Research Reports

An Economic Analysis of Alternative Mangrove Management Strategies in Koh Kong Province, Cambodia

by Camille Bann

Executive Summary

This report presents an economic analysis of the different uses of the mangrove resource of Koh Kong province, Cambodia. The objective of the study is to provide information on the economic benefits and operational practices of key activities in the area that might be employed in the identification of an economically optimal management strategy for the mangrove resource. A parallel objective of the study has been to train a team of Cambodians in survey techniques, data collection and analysis, and ultimately on the economic appraisal of natural resource use.

Mangrove ecosystems are valuable, both in terms of their direct use and indirect use values. Direct use values are the products and uses derived directly from the mangrove (e.g., fuelwood, food, construction materials, and use of the area as a site for human settlement). Indirect use values are the ecological services provided by mangroves which support indirectly economic activities. Ecologically, mangroves act as a natural barrier to shoreline erosion, reduce the effects of storm surges and flooding, maintain water quality, and support a wide range of wildlife. All of these ecological functions indirectly support economic activities and therefore are of value.

Perhaps the most well-known ecological service provided by mangroves is the support they provide to local and commercial fisheries. Mangroves act as nurseries and shelters for many species of commercially important finfish and crustaceans.

The mangrove areas in Koh Kong province cover an area of 63,700 hectares and have been described as ecologically and economically significant to Cambodia and all other countries situated around the Gulf of Thailand. Furthermore, this environment is the only site in all of continental Southeast Asia considered appropriate for the establishment of a coastal biosphere reserve. The mangrove forests and related environments of Koh Kong are therefore of vital international importance for nature conservation.

Most of the mangrove areas in Cambodia have been designated within the protected areas system, such as Peam Krasaop Wildlife Sanctuary. Koh Kapik and associate islets situated within Peam Krasaop Wildlife Sanctuary, have been nominated as a wetland of international importance under the Ramsar Convention. However, management plans for these areas are yet to be developed.

As for other mangrove areas in Cambodia, the mangroves of Koh Kong, which currently support a number of households, are threatened largely by the clearing of mangroves for intensive shrimp farms, and for commercial and domestic charcoal production. Charcoal production, which is illegal, has recently been stopped by the provincial government, leaving a number of families unable to support themselves, even through fishing due to declines in fish productivity. No other viable employment alternatives for local people have been identified.

In certain circumstances using the mangrove resource for productive purpose, such as charcoal productive or shrimp farming, may be justified. Typically, however, such decisions are based narrowly on the potential financial returns. The alternative uses of the mangrove resource and the many important environmental values of mangroves that are subsequently lost, often irreversibly, as a result of these productive activities are ignored. This is a serious oversight in cases where the economic value of a mangrove's resources and natural services *exceed* the gains from productive uses.

One reason why the full range of mangrove values are not considered in the appraisal process, is that many of these values are not sold in conventional markets. They therefore do not have market prices (e.g., forest products such as fuelwood and the storm protection function of a mangrove). This shortcoming often means that decisions are biased towards development options whose output is marketed and therefore easily measured (e.g., shrimp farming). However, such a partial evaluation of the mangrove ecosystem runs the risk of supporting development options that are in fact *not* economically optimal.

In order, therefore, to make rational management decisions for the mangroves of Koh Kong, the full range of benefits and costs associated with the different uses of the mangrove ecosystem must be evaluated. Such a comprehensive approach can provide information to decision makers on the environmental and social costs and benefits of different management options, and is therefore one important tool for meeting the objective of sustainable management.

This study presents an economic evaluation of the two key uses of the mangrove resource in Koh Kong - local community use and commercial shrimp farming.

Since local people are heavily dependent on the mangrove resource, community- based alternatives to unsustainable and destructive practices are seen as central to the success of any management strategy in Koh Kong.

A survey of 90 households was undertaken in three villages within Koh Kapik - the study area (Koh Sra Lao, Koh Kapik, and Lamdam) to provide information on the traditional uses of the mangrove area by local communities. The research focussed on the economic valuation of non-timber forest products collected by households from the mangrove area: fuelwood, construction materials, and crabs, shrimp, fish and snails. The charcoal industry, which was active at the time of survey, was also studied.

The survey results show that 94% of the population are in-migrants, attracted to the area by the potential returns from fishing and charcoal production at a time when population and hence resource exploitation was low. The greatest influx into the area occurred during the period 1985-90. A high proportion of households are now in debt and unable to leave the area due to lack of funds.

Nearly 90% of households are dependent on fishing for their livelihood. However, fish productivity has reportedly declined dramatically in recent years due to the increased number of fishers, the loss of mangrove areas due to the construction of shrimp farms, and water pollution from these farms. Households in Koh Sra Lao claim to have turned to charcoal production because of low fishing yields, while many villagers in Lamdam are reportedly involved in logging activities in nearby Koh Kong Island. If these explanations are correct a linkage can be made among shrimp farming, declines in fish yields, and changes in the activities of local people resulting in new and additional stresses on the resource base.

Local fishing benefits are estimated at US$84 per hectare (the benefits from commercial fishing have not been estimated). Fuelwood is valued at US$3.50 per hectare.

Valuation of the many indirect functions of the mangrove resource was not possible due to data limitations. However, a qualitative assessment of these indirect values reveals that many are considered to be of great importance and value, such as the storm protection function of the mangroves and biodiversity benefits.

Following the closure of the charcoal kilns, the Government intends to fully regenerate the mangrove forest, and then regulate and legalise the charcoal industry. It is recognised that local people need to produce charcoal because they cannot afford to buy fuel. However, what level of charcoal production would be sustainable for the area is as yet unclear, and would require careful consideration in any future management plan.

Results from this study suggest that sustainable charcoal production could provide benefits of US$413 per hectare. Charcoal production would only be allowed in areas where the mangrove has already been disturbed or replanted, and not in areas of high ecological value such as within Koh Kapik.

An important result of this study, is that on a narrow financial analysis alone (without accounting for the wider environmental and social costs imposed by the industry) shrimp farming in Koh Kong is unprofitable and unsustainable. Farms are typically abandoned after five years of operation.

While 50% of farms made a profit in the past year, overall shrimp farms in the area suffered an average loss of US$1,103 per hectare. Largely due to problems with disease (associated with poor water quality management), it is rare for farms to have two successful harvests a year, and in some cases both harvests have failed. Individual farms have reported losses ranging from US$40,000-$240,000.

The real costs of shrimp farming are in fact much higher than this. The analysis does not account for the environmental costs associated with shrimp farming such as loss of mangrove areas, water pollution, and the associated declines in fish productivity. Social equity issues are also of top concern because many local people feel marginalised by the shrimp farms, and because the benefits from shrimp farming are gained largely by Thai investors, not by Cambodia.

Future management of the shrimp farming industry requires a focus on sustainable practices, not short-term profit, and greater involvement of the local community.

An integrated management strategy for the mangrove areas needs to be developed which: safeguards the important ecological functions of the mangroves; allows sustainable traditional productive uses of the mangrove by local communities; and supports a sustainably managed commercial shrimp farming industry in designated areas. A zoning system is proposed consisting of a core area representing areas of high ecological value such as Koh Kapik. This area could be afforded total protection, or permitted to be utilized for sustainable local use. The remaining area--the multiple use area--could be used for sustainable traditional uses, and shrimp farming and charcoal production in appropriately identified zones.

A further issue, supported by local authorities, is that of relocating families out of the sensitive mangrove areas. Land is available in upland areas in the province where crop cultivation is possible alongside fishing. The standard of living in the villages within Koh Kapik is low and dependent on fishing, returns from such are no longer sufficient to support families. Households in the area have thus expressed an interest in relocation, if land is allocated to them. While an in-depth assessment of the suitability of the assigned location for relocation was not possible during the time frame of this study, the possibility of voluntary relocation is not completely ruled out. Relocation may be necessary to afford complete protection of ecologically valuable areas and may potentially improve the living standards of the local people. Relocation compensation (support) is estimated at US$1,940 per household to cover the cost of house construction and living expenses up to the first harvest.

The mangroves of Koh Kong are central to the livelihood of coastal households, are of high ecological importance and represent a base for sustainable economic exploitation *if* carefully managed. These substantial benefits of the mangrove ecosystem will be forgone if the mangrove areas are lost or damaged through uncontrolled resource use and inappropriate development.

1.0 INTRODUCTION

There are estimated to be 85,100 hectares of mangroves in Cambodia in fringe coastal areas along the Gulf of Thailand (Mekong River Commission, UNDP, FAO, 1994). The vast majority (63,700 hectares) are located in Koh Kong Province.

While the total area of mangrove forest in Cambodia is small compared to surrounding countries in the Gulf of Thailand, these forests, particularly in Koh Kong Province, have been relatively undisturbed until recently. However, Cambodia's mangroves are now under intense pressure from competing resource uses. Two important threats to the mangrove

resource are the clearance of mangrove areas for intensive shrimp farming and charcoal production. Neighbouring countries such as Thailand and Vietnam have seen widespread destruction of their natural coastal resources as a result of unmanaged exploitation. Sound management strategies for Cambodia's mangrove areas are *urgently* needed to avoid a similar outcome.

Mangrove ecosystems are valuable, both in terms of their direct use and indirect use values. Direct use values are the products and uses derived directly from the mangrove (e.g., fuelwood, food, construction materials, and use of the area as a site for human settlement). Indirect use values are the ecological services provided by mangroves which indirectly support economic activities. Ecologically, mangroves act as a natural barrier to shoreline erosion (and stabilize fine sediments, thereby helping coasts to accrete), reduce the effects of storm surges and flooding, maintain water quality, and support a wide range of wildlife. All of these ecological functions indirectly support economic activities and therefore are of value. For example, the storm protection function of a mangrove may have indirect value through the protection afforded to coastal property and economic activities.

Perhaps the most well-known ecological service provided by mangroves is the support they provide to local and commercial fisheries. Mangroves are well-known for their high biological productivity and their consequent importance to the nutrient budget of adjacent coastal waters. They export organic matter, mainly in detritus form (leaf litter) to the marine environment, thereby providing a highly nutritious food source for animals found in the mangrove areas as well as for those in neighbouring estuarine and marine ecosystems. Mangroves also support off-shore fisheries by acting as nurseries and shelters for many species of commercially important finfish and crustaceans.

Often, local coastal communities are dependent on the natural resources that mangroves provide in the form of food, firewood, construction materials and medicine, and on their ecological services and functions for their livelihood. The impact on local livelihoods of activities that damage mangrove areas is therefore a fundamental consideration in the design of management plans. This is certainly a key factor in Koh Kong, since local people are heavily dependent on the mangrove resource. Community-based alternatives to current unsustainable, destructive, and in some cases inequitable practices are thus central to the success of any management strategy in Koh Kong.

In certain circumstances, using the mangrove resource for productive purpose, such as charcoal production or shrimp farming, may be justified. Typically, however, such decisions are based narrowly on the potential financial returns. The alternative uses of the mangrove resource and the many important environmental values of mangroves that are subsequently lost, often irreversibly, as a result of these productive activities are ignored. This is a serious oversight in cases where the economic value of a mangrove's resources and natural services exceed the gains from productive uses.

One reason why the full range of mangrove values are not considered in the appraisal process, is that many of these values are not sold in conventional markets. These values/products therefore do not have market prices (e.g., forest products such as fuelwood and the storm protection function of a mangrove). This shortcoming often means that decisions are biased towards development options whose output is marketed and therefore easily measured (e.g., shrimp farming). However, such a partial evaluation of the mangrove ecosystem runs the risk of supporting development options that are in fact not economically optimal.

In order to make a rational choice between conservation and development options, or between a decision to halt, modify or continue with an activity that is inflicting damage on a mangrove, alternative management options must be properly evaluated. This entails a comprehensive cost benefit analysis (CBA) which incorporates the full range of benefits and costs associated with the different uses of the mangrove ecosystem. A comprehensive CBA can provide information to decision makers on the environmental and social costs and benefits of different management options, and is therefore one important tool for meeting the objective of sustainable management.

2.0 BACKGROUND

2.1 Mangrove Distribution in Cambodia

The Cambodian coastline extends some 435km between the Thai border and the Vietnamese border. It includes a large estuary in the northern part (Koh Kong Province) and the great bay of Kompong Som. Three provinces and one

independent resort city lie along the coastline with a population of slightly more than 675, 000 inhabitants. Of the total populace, 476, 000 reside in Kampot Province, 120, 000 in Kompong Som, 79,000 in Koh Kong, and the rest in Kep Resort City. Four main islands (Koh Kong, Koh Rong, Koh Rong Sanlem, and Koh Thmey) and a number of small islands are located nearshore. The three main islands off-shore are Koh Tang, Koh Pring and Koh Polowaii. The total Exclusive Economic Zone (EEZ) area is estimated to be 42,000 km^2, about 23% of Cambodia's land area.

Mangrove forests occur in Cambodia's three coastal Provinces on the Gulf of Thailand--Koh Kong (where they are most abundant), Kompong Som (where there are only a few patches on the shore), and Kampot. While mangrove forests spread almost all along the coastline, large, and dense forests are found at the main estuarine areas--Peam Krasaop, Andong Tuk, Sre Ambel, Chak Sre Cham, and the Delta of Prek Kampot.

It was estimated in the past that mangrove forest covered only 37,000 ha (Chea Peng Chheang, Department of Fisheries). The Land Cover maps published by the Mekong River Commission/UNDP/FAO (1994), however, show that in 1992/3, the mangroves consist of about 85,100 ha. Of these land area, 63,700 ha are located in Koh Kong Province, 13,500 ha in Sihanoukville, and 7,900 ha in both Kampot Province and Kep Resort City.

A degree of uncertainty surrounds current estimates on Cambodia's mangroves. The data were derived largely from a 1:25,000 aerial photographs taken in December 1994 that have not been systematically ground truthed due to safety and security constraints. The GIS land use maps that have been made by interpreting the 1991 aerial photographs were not systematically ground truthed either. Reports were based on small scale projects and on on-site reconnaissance of selected areas that are accessible by boat or road; there are very limited aerial reconnaissance in the vicinity of Koh Kong province.

2.2 Mangrove Distribution in Koh Kong Province

Koh Kong province covers an area of 11,160 km^2 and borders Thailand to the west, Pursat province to the north, Kompong Speu province to the northeast, Kampot and Kompong Speu province to the east and southeast and the South China Sea and Thailand to the south and south west. The coastline is approximately 260 km long. The Cardamon Mountain range surrounds one side of the the coast of Koh Kong province while islands and ocean are on the other side. Koh Kong is divided into seven districts: Dongtung, Mondulsema, Koh Kong, Kirisakor, Botumsakor, TmarBing, and Sre-Ambul.

Koh Kong has the vast majority of mangrove forests in Cambodia, with some of the last remaining areas of pristine mangroves in Southeast Asia. Mangroves are spread along Dongtung, Mondulsema, Koh Kong, Kirisakor, Botumsakor, and Sre-Ambul districts.

The mangrove areas in Koh Kong province have been described as ecologically and economically significant to Cambodia and all other countries situated around the Gulf of Thailand. Furthermore, this environment is the only site in all of continental Southeast Asia considered appropriate for the establishment of a coastal biosphere reserve. The mangrove forests and related environments of Koh Kong are therefore of vital international importance for nature conservation.

Most of the mangrove areas have been designated within the protected areas system under the Royal Decree Creation and Designation of Protected Areas' signed on November 1, 1993 by King Sihanouk (Table 2.1). These protected areas include the Peam Krasaop Wildlife Sanctuary (31,022 ha), and Botum Sakor National Park (171,250 ha). In addition, Koh Kapik (12, 000 ha) and associate islets situated within Peam Krasaop Wildlife Sanctuary, have been nominated as a wetland of international importance under the Ramsar Convention (AWB 1994). All of these areas are under the responsibility of the Ministry of Environment (MOE). Management plans for these areas are yet to be developed.

Table 2.1. Protected Areas located in the Coastal and Marine Zone of Cambodia

Name	Area (ha)	Province

National Parks		
Phnom Bokor	140, 000	Kampot
Kep	5, 000	Kampot
Ream (Preah Sihanouk)	15, 000	Kompong Som
Botum Sakor	171, 250	Koh Kong
Kirirom	35, 000	Koh Kong, Kampong Speu
Wildlife Sanctuaries		
Peam Krasaop	23, 750	Koh Kong
Phnom Samkos	333, 750	Koh Kong
Aural	253, 750	Koh Kong, Pursat, Kampong Channang, Kampong Speu
Multiple Use Management Areas		
Dong Peng	27, 700	Koh Kong

Source: ADB, May 1996

In recent years, mangrove forest areas have been severely degraded. The exact extent of this degradation is not known. Table 2.2 presents the estimates of the rate of mangrove forest degradation in Cambodia. In Koh Kong, most of the degraded areas are in Mondulsema and Dongtung districts where mangrove areas have been converted to intensive shrimp farms (Dongtung District) and where extensive cutting for charcoal production has occurred. Degradation is also evident in Peam Krasaop Wildlife Sanctuary.

Table 2.2. Estimated Rate of Mangrove Forest Degradation, 1995

Province/City	Total Areas (ha)	Area of degradation (ha)	Density degradation (%)
Koh Kong	63, 700	1, 500	40-50
Kompong Som	13, 500	800	35-40
Kampot	7, 900	400	50-60

Source: ADB, May 1996

2.3 Ecological Characteristics

An initial field study (DNCP/MOE 1995) found 42 species of trees and shrubs belonging to 20 families in the mangrove forest of Koh Kong. The most dominant species are of the family Rhizophaceae (species Mucronata and Apiculata); family Combretaceae with genera Lumnitora; and, family Avicenniacae with genera Avicennia.

