EEPSEA

2016-RR5

An Estimation of the Production Function of Fisheries in Peam Krasaob Wildlife Sanctuary in Koh Kong Province, Cambodia

Kong Sopheak and Cheb Hoeurn

WorldFish

Published by WorldFish (ICLARM) – Economy and Environment Program for Southeast Asia (EEPSEA)
EEPSEA Philippines Office, WorldFish Philippines Country Office, SEARCA bldg., College, Los Baños, Laguna
4031 Philippines; Tel: +63 49 536 2290 loc. 196; Fax: +63 49 501 7493; Email: admin@eepsea.net

EEPSEA Research Reports are the outputs of research projects supported by the Economy and Environment Program for Southeast Asia. All have been peer reviewed and edited. In some cases, longer versions may be obtained from the author(s). The key findings of most *EEPSEA Research Reports* are condensed into *EEPSEA Policy Briefs*, which are available for download at www.eepsea.org. EEPSEA also publishes the *EEPSEA Practitioners Series*, case books, special papers that focus on research methodology, and issue papers.

ISBN: 978-971-9994-98-5

Front cover photo:Koh Kong, Cambodia. Photo by Davy Demaline under the creative commons license at https://www.flickr.com/photos/davydemaline/8867694621/

Suggested Citation: Kong, S. and Cheb H. 2016. An estimation of the production function of fisheries in Peam Krasaob Wildlife Sanctuary in Koh Kong province, Cambodia. EEPSEA Research Report. No. 2016-RR5. Economy and Environment Program for Southeast Asia, Laguna, Philippines.

An Estimation of the Production Function of Fisheries in Peam Krasaob Wildlife Sanctuary in Koh Kong Province, Cambodia

Kong Sopheak
Cheb Hoeurn

February, 2016

Comments should be sent to:
Kong Sopheak, Graduate Program in Development Studies of the Faculty of Development Studies, Royal University of Phnom Penh, Cambodia
Address: Russian Blvd., Room A216, Level 2, RUPP Main Campus, Sangkat Beoung Kok II, Khan Toul Kork, Phnom Penh, Cambodia
Tel: +855 17 477 930; Fax: +855 23 880 116
Email: kong.sopheak@rupp.edu.kh/kong.sopheak54@gmail.com

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics. Its goal is to strengthen local capacity in the economic analysis of environmental issues so that researchers can provide sound advice to policymakers.

To do this, EEPSEA builds environmental economics (EE) research capacity, encourages regional collaboration, and promotes EE relevance in its member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam). It provides: a) research grants; b) increased access to useful knowledge and information through regionally-known resource persons and up-to-date literature; c) opportunities to attend relevant learning and knowledge events; and d) opportunities for publication.

EEPSEA was founded by the International Development Research Centre (IDRC) with co-funding from the Swedish International Development Cooperation Agency (Sida) and the Canadian International Development Agency (CIDA). In November 2012, EEPSEA moved to WorldFish, a member of the Consultative Group on International Agricultural Research (CGIAR) Consortium.

EEPSEA's structure consists of a Sponsors Group comprising its donors (now consisting of IDRC and Sida) and host organization (WorldFish), an Advisory Committee, and its secretariat.

EEPSEA publications are available online at http://www.eepsea.org.

ACKNOWLEDGMENT

We wish to express our sincere gratitude to the Economy and Environment Program for Southeast Asia (EEPSEA), without which this study would not have made it beyond the first draft of a research proposal.

Our biggest thanks go to Dr. Herminia Francisco for her guidance, support, and genuine confidence in the feasibility of this endeavor. Also, we would like to thank Prof. Jeffrey R. Vincent, Prof. Wiktor Adamowicz, Dr. Pham Khanh Nam, and Dr. Truong Dang Thuy for their critical comments and useful suggestions. Dr. Noor Ani Zakaria, Ms. Mia V. Mercado and Ms. Rhona Coronado were instrumental in coordinating this project, and for this we are grateful.

Lastly, thank you to the students of the Department of Environmental Science of the Royal University of Phnom Penh who assisted in this study.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	**1**
1.0 INTRODUCTION	**1**
1.1 Background	1
1.2 Description of the Problem	3
1.3 The Significance of this Study	3
1.4 The Hypothesis of the Study	4
1.5 The Scope of the Study	4
2.0 REVIEW OF LITERATURE	**5**
2.1 Total Economic Value	5
2.2 The Ecological Services of Mangrove Forest	5
2.3 The Relationships between Mangroves and Fisheries	6
2.4 Environmental Valuation Techniques	6
2.5 Mangrove Valuation Studies in Cambodia	7
3.0 THE STUDY SITE	**9**
4.0 RESEARCH METHOD	**9**
4.1 The Market Price Method	10
4.2 The Empirical Model of Production Function	10
4.3 Sampling Procedures	10
4.4 Methods of Data Gathering	11
5.0 RESULTS AND DISCUSSION	**11**
5.1 Household Characteristics and Socioeconomic Characteristics	11
5.2 Economic Valuation of Mangrove Forests	15
5.3 Indirect Value of Mangrove and Fishery Linkages	22
5.4 Perceptions of the Mangrove Ecosystem	24
6.0 CONCLUSIONS AND POLICY IMPLICATIONS	**26**
LITERATURE CITED	**27**

LIST OF TABLES

Table 1.	Economic valuation techniques	6
Table 2.	Mangrove valuation studies in Cambodia	8
Table 3.	Sample size	11
Table 4.	Household characteristics and socioeconomic characteristics	13
Table 5.	Fuelwood collected by households in the surveyed villages	16
Table 6.	Charcoal bought by households in the surveyed villages	18
Table 7.	Mangrove trees collected by households and used for house construction	18
Table 8.	Snails collected by households	19
Table 9.	Vessel characteristics and value	19
Table 10.	Strengths of boat engine used by households	21
Table 11.	Moang net use by households	21
Table 12.	Fishing trips, gear, catch, price and costs	23
Table 13.	Instrument variables (2SLS) regression of profit function	23
Table 14.	Instrument variable (2SLS) regression of supply function	24
Table 15.	The advantages of the mangrove ecosystem	25
Table 16.	Storms, flooding and salt-water intrusion	25

LIST OF FIGURES

Figure 1.	Total economic value	5
Figure 2.	Number of mangrove studies in Cambodia, 1990–2014	7
Figure 3.	Map of the coastal provinces of Cambodia	9
Figure 4.	Fuelwood collected from mangrove forest in a surveyed village	16
Figure 5.	Mangrove forest near a surveyed village	16
Figure 6.	Vessels used for fishing in the surveyed villages	20
Figure 7.	A 13-hp engine	20
Figure 8.	A 24-hp engine	20
Figure 9.	Gill nets	21
Figure 10.	Participation in mangrove conservation and restoration	26

AN ESTIMATION OF THE PRODUCTION FUNCTION OF FISHERIES IN PEAM KRASAOB WILDLIFE SANCTUARY IN KOH KONG PROVINCE, CAMBODIA

Kong Sopheak, Cheb Hoeurn

EXECUTIVE SUMMARY

This report presents an economic analysis of the different uses and the indirect use value of mangroves in terms of their support as nurseries and breeding grounds for commercially important finfish in Koh Kong, Kep, Kampot, and Preah Sihanouk, which are four coastal provinces of Cambodia. This study primarily aimed to provide quantitative information on the direct and indirect use values of mangrove (in monetary terms) to policy makers through four case study villages.

Mangrove forests provide valuable benefits—they have direct and indirect use values for local communities. The direct use values of mangroves are products directly derived from mangroves (e.g., timber, fuelwood, wood for construction materials, and food). The indirect use value of mangroves is found through the support they lend to local and commercial fisheries by acting as nurseries and breeding grounds for many species of commercially important finfish.

This study surveyed 300 households in four different locations that have different mangrove characteristics. A total of 75 households in each location were surveyed in order to collect information on the traditional uses of mangrove extracted by the local communities. This study estimated the direct use value of mangrove products collected by households, including fuelwood, charcoal, wood for construction materials, fish, and snails. The study also estimated the indirect use value of mangrove forest resulting from its nursery and breeding ground services for commercially important finfish.

The results show that the estimated net total mean value of the direct use value of mangrove obtained by households is USD 10,493.82 per year. The estimated aggregate mean value of fuelwood collected by households is USD 98.02 USD per household per year, while the aggregate mean value of all the fuelwood collected by all the households across all the villages is USD 54.81 USD per household per year. The aggregate mean value of mangrove poles collected by households is USD 615.37 per household per year, with the aggregate mean value of all the poles collected by all the households in all the villages being USD 181.88 per household per year. The aggregate mean value of the snails collected by households is USD 214.89 per household per year, and the aggregate mean value of all the snails collected by all households across all the villages is USD 72.28 per household per year. The mean value of fishing households is approximately USD 2,793.13 per household per year in the normal season and USD 5,504.22 per household per year in the fishing season. In total, the mean value of the direct use value of mangrove from fuelwood collection, mangrove pole collection, snails, and fisheries is estimated at USD 5,076.95 per household per year. The indirect use value of mangrove in terms of its value as breeding and nursery grounds for fish is approximately USD 44.82 per household per year.

Both the direct and indirect values derived from mangrove forests are very high. Thus, failing to find and implement appropriate management strategies and policies on mangroves conservation would lead not only to serious or irreversible ecological degradation, but also to substantial economic losses.

1.0 INTRODUCTION

1.1 Background

Mangrove ecosystems are an important category of wetland system that shelters coastlines and estuaries (Suthawan 1998). Mostly, mangroves are found in the tropics, and they are rich in flora and fauna. The major environmental services of mangroves include flood control, storm protection, shore stabilization, and the prevention of soil erosion. Mangroves are also a biomass export and a nursery ground for marine life. The main ecological service provided by mangroves is the support they provide to local fisheries. Mangroves act as nurseries and shelters for many species of commercially important finfish and crustaceans (Bann 1997). About 85,100 hectares (ha) of mangroves in Cambodia fringe the coast of the Gulf of Thailand. About 75% (63,200 ha) of these mangroves are found in Koh Kong; while 16% (13,200 ha) are located in Sihanoukville. The remaining 9% (7,300 ha) are located in Kampot (Ministry of Environment 2005). Cambodia's mangrove resource is important to the local communities; more than 70% of the coastal population in Cambodia relies on their products and resources (Rizvi and Singer 2011). During the last few decades, however, mangroves in Cambodia have been rapidly disappearing at an alarming rate of approximately 1,362 ha (1.6%) from 1990–2000 and 1,617 ha (1.9%) from 2000–2010 (Steffen and Greg 2012).

Mangrove areas in Cambodia have been designated within the protected areas system, such as the Peam Krasaop Wildlife Sanctuary (PKWS). Koh Kapik and the associated islets situated within PKWS have been nominated as a wetland of international importance under the Ramsar Convention. However, management plans for these areas are yet to be developed. Mangroves in Cambodia are under intense pressure from competing resource uses. Fish stocks have depleted from 10–20 kilograms per night (kg/night) to 3–4 kg/night (using small-scale fishing gear) (Koch 2004), and the extent of mangroves has been much reduced due to the demand for wood, timber, and land to expand agriculture and aquaculture production and residential development (An et al. 2009). The rapid decline of mangrove forests not only threatens fishery productivity, but also leaves many coastal areas vulnerable to natural disasters (Barbier 2007; Marsche 2012).

