products but values are apparently not formally recorded in the literature and it is furthermore difficult to relate these values to annual production per hectare.

The annual values of production per hectare for mangrove goods were found to vary from around 450 US dollars in Viet Nam and the Philippines to in excess of 4 000 US dollars in the case of China. Similarly, service values range from zero in Cambodia, Malaysia, Philippines and Viet Nam to in excess of 17 000 dollars in the case of China. Using the weighted mean regional value of mangrove production of US$ 2 870 the value of the annual production of goods and services by mangrove habitats bordering the South China Sea may be estimated at a total value of US$ 5 170 million per annum.

Table 5 presents the costs and benefits with respect to mangroves, over the first five years of SAP implementation, whilst Table 6 presents a summary of the costs and benefits. From Table 6 it can be seen that the costs represent 0.2% of the estimated net benefits amortised over the five years.

It is important to recognise that the actions costed in the SAP are only those actions undertaken at a regional level to ensure co-ordination of national actions and the sharing of experience and expertise across national boundaries. The costs associated with these activities have been tabulated in each section of the regional Strategic Action Programme; see Table 5 on pages 7 and 8 of UNEP, 2008, for the costs associated with the mangrove related activities.

The RTF-E is of the opinion that national level management costs might be expected to reach between 15 and 20% of the total national costs of the management interventions and that correspondingly, regional management and administrative costs might

Table 4
Summary of Total Economic Values (TEV) of annual production of three key habitats in seven countries bordering the South China Sea. Values are presented in US dollars per hectare, standardised to the year 2007 whilst the regional values have been weighted and calculated according to the procedures outlined above. (Except for the total area of mangrove, which corresponds to that given by national authorities based on satellite imagery, all entries in this table have been rounded to 3 significant figures.)

		Cambodia	China	Indonesia	Malaysia	Philippines	Thailand	Viet Nam	Weighted regional values
Mangrove	TEV of annual production per ha (US$)	882	22 000	2 800	3 640	479	3 190	454	2 870
	Total Area (ha)	72 350	23 446	934 000	532 100	28 014	62 618	156 608	1 809 136
	Value of Total Annual Production 10^6 US$	63.8	515	2 610	1 940	13.4	2 000	71.1	5 190
Coral Reefs	TEV of annual production per ha (US$)	Not available	Not available	8 110	Not available	421	7 150	964	1 540
	Total area in the South China Sea (ha)	2 810	Not available	39 300	44 300	464 000	90 000	110 000	750 300
	Value of Total Annual Production 10^6 US$	Not available	Not available	319	Not available	195	644	106	1 100
Seagrass	TEV of annual production per ha (US$)	1 190	6 940	Not available	Not available	35	4 100	2 260	1 180
	Total known area (ha)	33 800	1 960	3 040	222	23 200	2 550	8 940	73 800
	Value of total Annual Production 10^6 US$	40.1	13.6	Not available	Not available	814	10.5	20.2	87.2

Table 5
Summary of the regional costs and benefits of achieving the Mangrove targets defined in the Strategic Action Programme computed values of future benefits and costs in US$ $\times 10^3$. All values, excepting discount factors and total column sums, have been rounded to 3 significant figures.