Mangrove forest zonation in Koh Kong is believed to be similar to plant community structure in Chattaburi province Thailand. The edges of the estuaries and canals are dominated by Rhizophora apiculata and R. mucronata. Further inland are Avicennia and Bruguiera followed by Xylocarpus, Ceriops and Lumnitzera. Finally, a combination of Nypa fruticans and others can be found in the transitional zones between true mangroves at the seaward edge and inland forest (rear mangroves) which are dominated by Melaleuca trees.

2.4 Socio-Economic Data

Koh Kong has an estimated population of 80,000. Population density in the province is low compared to other parts of the country, especially provinces in the Mekong Basin. Dongtung (where Koh Kong provincial town is located) and Sre Ambul districts have the highest population.

Approximately 54% of the population are adults (16 years of age and older) and an estimated 51% of the provincial population is composed of women. This is different from other provinces in Cambodia where women represent 54-60% of the adult population. There are approximately 119 villages with an average of 650 persons, excluding 7-10 families of resettled people. In-migration is an important issue in Koh Kong because of perceived economic opportunities available there.

According to local population statistics, 90% of the population are ethnic Khmer, 5.58% Muslim, 2.34% ethnic Thai, 1.84% ethnic Vietnamese, and 0.16% by large numbers of ethnic Thais. However, there is a strong Thai influence in the form of language, foreign investment, and currency use.

The main types of employment in the Koh Kong are: fishing, farming, government staff, collection of non-timber forest products (NTFP), trading, woodcutting, and charcoal production. Most farmers in Koh Kong province are located in Dongtung and Sre-Ambul Districts. Many coastal people are farmers as well as fishermen.

Khmers living along the coast have many types of jobs, but are mainly fisherfolk, government staff, and up to recently--charcoal producers. A much smaller population of Thais is also involved in most professions. Most of the Muslim population are fishermen, while most Vietnamese are traders and labourers.

Table 2.3. Key Socio-Economic Indicators

Area (km^2)	11,160
Population (thousands, 1995)	79
Population density (per km^2)	7
% of rural population	77
Number of districts	7
Number of communes	30
Number of villages	119
Rice cultivation (ha, 1995)	4,836

Rice yield (ha, 1995)	1.3
Per capita rice production(kg per person, 1995)	79
Per capita GDP	n.a
Number of protected areas (two shared with other provinces)	4
ha of protected areas (exclusively in Koh Kong)	556,450
Number of minefields	91
Area of minefields (ha)	25,810

Source: ADB, May 1996

3.0 RESEARCH FRAMEWORK

3.1 Research Objective

The objective of the study was to provide information on the economic benefits and operational practices of key activities in the area. This information is important for the identification of an economically optimal integrated management strategy for the mangrove resource in Koh Kong Province.

The Study Area: Koh Kapik

The main study area is Koh Kapik, the proposed Ramsar site. Research on this area may be used as basis for suggesting an optimal management strategy for the total mangrove area of Koh Kong. Koh Kapik is close to the Thai border, southeast of Koh Kong town. The area (12,000 hectares) includes all of Koh Kapik with associated islets together with part of the mainland between Prek Thngo and Prek Khlang Yai. A much wider area which includes this site is a designated Wildlife Sanctuary--Peam Krasaop (31, 022 ha). Table 3.1 presents land cover and use in Peam Krasaop Wildlife Sanctuary (refer to Coastal Zone Land Use Cover Map).

Table 3.1. Land Cover / Use in Peam Krasaop Wildlife Sanctuary

Description of Land Cover	Hectare
Mangrove Forest	
Mangrove forest 0-5m	2,025
Mangrove forest 5-15m	2,018
Mangrove forest greater than 15m	4,145
Cleared mangrove forest area (Rhizophora)	2,634
Upper mangrove forest (rear mangrove forest)	25
Mangrove fern	116
Other Vegetation Cover	
Nypa	357
Melaleuca leucadendron / Rear mangrove	2,196
Broad leaf evergreen forest	4,279
Secondary forest	3,254
Bushland	163
Bushland and trees/low density	

Shrubland	18
Shrubland and scattered trees	153
Grassland	69
Grassland and scattered trees	672
Grassland and trees / low density	338 72
Agricultural Land	
Orchard	
Upland crops	103
Rice field	29
	171
Other land use / land cover	
Active shrimp farm	
Abandoned shrimp farm	219
Charcoal kilns (aggregate area)	292
Villages	28
Temple/Pagoda	3
Beaches	44
Permanent water body	7,547
	51
TOTAL	**31,022**

Source: Integrated Resource Information Centre, Phnom Penh (IRIC 1997)

There are three villages in the area--Koh Kapik, Koh Sra Lao, and Lamdan. All of these villages are dependent on the mangrove resource for their livelihood. The area of Koh Kapik is valuable for the large area of mangroves and rear mangrove communities which are representative of the coasts of Cambodia and Thailand and which have been largely destroyed elsewhere. Although some areas are under threat of disturbance, there are large areas of old growth mangroves such as *Rhizophora apiculata* and *Lumnitzera littorea* with an abundance of epiphytes.

Three major vegetation types have been identified (AWB/SSE 1994):

Mangrove: Most of the members of the mangrove community are characteristic of areas which are inundated only at some high tides and where there is a large degree of freshwater influence. The islands and creeks are typically fronted by *Rhizophora apiculata*, one of the most common of the mangrove species present, and stands of Nypa palms. Immediately behind this fairly narrow strip of *Rhizophora* is an interesting mixture of other mangrove species, the most common of which are: *Brugiera gymnorrhiza*, *B. sexangula*, *Ceriops tagal*, *Lumnitzera littorea*, *Heritiera littoralis*, *Xylocarpus granatum*, *Hisiscus tiliaceus*, *Phoenix palludosa*, *Acrosthicum speciosum*, *Aegialitis sp*. and, *Acanyus sp*.

'Rear mangrove' community: On some of the islands and on the mainland between Prek Khlang Yai and Prek Thngo, the mangrove community forms a narrow band. It is followed by a community above the high tide mark and probably only subject to freshwater inundation during the wet season. This community is dominated by *Melaleuca leucodendron*.

Beach strand vegetation: At the south side of Koh Kapik, and on the sandy areas of some of the islands, there are small areas of typical beach strand vegetation dominated by *Casuarina equisitifolia* with some *Terminalia catappa*.

3.2 Key Analytical Steps

(i) Identification of key productive uses and ecological functions of the mangrove resource which may be included in the economic valuation process (see Section 4).
(ii) Economic valuation of traditional uses of mangroves and qualitative discussion of ecological functions (see

Section 6)
(iii) Economic analysis of shrimp farming (see Section 7)
(iv) Selection and specification of management options that are technically and politically feasible, and generate sustainable returns from the resource base (see Section 8).
(v) Discussion of crop cultivation in upland areas and the issue of relocation (see Section 9).

3.3 Research Components

(i) A survey of 90 households in three villages within Koh Kapik area was conducted to provide the primary data needed to quantify the scale and value of traditional mangrove uses. Both marketed and unmarketed goods are included in the analysis. The survey included research on the charcoal industry in Koh Kong which was still active at the time of survey.
(ii) Survey of eight shrimp farms in the area to provide information for economic evaluation of shrimp farming in Koh Kong.
(iii) Forest inventory to determine number of trees in one hectare of forest to provide information on the mangrove area required to produce a given quantity of charcoal.
(iv) Market survey to provide qualitative information for economic valuation.
(v) Survey of households in upland areas in order to assess the viability of relocation.

4.0 IDENTIFICATION OF MAIN PRODUCTIVE USES AND ECOLOGICAL FUNCTIONS FOR VALUATION

4.1 Total Economic Value

The Total Economic Value (TEV) of a natural resource such as mangroves provides a framework for valuation (Table 4.1). TEV comprises direct use value, indirect use value, option value, and existence value. The relative importance of the individual components of TEV for a given mangrove area is site specific. An understanding of the study area is therefore necessary to identify key values that should, where possible, be included in the economic analysis. The key productive use values and ecological values for Koh Kong are identified in Table 4.2 and discussed in more detail in Section 6.

Table 4.1. Total Economic Value of Mangrove Resource

Use Values			**Non-Use Values**
Direct Value	Indirect Value	Option Value	
Timber Firewood Woodchips Charcoal Fisheries Forest resources: food,	Shoreline / riverbanks Stabilization Groundwater recharge and discharge Flood and flow control Storage and recycling of human waste and pollutants	Future use as per (1) and (2)	Cultural and aesthetic Spiritual and religious

medicine, construction materials, tools, dyes, wildlife Agricultural resources Water supply Water transport Genetic resources Tourism and recreation Human habitat Educational, historic and scientific information	Maintenance of biodiversity Provision of migration habitat Provision of nursery and breeding grounds for fish Nutrient retention Coral reef maintenance and protection Prevention of saline water intrusion		

4.1.1 Direct Use Value

Direct use values are the values derived from the direct use or interaction with a mangrove's resources and services. Direct use values include both consumptive uses of a mangrove's resources (e.g., fuelwood collection, hunting, and fishing) and non-consumptive uses of a mangrove's 'services' (e.g., recreation, tourism, and in-situ research and education). Direct use of mangroves could involve both commercial and non-commercial activities. Non-commercial activities are often very important for the subsistence needs of local populations.

4.1.2 Indirect Use Value

Indirect use values are the indirect support and protection provided to economic activity and property by the mangrove's natural functions, or regulatory 'environmental' services. For example, the storm protection function of a mangrove system may protect agricultural production, infrastructure, properties, and even human lives. Groundwater recharge might replenish aquifer supplies in the area used for domestic agricultural and industrial purposes in other regions.

4.1.3 Option Value

Option value is a type of use value in that it relates to future use of mangroves. Option value arises because individuals may value the option to be able to use a mangrove some time in the future. Thus there is an additional 'premium' placed on preserving a mangrove system and its resources and functions for future use. Option value may be particularly important if one is uncertain about the future value but believes it may be high, and if current exploitation of the mangrove or its conversion to other uses results in irreversible effects. For example, mangrove resources may be underutilized today but may have a high future value in terms of scientific, educational, commercial and other economic uses. Similarly, the environmental regulatory functions of the mangrove ecosystem may become increasingly important over time as economic activities develop and spread in the region.

Bequest values are a special category of option values. Such values arise from individuals placing a high value on the conservation of mangroves for future generations to use. The motive is the desire to pass something on to one’s descendants. Bequest values may be particularly high among the local populations currently using or inhabiting a mangrove in that they would like to see their way of life and culture that has 'co-evolved' in conjunction with the forest passed on to their heirs and future generations.

Option and bequest value are difficult to assess as their estimation involves some assumptions concerning future incomes and preferences, as well as technological change.

4.1.4 Non-use Values

Non-use values are derived neither from current direct nor indirect use of the mangrove. There are individuals who do not use the mangrove but nevertheless wish to see them preserved 'in their own right'. These 'intrinsic' values are often referred to as existence values. Existence value is derived from the pure pleasure in something's existence, unrelated to whether the person concerned will ever be able to benefit directly or indirectly from it. Existence values are difficult to measure as they involve subjective valuations by individuals unrelated to either their own or other's use, whether current or future. However, several economic studies have shown the 'existence value' of ecosystems constitutes a significant percentage of total economic value.

4.2 Measuring the Economic Value of Mangrove Characteristics

Valuing a mangrove resource essentially means valuing the characteristics of a system (see TEV framework in Table 4.1). The purpose of the economic analysis is to make the total economic value of the mangrove resource explicit (in monetary terms), such that the value of the resource may be incorporated more fully in the economic assessment process. This is necessary for a fair comparison to be made between alternative uses of the mangrove resource. The different valuation techniques that might be employed to value the different characteristics of a mangrove are summarised in Table 4.3.

The direct use values of mangrove resources and services are relatively straightforward to measure, usually involving the market value of production gains. The indirect use value of an environmental function is related to the change in the value of production or consumption of the activity or property that it is protecting or supporting. However, as this contribution is typically not marketed and is only indirectly connected to economic activities, indirect use values are difficult to value. The first step to valuation is deciding whether the service supports economic productivity or is protecting economic activities and property. Where economic production is being supported, the value of these functions can be measured through *changes in productivity* - in other words, the value of productivity gained (or lost) of marketed goods and services as a result of environment improvement (degradation). Where economic activity or property is being protected, the value can be expressed in terms of *preventive expenditures* that would be required if the function were degraded or irrevocably disrupted; the *damage costs avoided* by these functions operating normally; the *costs of replacing* these functions with alternatives; or the *relocation costs* required if these functions were lost (Barbier *et al*. 1991).

Ideally, when analysing the economic benefits of alternative management options, the TEV of the mangrove resource under each option would be assessed and compared. However, valuing *all* the characteristics of the mangrove resource would be time consuming and costly, and in certain cases impossible, given data limitations. Furthermore, valuation of all benefits is usually only necessary under certain circumstances (when it is necessary to determine whether the mangrove should be preserved or to determine its total contribution to the welfare of society). Where the research objective is to determine if an alternative use or conversion of mangrove resources should proceed, partial valuation of a mangrove's net benefits is typically sufficient. That is, valuation of a few key mangrove benefits may be enough to indicate that the loss to society (foregone benefits) of converting or diverting mangrove resources is not economically justifiable.

It is therefore important to identify the key productive uses and ecological function of the mangrove system under study, in order that research efforts may be concentrated on components of high value. Valuation of all significant values may still not be possible, for example where the required physical data are unavailable. In such cases, a detailed qualitative assessment should be provided. Based on the information currently available, an assessment of the importance of the direct and indirect values of the mangroves of Koh Kong is presented in Table 4.2.

Table 4.2. Identification of Key Productive Use Values and Ecological Values

Key Value	Importance		
	High	Medium	Low
Charcoal	X		

Fuelwood	X		
Construction material	X		
Medicine			X
Wildlife		X	
Marine fisheries	X		
Recreation and tourism		X	
Education and scientific value	X		
Water transport		X	
Biodiversity	X		
Groundwater recharge and discharge		?	?
Flood and Flow control		?	
Shoreline stabilization and erosion control	X		
Sediment retention	X		
Nutrient retention	X	X	
Water quality and maintenance		X	
Storm protection	X		
Micro climate stabilization	X		

Table 4.3 Valuation Techniques Commonly used to Value the Different Value Components of a Mangrove Resource

TEV	Valuation Technique
Direct Use Values	
Timber	Market analysis
NTFPs (e.g. fish, nypa, medicine, traditional hunting and gathering)	Market analysis, price of substitutes, indirect substitution approach, indirect opportunity cost approach, value of changes in productivity, barter exchange approachTravel cost method, hedonic prices
Educational, recreational and cultural uses	Hedonic prices, [replacement cost]
Human habitat	

Indirect Use Values Erosion prevention (shoreline) Erosion prevention (riverbanks) Storage and recycling of human waste and pollutants Maintenance of biodiversity Provision of migration habitat Provision of nursery grounds Provision of breeding grounds Nutrient supply Nutrient regeneration Coral reef maintenance and protection	Damage costs avoided Preventive expenditure Value of changes in production [Relocation costs] [Replacement costs]
Option Value	Contingent valuation method
Existence Values	Contingent valuation method

5.0 HOUSEHOLD SURVEY

There are three villages (Koh Sra Lao, Koh Kapik, and Lamdam) and approximately 581 households in Koh Kapik. A survey of 90 households (Koh Kapik village: 36 households; Koh Sra Lao: 36 households; and, Lamdam: 18 households) representing 15% of the total was undertaken in December 1996. The survey was necessary to provide the information needed to quantify the importance of the mangrove area for traditional uses. Information on the three study villages based on the survey results is presented in below.

5.1 Summary of Socio-economic Conditions in Study Area

Population has grown rapidly in the three study villages over the last 15 years, largely as a result of in-migration. Economic factors explain this trend, with migrants attracted by the high potential returns from fishing and charcoal production in what was, prior to the late 80s, an area of low population and resource exploitation. Overall, only 6% of households originate from Koh Kong Province. The remaining population originates from 13 of the 18 provinces in Cambodia. The majority (36%) originate from the other coastal provinces of Kampot and Sihanoukeville, and from Kandal province and Phnom Penh 22% (Diagram 1).

A high percentage (76%) of migrants came to the area during the period 1980-1995. The greatest influx of people was between 1985-90 (37%). Prior to 1980, in-migration was relatively low (3%), and since 1995 it has fallen to 10% (Diagram 2).

By comparison, out-migration is minimal. It is estimated that 2% of the population has moved to other areas in the past 5 years, either to study or to get married. A key reason for the lack of movement out of the area, despite the low living standards now facing the majority of households, is the fact that a lot of people lack the resources to move being heavily in debt.

An estimated 87% of households are dependent on fishing for their livelihood (for 65.5% of households fishing is their only form of income). At the time of survey 6% of households were involved in charcoal production (only in Koh Sra Lao) and 8% were involved in other activities such as trading fish or general products (Diagram 3). As of January 1997 no charcoal kilns were in operation in Koh Sra Lao and it is assumed that ex-charcoal producers will now turn to fishing as their only alternative means of income. This increases to 93% the number of households dependent on fishing.

As many as 90% of households (excluding charcoal producers) claim that it was harder to fish than it was five (5) years before. The main reasons are: more fishermen (40%), loss of mangrove area (31%), water pollution caused by shrimp farms (16%), illegal fishing, and use of modern fishing equipment (16%), and loss of mangroves due to charcoal production (3%). See Diagram 4).

