IUCN
The World Conservation Union

Ecological and socio-economic values of Mangrove ecosystems in tsunami affected areas:

Rapid ecological-economic-livelihood assessment of Ban Naca and Ban Bangman in Ranong Province, Thailand

MINISTERIO
DE MEDIO AMBIENTE

This report was produced with the generous financial support of the Organismo Autónomo Parques Nacionales (OAPN) of the Ministry of Environment of Spain, under the project “Rehabilitating Coastal Ecosystems in a Post Tsunami Context: Restoration of Mangroves in Sri Lanka and Thailand”. The views expressed in this document do not necessarily represent OAPN, Ministry of Environment or IUCN, and are those of the authors alone.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

There seems to be an increasing frequency of extreme natural events in the first few years of the twenty first century, and with it an unusual but progressively more focus turning to the conservation of ecosystems and indeed the role of natural resource management in both mitigating the sheer quantum of damages as well as rehabilitating lives, livelihoods and economies post disaster. The focus on mangrove ecosystems and their constituent natural resources to a large extent has been brought to centre stage by the sobering effects of the Indian Ocean Tsunami on the coasts of several South Asian, East African and Southeast Asian countries.

For the coastal poor in developing countries as well as the managers of mangrove ecosystems, the value in maintaining these ecosystems is perhaps not surprising. Local users have long recognized the ecological and socio-economic values of mangrove ecosystems to their lives and livelihoods. Well-protected mangroves, for example, have been dubbed the 'supermarkets' of the coastal areas. These resources at times provide an escape route out of poverty. A wide range of food, fibre and medicines are attributable to mangrove ecosystems. Equally importantly, these ecosystems also provide valuable life support services (such as the fisheries nursery and habitat, coastal protection, or water quality services yielded). Mangroves also play a vital role in the interconnected nature of coastal ecosystems (such as coral reefs, mangrove forests and sea grasses), which provide joint benefits to human populations. In turn, these economic benefits accrue to local, national, and global populations. For many coastal communities in southern Thailand, which are hosts to a large part of Thailand's mangrove ecosystems, there is increasing concern about the status of these ecosystems. Mangroves ecosystems had already been under threat in Thailand since 1970s from coastal developments including hatchery, aquaculture, tourism- related infrastructure, and so on. Concerns about mangrove ecosystems have been heightened following the devastation of the Indian Ocean Tsunami.

Framed after the devastation of the Indian Ocean Tsunami, the aim of this study is to explore the role that mangrove ecosystems play in providing and sustaining livelihoods through the diverse ecosystem products and services. Thus the study seeks to document and share policy and technical information and lessons – namely the ecological and socio-economic values of mangrove ecosystems - in order to promote the integration of mangrove conservation and restoration into post-tsunami reconstruction and coastal management processes. Indeed it has been stated that communities that conserved mangroves for example were better protected against damages than those that did not.

Mangroves ecosystems are ecologically valuable for a variety of reasons. First, they are critical components of the coral reef ecosystem in that they provide *complex habitat structure* for numerous juvenile fish species. In fact, more than 75% of commercially caught fish may inhabit mangroves at some point of their life. In addition to providing essential habitat, mangrove ecosystems *stabilize near shore sediments and help mitigate coastal erosion*. Mangroves also *interrupt freshwater discharge*, are *sinks for organic and inorganic materials as well as pollutants*, and also of vital ecological value in the generation of an environment with clear, nutrient poor water that *promotes the growth of coral reefs offshore* (Ogden, 1988). In addition to these physical interactions there are several biological and biogeochemical interactions between these interconnected ecosystems, where mangrove ecosystems are of significant ecological value.

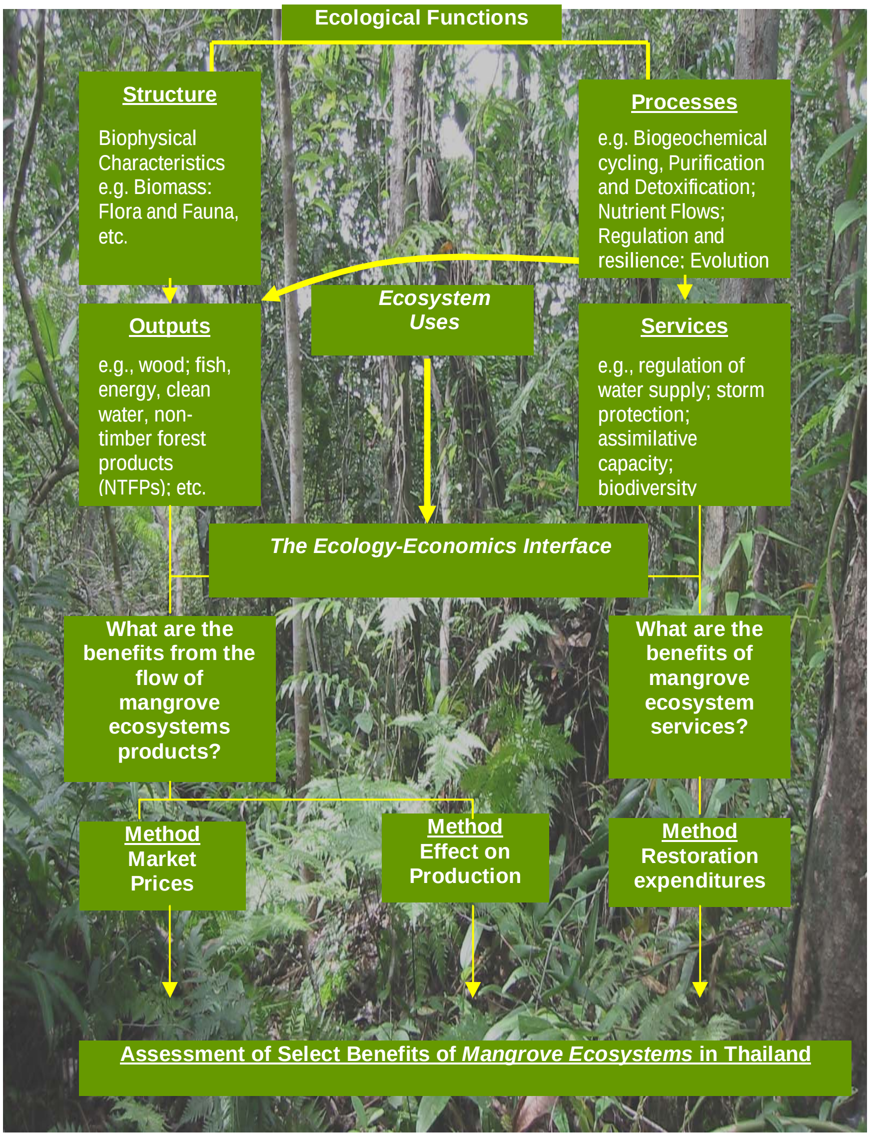
Mangrove forests, for example, form dense thickets of prop roots and aerial stems, which in turn trap sediments and move the shallow mud flats and delta areas seaward. The mud, stems, and roots make excursions into mangroves difficult. *Mangroves are highly productive areas contributing to the food chains of many species*. The biomass and diversity of invertebrates per unit area of mangroves and adjacent mud flats is very high. Many oceanic organisms rely on mangroves for part of their life cycle, so *mangroves are nurseries for ocean fisheries*. The thick mangrove forests also protect low coastal areas in storms. However, humans have tended to look upon mangrove swamps as useless vegetation blocking their access to the coast, so mangroves have been destroyed in many areas by human development. Given the key position mangrove forests in the life cycles and food chains of coastal oceans, this destruction adversely affects coastal fisheries.

These diverse ecological values of mangrove ecosystems intersect with the standard framework for understanding the economic value of mangrove ecosystems through the Total Economic Value framework. TEV highlights the multidimensional nature of economic value of ecosystems, which ranges far beyond direct use values and encompasses indirect use values, optional values and non-use values. TEV is useful to relate to the socio-economic values (for example livelihoods) through direct-use values such as fish, molluscs, crustaceans, medicines, and forest products. Moreover, mangrove ecosystems also indirectly support economic activity – for example through habitat provision, nutrient recycling, water purification, and flood control. One key indirect value is the protective function of mangrove ecosystems against wave and storm energy, both in terms of ongoing coastal erosion and from potentially destructive cyclones, typhoons and tsunamis.

The concept of TEV has also come in tandem with a development of valuation techniques for quantifying a wide array of values and expressing them in monetary terms. However, there have been increasing calls to alter and adapt conventional environmental valuation methods so they are better able to deal with a real-world field and management situation given time, data, capacity and funding constraints; but are still credible and applicable to the realities of capturing non-market and livelihood costs and benefits.

In order to decipher and understand the links between ecological and socio-economic values, a framework (Figure 1) and rapid ecological-economic-livelihood assessment was developed. The framework provides an economic and livelihood link and rationale for the conservation of mangrove ecosystems.

Figure 1: A framework to assess the links between Ecological and Socio-economic values of Mangrove Ecosystems in Tsunami affected areas in Thailand



The overall questions the rapid ecological-economic-livelihood assessment sought to address include:

a. What are the direct values of different mangrove ecosystem products (e.g. fish, crustaceans, molluscs and products)?
b. What are the indirect values of different mangrove ecosystem services (e.g. coastal protection and fish habitat)?
c. How, overall, are the economic and financial benefits of different mangrove goods and services distributed between different beneficiaries (e.g. local communities, regional/province economy, etc)?
d. What would be the economic and livelihood impact over time of continued mangrove loss?
e. What is the economic rationale for mangrove rehabilitation and management?

The study was conducted on the environs of Laemson National Park, and in particular two villages, namely Ban Bang Man and Ban Naca, Ranong Province that relied heavily on the conserved mangrove ecosystems of the park.

The results of the valuation are summarised below in Table 1, and show the tremendous socio-economic values derived from conserved mangrove ecosystems. Roughly 40% of the incomes below are in subsistence livelihood form and are often undetected.

Table 1: The Diverse Socio-economic values of mangrove ecosystems in Ban Naca and Ban Bangman

Ban Naca	**Value**
Total Village Value for Mangrove fish, crustaceans, molluscs, and forest products (Baht)	**25,643,041**
Total Value per HH/year for Mangrove fish, crustaceans, molluscs, and forest products (Baht)	**377,736**
Total Value per HH/year (US$) for Mangrove fish, crustaceans, molluscs, and forest products	**9,443**
Total Value hectare/year (Baht) for Mangrove fish, crustaceans, molluscs, and forest products	**53,423**
Value per hectare of mangroves/year (US$) for Mangrove fish, crustaceans, molluscs, and forest products	**1,336**
Ban Bangman	
Total Village Value for Mangrove fish, crustaceans, molluscs, and forest products	**63,484,437**
Total Value Per HH/year (Baht) for Mangrove fish, crustaceans, molluscs, and forest products	**577,101**
Total Value Per HH/year (US$) for Mangrove fish, crustaceans, molluscs, and forest products	**14,428**
Total value of ha/year (Baht) for Mangrove fish, crustaceans, molluscs, and forest products	**240,471**
Value per hectare of mangroves/year (US$) for Mangrove fish, crustaceans, molluscs, and forest products	**6,012**
Total for Ban Naca and Ban Bangman for Mangrove fish, crustaceans, molluscs, and forest products	**89,127,478**

Present value of the contribution of mangrove ecosystems to fisheries production for Ban Naca is US$ 20,174 per household and US$ 2,853 per hectare. Present value of the contribution of mangrove ecosystems to fisheries production in Ban Bangman translates to US$ 30,822 per household and US$ 12,843 per hectare. Clearly the loss of these benefits would impact the hardest on the communities residing nearby mangrove forests and who are dependent on the fisheries for subsistence and income.

Finally, the value of coastal protection was derived using the costs of restoration approach, the result of which are summarised below in Table 2. This represents a minimum value for maintaining coastal protection.