In Cambodia, the Fishery Law of 1987 declared that exploiting mangroves for any purpose is illegal. As a result, shrimp farming activities declined due to the loss of shrimp productivity, which automatically reduced the pressure on mangrove clearance. About 70% of shrimp farms were abandoned by 1996 (Mastaller 1999). It is unknown how many shrimp farms currently exist, but only a few are believed to be presently operating. In 1994, the Government also issued a decree that banned cutting mangroves for charcoal along coastal areas. Then, the Anti-charcoal Kiln Committee was established, which consisted of the local authority, Ministry of Environment (MoE) staff, and other relevant agencies, to control illegal charcoal activities. The committee was active for a short time but, due to a lack of resources, failed to stop all charcoal production. Several new government initiatives on coastal projects have been undertaken that have relied on working groups constituted by provincial departments of the Environment, Fisheries, Tourism, and Public Work and Transportation. In addition, three central-level coordinating bodies exist:

1. the National Committee for Land Management Urbanization and Construction, created in 1997 to regulate construction planning based on a zoning plan;
2. the National Steering Committee for Coastal Zone Management under the MoE, created in 1997 to address coastal management issues; and
3. the Coastal Coordinating Unit within the MoE, which addresses environmental problems.

These committees look after the overall management work in coastal provinces and contribute to the management of mangrove forests, including the prevention of conversion of mangrove to shrimp farming, charcoal production, and salt farming.

Even though these mangrove conservation efforts have been widely implemented, there is little evidence that they have been effective. This is because the value of the role of mangrove forests is underestimated, and also because government policy is biased toward other development purposes. Economic decisions based only on the direct goods and services of mangroves (e.g., forestry resources) represent a minor part of the total economic value of mangroves. The underestimation of the indirect value of mangrove forests constitutes part of this policy failure (Suthawan 1998). The exploitation of mangroves for charcoal, wood, fish ponds, or similar "productive uses" is often pursued based on narrow economic valuations that focus on a single use of the mangrove forest. The indirect uses of mangroves, particularly when they act as nurseries and breeding grounds for commercial finfish and crustaceans, need to be captured in order to assess correctly the foregone benefits of mangroves and to compare them with the actual returns of uses that are given a development priority. The production function approach has strengths as a method in estimating the indirect value of mangroves; it can show the relationships between fish caught and mangrove areas and other related inputs.

This study uses the Market Price Method to estimate the direct use value of mangroves, and uses the Production Function Method to estimate the indirect value of mangroves for fisheries in coastal provinces of Cambodia.

1.2 Description of the Problem

Global mangrove area has been rapidly declining, with around 35% of the total mangrove area lost in the past decades. Coastal mangrove systems are now considered one of the most threatened ecosystems on earth, even more than coral reefs and tropical forests (Valiela, Bowen, and York 2001). Many models have been constructed to underpin the reasons for this decline, the time period, and how mangrove forests are being converted to other land uses; but most of these models just provide implications based on their assumptions. Models for quantifying the relationship between variables using empirical data and statistical methods are rarely found.

Mangrove forests and aquatic resources along the coastal areas of Cambodia have been placed under pressure by inward migration, marketing opportunities, and land reclamation (i.e., filling waterways with sand to create artificial land) (Rizvi and Singer 2011). The deforestation of mangrove forest takes place for several reasons, including the need for wood, fuelwood, and for cultivation; these things are overexploited by local users. During the last few decades, mangrove forests in Cambodia have rapidly disappeared at the alarming rate of approximately 1,362 ha (1.6%) from 1990–2000 and 1,617 ha (1.9%) from 2000–2010 (Steffen and Greg 2012). Fish stocks have declined due to the extent of mangrove depletion for wood and timber and for land for the expansion of agriculture, aquaculture, and residential development (An et al. 2009). Consequently, fish catch per unit effort has reduced from 10–20 kg/night to 3–4 kg/night (using small-scale fishing gear) (Koch 2004). The rapid decline of mangrove forest not only threatens the productivity of fisheries but also leaves many coastal areas vulnerable to natural disasters (Barbier 2007; Marsche 2012).

Failing to find and implement appropriate management strategies and policies can lead to substantial economic losses and unsustainable ecological degradation. The authority responsible for coastal management in Cambodia has not yet been clearly identified, and the responsibilities of different authorities overlap. Reducing the deforestation of mangrove forests is one of the issues that typically suffers as a result of this lack of transparency and coordination. The Department of Fisheries of the Ministry of Agriculture, Fisheries, and Forestry (MAFF) are mandated to manage flooded forest, whereas the Department of Nature Conservation and Protection of MoE is supposed to monitor mangrove forests. However, in an attempt to ensure the sustainable management of mangrove forests, provincial governments have recently stopped commercial and domestic charcoal production, declaring it to be illegal. Responsible institutions, such as the Forestry Administration (FA), MAFF, MoE, and local villages, communes, and district and provincial authorities have strongly encouraged and have been involved in rehabilitating mangrove forests. Unfortunately, these activities have failed, largely because the nonmarket values of mangrove forest have not been fully realized and considered in the appraisal process. There are other contributory factors that can affect fishery productivity, which remain unknown.

1.3 The Significance of this Study

Mangrove forests play a significant role in supporting local and national economies and the coastal environment through the provision of construction materials and energy. They also serve as fish breeding and nursery grounds and as habitats for waterbirds and mammals. Moreover, they prevent coastal areas from eroding and reduce natural hazards from storms and waves, thus, maintaining the balance of the natural environment of coastal areas. In particular, mangroves indirectly support economically important fisheries by providing free ecological services such as habitats, food, and good water quality.
Thus, overexploiting mangroves can adversely affect fisheries, and ultimately affect local people's livelihoods in coastal communities.

Given the fact that a majority of the population in coastal areas depends heavily on fisheries, information that clearly describes the function of mangroves within the context of fisheries is needed so that communities can better understand how important mangroves are. Although several interventions designed by government institutions, and concerned NGOs and INGOs have been solely and jointly implemented with regard to sustainable fisheries management in coastal areas, there is little evidence that these attempts have been effective. For instance, the implementation of the Coastal Zone Management Project (funded by Danida) and the Participatory Management of Coastal Resources Project have not produced fruitful results because stakeholders—particularly local communities—have little awareness of the plans entailed in such initiatives and of the nonmarket value of mangrove forest. The values of the roles of mangrove forests are always underestimated and decision making is biased in favor of other development purposes. This is because economic decisions are taken based only on the value of direct goods and services provided by mangroves (e.g., forestry resources) even though this represents only a minor part of the total value of mangroves. One reason for accounting for only the productive uses of mangroves is the ease with which this output can be marketed and illustrated. By attempting to illustrate the total economic value of mangrove forest, this study aims to address three main research questions:

1. How many valuation studies on mangrove forests and on the links between mangroves and fisheries have been carried out, both published and unpublished, in Cambodia?,
2. What are the direct use values of mangrove in the coastal provinces of Cambodia?
3. What are the impacts of the indirect values of mangrove? (e.g., acting as nurseries and breeding grounds for fisheries in coastal provinces of Cambodia)

The results of this study will provide empirical information on the value of mangrove forests and on the number of valuation studies on mangroves that have been carried out in Cambodia. This information is useful for farmers, local authorities, and policy makers; and will help them to make better decisions that would avoid bias toward development options where the output is easy to market and measure. The results of this study will also generate a case study on the indirect value of mangroves and their links to fisheries, which will use a production function approach. The geographical focus of the study is Kep, Kampot, Preah Sihanouk and Koh Kong provinces, where all the mangrove forests of Cambodia are located.

Given the important role mangrove forests play in supporting the productivity of fisheries and the livelihoods of people in coastal communities, it is time that local authorities and policy makers realize the importance of the nonmarket value of mangrove forests. All stakeholders should realize that some of the keys to increasing fisheries productivity in coastal areas are

1. to review and assess the valuation studies on mangrove forests carried out in Cambodia,
2. to estimate the direct use values of mangrove forests in the coastal provinces of Cambodia, and
3. to estimate the impact of the indirect values of mangrove forests on fishery productivity in the coastal provinces of Cambodia using the production function approach.

1.4 The Hypothesis of the Study

This study aims to measure how the changes in the characteristics of mangroves as inputs lead to changes in fish catch as output during both normal and fishing seasons. The research hypothesizes that mangrove forests play a role in improving the productivity of the fisheries of adjacent communities.
This study estimates the production functions for this activity, allowing for how the characteristics of mangrove forests impact productivity. The production functions of the mangrove-related fishery activities of local communities are estimated. In the production functions, the study includes variables that reflect the quality of mangrove forests to allow these variables to impact on productivity. The distance from fishing sites to mangrove forests is also included (where appropriate) in order to test for the effect of the distance to the forest on productivity.

1.5 The Scope of the Study

The study was conducted in four coastal provinces of Cambodia where all the Cambodian mangrove areas are located, namely, Koh Kong, Kep, Kampot, and Preah Sihanouk provinces. In assessing the economic value of mangroves, this study emphasizes the "use value" only, which accordingly comprises the direct and indirect use values. The value of biodiversity and the nonuse values of mangroves are not assessed in this study. Although there are several components of use value that should be considered, it is not possible to address them all immediately. The present study identifies only two components where data availability allows the conduct of useful economic valuation methods. These components include the direct use value of mangroves in terms of local community usage and the indirect value in terms of offshore fishery linkage. The agencies that are likely to use the results of this study are mangrove community forestry, Fauna and Flora International (FFI), the International Union for Conservation of Nature and Natural Resources (IUCN), Conservation International (CI), the Fisheries Action Coalition Team (FACT), MAFF, MoE, and the Fisheries Administration (FiA).

2.0 REVIEW OF LITERATURE

2.1 Total Economic Value

Economic valuation methodology focuses on the monetary measurement of a change in an individual's well-being based on a change in environmental quality. This measured value is known as total economic value (TEV) and consists of use value (UV) and nonuse value (NUV). Use values can be categorized into direct use (DUV), indirect use (IDV) and option value (OV). Unlike UV, NUV is more difficult to define and measure, and can be subdivided into existence value (EV) and bequest value (BV) (Figure 1).

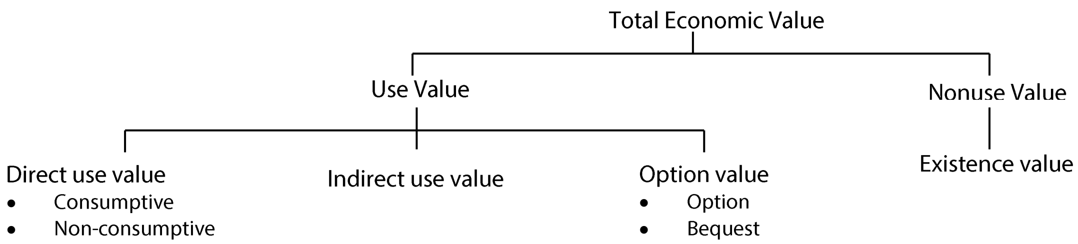

Figure 1. Total economic value

Direct use values refer to ecosystem goods and services that are used directly by human beings. They include the value of consumptive uses such as harvesting of food products, timber for fuel or construction, and medicinal products and hunting of animals for consumption; and the value of non-consumptive uses such as the enjoyment of recreational and cultural activities that do not require harvesting of products. Direct use values are most often enjoyed by people visiting or residing in the ecosystem itself. Meanwhile, *indirect use values* are derived from ecosystem services that provide benefits outside the ecosystem itself. Examples include the natural water filtration function of wetlands, which often benefit people far downstream; the storm protection function of coastal mangrove forests, which benefit coastal properties and infrastructure; and carbon sequestration, which benefits the entire global community by abating climate change. These functions often affect activities that have directly measurable values, allowing their values to be estimated. *Option values* are derived from preserving the option to use in the future ecosystem goods and services that may not be used at present, either by oneself (option value) or by others/heirs (bequest value). Provisioning, regulating, and cultural services may all form part of option values to the extent that they are not used now but may be used in the future. *Nonuse values* refer to the enjoyment people may experience simply by knowing that a resource exists even if they never expect to use that resource directly themselves. This kind of value is usually known as *existence value* or, sometimes, passive use value.

