Project: Assessment of the Status of Marine Fisheries Resources and Management Practices in Sre Ambel Lagoon, Cambodia

Final Report

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ABSTRACT

Sre Ambel is the most productive coastal area for marine fisheries in Cambodia. Fisheries and aquaculture play an important role in the national economy and contribute to food security. This sector provides employment and economic benefits to Cambodians involved in its activities. The Sre Ambel area is a low-lying coastal zone located in the Koh Kong Province in the Southwest part of Cambodia. The government made a lot of efforts to improve marine fisheries status in this area. The total fishing area comprised of both the lagoon and the brackish water rivers outside the lagoon is approximately 15,000 hectares. However, there are thousands of hectares where rice field cultivations are likewise being practiced. Notably, the two major occupations in this area are fisheries and agricultural practices. The problem addressed in this research is the decline of fish catch since the last five years. Since 2005 there has not been any solid proof to confirm the cause of this problem. Some people claimed that the current problem is due to the weak enforcement of regulations. They observed that the number of fish has been gradually declining since 2005. Notwithstanding the steady decline of fish supply, a huge number of fishers still fish in the lagoon. Therefore, the research question in this study is "Does the decline of fish resources result from an increase in the use of fishing gears or other factors such as catch restriction, management style, policy inadequacy, etc.?

The main objective of this dissertation is to evaluate the factors that contributed to fish decline in the lagoon. This dissertation looked at the exact answers to the above question and tried to solve the problem through various measures. Five specific objectives were formulated: 1) To determine the current fisheries performance in the area, 2) To investigate the linkage between socioeconomic growth and fish catch, 3) To identify the factors affecting the decline of fish catch, 4) To identify the conflicts and solutions across policy level, and 5) To propose a policy alternative for the lagoon management. Two fishing communities were selected for the 210 household interviews. Principal Component Analysis (PCA) was the method used to combine various variables into major groups of factors affecting fish decline. Empirical investigation of current marine extractive reserve (MERs) management within its real life context was conducted using multiple sources of evidence. Qualitative data were analyzed using Weighted Average Index (WAI) and quantitative data were analyzed using SPSS.

Fisheries data indicate a decline of fish catch over the last five years. Household fish catch decreased from 4 tons per season in 2005 to 2 tons per season in 2009. Two types of fishermen were found: 1) medium scale and 2) large scale with some large scale fishing in the deep water of the lagoon. Based on the survey of fishermen's perceptions, the decline of fish catch resulted from the following factors: decreasing number of fishing trips, socioeconomic growth, increasing cost of materials, lagoon morphology changes, top-down management style, no social and environmental safeguard measures, use of illegal fishing gears (both local and outsider), foreign vessels, sand excavation and navigation, industrial growth, intensive farming system, water pollution, and global economic crisis. The most important factors were related to the regulations and law enforcement and inadequate policies to control the depletion of marine resources. These factors contributed to the decline of fish catch in the region for the last five years. One of the factors that had a huge impact was the inadequate lagoon fisheries management due to the lack of an appropriate

extractive reserve and strict law enforcement. To solve these problems this dissertation proposes the establishment of a Management Forum which would provide a mechanism to address stakeholders' concerns and possibly provide a multi-faceted solution to the problem. Any single solution would not likely overcome the existing issues. The proposed management model and capacity building alternative are important elements.

This dissertation also explored the management concepts of extractive reserve instruments to find the most effective application in the coastal areas of Cambodia. Since there are various extractive models in the world, the most important objective was to determine which extractive reserve model is best suited to real practices where the ability of the fisheries' residents to apply laws and guidelines vary from one place to another. To reflect these objectives, the study looked at various examples around the world, especially from various Latin American countries. The level of local ability to apply laws and regulations was determined using the Weighted Average Index method. The result shows that the fishers' education level is sufficient to read and understand the laws and regulations, but their level of compliance is low due to dissatisfaction and lack of trust. Although the level of satisfaction towards existing guidelines is poor, the local people are still willing to establish new appropriate guidelines for future effective application. Therefore, local fishers have the ability to apply laws and regulations under the new extractive reserve aspects. An extractive reserve policy combines all available instruments to manage the lagoon.

A management design that builds resilience in social-ecological systems may lead to the sustainable use of resources. Common-pool resource management plans should be participatory and adaptive, and they should provide a match between the scale of management institutions and the scale of the resource itself. In order to be adaptive, management institutions must create opportunity for learning and for building capacity to adapt to change. The best alternative is to develop strong collaboration among the various stakeholders in the area. It transforms an open-access to common property resource use regime.

Keywords
Factors of Fish Decline, Marine Protected Area, Concept of Extractive Reserve, Conflict and Solution across Policy Level, Proposed Policy Alternative for Lagoon Management, Local-Base Knowledge of Fisheries Management, Scientific Knowledge of Fisheries Management.

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CHAPTER 1
INTRODUCTION

1.1 Context of the Study

This dissertation aims to contribute to the efforts for sustainable natural resources and environmental management, that is, a management "that meets the needs of the present without compromising the ability of future generations to meet their needs" (WCED, 1987). The concept of sustainability encompasses the idea of "constancy of total natural capital" (Costanza and Daly, 1992); that is the capacity of natural environment to provide ecosystem services and resources and to assimilate waste (Goodland, 1995). Sustainability will be achieved only when the scale of human economy is kept within the capacity of the overall ecosystem on which it depends," as Goodland (1995) explains. Another key aspect of sustainability is the ability of a system to maintain its adaptive capacity (Holling 2001). This issue of adaptive capacity, or resilience, is a major theme in the dissertation, as a way of addressing the dynamics of the system.

Many sustainability analyses of resource use tend to be static. They do not address the phenomenon of change in management systems and how humans respond to such change. Hence, studies are needed to analyze changes in resource management systems and adaptive responses. Such responses must ensure future options of resource use. For this reason, this research focuses on the dynamics of changes in a natural lagoon resources management system and on the linkages between the social and ecological aspects of such a system. This is done by examining a case study scenario in a small-scale fisheries management.

Firstly, this introductory chapter presents a paradigm citation in natural resources and environmental management science and some commonly used analytical tools. Secondly, it poses the main research problem as well as five specific questions related to it. Thirdly, it introduces the research objectives.

For many decades, resource managers and scientists have proposed management plans based exclusively on the biological aspect of resource management, and in particular on the assumption that nature is equilibrium-centered and predictable, provided that enough data are available. For instance, environmental management plans focused on the population dynamics of single species (e.g., biological models in fisheries) or on the preservation of ecosystems, without the interference of human actions (e.g., national conservation areas in Cambodia). However, failure in achieving sustainable resource use led many scientists to address the inadequacy of such conventional management approaches, particularly, in the past three decades (Larkin 1977, Clark and Munn 1986, Ludwig et al. 1993, Gunderson et al. 1995). Scientists have started to realize the importance of managing 'human' as part of the ecosystem, the need for managing entire ecosystems, instead of specific target species, and the significance of recognizing the complexity of system dynamics. In other words, a paradigm shift in natural resource and environmental management science has started to occur. Management has started to move, at least in theory, form a 'biological-centered approach' (Jasanoff et al. 1997, Kates et al. 2001) and

from a single population approach to a system dynamics approach, and in particular, a complex systems approach (Kauffman 1993, Levin 1999).