Table 2: Summary of Results of Costs of Restoring Mangrove Ecosystem

Site level Damage	Mangrove Forest Area Damaged (Hectare)	Per Hectare Cost for replanting/monitoring in Thai Baht	Estimated Costs in Year 0	Net Present Costs of Restoration of Mangroves in Baht (using 10% discount rate)
Ban Naca and Ban Bangman	**30**	**29,094/5,819**	**872,820**	**1,295,918**

The valuation demonstrates that coastal communities rely heavily on mangrove ecosystems for their livelihoods, which is clearly apparent by the diversity of mangrove resource uses. The economic costs of mangrove ecosystem loss and degradation is expected to be felt the hardest by the poor at the local level, without options for alternative livelihoods and capacity to cope against disasters. Finally, the valuation demonstrates the economic and development wisdom of conserving the environment in post-tsunami reconstruction and of the importance of factoring ecosystems into coastal zone development and rebuilding as such actions would translate into not only to sustained provincial economies but more importantly to sustained livelihoods of the poor coastal communities.

ACKNOWLEDGEMENT

The authors wish to acknowledge the support of OAPN by making funding available to undertake this important rapid ecological-economic-livelihood assessment. Numerous individuals were involved from the planning, to the data collection and data analysis, and the final write-up of this report. This included Dr. Sitanon Jesdapipat, Director, Centre for Ecological Economics, Chulalongkorn University; IUCN Thailand Country Office and a team of 4 data collectors, who were commissioned to undertake the rapid data collection of mangrove products and services. The authors acknowledge their invaluable contribution.

In particular the study team wishes to thank the villagers who assisted the data collection team and made their time available for discussions. The study team recognises that this was a difficult period, as communities remained saddened by the trauma of the Tsunami. Thanks are due to the officials of the Marine and Coastal Department for their collaborative spirits, without which the first step in research during this difficult time would have been impossible. The study benefited from comments on an earlier draft from Mikkel Kallesoe, Regional Environmental Economics Programme, IUCN Asia, Janaka de Silva, IUCN Thailand and Thushara Ranasinghe, Programme Officer, Regional Environmental Economics Programme, IUCN Asia.

1. INTRODUCTION

While extreme natural events have always been a part of human experience, perhaps the first few years of the twenty first century have all too often seen the devastation from these events in the form of devastating floods, cyclones, typhoons, earth quakes and tsunamis. These extreme natural events have wreaked havoc through the Gulf of Mexico, in the mountain regions of South Asia, and on the coasts of the Indian Ocean countries. As a response, greater attention around the world is being paid to strategies and plans on disaster preparedness, minimising and mitigating damage as well as rehabilitating lives, livelihoods and economies post disasters. Interestingly, investment in the conservation and management of natural resources is being offered as a key element of natural disaster management and vulnerability reduction. But it would not be unwarranted for a national-level decision-maker to ask why and what is the value-added of conservation and natural resources management to disaster management. An examination of the Indian Ocean Tsunami disaster in Thailand provides insights into the role that conservation and natural resource management can play.

The Indian Ocean Tsunami, triggered as a result of a massive underground earthquake, struck several countries of the South Asian, Southeast Asian and East African region on December 26, 2004. This disaster is clearly one of the most profound tragedies of recent human history. The details of the tsunami's immediate impacts are sobering: that over 250,000 people have been reported killed, an estimated five million persons have been rendered homeless; there is massive displacement of populations and extensive damage to infrastructure and natural resources.

Thailand is one of the countries that was severely struck by the tsunami. The tsunami, although limited to 6 provinces on the western coast of peninsular Thailand, impacted more than 50,000 people and it is thought that more than 5,000 lives were lost.

In terms of natural resources, the affected areas of Thailand included nationally and globally significant coastal ecosystems containing mangrove forests, estuaries, coral reefs, dunes and beaches and sea grass beds. Of particular interest is the increasing recognition of mangrove ecosystems, which are believed to yield a wide range of ecosystem products used for food, construction, fuel, income and other uses (such as fisheries, tourism, and building poles). More importantly, mangrove ecosystems are vital because they deliver ecosystem services that underpin human well-being such as the role they play in mitigating damage and protecting coastal inhabitants' lives, livelihoods and assets when extreme events occur. Mangrove ecosystems also provide food security and livelihoods to the poor coastal inhabitants through the service provision of fisheries nursery and habitat and water quality yielded. In turn, these ecosystem products and services both directly and indirectly contribute significantly from the coastal household all the way up to the national economy. For example it has been estimated that the 6 southern provinces affected by the tsunami generate about $2 billion annually through tourism and fisheries alone.

Damage to coastal ecosystems means that life supporting and economically beneficial services provided by nature may be impaired or lost, which in turn means increased vulnerability, loss of income and livelihood activities and government revenues. These losses are incurred throughout the economy — and are felt especially by the poorer and more vulnerable groups who live in coastal areas and whose livelihoods have been devastated by the tsunami.

As the focus of post-tsunami relief and reconstruction shifted from emergency relief to long-term rehabilitation and reconstruction, it became imperative that evaluation of ecological and socio-economic values of mangrove ecosystems be undertaken. If it is indeed true that mangrove ecosystems play a vital role in the lives of coastal inhabitants, then it should be apparent that any attempts at reconstruction must also consider the needs to rehabilitate and restore the natural infrastructure (such as mangrove forests) — in order to restore existing livelihood and income activities, to allow for future economic growth, and to ensure that there is continued provision of the vital services which underpin coastal settlements and economies and guarantee their future security and sustainability (through storm and flood control, coastal protection, water supplies and quality). Equally, it is critical to ensure that long-term redevelopment and reconstruction does not impact negatively on the valuable capital that is mangrove ecosystems.

Interestingly, observational and anecdotal statements by some coastal communities during fieldwork for this study suggest that the losses were less severe for sites where mangrove ecosystems were well in tact. Where there were no standing or degraded mangrove forests, unthinkable losses and damages were visible, such as the Ban Namkhem in Phang Nga Province. Whether scientifically validated or not, these statements bare resemblance to the perceived function of mangrove ecosystems for coastline protection. Indeed, the response has been telling, as rehabilitation and reforestation of mangroves along the shores by forest officials and local communities are visible. It is not the aim, or scope, of the study to investigate or test these claims.

While decision-makers are now grappling with a progressively more uncertain world of extreme events post-tsunami as well as calls for more and better disaster preparedness and management, it becomes opportune to impress on decision-makers about the importance of factoring ecosystems into coastal zone development and rebuilding, and the economic and development wisdom of this. There is a need to clearly assess, calculate and share information on the ecological and socio-economic values associated with mangrove coastal ecosystems— and the economic benefits of managing them wisely in the future.

The aim of this study is to explore the role that mangrove ecosystems play in providing and sustaining livelihoods through the diverse ecosystem products and services generating in a post tsunami context. Thus the objective of the study is to document and share policy and technical information and lessons learned in order to promote the integration of mangrove conservation and restoration into post-tsunami reconstruction and coastal management processes. For this purpose, and bearing in mind the limited time and resources available, the study relied on a rapid ecological-economic-livelihood assessment methodology to ascertain credible, practical and policy relevant information. The study was conducted on the environs of Laemson National Park, and in particular two villages, namely Ban Bang Man and Ban Naca, Ranong Province that relied heavily on the conserved mangrove ecosystems of the park.

Overall questions that the rapid assessment sought to address included:

a. What are the direct values of different mangrove ecosystem products (e.g. fish, crustaceans, molluscs and products)?
b. What are the indirect values of different mangrove ecosystem services (e.g. coastal protection and fish habitat)?
c. How, overall, are the economic and financial benefits of different mangrove goods and services distributed between different beneficiaries (e.g. local communities, regional/province economy, National economy etc)?
d. What would be the economic and livelihood impact over time of continued mangrove loss?
e. What is the economic rationale for mangrove rehabilitation and management?

The study is structured as follows: the following Section 2 presents a basic understanding of mangrove ecosystems such as those in Ranong Province and highlights their ecological importance. Section 3 consults and reviews the relevant literature on the nature of socio-economic values of mangrove ecosystems, ways of valuing these with the purpose of identifying the most appropriate methods to undertake a rapid ecological-economic-livelihood assessment. Section 4 therefore presents a framework that links mangrove ecological values with socio-economic ones, and elaborates a methodology for assessing the socio-economic values of mangrove ecosystems. Section 5 describes the study sites at both the provincial and local levels. Section 6 reports and discusses the major results of the valuation exercise. Finally, section 7 summaries the arguments and presents conclusions.

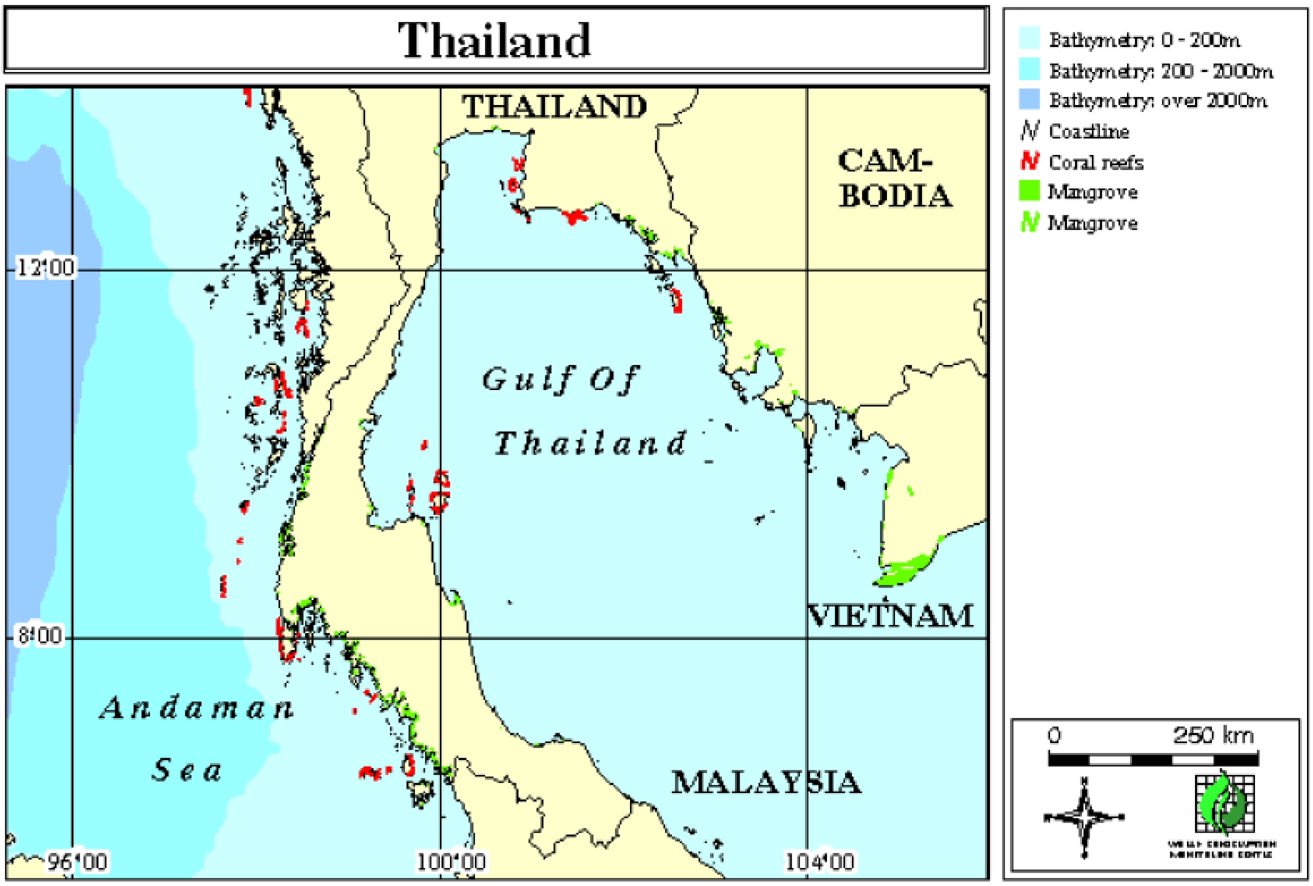
2. MANGROVE ECOSYSTEMS - ECOLOGICAL VALUE

Acknowledgement that there has been damage to mangrove ecosystems by the tsunami is clear, but whether there is a need to factor mangrove ecosystems into coastal development per se as a justification for the rehabilitation of livelihoods is not so equally clear. The reason is that the role of mangrove ecosystems in sustaining livelihoods and economies is often poorly understood, rarely articulated and often undervalued. In fact the status and functions of mangrove ecosystems inextricably relates to the production of economically beneficial ecosystem products and services. Among ecologists and those most directly dependant on mangrove ecosystems, their importance has long been recognized for the many and varied ecosystems services they provide. Ecosystem services include maintaining biodiversity, carbon sequestration and maintaining the gaseous composition of the atmosphere, regulation of water flows and supplies, controlling floods, preserving and regenerating soil, recycling nutrients, filtering pollutants, and assimilating waste (Dasgupta and Maler, 2005).