2.2 The Ecological Services of Mangrove Forest

Mangroves are highly productive ecosystems and they generate a number of direct and indirect goods and services. These include products such as timber, fuelwood, honey and wax, fish, fish fingerlings, forage, etc.; and services such as flood control, erosion control, storm surge protection, shoreline protection, groundwater recharge, nutrient recycling, microclimate regulation, ozone layer stabilization, and recreation (Dixon and Lal 1997; FAO 1982). Mangrove swamps are also natural sewage treatment plants. For example, the *Rhizophora* mangroves that predominate in the fringe habitat have a well-developed prop-root system that is flooded semi-diurnally by tides and may provide fish with a habitat. By creating a physical barrier that slows water movement from the land and traps sediment, mangroves reduce erosion along estuaries and creeks. If managed incorrectly, removing mangroves can result in shoreline erosion and the mobilization of marine sediment. This can cause sedimentation resulting in the shallowing of estuaries and waterways and a reduction in water quality, which ultimately leads to a decline in fishery productivity.

2.3 The Relationships between Mangroves and Fisheries

Most studies agree that mangrove forests play a significant role in preventing natural disasters such as floods and storms, and also in lessening their impact (Das and Vincent 2009). Mangrove forests also protect cultivation conditions by preventing saline intrusion (Phan and Quan 2012; Russell 2012; Saint-Paul and Schneider 2010). With regard to fisheries, mangroves provide nursery habitats for fish, which are an important determinant of fish yields (Barbier 2000; Barbier and Strand 1998; Rönnbäck 1999). Offshore fishery productivity is strongly correlated to the area of mangrove; thus, a decline in mangrove area reduces near-shore and off-shore fishery yields (Grasso 1998). Lal (1990) assumed that half of the fish stock is mangrove-dependent. Studies in Eastern Australia have estimated that around 67% of the entire commercial fish catch is composed of species dependent upon mangrove estuarine areas (NT DIPE 2002).

2.4 Environmental Valuation Techniques

Economic valuation offers a way to compare the diverse benefits and costs associated with ecosystems. Economic valuation attempts to measure and express the ecosystem in a common denominator, typically a monetary unit. All benefits and costs are valued in terms of their effects on humanity. Economic valuation methodology involves the monetary measures of a change in individual's well-being with regard to a change in environmental quality. Most economic valuation methods can be adapted to better reflect the local values of mangroves, although different techniques have varying degrees of potential. Many techniques are survey-based, which means that a local assessment step can be quite easily added to the process. Local values can be assessed by focusing on resources of value to livelihoods assessing nonmarket as well as market values, and involving communities in survey design and analysis. The economic valuation techniques commonly used are given in Table 1.

Direct use surveys can identify a wealth of information about local values as well as data for economic analysis. However, intangible components such as cultural or spiritual values, which can be as or more significant for local people, are difficult to quantify in economic terms, though not impossible. Approximate values can be assigned using survey-based methods such as contingent valuation or ranking to elicit willingness to pay.

Table 1. Economic valuation techniques

Valuation Techniques	Description
Hedonic pricing	Hedonic methods look at differentials in property prices and wages between locations, and isolate the proportion of this difference that can be ascribed to the existence or quality of mangrove goods and services.
Travel costs	Mangrove forests typically hold a high value as a recreational resource or destination. Although in many cases, no charge is made to view or enjoy natural ecosystems and species, people still spend time and money to reach mangrove forests. This spending on transport, food, equipment, accommodation, time, etc. can be calculated, and a demand function constructed relating visitation rates to expenditures can be made. These travel costs reflect the value that people place on leisure, recreation, or tourism aspects of mangrove forests.
Replacement costs	Even where mangrove goods and services have no market themselves, they often have alternatives or substitutes that can be bought and sold. These replacement costs can be used as a proxy for mangrove resource and ecosystem values, although they usually represent only partial estimates or typically exaggerate the value of ecosystem services.

Table 1 continued

Valuation Techniques	Description
Effects on production	Other economic processes often rely on mangrove resources as inputs, or on the essential life support provided by wetland services. Where they have a market, it is possible to look at the contribution of mangrove goods and services to the output or income of these wider production and consumption opportunities in order to assess their value.
Damage costs avoided	The reduction or loss of mangrove goods and services frequently incurs costs in terms of damage to, or reduction of, other economic activities. These damage costs avoided can be taken to represent the economic losses foregone by conserving mangroves.
Contingent valuation	Even where wetland goods and services have no market price and no close replacements or substitutes, they are frequently of a high value to people. Contingent valuation techniques infer the value that people place on wetland goods and services by asking them their willingness to pay for them (or willingness to accept compensation for their loss) under the hypothetical scenario that they would be available for purchase.
Choice experiment	The choice experiment method is similar to contingent valuation in that it can be used to estimate economic values for virtually any ecosystem or environmental service, and can be used to estimate nonuse as well as use values. It is a hypothetical method—it asks people to make choices based on a hypothetical scenario. However, it differs from contingent valuation because it does not directly ask people to state their values in dollars. Instead, values are inferred from the hypothetical choices or tradeoffs that people make. The choice experiment method asks the respondent to state a preference between one group of environmental services or characteristics at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost.

2.5 Mangrove Valuation Studies in Cambodia

There have not been many economic valuation studies on mangroves in Cambodia. A keyword search for "mangroves in Cambodia" or "mangrove economic valuation in Cambodia" using Google and Google Scholar Search, supplemented by visits to the offices and libraries of NGOs, shows that between 1990 and 2014, there were 33 published or unpublished papers on mangrove studies in Cambodia (Figure 2). Most of the studies focused on mangrove management, including conservation and replanting programs (Table 2). Only five studies focused on the economic valuation of mangroves through the application of economic valuation methods. The shortage of economic valuation studies of mangrove forests in Cambodia means that there is little evidence of the quantitative value of mangroves, which has probably not been considered in decision-making processes. The number of economic valuation case studies on mangroves in Cambodia needs to be conducted to fill this gap and to reduce the decision-making bias that allows the conversion of mangrove forests to other land use options.

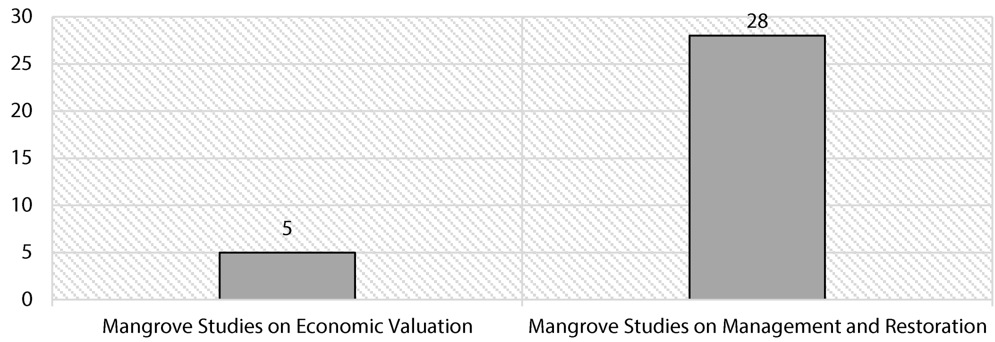

Figure 2. Number of mangrove studies in Cambodia, 1990–2014

Table 2. Mangrove valuation studies in Cambodia

Author and Year	Title of Study	Ecosystem Services	Method Used	Value	Funding
Bann (1997)	An Economic Analysis of Alternative Mangrove Management Strategies in Koh Kong Province, Cambodia	Food (local community use and commercial shrimp farming)	Market price	Local fishing benefits were estimated at USD 84/ha; fuelwood was valued at USD 3.50/ha; sustainable charcoal production could provide benefits of USD 413/ha; overall shrimp farms in the area suffered an average loss of USD 1,103/ha; individual farms have reported losses ranging from USD 40,000–240,000.	EEPSEA
Ke (2008)	National Report on Mangroves in South China Sea: Cambodia	Commercial shrimp farming, firewood, construction wood, medicinal plants, food, roofing material	Cost and benefit analysis Market price	The net value resource use in Ream National Park was estimated at USD 1.24 million or an average of USD 233 for every household living in and beside the National Park. Local fishing benefits were calculated to be USD 84/ha. Although 50% of farms made a profit, overall shrimp farms suffered an average loss of over USD 1,000/ha. Mangrove clearance would result in a loss of local income of around USD 500/ha. Firewood value was estimated to be USD 112,062 per year; construction wood, USD 23,659 per year; medicinal plant, USD 10,788 per year; food value, USD 17,695 per year; and roofing materials, USD 13,397 per year.	UNEP, UNEP/GEF South China Sea Project, Global Environmen t Facility
Emerton, Seilava, and Peraith (2002)	Bokor, Kirirom, Kep, and Ream National Parks, Cambodia: Case Studies of Economic and Development Linkages	Storm protection and erosion prevention, provisioning services (breeding grounds for fish, firewood, medical plants and construction materials)	Cost and benefit analysis	The provisioning benefits of mangroves may be worth even more than their coastal protection value. The 1,800 ha of Ream National Park in Cambodia was valued at USD 300,000 for storm protection and erosion services alone. The provisioning services of the park, such as breeding grounds for fish, firewood, medicinal plants and construction materials, were valued at USD 600,000.	-
De Groot et al. (2006)	Valuing Wetlands: Guidance for Valuing the Benefits Derived from Wetland Ecosystem Services	Wetland ecosystem service	Market price	The average yearly household value of the Veun Sean wetland, Cambodia, was USD 3,200 in 2005, with USD 425 per household per year in fisheries value, or USD 650 per year to poorer households from income earned from selling fish, mainly used to purchase rice.	-
ADB (1999)	Draft Coastal and Marine Protected Area Plan, Coastal and Marine Environmental Management in South China Sea, Phase 2	Mangrove forest, coastal wetlands, coral reefs, and sea-grass	Market price Cost and benefit analysis	The net annual benefits of mangrove forest were estimated at USD 4.9 million per year (USD 183/ha per year). Coastal wetlands provide net annual benefits of USD 7.1 million per year (USD 130/ha per year). Coral reefs provide net annual benefits of USD 0.14 million per year (USD 300/ha per year). Seagrass provides net annual benefits of USD 0.05 million per year (USD 300/ha per year). In total, the economic value of major coastal resources in Cambodia was approximated at USD 12.2 million per year.	

Note: ADB = Asian Development Bank; EEPSEA = Economy and Environment Program for Southeast Asia; UNEP = United Nations Environment Programme

In summary, many studies attempted to assess the direct use value of mangrove forests using the market price method, but very few of them assessed the indirect value of mangrove forests, especially via the production function approach. Mostly, the total economic value of mangroves has not been captured, particularly its indirect value, which has been overlooked and underestimated. This means that there is a gap where the total economic value of mangrove forests should be recognized; this gap has contributed to the failure in policy, management, and enforcement of mangrove protection.

3.0 THE STUDY SITE

The coastline of Cambodia is rarely visited and is sparsely populated. Coastal ecosystems can be divided into coastline forest marine zones and mangrove forest (Figure 3). Mangrove forests interface with the coastline in the four provinces of Koh Kong, Kep, Kampot, and Preah Sihanouk. This study covered all of these provinces. Koh Kong province is situated in the southeastern geography of Cambodia and covers an area of 11,160 square kilometers. Koh Kong's coastline accounts for 260 kilometers (km) of Cambodia's total coastline of 460 km, and the vast majority of Cambodia's mangrove forests (63,700 ha) can be found here (Bann 1997). Kep is located on the coast of the southwestern area of Cambodia. The eastern part of the province has abundant natural resources, fisheries, mangrove forests, and salt farms. The western part of the province has salt farms and many mangrove forests, with a total area of 500 ha. Kampot province is located in the southwest, with a total coastline of 73 km^2, which consists of 7,900 ha of mangrove. Preah Sihanouk province is located in the north of Kampot province, with the Gulf of Thailand on the south and west. The total area of mangrove forest in this province is 13,500 ha. All mangroves in Cambodia are designated protected areas.