Given the declines in fish yields, interviewees were asked what alternatives existed to fishing and charcoal production. The majority felt that there are no alternatives (66%),15% of households said they would return to their birth village, 10% would farm in upland areas, 3% would collect upland wood, and, 4% would trade (Diagram 5). Those who would return to birth village are typically those who still have land in their birth village and are not in debt. Thus, they can afford to make the move.

Only 15% of households claim not to face any economic problems. The main economic problems faced by other families include: poverty/low standard of living (34%); loss or lack of fishing equipment (28%); declining fish productivity (18%); health problems (10%); food security (9%); illegal check points (8%); and other reasons such as too many children and shortage of water in the dry season (5%). See Diagram 6.

The main environmental problems cited by households include: storms and unstable climate patterns (66%), deforestation (36%), water pollution created by shrimp farms (9%), use of illegal fishing techniques (14%), loss of fish (8%), and catching of wild water birds (1%). See Diagram 7.

Nearly all households interviewed (94%) consider themselves totally dependent on the mangrove forest or for it to be very important to them. Only 2% did not consider mangroves important to their livelihood (Diagram 8).

The vast majority of households (93%) were not supportive of the shrimp farms in the area. The main reason for this were: water pollution caused by the farms leading to the loss of fish (60%); loss of mangroves (9%); restricted access to fishing areas (4%); and the shortage of fresh water (1%). See Diagram 9.

Households were asked to estimate their monthly income. Annual income estimates derived from this information are presented in Table 5.1. The highest incomes were in Lamdam and the lowest incomes in Koh Sra Lao.

Table 5.1. Net Income per Household, Based on Survey Information (US$)

Village	Average Income per hh /per year	Average income fish only	Average income fish plus other activity	Charcoal only	Charcoal plus other activity	Trader (fish or general products) / Creditor
Koh Sra Lao[1]	2,023 (408-14400]	1,296 (408-3840]	1,070 (432-2880]			6,120 (2160-14400]
Koh Sra Lao Charcoal producers[2]	1,800 (960-2880]	n.a	n.a	2,140 (1600-2880]	1,120 (960-1200]	n.a.
Koh Kapik[3]	2,703 (288-14400]	1,832 (288-4800]	3,960 (960-9600]	n.a	n.a	7,987 (1400-14400]
Lamdam	2,811 (480-7200]	2795 (1440-2880]	2,160 (1440-2880]	n.a	n.a	3,520 (480-7200]

Notes:

1 Other employment in addition to fishing in Koh Sra Lao include: soldier, nurse, lottery ticket seller; charcoal kiln worker (employed to collect wood or put charcoal into bags).

2 Other employment undertaken by charcoal producers in Koh Sra Lao include: video seller, repair man, fishing.

3 Other employment in addition to fishing in Koh Kapik include: policeman, seller of general products

4 Other employment in addition to fishing in Lamdam include: carrying wood from sawmill and trading.

Traders/creditors had the highest incomes ranging from US$3,520-7,989. Income from fishing ranged from US$1,296-2,795 per year, and income from charcoal ranged from US$1,120-2,140.

Background information pertaining specifically to the three study villages is discussed in succeeding pages.

5.2 Koh Kapik

The population of Koh Kapik is estimated to be 1,149, consisting of 225 households. The people are mostly ethnic Khmer (with around 10 Thai and Vietnamese families). The nearest markets are Dong Tung (50km away) and Park Klong market (40 km away).

Only 11% of households originate from Koh Kong Province. Other households are from: Kampot (22%); Sihanoukeville (19%); Takeo (14%); Kandal (11%); Phnom Penh (8%); Kompong Speu (6%); Pursat (3%); Kompong Cham (3%); Siem Reap (3%). Most migrants (72%) moved to Koh Kapik between 1980-1995 (pre-1980: 8%; post-1995: 6%).

Based on the survey information, the average income per household per year is US$2,703. Most household (91.5%) depend on fishing as their source of income (80.5% only fish, while 11% fish, run a small shop, or serve as local policeman). Few (8.5%) are involved in the trade of either fish or general goods.

Fish is sold to traders in the village (there are reportedly six traders in the village) and then exported to Thailand. Most fishermen own boats and only a few has to borrow money in order to support their fishing activities.

All interviewees claimed that it was harder to fish now than it was five years ago. The main reasons for this were: increased number of fishermen from within the village and outside such as from Thailand (47%); loss of mangrove forest to shrimp farms and charcoal production (47%); water pollution from shrimp farms (31%); and, the use of illegal equipment and fishing methods (e.g. use of dynamite and poisonous substances) and modern fishing equipment by outsiders (19%).

When questioned about alternative livelihoods to fishing, 64% believed there was no alternative. Others said that they would: farm in upland (11%); return to birth village (19%); trade (3%); and collect wood in the upland (3%).

About 25% of the families claimed to have no problems. The main economic problems facing other families (in order of importance) are: poverty, declining fish productivity, food security, illegal check points, loss and lack of fishing equipment, and too many children.

The main environmental problems are considered to be: storms and unstable rain patterns (72%), deforestation (36%), illegal fishing techniques (19%), water pollution of shrimp farms (17%), loss of fish (8%), and others (6%).

Approximately one-third of all the households see themselves as totally dependent on mangroves, the remaining two-thirds of households consider the mangrove important.

The main products collected from the mangrove area are: fuelwood, snails, and crabs. The village recognised the importance of the mangrove resource as a habitat for crab, fish, and local aquatic animals on which they depend for food.

Wildlife in the area includes lizards, leopard, wild pig, deer, pangolin, porcupine, and hornbill. Wildlife is reportedly not collected by the villagers.

Nearly all interviewees (97%) are unhappy about the shrimp farms (3% did not answer). Construction of a dike apparently restricted the flow of the river from many to one waterway that is filling with silt and restricting the depth of the river. Complaints have been made to the government, but there has been no response. The main problems with shrimp farms include: water pollution leading to loss of fish (64%); loss of mangroves (11%); restricted access to fishing area (8%); and, shortage of fresh water (3%).

5.3 Koh Sra Lao

The population of Koh Sra Lao is estimated to be 1,046 made up of 226 households. The ethnic origin of villagers are Khmer, Thai, and Cham. The nearest local market is Dong Tong, located 40 km from the village.

Originally the village consisted of only 10 households, but it has grown rapidly as a result of in-migration. Only 3% of households are originally from Koh Kong province. The remaining population has migrated from: Kampot (31%), Kandal (17%), Phnom Penh (14%), Prey Veng (11%), Sihanoukeville (6%), Takeo (6%), Svay Reing (3%), Banteay Meancheay (3%), Pursat (3%), Battambang (3%), and Kompong Speu (3%).

For households not involved in charcoal production, 100% of migrants moved to the area between 1980-1995, with the highest influx (50%) in the 1985-1989 period. For charcoal producers, migration to the area did not start until 1985. About 50% of charcoal producers moved to the island after 1995. The majority of charcoal producers (60%) were previously farmers in their home village.

The majority of the people in the village are fishermen. At the time of survey, 84% of households were dependent on fishing for their livelihood (for 66% of households, fishing is their only source of income); 13% were involved in charcoal production and 3% were buying and selling fish or general products. It is assumed that charcoal producers will now turn to fishing as their only alternative source of income following the destruction of their kiln, raising the number dependent on fishing to 97%.

In the past, everyone in the village fished. It is claimed that people in the village turned to charcoal production because of the fall in fish yields (especially in the rainy season). The only alternative to charcoal production in the rainy season is to sell their labour.

An estimated 98% of fishermen borrow money in order to buy fishing equipment. The loan is paid off by supplying the creditor with a certain percentage of the fish catch. Fish is sold to Park Klong market, Mondlesema District, 30km from the village.

A high percentage of households (81%) find it more difficult to fish now than compared to 5 years ago. The main reasons for this are: more fishermen 50%; loss of mangrove due to shrimp farms 27%; water pollution from shrimp farms 8%; loss of mangrove due to charcoal production 4%; and, illegal fishing 8%.

A small number of families (between 4-10) have gardens located in the upland area and grow coconut, banana, cassava, sugarcane, mango, and jackfruit. Cassava is sometimes sold. One household started to cultivate tekke fish in the past year (the viability of this activity is not known). Illegal logging is evident in the upland areas of Koh Sra Lao.

Hemp is illegally grown by local people in Koh Kong Province financed by Thai investors. Some women in Koh Sra Lao are occasionally employed to take the leaves off the plant. Normally 1kg of fruit can be prepared in a day for which they are paid 25Baht. This is not a popular job as payment is so low.

alternatives to fishing or charcoal production: 12% would farm in the upland area; 12% would return to their home village; 4% would trade; and 4% would collect wood in the upland.

Twelve percent of households claim not to face any economic problems. Main economic problems faced by other households include: loss/lack of fishing equipment (62%); poverty/low standard of living (46%); health problems (27%); fall in fish productivity (8%); food security (8%); and water pollution (4%).

The main environmental problems facing the households are: deforestation (54%); storms/unstable climate patterns (43%); water pollution from the shrimp ponds (31%); illegal fishing techniques (15%); harvesting of wild water birds (4%); and, the loss of fish (4%).

Most households consider themselves totally dependent on the mangrove or claim that the mangrove is very important to

them (94%). The main products collected from mangrove areas are: fuelwood; wood for charcoal; horse and stone crab; and, snails (one type of snail is collected for food, a second type of snail is sold to shrimp farms as shrimp feed).

Houses are built from products collected from the mangrove areas, or bought from outside depending on the wealth of the household. Medicine is collected from upland areas, not from the mangrove. Wildlife in upland area includes: tiger, wild pigs, fishing cat (small tiger), water bird, pigs, monkeys, and snakes. There are monkeys in the mangrove area, but they are not harvested by the village. The degree of dependence on upland resources for medicine and food is not clear.

The village understands that activities destroying the mangrove areas will affect their livelihood. They recognised that the mangroves are important for storm protection, as a source of charcoal and fuelwood, and as a habitat for crab (an important food source).

The vast majority of households, 85%, do not support the shrimp farms because the shrimp farms have cleared areas of mangrove forest (while charcoal producers only cut the trees which can then grow back). It is asserted that before the shrimp farms were constructed, the productivity of the mangrove areas was much higher. In particular, effluent discharge is polluting the waters and affecting fish productivity.

5.4 Lamdam

Lamdam village was established in 1984 and consists of approximately 130 households. The villagers are mainly fishermen or traders (the village is used as a fishing port). Before 1984, the area was a military base and families of the soldiers came settled there. There are estimated to be 15 Thai, 15-20 Vietnamese and 3-4 Cham households living in the village. Lamdam hosts a local market supplied with goods bought by traders from Dong Tong and Park Klong markets (2-3 hours by boat; 35-40 mins by speed boat).

Only 6% of households are originally from Koh Kong province. The remainder are from: Kampot (39%); Kandal (11%); Phnom Penh (11%); Kompong Cham (11%); Kompong Speu (11%); Sihanoukeville (6%); and Battambang (6%). Most households (78%) moved to the area between 1980-1995; 17% of households arrived after 1995, possibly attracted by logging activities in nearby upland areas.

A high percentage of households (72%) claims that it is more difficult to fish now compared to five years ago. The main reasons for this are: more fishermen (47%); loss of mangrove area and construction of shrimp farms (44%); water pollution from shrimp farms (31%); use of modern fishing equipment and, illegal fishing (19%).

According to Mr. Cheam Touch it used to be very easy to generate income in the area. Now, with the fall in fish productivity, it is much harder. For example, in 1990 it was possible to catch 10 kg of crab meat. Now, fishermen bring home only 1 kg of live crab (4 kg crab=1 kg meat). Because it is no longer possible to collect crab, villagers have become workers, cutting wood in upland--and sometimes--mangrove areas. The wood is sold for fences, fuelwood, and charcoal.

A typical family is one where the husband fishes in the dry season and works as an employee with a logging company in the rainy season. The wife is a trader. According to the village chief, living standards are still considered to be better in Lamdam than other places in Cambodia and people still come to the village to earn money to send home. Since returns from fishing are said to be insufficient to support families, it can be assumed that high incomes are possible because of involvement in logging activities, some of which are illegal (Box 5.1). Security is a problem in upland areas, although this has improved with the recent defections of the Khmer Rouge to the government.

Most households (67%) believe there is no alternative to fishing. A few (6%) would farm in the uplands, 11% would return to their birth village, and 6% would trade.

The main economic problems facing households are: fall in fish productivity (22%); loss/lack of fishing equipment (17%); illegal check points (11%); health problems (6%); poverty (6%); food security (6%); other (11%) (too many children, not enough fish to eat).

The main environmental problems facing the village are: storms and unstable climate (83%); deforestation (11%); loss of fish (11%); and water pollution from shrimp farms (6%).

There are reportedly no charcoal kiln producers in the village. However, the village would like the charcoal kilns to be legalised and regulated. The number of kilns allowed to operate and the areas where people can collect wood for the kilns should be stipulated.

There are two shrimp farms in Lamdam. The local people are unhappy with the farms, but have no voice on the matter and are unable to do anything about the farms. Virtually all households (94%) are against the farms. The main reasons for this are: pollution leading to fish loss (33%) and the loss of mangroves (6%). The main problem is polluted water discharged from the ponds. Pollution causes crabs to escape to deeper and cleaner waters, making them harder to catch and also results in death of fish and snails.

Box 5.1: Logging Activities in Koh Kong

Both Khmer and Thai logging companies are operating in the upland areas in Koh Kong. The logs are typically sold directly to Thailand. Companies employ 200-300 workers. An estimated 30-40 households from Lamdam village are employed by the logging companies. In addition, more than 100 workers from Lamdam are involved in the collection of sawn timber from nearby Koh Kong island which is under the control of the navy. It is estimated that more than 100 electric saws are in use on the island (one owner may have 2-3 saws). One machine can cut 1-2 m^3 wood per day. Soldiers are paid 10, 000 Baht/month (US$400) per machine. Anyone can cut wood provided they pay the soldiers.

Workers who carry wood from the island can earn 400-1000 Baht per m^3 depending on the distance the wood is carried. A worker can transport on average 2-3 m^3 per day, thereby earning between 800-2000 Baht per day (US$32-$80). Workers operating cutting machines are paid between 500-700 Baht (US$20-28)/$m^3$ (i.e., US$40-$56 per day including food). Trees are reportedly cut indiscriminately, often on steep slopes.

6.0 VALUATION OF MANGROVE GOODS AND SERVICES

6.1 Values Selected for Economic Analysis

The research focused on the economic valuation of non-timber forest products (NTFP) collected by households from the mangrove area. All NTFP collected by households, and considered to be of high importance, have been included in the analysis. These include fuelwood, construction materials, and, crabs, shrimp, fish and snails (Table 4.2). Information on charcoal production is also included. This information highlights the traditional uses of the mangrove area by local communities and the high monetary value of these products.

For the indirect use values of the mangrove resource, where monetary assessment was not possible, a qualitative analysis is presented and results from other studies highlighted.

6.2 Direct Use Values

Mangrove forests in Koh Kong are directly harvested for a number of products. Mangrove wood collected for fuelwood, charcoal production and house construction is widely used by all villagers. While other studies cite the use of non-wood products such as resins, medicines and reed/cane, survey work for this study did not show use of these products to be significant.

6.2.1. Fuelwood

Fuelwood is an important resource collected from the mangrove. It is used locally for cooking and sometimes, small amounts are burned to repel mosquitoes and other insects. Between 55%-66% of households collect fuelwood from mangrove areas near their homes. Fuelwood is readily available, with 80% of household claiming that it is *now* more

difficult to collect fuelwood now than it was compared to five years ago. Types of fuel used by households are presented in Table 6.1.

Table 6.1. Types of Fuel Used by Households

	% HH Collecting Fuelwood	%HH Purchasing Fuelwood	%HH Purchasing Charcoal	%HH Buying Gas	% Post January 1997
Koh Sra Lao	58%	0%	47%	0%	100%
Koh Kapik	55%	0%	39%	19%	81%
Lamdam	66%	6%	22%	6%	94%

Note: Some households buy charcoal and collect fuelwood.
Gas is purchased predominantly by traders.

Tables 6.2-6.4 summarise the use and value of charcoal and gas in the study villages. At the time of survey, significantly higher quantities of fuelwood and charcoal were being used in Koh Sra Lao, presumably because of the demands of the charcoal kilns. Since the market price of fuelwood is unknown, the value of fuelwood has been based on the average expenditure per household on charcoal for each village as the closest available substitute (Table 6.2). The total value of fuelwood, at the time of survey, is estimated at US$42,302 per year.

If charcoal is no longer available, it is assumed that households previously using charcoal will collect fuelwood instead. Using US$96 as the average expenditure per household per year on gas (the closest substitute to fuelwood if charcoal is no longer available), fuelwood can be valued at US$50, 880 per year.

Table 6.2. Summary of Charcoal Value and Use (US$)

Village	Average quantity Kg /HH/year	Average cost[1] HH/year	Source
Koh Sra Lao	3051	244	Charcoal producer
Koh Kapik	594	47.52	Charcoal producer
Lamdam	640	51.20	Charcoal producer

Note: Based on a price of 2 Baht/kg

Table 6.3. Summary of Gas Value and Use

	Average Number of Tanks Purchased/HH/ Year	Cost Per Tank/ Baht	Average Cost Per HH/Year / US$	Source
Koh Sra Lao	0	-	-	-
Koh Kapik	16	200	128	-

Lamdam	8	200	64	Imported from Thailand and bought in Park Klong market

Table 6.4. Summary of Fuelwood Use and Value

Village	Average quantity collected kg/ HH/yr	% of HH who collect fuelwood	Average Petrol Costs/Year /US$	Average net value to HH/ Year /US$	Average net value to village/Year /US$[no. of HH * average net value /HH/Year]
Koh Sra Lao[1]	21,019 [400-72000]	58%	10.29 [0-33]	244	131*244 = 31964
Koh Kapik	3488 [900-7,200]	55%	12 [0-17.28]	48	124*48 = 5952
Lamdam	9668 [900-18000]	66%	13.50 [11.52-14.40]	51	86*51 = 4386

Note: Quantity collected is considerably higher in Koh Sra Lao. It is assumed that this is because at the time of survey, fuelwood was being collected for charcoal kiln production as well as domestic use.