Ecosystem services are not only of direct value, they offer indirect benefits too by supporting and promoting the natural resource base upon which economic activities are founded. Yet despite the importance and the tremendous value of products and services provided, mangrove ecosystems and their constituent resources have been subject to increase degradation and decline over time. A major underlying economic reason for this state of affairs is that ecosystems - and the many services they provide - are often under valued or not valued at all. Hence, the demonstration of the ecological values of mangrove ecosystems and how these relate to socio-economic values is necessary if they are to be factored into coastal developments through mangrove rehabilitation and conservation.

In Thailand, the Andaman Sea coastline stretches over some 954 kilometres from the border with Myanmar in the north to Malaysia in the south. This coastline is renowned world over for its pristine beaches, coral reefs and mangrove forests. Perhaps the most important but little known feature about these coastal ecosystems is how they are ecologically connected and interlinked. Often along this coastline, mangrove forest, coral reefs and sea grasses are found together and are closely linked (see Map below). Coastal ecosystems consist of a mosaic of interconnected environments and associated animal and plant communities - especially mangrove ecosystems - *which are of vital ecological value to a coral reef and sea grass ecosystems hence are integral parts of interdependent coastal ecosystems*.

Mangroves occur along shorelines and in tidal creeks or estuaries; and are critical ecological components of the coral reef ecosystem in that they provide *complex habitat structure* for numerous juvenile fish species. In fact, more than



Source: UNEP World Conservation Monitoring Center

75% of commercially caught fish may inhabit mangroves at some point of their life. In addition to providing essential habitat, mangrove ecosystems *stabilize near shore sediments and help mitigate coastal erosion*. Mangroves also *interrupt freshwater discharge*, are *sinks for organic and inorganic materials as well as pollutants*, and also of vital ecological value in the generation of an environment with clear, nutrient poor water that *promotes the growth of coral reefs offshore* (Ogden, 1988). In addition to these physical interactions there are several biological and biogeochemical interactions between these interconnected ecosystems, where mangrove ecosystems are of significant ecological value (see Figure 2 below).

Mangrove ecosystems, found on low, muddy, tropical coastal areas around the world, are woody plants that form the dominant vegetation of mangrove forests. They are characterized by their prop roots, their ability to tolerate regular inundation by salt water, and by precocious (pre-dispersal) germination of their seeds and development of their seedlings. Woody plants sharing these adaptations are all called mangroves although not closely related; the mangroves below belong to *Rhizophoraceae*, *Meliaceae*, and *Verbenaceae*.

Mangrove forests form dense thickets of prop roots and aerial stems, which in turn trap sediments and move the shallow mud flats and delta areas seaward. The mud, stems, and roots make excursions into mangroves difficult. Mangroves are highly productive areas contributing to the food chains of many species. The biomass and diversity of invertebrates per unit area of mangroves and adjacent mud flats is very high. Many oceanic organisms rely on mangroves for part of their life cycle, so mangroves are nurseries for ocean fisheries. The thick mangrove forests also protect low coastal areas in storms. However, humans have tended to look upon mangrove swamps as useless vegetation blocking their access to the coast, so mangroves have been destroyed in many areas by human development. Given the key position mangrove forests in the life cycles and food chains of coastal oceans, this destruction adversely affects coastal fisheries.

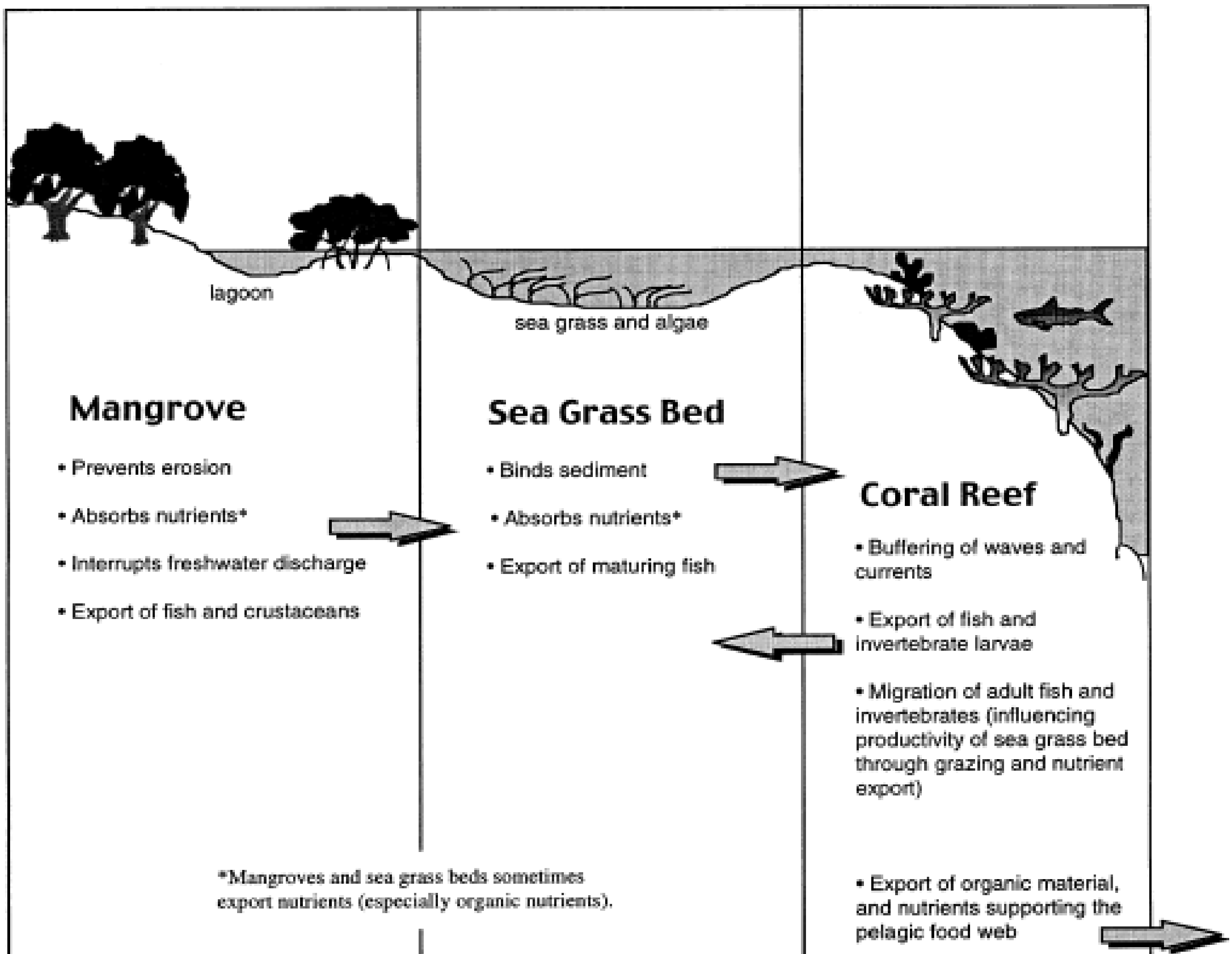


Figure 2: Interactions in coastal ecosystems showing the connections between mangroves, sea-grass beds and coral reefs.

2.1 Damages to Mangrove Ecosystems

As a result of the tsunami waves and the essential protective role function of coastal ecosystems, damages to mangrove ecosystems would be evident. Mangrove forests in the Ranong Province are the largest coastal ecosystem and occupy an estimated area of 250.92 square kilometres or 25,092 hectares (see Table 1 below). Nevertheless, damage to mangroves was proportionately the least and only .882 square kilometres or 88.2 hectares amounting to only .35% of the entire mangrove forest was reported damaged (Tangjaitrong et. al. 2006). The status of mangrove forests pre-tsunami is mixed as these forests were subjected to threats such as infrastructure (roads) development, settlements, coastal aquaculture (up to the late 1990s), and the use of mangrove forest as landfills. However, since the 1990s there has been growing recognition and action to conserve mangrove forests in Thailand especially through protected areas.

Partly as a result of conservation as well as anecdotal and theoretical reason for this relative low loss of mangrove forest is attributed to the fact that coral reefs were the first line of defence and absorbed the brunt of the tsunamis impact.[1] In this sense, it would be rational to expect that coral reefs would be proportionately more damaged followed by damages to sea grasses – the second line of defence. This is evident in table 1, where 58% of coral reefs and about 5% of sea grass sites were reported damaged. To assess the impact of the tsunami, the Department of Marine and Coastal Resources, of MONRE undertook rapid assessments in 174 out of 324 coral reef sites with the support of eight Thai universities from 30 December 2004 to 15 January 2005. The 174 sites were selected across the all six affected provinces inside and outside protected areas and include key snorkelling and diving sites as well as sites not visited by tourists.

Table 3: Select Data on Ranong Province area under Mangrove forests, Coral reefs and Sea grass Beds and Damages

Province	Total Area (Sq. Km.)	Mangrove forest area (Sq. Km.)	Mangrove Forest Area Damaged (Sq. Km.)	% Damage Mangrove	Coral Reefs area (Sq. Km.)	Coral Reefs area damaged (Sq. Km.)	% Damage Corals	Sea grass Beds area (Sq. Km.)	Sea grass Beds area damaged (Sq. Km.)	% Damage Sea grass Beds
Ranong	**3298.045**	**250.92**	**.882**	**.35%**	**2.57**	**1.49**	**58%**	**1.234**	**.06**	**4.86%**

Sources: Department of Disaster Mitigation and Prevention (2005); Australian Institute of Marine Sciences (2006); DMCR (2005).

[1] As mentioned above, this is a function that coral reefs provide for mangroves and sea grasses.

3. REVIEW OF LITERATURE – MANGROVE ECOSYSTEMS SOCIO-ECONOMIC VALUES

The standard framework for understanding the economic costs and benefits or the economic value of ecosystems is entitled Total Economic Value (TEV – see Figure 3 below). TEV highlights the multidimensional nature of economic value of any ecosystem, which ranges far beyond direct use values and encompasses indirect use values, optional values and non-use values. In this sense, TEV presents a more complete picture of the economic importance of ecosystems as well as clearly demonstrates the high and wide-ranging economic costs associated with their degradation, which extend far beyond the loss of direct use values.