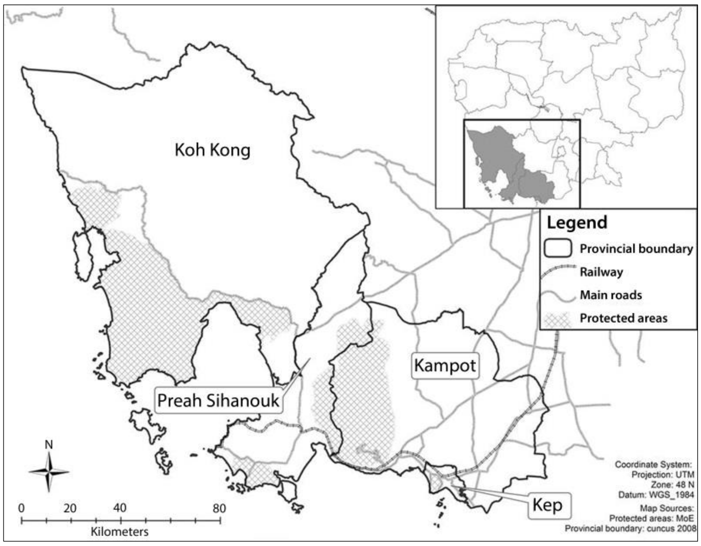

Figure 3. Map of the coastal provinces of Cambodia

4.0 RESEARCH METHOD

In assessing the economic value of mangroves, this study focuses on the "use value" only, which comprises direct and indirect use values. The value of biodiversity and the nonuse value of mangroves are not assessed in this study. There are several components of use value that should be considered. However, it is not possible to address them all immediately. The present study identifies two components where data availability allows the conduct of useful economic valuation methods. These components include the direct use value of mangroves in terms of local community usage and the indirect value in terms of offshore fishery linkage.

4.1 The Market Price Method

The direct use value of the mangrove based on local use was assessed from the net income generated by locals from the mangrove in terms of timber, fuelwood, wood used in house construction, and animal products such as birds and snails collected, which were directly collected from the mangrove swamp. The market price method was used to calculate the gross income generated for the products that were sold. However, for the products that were used only for subsistence purposes, the gross income was calculated based on surrogate prices with the market prices of the closest substitute for such a product and the opportunity cost of time spent in collecting the product. By doing so, the cost of extraction was deducted from the gross income to derive the direct use value. The formula for calculating the net income generated from the direct use value of mangrove is

$$NI = \sum\{P_i\, Q_i - C_i\} \qquad \text{Equation (1)}$$

where:

NI	=	net income generated from the direct use value of mangrove,
P_i	=	price of product *i*,
Q_i	=	amounts of product *i* being collected, and
C_i	=	costs involved in the collection of product *i*.

The data on the frequency and quantity of different products collected from the mangrove as well as the time and labor spent in collecting those products were collected through household surveys; the opportunity cost of time spent collecting the products was collected via focus group discussions.

4.2 The Empirical Model of Production Function

Indirect use value is determined by the contribution of resources in terms of their environmental and ecological services to support current production and consumption. One important ecological service of mangroves is the support it lends to offshore fisheries by serving as a nursery ground. Even though reduced production of offshore fisheries is normally attributed to overfishing or open access, the situation worsens when the mangrove area decreases. However, mangrove forests in Cambodia are not subject to complete open access because all mangrove forests are designated protected areas. This means that no outsiders can enter the fishing grounds within mangrove areas, and only local fishers can access the local mangrove areas. The authors used the profit function model to estimate the indirect use value of the mangrove in terms of its support to offshore fisheries, using the following description:

$$\pi = f(p, w, K, E). \qquad \text{Equation (2)}$$

A profit function relates profit (π) to the price of output (p), the prices of inputs (w), fixed factors (K), and environmental quality (E).

Fixed factors include both produced capital (e.g., boats and gear) and human capital (e.g., fisher's education and experience). The supply function is derived from the profit function and relates output (q) to the same variables:

$$q = f(p, w, K, E). \qquad \text{Equation (3)}$$

4.3 Sampling Procedures

The study involved multi-stage sampling. First, the authors selected the four coastline provinces of Cambodia where all the Cambodian mangrove forests are located. Then, the study clustered to select one village from each province by considering the variation of its mangrove forest density and the total number of fishermen in each village respectively. Community leaders and commune chiefs were consulted in order to identify the best villages to conduct the household survey. As a result, four villages were selected for the household survey (Table 3). A total of 300 households were surveyed across four different villages (75 households in each location).

Table 3. Sample size

Villages Surveyed	Commune	District	Total Households	Sample Sizes
Phum Ti Buon, Koh Kong	Dongtoung	Kheamarakphumen	1,275	75
Phum Thmey, Kep	Prey Thum	Kep	571	75
Kampong Kaes, Kampot	Trapeang Sangkae	Teuk Chhu	312	75
Phum Pir, Preah Sihanouk	Kampenh	Steung Hav	197	75
Total sample size				300

4.4 Methods of Data Gathering

The study combined both qualitative and quantitative data sources, including literature review, key informant interviews (KII), focus group discussions (FGD), and a household survey. The literature review was processed online, and KIIs were done by visiting relevant government agencies and international agencies (e.g., FFI, CI, IUCN, FiA, MoE, and MAFF). The purpose of reviewing the existing literature and conducting KIIs was to determine the number of valuation studies on mangrove forests that have already been conducted in Cambodia. The FGDs were conducted with fishermen in order to gather primary data for inputting into the production function model such that the impact of mangrove forests on fisheries can be estimated. The household survey was conducted with fishermen for the same reason. The primary data were gathered through face-to-face interviews. All data collection activities were done by the research team and eight experienced enumerators. All the enumerators were trained by the research team on interview techniques and survey administration. A variety of field approaches for gathering primary data were employed:
(1) pretesting of questionnaires, (2) analysis of pretest data, (3) training of enumerators, and
(4) commencement of the main survey.

The surveys were conducted from 1–16 August, 2014. Each village location was surveyed for four days by six enumerators. To control enumerator bias, the same six enumerators were hired to interview all 300 households across the four different locations. Thus, the same six enumerators surveyed 75 households in one village and then moved to survey another 75 households in the next selected village.

The surveyed households were selected in the following manner: the end of the bay was the starting point from where the households were counted—the last house in the village was surveyed; then, moving forward from this point, three households were skipped, then the next household was surveyed, and so on. When the head of the household was not at home during the survey period, the enumerators interviewed the oldest member of the household instead, provided that they were over 18 years of age. Interviewees were asked to recall their fish catch for one year so that the researchers could capture the different values during the normal and fishing seasons. The enumerators were advised to give the interviewees enough time to think and recall before giving their answers. Also, the enumerators were trained to clarify any "suspicious" answers from the interviewees. For example, if the interviewee answered that they went fishing about 20 km from the mangrove area and they said it took around 10 minutes, then the enumerators were trained to question the interviewee by asking "is it really 20 km in 10 minutes by boat?" Then, if the interviewee said it was only 10 km, then the enumerator would note the answer as 10 km instead of 20 km.

5.0 RESULTS AND DISCUSSION

5.1 Household Characteristics and Socioeconomic Characteristics

5.1.1 Phum Ti Buon village

Phum Ti Buon village is located in Dongtoung commune in Kramaratphomen district, Koh Kong province, and comprises 1,275 households (6,454 people). According to the village chief of Phum Ti Buon in 2014, the total mangrove area that households depend on is 23,750 ha. The majority of the people living in this area are Khmer Islam (80%) and Khmer (20%). The distance from the village to the nearest market (Dongtoung market) is about 5 km.

Based on the information revealed by the survey, men constitute 81.3% of household heads and women constitute 18.7% of household heads (Table 4). Some 52.7% of respondents are educated to primary school level, 45.3% are illiterate, and 12.0% are educated to secondary school level. The lower percentage of educational attainment of the household head was because these individuals lived through the chronic civil wars in Cambodia from 1975 to 1979. The mean ages of the male household head and female household head is 43.6 and 49.1 years, respectively. Households with 2–4 members, 5–7 members, and 8 or more members make up 32.5%, 50.1%, and 17.4% of households, respectively. The mean household size is 5.8 persons per family. Most of the households (78.3%) moved to live in Phum Ti Buon village more than 20 years ago, and the remaining 21.7% of households recently moved to the village (around five years previously). The main occupation of the respondents is fishing (94.6%), followed by trading fish or trading general products (29.7%).

All the respondents said that mangrove forests have a positive impact on fishery activities. They believe that mangrove forests play a very important role in protecting them from storms (89.3%), preventing saltwater intrusion (28%), supporting fish habitats (97.3%), maintaining water quality (17.3), producing wood and fuelwood (74.7%), supporting wildlife habitats (97.3%), and providing recreational value (96%). The main reasons why mangroves are being depleted were because mangroves are being used for building houses and for claiming land to live on (96%), for planting crops (1.3%), and for collecting collection wood and fuelwood (50.7%). Some 76% of respondents said that in the last five years, the area of mangrove forest has increased a lot, 8% said that the mangrove has increased a little bit, 4% said that the mangrove has decreased a little bit, and 5.3% said that the mangrove has decreased a lot. There are two main reasons the area of mangrove forest has increased a lot over the last five years: (1) the prohibition of mangrove logging by the director of Peam Krasaob Wildlife Sanctuary has had an impact, and (2) the implementation of mangrove replanting projects has made a difference—at least three mangrove replanting projects have been implemented at the project sites in the last three years.

5.1.2 Thmey village

Thmey village is located in Kampong Penh commune in Kampot district, Kampot province. This village has approximately 571 households. According to the village chief of Thmey in 2014, the total mangrove area that households depend on is 500 ha. The majority of the people living in this area are Khmer Islam (90%) and Khmer (10%). The distance from this village to the nearest market (Kep market) is about 15 km.

Based on the survey information, male household heads make up 53.8% of the households surveyed, and female household heads make up 46.2% (Table 4). Some 65.5% of respondents are educated to primary school level, with 26.9% of respondents being illiterate, 7.6% of respondents educated to secondary school level, and none were able to enter the high school level. The lower percentage of educational attainment of the household head is because these individuals lived through the chronic civil wars in Cambodia from 1975 to 1979. The mean age of male household heads and female household heads is 47.4 years old and 39.3 years old, respectively. Households with 2–4 members, 5–7 members, and 8 or more members make up 30.7%, 57.8%, and 11.5% of households, respectively. The mean household size is 5.4 persons per family. Most of the households (70%) moved to live in Thmey village more than 20 years ago and the remaining 30% recently moved to the village (in the previous five years). The main occupation of the survey respondents is fishing (68%), followed by trading fish or trading general products (20%), and planting crops (16%).