Years	Values in US$ ha^{-1}	2008	2009	2010	2011	2012	Total
Target 1 Area of mangrove saved benefit increased i.e. rate of loss avoided − 1.61% per annum		185	369	554	739	924	
i Value of Mangrove Goods	1 590	293	585	878	1 170	1 460	
ii Value of Mangrove Services	1 290	238	475	713	951	1 190	
iii Total	2 870	530	1 060	1 590	2 120	2 650	
Target 2 Non-conversion of mangrove, sustainable use ha		33 320	66 640	99 960	133 280	166 600	
i Mangrove goods	1 590	52 800	106 000	158 000	211 000	265 000	
ii Mangrove services	1 290	42 900	85 800	129 000	172 000	214 000	
iii Total	2 870	95 700	191 000	287 000	383 000	479 000	
Target 3. Improved management relating to sustainable use ha	0	120 554	241 109	361 663	482 218	602 772	
i Mangrove goods computed benefits in US$ $\times 10^3$	1 590	9 550	19 100	28 700	38 200	47 800	
ii Mangrove services	1 290	7 760	15 500	23 300	31 000	38 800	
iii Total	2 870	17 300	34 600	51 900	69 300	86 600	
Target 4.Replanting of deforested mangrove land ha		4 200	8 400	12 600	16 800	21 000	
i Mangrove goods	1 590	0	0	0	0	1 110	
ii Mangrove services	1 290	0	0	0	0	901	
iii Total	2 870	0	0	0	0	2 010	
Target 5.Enrichment planting to increase mangrove biodiversity ha		2 240	4 480	6 720	8 960	11 200	
i Mangrove goods	1 590	0	0	0	0	592	
ii Mangrove services	1 290	0	0	0	0	481	
iii Total	2 870	0	0	0	0	1 070	
Total for goods	1 590	62 700	125 000	188 000	251 000	315 000	
Total for services	1 290	50 900	102 000	153 000	204 000	256 000	
Grand total	2 870	114 000	227 000	341 000	454 000	571 000	1 706 000
Summary							
COSTS at 2006 prices		765	828	655	711	370	
Discount factor NPV for 2006 $i = 4\%$		0.9246	0.8890	0.8548	0.8219	0.7903	
Costs 2006 value		707	736	560	584	292	
Costs 2007 values from 2006)[a]		736	765	582	607	304	2 994
BENEFITS at 2005 prices		114 000	227 000	341 000	454 000	571 000	
Discount factor for NPV 2005 $i = 4\%$		0.8890	0.8548	0.8219	0.7903	0.7599	
Benefits 2006 values		101 000	194 000	280 000	359 000	434 000	
Benefits 2007 values (compounded $i = 4\%$ from 2006)		109 000	210 000	303 000	388 000	469 000	1 479 000
Net benefits		108 000	209 000	302 000	388 000	469 000	1 476 000

[a] A nominal discount rate of 4% has been used.

Table 6
Summary of benefits (US$) in terms of cumulative natural production saved over the first five years of SAP implementation and the costs of executing the mangrove component of the Strategic Action Programme at regional and national levels.

Total benefit	1 480 000 000
Total regional costs	2 990 000
Estimated total national costs	300 000 000
Total costs	303 000 000
Total Net benefit	1 177 000 000
Benefit-Cost ratio	4.88
Costs as percentage of benefits	20.5%

be expected to reach a maximum of 1% of the total value of the interventions. Using these figures it is possible to extrapolate that the costs of national level actions might reach as much 300 million US$ over the first five years if the targets of the regional SAP are to be met.

3. Discussion

The most comprehensive dataset compiled was that for mangroves (reported here) whilst the least comprehensive were those for coral reefs and wetlands (UNEP, 2007b) Only three national datasets were found for coral reef goods and, in the case of wetlands, the bulk of the data were from Viet Nam. This results in a regional value of coral reef production of a modest US$ 1 500 per hectare per annum. Similarly, for wetlands it results in a value of around US$ 300 per hectare per annum, compared with the regional value for mangrove of nearly three thousand dollars per hectare and the value of US$ 1118 per hectare for seagrass meadows. The total annual value of mangrove production in the South China Sea exceeds US$ 5.1 billion[7] per annum compared with around US$ 1.2 billion for wetlands and coral reefs and a mere US$ 86 million for seagrass habitats. On first principles, one might expect the total value of mangrove goods to exceed those for coral reefs and seagrass because the former will include values for mangrove timber and other direct derivatives that have few, if any, equivalents in coral reef and seagrass habitats. In contrast, one would expect that the service values for coral reefs would be greater than those of the other three habitats given the extensive coral reef tourism in the region. Similarly, if the world market value of carbon storage were added it would greatly increase the value of mangrove annual production.

Examination of any one portion of this dataset reveals wide variation in farm gate prices. Mangrove timber from Indonesia, for example, apparently varies from US$ 76 to in excess of US$ 5000 per cubic metre. In this instance, a weak but significant negative

[7] The American billion is used in this document, i.e. 10^9.

Table 7
Comparison of the economic values of the service functions of coastal habitats as determined by Costanza et al. (1997) and the annual regional production values derived in the present study. All figures for this study have been expressed to 3 significant figures only.

	Area ha $\times 10^3$	After Costanza et al., 1997		Present study	
		Value of services US$ ha^{-1} yr^{-1}	South China Sea total annual services value US$ $\times 10^6$	Annual production value for the SCS US$ ha^{-1} yr^{-1}	South China Sea total annual production value US$ $\times 10^6$
Mangroves	1 800	9 990	17 973	2 870	5 170
Coral reefs	750	6 075	4 558	1 540	1 160
Seagrass	74	19 004	1 402	1 180	87
'Wetlands'	4 200	14 785	62 114	295	1 240

correlation exists between the value per cubic metre and the stock or, more precisely, the area of mangrove from which the timber is derived. This issue of widely differing prices within each country is addressed through the calculation of weighted mean national values. The weighted mean national and regional values are highly conservative because they take the total value for stocks that are under exploitation and spread this over the total stock, both used and unused, rather than transferring values derived from used to non-used stocks and summing the resultant figures.