Table 6.5. Use and Value of Fuelwood Assuming Charcoal Is Unavailable

Village	% of HH collecting fuelwood	Value per village per year @US$96 per household[1]
Koh Sra Lao	100%	226*96 = 216, 96
Koh Kapik	81%	182* 96 = 17, 472
Lamdam	94%	122* 96 = 11, 712

Note : Based on the average cost of purchasing gas per year, as the next closest substitute.

6.2.2 Charcoal

The History of Charcoal Production In Koh Kong

Mangrove species are well suited for charcoal production, their wood being dense and hard, with high calorific value and producing little smoke on burning. Mangrove species such as *Rhizophora apiculata* and *Rhizophora mucronata* are especially valued.

Traditionally, charcoal was produced in Koh Kong on a small scale for domestic purposes with limited impact on the mangrove resource. Since 1979 however, entrepreneurs from Thailand, Singapore, and Malaysia, begun buying charcoal and this led to the creation of a thriving charcoal market in Park Klong Commune and in Koh Kong Provincial town.

In 1992, there were more than 300 charcoal kilns producing over 24,000 tons of charcoal-- 94% of which was exported to Thailand. Around 100,000 tons of mangrove wood is needed to produce this amount of charcoal (Chea Peng Chheang 1994). In 1994, 200 kilns with diameters between 8-10m were destroyed by the Anti-charcoal Kiln Committee set up by the local authorities to control illegal charcoal activities. The committee was active for only a short while during this period due to a lack of resources, and, as a consequence, failed to stem charcoal production in the area. In time, the number of kilns using smaller diameter of 3-5m increased and operated deeper inside the forest to avoid detection.

Despite the fact that the export of charcoal has been made illegal since mid-1994, the number of kilns continued to increase--even in Peam Krasaop Wildlife Sanctuary. According to one commune chief, the number of kilns had reached almost 1,000 by November 1994. The total number of kilns located in Koh Kapik is unknown, although there were estimated to be 30 kilns operating in Koh Sra Lao village. Charcoal production in Koh Kong has destroyed large areas of mangrove forest, resulting in loss of species diversity, sedimentation, and erosion.

Concerns over the effects of charcoal production on the mangrove resource, led to a second attempt by the charcoal kiln committee in July 1996 to stop charcoal production. By January 1997, the Committee had demolished virtually all of the charcoal kilns in the area and was in the process of closing the few remaining (*pers. com.* Pall San).

Following the closure of the charcoal kilns, the Government intends to fully regenerate the mangrove forest and then to regulate and legalise the charcoal industry. It is recognised that local people need to produce charcoal because they cannot afford to buy fuel.

However, the level of charcoal production that would be sustainable for the area is as yet unclear, and needs to be considered in any future management plan.

Local People, Charcoal Production, and the Issue of Resettlement

Many households in Koh Kong have become dependent on charcoal production. Most claim to have turned to charcoal production because fish catch is no longer sufficient for survival. The fact that charcoal production increases in the rainy season when it is difficult for people to fish would appear to support this linkage affect. The only other option in the rainy season when it is not possible to fish is to collect snails but the returns from this are low. Some families do nothing at this time.

As yet, no viable livelihood alternatives to fishing have been identified in the area and the majority of people are very poor. The possibilities appear limited as there is no land available for crop cultivation. One possible solution, promoted by the provincial government, is to relocate people living in environmentally sensitive areas (such as the proposed Ramsar site) to a new village located in the upland area where they can cultivate crops as well as fish.

In support of relocation is the fact that most people (around 94%) have migrated from other provinces since 1985 to villages located in areas with limited carrying capacity and therefore inappropriate for extensive human settlement (often within protected areas). A problem is that the Government does not have money to support such a transition. The issue of relocation is discussed in more detail in Section 9.

More than 30 households had their kilns destroyed in Koh Sra Lao village. Discussions with the chief of Koh Sra Lao and ex-charcoal producers were conducted after the charcoal kiln campaign (January 1997). According to the village chief, some ex-charcoal producers have returned to their birth village following the destruction of their kilns. However, the majority have no money and cannot leave. Some have borrowed more money to buy a boat and engine for fishing. Some

women are being hired to extract crabmeat from horse crab, for which they are paid 10 Baht/kg. If there is a lot of crab they can extract 3-4 kg per day, 6 months a year. Women may also prepare bamboo traps for catching stone crab in the rainy season. Bamboo is bought from people who have bamboo on their land (60 Baht a stand). From this 7-10 traps can be made which are sold to fishermen or alternatively traded for a percentage of the catch.

The general feeling of people in Koh Sra Lao village is that if they had enough money they would prefer to move back to their birth village rather than start somewhere new. However, if the government prepared a new village for them, they would move.

According to the village chief, people in Koh Sra Lao are not upset because they know the effect of charcoal production on the mangroves. Fishers are very happy with the decision. The big problem is said to be debt with an estimated 50% of charcoal producers owing between 4,000-20,000 Baht (US$160-800).

An ex-charcoal producer from Kompong Cham who moved to Koh Sra Lao in 1993 stated that she would like to return home but has no money. She would move to another village if the Governor prepared land for her. She believes that most people in the village feel the same way. She was offered no compensation after her kiln was destroyed. The family will now trap stone crab, there being no other alternative. The household knows that charcoal production is illegal, but would prefer to be allowed to produce charcoal because catching crab is difficult and traps are often stolen.

Economic Analysis of Charcoal Production

An economic analysis of charcoal production was undertaken as part of this project to provide information on what level of charcoal production might be sustainable for the area. Ten charcoal producers were surveyed in December 1996. On the average, kilns were found to produce 28 habs (1,680kg) of charcoal per month.

The duration of burning depends on the size and location of the kiln. For example, if the kiln is close to water, it may become damp at high tide and take time longer to burn. A small kiln in a good location may take 15 days to burn while a big kiln, 30 days. Smaller kilns therefore have a quicker turn overrate. After burning the kiln cools for 7-10 days depending on the size. The production cycle (i.e. wood collection, loading of the kiln, burning and cooling) ranges between 21-40 days (assuming that wood is collected during the burning/cooling period). A production cycle of one month was used in the analysis.

Due to high demand and high prices charcoal production was a lucrative practice in the past. Since 1991 (when charcoal prices became available), prices rose steadily from approximately 60 Baht/hab to a high in late 1995 of 270 Baht/hab following the charcoal ban. Prices plummeted for a period in 1994 to 140 Baht, presumably due to the dumping of illegal products on the market to avoid persecution at a time when monitoring was high (Smith 1996).

A lower price of 120 Baht/hab is used in calculations as the average farm gate price quoted by charcoal producers. Sellers in Park Klong market buy from traders or middlemen for 192 b/hab, and sell for 240b/hab. Prices appear to be lower in Dong Tong Market. Charcoal is bought from producers for 132b/hab and sold for 180b/hab. The reason for this difference is not clear. Bad quality charcoal is bought for 60-90 Baht/hab and sold for 90-120Bath/kg.

Benefits to Households

Based on survey results, households can earn US$927 a year from charcoal production. If the costs of kiln construction are taken into account (assuming that the life-time of the kiln is 3 years), net profits are US$868 per year (Table 6.6).

Similar calculations performed for the individual kilns reveal net incomes per kiln of US$71-1, 614 (taking into account kiln construction costs, but not debt). However, according to survey results, 60% of households borrow money. A typical arrangement is for half of the returns from the sale of charcoal to go to the creditor. In such cases, the average gross returns to family per year is US$464. An alternative arrangement is for the debtor to sell all charcoal to a creditor at a preferential price and to be bound to buy all goods from him at an inflated rate.

Table 6.6. Net Benefits Per Kiln Per Year (US$)

	Prod kg/yr[1]	Returns @ 0.08/ kg	Cons cost/3 years	Hired Labour costs[3]	Net Ben (B-C-D)	Net Ben (B-D)	Debt
Average [min/max]	20,160 [10,800-21,600]	1,612 [864 - 1,728]	104 [53-200]	640 [0-740]	868	927	266 [160-400]

Notes:
1 1 hab = 60 kg
2 Construction cost per kiln range from US$159 -600. The average life of a kiln is 3 years.
3 Between 0-2 workers are hired per kiln (with an average of one worker per kiln). The average salary is 1,100 Baht/month, ranging from 500-2000 Baht/month. Family labour is considerable averaging 11.5 man-months per kiln per year. At an average salary of 11,00 Baht, the opportunity cost of family labour could be estimated at US$505. This has not been included in the calculations on the bases that employment opportunities in the area are limited and therefore the opportunity cost of labour low.

Approximately 60% of households claim to sell all charcoal produced (left over charcoal ash is sometimes use domestically). Other households use on average 52kg of charcoal a month or 628 kg a year for domestic purposes. This reduces their net income by 1,256Baht (US$50.24)

Net returns from charcoal production can therefore be taken to range from US$868-$413.76 per year. The maximum amount represents returns to a family who is not in debt and sells all charcoal produced while the minimum, is the returns to a family in debt and who uses charcoal domestically.

These estimates are lower than those presented in previous studies. This is due to the fact that other estimates represent gross values (i.e. no account is taken of costs) and are based on higher prices for charcoal.

Benefits to Traders and Creditors

Around 30% of the households sell charcoal to creditors, 30% to Thai traders, and 40% to local traders. Charcoal is exported to other Cambodian provinces and to Thailand. Demand is high locally, nationally, and regionally due to its competitive price.

Assuming a trader or creditor buys all the charcoal produced by a single kiln in a year (20,160 kg/year) at US$0.08/kg (selling price reported by charcoal producers) and sells to the market for US$0.128 (market price), then, he will be making a profit of US$959 per year per kiln. This analysis suggests that the only people really earning money from charcoal production are the larger producers who have not borrowed money to produce, and the traders, and creditors. Smaller producers who borrow money to set themselves up, and hence are tied to their creditors who control the production and sale of the product, often remain trapped in debt.

Value of Charcoal Produced in Study Area Pre-January 1997

Charcoal can be valued 80,640 Baht (US$3,226) assuming that a typical kiln produces 336 habs and given a market price of 240 Baht/hab. With an average cost of US$744 (hired labour costs plus construction costs) per kiln operator, the net benefit is estimated as US$ 2,482. The estimated number of kiln operators in Koh Sra Lao in 1996 is 30, thereby generating a total net benefit from the area of US$74, 460 per year.

Quantity of Wood Required to Produce Charcoal

Charcoal producers were questioned on their wood collection practices. While the results should be used with caution as quite a large range in survey responses is evident, they do give some indication of the amount of mangrove wood required per kiln. The information is summarised in Table 6.7.

Table 6.7 Estimates of the Quantity of Mangrove Wood Used for Charcoal Production

	Average	Comment
Number of boats of wood collected / year	76	Number of boats ranges from 40-120.
Number of kg of wood per boat	1,343	Number of kg of wood per boat ranges from 600-4000
Kg of wood used / year	**121, 467**	**Average number of boats multiplied by average kg of wood per boat**
Average number of trees per boat	3.5	Range 1-15
Average number of trees collected per year	266 - 538	266 Based on average number of boats multiplied by average number of trees per boat. (Range per survey result 220-823 with an average of 538)
Weight of tree / kg	418	Range 75-1000 (weighted average used)
Kg of wood used / year	**111188-22484**	**Average weight of tree multiplied by number of trees collected per year**

Producers were also questioned on the quantity of wood required for one kiln. Based on survey responses, an average 3.6 kg of mangrove wood is needed to produce 1kg of charcoal. This is close to the Chea Peng Chheang estimate in 1995 of 4:1. Assuming that the ratio of mangrove wood to charcoal is 3.6:1, and the average production per year is 20,160, the average quantity of mangrove wood used per year is 72,576. The two estimates of the quantity of wood used per year presented above, while quite similar, are higher than the estimates based on the quantity of wood needed per kiln. They suggest that the ratio of mangrove wood to charcoal is around 6:1.

Forest Inventory

A rapid forest inventory was undertaken in December 1996, in order to provide rough estimates of the number of trees in a hectare of mangrove forest. The results are presented in Table 6.8

Table 6.8 Estimated Number of Trees in One Hectare of Mangrove Forest

	No. of trees diameter 0.15-0.20	No. of trees from 0.1m	Total	Hectares required per kiln	Comment

		diameter			
Long time disturbed area, close to Koh Sra Lao	304	368	672	0.34	Selective cutting Some old trees
Regeneration area (In front of check point)			1088	0.20	Clear cut area Natural regeneration
Undisturbed mangrove forest (Koh Kapik)	368	192	560	0.40	Less trees because big old trees dominate

Notes: A 25m*25m area was covered for each category. Trees bigger than 0.1 were included in the count

Assuming that 400 kilns were operating in Koh Kong up to December 1996, and that each kiln uses an average of 266 trees per year, a total of 106,400 trees would have been required per year. The mangrove area used by these kilns is estimated to be between 98-190 hectares.

With 30 kilns operating in Koh Sra Lao, an estimated 7,980 trees were used per year, affecting 7.33-14.25 hectares of mangrove. The area of mangrove forest required per kiln per year can be estimated to be between 0.20 -0.40 hectare.

Assuming a 30-year cutting cycle, and that only the disturbed areas would be allocated for charcoal production, the potential returns per hectare per year for sustainably managed charcoal production can be estimated at US$243-413.5[19].

Table 6.9 summarises the key data available on the charcoal industry in Koh Kong.

able 6.9. Key Data Relating to Charcoal Production in Koh Kong

Parameter	Before March, 1994	After June, 1995	Per survey December 1996
Type of kiln	Large mosque shape (5-6 m diameter, 3-4 m height)	Small; mosque shape (2 -2.5m diameter, 1.5-2m height)	Small mosque shape (on average 2.4m diameter, 2.4 m height)
Location	Non-flooded upland	on flooded area	on flooded area
Construction material	Brick and clay mud	Fiber clay (straw and clay)	Bricks, clay and straw
Number of kilns	132	400	400
Number of locations	22	> 100	
Ownership	40	Unidentified but > 40	Typically one hh operates one kiln

Average number of workers	4-7 persons (displaced)/kiln	1-2 persons (displaced)/kiln	1-3 workers/kiln
Construction cost	US$ 400 / kiln	Labour cost only	US$ 160-600 / kiln(average US$312)
Life cycle of kiln	2-3 years	1 year	3 years
Owner responsibility	Investment, labour food, safety	self labour, family labour	Sometimes investmentlabour
Labour responsibility	cutting tree, incineration	Selling to contacted middleman	Cutting trees, incineration, selling charcoal
Time spent cutting trees	1 month	1 week	12 days/month
Time spent for incineration	2 months	2 weeks	15 days
Size of targeted trees	10 meters height	Any	Any
Size of stake to be incinerated	(0.2 * 1.5 m) size; peeled	(0.1 or less * 1m) size; peeled	
Number of stakes input	600	100-200	
Output	1.5 - 2 tons/kiln/ time	0.3 - 0.5 tons/ kiln/time	Average 1.6 tons/kiln/ time[0.9-1.8]
Farm gate price	US$ 0.04 kg	US$0.03 - 0.04 / kg	US$0.02
Export market price	US$ 0.05 - 0.07/kg	US$ 0.05 - 0.07 / kg	US$0.03-0.04

Source: Original Table ADB, May 1996, with additional data from this study.

6.2.3 House Construction

Mangrove wood is often used for building houses, boats, and fences. The species *Rhizophora macronata* is ideal for making fences, beams for houses, and foundation pilings. The leaves of Nypa fruticans are used as shingles on the roofs of houses (MOE/IDRC 1995). All households within the three study villages use mangrove wood in combination with upland wood for building houses. Roofs are typically made of corrugated iron or seagrass (leaves). Upland wood is either collected from upland areas or bought from the sawmills, mangrove wood is collected from the forest. The proportion of upland to mangrove wood used per house is unknown. Information on the cost of building and repairing houses is presented in Table 6.10. These figures are based on expenditures in house construction as expressed by households. It is not clear what proportion of this cost can be attributed to labour and what proportion can be attributed to the purchase of materials. It is also not clear why house construction is higher in Koh Kapik relative to the other study villages. Houses typically last 3 years and are repaired once a year. In Lamdam, households have to repair house stilts every year because salt destroys the wood.

Table 6.10 Cost of House Construction and Repair

Village	Average construction time/days	Average Construction Cost/hh per 3 year period	Construction Cost per village/ year	Average Repair Cost/hh /year	Repair Cost per village /year
Koh Sra Lao	27	557	125,882	47.50	10,735
Koh Kapik	25	954.82	214,834	71.25	16,031
Lamdam	113	511	51,100	37.20	4, 836

6.2.4 Marine Fisheries

Mangrove ecosystems are an important support to in-shore and off-shore fisheries. They provide nurseries and shelters for important marine stock, while decomposed litter-fall supplies a considerable amount of nutrients that can be used directly by fish and other aquatic species. Detritus matter is exported to nearby sea-grass beds, coral reefs and other coastal communities.

The value of mangrove forest as a food source as well as shelter and nursery for both culture and capture fisheries along coastal areas of Koh Kong is not well understood but is considered to be high. This mangrove function is especially important to local communities given that over 80% of the Koh Kong population are fishermen.