Table 4. Household characteristics and socioeconomic characteristics

Characteristic	Whole Sample	Phum Ti Buon	Thmey	Kampong Kaes	Phum Pir
Gender of household head					
Male (%)	64.7	81.3	53.8	65.4	45.5
Female (%)	35.3	18.7	46.2	34.6	54.5
Mean age of household head					
Male	43.6	43.6	47.4	46.7	38.6
Female	44.1	49.1	39.3	43.5	43.4
Educational attainment of household head					
None (%)	40.7	45.3	26.9	44.2	30.3
Primary school (%)	46.7	52.7	65.5	44.3	48.5
Secondary school (%)	11.7	12.0	7.6	7.7	21.2
High School (%)	0.9	0.0	0.0	3.8	0.0
Mean number of years of schooling of household head					
Male	2.9	2.6	3.4	3.0	4.0
Female	2.1	1.1	2.4	1.5	3.0
Household size					
Single person household (%)	0.0	0.0	0.0	0.0	0.0
2–4 members (%)	37.2	32.5	30.7	33.3	22.6
5–7 members (%)	51.8	50.1	57.8	60.0	64.3
8 or more members (%)	11.0	17.4	11.5	6.7	13.1
Mean household size (male-headed household)	5.3	5.2	5.6	5.4	5.9
Mean household size (female-headed household)	5.3	6.6	5.0	5.0	5.9
Mean household size (all households)	5.3	5.8	5.4	5.2	5.6
Occupation					
Crop plantation (%)	8.9	0.0	16.0	19.6	6.1
Aquaculture (%)	0.0	0.0	0.0	0.0	0.0
Fishermen (%)	82.3	94.6	68.0	68.6	97.0
Trading fish or general products (%)	27.0	29.7	20.0	25.5	21.2
Sources of income					
Mean of income from crop plantation (USD/year)	211.2	0.0	287.5	262.5	295.0
Mean of income from aquaculture (USD/year)	0.0	0.0	0.0	0.0	0.0
Mean of income from fishermen (USD/year)	9,271.4	16,658.6	4,206.8	4,798.0	10,840.0
Mean of income from trading fish or general products (USD/year)	1,646.6	1,926.0	1,662.9	1,419.6	1,578.0

All the respondents said that mangrove forests have a positive impact on fishery activities. They believe that mangrove forests play a very important role in protecting them from storms (90.5%), preventing saltwater intrusion (47.6%), supporting fish habitats (100%), maintaining water quality (76.2%), producing wood and fuelwood (100%), supporting wildlife habitats (100%), and providing recreation value (100%). The main reasons for mangrove depletion are to build houses and to claim land to live on (35.2%) and to collect wood and fuelwood (43.7%). In the last five years, 37.3% of respondents said that the mangrove forest has increased a lot, 24% said that it has increased a little bit, 14.7% of respondents said that the area of mangrove has not changed, 17.3% said that it has decreased a little bit, and 6.7% of respondents said that the area of mangrove has decreased a lot.

5.1.3 Kampong Kaes village

Kampong Kaes village is located in Trapeang Sangkae commune in Kampot district, Kampot province. This village has 312 households (1,482 people). According to the village chief of Kampong Kaes in 2014, the total mangrove area that households depend on is 1,795 ha. The majority of the people living in this area are Khmer Islam (85%) and Khmer (15%). The distance from this village to the nearest market (Kampot market) is about 11 km.

Based on the results of the survey, men make up 65.4% of household heads, and women make up 34.6% of household heads. A majority of the respondents are educated to primary school level (44.3%), followed by illiteracy (44.2%), a secondary school education (7.7%), and a high school education (3.8%). The lower percentage of educational attainment of the household head was because these individuals lived through the chronic civil wars in Cambodia from 1975 to 1979. The mean age of male household heads and female household heads is 46.7 and 43.5 years, respectively. Households with 2–4 members, 5–7 members, and 8 or more members make up 33.3%, 60.0%, and 6.7% of households, respectively. The mean household size is 5.2 persons per family. Most of the households (80%) moved to live in Phum Ti Buon village more than 20 years ago, while the remaining 20% of households moved to the village recently (in the previous five years). The main occupation of the respondents is fishing (68.6%), followed by trading fish or trading general products (25.5%), and planting crops (19.6%).

All the respondents said that mangrove forests have a positive impact on fishing activities. They believe that mangrove forests play a very important role in protecting them from storms (90.9%), preventing saltwater intrusion (36.4%), supporting fish habitats (100%), maintaining water quality (50%), producing wood and fuelwood (97.7%), supporting wildlife habitats (81.8%), and providing recreational value (77.3%). The main reasons for mangrove depletion are to claim land to live on and to build houses (39.4%) and the collection of wood and fuelwood (87.9%). Some 86.6% of respondents said that the mangrove forest area has increased a lot in the last five years, while 3% of respondents said that the mangrove area has increased a little bit, 3% said it has not changed, 4.5% said that it has decreased a little bit, and 3% of respondents said that the mangrove area has decreased a lot. There are two main reasons for the increase in area of mangrove forest over the last five years: (1) the director of Trapeang Sangkae Ecotourism Fishing Community prohibited mangrove logging, and (2) a mangrove restoration project, which began in 2010 and which is supported by the Global Nature Fund in collaboration with BMZ (Federal Ministry for Economic Cooperation and Development) and the FACT (Fisheries Action Coalition Team) organization.

5.1.4 Phum Pir village

Phum Pir village is located in Kampenh commune in Stueng Hav district, Preah Sihanouk province. This village has 557 households (1,035 people). According to the village chief of Phum Pir in 2014, the total mangrove area that households depend on is 9,707 ha. The majority of the people living in this area are Khmer (75%) and Khmer Islam (25%). The distance from this village to the nearest market (Kampenh market) is about 15 km.

Based on the survey information, men make up 45.5% of household heads, and women make up 54.5% of household heads. The majority of respondents are educated to primary school level (48.5%), followed by illiteracy (30.3%), and secondary school level education (21.2%). The lower percentage of educational attainment of the household head was because these individuals lived through the chronic civil wars in Cambodia from 1975 to 1979. The mean age of male household heads and female household heads is 38.6 and 43.4 years, respectively. Households with 2–4 members, 5–7 members, and 8 or more members make up 22.6%, 64.3%, and 13.1% of households, respectively. The mean household size is 5.61 persons per family. Most households (85.7%) moved to live in Phum Pir village more than 20 years ago, while the remaining 14.3% households moved there recently (in the previous five years). The main occupation of respondents is fishing (97%), followed by trading fish or trading general products (21.2%), and planting crops (6.1%).

All the respondents said that mangrove forests have a positive impact on fishing activities. They believe that mangroves play an important role in protecting them from storms (87.9%), preventing saltwater intrusion (33.3%), supporting fish habitats (97%), maintaining water quality (39.4%), producing wood and fuelwood (75.8%), supporting wildlife habitats (60.6), and providing recreational value (57.6%). The main reasons for mangrove depletion were because mangrove areas are used for claiming land to live on for housing (33.3%) and for the collection of wood and fuelwood (54.5%). Some 21.2% of respondents said that the mangrove forest area has increased a lot in the last five years, while 18.2% of respondents said that the mangrove area has increased a little bit, 9.1% said it has not changed, 6.1% said that it has decreased a little bit, and 45.5% of respondents said that the mangrove area has decreased a lot. At the time of writing, only one mangrove restoration project has taken place in this community.

5.2 Economic Valuation of Mangrove Forests

5.2.1 Value selected for economic analysis

This research focuses on the economic valuation of non-timber forest products (NTFP) collected by households from the mangrove area. All NTFP collected by households are included in the analysis. These include fuelwood, wood for repairing and building homes, fish caught, and snails collected. 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.

5.2.2 Direct use values

Mangrove forests are directly collected for a number of products. Mangrove wood is collected for fuelwood, house construction, and repair materials; it is widely used by all villagers. The use of non-wood products such as resins, medicines, and reed/cane in the surveyed villages did not show the use of these products to be significant.

Fuelwood. Households collect fuelwood from the mangrove and use it as the main energy source for cooking, and this wood is sometimes burned to repel mosquitoes and other insects (Figures 4 and 5). The results showed that the percentages of households in Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir that collect fuelwood from mangrove areas is 33.3%, 65.4%, 71.2%, and 42.4%, respectively (Table 5). Most households reported that in the last five years, it has become more difficult to collect fuelwood from the mangrove forests, particularly after the mangrove communities were established. On average, each surveyed household in Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir collected fuelwood from the mangrove forest at the rates of 223.08, 614.16, 553.80, and 298.92 kilograms per year, respectively (Table 5). Fuelwood was collected at a frequency of 40.32 times per year in Phum Ti Buon, 21.24 times per year in Thmey, 32.04 times per year in Kampong Kaes, and 34.68 times per year in Phum Pir.

Using the market prices of fuelwood of USD 0.119, USD 0.110, USD 0.079, and USD 0.077 per kilogram, the mean value of fuelwood collected by households in the four surveyed villages is USD 89.19 per household per year in Phum Ti Buon, 119.57 USD per household per year in Thmey, USD 116.81 per household per year in Kampong Kaes, and USD 66.51 per household per year in Phum Pir. The mean value of the fuelwood collected by all the households in all the surveyed villages is USD 29.70, USD 78.19, USD 83.16, and USD 28.20 per household per year for Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir, respectively. The aggregate mean value of fuelwood collected per household is USD 98.02 per household per year, while the aggregate mean value of all the households in all four villages for fuelwood is estimated to be USD 54.81 per household per year.

Figure 4. Fuelwood collected from mangrove forest in a surveyed village

Figure 5. Mangrove forest near a surveyed village

Table 5. Fuelwood collected by households in the surveyed villages

Village	HHs Collected Fuelwood (%)	Amount of Fuelwood (kg/year)	Frequency of Collecting Fuelwood (times/year)	Prices of Fuelwood (USD/kg)	Mean Value of the Collected Households (USD/hh/year)	Mean Value of All Households in Village (USD/hh/year)
Phum Ti Buon	33.3	223.08	40.32	0.119	89.19	29.70
Thmey	65.4	614.16	21.24	0.110	119.57	78.19
Kampong Kaes	71.2	553.80	32.04	0.079	116.81	83.16
Phum Pir	42.4	298.92	34.68	0.077	66.51	28.20
Total					98.02	54.81

Note: USD 1 = KHR 4,000

Charcoal. The high density and hardness of mangrove wood is well suited for charcoal production. Mangrove wood has a high calorific value and produces little smoke when burned. However, based on the survey information and on the responses from each of the village chiefs, no households are currently allowed to collect mangrove for charcoal production. Households purchase charcoal from the market, thus, the value of charcoal was not included in the analysis.

The percentage of households in Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir that purchase charcoal are 50.6%, 30.4%, 20.7%, and 47.5%, respectively (Table 6). The value of charcoal is based on the average expenditure per household on charcoal for each village. Each household purchases an average of 362.4 kg/year of charcoal in Phum Puon, 291.6 kg/year in Thmey, 258 kg/year in Kampong Kaes, and 328.8 kg/year in Phum Pir. The frequency of the purchase of charcoal is about 25.2 times per year in Phum Ti Buon, 37.2 times per year in Thmey, 40.8 times per year in Kampong Kaes, and 31.2 times per year in Phum Pir. Using the market price of charcoal of USD 0.25, USD 0.20, USD 0.20, and USD 0.25 per kilogram, the mean value of purchasing charcoal for a household in each of the four surveyed villages is calculated to be USD 190.26 per household per year in Phum Ti Buon, USD 180.79 per household per year in Thmey, USD 175.44 per household per year in Kampong Kaes, and USD 213.72 per household per year in Phum Pir. The mean value of charcoal in all the households in each village is USD 96.27 per household per year in Phum Ti Buon, USD 54.96 per household per year in Thmey, USD 36.31 per household per year in Kampong Kaes, and USD 101.5 per household per year in Phum Pir. The aggregate mean value of charcoal purchasing households is approximated at USD 190.05 per household per year, while the aggregate mean value of all the households in all four villages for charcoal is USD 72.26 per household per year.

House construction and repair. Mangrove poles are often used for building and repairing houses, boats, and fences. The species *Rhizophoramacronata* is ideal for making fences, beams for houses, and foundation pilings. All the households in the four surveyed villages collect mangrove poles for building and repairing houses in combination with upland wood. Upland wood is either collected from upland areas or bought from sawmills; mangrove poles are collected from the mangrove forest. Based on the survey results, 22% of the households collect mangrove poles to build and repair houses. On average, each household collects 386 trees per year, 20.28 times per year to build and repair houses. Using the closest market prices to mangrove poles of USD 1.075 per tree, the mean value per household of mangrove trees used for house construction is estimated at USD 701.26 per household per year.