Scientists from different schools of thought addressed the relationship between humans and nature. Such schools include human ecology, cultural ecology, ecological anthropology, human geography, environmental history, ethno-ecology, political ecology and ecological economics (Davidson-Hunt and Berkes, 2002). In this dissertation, it borrows insights and analytical tools from many of these fields and sub-disciplines in order to understand the linkage between human applicability and marine capture fisheries system, and the dynamics changes of the socioeconomics with the changes of fish community.

It is important to note that social systems, as defined here, encompass the social economical and cultural aspect of human societies, including their ethics (values) and worldviews. Hence, the term social system is sometimes interchangeable with socio-economic system in this dissertation.

In resource management systems, both social and ecological systems (fish community) change and co-evolve. Linkages between the social and fish resources aspects of a common-pool resource management system are often analyzed through management institutions (such as property right) and systems of knowledge (Hanna et al. 1996; Berkes and Folke, 1999).

A common-pool resource is a class of resources for which exclusion is difficult and joint use is characteristic among all beneficiaries (Berkes, 1989, Feeny et al. 1990). An open-access fisheries are example of common-pool resources. The exploitation of a fish stock by one fisher directly affects the stock availability to other fishers who are difficult to exclude from the system. The evolution of the CPR theory has immensely contributed to the understanding of socio-economic and fish resources linkages in natural resources and environmental management systems (McCay and Acheson 1997; Berkes, 1989; Ostrom, 1990; Bromley, 1992). In particular, the CPR theory has addressed the implications of possible property regimes under which natural resources may be managed. These include four 'pure' property regimes: government's property, private property, communal property and open access (Feeny et al. 1990) or a combination of them. An example of the latter is co-management arrangements in which resource management is shared between the government and local users. Property-rights regimes are part of the institutional framework of any resource management system.

Institutions are any formal constraints (rules, laws, and constitutions) or informal constraints (norms of behavior, conventions, and self imposed codes of conduct) that mold interactions in a society (North, 1994). In management systems, institutions are the working rules or rules-in-use that control resource use (Ostrom, 1990). The way institutions are designed and how institutional changes occur strongly influence the interaction between humans and nature (Hanna et al. 1999). Ostrom (1990, p.51) argues that "all rules are nested in another set of rules that define how the first set of rules can be changed". That is, institutions are hierarchically structured. Moreover, institutions are dynamic and have an adaptive character. In resource management, institutional changes may occur in response to changes or disturbances in either the socioeconomics or fish ecological system.

An institutional change occurs because some individuals (organizations) exercise their bargaining power to create new rules in a society where it is perceived that they, or the entire rural society, could do better by restructuring the institutional system (North, 1994). Institutional changes within management systems can improve productive efficiency, alter the distribution of income, reallocate economic opportunity or redistribute economic advantages. The first three options have a positive contribution to social welfare, while the fourth is just a redistribution of welfare (Bromley, 1989). One should keep in mind, however, that some institutional change decreases productivity and rural social welfare instead of increasing them; that is, ineffective institutions may also be created. Institutional changes are a result of organizational actions based on current knowledge (and mental models) and on the institutional status quo.

1.2 Research Problems

Economics diversification within national economies, away from a high dependence on the extraction of natural resources, is seen by many development specialists as both a path leading to greater economic growth and an indicator of it. Most economies in the world have gone through stages of evolution which tend to start in a predominantly natural resource extracting phase and gradually move to agriculture, followed or paralleled by the development of manufacturing and service sectors. Diversification of economic activities at the household and community levels is seen as an important part of the process. In terms of poverty reduction, diversification is seen both as: a) a coping strategy of the poor to deal with increasing uncertainty in rural areas, as a result of the degradation of natural resources, increasing competition and the encroachment of global influences, and b) as a development strategy for enabling the poor to graduate out of poverty. More and more the rural sector strategies of governments in developing countries are focusing on the role of livelihood diversification as a mechanism to achieve these two aims. In addition those government and NGO agencies concerned with the conservation of natural resources see livelihood diversification as a mechanism to encourage people to move away from the harmful exploitation and degradation of those resources. (Jock Campbell et al. 2005).

Marine fisheries are an important renewable resource. For the last five years, resident and nonresident fishermen spent much of their time fishing in the Sre Ambel Coastal Lagoon. The real problem in the lagoon is the poor connection between restrictions and fishing application on the ground. This drastic gap causes local conclusion of the decline of fish resources in the lagoon. The number of fish has been gradually declining since 2005. Notwithstanding the steady decline of fish supply, a huge number of fishers still fish in the lagoon. Does the decline of fish resources result from an increase in the use of fishing gears or other factors such as climate change, catch restriction control…etc? Despite the importance of fisheries to regional, state, and local economies, regulatory decisions are often made by the central government of Cambodia and even by the local administrative authorities with little information on the possible socioeconomic effects of regulations. Because people are the ultimate beneficiaries of fisheries management, both fisheries professionals and central government should consider the social and economic effects of their management efforts (DoF, 2000). Knowledge of the socioeconomic effects of various catching restrictions will allow resident and nonresident fishermen at the Sre Ambel Lagoon to participate and make regulations that address the needs of the fishery in

their own localities. Valuation of natural resources (marine fish) is necessary to substantiate management actions and allocation decisions. An estimate of the consumption value of a marine fishery is necessary in evaluating potential effects of catch restrictions on a marine fishery and enables evaluation of the interactions between changes in catch restrictions and the value placed on the fishery.

Marine fish catches and socioeconomic data can be combined to develop a marine fishery management plan through the development of harvest policies that address the goals and viewpoints of fishers and fishery communities. The imposition of harvest restrictions may meet goals of maintaining the conservation of fish population. However, it may be unsuccessful if the regulations are not accepted by resident and non-resident fishers or if such restrictions reduce fishers' participation in the marine fish conservation activities. To determine if harvest restrictions are successful overall, an evaluation of their effects on the fish population and the socioeconomic environment in which that fishery exists is necessary.

Analysis of the social effects of the current situation and hypothetical catch restrictions can provide central government and local authorities with valuable information about fishers' acceptance of current restrictions and direction for future management. Placing management decisions in the context of an economic decision-making process may make decisions concerning the resource more objective and may more accurately reflect the consumption value placed on that resource by its users. So far, there is a dearth in research concerning the extent of the impact of socioeconomics activities on marine fish growth in the lagoon of Sre Ambel. For this reason, this research focuses on the dynamics of changes in a natural lagoon resources management system and on the linkages between the social and fish catch aspects of such of system.