Local Fishing Fishing is the main source of income for the majority of coastal families. Local fishing tends to occur near the shore since boats are typically 5Hp and local people cannot afford the equipment needed to fish off-shore.

Species caught and fishing techniques in the three study villages vary according to the season, location, and equipment available. Proximity to fishing grounds appears to be a key factor (there are no boundaries regarding where people can fish). In Koh Kapik, 80% of households collect shrimp as the village is close to the Big Gulf. Only 8% of households collect crab. In Koh Sra Lao (which is close to the mangrove), 70% of households catch crab, and only 3% catch shrimp. Proximity to the mangrove resource is also one explanation why charcoal is produced in Koh Sra Lao and not in Koh Kapik. In Lamdam people mainly catch crab. Few households (6%-14%) catch fish as the price is low. Fish caught is often used for domestic consumption. It is also used as bait.

Shrimp fishing is more expensive, requiring a big engine boat and fishing net in order to fish in the Big Gulf. However, income from shrimp is higher than that from crab, hence living conditions are generally better in Koh Kapik than in Koh Sra Lao. The fact that no one produces charcoal in Koh Kapik may reflect the linkages between low income levels and charcoal exploitation, but location would be another factor. Big shrimp are caught in the rainy season and small shrimp in the dry season. Typically fewer days are fished during the rainy season, but the price of big shrimp is much higher.

It is often not possible to fish in June and July due to storms (also when there is a lot of rain the water is shallow and yields are low). When not fishing, time is spent repairing fishing equipment (this is usually the responsibility of the wife). According to fishers in Koh Kapik, households only used to fish in the rainy season and had enough to eat. Now this is impossible because of declining yields caused by the big boats from Thailand and the use of modern equipment.

Stone crab can be caught all year round, but are typically only caught in the rainy season when it is not possible to catch horse crab (the income from stone crab is low). It is reportedly not possible to catch crab using a net any more because of overfishing and the increased use of traps. Horse crab is collected on average for 6 months of the year, 21 days per month, while stone crab is collected between 5-9 months a year.

A lot of families collect snails during the rainy season when the weather is too bad to collect crabs and income levels are low. Snails are typically collected for 20 days a month, 3 months a year, and sold for 18-20Baht/kg. One person can collect around 3 kg per day. Snails are used domestically, sold in the village or exported to Thailand where they can be sold for a high price. They are usually collected by young boys with good eyesight and agility.

Push nets, while illegal, are commonly used. Officials at the Fisheries Department are aware of illegal fishing activities but do not have the resources to monitor and control such activities.

Economic Analysis of Fishing Activities *Expenditure on Fishing Equipment* Information collected from Koh Sra Lao on expenditure on fishing equipment is discussed below and summarized in Table 6.11.

Nets and Traps. Crabs are caught using nets and traps. On the average. three nets are used each season as the crabs destroy the nets. One net costs 3,000 Baht, so expenditure on nets per year is 9,000Baht (US$360). The string around the net costs 500 Baht and lasts for three seasons. Fish caught in the nets are either sold or used as bait as they are of poor quality.

Traps are used to catch stone crab and are normally made of metal. Two hundred traps cost 3,000-3,500 Baht (US$120-$140) using family labour, or 20 Baht each if someone is hired to make the traps. A trap will normally last one season. Bamboo traps are sometimes used to catch stone crab but are are not popular as they are often destroyed by monkeys.

Bait. Bait is bought from fishers using nets and costs 5-7 Baht/kg. The use of fishing nets is illegal. However, it is argued that if nets were not used there would be no bait--without bait it would not be possible to catch crab. Around 10 households in Koh Sra Lao catch fish, but this activity is not popular because prices are low.

Bait is put in traps to collect stone crabs. An average of 7-15 kg of baits are used per trip. Assuming that horse crab is typically collected 92 days a year, the average cost of bait per household per year is estimated at 6,072 Baht or US$243 (11 kg per day * 92 days * 6 Baht per kg).

Fishing Boats. Most people buy boats; only few households build their own boat. Boat prices depend on the size of the boat and the engine. Most boats have a 5HP engine (approximately 10% of boats have an 8HP engine).
A new boat with a 5HP engine (length 8-9m; width 1.2-1.5m; height 0.6-0.5m) for fishing crab or shrimp (but not in the big sea) costs between US$620-720. A second-hand boat without an engine costs around US$280. Total expenditure on net, trap and bait per year amounts to US$740.

Table 6.11. Summary of Expenditure on Fishing Equipment (US$)

Product	Cost	
Boat	620-720	
Net	367/year	Horsecrab
Trap	120-140/year	Stonecrab
Bait	243/year	Used with traps

A summary of the fishing practices for the three study villages is presented in Tables 6.12-6.19. Estimates of the returns to households net of the cost of fishing equipment and petrol are derived for each species (the cost of fishing boats is not included). Strictly speaking, these estimates overstate the net benefits to households. The opportunity cost of time spent fishing is not accounted for on the assumption that this is close to zero in the study area, given that there are limited

employment alternatives in the place. No data were available on the quantity of fish used for domestic consumption.

Table 6.12. Koh Sra Lao: Summary of Benefits from Fishing per Species
Table 6.14. Lamdam: Summary of Benefits from Fishing per Species

Table 6.15. Horsecrab: Collection Practices

	Ave. no. months collect / year	Ave. no of days / month	Ave. no days / year	Ave. quantity kg/day	Ave. travel time hrs/day	Ave. collection time hrs/day	Ave. cost of petrol/ trip
Koh Sra Lao	6 [5-6]	21 [17-5]	126	2.7 [2-3.5]	2.4 [0.5-4]	9.8 [2-24]	50.41 [20-97.5]
Koh Kapik	6	22	132	5	1.25	5	54
Lamdam	5 [2-6]	21 [15-25]	105	4.5 [2.5-6]	1.6 [1-2]	5 [2-8.5]	48 [22-75]

Table 6.16. Stone Crab: Collection Practices

	Ave. no of months collect/year	Ave. no of days collect month	Ave. no of days / year	Ave. quan. collect kg/day	Ave. travel time	Ave. collection time hrs/day	Ave. litres of petrol /trip
Koh Sra Lao	5 [3-6]	18.5 [15-24]	92.5	3.5 [2-5]	3.25 [3-4]	5.5 [2-9]	52 [39-70]
Koh Kapik	9 [3-12]	13 [10-15]	117	2.2 [1.5-2.6]	1	3 [4.5-45mins]	54
Lamdam	5.6 [2-12]	16.25 [10-25]	91	4.4 [2-7.5]	2 [1-5]	5 [2-8.5]	70

Table 6.17. Shrimp: Collection Practices

	Ave. no of months collect / year	Ave. no of days collect month	Ave. no days collect / year	Ave. quan. collect kg /day	Ave. travel time hrs/day	Ave. collection time hrs/day	Ave. litres of petrol/day
Koh Sra Lao	3				3	12	45
Koh Kapik	9 [3-12]	12	108		3.3 hrs	10.6 hrs	

Lamdam	6	7	42	5		10 [incls travel time]	

Table 6.18. Fish: Collection Practices

	Ave. no of months collect / year	Ave. no of days collect month	Ave. quan. collect / day / kg	Ave. travel time/trip	Ave. collection time/trip	Ave. litres of petrol/trip
Koh Sra Lao	12	3	5	1	4.5	41
Koh Kapik						
Lamdam	12	10	25		12 hrs [incl travel]	15

Table 6.19. Areas Fished

	Shrimp	Horsecrab	Stonecrab
Koh Kapik	Big Gulf Small Bay Chroy Brose Ao Vao Cham Kadong Koh Kong Krong Andong Touek Phnom Krong	Big Gulf Near House	Big Gulf Near House
Koh Sra Lao	Koh Kong Krad Chroy Brose Big Gulf A la Lean Patas Bay	Near House A la Lean Patas Bay Big Gulf Preak Scach Barang Island Chroy Brose Tareach Island Kabong Island Sang Tinoing Island Koh Kray	Big Gulf Barang Island
Lamdam	Big Gulf	Ta Ek Big Gulf An Dong Teuk Ao Vao Chroy Brose	Ta Ek Big Gulf Ao Vao Phea Mart

		Phum Thev Koh Sra Lao In front of Lamdam Small Gulf	

Net benefits from fishing per village and per household are summarised in Table 6.20. The net average benefits per household are considerably lower than gross income estimates presented in Table 5.1. Net benefits per species are presented in Table 6.21.

Table 6.20. Net Benefits per Village, per Year (US$)

	Koh Kapik	Koh Sra Lao	Lamdam
Net benefits per village	309, 239	121, 472	56, 695
Average net benefits per HH	1, 373	537	436
Average gross income per household survey	1, 832	1, 296	2, 795

Table 6.21. Net Value per Product (US$)

Product	Net Value (selling price for fishers)	Net Value (market price)
Shrimp	535, 015	756, 007
Horsecrab	198, 477	198, 478
Stonecrab	47, 065	47, 065
Snails	2, 034 (gross benefit)	4, 406 (gross benefit)
Total	487, 406	1,005,956

Fishing Debt

According to the village chief of Koh Sra Lao, 93% of fishers have debts ranging from US$400-$2,000. This is lower than the estimates reported in Table 6.22 that are based on the household survey information. Some people are said to succeed in reducing their debt, others do not. A big problem is that fishing equipment is frequently stolen, so the debt is always increasing, no matter how hard fishers work.

Creditors typically do not charge interest on monies lent but buy fish from their debtors at low prices. Debtors are required to buy all fishing equipment, and sometimes household goods from them at inflated prices. For example, a new 5 HP engine costing US$260 would be sold by a creditor for US$300-$320, a US$640 boat would typically cost US$720, and nets are 200b (US$8) more expensive if purchased from a creditor. Creditors are reportedly reluctant to provide credit now because of low fishing yields and as a consequence the long payback periods.

Table 6.22 Amount Borrowed

	% of HH who borrow	Average amount borrowed
Koh Sra Lao	35%	14,286 Baht [US$571]
Koh Kapik	55%	13,492 Baht [US$540]
Lamdam	27%	4,360 Baht [US$174]

Box 6.1 Mussel Cultivation

Approximately 10 families (12.5% of the total) cultivate mussels in Koakan village. The shallow waters near the village make it a suitable location for planting sticks for mussel cultivation. Other households are involved in fishing, shrimp farming and prior to December 1996 charcoal production.

Mussels are sold to nearby shrimp farms for feed, although some shrimp farms have stopped buying mussels because of doubts concerning the quality of the mussels. The price of mussels is 2 Baht /kg.

Mussels need salty water, so if there is a lot of rain, production is often poor. Production is therefore uncertain due to unpredictable rain patterns. The largest producer in the village earned US$3,600 (45,000kg) and US$2,800 (35,000kg) the past two years. In addition, 4-5,000 kg per year were used for domestic consumption.

The biggest producer has planted 7000 sticks this year. Other families have planted between 1-5, 000. Production costs are high. One stick costs 5 Baht and is bought from the upland area. Five people were hired for 7 days to plant 7, 000 sticks at 100 Baht per person (US$20 total). When mussels are harvested, five people are hired for two months and are paid 2-300 Baht per ton.The viability of mussel cultivation at other locations in the area is unclear.

Commercial Fishing

Information about Cambodia's marine fisheries is limited. Available records cover fishing boats, total annual commercial capture by province, species composition by seven broad categories and commercial capture by type of fishing gear. Data do not clearly distinguish between in-shore and off-shore fisheries.

Number and size of fishing vessels. Annual reports of the number and size of licensed Cambodian fishing vessels have been compiled since 1983. The total number of licensed vessels ranged from a low 2,843 in 1983 and 3,675 in 1990 to a high 6,173 in 1994 and 6,087 in 1988. However, the reports include only licensed vessels and it is well known that unlicensed vessels are fishing in Cambodian waters (both inshore and offshore). The number of unlicensed vessels is either not known or not reported. The reports also show huge unexplained fluctuations from year to year in the number of vessels registered in different categories of vessel size and motor size. There are no data on the location or intensity of use of these boats or their gear, but it is fairly clear that most of the vessels are not capable of operating beyond the inshore area.

Annual commercial catch. Annual reports of total commercial inshore marine capture in coastal zone provinces have

been compiled since 1980, and the distribution of this capture among seven categories of seafood has been compiled since 1990.

Total landings can be seen to have ranged from a low value of 814 tons in 1981 and 1,200 tons in 1980 to a high value of 39,900 tons in 1990 and 36,400 in 1991. The reports suggest that the increased landings in 1990s are mostly attributable to Koh Kong Province.

The accuracy and completeness of the figures are unclear, and the quantity of fish being captured in Cambodian waters and landed in foreign ports is not known.

There are no time series, species-specific, and site-specific data that define existing conditions and trends in the stocks and habitats of commercial marine species (some limited data are available on the distribution and relative densities of squid, cuttlefish, and shrimp).

Commercial capture by type of fishing gear. Marine fish production data collected by the Department of Fisheries are not systematically recorded. There are no data related to catch per unit of effort that makes it difficult to identify trends of specific fisheries resources and the impact of specific harvesting and management practices. Table 6.23 classifies catch per unit of effort based on existing data.

The ADB report concludes that based on anecdotal evidence from field investigations, the catch of about 3,000 boats and small gill-netters may not be included in the recent statistical data. Inclusion of these data could double recent shrimp and crab catches by about 3,000 tons and 2,000 tons respectively, and adds about 5,000 tons to the total annual commercial marine catch.

Table 6.23. Catch Effort by Gear Type, 1994 (tons)

Type of Gear	Koh Kong	Kampong Som	Kampot
Mackerel purse seine	1,200	4, 500	
Anchovy purse seine	850	200	
Shrimp trawl	1,100 + 4, 845 trashfish	200 + 1, 000 trashfish	150 + 1, 430 trashfish + 132 seacucumber
Shrimp gill net	1,295	500	379
Fish gill net	2, 000	500	1,507
Crab trap	212	150	1,031
Squid trap	487	120	-
Fish stake trap	200		-
Hook-and line	300	300	30
Push net	626	500	1,838 + 350 cuttlefish
Shellfish collector	135	7	873

Beach seine net	50	100	100 + 68 cuttlefish
Crab gill net	400	350	500+ 89 lobster

Source: ADB. May 1996

Off-shore fisheries

Reliable records of fisheries activities in the offshore areas of the EEZ are unavailable in Cambodia. General impressions of this sector are that there seems to be little fishing activity by Cambodian vessels in off-shore areas because Cambodian vessels are not equipped to stay at sea overnight and cannot reach these areas in a one-day round trip. Therefore, from the Cambodian perspective, these areas are unexploited. Oil company employees and others familiar with these waters are of the impression that foreign fishing vessels operate freely in these areas, including the undisputed area that is claimed only by Cambodia.

Prior to 1990, Cambodian waters were believed to have been exploited much less intensively than other parts of the Gulf of Thailand. The latter are dramatically overfished following the mechanisation of the Thai fleet in the 1960s.

6.2.5 Medicine

Coastal people have traditionally used various resources extracted from mangroves for medicinal and other purposes. Previous studies in Koh Kong cite the use of the species *Exciecaria agallocha* as an anti-diarrhoea treatment, and a fungus called Sam Bok Sramoch ('Home of Ant'), which is dried and used as a medicine for lung disease (IDRC/MOE 1995). However, the use of traditional medicine from mangrove areas was not evident from the survey results.

6.2.6 Wildlife Resources

Wildlife resources that are hunted (e.g. for meat, skins, fur), or gathered (e.g., honey from bees, tortoise, birds eggs) will either have a commercial or subsistence value. Detailed information on wildlife in Koh Kong's mangrove areas is yet to be collected.

6.2.7 Recreation and Ecotourism

The mangroves of Koh Kong have ecotourism potential, but this is unlikely to be developed on a significant scale in the near future. A specialised tourism attraction that might be developed is bird watching as the area is important for migratorybirds.

6.2.8 Education and Scientific Research

There has been no scientific research undertaken at the site, although the area could potentially be used to test different management strategies for the utilization of Melaleuca forest. The education and scientific research value of the study site is therefore considered to be high.

6.2.9 Water Transport

Villages in Koh Kong are situated near channels, along rivers, or on islands near and inside the mangrove forest areas. Travel is mostly by boat. The waterways within the mangrove boundary are therefore important conduits for goods and public transport. The lack of an alternative transport system suggests that the value of mangrove transport is high.

6.2.10 Other values

Nypa fruticans are valuable for many purposes. In addition to house construction, nypa leaves are used to make crab traps and as a cover for Num Chak (a local cake) or Num An Sam (a traditional cake commonly eaten during Khmer New Year). Mats are also made from nypa palms. In the past, mangrove barks from *Rhizophora spp*and *Ceriops spp* were used in tannin production for dying of fishing nets. This practice has been replaced by nylon fishing nets (IDRC/ MOE 1995).

6.3 Indirect Use Values

A qualitative discussion of the indirect use value of mangroves in Koh Kong is presented below. Due to data constraints, it was not possible to place a monetary estimate on these functions within the time frame of this study. However, many of these functions are believed to be of significant value in Koh Kong, and will be lost if the mangroves are not conserved.

6.3.1 Biodiversity Benefits

Biodiversity refers to the different types of biological diversity - species, habitats, or traits - which exist in any given system. Biodiversity includes direct and indirect use values, option, and existence value.

Koh Kapik is considered to have a high biodiversity value. The site is an excellent representative of a mangrove system backed by Melaleuca, which is rapidly being lost elsewhere. It is also considered to be an internationally important site for migratory birds.

Biodiversity benefits are inherently difficult to estimate because a large part of its value lies in undiscovered species of unknown uses that might have potential commercial value sometime in the future (e.g., commercial medicinal or agricultural value). The biological diversity of a mangrove may also have a valuable role in maintaining its regulatory functions.