Households collect mangrove poles to build and repair houses in Phum Ti Buon (36%), Thmey (31.3%), Kampong Kaes (27.8%), and Phum Pir (25.0%) (Table 7). The average number of mangrove trees collected by households in the four surveyed villages is 397, 348, 489, and 249 trees per year in Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir, respectively. On average, the households collect mangrove poles 12, 18, 24, and 32 times per year in Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir, respectively. Using mangrove pole prices of USD 1.393 (Phum Ti Buon), USD 0.839 (Thmey), USD 0.852 (Kampong Kaes), and USD 0.993 (Phum Pir) per tree, the mean value of mangrove poles collected by households to construct and repair houses is estimated at USD 553.02, USD 444.74, USD 833.25, and USD 630.50 per household per year, respectively. The mean value of all the households in each village for collecting mangrove poles for the construction and repair of houses is estimated at USD 199.08 (Phum Ti Buon), USD 139.20 (Thmey), USD 231.64 (Kampong Kaes), and USD 157.62 (Phum Pir) per household per year. The aggregate mean value of mangrove poles collected by all households is USD 615.37 per household per year, while the aggregate mean value of all households in all four villages is USD 181.88 per household per year.

Table 6. Charcoal bought by households in the surveyed villages

Village	HHs that Purchase Charcoal (%)	Amount of Charcoal Purchased (kg/year)	Frequency of Purchasing Charcoal (times/year)	Price of Charcoal (USD/kg)	Mean Value of Purchasing Households (USD/hh/year)	Mean Value of all Households in Village (USD/hh/year)
Phum Ti Buon	50.6	362.4	25.2	0.25	190.26	96.27
Thmey	30.4	291.6	37.2	0.20	180.79	54.96
Kampong Kaes	20.7	258.0	40.8	0.20	175.44	36.31
Phum Pir	47.5	328.8	31.2	0.25	213.72	101.50
Total					190.05	72.26

Note: USD 1 = KHR 4,000

Table 7. Mangrove trees collected by households and used for house construction

Village	HHs that Collect Mangrove Trees (%)	No. of Trees Collected (trees/year)	Frequency of Collecting Trees (times/year)	Price (USD/tree)	Mean Value Collected Households (USD/hh/year)	Mean Value of All Households in Village (USD/hh/year)
Phum Ti Buon	36.0	397	12	1.393	553.02	199.08
Thmey	31.3	348	18	0.839	444.74	139.20
Kampong Kaes	27.8	489	24	0.852	833.25	231.64
Phum Pir	25.0	249	32	0.993	630.50	157.62
Total					615.37	181.88

Note: USD 1 = KHR 4,000

Medicine. Mangroves can be used for medicinal and other purposes. The species *Exciecaria agallocha* is used as an anti-diarrhea treatment, and a fungus called Sam Bok Sramoch ("Home of Ant") is dried and used as a medicine for lung disease. However, the use of traditional medicine collected from mangrove areas was not covered in the survey.

Wildlife resources. Villagers hunt for meat, skins, or fur in mangrove forests. They also gather honey from bees. Tortoise and birds eggs have either a subsistence or commercial value. However, the use of these resources is prohibited so this information was not collected in the survey.

Snails. The percentages of households that collect snails in each village is as follows: Phum Ti Buon, 30.7%; Thmey, 26.7%; Kampong Kaes, 48.0%; and Phum, Pir 32.0% (Table 8). On average, the amount of snails each household collects from the mangrove forest is 734.24, 375.92, 489.76, and 590.36 kilograms per year in Phum Ti Buon, Thmey, Kampong Kaes, and Phum Pir, respectively. The frequency with which snails are collected from mangrove forest is 103.56 times per year in Phum Ti Buon, 82.44 times per year in Thmey, 101.40 times per year in Kampong Kaes, and 85.56 times per year in Phum Pir. Using market prices of snails of USD 0.426, USD 0.392, USD 0.331, and USD 0.402 per kilogram, the mean value of snails collected by households is USD 312.78 per household per year in Phum Ti Buon, USD 147.36 per household per year in Thmey, USD 162.11 per household per year in Kampong Kaes, and USD 237.32 per household per year in Phum Pir. The mean value of snails collected by all the households in each village is USD 96.02 (Phum Ti Buon), USD 39.34 (Thmey), USD 77.81 (Kampong Kaes), and USD 75.94 (Phum Pir) per household per year. The aggregate mean value of snails collected by households is USD 214.89 per household per year, while the aggregate mean value of all the households in all the surveyed villages for the collection of snails is USD 72.28 per household per year.

Table 8. Snails collected by households

Village	Households that Collect Snails (%)	Amount of Snail Collected (kg/year)	Frequency of Collection (times/year)	Prices of Snails (USD/kg)	Mean Value of Collected Households (USD/hh/year)	Mean value of All Households in Village (USD/hh/year)
Phum Ti Buon	30.7	734.24	103.56	0.426	312.78	96.02
Thmey	26.7	375.92	82.44	0.392	147.36	39.34
Kampong Kaes	48.0	489.76	101.40	0.331	162.11	77.81
Phum Pir	32.0	590.36	85.56	0.402	237.32	75.94
Total					214.89	72.28

Note: USD 1 USD = KHR 4,000

Fishing. Fishing is the primary source of income for the majority of coastal families. Local fishing tends to occur near the shore because the boats are typically 5 horsepower (hp), 8 hp, 13 hp and 24 hp, and local people cannot afford the equipment needed to fish offshore.

Fishing vessels. Based on the survey information, 95.7% of respondents in Phum Ti Buon, 91.7% in Thmey, 86.2% in Kampong Kaes, and 90.9% in Phum Pir have their own fishing vessels; the remaining fishers in each village go fishing with a neighbor's vessel. The vessels that the households use for fishing in the four surveyed villages have an average width of 1.82 m, length of 10.69 m, and weight of 1.27 metric tons (Figure 6). Table 9 presents the characteristics of the fishing vessels used in the four villages and also for individual vessel value, if sold. On average, vessel value is USD 730.46 in Phum Ti Buon, USD 511.60 in Thmey, USD 526.70 in Kampong Kaes, and USD 834.21 in Phum Pir.

Figure 6. Vessels used for fishing in the surveyed villages

Table 9. Vessel characteristics and value

Village	Width (m)	Length (m)	Weight (t)	Value if sold (USD)
Phum Ti Buon	1.87	11.37	1.39	730.46
Thmey	1.40	7.18	1.04	511.60
Kampong Kaes	1.40	8.60	1.14	526.70
Phum Pir	2.21	11.89	1.50	834.21

Note: USD 1 = KHR 4,000

Horse power engine. The households in the four surveyed villages used vessels with 5 hp, 8 hp, 13 hp and 24 hp, which can be run either on diesel or gasoline (Figure 7 and Figure 8).

Figure 7. A 13-hp engine

Figure 8. A 24-hp engine

The power of the engines used by households in the surveyed villages varies (Table 10). In Phum Ti Buon, 4.0% of households used vessels with 5 hp, 5.3% used 8 hp, 78.7% of households used 13 hp, and 12.0% of households used 24 hp. In Thmey, 41.3% of the household respondents used vessels with 5 hp, 34.7% used 8 hp, 13.3% used 13 hp, and 10.7% used 24 hp. In Kampong Kaes 25.3% of the household respondents used vessels with 5 hp, 25.3% used 8 hp, 37.3% used 13 hp, and 12.0% used 24 hp. In Phum Pir, 25.3% used vessels with 5 hp, 13.3% used 8 hp, 37.3% used 13 hp, and 24.0% used 24 hp.

Table 10. Strengths of boat engine used by households

Village	5 hp (%)	8 hp (%)	13 hp (%)	24 hp (%)
Phum Ti Buon	4.0	5.3	78.7	12.0
Thmey	41.3	34.7	13.3	10.7
Kampong Kaes	25.3	25.3	37.3	12.0
Phum Pir	25.3	13.3	37.3	24.0

Fishing gear. The fishing gear commonly used by most households is the gill net (Figure 9). Previously, the households in the surveyed villages said that they also used other types of fishing gear, which are illegal, such as the trawl net and the motor pushing net, but these fishing gears are strictly forbidden by the local authority and by mangrove community leaders. In the Fisheries Law, Article 98 says that any households found to be using illegal fishing gear can be punished with 3–5 years in jail.

The gill net is locally called a *moang* net. The moang net is set at the bottom of the water inside the mangrove areas. The households across the four villages used moang nets differently depending on the fish species they wanted to catch (Table 11). In Phum Ti Buon, the households used moang nets with an average height of 2.87 m, a length of 557.58 m, and a mesh size of 4.21 mm; the total value of the moang nets used is USD 478.55 USD. In Thmey, households used moang nets with an average height of 4.76 m, a length of 205.45 m, and a mesh size of 2.42 mm; the total value of the moang nets used is USD 106 USD. In Kampong Kaes, households used moang nets with an average height of 4.64 m, a length of 187.27 m, and a mesh size of 2.42 mm; the total value of the moang nets used is USD 76.25 USD. In Phum Pir, households used moang nets with an average height of 3.10 m, a length of 849.28 m, and a mesh size of 3.75 mm; the total value of the moang nets used is USD 503.92.

Figure 9. Gill nets

Table 11. Moang net use by households

Village	Height (m)	Length (m)	Mesh size (mm)	No. of pieces	Total value (USD)
Phum Ti Buon	2.87	557.58	4.21	9.07	478.55
Thmey	4.76	205.45	2.42	2.27	106.00
Kampong Kaes	4.64	187.27	2.42	2.55	76.25
Phum Pir	3.10	849.28	3.75	3.86	503.92

Note: USD 1 = KHR 4,000

Fish species. Based on the survey information, households catch different fish species according to the season. The normal season is eight months in length and runs from March to October. The fishing season is four months in length and runs from November to February. The fish species caught by the households include Bluetail Mullet (*Moolgarda bucharnai*), Squaretail Mullet (*Ellochelon vargiensis*), Chacunda Gizzard Shad (*Anodontostoma chacunda*), Quoy's halfbeak (*Hyporhamphus quoyi*), Doublebarred Spinefoot (*Siganus virgatus*), Brownstripe snapper (*Lutjanusvitta*), and Lizardfish (*Saurida sp.*).

Fishing frequency, number of fishers, gear used. On average, households go fishing for 1.37 days per trip in the normal season and 1.08 days per trip in the fishing season. They normally go fishing for approximately 18.79 trips per month in the normal season and 21.58 trips per month in the fishing season. The average number of people that go on a fishing trip is 3.04 persons in the normal season and 3.09 persons in the fishing season. The average amount of fishing gear used by households per trip is 3.18 fishing gear in the normal season and 3.39 fishing gear in the fishing season.

Fish catch, prices, and mean value of fishing households. On average, fishers catch 31.73 kg of fish per trip in the normal season and 93.81 kg of fish per trip in the fishing season. Using the market prices of fish of USD 0.75/kg in the normal season and USD 0.51/kg in the fishing season, the value of the fish is estimated at USD 23.79 per trip in the normal season and USD 47.84 per trip in the fishing season. The net mean value of fish is estimated at USD 9.98 per trip in normal season and USD 17.85 per trip in the fishing season. Annually, the mean value of fishing households is approximately USD 2,793.13 per household per year in the normal season and USD 5,504.22 per household per year in the fishing season (Table 12). In Phum Ti Buon, the mean value of fishing households is estimated at USD 5,913.87 per household per year in the normal season and USD 11,339.51 per household per year in the fishing season. In Thmey, the mean value of fishing households is estimated at USD 890.61 per household per year in the normal season and USD 1,289 per household per year in the fishing season. In Kampong Kaes, the mean value of fishing households is estimated at USD 2,146.22 per household per year in the normal season and USD 2,519.75 per household per year in the fishing season. In Phum Pir, the mean value of fishing households is estimated at USD 2,221.84 per household per year in the normal season and USD 6,868.66 per household per year in the fishing season.