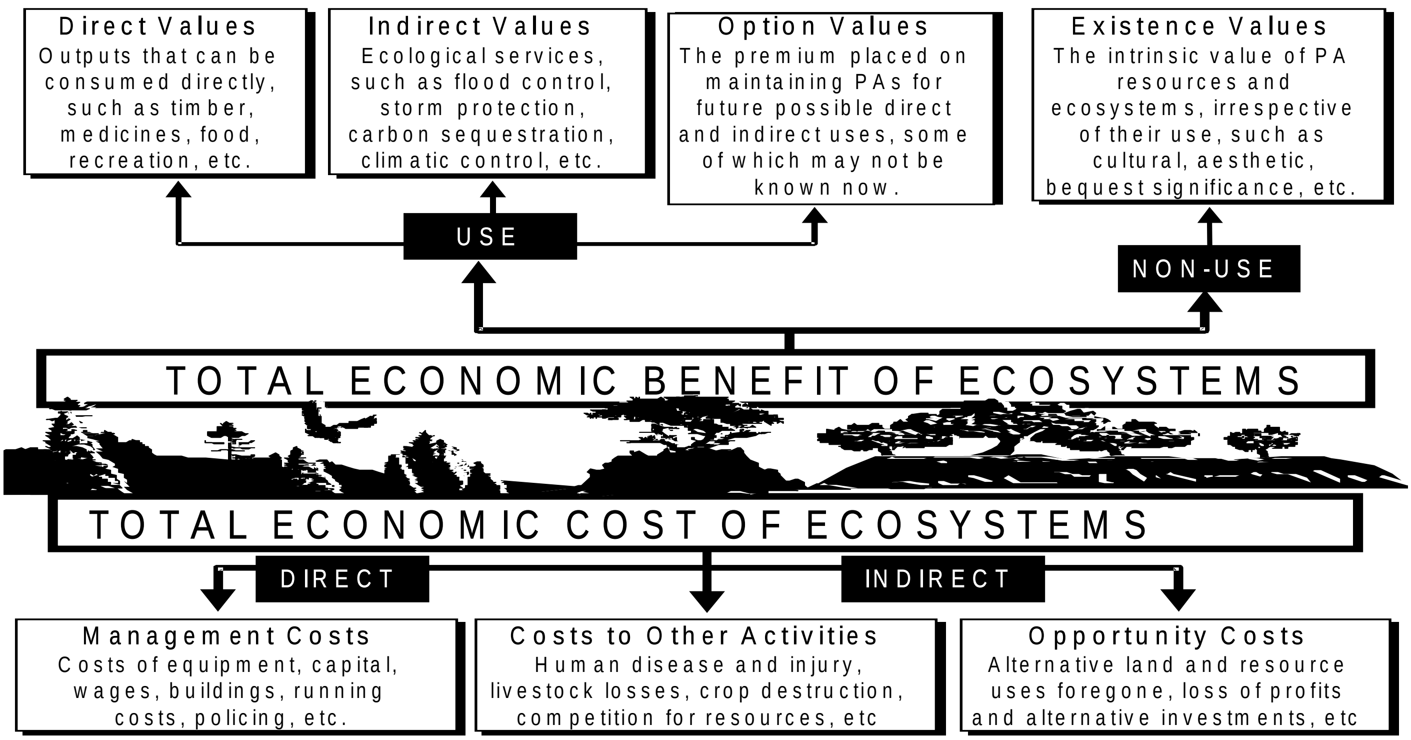
In addition to the direct-use values such as food, medicines, and forest products, mangrove ecosystem also indirectly support economic activity – for example through habitat provision, nutrient recycling, water purification, and flood control. One key indirect value is the protective function of mangrove ecosystems against wave and storm energy, both in terms of ongoing coastal erosion and from potentially destructive cyclones or typhoons (see also Box 1). Option values of mangrove ecosystems refer to the direct or indirect use of these ecosystems in the future. Mangrove ecosystems are also valuable in terms of *non-use values*, which may arise because individuals derive satisfaction from knowing that the ecosystems exist, and will continue to exist for future generations (*existence and bequest values*).

The concept of TEV (see figure 3) has also come in tandem with a development of valuation techniques for quantifying a wide array of values and expressing them in monetary terms. Examples of valuation techniques relevant to this study are given in the following section. However, there have been increasing calls to alter and adapt conventional environmental valuation methods so they are better able to deal with a real-world field and management situation given time, data, capacity and funding constraints; but are still credible and applicable to the realities of capturing non-market and livelihood costs and benefits. Over time, there has been increasing shift towards rapid economic assessment methodologies, particularly to address the sometime extremely costly nature of valuation exercises.

Box 1: Products, services and functions

Mangrove ecosystems
Shoreline stabilization
Storm protection
Water quality
Micro-climate stabilization
Groundwater recharge and discharge
Flood and flow control
Sediment and nutrient retention
Habitat protection and biodiversity
Biomass, productivity and resilience
Gene bank
Recreation, tourism and culture
Hunting and fishing
Forestry products
Water transport
Baan (1997)

Figure 3: Total economic value of the Ecosystems



3.1 Studies on the Economic Values of Mangrove Ecosystems

There is a growing body of literature on mangrove ecosystem values. Studies thus far have focused in on direct benefits of mangrove ecosystems such as fisheries, timber, fuelwood, and tourism and there have been some attempts at indirect benefits such as coastal protection (See tables 2 and 3). For example, Constanza et al. (1997) estimate the total annual economic value of mangroves at more than US$900 000 per km^2.

Nevertheless, valuation of mangrove ecosystems is still a developing field as witnessed by some results. Valuation of mangroves in the American Samoa have been estimated at US$104,000 per km^2 (total value of about US$50 million a year) but the mangrove only cover an area of less than 0.5 km^2. Sathirathai and Barbier (2001) derive very high values of US$2.7 million to US$3.5 million per km^2 for mangroves in Thailand.

While valuation methodologies that rely on market prices are well tried and tested on marketable mangrove ecosystem products, however, often the basis of calculating values tends to be overestimated as distinction is not made between what is the actual or potential value, gross or net values or even whether the good is over harvested and unsustainable yet revealing high values. In the case of mangroves, good examples (Sathirathai and Barbier, 2001) and bad examples (Constanza, 1997) exist. Nevertheless, there is growing interest in understanding the biophysical changes to mangrove ecosystems and the links to production as a means of determining credible values

There have also been advances in using valuation methodologies for assessing the protective values of ecosystems. These tend to be based on costs and the main types of cost-based methods are:

1. The **expected damages** avoided by maintaining the ecosystems' protective functions, such as the costs of replacing infrastructure, or the losses to productive values of land.
2. The **defensive expenditures** required replacing or restoring the protective function of the ecosystem, such as the costs of constructing and maintaining sea wall or windbreak infrastructure.
3. The **costs of relocating** communities if protective functions are lost.

However, there are several problems associated with cost-based approaches for valuing environmental functions. Spaninks and van Beukering (1997) suggest that the expected damages approach may tend to *undervalue* protective functions. The expected damages approach does not take into account the tendency for people to be risk-averse, and to be willing to pay more to prevent risks. Generally, the expected damages approach also fails to account for the value of avoided injuries and fatalities.

Spaninks and van Beukering (1997) also suggest that it is difficult to assess whether defensive expenditures on protective infrastructure effectively substitute for the protective functions of mangrove ecosystems. In contrast, Baan (1997) suggests that such defensive expenditure approaches could *overvalue* the indirect use values of ecosystems – or for example, if the costs of maintaining protective infrastructure are greater than the benefits afforded by the original ecosystems.

Due to these limitations, cost-based valuation approaches are generally regarded as *second-best v*aluation techniques. Alternative *first-best* methods include:

Hedonic methods – differences in degree of protection provided by mangrove ecosystems could possibly be reflected in the difference in the price paid for land in these areas.
Contingent valuation methods – these could reveal the willingness to pay for protective functions.

Such first-best methods, however, may not necessarily be the most appropriate approaches to assessing protective functions of ecosystems. The accuracy of these methods tends to be heavily dependent on the time, data information and human and financial resource availability. In situations where these resources are scarce, it is often more cost-effective approach to undertake credible cost-based methods to valuation.

Review of evidence: mangrove ecosystems

A review of studies, which value mangrove ecosystems, reveals that most studies acknowledge but do not assess the indirect benefits of ecosystems in protecting coasts. Generally, case studies focus on direct extractive use values, and/or direct tourism and recreational values.

The four studies summarised in the table 4 below attempt to place a value on the shoreline protective values of mangrove ecosystems. All four studies use cost-based approaches.

One study of the Pagbilao Forest, Philippines, calculated indices of protective values for different management scenarios, for multi-criteria analysis. The studies from Thailand and Vietnam calculate the expenditure, which would be required on constructing or maintaining protective coastal infrastructure, if the mangroves were removed. One commonly cited study (Ruitenbeek 1992) calculated the potential loss of agricultural productivity due to shoreline erosion in Bintinu Bay, Indonesia.

The majority of studies focus on the function of mangrove ecosystems in stabilising coastlines and preventing erosion from waves. Only one study (Tri et al 1996) focussed specifically on protection from extreme weather events – floods and typhoons. The regional focus of this study was the 3000km coastline of Vietnam, which has suffered considerable damage in the past from tropical cyclones.

Table 4: Assessment of the shoreline protective values of mangrove ecosystems

<table>
<tr><th>Author (year)</th><th>Site, country</th><th>Protective values Assessed</th><th>Valuation Methods</th><th colspan="2">Protective values results</th><th>Other values assessed</th></tr>
<tr><td>Jansenn and Padilla (1998)</td><td>Pagbilao Forest, Philippines</td><td>Shore protection</td><td colspan="3">Indices for shore protection of alternative management scenarios for multi-criteria analysis</td><td>Various</td></tr>
<tr><td>Ruitenbeek (1992)</td><td>Bintuni Bay, Indonesia</td><td>Shoreline erosion prevention</td><td>Loss of agricultural productivity as a result of erosion</td><td colspan="2">Rp 1.9 million per household.</td><td>TEV – various.</td></tr>
<tr><td>Suthawan (1999)</td><td>Surat Thani, Thailand</td><td>Coastline protection and stabilisation</td><td>Preventative expenditure on protective coastal infrastructure</td><td colspan="2">12 400 Baht (US$480) per 75m-wide rai of mangrove per year.</td><td>TEV - various</td></tr>
<tr><td rowspan="4">Tri et al (1996)</td><td rowspan="4">Nam Ha Province, Vietnam</td><td rowspan="4">Protection against damage to coast from floods and typhoons.</td><td rowspan="4">Avoided expenditure on sea dike infrastructure maintenance and repair.</td><td>Discount rate</td><td>Present value (VND per ha)</td><td rowspan="4">Costs of mangrove rehabilitation and direct extractive use values. Positive benefit-cost ratios.</td></tr>
<tr><td>3%</td><td>0.79 million</td></tr>
<tr><td>6%</td><td>0.56 million</td></tr>
<tr><td>10%</td><td>0.37 million</td></tr>
</table>