6.3.2 Storm Protection

Mangroves serve as natural barriers against strong winds, tidal bores, and waves. The buffer zone offered by shoreline mangroves in Koh Kapik is recognised as helping to protect against the damaging effects of large storms and tidal surges. It may be one of the main reasons why Koh Kong has not been devastated by any natural disasters. However, local people do sometimes suffer from huge waves, storms, and strong streams and have on occasion moved their floating houses or boats into the forest or island for shelter and protection from destructive natural forces. The survey results show that storms and unstable weather patterns are the biggest concerns of villages in the area.

The storm protection of mangrove in Koh Kapik therefore has indirect value through the protection afforded to coastal property and economic activity. A possible valuation approach is to estimate the amount of area and damage to economic activity and property that would be effected by high winds and storms if no protection was provided by mangroves. The value of this damage avoided would be one estimate of this function's worth. Alternatively, any preventive or relocation expenditures would also provide a value estimate, as well as the costs of building alternative wind breaks or sea walls.

Using the estimates on the cost of house construction (Table 6.10), if villages within Koh Kapik were to suffer storm destruction, the loss to property alone can be estimated at US$391,816. This estimate may be taken as an upper bound figure for the damage protection function of mangroves since it is unlikely that all houses would be completely destroyed by storms. However, because many houses on silts are located by the water's edge, it is assumed that the damage would be significant. Further, this figure does not account for the probability of such an event occurring given the deterioration or loss of the mangrove (again, on the information available it may be assumed that this probability would be high).

6.3.3 Groundwater Recharge and Discharge

Groundwater recharge refers to the role of mangroves in supplying aquifers. Groundwater discharge involves the role of all mangroves in releasing water from aquifers. This may be an important 'safety valve' to prevent flooding when upland water tables are high. These values are considered to be low for Koh Kong.

6.3.4 Flood and Flow Control

The flood and flow control services of mangroves in Koh Kong are important. In order to value this function, it is necessary to know the extent and frequency of flooding in the flood plain area that would occur if this mangrove function did not exist. Several scenarios might be constructed (e.g., 50% loss of flood control, 75% loss). The types of economic activity and property that would be affected, and their values, would also have to be known. Various techniques could then be used, including estimating the damage costs of flooding avoided, the flood prevention expenditures, the costs of relocation and the costs of constructing any alternatives or substitutes for mangrove flood and flow control.

6.3.5 Shoreline Stabilization /Erosion Control

Mangroves in Koh Kong are important for protecting the coastline from erosion, thus preventing the loss of valuable agricultural land and property. ADB (1996) concluded that to date there were no serious problems with coastal erosion in Koh Kong. This was tentatively attributed to benign meteorological and oceanographic conditions.

Valuation of the shoreline stabilization function of mangroves requires an estimate of the net area of land that would be lost without this stabilising influence. In some cases (see sediment retention) mangroves may actually lead to land accretion. Any such positive additions of land should be added to that saved through shoreline stabilisation and erosion control. The change in productivity approach can then be employed. For example, the value of the marginal agricultural productivity of any arable land, or the value of any real estate and the value of any property that might be potentially lost.

6.3.6 Sediment Retention

The sediment retention function of mangroves may have two important effects. Firstly, it may lead to accretion of arable land within mangrove areas, and secondly it may protect downstream economic activities and property from sedimentation. The sediment retention value of mangroves in Koh Kong is believed to be high.

6.3.7 Nutrient Retention

Organic nutrients, including those from humans and animal waste, are often also trapped along with sediment by mangroves. The nutrient retention value of mangroves in Koh Kong is believed to be high to medium.

6.3.8 Water Quality Maintenance

Nutrient and sediment retention by mangrove are also linked to their other water quality maintenance functions, such as nutrient transformation (i.e., actual uptake of mangroves vegetation), retention of toxins, and particle suspension.

6.3.9 Micro-climate Stabilization

The overall hydrological, nutrient and material cycles and energy flows of mangroves may stabilize local climatic conditions, particularly humidity and temperatures. This in turn has an influence on any agricultural or resource-based

activities, as well as on the stability of natural ecosystems and the mangrove itself. The microclimate stabilization function of mangroves in Koh Kong is considered to be high.

6.4 Summary of Results

A summary of the value of the mangrove forest components analysed in this study is presented in Tables 6.24 and 6.25. Value estimates per hectare have been derived for the sustainable traditional use of the mangrove by local communities and for sustainable charcoal production. Table 6.26 summarises the results from other mangrove valuation studies.

Table 6.24.Summary of Net Benefits (US$)

Resource/Service	Total value per survey results/year	Sustainable Traditional Use-Value per hectare/yr[1]	Sustainable Charcoal production-Value per hectare/yr
Fuelwood	42, 302	3.5	
Charcoal			413
Local Fishing	1, 005, 956	84	
Storm protection function	391, 816	32	
Total	1,440,074	119.50	413

Notes:[1] Based on the area of Koh Kapik, i.e., 12,000 hectares

Table 6.25. Average Net Benefits to Households / Year (US$)

Forest product	Koh Kapik	Koh Sra Lao	Koh Sra Lao (Charcoal producers)	Lamdam
Fuelwood[1]	48	49	244	51
Charcoal	-	-	640	-
Fishing	1,373	537	-	436
Construction materials[2]	159	93	93	85
Total	1,580	679	947	572

Notes:

[1] Fuelwood benefits for Koh Sra Lao (non-charcoal producers) based on the average benefit of other two villagers.

[2] Based on house construction value, assuming 3-year life time of house and that 50% of construction materials come from mangrove areas.

[3] Due to data limitations it was not possible to include the net benefits to traders and money lenders involved in fishing and charcoal production. These categories can therefore be seen as underestimates.

Table 6.26. Results from Other Studies, US$/Ha/Year

	Thailand Christensen 1982	Fiji Lal, 1990	Indonesia Ruitenbeek, 1992	Philippines Jansen and Padilla, 1996	Giesen *et al*, 1991	Costanza *et al*, 1989	Dixon, 1989	Primavera, 1993	Koh Kong
Forestry	30	6	67	151					
Fisheries	130	100	117	60	600[1]	62.66			
Erosion	165	52	3						
Biodiversity			15[2]						
Storm protection									32
Purification		5820[3]							
Local Uses	230		33						87.5
Charcoal									413
Intact Mangrove System							500-2500 [forestry & fisheries benefits]	11, 600	

Notes:

[1] Marine fishery production is linked to an area of healthy mangroves (i.e., fishery impacts were quantified based on the number of hectares of healthy mangroves in each project year) This value appears to be high when compared to other studies. It is possible that the high per hectare value represents a net present value per hectare rather than an annual value, or the study may be reporting an average value rather than a marginal value. The average value may represent the total net value of the fish catch divided by the total area of mangroves. This would be a valid value only if mangroves were the sole factor influencing the size of the catch.

[2] Based on the commercial value of medicinal plants from mangroves. Ruitenbeek argues that this biodiversity benefit is only relevant if it is 'capturable biodiversity benefit', defined as 'the potential benefit which the country might be able to capture from the international community in exchange for maintaining its biodiversity base intact'.

[3] Based on the cost of constructing a sewage treatment plant.

7.0 Economic Analysis of Shrimp Farms

7.1 Shrimp Farming in Koh Kong

Since its introduction in 1985 shrimp culture has developed rapidly along Cambodia's coastline. The highest concentration of shrimp farms in Cambodia is in Koh Kong province. A clear reason for this is Koh Kong's proximity to the Thai border, facilitating Thai investment. Shrimp farming began in Koh Kong in 1988 with a modern extensive farm of 5 hectares. By 1991, intensive shrimp farms involving high stocking densities, formulated feeds, aeration, and regular water exchange, financed by Thai shrimp farmers and businessmen were in operation. The farms are situated in three districts in Koh Kong province--Mondulsema, Koh Kong, and Dongtung -- all of which support large areas of mangrove forest.

Thai influence in the shrimp farming industry in Koh Kong is intense. Thai investors enter into joint ventures with Cambodians to gain concession licences to operate the shrimp farms. The Fisheries Department of the Ministry of Agriculture is responsible for issuing licenses for shrimp farms. Investment and labour, and almost all the inputs required such as feed, seed, chemicals and equipment are supplied from Thailand. Almost all production is exported back to Thailand. With Cambodians supplying only cheap labour, the benefit to Cambodia is minimal.

Information on farm numbers, production and area covered in Cambodia is given in Table 7.1. Estimates based on aerial photography (1994) indicate that there are approximately 360 ha of land along the coast of Koh Kong being used for aquaculture which contradicts the value reported in Table 7.1. The reason for this contradiction is not clear.

A review by the ADB (late 1995) showed licensed shrimp farms in Koh Kong province to have increased to 1,000 ha (1.56% of the total mangrove area), with 280 ha stocking and growing out and 150 ha under construction. The rest were waiting for the opportunity to sell or to establish joint ventures with Thai shrimp farms. The latest statistics for 1996 (Table 7.2) show the total area of shrimp farms to be 904.80 hectares. The area of shrimp farms in Koh Kapik is unknown, but 511 ha are assigned to shrimp farming in Peam Krasaop Wildlife Sanctuary (Table 7.2).

A feature of the 1996 figures is the high area of abandoned 'unprofitable' shrimp farms (71% of total area devoted to shrimp farming). This illustrates the fact that the industry in Koh Kong is increasingly plagued by the self-induced negative side-effects of its operations. Economic losses are common due to shrimp disease, and sea pollution of culture areas caused by indiscriminate discharge of pond effluents (ADB, 1996). Resource conflicts, particularly with farms located in or near mangrove areas, are also increasing.

Table 7.3 shows shrimp productivity in Koh Kong since 1991. The year 1996 can be seen as the first year in which total production in Koh Kong fell, suggesting that the productivity of farms has declined.

Table 7.1. Data on Shrimp Farms in Cambodia

Province	Farm area (ha)	Number of farms	Production (tons)
Kampot	422	63	23
Koh Kong	**850**	**54**	**450**
Total	1272	117	473

Source: Department of Fisheries, MAFF 1995

Table 7.2. Shrimp Farms in Koh Kong, 1996 Statistics

Total area of shrimp farm	904.80
Area under use[1]	261.00
Area under construction	0
Abandoned area	643.80

Source: Dept Fisheries, Koh Kong, 1966

Notes:
[1] According to the Shrimp Farm Association, the area under use is 267 hectares. There are 88 owners and a total of 234 ponds.

Table 7.3. Shrimp Production, Koh Kong

Year	Production (tons)
1991	5
1992	50
1993	470
1994	510
1995	730
1996[1]	604

Source: Dept of Fisheries, Koh Kong

Notes:
[1]The 1996 total may overestimate production in the range of 20-40 tons representing fish and oyster production which may not have been netted out.

Pond yields are reported to be up to 7-8 ton/ha/crop which is relatively high. High potential profits continue to attract investors. In reality, however, shrimp farming requires hefty initial investment and operating costs, and has proven to be a risky business for investors in Koh Kong. Productivity has been very unpredictable and depends on disease, water quality, technique, and climate. An estimated 87% of farms have experienced a fall in productivity since they started producing and poor yields have meant that many shrimp owners have made losses and can no longer afford to run their farms. Typically, farms are abandoned after five years.

These problems have led to the local Government and concerned Ministries (MAFF and MOE) to place a moratorium on further licensing of shrimp farms.

In Thailand and in most other countries where it has been attempted, widespread semi-intensive and/or intensive culturing of shrimp has resulted in a catastrophical collapse of the industry, primarily through disease (Lin 1989; Phillips *et al* 1993; Wigglesworth 1994). The precise reasons for failure are unknown (Kikuchiu 1993). Poor water quality is

commonly cited as the reason, there being a generally accepted, but little understood relationship, between poor water quality and disease proliferation.

Collapse can be more gradual as pond productivity generally declines at a rate of 3-8% per production cycle (Tiensongrusmee and Phillips 1994; Funge-Smith and Briggs 1994a; Primavera 1993). The exact reason has not been identified, although deterioration of pond sediment quality, the loss of essential minerals from pond soil, and poor pond management (which lead to low oxygen and high ammonia concentrations) are common explanations.

The shrimp farming industry in Cambodia appears to follow the path of the industry in Thailand. The explosion of intensively operated shrimp farms from the mid-eighties has negatively impacted the coastal zone, while failing to establish a sustainable industry. Abandonment of shrimp ponds is common due to either a drastic collapse caused by disease infestation or gradually, due to yearly reductions in the productivity of the pond. The difference between Thailand and Cambodia is that Thailand has at least benefited socially and economically. In 1992, product export was valued at $124 million dollars, close to 1% of Thailand's GDP (FAO/NACA 1995).

7.2 Survey Results

Eight shrimp farms were surveyed in Koh Kong in December 1996, in order to provide information on farm management practices, investment costs, and productivity. All farms practice intensive shrimp farming. The average farm size is 5 ha, with a total of 5 ponds of just over 1 ha each (Table 7.4). All farms cleared an area of mangrove forest equal to the size of the farm. The main species farmed is *P. morodon*. All farms have sediment ponds for waste. However, untreated wastewater is being discharged directly into the sea.

Table 7.4. Summary of the Size and Age of Shrimp Farm

Average age of farm (years)	Average size of farm (hectares)	Average no. ponds per farm	Average size of ponds (hectares)
2(1-4)	5(1-10)	5(1-9)	1.1(0.7-1.5)

Note: Figures rounded to nearest decimal

7.3 Financial Cost- Benefit Analysis of Shrimp Farming

Information on investment costs, operating costs, and productivity was provided by the shrimp farm owners. These data are used to calculate the financial returns to shrimp farming.

Investment at the construction stage includes the cost of a license and expenditure on farm construction and equipment (e.g., dike construction, gates, fan for aerating water). The average expenditure at the construction stage was estimated to be US$28,662 per hectare.

Only 25% of farms surveyed were operating under license. Licenses are valid for the lifetime of the farm and cost between US$800-$1,200. Technically, the fisheries department needs to be informed each year of the farm's intention to continue its operations.

Costs per harvest include expenditure on labour and inputs such as larvae, food, and Ca_2Co_3 which are all imported from Thailand. A tax of 2,000 Baht/ha year is payable to the Department of Fisheries. However, only one shrimp farm owner mentioned this tax.

On the average, a farm hires 8 workers (ranging from 2-15). Typical salaries are: cook, 600-1,000 Baht/month; worker,

1,000-1,500 Baht/month; manager, 2,000-2,800 Baht/month; and technical expert 25,000 Baht /month. A farm spends US$7,566 for labour on the average per year. The average expenditure per year, per hectare on inputs and labour is estimated at US$38,777 (ranging from US$12,604 - $87, 520).

Productivity per harvest ranges from 3-16 tons per hectare, with an average of 5 tons per hectare. Sixteen tons per hectare is very high and represents the first harvest of a newly constructed farm. Excluding this figure, productivity per harvest ranges from 3.1- 4.4 tons per hectare, with an average of 3.6 tons per hectare.

Table 7.5. Relationship between Farm Productivity and Age

Age of farm / years	Yield/ha/Harvest	Gross value US$ per hectare / harvest @120Baht kg	Gross value US$ per hectare / harvest @ 35Baht / kg	Gross value US$ per hectare / harvest @ 185 Baht / kg
1	16	76, 800	22, 400	118, 4000
2	3.78	18, 144	13, 230	27, 972
3	3.26	15, 648	4,564	24, 124
4	3.12	14, 976	4,368	23, 088

The price of shrimp ranges from 30-185 Baht/kg depending on size and quality. The shrimp are sold to Thailand. Prices are dependent on the international market and have fallen over recent years from a high of 210 Baht. Using a price of 120 Baht/kg (weighted average) and using the average productivity of 5.1 tons/hectare/harvest, the average gross income from shrimp production per harvest can be estimated at US$24,480 per hectare. Table 7.5 shows gross returns at different price levels and indicates a relationship between farm age and productivity.

Assuming a five-year productive life of a shrimp farm, and two successful harvests per year at 5.1 tons/hectare/harvest, net income per farm is estimated at US$4,451 per hectare. If however, one harvest fails because of disease or technical problems (which is very common), the farm will loss US$20,029 per hectare. A year of loss in which both harvests fail means losses of US$44, 509. At 120 Baht/kg productivity has to be at least 4.7 tons/kg to breakeven. At a productivity rate of 3.6 tons per harvest, a loss of US$9,949 per hectare is incurred.

Given the risks facing shrimp farming, it is becoming increasingly rare for farms to have two successful crops a year. Half of the farms surveyed have incurred losses ranging from 1-6 million Baht (US$40,000-$240,000).

The calculations for each of the eight farms surveyed revealed that 50% of farms are making profits of between US$17,508-$100,880 (US$1,782-$100,880 per hectare), and 50% to be making losses of between US$3,602-$162, 216 (US$1,125-$20,481 per hectare).

Excluding the farm with the unrealistically high productivity rate of 16ton/harvest, profits range from US$74,658-17,508 per farm (US$11, 109-1,782 per hectare).

Overall, the farms are making a loss of US$8,826, or US$1,103 per hectare.

Calculations for individual farms are based on the investment, operating and productivity figures, and selling price of shrimp of the individual farms covered in the survey. Shrimp prices ranged from 98-158 Baht /kg and obviously affected

profit margins.

The survey results show that intensive shrimp farming in Koh Kong as currently managed is unsustainable. On a narrow financial analysis alone (without accounting for the wider environmental costs imposed by the industry), shrimp farming is seen to be unprofitable.