1.3 Research Questions

What can one learn from investigating the dynamics changes in socioeconomics systems in the relationship with marine fishery resources in the study areas in order to recommend an appropriate policy to ensure the sustainability of the management system?

To address the above problem statement and the objectives, the following research questions are raised:

What is the status of the current marine fisheries resources in the area?
How do the communities help to build the fisheries resources management structure in the lagoon? **What** are the key factors that threaten its sustainability?
Which incentives and constraints have influenced the development of the marine fisheries resources system? **What** policies across organizational scales may help solve stakeholder conflicts over resources use? **What** can be done to ensure the social and economic sustainability of fisheries in the lagoon?

1.4 Research Objectives

The objectives of this study will examine the current marine fishery status and the linkage between socioeconomics and fish resources in the Sre Ambel Lagoon;

(1) Assessment of the performance of marine fishery catch during the last five years in the lagoon of Sre Ambel, (2) Assessment of the capacity of communities to apply the rules and regulations in marine fisheries resources management, (3) Examine the factors that are responsible for the low fish catch rate in artisanal marine fisheries of Sre Ambel Lagoon, (4) Assessment of marine fish economics in the Sre Ambel Lagoon of Cambodia, and (5) Assessment of stakeholder conflicts and solutions across policies scale in Sre Ambel Lagoon.

CHAPTER 2
ANALYTICAL FRAMEWORK AND RESEARCH METHODOLOGY

2.1 Analytical Framework

To address the research question, it is proposed an analytical framework based on Berkes and Folke (1998), which includes the following components: (1) resource system (ecosystem), (2) socio-economic system (people, technologies, and markets), (3) pertinent local and scientific knowledge, (4) local and government institutions, and (5) management problems, crises, and adaptations. These components should not be seen as distinct elements, but as interconnected elements of resource management systems. Indeed, the key point of studying the dynamics of social-ecological systems is to analyze the feedback interactions among these components.

In understanding the evolution of fish resource system attention should be given to its general physical attributes and value characteristics (Berkes and Folke, 1998) including the way such attributes and characteristics are organized in the system of the lagoon. In particular, attention should be given to changes in patterns of fish biodiversity (Warren and Pinkston, 1998; Niamir Fuller, 1998), the fish resource boundaries and the history of fish resource use (Regier and Baskeville, 1986). As well, the types of unexpected events (surprises) that the resource system has experienced and the processes that trigger change and facilitate renewal (Holling, 1986) should be investigated.

Socioeconomic System: People, Technologies and Markets: The analysis of fish management systems should focus on the social groups and the organizations of fish resource users (Brooks 1986; Berkes and Folke, 1998). In different societies, resource users are organized differently according to their culture, the nature of the resource they exploit, and their historical experiences. Hence socio-economic and cultural heterogeneity should be addressed. For instance, the degree of economic diversification is directly related to a community approach to management (Hanna, 1996). Attention should also be given to policies and economies at the local or regional level, and to religion and education levels of resource users as they might directly or indirectly influence local management arrangements (Warren and Pinkston 1998). In addition, the degree of economic dependence on resources also influences people's willingness to participate in its management (Hanna, 1998). As economic dependence on fish resources changes over time, especially since 2005 while Cambodia had been unable to formulate and enforce an effective fishery laws and regulation, a historical study should be undertaken on the way this and other socio-economic factors have influenced the management arrangement. In particular, one should study market influences on resource management (Hanna, 1998).

The social mechanisms and safety nets that some societies have developed in response to environmental uncertainties and variability in market systems (Folke et al. 1998; Niamir-Fuller, 1998) should also be investigated. In addition, research should focus on technology diversity (Brooks 1986) and technology efficiency in resource exploitation, as well as on technological changes and technological development, which may have either a positive or a negative effect on management systems (Ravetz, 1986).

Pertinent Local and Scientific Knowledge: Human adaptations to changes in resource systems in the lagoon are based on a repertory of behavioral responses or "a response pool" in Brooks' (1986) terminology. Brooks (1986) points out that "in order to increase the capacity of organizations or communities to adapt to future changes it is important to deliberately cultivate their response pool variability". In local management systems, the response pool variability is often based on the local knowledge about the dynamics of the local resource system, management practices and the efficiency of the technologies used. Hence, it is important to investigate such knowledge, as well as who holds this local knowledge and how it is transmitted. In 'modern' management systems, the response pool variability is largely based on scientific knowledge, often achieved from different systems. In examining the possible response pool of a management system, both the scientific and the local knowledge that is available should be considered.

Local and Government Institutions: In studying the evolution of management institutions it is important to trace changes in property regimes and to identify what has triggered such changes. In each type of management arrangement the role of resource users, government, and non-government organizations (NGOs) should be investigated as well as the decision-making, enforcement and monitoring processes (Berkes and Folke, 1998b). For instance, local-level decision-making enables rapid institutional feedback to changes in the ecosystem.

A detailed research study on property-rights institutions regarding use rights, rights to exclude others, rights to manage, rights to sell and how rights are transferred should be performed. In addition, a historical analysis of government regulations regarding the use and appropriation of natural resources, and under what circumstance these regulations were created, should be performed.

In studying management institutions, attention should be given to how management practices are embedded in institutions, what the key elements are behind adaptive institutional responses and why some management institutions fail since the laws and regulations existed everywhere throughout the county.

Management Problems, Crises and Adaptations: Fish resource management systems are often impacted by socio-economic development at local or regional levels. Hence, there is a need to evaluate management problems and their relationship to local and regional development. Environmental surprises may also create management problems and may even lead the management system to a crisis. Gunderson et al. (1995) argue that crises play an important role in resource management systems because they may trigger learning opportunities and may lead the system to a renewal phase. Thus, when studying the dynamics of social-ecological linkages, it is important to evaluate crisis events, learning processes, source of knowledge and management adaptations. When examining six resource management cases, Gunderson et al. (1995, p.506-7) noted that during the renewal phases, learning appears to have occurred by: (a) the transference of 'knowledge gained in other systems and applied to the system in crisis', (b) 'the sudden release in local understanding that had accumulated in a separated context' (knowledge held in memory) and (c) 'putting various pieces together during the crisis'.

To study management adaptations, one should research how human societies have perceived and responded to past environmental surprises and management crises. Moreover, one should search what the lessons learned were and how they were incorporated into warning, responding, and adapting mechanisms (Timmerman, 1986).

The previous sections presented the research question and discussed the pertinent components of the proposed analytical framework. In the subsequent sections, the case study will be presented. The level of marine fish catch during the past several years will be addressed and a comparison of the annual changes in the said levels will likewise be presented.

Introduction of the Case Study: Cambodia's Coastal Fisheries Overview: Fisheries and aquaculture play an important role in the national economy and contribute to food security. This sector provides employment and economic benefits to Cambodians involved in its activities. The Ministry of Planning (2002) indicates that Cambodia derives 16 % of its GDP from the fisheries sector.