The general absence of values for functions such as ecotourism, nursery functions for demersal fish and shoreline protection is a cause for concern as all such values are likely to be quite high. The valuation of the nursery function of mangroves is of some interest as, apparently, in no case has any attempt been made to value the natural production resulting from the use of mangroves by offshore demersal fish and crustaceans as nursery areas. This is somewhat surprising in that McNae (1974), for example, was able to demonstrate a strong statistical correlation between the offshore catch of penaeid shrimp and the area of mangrove on the adjacent coastline. Such a relationship could have been used to value this function, despite the fact that the correlation is statistical and not necessarily causal. In contrast, valuations have been made either in terms of the market value of larval fish and crustaceans caught in the mangrove area for sale to mariculture farmers or through a shadow pricing method using the costs of producing such larvae through alternative means. Neither of these methods can be considered ideal, nor do they actually represent a 'true' evaluation of the 'nursery function'; nevertheless, they were used in the absence of other data.

The high value for the annual production of mangroves in China of US$ 21 000 per hectare reflects the high value for the service of sediment retention by mangroves determined by the difference in annual cost of dredging of Fangchenggang Port before and after the removal of mangroves. It might be thought that such a high value would distort the weighted mean regional value. However, the total area of mangrove in China is only 23 thousand hectares compared with nearly 2 million hectares along the Indonesian coast of the South China Sea. Consequently, this very high value in this single location does not distort the regional value for this service that computes at a modest US$ 66 per hectare annually.

Although, as noted above, sipunculid worms are found in all mangrove areas in all countries, they are eaten only in three countries of the region and 'farm gate values' are available only in two (China and the Philippines). The contribution of the weighted mean regional value for sipunculid worms to the total economic value of mangrove production in the region is therefore exceedingly small. If a 'benefits transfer' method of determining value were used to value the entire South China Sea stock of sipunculid worms then this figure would become exceedingly large distorting the figure for regional value.

As discussed above, it is important to recognise that the values for goods and services, both individually and collectively, are extremely conservative as a consequence of both the manner in which they have been calculated using weighted means and the absence of many values from the matrix. Where data are lacking for a good or service from one country, the consequence will be a lowering of the weighted mean regional value. Given the absence of values for many goods and services in each habitat, the values are likely to be as low as 50% or less of the real value. For comparison, the values for natural ecosystem services derived by Costanza et al. (1997) are presented alongside the annual production values from the present study in Table 7.

It is important to note that the two studies are not directly comparable because Costanza et al., compiled values for 'services' only and used a benefits transfer approach assuming that the values for individual services were equally applicable regardless of location. In contrast the present study uses production values that are dominated by direct extractive resource use with comparatively few values for ecosystem services. It is nevertheless instructive to place the two sets of values side-by-side because the number of studies that have attempted to value coastal habitats are extremely limited and there has been a tendency on the part of ecologists to simply accept the values presented by Costanza as being applicable anywhere in the world.

In the case of all four habitats, the values proposed by Costanza et al. (1997) for ecosystem services per hectare are greater than the production values derived in this study from both goods and services combined. In the case of the present study it has been noted that the data for coral reefs, seagrass and coastal wetlands are more deficient than those for mangroves. Even in the case of mangroves however the value derived by Costanza et al. (1997) is three and a half times as great as the value presented here. A number of reasons may be posited for this disparity the first being that Costanza has *de facto* used a benefits transfer method of valuing the services, consequently single high values may distort his estimates. The second reason is that as noted above the present estimates are highly conservative, being derived from a weighting process that takes into account the existence of stocks that are either unused and consequently have no market value, or for which no farm gate prices were available.

4. Conclusions

The original outcome of the project was simply anticipated as being "*regionally applicable values for habitat goods and services*". Not only have such values been derived but the specific targets of the revised SAP have been valued or, more specifically, the incremental benefit derived from achieving the target has been valued. The values saved by achieving the targets have been compared with the costs of implementing the interventions defined in the regional SAP through a cost benefit analysis suggesting that the proposed interventions would be highly cost effective in the case of mangroves.