The direct use value of the mangrove. Given that the direct use value of the mangrove is the sum of the value of fuelwood, mangrove poles, snails, and the fishery value that households obtain directly from the mangrove, the mean value of the direct use value of mangroves is estimated to be USD 5,076.95 per household per year.

5.3 Indirect Value of Mangrove and Fishery Linkages

Our results show that mangrove area, distance from the mangrove area to the fishing site, price of fish, fuelwood degradation, pole degradation, and horse power would significantly increase the profits of fishermen (at 1% significance level) in both the normal season and the fishing season. Meanwhile, the age and education of the head of a fisher household would significantly increase the profits of fishermen only in the normal season. This means that age or fishing experience and educational level would not increase the profitability of fishing in the fishing season due to the higher stock of fish compared to the normal season.

Increasing the area of mangrove by 1% would significantly increase profitability by 0.29% in the normal season and 0.26% in the fishing season (Table 13). The negative coefficient of the distance from the mangrove area to the fishing site means that if the distance from the mangrove area to the fishing site would increase by 1%, then the profitability of the fishing would decrease by 0.18% in the normal season and by 0.03% in the fishing season. The further the distance from the mangrove area to the fishing site, the less profit the fishermen would make. Conversely, the closer the fishing site is to the mangrove area, the greater the profit would be in both the normal and the fishing seasons. If the price of fish would increase by 1%, then profitability would increase by 0.89% in the normal season and 0.87% in the fishing season. Interestingly, if the fuelwood and pole degradation rate would increase by 1%, then profitability would slightly decrease as well. Increasing the capacity of the horse power would also increase the profitability of the fish catch. However, if the size of the boat would increase by 1%, then profitability would decrease by 0.018%; this is due to the higher cost of a big boat compared to a small boat. Based on the results, the indirect use value of mangrove in terms of its value as a breeding and nursery ground for fish would be USD 44.82 per household per year.

Table 12. Fishing trips, gear, catch, price and costs

Village	No. of Days per Trip	No. Trips per Month	No. of People per Trip	No. of Fishing Gear	Ave Catch (kg/trip)	Ave Price (USD/kg)	Costs (USD/trip)	Mean Value of Fishing HHs (USD/hh/year)
Normal season	1.37	18.79	3.04	3.18	31.73	0.75	13.81	2,793.13
Phum Ti Buon	1.18	21.29	2.79	4.19	55.45	0.66	16.98	5,913.87
Thmey	1.61	17.17	3.03	2.37	20.47	0.84	14.51	890.61
Kampong Kaes	1.60	15.16	3.19	2.97	25.35	0.81	13.16	2,146.22
Phum Pir	1.09	21.55	3.18	3.20	25.67	0.72	10.60	2,221.84
Fishing season	1.08	21.58	3.09	3.39	93.81	0.51	29.99	5,504.22
Phum Ti Buon	1.05	25.27	2.84	4.49	159.46	0.53	48.90	11,339.51
Thmey	1.14	20.03	2.79	2.63	36.73	0.54	15.13	1,289.00
Kampong Kaes	1.00	18.31	2.70	3.00	56.80	0.46	14.66	2,519.75
Phum Pir	1.13	22.74	4.04	3.45	122.26	0.52	41.30	6,868.66

Note: USD 1 = KHR 4,000

Table 13. Instrument variables (2SLS) regression of profit function

Village	Normal Season		Fishing Season	
	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
lnmgarea	0.2992311***	(0.0224918)	0.2647373***	(0.0183617)
lnmgdist	−0.184304***	(0.0800820)	−0.0342511***	(0.0075005)
sizeboat	−0.0099846	(0.0063171)	−0.0189080***	(0.0027460)
lnprice	0.8901477***	(0.0863932)	0.8750553***	(0.0117413)
woodfueldegra	0.0000184***	(0.0000067)	-0.0000144**	(0.0000053)
poledegra	−0.0000147**	(0.0000070)	0.0000229***	(0.0000048)
horsepower	0.0491126***	(0.0115196)	0.0475340***	(0.0098690)
Sizenet	−0.0000070	(0.0000252)	−0.0000023	(0.0000118)
netmesh	−0.0015701	(0.0017360)	−0.0045687	(0.0031270)
numberpiece	0.0002148	(0.0027604)	0.0075398	(0.0030387)
sex	−0.0319171	(0.0560553)	0.0444313	(0.0330597)
age	0.0065854***	(0.0020164)	0.0040707	(0.0040216)
edu	0.0272846*	(0.0141323)	0.0056731	(0.0263243)
constant	3.8953710***	(0.9019080)	4.6008400***	(0.1461239)
Observation	186		182	
Adj R-squared	0.5307		0.5524	

Notes: (1) Robust standard errors are in parentheses. (2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

If the mangrove area would increase by 1%, then the fish catch would also increase by 0.22% in the normal season and by 0.18% in the fishing season (Table 14). The negative coefficient of distance from mangrove area to fishing site means that if the distance from the mangrove area to the fishing site would increase by 1%, then the profitability of the fishing would decrease by 0.17% in the normal season and by 0.04% in the fishing season. The further the distance from the mangrove area to the fishing site, the less profit the fishermen would make. Conversely, the closer the fishing site is to the mangrove area, the greater the number of fish that a fisherman would catch in both the normal and the fishing seasons. If the fuelwood and pole degradation rates would increase by 1%, then the fish catch would slightly decrease in both seasons. Increasing the capacity of the horse power used would also increase the fish catch. If the size of net would increase by 1%, then the fish catch would slightly decrease in both seasons. However, the variables of the size of boat, the price of fish, gender, education, and the age of the fisherman would not significantly increase the size of the fish catch in the normal season. However, the variable size of the net mesh, the number of nets used, the size of the boat, and gender of the fisher (male) would significantly increase the fish catch in the fishing season.

Table 14. Instrument variable (2SLS) regression of supply function

In Fish Catch	Normal Season		Fishing Season	
	Coefficient	Robust Standard Error		Coefficient
lnmgarea	0.2225086***	(0.0118615)	0.1832131***	(0.0125216)
lnmgdist	–0.1729917***	(0.0333471)	–0.0487266***	(0.0093710)
sizeboat	–0.0072273	(0.0053165)	–0.0043642**	(0.0019116)
lnprice	–0.0746186	(0.0576654)	–0.0387022	(0.0244230)
woodfueldegra	0.0000089***	(0.0000011)	0.0000365***	(0.0000052)
poledegra	–0.0000215***	(0.0000022)	–0.0000207***	(0.0000053)
horsepower	0.0329695***	(0.0075459)	0.0472509***	(0.0029054)
sizenet	–0.0000065***	(0.0000021)	–0.0000182***	(0.0000619)
netmesh	–0.0027886	(0.0018800)	0.0047807***	(0.0013976)
numberpiece	–0.0011475	(0.0017468)	–0.0047755*	(0.0018997)
sex	–0.0090702	(0.0595610)	0.1239595*	(0.0689945)
age	0.0007781	(0.0055366)	0.0045626	(0.0046915)
edu	0.0176605	(0.0146180)	0.0083311	(0.0156011)
constant	1.7129930***	(0.5575989)	2.0186990***	(0.1543587)
Observation	188		197	
Adj R-squared	0.6409		0.6482	

Notes: (1) Robust standard errors are in parentheses. (2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.4 Perceptions of the Mangrove Ecosystem

The mangrove ecosystem plays a very important role in providing and supporting ecological services. Local communities acknowledge that mangroves provide benefits in the following ways: by providing protection from storms (85.3%), by providing protection from saltwater intrusion (38.7%), by acting as a nursery and breeding ground for fish (97.3%), by maintaining water quality (41.7%), by producing fuelwood and charcoal (80.7%), by protecting wildlife habitats (86.3%), and by ensuring tourism and recreation value (81.7%) (Table 15).

Based on the answers from respondents in the surveyed villages (Table 16), the local communities are mostly affected by hazards at the lowest levels. Local communities are affected by storms at the strongest level of 13.5%, at a strong level of 32.4%, a medium level of 14.9%, a low level of 25.1%, and at the lowest level of 14.2%. In terms of flooding, local communities experienced flooding at the strongest level of 3.2%, at a strong level of 1.1%, a medium level of 18.4%, a low level of 21.6%, and at the lowest level of 55.7%. Saltwater intrusion was experienced at the strongest level of 1.2%, at a strong level of 4.5%, a medium level of 11.4%, a low level of 26.9%, and at the lowest level of 55.9%.

Table 15. The advantages of the mangrove ecosystem

Advantage of Mangrove Ecosystem	All Villages	Phum Ti Buon	Thmey	Kampong Kaes	Phum Pir
Protection from storms	85.3	89.3	86.7	86.7	78.7
Protection from saltwater intrusion	38.7	28.0	49.3	42.7	34.7
Act as nursery and breeding ground for fish	97.3	97.3	98.7	100.0	93.3
Maintains water quality	41.7	17.3	56.0	61.3	32.0
Produces fuelwood and charcoal	80.7	74.7	73.3	97.3	77.3
Protects wildlife habitats	86.3	97.3	100	88.0	60.0
Ensures tourism and recreation value	81.7	96.0	100	85.3	45.3

Table 16. Storms, flooding and salt-water intrusion

Level	All Villages	Phum Ti Buon	Thmey	Kampong Kaes	Phum Pir
Storms					
Strongest	13.5	33.3	13.6	0.00	4.30
Strong	32.4	49.3	36.4	15.6	25.7
Medium	14.9	12.0	24.2	18.8	5.70
Low	25.1	5.30	16.7	39.1	41.4
Lowest	14.2	0.00	9.10	26.6	22.9
Flooding					
Strongest	3.2	1.3	5.7	3.4	3.6
Strong	1.1	2.7	0.0	0.0	0.0
Medium	18.4	33.3	11.3	0.0	10.7
Low	21.6	32.0	17.0	3.4	21.4
Lowest	55.7	30.7	66.0	93.1	64.3
Salt-water intrusion					
Strongest	1.2	1.3	0.0	3.3	0.0
Strong	4.5	8.0	1.6	4.9	2.1
Medium	11.4	10.7	8.1	14.8	12.8
Low	26.9	26.7	33.9	24.6	21.3
Lowest	55.9	53.3	56.5	52.5	63.8

In the recent years, local communities have been less affected by storms, flooding, and saltwater intrusion. These positive outcomes are derived from implementing mangrove conservation-related projects by the local government and NGOs. In the past three years, the local communities confirm that 92.4% of mangrove conservation projects have been implemented and 85.9% of mangrove replanting projects have been put in place, both solely and jointly implemented by local government and NGOs. On average, at least 1.06 projects have been implemented in the surveyed villages, aggregated from 0.93 projects in Phum Ti Buon, 0.96 projects in Thmey, 1.40 projects in Kampong Kaes, and 0.95 projects in Phum Pir. Some 61.1% of the total respondents participated in mangrove conservation and replanting projects; the remaining 38.9% did not participate in these project activities (Figure 10). As a result of the implementation of mangrove conservation and replanting programs by local government and NGOs, the local communities have observed that the mangrove forests have increased during the last five years. Some 62.3% of respondents said that the mangrove forests have increased a lot, 13.7% said that the forests have increased a little bit, 7.3% said that there has been no change, 7.0% said that the forest had decreased a little bit, and 9.7% said that the mangrove has decreased a lot.