During recent decades, the productivity of Cambodia's fisheries resources, including fishes, crustaceans, and mollusks, has declined dramatically. This is believed to be due to the increased pressures on natural resources and their ecosystems associated with burgeoning human populations. The general push for economic growth and development of fishing technology are also thought to have contributed to this problem. Cambodia is one of the ASEAN countries bordering the Gulf of Thailand. Its short coastline of 435 km extends from the Thai border in the north to the Vietnamese border in the south.

Cambodia's fisheries are divided into inland and marine capture fisheries. Inland capture fisheries are significantly more important to Cambodians than marine fisheries, accounting for more than 70% of Cambodia's total volume of fish production. In terms of value, however, marine fisheries account for nearly 40% of the country's fisheries production (Try, 2001).

A few comments regarding the accuracy of fisheries statistics in Cambodia are necessary. The statistics presented in this report are the most accurate available to the Department of Fisheries (DoF), however, a reliable statistical system and data collection protocol have not yet been developed. The fact that fish are not landed at central locations, together with direct exports by foreign vessels and other factors, contribute to inaccuracies.

The coastal area is divided into two provinces, Koh Kong in the north and Kampot in the south, and two municipalities, Sihanoukville and Kep (Figure 2.1). Cambodia's marine capture fisheries are characterized by a multitude of species and the use of a range of fishing gears. Reference to DoF fisheries statistics indicates that marine fisheries production as recorded by DoF has not yet shown a decrease by species and landing place, but there has been a decrease by province and grade as according to fish value and size in domestic fish markets.

The coastal population of Cambodia is only about 1 million people. Estimates of the number of people involved in coastal and marine fisheries differ widely. One estimate is

that about 40% of the coastal populations are fulltime fishers and 30% are part-time fishers. Another estimate provides that only 10% of the coastal populations are involved in fisheries, including processing and marketing. The majority of fishers are operating on the small-scale or subsistence level and these fishers do not need to be licensed. Moreover, the majority of fisher households also have small farming plots. The civil war and the Khmer Rouge regime severely disrupted the traditional fishing community system in Cambodia. During this period, coastal and marine fisheries were almost completely abandoned and only rice farming was encouraged. In recent years, there has been a significant migration of poor people from inland rural areas to the coast. These people mostly engage in fisheries because it requires little investment and is open access, although they typically have no experience in marine fisheries.

The Sre Ambel area is a low-lying coastal zone (Figure 2.1) located in the Koh Kong Province in the Southwest part of Cambodia. The government has intensely concentrated on this area in order to improve marine fisheries status. The total fishing area comprised of the lagoon and the brackish water rivers outside the lagoon is approximately 1500 hectares. However, there are thousands of hectares where rice field cultivation is being practiced. Two major occupations are fisheries and agricultural practices. Recently, there has been an increase in rice field cultivation as more investors opted to invest in industrial crops such as sugar cane and coconut oil.

Fishery is one of the major occupations in the Sre Ambel region as fish and other aquatic resources ensure a sustainable livelihood and food security to the local population and they can be transported to the cities. Aside from rice, fish is considered as one of the major staples of the area. However, this coastal area's resources are currently threatened by increasing exploitation (i.e. illegal fishing) and environmental degradation. Fishery is considered as an open-access resource which is accessible to most of the population unlike agricultural land in this area which is primarily held as a private ownership. There have been claims that fish catch declined yearly since 2005 notwithstanding the restrictions and regulations concerning fish catch introduced in the area. Alarmingly, some fish species disappeared during the last five years. In contrast, the government claimed that the statistics of marine fish catch remained constant and some part of the coastal area have shown high yields. According to the fishers during the early field investigation for this research in January 2009, however, fish catches have gradually declined since investors opted to heavily invest in industrial crops and industrial-purpose activities. Until recently, no research has been undertaken to verify if fish catch did in fact decrease during the last few years and to determine the factors affecting fish catch decline in the last five years.

This paper aims to determine whether fish catch had in fact declined and to what extent the decrease was brought about by any environmental factors. More specifically, this paper seeks to: 1) assess the number of efforts monthly for each of the last five years; 2) assess the average catch during each effort, taking into account the season of fishing as well; 3) assess the capacity of boats and other inputs used for fishing; and 4) compute the quantity of fish catches.

The Sre Ambel Lagoon Setting: During 1990s, there were no regulations or restrictions governing fish catches in the area. Fishermen could employ whatever means

they can to catch fish in order to maximize the profits. Up until the year 2000, some regulations regarding the use of fishing gears were enforced, but they were not very effective. Shrimp cultures which are considered as a big source of income from small fish species were considerably established in the coastal areas of Cambodia including the Sre Ambel Lagoon. Unfortunately, the government of Cambodia thinking that shrimp cultures would cause the decline of the fish population and valued species restricted the practice of shrimp culture in 2003. This was a big blow to majority of the fishermen because shrimp products are a huge source of income. Most of them considered that the decline of marine fish catches and fish species within the lagoon area was due to population growth, increase in demand for fish products, and the use of illegal fishing gears all year round, especially since fishers residing outside the lagoon area have been involved in large scale fishing inside the lagoon.

A few years later in the Sre Ambel Lagoon, there was an attempt to improve the fishing techniques and modify the fishing gears to avoid the overexploitation of fish resources while at the same time being responsive to the demands of both the individual and commercial consumers. The quest has been conducted by ASFC since 2007. However, the fishermen persisted in applying the old methods using fishing gears due to economics. Traditionally, the use of poor quality fishing materials limits the catch levels (Touch & Todd, 2003), but it enhanced the fish resources recruitment. Some of the synthetic nettings were, for instance, very expensive and poor in quality.

Similarly, hooks are eaten up by rust and thus lose their efficiency in less than six months. The dearth and high cost of fishing gear accessories are other problems and many fishermen were often constrained to seek cheaper local options (FAO, 2003). The buoyancy of various floats and the gravitational force of the cement sinkers are not quantified and the technique of suspending the gear was more of a guess work than science, compromising on gear efficiency.

The research was focused on the Srok Sre Ambil Lagoon management system. The Lagoon is located in the coastal zone in the Sre Ambil District of Koh Kong Province, along the southern part of the Cambodian coast (Figure 1). This area was chosen because both the management system and the local socio-economic system have experienced several changes in the last five years. The baseline for the study was 2005. This baseline was selected based on the possibility of acquiring reliable information about that period stored in the memory of the elderly inhabitants of the area. To my knowledge, substantial documented information about the Sre Ambil region does not exist for earlier periods.

It was first visited the study area in August 2007, when it was traveling along the coast of Koh Kong Province, Cambodia, while searching for a case study area for my dissertation. At that time, it was found for a case in which the depletion of fisheries resources had occurred (as recounted by the elderly inhabitants), followed by changes in fishing rules and a restoration of resources. The Sre Ambil Lagoon was the only case we (all researchers) found during this field investigation. The coastal zone of Koh Kong Province was originally inhabited by the local people who depended on fishing for their livelihoods. However, the outsiders first arrived to this area during the fall of the Khmer Rouge Regime. Until the mid-90s many different groups' settlements were very sparse and

populations were small. New settlements emerged and some eventually became crowded areas, what we called Sre Ambil. By the early 2000s, the native population was almost non-existent. Nevertheless, some aspects of their culture and technologies were adopted by the outsider settlers. For example, it is said that the fishing technologies and strategies existing during the 2000s in the Sre Ambil coast were based on a combination of both new comers and local native people.