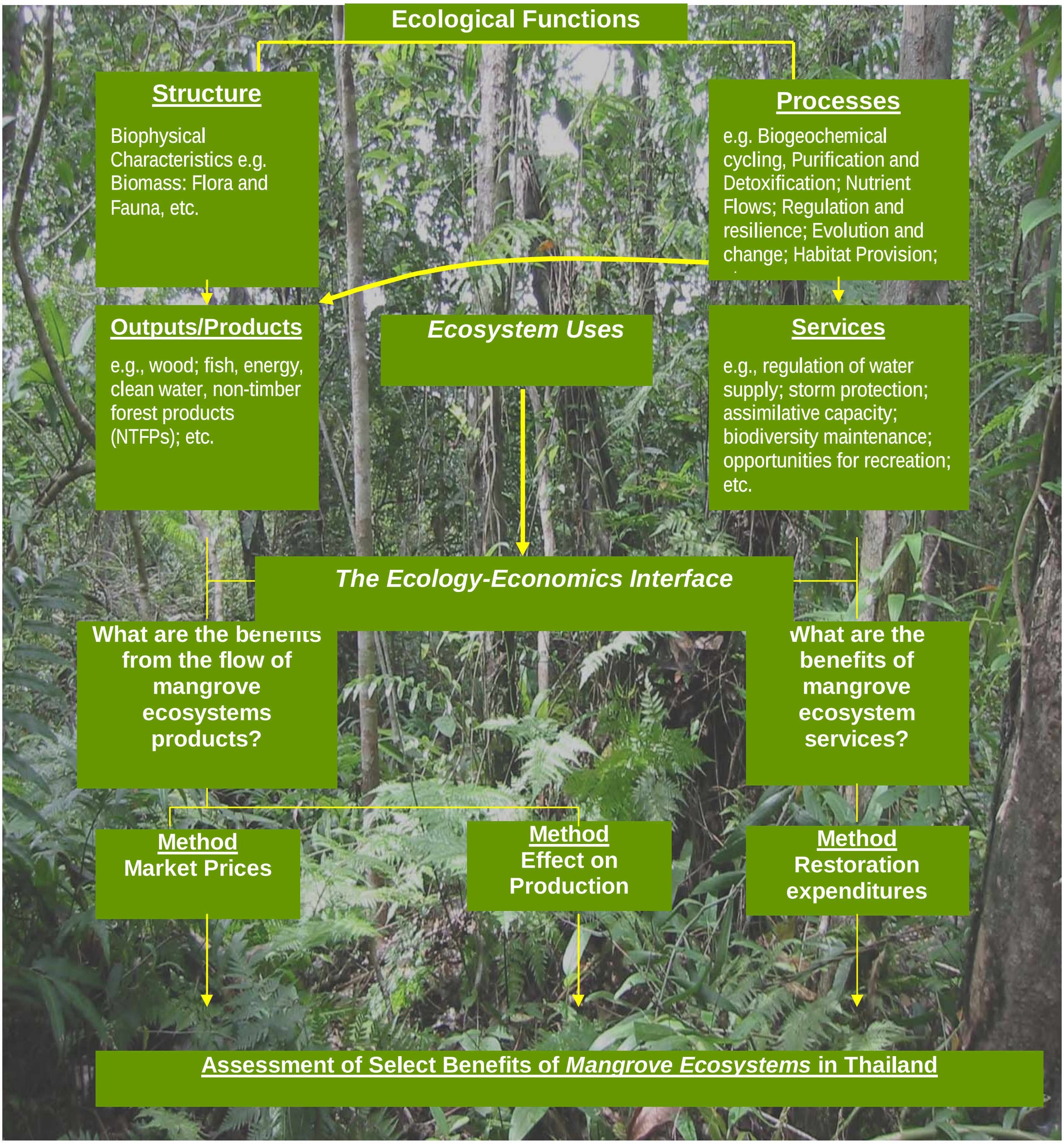
3.2 Summary

While several studies on mangrove ecosystem valuation exist, nevertheless the mangrove valuation is a growing field. This study builds on the important lessons from studies on mangroves valuation using market prices and effect on production approaches in its methodology section below. The majority of studies on the economic values of mangrove ecosystems do not assess the indirect values associated with shoreline protection functions – however, from TEV studies which include an assessment of indirect values, it appears that the values attributable to the protective functions of coastal ecosystems tend to be a significant component of total economic value. Only one study identified by this review (Tri et al 1996) focussed specifically on the value of coastal ecosystems in providing protection against extreme weather events such as floods and typhoons, with some discussion of the increasing risks of these events with climate change. All studies reviewed in this paper employed cost-based approaches to assessment and this study will develop this method further using Tri et. al (1996).

4. METHODOLOGY – LINKING ECOLOGICAL AND SOCIO-ECONOMIC VALUES

With respect to the literature review above, the methodology for this study was developed keeping in mind the rapid nature of the ecological-economic-livelihood assessment recognising that there is limited time, and financial and human resources availability. At the same time, the methodology had to be credible in eliciting the mangrove ecosystem benefits in the select site. The methodology design drew its inspiration for the following framework developed for this study (see figure 3):

Figure 4: A framework to assess the links between Ecological and Socio-economic values of Mangrove Ecosystems in Tsunami affected areas in Thailand



The framework, simply put, states that there is an inextricable link between the maintenance of the ecological functions (structure and processes) of a mangrove ecosystem that result in the provision of ecosystem services. More specifically, healthy mangrove ecosystems are of vital ecological value for the provision of ecosystem services such a fish and coastal protection, and in turn generate tremendous socio-economic value to both the people on site (coastal households) and people who live far away but benefit from the services provided. Loss and damage to mangrove ecological functions would not only affect those on-site in terms of livelihood and economic options foregone, it would also impact on those off-site that benefit from the many services provided.

The overall questions that the rapid ecological-economic-livelihood assessment sought to address include:

f. What are the direct values of different mangrove ecosystem products (e.g. fish, crustaceans, molluscs and products)?
g. What are the indirect values of different mangrove ecosystem services (e.g. coastal protection and fish habitat)?
h. How, overall, are the economic and financial benefits of different mangrove goods and services distributed between different beneficiaries (e.g. local communities, regional/province economy, etc)?
i. What would be the economic and livelihood impact over time of continued mangrove loss?
j. What is the economic rationale for mangrove rehabilitation and management?

In answering the above questions, the methodology would have to rely on primary data collection as well as the use of secondary data sources. It is important to mention here that data collection methods used were in relation to the mangrove habitat type. With terrestrial habitats, such as the mangrove, direct sampling survey techniques were deemed suitable because respondents were able to relate the benefits of mangrove ecosystems in terms of products and services provided.

Primary data collection was commissioned to a national consultant, who led a team of data collectors to collect data on direct use of mangrove forests in select site. Initially a multidisciplinary team consisting of ecosystem specialists and economists visited Laemson National Park, Ranong Province between 21- 24 September 2005 to familiarize with and select potential sites by applying a test criteria for site selection. The criteria used in the selection of the site are as follows:

- The site is in the environs of a protected area
- The site is affected by the Tsunami.
- The site has easy and economical access to: level of official and local cooperation; Sites selected must have sufficient critical mass in terms of extraction, and dependency by villagers; and
- Level of personal security for the data collection staff.

Based on these criteria, the following villages were chosen for subsequent surveys:

Ranong Province: Ban Naca and Ban Bang Man

The assessment related to indirect benefits of mangrove ecosystems relied on secondary sources of data by determining the effect of production on fish, crustaceans and molluscs catch as well as the cost of restoring shoreline protection values. For this purpose, reliance on post tsunami assessments in Thailand, official government statistics as well as economic valuation of mangrove ecosystems literature was collected. Table 4 lists the products and services that this study will value and the methods for valuing them.

Table 5: Products and Services to be Valued and the Methods of valuing for this study

Products and Services to be Valued	Methods of Valuing
Non-fish mangrove forest products (NFMFP)	Market prices and close substitutes
Fisheries production through habitat provision	Effect on production
Coastal protection	Restoration Costs

4.1 Valuation methodology

Direct Use Costs - Market prices[2]

The market price method will be used to value NFMFP. The most straightforward and simplest method for valuing coastal ecosystem products is the use of market prices: how much it costs to buy, or what it is worth to sell. In a well-operating and competitive market these prices are determined by the relative demand for and supply of the product in question, and should hence reflect its true scarcity, and equate to its marginal value.

There are three main steps involved in collecting and analysing the data required to use market prices to calculate the value of the selected products:

- Find out the quantity of the product collected;
- Collect data on its market price;
- Multiply price by quantity to determine its value.

[2] Borrowed from Emerton and Bos (2005)

These data are generally fairly easy to collect and analyse. However, when applying this technique it is important to ensure that the data collected covers an adequate period of time and sample of households. Factors to bear in mind also include the possibility that prices and collected quantities may vary between seasons, for different socio-economic groups, at different stages of the marketing or value-added chain, and in different locations.

The greatest advantage of this technique is that it is relatively easy to use, as it relies on observing actual market behaviour. Few assumptions, little detailed modelling, and only simple statistical analysis are required to apply it.

There are however also situations where this technique should not be applied in isolation. For example, in the above mentioned situation where mangrove products are not primarily collected for sale but rather for subsistence use within the household, as well as in situations where a variety of subsidies and market interventions distort the price of the products.

Effect on Production – Fish production and habitat

The effect on production method has been selected as appropriate for valuing the service of fish habitat since this method allows for assessing the value of ecosystem services by looking at their contribution to other sources of production – in this case near shore fisheries. Effect on production techniques can thus be used to value ecosystem services that clearly form a part of other, marketed, sources of production.

There are three main steps involved to collect and analyse the data required for valuing mangroves as breeding grounds:

- Determine the contribution of healthy coastal ecosystems (coral reefs, mangroves and sea grasses) to near shore fisheries;
- Relate the loss of fish habitat to a physical change in near shore fisheries catch;
- Estimate the market value of the loss in production.

The effect on production method relies on a simple logic, and it is relatively easy to collect and analyse the market information that is required to value changes in production of ecosystem-dependent products (see above, market price techniques).

The most difficult aspect of this method is determining and quantifying the biophysical or dose-response relationship that links changes in the supply or quality of ecosystem products and services with other sources of production. For example, detailed data are required to assess exactly the impacts of the loss of coastal ecosystems and breeding grounds on local fisheries production. To be able to specify these kinds of relationships with confidence usually involves wide consultation with other experts.

Restoration Costs - Coastal Protection Ecosystem Proxies

One way to assess the damage of tsunami on ecosystem services would be to ascertain what would be the cost of restoring the ecosystem back into a good healthy condition. The tsunami presents an opportunity to examine what could be the real costs involved in restoration efforts. For this purpose, secondary sources would be used to elicit the expenditures or ***costs required for ecosystem restoration*** back into a healthy state. Expenditures include capital costs, operation and management costs and labour costs. This method can be used as a proxy but credible estimation of damages to coastal protection functions.

Primary Data Collection:

In order to ensure a rapid data collection methodology, participatory data collection methods were combined with a brief household questionnaire for the purposes of collecting primary data. Such an approach provides a rapid, interactive mode for data collection. Initially a PRA is conducted with the local community, and the local community in consultation with field data collection team, develop local maps showing all household dwelling units, roads, service facilities, location of mangrove forests areas as well as village level socio-economic information such as households characteristic (income level, harvest level). The information collected on household units and is then used to select a representative sample taking into harvest levels (thus those that are engaged in mangrove extraction are part of the representative sample) This participatory exercise also is an entry point for the survey team to familiarize themselves with the general social, economic and environmental conditions of the village.

Subsequent follow-up interviews using the household questionnaires were arranged with selected members of the group. As mentioned above, surveyed households included those extracting products. A total of 63 households were interviewed for this study.

The questionnaire designed for this purpose focused in on key information such as literacy and ethnicity, household characteristics, livelihood activities, types of mangrove products collected on a monthly basis, amount sold and amount used for subsistence. The information collected was confirmed by households and triangulated with existing studies on mangrove extraction in Thailand (see Sathriathai, 1998; Tung Tase Conservation Committee 2003*)*. Because of the close proximity to the market and the easy access by buyers to the villages, harvesters receive market prices. These are non-distorted prices that could be used to estimates values of resources. Where in a rare case a commodity is not sold, estimates of close substitutes product prices were devised to estimate the proxy prices. An example is the natural dyes collected from the mangrove forests. Substitutes that could have been bought from the market are used to derive proxy prices.

Secondary data collection:

Bearing in mind the nature of the habitat, limited time and financial resources, the study had to rely on secondary sources for data – often available in soft version or through the internet - to estimate ecosystem services values. Literature was also collected on coastal ecosystem restoration and rehabilitation methods, their pros and cons and the costs involved of different approaches. Several valuation and coastal zone management project were consulted and data and results, which were applicable to the select sites, were used for estimating costs of restoration.

Limitations

The study relied on a rapid ecological- economic-livelihood assessment methodology so was interested in generating 'ball park' figures rather than exact and precise numbers through costly studies. Such ballpark figures are often tremendous credible, cost effective and raise awareness and profile of the value ecosystems, and are easily understandable by decision-makers and the public. Nevertheless, the study had to be completed in such a short-time span with limited finances. Therefore, more extensive surveys of the area and site candidates was not feasible.

5. ABOUT THE STUDY SITE: RANONG PROVINCE AND BAN BANG MAN AND BAN NACA

Ranong is one of the southern provinces of Thailand, located on the shore to the Andaman Sea. Ranong has the fewest citizens of any province in Thailand. Neighbouring provinces are Chumphon, Surat Thani and Phang Nga. To the west, it also borders to Kawthaung Province, Union of Myanmar.