7.4 Environmental Cost Benefit Analysis (CBA)

Typically, CBA is based on financial data and does not account for the wide social and environmental costs to society. However the environmental impacts associated with shrimp farming are significant and should be incorporated in any evaluation in order to present an accurate statement on the economic benefits or costs of the industry.

At present, shrimp farming in Koh Kong is practised in a way detrimental to the environment. Large areas of mangrove forest have been cleared for shrimp farms, untreated liquid waste is discharged directly into nearby waters, and some farms are operating without sediment ponds.

A qualitative description of the possible ecological costs associated with shrimp farming is presented below:

(i) Loss of mangroves

Shrimp ponds are often located in mangrove areas where close proximity to the ocean means that tidal energy and the short length of the canals can provide cost savings in water exchange, and perhaps a cleaner source of supply water.

Intact mangroves provide a range of goods and services (Sections 6.2 and 6.3) which will be foregone if mangroves are lost. The impacts associated with the removal of mangroves for shrimp ponds are usually external to the decision making process, often because it is difficult to assess them quantitatively due to lack of scientific data. Hence most economic analyses demonstrates that there are higher returns from intensive shrimp farms than from intact mangrove (FAO/NACA 1995).

However, the economy may be substantially affected when mangrove long term sustainability, its multi-purpose uses (i.e., wood production, nursery/breeding grounds for crabs), and unsuitability of the acid sulphate sediments are considered in the analysis (FAO/NACA 1995).

Shrimp farming in Koh Kong has resulted in the widespread destruction of mangrove forests through their conversion to ponds, with the resultant loss of associated biodiversity and other resources and ecological functions of the ecosystem (assumed decreases in off-shore fisheries). This is detrimental to both the stability of the system and to the livelihoods of the local people.

(ii) Groundwater depletion

Groundwater is sometimes pumped to the culture ponds to dilute salt water in the belief that brackish water is best for rearing shrimp. Groundwater depletion has resulted from excessive pumping. The emptied aquifers are then subjected to salt water intrusion. Furthermore, the fall in water level and attendant compaction of aquifers can lead to land subsidence and vulnerability to floods.

Irreversible change in the soil composition of both prawn pond and adjacent areas may change irreversibly. Pond salinisation and the use of chemicals may affect the soil so as to preclude conversion to agriculture or even other aquatic crops

(iv) Eutrophication as a result of the use of antibiotics and chemicals

(v) Pollution of coastal waters and neighbouring communities from the discharge of harmful effluents from shrimp ponds (e.g., excess lime, organic wastes, pesticides, chemicals, and disease micro-organisms)

The release of such products may directly or indirectly affect estuarine and marine organisms and produce resistant strains of pathogens. Impact on water quality can be considerable when the cumulative impacts from water exchange during the grow-out cycle, pond drainage during harvesting, and illegal pond sediment disposal are taken into account (Dierberg *et al* 1996).

(vi) Sediment disposal

The sediment that accumulates within the rearing cycle is removed or allowed to oxidize after each production cycle as a maintenance measure to safeguard against deteriorating water quality during the next cycle.

Estimates of the amount of sediment generated per hectare in Thailand are: 185-199 t/dry wt/ha or 139-150 m^3 (Funge-Smith and Briggs 1994); and, 200-836 t/dry wt/ha or 151-629 m^3/ha (Tunvilai *et al*1993).

Sediment removal is almost exclusively done in Thailand, which has led to water pollution (if disposal is done in an illegal manner), salinization of soils and water, and a solid waste disposal problem.

(vii) Abandoned shrimp ponds

The average lifetime of an intensive shrimp pond in Koh Kong is estimated to be 5 years before disease outbreaks make the enterprise unprofitable. Abandonment of ponds is therefore a common phenomenon. In Thailand this has resulted in a pattern that has been dubbed 'shifting aquaculture', as investors move on to new, unspoiled locations.

While shrimp farms negatively impact the environment, ironically they require large ecological support areas, large amounts of clean, nutrient rich water, wild shrimp fry from undisturbed mangrove lands, and in its intensive and semi-intensive forms, fish and cereals feed (in the form of pellets) to be sustained.

Most commercial shrimp farms, particularly the more intensive systems, are widely regarded as ecologically unsustainable. In these systems resources are pumped in, used up, and pumped out in a linear fashion, rather than being recycled. This leads to the accumulation of wastes in the recipient ecosystems, often raising severe and irreversible environmental problems.

Shrimp farms depend entirely on the resource base which, directly or indirectly, is linked to the very ecosystem they degrade. The lack of recognition and respect of these linkages makes the farms inherently liable to collapse, as the degradation of their support systems remains unnoticed (Larsson *et al*, 1993).

7.5 Equity Concerns

When mangrove areas are converted to shrimp farms, the potential for multiple use of the resource is lost to a single use that, if not carefully managed, provides only short-term gains for a small number of investors. In Cambodia these gains are not even felt nationally. A communal resource is thus transformed into a privately owned, single purpose resource because local populations typically lack formal property rights to the mangrove areas. Local communities therefore become marginalised from the traditional benefits provided by mangroves such as materials for fuel and construction and aquatic products.

Over 90% of local people in Koh Kong do not support shrimp farms in the area. Mangrove conversion and water pollution by shrimp farms are seen by local people to be one of the key factors in explaining the decline in fish productivity over recent years. The depletion of coastal fisheries has further marginalised subsistence fishermen dependent on mangroves. Shrimp farms have also restricted access to local fishing areas and created a shortage of fresh water for local communities in some cases.

The distributional reality must be a factor in any assessment of a shrimp farm's economic viability. Any development must show, over and above financial profitability, a responsiveness to society's needs (in addition to the requirement that

environmental resources are not threatened).

7.6 Intensive versus Extensive Shrimp Farming

Local communities might benefit from the development of low to medium intensity shrimp farming, which is likely to result in less environmental damage and, if properly implemented, could satisfy economic, ecological, and social criteria.

In Kampot, farms mostly use traditional (extensive) farming methods. The extensive farms rely on natural supplies of feed and seed, with no feeding, fertilization, or stocking. Consequently, pond productivity remains low at less than 100 kg/ha/year. The ponds are often constructed in or close to the mangrove areas. Some farmers use the ponds as a reservoir of water into salt pans. Water management practices are simple. Farmers let the water into the ponds during high spring tides. The water is exchanged each month. Harvesting of shrimp (mainly *Metapenaeus species* and some *P. merguensis*) is carried out during the monthly draining of water and also by more regular trapping or netting of shrimp in the pond. Fish may also be harvested along with the shrimp (ADB 1996).

A survey on sustainable shrimp farming management (NACA 1995) concluded that extensive shrimp farms have low pond yields of 32 kg/ha/year and an overall national sales value of US$ 25, 000. In contrast, the intensive shrimp farms have an average production of 7,545 kg/ha/year, with a national sales value of US$42 million/year. However, intensive shrimp farms face significant environmental problems and an estimated national loss due to disease of US$14.5 million/year and total environmental-related losses of US$28.6 million/year (ADB 1996).

7.7 Improved Farming Practices and Sustainability

It is generally felt that improved technical management is needed if the performance of intensive shrimp farming is to be improved. However, to date, no solutions have been found for making concentrated semi-intensive and intensive operations ecologically sustainable. Part of the answer may lie in deployment of water treatment and minimal use systems, especially in locations where there are numerous farms that use common discharge canals and source waters.

Sustainability in the aquaculture industry is thought to rest largely on two major factors; site selection, and pond management. An overriding factor may be the location of the farm *vis a vis* other farms in the immediate area (i.e., the density of farms within an area may be more important than the farm's intensity).

Better wastewater treatment practices are required and minimal water use systems aimed at making aquaculture more hydraulically closed need to be developed. However, before this is possible, technical and economic feasibility studies on enhanced nitrification systems and organic solids removed by oxidation between production cycles and/or utilization of plastic pond liners need to be conducted.

Partial re-circulating and integrated intensive farming systems are just beginning to be considered in Thailand and are producing promising results. By providing on-site treatment of effluents from the shrimp grow-out ponds, there is less reliance on using outside water supplies, believed to be the source of contamination (Dierberg *et al* 1996).

7.8 The Shrimp Farm Association in Koh Kong and Problems faced by the Shrimp Industry

A Shrimp Farm Association was formed in Koh Kong in October 1994. The objective of the Association is to provide technical advise to members and strengthen the cause of shrimp farming in the province. Membership is 500 Baht per month and 85 of Koh Kong's 88 shrimp farm owners are members. Fishers may be invited to join the Association in the future to promote dialogue between the two groups.

According to the Association, productivity has always been very changeable with some farmers losing money from the beginning and others having good results. For example, one producer lost money the first year and had one good and one bad harvest in the second and third year of production. Sometimes in the same area half the ponds are good and the other half bad. However, the Association is optimistic that sustainable yields are possible with improved management.

The main problems faced by shrimp farmers are discussed below:

(i) Lack of technical knowledge. Many shrimp farmers in Koh Kong lack the technical knowledge and expertise necessary to farm shrimp successfully.

(ii) Environmental Conditions. The area is considered difficult in terms of soil and climate

(iii) Disease. The incidence of disease is high. Larvae take four to four and a half months to grow into shrimp during which time many diseases can occur. The first month is the most risky time--if shrimp catches a disease during this period everything is lost. After the first month, the shrimp can be harvested and it is possible to get some money back.

There are around four types of common diseases. The most serious is red disease which is common in the Gulf of Thailand and for which there is no treatment. With this disease, the shrimp dies within 1-2 hours, and the disease spreads quickly.

A second type of disease, white disease, can be treated. However, medicine has to be bought from Thailand and this takes time and money.

In October 1996, 81 ponds (38%) were reported to have disease resulting in an estimated total loss of 36m Baht (US$1,440,000)

(iv) Natural causes. Losses sometimes occur as a result of natural causes. For example, shrimp require salty water. However, during the rainy season (July-September) water in the river may become fresh and there may not be enough carbon sulphate in the water for the shrimp to develop a hard skin. The hard skin shrimp then eat the soft skin shrimp, so the shrimp have to be harvested immediately. Because the shrimp weigh less at this stage, the price is low and money is lost. According to the Association, farmers often only cultivate once a year because of the risks during the rainy season.

(v) Fluctuations in price. The price of shrimp is not stable and is dependent on the quota that other countries buy and supply. The price of shrimp in Koh Kong is closely linked to prices in Thailand, since all shrimp is sold to Thailand (and then on to 56 countries worldwide). The international demand for shrimp, and consequently the price for shrimp, has fallen recently. This has affected Thailand's demand for shrimp produced in Koh Kong. Other markets for Cambodian shrimp (e.g., Hong Kong and Taiwan) are small compared to the Thai market, so producers are faced with excess supply.

The current price of shrimp is 30-185 Baht/kg depending on size and quality. Previously, top quality shrimp was sold at 200-210 Baht per kg. Prices have therefore fallen by 15-20 Baht.

(vi) Illegal checkpoints. Illegal checkpoints are said to be common. Shrimp farmers have to pay additional money when buying equipment and inputs for the farms and delays are common.

(vii) Environmental management. The Association claims to be stressing good environmental management. However, some owners do not see this as a priority. Not all farms have a reserve pond for storing waste. These farms discharge waste directly into the water, which affects the marine environment, other farms and people living nearby. Only one farm owner has a machine for cleaning reserve ponds, which costs 100,000 Baht (US$4,000). The machine is hired out to other farms for 15, 000 Baht (US$600) per hectare plus petrol.

Request to the Government

(i) Assistance in defining new markets for shrimp, to reduce the dependence on unstable markets in Thailand

(ii) Technical assistance

(iii) Provision of credit to farmers who after 2-3 years are unable to continue production due to financial losses

(iv) Elimination of illegal checkpoints

7.9 Recommendations

Shrimp farming as currently practised in Koh Kong is unsustainable. In order for Cambodia to move towards a sustainable aquaculture industry and coastal zone environment, shrimp farms need to be carefully managed within an integrated mangrove management plan.

Improvements in shrimp farm management will require not only strict environmental management and technical improvements, but institutional support as well.

In the past, government policy has promoted intensive shrimp farming without addressing adequately the environmental and social impacts of the industry. Sustainable pond management techniques, pollution abatement, and rehabilitating abandoned shrimp ponds to some productive function should be emphasised.

While the Government has taken a strong line on charcoal production, it has been reluctant to take steps against the shrimp farms. It is argued that shrimp farms should not be closed since they were operating before the creation of the 1993 Royal Decree on Protected Areas and people have invested a lot of money. An integrated management plan will require that actions be taken against all parties threatening the natural resource base.

The survey results show shrimp farming to be uneconomic even on a narrow financial analysis. From a broader social perspective, the additional social costs imposed by the environmental damage make shrimp farming even less economic.

The survey results suggest that shrimp farmers are acting irrationally (i.e., shrimp farming is not financially viable, yet investment continues in this area). A possible explanation for this is that, in the past, farmers have been attracted by the high potential returns from a successful production cycle, without appreciating the risks associated with poor management and over-exploitation. Moreover, due to the lack of any industrial standards or management requirements, investors have no reason to behave responsibly. The fact that they do not have to account for their impacts on the environment and society has promoted a 'hit and run' mentality whereby investors simply abandon unprofitable ponds. Unless sound management of the shrimp industry is enforced, such a trend will logically result in collapse of the natural resource base, a common occurrence elsewhere in the region.

In the future, Government policy should focus on sustainability issues. A balanced policy would include education on environmental management, technical assistance, monitoring and enforcement, rehabilitating abandoned ponds, strict controls on areas within the coastal zone where shrimp farming might be permitted, and, a strong emphasis on community involvement.

8.0 SELECTION AND SPECIFICATION OF MANAGEMENT OPTIONS

Management plans for the mangroves of Koh Kong have yet to be developed. A broad discussion of possible management options is presented below.

Mangroves should be managed in a way that ensures sustainable use of mangroves for traditional purposes by local communities, and controls commercial productive uses of the mangrove resource (charcoal production and shrimp farming) such that other values of the mangrove resource are not damaged. Commercial fishing activities also need to be regulated in order that conflicts between local and commercial fishermen are minimised. An *integrated management plan* for the mangroves in Koh Kong is therefore proposed.

The main productive uses of the mangroves to be incorporated within the integrated management plan are: (i) traditional uses, (ii) charcoal production, (iii) shrimp farms, and (iv) commercial fisheries.

Management Zoning System

A zoning system has been proposed for the mangrove areas of Koh Kong (IDRC 1995; AWB 1994). The mangrove area may be divided into 2 main zones--a conservation zone (or core zone) and a multiple use zone.
Koh Kapik is a possible conservation zone, since the mangrove resource in this area is relatively unspoilt and of high biodiversity value. The conservation zone will be carefully protected from any impacts which might threaten the mangroves in their natural state. Traditional sustainable uses of the mangrove area by local communities may be permitted (possibly including limited selective cutting of mangrove forest for domestic charcoal production). No shrimp farms will be allowed in the core conservation zone.

The multiple use zone may be utilised but under strict management guidelines and based on sustainable yields. Some shrimp farms will be allowed, provided they are managed sustainably.

To be successful any management plan must account for the needs of local communities given their intricate relationship with mangrove areas. Research into viable alternative income sources for communities within mangrove areas would be valuable in this respect. Alternative income sources that might be developed include: frog culture; crab culture; seaweed culture; and oyster and mussel farms. However, it is not known what alternatives would be suitable for conditions in Koh Kong and supported by local communities. Pilot projects might be an effective way of determining this.

An outline of a possible zoning system for mangroves in Koh Kong is presented in Table 8.1, a range of management options is presented in Table 8.2, and the benefits of sustainable mangrove management are presented in Table 8.3 .

Table 8.1. Broad Description of Possible Management Zones for Mangroves in Koh Kong Province

Management Zone	Management Options
CORE AREA Koh Kapik 12, 000 ha (within Peam Krasaop Wildlife Sanctuary)	Protection of total forest area
	X% of forest area protected X% of forest area used for sustainable traditional community uses
	Sustainable traditional community uses allowed in total area Ecotourism
MULTIPLE USE AREA 51,700 ha Includes part of Peam Krasaop Wildlife Sanctuary	x% of forest area protected Sustainable traditional community use of forest area x% of forest area allocated for conversion to shrimp farms x% of forest area utilised for commercial charcoal production Eco-tourism

Table 8.2. Broad Management Options for Mangrove Resource in Koh Kong

Management Option	Description

Protection	Prohibition of productive uses Costs: Foregone benefits of sustainable traditional/commercial uses. cost of enforcement of protected area; cost of regeneration of mangrove areas (if necessary)
Sustainable traditional community use of forest resources	Communities are allowed to collect forest products and produce charcoal on a sustainable basis Optimal selective cutting cycling to be determined for charcoal production Prohibition of shrimp farms Management Considerations Promotion of alternative livelihoods for local communities dependent on mangrove resource. Management of fisheries to reduce conflicts between resource users
Commercial charcoal production	Use of mangrove forest for sustainable commercial charcoal production under range of cutting cycles
Conversion to intensive shrimp farms	Introduction of sustainable management practices, e.g. buffer zones / green areas, enforcement of environmental standards on water and waste discharges and other environmental impacts associated with shrimp farms
Conversion to intensive shrimp farms, plus commercial charcoal production	Introduction of sustainable management practices
Subsistence traditional use of forest resource and intensive shrimp farms	Multiple use option that recognises the requirements of coastal communities and the potential for shrimp farming.

Table 8.3. Benefits of Sustainable Management

Environmental Benefits (i) Preserved biodiversity of the mangroves themselves as well as the biodiversity of marine ecosystems for which the mangroves provide habitat, nutrients, and protection from sedimentation. The mangroves also provide habitat for migratory birds, and are a source of medicinal plants.