The Sre Ambel Coastal Fisheries: The coastal area is divided into two provinces, Koh Kong in the north and Kampot in the south, and two municipalities, Sihanoukville and Kep (Figure 2.1). Cambodia's marine capture fisheries are characterized by a multitude of species and the use of a range of fishing gears. Reference to DoF fisheries statistics indicates that marine fisheries production as recorded by DoF has not yet shown a decrease by species and landing place, but there has been a decrease by province and grade as according to fish value and size in domestic fish markets.

Srok Sre Ambel coastal fisheries provide a large amount of fish resources in the central demand of the Koh Kong Province and allocates to the demand in Phnom Penh as well. Regional records indicate that total marine fisheries production in the Lagoon of Sre Ambel increased significantly after 1999 according to the local assessment conducted in some places. It seemed to have started to decline a few years later according to the regional fishery authority. However, a corresponding system for the collection of marine capture fisheries statistics for areas surrounding the lagoon does not exist. The DoF is seeking assistance from NGOs and other agencies in resolving this problem.

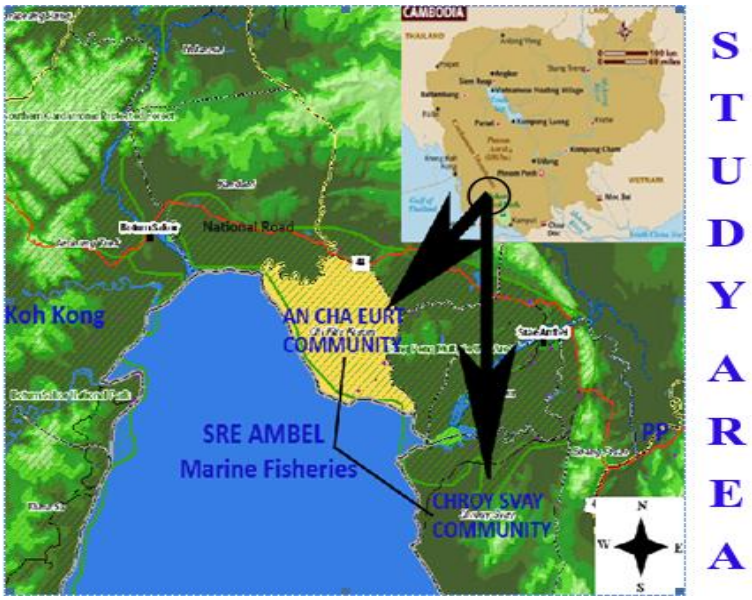

Fig. 2.1: Sre Ambel Community Fisheries

During the mid 20th Century, several changes occurred in fishing communities along the Sre Ambel coast. A survey of the evolution of fishing activities in coastal line and on the socio-economic status of artisanal fishers was carried out in 1999 in 3 coastal communities (Touch, 1999). This survey showed that a shift from agriculture to fishing

occurred in several of these communities. An intensification of the commercialization of fishing products, especially through middlemen, also occurred due to an increase in market demand from large town and an improvement in the local road network. The development of tourism also influenced market transactions of fishing products in some of these fishing communities. Tourism gave fishers the opportunity to sell their products directly to local consumers, diminishing, in some cases, their dependence on middlemen. In other cases, however, middlemen were still in control of most of the fishing market, as they bought products from fishers and sold them to local restaurants and retail stores. The development of tourism also promoted an increase in the value of lands owned by fishers and an improvement in the living standards in fishing communities due to cultural influences. Due to the fact that a large percentage of marine products come from the Sre Ambel Lagoon, the provincial authority came to see the economic potential of the area and started to channel some part of the national and donors' budgets to improve its transportation and infrastructure, linking the lagoon to the center of the province as well as other municipalities.

The Sre Ambel Lagoon Region: Despite the development of the area in the early part of the year 2000, the Sre Ambel Lagoon region remained quite isolated until the 2005s. Most communities were living on household agriculture and subsistence fishing. Many socio-economic and ecological changes have occurred since then, and as of year 2007, fishery-related activities have come to dominate the economy of most communities. It is important to note, however, that fishing continues to be an important source of cash or in-kind household income.

In 2006, the economy of Sre Ambel Lagoon was driven by successive businesses, including a harbor, sand exploitation, industrial crops, and a ceramic industry (Ing T. and Kathe R. Jensen, 2007). Shrimp catch (*Farfantepenaeus paulensis and F. brasiliensis*) and mullet (*Mugil platanus, Mugil spp*.) are the main fishing resources.

There are two communities around the Sre Ambel Lagoon. As of the year 2000, there were only a few professional (licensed) fishers, two sports (licensed) fishers and several unlicensed fishers living in these communities. The Sre Ambel Lagoon is an assembly of three interconnected small basins, Sre Ambel, Trapeang Rong, and Tmar Sar with a total area of approximately 15000 ha. This is a shallow lagoon with most of its area between 0.20 m and 6.0 m deep, with a few points reaching about 10 m deep along channels running through the Lagoon area. For the most part, the Lagoon has a sandy bottom and brackish water. Freshwater input is mainly acquired through rainfall surface water and springs which feed the Lagoon at nine or more points. The water level in the Lagoon system rises as the season progresses. Throughout most of the year, there is a sandbar between the sea and freshwater channels. Without any management, when sufficient water pressure builds up, a channel naturally bursts through the sandbar to the sea, and the Lagoon's water level drops.

2.2 Research Methodology

2.2.1 Introduction

Data collection was conducted systematically. Research questions were developed to address the issue of research and scope of the research. By then, the required data and information were identified accordingly to respond to the research questions. Following the determination of sample size, sampling units were chosen through a powerful randomized sampling method. The randomized sampling units were then replicated among the target area. Data were recorded in spreadsheet data files prior to transfer to SPSS software. The method of data analysis in this research was a combination of ANOVA, WAI, and Factor Analysis. It was also presented in normal graph using Excel in some cases. ANVA was used to look at the comparison of fish catch between several years. WAI was used to measure the level of satisfaction of law, regulations, and education of the fishers, while Factor Analysis was used to identify the factor that affected fish decline in the area.