This study has chosen to avoid the use of a benefits transfer approach to computing missing values at both national and regional levels. Consequently, the total (available) economic values presented here are highly conservative underestimates of actual

values. They thus present a baseline value upon which to build as further data and information become available.

In addition what has resulted from this work is a standardised method for computing national and regional weighted mean values of resources and services that can be applied more widely in handling and manipulating economic valuation data from multiple locations across any time span. The techniques can be applied in any region where multiple currencies, varying exchange rates and widespread inter-locational variations in farm gate prices are found.

Acknowledgements

The authors recognise that the work reported here was the outcome of collective discussion and analysis conducted during the various meetings of the Regional Task Force on Economic Valuation, convened over the period from 2003 to 2008, under the auspices of the UNEP/GEF South China Sea Project. Accordingly the authors wish to acknowledge the significant contributions to those discussions made by members and alternates and their significant intersessional work, but who could not be contacted prior to completion of this article. They are: Mr. Sy Ramony, Chief, National Park and Wildlife Sanctuary Office, Department of Nature Conservation and Protection, Ministry of Environment, Cambodia; Mr. Li Kaiming, Vice President, South China Institute of Environmental Sciences, State Environment Protection Agency, Guangdong Province, China; Dr. Matius Suparmoko, retired economist from Indonesia; Dr. Thanwa Jitsanguan, Assistant Professor and Vice President for Special Projects, and Dr. Nuchanata Mungkung, Assistant Professor both of the Faculty of Economics, Kasetsart University, Bangkok, Thailand; and Dr. Tridoyo Kusumastanto Professor of Marine Economics Policy, Bogor Agricultural University, Bogor, Indonesia. The authors further recognise that without the financial support of the Global Environment Facility and the intellectual and leadership skills of the Project Coordinating Unit this work would not have been possible.

References

Costanza, R., D'arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'neill, R., Paruelo, J., Raskin, G., Sutton, P., Van Den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Ewel, K.C., Twilley, R.R., Ong, J.E., 1998. Different kinds of mangrove forests provide different goods and services. Global Ecology an Biogeography Letters 7, 83–94.

MacNae, W., 1974. Mangrove Forests and Fisheries. UNDP/FAO, IOFC/DEV/74/34. FAO, Rome, Italy, pp. 1–35.

Millennium Ecosystem Assessment, 2003. Ecosystems and Human Well-being: a Framework for Assessment. <http://www.milleniumassessment.org/en/index.aspx>.

Nunes, P.A.L.D., van den Bergh, J.C.J.M., 2001. Economic valuation of biodiversity: sense or nonsense? Ecological Economics 39, 203–222.

Talaue-McManus, L., 2000. Transboundary Diagnostic Analysis for the South China Sea. EAS/RCU Technical Report Series No. 14. UNEP, Bangkok, Thailand.

Toman, M., 1998. Why not to calculate the value of the world's ecosystem services and natural capital. Special section: forum on valuation of ecosystem services. Ecological Economics 25, 57–60.

Turner, R.K., Adger, W.N., Brouwer, R., 1998. Ecosystem services value, research needs, and policy relevance: a commentary. Special section: forum on valuation of ecosystem services. Ecological Economics 25, 61–65.

UNEP, 1999. Strategic Action Programme for the South China Sea. Draft Version 3, 24 February 1999). UNEP, Bangkok, Thailand, p. 69. UNEP SCS/SAP Ver. 3.

UNEP, 2002. Second Meeting of the Project Steering Committee for the UNEP/GEF Project "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand". Report of the meeting. UNEP/GEF/SCS/PSC.2/3. UNEP, Bangkok, Thailand, p. 110.

UNEP, 2003. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the First Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.1/3. UNEP, Bangkok, Thailand, p. 28.

UNEP, 2004. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Second Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.2/3. UNEP, Bangkok, Thailand, p. 34.

UNEP, 2005. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Third Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.3/3. UNEP, Bangkok, Thailand, p. 70.

UNEP, 2006. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Sixth Meeting of the Regional Working Group on Mangroves. UNEP/GEF/SCS/RWG-M.6/3. UNEP, Bangkok, Thailand, p. 76.

UNEP, 2007a. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Sixth Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.6/3. UNEP, Bangkok, Thailand, p. 44.

UNEP, 2007b. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Seventh Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.7/3. UNEP, Bangkok, Thailand, p. 69.

UNEP, 2008. Strategic Action Programme for the South China Sea. UNEP/GEF/SCS Technical Publication No. 16. UNEP, Bangkok, Thailand, p. 64.