Ranong is located on the Kra Isthmus, the narrow strip that connects mainland Thailand with the Malay Peninsula, on the west side of the Phuket mountain range. It has a long coast on the Andaman Sea. The province is known for having the most rainfall of all Thailand, the rainy season lasting for about 8 months. In 1955 the annual rainfall reached 6699.5 mm, compared to about 1200 in central Thailand.

Eighty percent of Ranong is covered by forests, and 67% are mountainous terrain. The Ranong Biosphere Reserve in the north of Amphoe Kapoe covering 303.09 km² was declared by UNESCO in 1997. It is the fourth biosphere reserve of Thailand, but the only one located at the coast to protect and research mangrove forests. Historically the main local industry was tin mining. White clay mining for the production of porcelain and fishing are the main industries today, together with rubber and cashew nut farming. As listed in the table below, the total area of the province is 3,298 square kilometres with a total population of 176,372 and a Gross Provincial Product of 12,308 million Baht.

Province	Province area (Sq. Km.)	GPP (Gross Provincial Product) (Mil. Baht)	Population (Person)
Ranong	3,298	12,308	176,372

Ranong is subdivided into 4 districts (*Amphoe*) and one minor district (King Amphoe). These are further subdivided into 30 communes (*tambon*) and 167 villages (*muban*).

The villages of Bangman and Naca .are situated in Tambon Naca in Suk Samran district, Ranong Province. Naca tambon consists of 8 villages distributed over an area of 285 km^2. Approximately 70% of the tambon consists of mountainous areas with 30% defined as within the coastal zone. The tambon is served by three main riverine water sources and also has 130 shallow wells and 19 subterranean water sources. The major occupations of the population are related to agriculture, fisheries and general employment. Agriculture in the inland areas consists of rubber, cashew, coffee and fruit orchards. The tambon has no industrial base, but does have a coffee mill. Two protected areas are found within the tambon, Laemson national park along the coast and the Klong Naca Wildlife Sanctuary which is the second largest sanctuary in Thailand (52,960 ha) spanning two provinces is situated along the provincial border with Surrathani.

The Naca Tambon budget in 2005 was 5 million baht and in 2006 this had increased to 13.8 million baht. In 2005, local taxes accounted for 128,242 bah of revenues, with the majority of revenue being generated through various government allocations. In terms of infrastructure, the tambon has 5 primary schools,2 high schools and 2 day care centres. The population is a mixture of Buddhists and Muslims and there are 6 mosques and 2 temples within the tambon. Approximately 95% of the tambon's population has access to water and sanitation. Seventy four residents in the Tambon died as a result of the tsunami, and approximately 238 fishing boats were lost, as were numerous aquaculture cages.

The villages of Ban Bang man and Naca are located close to the main road, and adjacent to the mangrove forests that border the kapur estuary. Ban Bang Man consists of 230 households and a total 1,487 persons of which 747 are male and 740 females. In Ban Naca, the population consists of 273 households of 1,157 persons, 567 of which are male and 590 females. The two villages account for 46% of the tambons population and households. Ban Bang man village is predominantly Muslim while Ban Naca's population consists of both Thai and Muslim. In addition, both villages also have Thai migrants from Myanmar who are residents. These persons do not have Thai citizenship but they are of Thai ancestry. Educational requirements for the villages are served by two primary schools. The primary livelihoods from these coastal villages are fishery related to fishing and aquaculture. However, most villagers also have small agricultural homesteads. In Bang ban Man, rubber, palm oil and fruit orchards contribute to the income generation. In Ban Naca village, small coffee holdings are also present. Approximately 40% of the population in Ban Naca conduct some amount of agricultural activity. In Ban Naca, there is also a growing ecotourism business that has been existence for approximately 2 years. The eco-tourism activities relate to trekking and rafting in the adjacent wildlife sanctuary. In villages, local village shops and shrimp farms provide labour opportunities for a small number of villagers.

Map 2: Ban Bangman and Ban Naka

6. RESULTS AND DISCUSSIONS

This section presents the results of the study. It begins by presenting and discussing the estimates of economic benefits of mangrove ecosystem products such as non-fish mangrove forest products and fish, crustaceans and molluscs in the next sub-section. This is followed by estimates of economic benefits of indirect values of select ecosystem services, namely fisheries habitat and coastal protection. Finally aggregate provincial level estimates are provided in the last sub-section.

.

6.1 Direct Values of Products

Often some of the key products that coastal household depend on are derived from mangrove ecosystems. The first step in the process of arriving at the economic benefits of mangrove products to livelihoods is to ascertain the value of mangrove products to households. As mentioned in the methodology section above, the information collected on household units from the PRA exercise was then used to select a representative sample taking into account harvest levels (thus those that are engaged in mangrove extraction are a part of the representative sample). The household survey enlisted the products collected, amount of each product consumed and/or sold, the market (or in the rare case substitute) price of the product, and the total household product values for the representative sample.

Table 6: Direct values of mangrove products per collecting household per year (Ban Naca)

Mangrove products	Sampled collecting HHs	Quantity collected/ per HH/year	Units	Average price/per unit(Baht)	Value Per HH/(Baht)	Total Number of collecting HH	Village Level Value (Baht)
Aquaculture (fish)							
เคย (Krill)	6	517	Kg	21	10,764	23	247,569
แมงกะพรุน (Jelly fish)	28	2,775	Kg	3	8,028	110	883,045
ปลาเก๋า (Grouper)	3	120	Kg	223	26,800	12	321,600
ปลาแดง (Emperor Red Snapper)	18	133	Kg	100	13,333	65	866,667
ปลากระบอก (Grey Mullet)	29	563	Kg	50	28,041	110	3,084,499
ปลากระพงแดง (Red Snapper)	35	97	Kg	119	11,629	137	1,593,163
ปลากระพงขาว (Giant Perch)	35	92	Kg	100	9,154	137	1,254,137
ปลาขี้ตัง (Spotted Scat)	6	470	Kg	53	25,067	23	576,533
ปลาดุกทะเล (Striped Catfish)	27	155	Kg	98	15,123	105	1,587,911
ปลามีหลัง (Striped Sea Catfish)	9	157	Kg	91	14,335	30	430,044
หอยหวาน (Spotted Babylon)	10	612	Kg	10	6,120	30	183,600
หอยกัน (Common Geloina)	13	294	Kg	13	3,839	35	134,350
Total Fish Aquaculture							**11,163,120**
Molluscs							
หอยนางรม (Oyster)	22	627	Kg	10	6,273	246	1,543,091
หอยเข็ม (Slipper Shell)	25	198	Kg	20	3,965	90	356,832
หอยแครง (Blood Cockle)	20	483	Kg	25	12,075	80	966,000
หอยจุ๊บแจง (Horn Snail)	33	159	Kg	34	5,453	100	545,300
หอยปะ (Asiatic Harb Clam)	9	277	Kg	10	2,773	50	138,667
หอยสันขวาน (Rodong)	20	172	Kg	40	6,888	80	551,040
Total Molluscs							**4,100,930**
Crustaceans							
กุ้งขาว (White Shrimp)	25	163	Kg	84	13,636	150	2,045,390
กุ้งลาย (Green Tiger Shrimp)	25	127	Kg	91	11,557	150	1,733,530
กุ้งกุลาดำ (Giant Tiger Prawn)	8	71	Kg	220	15,510	50	775,500
ปูดำ (Mud crab or Back Rice Crab)	35	634	Kg	114	72,490	50	3,624,490
ปูม้า (Blue Swimming Crab)	27	587	Kg	88	51,714	40	2,068,543
Total Crustaceans							**10,247,453**
Mangrove forest products							
ยอดเป้ง (Dwarf Date Palm crown)	13	157	Kg	3	471	50	23,538
หน่อไม้ (Bamboo shoot)	8	270	Kg	10	2,700	40	108,000
Total Mangrove forest products							**131,538**
Total Village Value							**25,643,041**
Total Value Per HH/year					**377,736**		

Mangrove products	Sampled collecting HHs	Quantity collected/ per HH/year	Units	Average price/per unit(Baht)	Value Per HH/(Baht)	Total Number of collecting HH	Village Level Value (Baht)
(Baht)							
Total Value Per HH/year (US$)					9,443		
Total Value hectare/year (Baht)							53,423
Value per hectare of mangroves/year (US$)							1,336

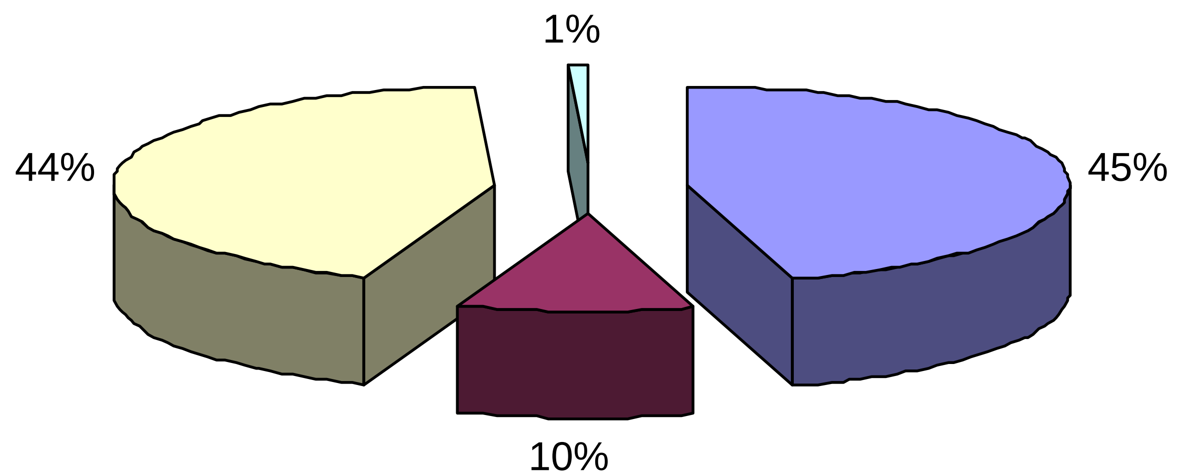
Table 6 above presents the average value of mangrove goods per collecting household per year and value for all the collecting households per year. The average household values are based on the data collected from 35 households from Ban Naca. There are 273 households and the sample represents around 13% of the total number of households in the village.

According to the table, the household dependency on mangrove ecosystems products is remarkably widespread. For example, 12 species of fish, 6 species of molluscs, 5 species of crustaceans and 2 mangrove forest products are collected. On average, annual value of gross income from fish species is 172,232 Baht (US$ 4,306) represented by the annual catch of 5,984kg of different species of fish and that adds most to the household income. In addition to that, collection of other mangrove products such as 1,917kg of molluscs, 1,581kg of crustaceans and 427kg of mangrove forest products adds 37,427 Baht (US$ 936), 164,906 Baht (US$ 4,123) and 3,171 Baht (US$ 79) respectively for the average annual income of mangrove dependent household.

Based on the results of the market price method, calculated average value of all the mangrove products per collecting household of Ban Naca is 377,736 Baht (US$ 9,443) per year. It was reported that out of 273 households in Ban Naca 137 households engage in fisheries, 247 engage in aquaculture Oyster farming and 191 engage in shrimp farming and the number of households engaged in collecting other products is listed in table 5 above. Using those information total use value of mangrove ecosystem for mangrove resource dependent households in Ban Naca was estimated at 25,643,041 Baht (US$ 53,423) per year.

Since there are 480ha of mangroves within Naca village, per hectare value of direct uses was derived at 53,423 Baht (US$ 1,335) per year. Per hectare estimates were derived by extrapolating the average value per household per year times the total number of households divided by the mangrove area used per site. These extractive uses are broadly sustainable (if they were not, it would not be possible to take the full value as a sustainable value of mangroves, as it would be leading to degradation and loss).Figure 4 depicted below illustrate the average contribution of fish, molluscs, Crustaceans and mangrove forests products for income of all the mangrove resource dependent household of Ban Naca.