2.2.2 Sampling Size Determination

For this specific purpose of the study a two-stage sampling technique was used in selecting the respondent fishermen. Two fisheries communities were selected out of the other six communities throughout Koh Kong Province because of the high marine fishing population. There were six (6) distinct fishing villages of the whole study area where the groups of fishers association live and fish. These six places are located along the shoreline of the Lagoon with equal distance of interval from one village to another (Figure 2.1). Data collection and record-keeping were done by fishers to monitor and assess trends in their local fisheries. This involves the standardized collection of information about fishers' daily and annual catch during the last five years, fishing gear, hours and fishing grounds. The first stage involved a random selection of three (3) fishing blocks from each of the two (2) identified fishing communities, thus giving a total of 6 blocks for the purpose of this study. Then a total of ninety (90%) local fishers (or 90% of total) composed of commercial fishers, heads of fishers, individual fishers were selected. (10%) head of commune chief and councils (or 10% of total) were randomly sampled from each of the three (3) blocks. This gave a total of 210 samples of questionnaires for this study, of which each block gave 35 samples of interview composition.

For the purpose of this study a two-stage sampling technique was used in selecting the respondent fishermen. Two communities were selected out of the eight (8) maritime communities in Koh Kong Province because of the high fishing population. There are three (3) distinct fishing villages in each community: Those villagers are located along the coastal line of Sre Ambel. The fishing villages and communities were identified with the assistance of the local fisheries authorities and during the workshop with local administrative commune councils. There are a total of 6 villages comprising two communities in the lagoon. The first stage involved a random selection of thirty (30) fishing families from each of the six (6) identified fishing villages, thus giving a total of 180 fishing families for the study. This figure is for the commercial fishers. However, an additional survey was conducted from 30 people who are semi-commercial fishers. Likewise, a total of (180) commercial fishermen (or 86% of total) using Motorized Fishing

Boats and (30) semi-commercial fishermen (or 14% of total) using Manual Propulsion Fishing Boats were selected for sampling. In sum, a total of 210 samples were selected in order to gather the data for the study.

Having arrived at the sampling size of the villages, the sample households were selected as follows. The population for the present study was arrived at by taking into account the total fisher households, whether or not they are involved as full-time or part-time fishers, in each village from the two communities. Then the sample size (n) of household units in the study area was determined by applying the following formula (Arkin and Colton, 1963):

$$n = \frac{Nz^2\, p(1-p)}{Nd^2 + z^2 p(1-p)} \qquad (2.1)$$

Where: n = sample size
N = total number of fishing households in the village
z= confidence level (at 95% level z = 1.96)
p = estimated population proportion (0.5, this maximizes the sample size)
d = error limit of 5% (0.05)

Application of the above sampling formula with the values specified which in fact maximizes the sample size, yielded a total required sample of 210. Including a reserve of 10 percent, the total sample requirement stands at 231. However the exact number of collected data was 225 samples. Having determined the sample size (n) using the aforementioned method, the households were then classified into two groups on the basis of size of fishing. Then proportionate random sampling was applied in order to ensure representation of all fishing categories in the sample.

2.2.3 Randomized Sampling Size

This may be the most important type of sample in this research. Random sampling allows a known probability that each variable unit will be chosen. For this reason, it is referred to as a probability sample and is the type of sampling that is used in lotteries and raffles. In this research, in order to select 210 respondents randomly from a population of 2000 families in the area, all the possible respondents were asked to write their names on a piece of paper which were then folded up and mixed together. From this pool of possible respondents 210 were picked or randomly selected. Thus, every name had an equal chance of being picked. The names of those 2000 families were obtained from the list of the two community fisheries and other isolated areas surrounding the lagoon.

2.3.4 Fish Catch Monitoring and Participatory Observation

Fish catch monitoring was conducted in the areas within the two communities where there is a strong fisher association. The data were used to support advocacy initiatives of the two fisher organization (e.g., stricter enforcement of laws in municipal fishing grounds and livelihood assistance). Data collected and analyzed in a systematic manner and formally presented to government and other sectors could be impressive and influential. All 210 fishers were trained during the early stages for training and analysis. Those fishers were provided with fish identification materials (picture book), data sheet and pencils, logbook, weighing scales, and calculator. The ruler used was a locally designed fish measurement board. The data record sheet given to all the fishers to assist them in data-gathering consists of many questions which identified the time to catch fish, place to catch fish, and fish volume.

Key informants were purposely selected community members and other concerned NGOs officials who are able to provide information on fishery performance, catch monitoring, application of policies, issues and constraints regard fishing and fish population changes based on their knowledge, skill or experiences with those subjects. The key informants were selected using the following process:

a) The type of information regarding the local name of fish species caught in the area, trends in fish catch, household incomes and fish population were identified;
b) The community leader or NGOs were identified and a meeting with them was arranged to explain what the purpose of the research was and what it seeks to achieve;
c) Community leader and NGOs were requested to identify individual fishermen that hold key positions or are widely respected. These include religious leaders, heads of fishers, health workers, and teachers; and
d) From among the people holding key positions, key informants were chosen depending on who can provide relevant information based on the five objectives previously mentioned.

Research field work started in early August 2009 and twelve field assistants were employed to conduct field interviews. At the outset, they were given a comprehensive training on the methodology, especially tools of research (interview questionnaires). The twelve field assistants were divided into 6 groups, each composed of 2 field assistants, who were then deployed in 6 blocks of the two fishing communities. Because of limitations brought about by the climate and the sheer volume of the questionnaire each group could complete only one questionnaire a day. Therefore, it took the group two months to complete all 35 questionnaires (August & September). After the questionnaires were completed at the sites of interviews, all groups of field assistants reported to me for initial check up of the results and monitoring. Group meetings were conducted every weekend and local key informants were sometimes invited to take part in the meeting informally. The meetings served as a venue to clarify all the answers and provide whatever missing information in the questionnaires. Data entry started in early October, after the field data collection was finalized.

2.2.5 Data Collection on Fish Catch and Fish Landing

The purpose of this research tool was to collect indicative data on trends in marine fish changes and exploitation, concerned problems and policy application regarding the restriction of fish catch, and the community fishing management. The survey generated basic information on the quantity and size of fish caught, fishing gears, fishing grounds, etc. This was especially significant to obtain feedback from the community. Two teams were arranged to go to the fishing grounds and fish landing sites and record information on fish species, weight and size using direct observation. In addition, the teams were tasked to record other information such as the total number of boats operating on the day and seasonality of fish abundance.

Data collection is readily adaptable to a variety of organisms (e.g., crabs, shells etc.). Fish catch monitoring was conducted in areas where there is a strong fisher association. Resources uses are both human and materials (fishing member and fishing gear). Human resources were from 40 volunteer's fishers and other stakeholders in each place, and there were six facilitators (who were likewise trained during the early stages of this study for data collection and analysis). Materials such as craft paper and pens, resource map, fish identification materials (picture book), data sheet and pencils, logbook, weighing scales, calculator, binoculars and boat were used.

Data recording of the daily fish catch and fish landing was conducted by me (PhD student) inside the lagoon, ports, and local markets. So far, although the interviews have been finished, fish monitoring are still underway at each site. Significantly, data regarding volume of fish catch during the last five years were gathered based on the recollection (memories) of the key informants. Fish catch monitoring for 2009 was conducted directly at the sites.