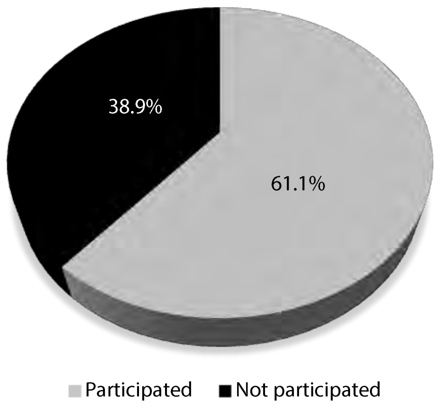

Figure 10. Participation in mangrove conservation and restoration

6.0 CONCLUSIONS AND POLICY IMPLICATIONS

The research focused on the economic valuation of non-timber forest products (NTFP) collected by households from mangrove areas. All NTFP collected by households have been included in the analysis. These include fuelwood, construction materials, fish, and snails. Medicine and wildlife resources are not collected by the households in the surveyed villages. Information on mangrove use for fuelwood, construction materials, fish, and snails was obtained via household survey.

The results show that the net total mean value of the direct use value of mangroves obtained by households is approximately USD 10,493.82 per household per year. The aggregate mean value of fuelwood collected per household is estimated at USD 98.02 per household per year, while the aggregate mean value of all the households in all four villages for fuelwood is approximately USD 54.81 per household per year. The aggregate mean value of mangrove poles collected per household is USD 615.37 per household per year, while the aggregate mean value of all the households in all the villages is USD 181.88 per household per year. The aggregate mean value of snails collected per household is USD 214.89 per household per year, while the aggregate mean value of all the households in all the villages for the collection of snails is USD 72.28 per household per year. The mean value of fishing households is approximately USD 2,793.13 per household per year in the normal season and USD 5,504.22 per household per year in the fishing season. In total, the mean value of the direct use value of mangrove use due to fuelwood collection, mangrove poles, snails, and fishing is USD 5,076.95 per household per year. The indirect use value of mangrove in terms of its function as a breeding and nursery ground for fish is USD 44.82 per household per year.

Both the direct and indirect values derived from mangrove forests are very high. Failing to find and implement appropriate management strategies and policies will lead not only to serious or irreversible ecological degradation, but also to substantial economic losses. Accordingly, the most viable investment option is to conserve mangrove forests rather than to clear them for other land uses.

More case studies measuring the economic values of mangrove areas should be conducted. The empirical evidence generated in this study would help bridge a critical knowledge gap and reduce policy biases, thereby improving the sustainability of mangrove ecosystems.

Mangrove replanting and restoration initiatives have been widely implemented through government agencies and NGOs, but the lack of involvement of local people remains a limiting factor. This should be addressed by further studying the roles of local communities and their collective abilities and willingness to pay for mangrove conservation and restoration. Better understanding of collective behaviors and readiness to change would result in more effective implementation of environmental protection strategies.

Finally, this study recommends developing alternative sources of energy in order to reduce mangrove cutting for fuelwood.

LITERATURE CITED

ADB (Asian Development Bank). 1999. Draft coastal and marine protected area plan, coastal and marine environmental management in South China Sea, Phase 2. ADB, Mandaluyong, Philippines.

An D.; Kong K.; Hout P.; and R. Mather. 2009. Integrated assessment for preliminary zoning scheme of Peam Krasob Wildlife Sanctuary, Southwestern Cambodia. International Union for Conservation of Nature and Natural Resources (IUCN), Gland, Switzerland and Phnom Penh, Cambodia.

Bann, C. 1997. An economic analysis of alternative mangrove management strategies in Koh Kong province, Cambodia. EEPSEA Research Report. International Development Research Centre, Ottawa, Canada.

Barbier, E.B. 2000. Valuing the environment as input: Review of applications to mangrove-fishery linkages. Ecological Economics. 35(1): 47–61.

———. 2007. Valuing ecosystem services as productive inputs. Economic Policy. 22(49): 178–229.

Barbier, E.B. and I. Strand. 1998. Valuing mangrove-fishery linkages: A case study of Campeche, Mexico. Environmental and Resource Economics. 12(2): 151–166.

Das, S. and J.R. Vincent. 2009. Mangrove protected village and reduced death toll during Indian super cyclone. Proceedings of the National Academy of Sciences. 106(18): 7357–7360.

De Groot, R.S.; M.A.M. Stuip; C.M. Finlayson; and N. Davidson. 2006. Valuing wetlands: Guidance for valuing the benefits derived from wetland ecosystem services. Ramsar Techical Report: Ramsar Convention Secretaria, Gland, Switzerland; and Secretariat of the Convention on Biological Diversity, Montreal, Canada.

Dixon, J.A. and P.N. Lal. 1997. Chapter 16: The management of coastal wetlands economic analysis of combined ecologic economic system. P. Dasgupta and K.G. Maler (eds.) *In* The Environmental and Emerging Development Issues, Vol. 2. Clarendon Press, Oxford. 399–424.

Emerton, L.; R. Seilava, R.; and H. Peraith. 2002. Bokor, Kirirom, Kep, and Ream National Parks, Cambodia: Case studies of economic and development linkages. *In* Review of protected areas and their role in the socio-economic development of the four countries of the Lower Mekong Region. Brisbane and IUCN Regional Environmental Economics Programme, Karachi, Pakistan.

FAO (Food and Agriculture Organization). 1982. Management and utilization of mangroves in Asia and the pacific. Food and Agricultural Organization of the United Nations, Rome, Italy.

Grasso, M. 1998. Ecological-economic model for optimal mangrove trade-off between forestry and fishery production: comparing a dynamic optimization and a simulation model. Ecological Modelling. 112(2): 131–150.

Ke, V. 2008. National report on mangroves in South China Sea: Cambodia. Ministry of Environment, Phnom Penh, Cambodia.

Koch, S. 2004. Peam Krosaob Wildlife Sanctuary demonstration site. International Waters Learning Exchange and Resource Network, Bangkok, Thailand.

Lal, P.N. 1990. Conservation or conversion of mangroves in Fiji. Occasional Papers of the East-West Environmental and Policy Institute. East-West Center, Honolulu, HI.

Marsche, M. 2012. Life, fish, and mangroves: Resource governance in coastal Cambodia. University of Ottawa Press, Ottawa, Canada.

Mastaller, M. 1999. Environmental management of the coastal zone of Cambodia: Assessment of sustainable livelihood alternatives to mangrove exploitation. DANIDA/Ministry of Environment, Phnom Penh, Cambodia.

MoE (Ministry of Environment). 2005. State of the coastal environment and socio-economy in Cambodia. Ministry of Environment, Phnom Penh, Cambodia.

NT-DIPE (Northern Territory Department of Infrastructure, Planning, and Environment) 2002. Mangrove mangement in the Northern Territory. NT-DIPE, Northern Territory.

Phan, N.H. and T.Q.D. Quan. 2012. Environmental impacts of shrimp culture in the mangrove areas of Vietnam. Annual Report of FY 2003, The Core University Program between Japan Society for the Promotion of Sciences (JSPS) and National Science and Technology (NCST). 195–203.

Rizvi, A.R. and U. Singer. 2011. Cambodia coastal situation analysis. Education. 2(2): 3.

Rönnbäck, P. 1999. The ecological basis for economic value of seafood production supported by mangrove ecosystems. Ecological Economics. 29(2): 235–252.

Russell, M.J. 2012. Shoreline and mangrove resource condition of the mainland coastline of Kien Giang Province, Vietnam: Key pressures and restoration requirements. Kien Giang Biosphere Reserve Project, Kien Gang, Vietnam.

Saint-Paul, U. and H. Schneider. 2010. Mangrove dynamics and management in North Brazil. Vol. 211. Springer Science and Business Media, Berlin, Germany.

Steffen, J. and M. Greg. 2012. Country environment profile: Royal Kingdom of Cambodia. European Union, Brussels, Belgium.

Suthawan, S. 1998. Economic valuation of mangroves and the roles of local communities in the conservation of natural resource: Case study of Surat Thani, South of Thailand. Economy and Environmental Program of Southeast Asia, Singapore.

Valiela, I.; J.L. Bowen; and J.K. York. 2001. Mangrove forests: One of the world's threatened major tropical environments. BioScience. 51(10): 807–815.

Strengthening local capacity in the economic analysis of environmental issues

Recent EEPSEA Research Reports

Fiscal Gap and Financing of Southeast Asia's Protected Areas: A Cross-Country Analysis
Gem B. Castillo, Chan Somaly, Li Wenjun, Li Yanbo, Luthfi Fatah, Sivannakone Malivarn, Kian Foh Lee, Alexander D. Anda Jr., Prinyarat Laengcharoen, Pham Duc Chien, and Benoit Laplante
2015-RR13

Farmers' Adaptation to Climate Change and Their Risk Preferences in Yongqiao District, China
Jin Jianjun, Gao Yiwei, Wang Xiaomin, and Pham Khanh Nam
2015-RR14

Cost-Benefit Analysis of the Introduction of the Indonesian Sustainable Palm Oil Standards: A Case Study in Jambi Province, Indonesia
Ernah
2015-RR15

Estimating the Economic Impacts of Climate Change on Crop Production in the Coastal Provinces of the Mekong Delta, Vietnam
Le Thi Diem Phuc, Vo Duc Hoang Vu, and Huynh Thi Dan Xuan
2015-SRG1

Leadership in Solving Social Dilemmas: An Experiment in Mekong Delta, Vietnam
Truong Cong Thanh Nghi, Ngo Hoang Thao Trang, and Trinh Van Hop
2015-SRG2

Willingness to Pay or Willingness to Accept: Determining the Appropriate Welfare Measure when Prefence is Reference-Dependent
Jack L. Knetsch and Phumsith Mahasuweerachai
2015-RR16

Willingness to Pay or Willingness to Accept: Determining the Appropriate Welfare Measure when Prefence is Reference-Dependent
Jack L. Knetsch and Phumsith Mahasuweerachai
2015-RR16

Environmental Satisfaction among Residents in Chinese Cities
Wang Chunhua and Zhang Changdong
2015-RR17

Using Feedback as a Tool for Household Energy Conservation: An Experimental Approach
Kannika Thampanishvong
2015-RR18

The Impact of VietGAP Vegetable Production on the Health of Farmers in Thua Thien Hue Province, Vietnam
Tran Huynh Bao Chau and Le Thi Quynh Anh
2015-RR19

Who Walks in the Shadows? Revealing the Blind Spots of the Natural Forest Protection Programme in China
Liu Zhaoyang, Andreas Kontoleon, and Xu Jintao
2015-RR20

Farmers' Adaptation to Flood Disasters: Evidence from the Mekong River Basin in Thailand
Phumsith Mahasuweerachai and Piyaluk Buddhawongsa
2015-RR21

Attitudes toward Flooding Risks in Vietnam: Implications for Insurance
Truong Cong Thanh Nghi and Ferdinand Vieider
2016-RR1

Impacts of and Adaptation to Extreme Weather Events: An Intra-household Perspective
Jaimie Kim B. Arias, Jefferson A. Arapoc, and Hanny John P. Mediodia
2016-RR2

The Economic Value of the June 2013 Haze Impacts on Peninsular Malaysia
Mohd Shahwahid H.O.
2016-RR3

Self-Protection against Flood in Cambodia
Chou Phanith
2016-RR4

An Estimation of the Production Function of Fisheries in Peam Krasaob Wildlife Sanctuary in Koh Kong Province, Cambodia
Kong Sopheak and Cheb Hoeurn
2016-RR5

EEPSEA is administered by WorldFish on behalf of its donors, Sida and IDRC.

Sida

IDRC CRDI