Figure 5: Direct Value of Mangrove Products Per Collecting Household per Year (Naca)



As can be seen mangrove dependent aquaculture fish contributes 45% of the income generated by mangrove products and 44% from crustaceans, 10% from molluscs and 1% from mangrove forest products. These mangrove ecosystem products play a vital role in the livelihoods of these households and the values above include the subsistence benefits provided, which are often not revealed if only traded products are considered.

Table 7: Direct value of mangrove products per collecting household per year (Ban Bang Man)

Mangrove products	Sample collecting HH	Quantity collected/per HH/year	Units	Average price/per unit(Baht)	Value Per HH/(Baht)	Total Number of collecting HH	Value Village
Aquaculture (fish)							
เคย (Krill)	13	218		30	6,554	91	596,400
ปลาเก๋า (Grouper)	6	180		180	32,400	42	1,360,800
ปลาแดง (Emperor Red Snapper)	8	129		100	12,900	56	722,400
ปลากระบอก (Grey Mullet)	27	616		53	32,602	194	6,324,719
ปลากระพงแดง (Red Snapper)	27	89		115	10,206	194	1,979,918
ปลากระพงขาว (Giant Perch)	27	107		101	10,825	194	2,099,990
ปลาขี้ตัง (Spotted Scat)	8	153		60	9,180	56	514,080
ปลาดุกทะเล (Striped Catfish)	14	117		96	11,256	98	1,103,124
ปลามีหลัง (Striped Sea Catfish)	7	154		71	10,910	49	534,600
ปลาทราย (Sand Goby)	12	390		65	25,350	84	2,129,400
หอยกัน (Common Geloina)	19	3,992		11	42,227	133	5,616,152
Total Fish Aquaculture							**22,981,583**
Molluscs							
หอยนางรม (Oyster)	11	3,045		29	88,574	184	16,297,595
หอยเข็ม (Slipper Shell)	15	174		19	3,255	120	390,656
หอยแครง (Blood Cockle)	10	145		25	3,557	80	284,592
หอยจุ๊บแจง (Horn Snail)	23	137		31	4,236	184	779,395
หอยชักตีน (Wing Shell)	10	240		20	4,800	80	384,000
หอยปะ (Asiatic Harb Clam)	7	137		28	3,820	56	213,943
หอยสันขวาน (Rodong)	9	187		37	6,844	72	492,800
Total Molluscs							**18,842,980**
Crustaceans							
กุ้งขาว (White Shrimp)	22	150		85	12,682	192	2,434,909
กุ้งลาย (Green Tiger Shrimp)	21	105		97	10,158	189	1,919,931
กุ้งกุลาดำ (Giant Tiger Prawn)	3	300		220	66,000	27	1,782,000
ปูดำ (Mud crab or Back Rice Crab)	27	701		100	70,133	138	9,678,400
ปูแสม(Medar's Mangrove Crab)	4	120		30	3,600	30	108,000
ปูม้า (Blue Swimming Crab)	21	392		100	39,200	100	3,920,000
Total Crustaceans							**19,843,241**
Mangrove forest products							
ใบจาก (Leaf of Nipa palm)	3	7,992		6	47,952	30	1,438,560
ยอดจาก (Nipa Palm)	3	1,800		2	3,600	30	108,000
ยอดเป้ง (Dwarf Date Palm crown)	19	148		3	445	90	40,074
หน่อไม้ (Bamboo shoot)	6	230		17	3,833	60	230,000
Total Mangrove forest products							**1,816,634**
Total Village Value							**63,484,437**
Total Value Per HH/year (Baht)					**577,101**		
Total Value Per HH/year (US$)					**14,428**		
Total value of ha/year (Baht)							**240,471**
Value per hectare of mangroves/year (US$)							**6,011.78**

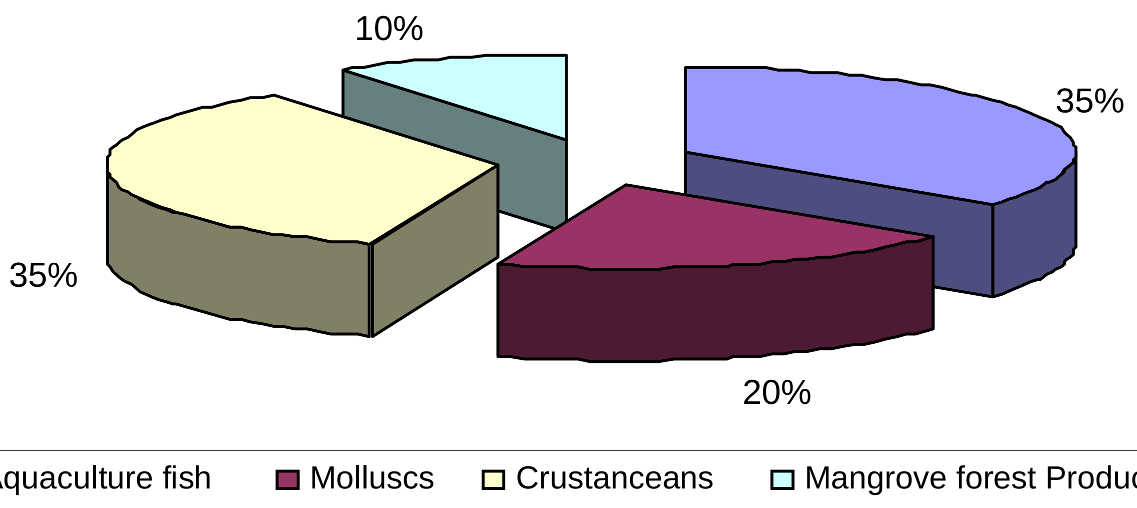
Table 6 above presents the annual average direct use values calculated for mangrove ecosystem products collected by households in tsunami affected Ban Bangman village. There are 230 households in the village and out of those 28 households (12%) were selected as the sample. In average a household in Ban Bangman harvests about 6,145 kg of 11 species of fish per year equal to an average income per fishing household of 204,409 Baht (US$ 5,110) per year. Average amount of molluscs harvested is 4,605 kg equal to average market value of 115,087 Baht (US$ 1,396) per year, crustaceans 1,768 kg per year equal to an average market vale 201,774 Baht (US$ 5,044) and mangrove forest products 10,170 kg per year equal to market value 55,831 Baht (US$ 1,396).

Total market-price value generated by the mangrove ecosystem for a mangrove dependent household in Ban Bangman was estimated at 577,101 Baht (US$ 14,428) per year.

There are 230 households in Ban Bangman village out of that 190 households engage in fisheries, 184 engage in aquaculture Oyster farming and 92 engage in shrimp farming and the number of households engaged in collecting other products is listed in table 6 above. Based on this information, total market-price value of mangrove ecosystem products earned by Ban Bangman is estimated to be 63,484,437 Baht (US$ 1,587,111) per year. It is reported that the total area of mangrove cover within Ban Bangman village is 264ha and using that figure per hectare value of mangrove products was estimated at 240,471 Baht (US$ 6,012) per year.

Following figure describes the contribution of different mangrove products for the income of mangrove ecosystem dependent household in Ban Bangman.

Figure 6: Direct Value of Mangrove Products Per Collecting Household Per Year (Ban Bangman)



According to the figure 5 above, aquaculture fish and crustaceans contribute 35% each of value for mangrove ecosystem products for the collecting household, molluscs contributes 20% and non-fish mangrove forest products contribute 10% of the value for collecting household.

Effect on Production – Fish Habitat

The effect of changes of mangrove cover on fisheries production was calculated based on few assumptions.

1. Mangrove ecosystem habitat changes over a period of 8 years and is totally degraded/converted;
2. Annual reduction of fisheries yield is 10% of the initial level of production;
3. When mangrove ecosystem is lost the fisheries production declines to 20% of the initial yields.

These assumptions are based on the scientific role of mangrove ecosystems in providing fish habitat and the contribution to the production of fisheries identified through literature review and expert consultation. Based on these assumptions effect on fisheries production was calculated. Present value of the contribution of mangrove ecosystems to fisheries production for Ban Naca (using 10% discount rate for 8 years time horizon) is US$ 20,174 per household and US$ 2,853 per hectare. Present value of the contribution of mangrove ecosystems to fisheries production in Ban Bangman was also calculated based on same discount rate and 8 years time horizon and for Ban Bangman the value of fish habitat translates to US$ 30,822 per household and US$ 12,843 per hectare. Clearly the loss of these benefits would impact the hardest on the communities residing nearby and dependent on the fisheries for subsistence and income.

6.2 Costs of Restoring Mangrove Ecosystem - Coastal Protection

The approach adapted to valuing coastal protection of coastal ecosystems is the cost of restoring ecosystem so that they once again provide the service. Put different, this approach seeks to obtain an estimate of what it would cost to restore coastal ecosystems to healthy and productive levels and ensure the delivery of coastal protection ecosystem services. Following Tri et. al. (1996), this approach differs from the cost of replacement approach using engineering structures to value coastal protection. More importantly, this approach meets the validity conditions that replacement costs are often suspect of, namely (i) restoring the service is equivalent in quality and magnitude; (ii) that the restoration is the least cost way of replacing the service; and (iii) that people are actually willing to pay the restoration cost to obtain the service. The latter condition has already been fulfilled by community and forest department initiatives undertaking restoration.

Table 8: Summary of Results of Costs of Restoring Mangrove Ecosystem

Site level Damage	Mangrove Forest Area Damaged (Hectare)	Per Hectare Cost for replanting/monitoring in Thai Baht	Estimated Costs in Year 0	Net Present Costs of Restoration of Mangroves in Baht (using 10% discount rate)
Ban Naca and Ban Bangman	**30**	**29,094/5,819**	**872,820**	**1,295,918**

Table 8 above summaries the amount of mangrove forest to be restored, the costs of restoration, immediate costs and the net present costs of mangrove restoration. Data on per hectare costs is from the Royal Forest Department as reported in Lewis (2001) adjusted to current value. While it is recognised that mangrove restoration will also contribute to increase in the flow of non-fish mangrove forest products and nursery function of mangroves, nevertheless the estimates are used as a proxy for coastal protection value. The annualised cost of per hectare restoration turns out to be Baht 43,224, which is fundamentally different from the replacement costs value derived by Sathrathai and Barbier (2001) of 147,160 Baht per hectare. In essence Baht 43,224 represents the minimum value of coastal protection, while the value derived by Sathrathai and Barbier (2001) represents a maximum value.

7. CONCLUSIONS

This study presents the economic arguments for factoring coastal ecosystems in a post tsunami context. The study does this by considering the ecological and socio-economic values of mangrove ecosystems such as those present in Ranong Province including the relationship between the ecological values of mangrove ecosystems with the socio-economic values. Mangrove ecosystems - it is found – have an integral role to play in the provision of mangrove products and services that have a demonstrable value to coastal livelihoods, and coastal communities are often heavily dependent on mangrove ecosystem products and services for their livelihoods. These ecosystem products and services manifest in the form of food, construction, fuel, income and other household uses. More importantly, mangrove ecosystems are vital because they deliver ecosystem services that underpin human well-being such as the role of coastal ecosystems play in mitigating damage and protecting coastal inhabitants lives, livelihoods and assets when extreme events occur. Coastal ecosystems also provide food security and livelihoods to coastal inhabitants through the service provision of fisheries nursery and habitat. Table 8 below presents mangrove product total values to study site households, villages and in per capita terms. Around 60% of all the mangrove products are sold in the market and thus the village economies contribute to more than 60% of the village level incomes.