2.2.6 Data Analysis

- Key informant and small group, open-ended interviews

These interviews were carried out with 220 people during fieldwork, including: fishers (different communities) owners of fish stores and restaurants (fish landing and fish value) the chairmen of the fishery community the commune clerk and councils the local fishery authority officer two former fishery inspector, staff of American Friend Services Committee Organization (AFSC). A researcher who was involved in the shrimp larvae stocking program, agricultural farming owner, and staff of the Department of Fishery Administration.

- Archival research
- Archives and materials researched include:
    - FAO fishery research in coastal zone.
    - Annual reports of fishery production in Cambodia
    - The current and former fishing regulations
    - AFSC field report
    - Census 2007
    - Fish catch monitoring in 2009

2.2.7 Data analysis of field notes, interviews and archival data

The research for the dissertation was carried out in Cambodia's remote area where communication is a bit difficult even in the local language. The questionnaires were translated into Khmer as in the area style of speaking. Therefore, the interviews, field notes, and archival materials were not translated into English until the writing stage, especially during the data entry. The steps followed in analyzing the data gathered are:

Step 1: coding and transcription of all field notes (about 350 pages of median-size notebooks) into a file organized according to the main issues (categories of the replies) (Note: the codes emerged from the data, i.e., the categories were not pre-established).

Step 2: transcription of recorded open-ended interviews (15 hours video tapes).

Step 3: coding (categories) of each paragraph of the transcribed interviews.

Step 4: organization of all paragraphs of transcribed interviews according to the main issues (categories).

Step 5: extraction of the information from field notes and transcribed interviews into a file.

Step 6a: steps 1, 2, 3, 4 and 5 were first performed from October 2009 to November 2009 as a portion of the data was then collected. The main findings were resumed in another file, which was then submitted for verification to 5 people who occupy positions that are relevant to the management of the Lagoon. One among the five people is district governor of Sre Ambel, while the other two are chairmen of fishery communities and the rest are local fishery administration officers.

Step 6b: steps 1, 2, 3 and 4 finalization is the start of data entry into the spreadsheet computer program which was previously entered into Excel prior to transfer into SPSS.

Step 7: analysis of all information to produce a final resume of data. During this process, I reviewed information from my field notes, the transcribed interviews, and the comments of the five people who checked my primary findings. The results are presented in a file. (Note: During this analysis, information was filtered by the researcher's understanding of the facts and processes after one year of fieldwork. That is, whenever some information was inconsistent with others or did not make sense to the researcher's perceptions, it was not considered in the analysis).

Both quantitative and qualitative data sets were collected using the aforementioned specified techniques. The fishery household survey provided information on idiographic characteristics, socioeconomic background, mean of livelihood, possessions of fixed and liquid assets, debts to port owners, level of education, adoption of innovations and adaptability, attitude and responsiveness toward modern technology use, and change in the way of economic life, fishing profile, catch per year, species majority and minority, and other factors concerning the lagoon's resources. Information on these factors was obtained in the form of figures, facts, statements, references reactions, cognizance, or preferences, using ranking or scaling techniques.

Organization and processing of data collected employing different methods require different techniques as well. Sets of raw data pertaining to households and places were processed using the SPSS/PC computer software, which offered most statistical tools

normally applied to social science studies as well as database management facilities. Other data derived through primary sources was organized and processed using graphic software. A pragmatic approach was adapted in applying specific tools – descriptive statistics, cross-tabulation, matrix construction, and charting, ranking, scaling, and diagnostic and inferential statistics using particular tests for description, diagnosis and analysis. The hinges of analysis, wherever applicable, were its nine components of people, place, activities, and external intervention, application of policies and regulations, fish catches, capacity of fishers in terms of education, industrial evolution, and lagoon management.

2.2.8 Test Normality of Data

Within-cell descriptive statistics is a testing statistics to assume that the data follow a normal distribution (mean, standard deviation and variance, standard error of the mean, skewness, and kurtosis) (Berenson et al. 1992). This is to test median, grouped median, and minimum and maximum values. The Analysis of Variance (ANOVA) was used to compare volume of fish catch from 2002 to 2009.

2.2.9 Factor Analysis

Among the plenty of variables collected some have been classified into specific factors such as factor of policy application, factor of education background, factor of agricultural practices, factor of mining exploitation, factor of fish catch and fish landing. The aim is to find out the level of correlation of variance among those factors which is generally produced from statistical analysis. From the result of this principal component analysis we would be able to interpret the result into a statement that would be useful to recommend alternative policies at the end of the dissertation. The steps in this factor analysis were as described below.

The correlation or covariance matrix was computed via the use of Bivariate Correlation tool. Those variables that have very small correlation with all the others were eliminated. The size of its communality and loadings were checked as well. The factor loadings were estimated. From these results we were able to know the method of extraction, either principal component or one of the factor analysis methods of extraction. The loadings were rotated to make them more interpretable. Rotation method made the loadings for each factor either large or small, not in between. A few factors were chosen by default. For each case, scores were computed for each factor and saved for use as input variables in other procedures. Scales and indexes are used for the quantitative interpretation of qualitative data, particularly ranking and scaling. They can be used to measure or assess attitudes and other forms of qualitative reactions. Their use in the social sciences is common, and they are significant because they provide quantitative measures that are amenable to greater precision, statistical manipulation, and explicit interpretation (Miller 1983, 174).

2.3 Plan of the Dissertation

This dissertation has five major chapters. In each of them, the follow chapters try to answer one of the five specific questions posed after the main research question. Each chapter stands by itself because the chapters were written as independent publishable

articles. Therefore, each chapter has a section describing the case study and the research methods used; these may contain overlapping material. Chapter I includes the introduction, research questions and objectives, and the aims of research. Chapter II consists of the literature review and the history of the study area and methodology. Chapter III focuses on the current performance of lagoon fish catch over last couple years. Chapter IV discusses overall socioeconomic growth overtimes in relationship to marine fish catch in the area. Chapter V examines the factors that are responsible for the decline of fish catch rate in the Sre Ambel Lagoon. This chapter looks at three main factors such as industrial growth, large farm cultivation with the use of chemical fertilizers, and illegal fisheries practices through the use of illegal fishing gears. These factors perhaps caused the social-ecological changes in the Lagoon management system. Chapter VI focuses the stakeholder conflicts and solutions across a policies level in the area. It investigates the major conflicts about the use of the Lagoon area and their roots. As well, it was analyzed about the Lagoon's major environmental and management problems in the late 1990s. It proposes the establishment of a co-management Forum for conflict resolution and resource management, in which the knowledge, values and concerns of all stakeholders may be taken into account. It also proposes the creation of a knowledge base, including both local knowledge and scientific knowledge, to help find common ground among stakeholders, which in turn could help resolve or manage conflicts more effectively. Chapter VII looks at a policy alternative for lagoon management. It discusses also the capacity of the fishermen in applying fishery guidelines, laws, and regulations. In this chapter, it goes deeply look into fisher knowledge about major fishery species and the Lagoon ecosystem dynamics, as well as fisher view of government management. It also addresses the problems of changing social values and loss of local knowledge. It concludes by showing the multiple roles that fisher knowledge may play in participatory management. Chapter VIII provides the conclusion and recommendation about the assessment respectively.