(ii)Decreased coastal erosion and increased protection against coastal storms and tidal waves.

Benefits to Human Welfare

(i) Sustainable flow of forest products, including wood products such as roundwood, poles, fuelwood, and charcoal, and nonwood products such as nypa palm shingles, bark for tannin, traditional foods, dyes, and resins.

(ii) Sustainable fisheries, both mangrove fisheries and nearby marine fisheries, for which the mangroves provide nutrients and serve as spawning grounds and nurseries (mangrove fisheries included finfish and crustaceans (shellfish).

(iii) Recreation (including ecotourism) for visitors to the mangroves. Mangroves also enhance recreation for snorklers and scuba divers in off-shore sea grasses and coral reefs by filtering out sedimentation.

(vi) Protection of freshwater supplies (inland aquifers) from salination, by serving as a ground water pump and a barrier between the aquifers and the sea.

(v) Nonuse benefits, including existence and bequest values related to the preservation of natural environments, for nationals and foreigners.

Benefits to Human Health

Increased safety and protection from coastal storms and tidal waves due to the mangroves serving as a buffer zone. Another indirect benefit may be improved health due to the availability of medicinal plant and foodstuff (e.g., fisheries) in the mangrove areas.

Global Benefits

The rehabilitation, conservation and management of mangrove areas may increase carbon storage. This is important globally as a measure to reduce greenhouse gas emissions.

9.0 CROP CULTIVATION IN UPLAND AREA AND THE ISSUE OF RELOCATION

One possible option for improving the livelihoods of households located within the mangrove areas, and reducing the pressures on the mangrove resource (especially in sensitive areas) is relocation. Land is said to be available in nearby upland areas where households could cultivate crops as well as fish. According to the First Deputy Governor of Koh Kong province more than 100 households have already voluntarily moved to a new village in the uplands called Wonk Ka Thak.

While the provincial office is promoting relocation, it is unable to support such a program financially. Households moving to uplands areas initially need assistance for building houses and for food up to the period of the first harvest. The provincial office has only been able to provide small amounts of sugar and rice to some households. Discussions were held with the village chiefs and households in Wonk Ka Thak village and village number 4, in order to gain some insight into the suitability and potential of the new village, and the current pressures to relocation in village 4.

9.1 Wonk Ka Thak village

Wonk Ka Thak village was established in June 1995 and currently has a population of 70 households (approximately

350 people). It is planned that eventually there will be 300 households (it is believed that the village could support up to 700 households and that similar areas in the vicinity could be developed). Currently 30% of the population are Khmer and 70% Muslim. Villagers cultivate crops as well as fish.

The village is well situated as it is accessible by water and road and surrounded by mountains (it is reported that a road from the village to the border has been proposed). The village is legally recognised, although the precise area of the village is yet to be delineated.

Villagers claim to originate from Village 4, which is located near Koh Kong provincial town. However, discussions with the chief of Village 4 revealed that most families are not from Koh Kong province, but have migrated to the area from all over Cambodia. These people have learnt about the opportunities in the upland areas from their relatives in Village 4, and generally stay in village 4 for only a few days before moving to Wonk Ka Thak.

There is no official procedure for moving into the village. People earn the rights to the land by clearing the forest and planting crops; there is a limit of two hectares per household. A problem is that some families clear the land in order to claim ownership and then do nothing.

The land is considered suitable for crops and for fruit trees (e.g., durian and rambutan). However, few families can afford to invest in long term crops such as fruit trees and would like to be provided credit for this.

It is hoped that once the land has been developed, income from cropping will be more profitable than from fishing. Many households were farmers before migrating to Koh Kong so are experienced in crop cultivation. Old people especially are attracted by the opportunity to cultivate crops as fishing is physically more demanding.

Around 30 households are already producing crops such as sugarcane, cassava, corn, sweet potato, and rice. However, at present the village does not have enough rice to eat, so corn and cassava are being sold to buy rice. Other households are starting to build houses and to clear the land. While villagers claim not to be clearing land on high slopes, such areas are said to being cleared indiscriminately by soldiers. Some families earn more money from fishing, but other families earn more money from crop cultivation, and some have stopped fishing altogether.

Seven households were interviewed. Six of these families have recently moved to the area (late 1995-1996) in order to cultivate crops. One family moved to the area in 1992 to be close to Thailand, as the husband is Thai. In 1992 there were only 3 households in the area.

The household in residence since 1992 cultivates crops on its 0.5 hectare of land. The husband is also employed by timber companies to transport wood at a wage of 100 Bt/day. This is not a regular income and 3,000 Bath a year may be earned by this activity. The household estimates its income to be 5,000 Baht (US$200) per year.

The most profitable crop grown is ganja. If a lot is planted to this crop, more than 10,000 Baht (US$400) can be earned per year. In 1996 only 10 stumps were planted and the household earned 300 Baht (US$12). Around 200 Baht is spent on fertilizer per year. Ganja is an illegal crop, so producers risk losing money if the crop is found and destroyed by the police.

The main crops planted by families who recently moved to the area include: cassava; sugarcane; chili; corn; bean, rice, cucumber, eggplant and lettuce. There are plans by some families to grow grapefruit; jackfruit, banana, mango, cashew nut, and pineapple. Chili is reportedly the most profitable crop after ganja and is currently harvested by 50 households. It is sold to Thailand where the market is strong. Initially chili takes 3 months to harvest; after this it can be harvested every week and the tree can last for three years. The seeds are sown manually. Typically, 500 Baht per m^2 is spent on fertilizer. Technique is important when planting chili, otherwise the crop may die or fail to produce fruit. Net income per hectare is estimated to be US$300 per year.

Household income estimates ranged from US$400 to US$800 from fishing. The average income from crop cultivation is US$120.

Mangroves are considered to be very important to villagers as a spawning area for fish; they are important food source. The villagers do not support shrimp farms, as they pollute the water and are associated with the decline in fish productivity.

The main problems facing the village are: poverty; water shortages in the dry season (the village would like to construct a catchment for water but they have no experience in this); lack of medicine, hospitals and schools; and no food security; The village does not yet have a mosque.

9.2 Village Number 4

Village 4 has a population of more than 5,700 people comprising of 1,128 households. The majority of households are muslim (700). The village was established before the civil war, disappeared during the Khmer Rouge regime (1975-9), and was reestablished. Families from all over Cambodia have settled here.

Most villagers are fishers catching crab, shrimp and fish in the Big Gulf. Between 10-20 households cultivate crops on the limited land available within the village. The village is suffering from severe over-crowding, poverty is widespread and the pressures on the natural resource base are damaging.

Around 30 households have moved to Wonk Ka Thak village for economic reasons. Living conditions in Village 4 have been poor since the late 70s. From 1979-93 there was a small, but not serious, decline in fish yields. Since 1993 there has been a big difference in yield because a lot of fishermen are coming from the outside (Thai fishing boats). Families have just enough fish to eat and there is not enough money for buying fishing equipment. Income estimates from fishing range from 10,000 -14,000 Baht (US$400-560) per year.

Despite the voluntary movement to upland areas, the population of Village 4 has increased by 60 new households. The village will always accept new households and, most of the people who move to the village are Muslim.

Discussions are being held at the district level about relocating 154 households, on a voluntary basis, to other areas. These people are expected to move within the year. The first priority is to move people out of the sensitive areas (i.e., people living near the water), and to move old people who are not strong enough to fish. There is no financial assistance from the Government, only help in the identification of areas for relocation.

The population of the village will still be too high after these people have moved and further initiatives will be needed. Some households do not want to move to the upland area, because of the fear of catching malaria. Others will move to the new village because they would like to cultivate the land.

The livelihoods of the people of the village are dependent on the mangrove resource. The village collects fuelwood and materials for house construction from the rear mangrove area close to the uplands. The mangroves are also recognised to be an important spawning area for fish and crab. However, crabs have become very scarce as a result of polluted water discharged by the nearby shrimp farms.

Mangrove areas around the village have been completely destroyed by shrimp farms and charcoal kilns; they have complained to the authorities but nothing has happened. The village is happy with the destruction of the charcoal kilns because they think that this will improve the mangroves and lead to an increase in marine productivity. According to the village chief, the main problems facing the village are: the growth in big engine boats using trawl nets which have destroyed the nets of local people reduced fish productivity, and illegal check points.

9.3 The Cost of Relocation

If it were decided that the total protection of the core area (Koh Kapik) was the best option, then it would be necessary to relocate communities currently living in the mangrove area. Alternatively, the best option may be to relocate some households in the mangrove area to reduce current pressures on the resource. Compensation for local people could be assessed in many different ways. Cash compensation (in addition to providing land and housing in viable new settlement areas) could be based on a transitional allowance (perhaps one year) equal to the average per capita income. Net per

capita income in the area can be seen to range from US$436-$1,373 (Table 6.25) and US$2,023-US$2,811 gross (Table, 5.1). Cambodia's GDP per capita is US$1,266 (GNP US$217).

There are an estimated 581 households in Koh Kapik. Relocation costs can therefore be estimated at US$391,594. This value was derived using US$674 average cost of constructing a house(Table 6.10) and 581 number of households. If one is to add the value of compensation of US$735,546 (obtained by multiplying 581 to US$1,266), then, the total cost of relocation will be US$1,127,140.

The cost per household can be estimated at US$1,940. This figure assumes that there is only one main wage earner per family and may need to be adjusted upwards for large families.

9.4 Conclusions and Recommendations

It was not possible on the information available to draw any firm conclusions on the suitability of Wonk Ka Tank village as a site for relocation. However, based on the site visit and discussions with concerned parties the following observations and suggestions can be made:

(i) In-migration to the new area is happening in an uncontrolled fashion. People from around the country are being attracted by the opportunity to own land. Careful and early management of the area is therefore required to avoid unsustainable exploitation practices in the upland areas.

If the area is to be earmarked for relocating people out of the sensitive mangrove areas, priority should be given to this purpose.

(ii) More information on the suitability of the area for crop cultivation is necessary to assess the viability of the area as a relocation site (e.g., soil suitability studies).

(iii) Indiscriminate cutting of trees is evident in the area. This needs to be carefully controlled. Education on forest management would be an important component in the management process.

(iv) Villagers lack the money needed to plant long term crops such as mango, jackfruit and rambutan. Credit might be provided for the purchase of seed and equipment. Technical assistance might also be provided (e.g., for successful cultivation of chilli).

(v)Water shortage is a problem. Technical assistance might be provided in this area, e.g., on the construction of wells.

(vi) Schools and hospitals need to be established in the area.

10.0 Conclusions and Recommendations

This report presents the findings of a twelve month economic research study (July 1996-June 1997) on the mangroves of Koh Kong province, Cambodia. The objective of the study is to provide information on the economic benefits and operational practices of key activities in the area to be employed in the identification of an economically optimal integrated management plan for the mangrove areas.

The mangroves of Koh Kong support a number of coastal households, are of high ecological importance, and represent a base for sustainable economic exploitation *if* carefully managed. In the past, a number of activities in the area (in particular shrimp farming and charcoal production) have been carried out in a way detrimental to the mangrove resource. Isolated policy initiatives introduced to address these issues have not been successful.

The main conclusion of this study is that given the complexity of the system and the linkages existing between different components of the system, only an integrated management plan for the area can be successful in sustaining the mangrove resource.

Two key uses of the mangrove, namely local community use, and commercial shrimp farming were analyzed. A survey of 90 households was undertaken in three villages within Koh Kapik, the study area, in order to provide information on the traditional uses of the mangrove area by local communities. The research focused on the economic valuation of non-timber forest products collected from the mangrove area by households such as fuelwood, charcoal, construction materials, and, crabs, shrimp, fish and snails. Eight shrimp farms were surveyed in order to assess the viability of shrimp farming in the area.

The main findings of this study relate to local activities such as fishing and charcoal production, commercial shrimp farming and the issue of resettlement.

All of these findings have a common theme, that of 'linkages' either between various activities, or between various physical components. These linkages highlight the complexity of the mangrove system and the fact that a single intervention in one area is unlikely to be of any real success in isolation as it will have knock on effects everywhere else.

Nearly 90% of households were dependent on fishing for their livelihood at the time of survey, this may now be as high as 93% assuming that ex-charcoal producers now turn to fishing as their only means of income. However, fish productivity has reportedly declined dramatically in recent years due to the increased number of fishers, the loss of mangrove areas due to the construction of shrimp farms and water pollution from these farms. As many as 90% of households involved in fishing claimed that it was harder to fish now compared to 5 years ago. Local fishing benefits are estimated to be US$84 per hectare.

Households claim to have turned to charcoal production and logging in upland areas because of low fishing yields mean that returns from fishing are no longer sufficient for subsistence purposes. If this is correct, a linkage can be made between, for example, shrimp farming, declines in fish yield, and the adoption of new activities by local people that result in new and additional stresses on the resource base.

Following the closure of the charcoal kilns in the area, the Government intends to fully regenerate the mangrove forest and then to regulate and legalise the charcoal industry. However, what level of charcoal production would be sustainable for the area is as yet unclear, and would require careful consideration in any future management plan.

The area of mangrove forest required per charcoal kiln per year is estimated by this study to be between 0.20-0.40 hectare. Assuming a 30-year cutting cycle, and that only already disturbed mangrove areas would be allocated for charcoal production, potential returns per hectare per year for sustainably managed charcoal production are estimated at over US$400.

An important result of this study is that on a narrow financial analysis alone shrimp farming in Koh Kong is unprofitable and unsustainable. Farms are typically abandoned after five years of operation. While 50% of farms made a profit in the past year, overall shrimp farms in the area suffered an average loss of US$1,103 per hectare. Largely due to problems with disease, associated with poor water quality management, it is rare for farms to have two successful harvests a year, and in some cases both harvests have failed. Individual farms have reported losses ranging from US$40, 000 - $240, 000.

The real costs of shrimp farming are in fact much higher than this. The analysis does not account for the environmental costs associated with shrimp farming. Unsustainable shrimp farming is linked to water pollution and the extensive clearing of mangroves for farm use, preventing accretion and wiping out of nursery areas. There is also a social linkage, in that it is causing grief among local people. Over 90% of local people oppose the shrimp farms. This could result in social unrest and security problems in the future if not adequately addressed.

The survey results show that 94% of the population have migrated to the area, attracted by the potential returns from fishing and charcoal production at a time when population and hence resource exploitation was low. The greatest influx into the area occurred during the period 1985-90.

The issue of the 'carrying capacity' of the mangrove resource base in Koh Kapik is linked to the possibility of relocation. The mangrove resource in Koh Kapik cannot adequately support the current population living within the area. Returns from fishing are low and no viable alternative livelihoods have been identified to date. Faced with low living standards, people can be seen to be making short term myopic production decisions which are not in the interest of long term management. This is despite the fact that villagers recognise that activities destroying the mangrove areas will affect their livelihood. Furthermore, there seem to be some barriers to mobility that are trapping people following the fall in living standards. This further exacerbates matters. These barriers include the lack of money to move (the majority of people have no money at all being in debt), insecurity in making the move, and lack of a place to go.

Relocation of families out of sensitive mangrove areas is supported by provincial authorities. Land is available in upland areas in the province where crop cultivation is possible alongside fishing. Some households in Koh Kapik have expressed an interest in relocation, if land will be allocated to them. While an in-depth assessment of the suitability of the assigned location for resettlement is lacking, the possibility of voluntary relocation is not ruled out as a way of protecting an ecologically valuable area and potentially improving the living standards of the local people. Relocation compensation (support) is estimated at US$1, 940 per household to cover the cost of house construction and living expenses up to the first harvest.

Past policy initiatives (charcoal kiln destruction and shrimp farm ban) have failed to protect the mangroves, because they were being pursued in a 'single policy' framework. Complex systems require integrated policy interventions so that one policy intervention in one sector does not simply create a problem in another sector because of the linkage effects. Without such an integrated approach the mangroves of Koh Kong remain threatened.

Recommendations

(i) A comprehensive integrated land use management plan for the mangrove areas needs to be developed which: safeguards the important ecological functions of the mangroves; allows sustainable traditional productive uses of the mangrove by local communities; and, supports a sustainably managed commercial shrimp farming industry in designated areas.

A land zoning system is proposed consisting of a core area representing areas of high ecological value such as Koh Kapik. This area could be afforded total protection, or permitted to be utilized for sustainable local use. The remaining area-- the multiple use area -- could be used for sustainable traditional uses, and shrimp farming and charcoal production in appropriately identified zones.

The management plan should be developed in close consultation with the local people. This has been very limited in the past. Local institutional capacity building should be emphasised and included throughout the development of the management plan.

(ii) The issue of relocation should be carefully and thoroughly assessed. Voluntary relocation of people living within Koh Kapik to nearby upland areas within the province may be viable following an adequate period of consultation with local people and a proper assessment of the suitability of new lands for relocation (e.g., soil suitability studies).

(iii) Efforts should be directed at working with the local people to manage their areas better, whether this is within the mangrove area or at new relocation sites.

Giving local people a greater stake in the mangrove resource would provide additional incentives for sustainable management. One possibility is to pay local people a wage to act as guardians of the mangroves. Such a system is currently practised in the South of Vietnam. This would also be an effective way of providing much needed local employment.

(iv) Studies to determine the sustainable level of charcoal production for the area need to be initiated. Before charcoal production is legally permitted in the area, a system needs to be put in place to regularise charcoal production. For example, the introduction of a licensing system to prevent the proliferation of charcoal kilns. A program to improve kiln

efficiency might also be started.

(v) Future management of the shrimp farming industry requires a tough focus on sustainable practices, not short term profit, and greater involvement of the local community. Efforts should be focused on technical improvements and the development of waste management models.

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dglover@idrc.org.sg | 30 June 2000