Table 9: Total Mangrove Product Values to Households, Villages and in per hectare terms for Ban Naca and Ban Bangman

Ban Naca	
Total Village Value	**25,643,041**
Total Value Per HH/year (Baht)	**377,736**
Total Value Per HH/year (US$)	**9,443**
Total Value hectare/year (Baht)	**53,423**
Value per hectare of mangroves/year (US$)	**1,336**
Ban Bangman	
Total Village Value	**63,484,437**
Total Value Per HH/year (Baht)	**577,101**
Total Value Per HH/year (US$)	**14,428**
Total value of ha/year (Baht)	**240,471**
Value per hectare of mangroves/year (US$)	**6,012**
Total for Ban Naca and Ban Bangman	**89,127,478**

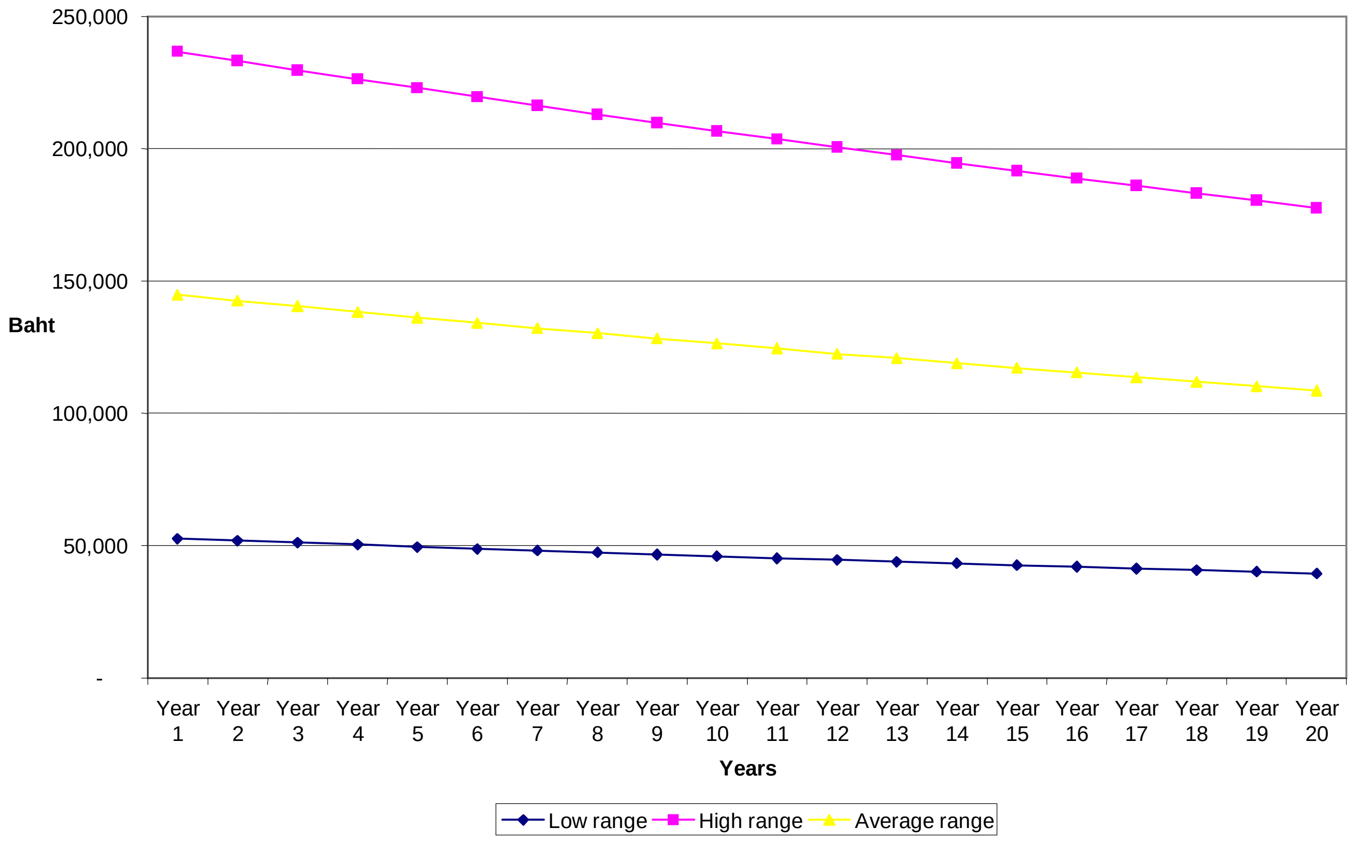
To scale up and focus in on coastal populations, and in the absence of precise data, Table 8 is created below based on the findings by Balk et. al (2005) that the population within 1 kilometre of coast in Ranong Province represents roughly 2% of the population, and the assumption that this coastal population contributes to 2% to the official provincial economies. Also in the absence of precise data, we assume that per capita incomes of these coastal households are the provincial averages, even though this may be an overestimation. Table 8 reveals that the select site contributes around 53.47 million Baht or 22% of marketed mangrove products to the coastal economy of Ranong.

Table 10: Per capita impact on Coastal Households

Province	Gross Provincial Product (Mil. Baht) 2% Contribution	Population within 1 Kilometre	Per Capita Income in Baht	Marketed Mangrove Products from site valuation (Mil. Baht)	Percentage Contribution to Coastal Economy
Ranong	**246**	**9,574**	**69,784**	**53.47**	**22%**

Finally, Figure 7 below analyses what would be the impact of mangrove loss over time in economic terms. This would be owing to the fact that mangrove ecosystems are not factored into coastal rehabilitation and development. According to www.esajournal.org, current mangrove deforestation rate has decreased from 3,000 hectares a year to 1,800 or roughly 1.5% per annum. In this sense, low range costs represent the lower value per hectare/year of Baht 53,423 of Ban Naca and high range costs represent the higher per hectare value of Baht 240,471 of Ban Bangman, and the average range costs represent the average of both figures. Figures 6 demonstrates what could be the losses under different scenarios per annum. If say Ranong mangrove ecosystems provide benefits in the high range to coastal communities the impact of 1.5% mangrove forest loss over 20 years in terms of mangrove products values would decline to 177,748 per annum – a loss of Baht 67,732. In the low range, benefits are expected to lower by Baht 13,936 and in the average range costs by Baht 38,334. are 836.12 Million Baht and high range costs amount to 1,633.23 Million Baht. Needless to say that these losses in benefits are expected to impact largely on the poorer coastal livelihoods and households over time that have fewer options. However, by factoring mangrove ecosystems into coastal rehabilitation, reconstruction and development, mangrove ecosystem benefits can be sustained and improved over time.

Figure 7: Scenarios of mangrove loss at 1.5% against low, average and high ranges



The main conclusions to draw out from this study are that mangrove ecosystems provide a key resource to the household, local and regional economies in terms of generating output, revenues, employment and commerce. However, often these economic benefits are hidden and miss detection. Failure to invest in their rehabilitation and restoration as well as failing to factor mangrove ecosystems in reconstruction and rehabilitation means that the select sites and provinces will accrue economic and financial costs.

The study has also demonstrated that coastal communities rely heavily on mangrove ecosystems for their livelihoods, which is clearly apparent by the diversity of uses mangrove resources are put to. The economic costs of mangrove ecosystem loss and degradation is expected to be felt the hardest by the poor at the local level, without options for alternative livelihoods and capacity to cope against disasters. Finally, the study demonstrates the economic and development wisdom of conserving the environment in post-tsunami reconstruction and of the importance of factoring ecosystems into coastal zone development and rebuilding as such actions would translate into not only to sustained provincial economies but more importantly to sustained livelihoods of the poor coastal communities.

SELECTED REFERENCES

APDC 2005, Comprehensive Estimation of Damage and Losses in Thailand. Pathumthani, Thailand.

Australian Institute of Marine Sciences 2006. Status of Coral Reefs in Tsunami Affected Countries: 2005. Australian Institute of Marine Sciences, Australia.

Baan, C. 1997a. An economic analysis of alternative mangrove management strategies in Koh Kong Province, Cambodia, EEPSEA Research Report.

Baan, C. 1997b. The Economic Valuation of mangroves: A Manual for Researchers, International Development Research Centre, Ottawa, Canada.

Balk D., Gorokhovich Y., and Levy M. 2005. Estimation of coastal populations exposed to 26 December 2004 Tsunami. CIESIN

Bangkok Post, July 8, 2006.

Coastal Resources Institute (CORIN). 1995. "The Effect of Aquaculture on Agricultural Land and Coastal Environment", Mimeograph, Prince of Songkla University, Songkla, Southern Thailand.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P. and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

Department of Disaster Prevention and Mitigation. 2005. Tsunami Disaster Situation. Ministry of Interior. Bangkok, Thailand.

Department of Marine and Coastal Resources (DMCR) 2005.Rapid Assessment of the Tsunami Impact on Marine Resources in the Andaman Sea, Thailand. Ministry of Natural Resources and Environment, Thailand.

Economic Statistics from two major sources: The National Economic and Social Development Board, http://www.nesdb.go.th/econSocial/macro/nad.htm#gpp

Government of Thailand 2005. The national rapid environment assessment. Bangkok, Thailand.

ICEM, 2003. Economic valuation: Its use in protected area management, Thematic paper 11. Review of Protected Areas and Development in the Lower Mekong River Region. Indooroopilly, Queensland, Australia.

Janssen, R. and Padilla, J. 1999. "Preservation or Conversion? Valuation and Evaluation of a Mangrove Forest in The Philippines", Environmental and Resource Economics, 14: 297-331.

Lewis III R.R. 2001. Mangrove Restoration - Costs and Benefi ts of Successful Ecological Restoration. Proceedings of the Mangrove Valuation Workshop, Universiti Sains Malaysia, Penang, 4-8 April, 2001. Beijer International Institute of Ecological Economics, Stockholm, Sweden.

Mangrove forests, 2004, from the Royal Forest Department, http://www.forest.go.th/stat/stat47/TAB3.htm;

National Statistical Office, http://service.nso.go.th/nso/data/data23.html

Nimsantichareon, Sompote. 2004. Marine Research Station Bulletin. Vol. 3, No. 11-12.

Ogden, J. C. 1988. The influence of adjacent systems on the structure and function of coral reefs. Proceedings of the 6th International Coral Reef Symposium, 1:123-129.

Ruitenbeek, 1992. Modeling Economiy-Ecology Linkages in Mangroves: Economic Evidence for Promoting Conservation in Bintuni Bay, Indonesia. Environmental Management Development in Indonesia Project Environmental Report 8.

Sathirathai, Suthawan and Barbier, Edward B. 2001. "Valuating Mangrove Conservation in Southern Thailand", Contemporary Economic Policy, Vol. 19, No. 2, 109-122.

Sathirathai, Suthawan. 1998. Economic Valuation of Mangroves and the Roles of Local Communities in the Conservation of Natural Resources: the Case Study of Surat Thani, South of Thailand. EEPSEA Research Report Series, Economic and Environment Programme for Southeast Asia, Singapore.

Spaninks, F. and van Beukering, P. 1997. Economic Valuation of Mangrove Ecosystems: Potential and Limitations, CREED Working paper No 14, International Institute for Environment and Development, London.

Spurgeon, J. and Roxburgh, T. 2005 A Blueprint for Maximising Sustainable Coastal Benefits: the American Samoa case study, Proc. 10th International Coral Reef Symposium, Okinawa, Japan.

Tangjaitrong, S. et. al. 2006. Assessment of Impact of the December 26, 2004 Tsunami on Mangroves along the Andaman Sea coast of Thailand. IUCN, Bangkok, Thailand.

Tri,N.H, Adger, N., Kelly,M., Granich,S., and Ninh,N.H. (1996) The Role of Natural Resource Management in Mitigating Climatic Impacts; Mangrove Restoration in Vietnam. Centre Social Economic Research on the Global Environment, University of East Anglia, CSERGE Working paper GEC 96-06. 27 pp. Norwich, UK.

White and Cruz-Trinidad, The Values of Philippine Coastal Resources. p. 24.

White, A.T.,Ross, M. and Flores, M. 2000. “Benefi ts and Costs of Coral Reef and Wetland Management, Olango Island, Philippines” in Cesar, H. (ed) Collected Essays on the Economics of Coral Reefs, CORDIO.