CHAPTER 3
CURRENT PERFORMANCE OF LAGOON FISH CATCHES

3.1 Introduction

This chapter assesses and reviews the state of the Sre Ambel marine fisheries and fishery resources, based mainly on fish catch statistics as imparted by the fishers based on their memory from 2002 to 2009 and relevant stock assessment and other complementary information available until 2004. The introductory chapters refer to the general situation and major trends of the area marine capture fish production and the state of the area's marine fishery resources. More detailed information is provided from all stakeholders in the area, together with a discussion of the major trends and changes that have occurred with the main fishery resources exploited in each area and comments on the stock assessment work undertaken in support of local fisheries management in the lagoon. Special sections address the general issue of caught species and other abundance species such as the five endangered species found in this research.

Cambodia is predominantly an agricultural country and land ownership for subsistence agriculture is crucial, especially for alleviating rural poverty. Almost 80% of the country's population live in rural areas and 75% are farmer-headed households that depend primarily on the culture of rain-fed rice. Average rice yield, however, is considered as one of the lowest in the world due to poor soil fertility and adverse climatic conditions over the past years.

Researcher estimated that as an average, a typical annual low-land and rain-fed rice farm's production is sufficient to sustain only about 7 -10 months of a household's consumption. Recently, efforts in increasing crop productions have been a major preoccupation of the government such that increase of annual crop production was observed from 1.7 tons in 1998 to 2.1 tons per hectare in 2002 (Lim ENSAT, pers.data.).

The coastal area of Cambodia is divided into two provinces, Koh Kong in the north and Kampot in the south, and two municipalities, Sihanoukville and Kep (Figure 2.1). Cambodia's marine capture fisheries are characterized by a multitude of species and the use of a range of fishing gears. Reference to DoF fisheries statistics indicates that marine fisheries production as recorded by DoF has not yet shown a decrease by species and landing place, but there has been a decrease by province and grade as according to fish value and size in domestic fish markets. Most the sources for the survey of the marine fish catch were taken from the recollection of the fishers and local residents as well as information from the stakeholders in the area. This study likewise conducted a perception survey from a different diversity of residents whose livelihoods are based on the marine resources, especially fish catch, shrimp, crab, and mollusk.

Notwithstanding the poor system of recording fish catches, records of marine fisheries production by province and municipality from 1992 to 2001 are still available at the governmental central level. These statistics are not at the species level, but grouped according to higher taxa and commercial or market names. DoF estimates that fish caught outside Cambodian waters constitute around one quarter of the recorded production. Fish

caught by subsistence fishers are not included in the official statistics. For Kep municipality there are no data from 1980 to 1996, due to the fact that administrative structure for this municipality was institutionalized only in 1996.

So far, there have been no stock assessments conducted in Cambodian marine waters. However, comments from fishers and the results of several related studies indicate that the threat of overfishing in the Gulf of Thailand is now at a critical stage and is such that it has affected fish catches at the Sre Ambel Lagoon as well.

The collection of catch per unit effort (CPUE) data for Sre Ambel's marine fisheries does not occur. Thus, the status of marine fisheries in terms of CPUE is unknown. Surveys from the residents and outsiders, such as commercial fishermen and non-commercial fishermen during the research field reconnaissance survey had given some indication as the hypothesis to reach this comprehensive quest. The results of long-term fish catches of fishermen indicate that daytime catches in the Sre Ambel declined from 90 kg/day in 2003 to 30 kg/day in 2005 and to 20kg/day in 2008. Catches of nighttime fishing operations declined almost 60% from 2005 to 2008 (Chief of fishery community, 2008). Results of studies in some places also highlight rapid declines in yield (Ibrahim, 1999). However, the scale of operation and types of fishing gears used differ between Sre Ambel lagoon and coastal fisheries. Hence, the researcher has decided not to use the data available at the governmental fisheries center, but has relied on local perception as a primary source of data.

3.2 Theoretical Reviews

The official area of the study site is 128,214 ha. Official population is 4901 families (2005). Key livelihoods are known to include farming and fishing (brackish and marine). Density is 4 people per km^{-2}. Average trend over the past three years shows **a c. 5% p.a.** increase. Road access is good year round to the main villages but poor to several outlying settlements. The main villages are mostly close to the services of the Sre Ambel town. The Commune has two parts (1) a densely populated coastal belt with a mosaic of cleared land, mangroves, Melaleuca swamp and forested hills, partly inside Dong Peaeng Multiple Use Area and (2) a huge, sparsely populated inland area of evergreen and deciduous forest on hills in the Sre Ambel catchment. It is comprised of two fisheries communities: Chhroy Svay Fisheries Community and Chikar Kraom Fisheries Community. Known biodiversity values include populations of elephants, primates and various other forest species in the upland areas and small numbers of rare large waterbirds in the coastal wetlands. The river systems support a breeding population of two of Asia's rarest reptile species, the Critically Endangered Royal Turtle Batagur baska, which is the focus of a WCS/Fisheries Administration conservation project and the Siamese Crocodile, which is partly covered by the WCS/FiA project and also by a new Fauna and Flora International crocodile-focused project. Forest clearance, economic land concessions, illegal hunting, logging and fishing practices are all important NRM issues. The Forestry Administration and Wild Aid conduct law enforcement patrols to address these issues and the American Friends Service Committee has a long-running project to strengthen communities managing their own natural resources, especially fisheries conservation program.

During the time of King Sihanouk's regime, the sea near Chroy Svay commune was rich in fishery resources. There were many varieties of shrimp, crab, and fish. Sometimes, they can even be caught by hand. After the time of Pol Pot, this area was still rich in natural resources, and 5 – 10 kg of shrimp and 20-40 kg of fish can be caught per day. Rowing boats and traditional gear were mostly used and only very few used trawlers.
During the 1980s, enough fish was being caught to sell to middlemen from outside Chroy Svay, so trawler fishers living in Stung Hav and Tamor Sawr found out that the area was rich in natural resources. Around 1987-1988, the first trawlers from Stung Hav and Tamor Sawr started to expand their fishing grounds into the sea around Chroy Svay. After the trawlers started to come, there was a decline in the volume of fish that was being caught. The trawlers used nets with small holes, which collected more fish, even the small ones. The local residents set their nets in the shallow water near Chroy Svay, but the boats from outside the area destroyed the nets. Although people were not aware of the law, they thought what these boats were doing was illegal.

In response, the locals asked the soldiers who were based in the villages at that time to help stop the outside fishing boats. They would collaborate to "arrest" these fishers and impose a fine. It turned out that some of the boats, especially those from Tamor Sar, were protected by soldiers. Others bought or rented guns to fight with the fisherman in this area. During the arrests, there was often conflict with shooting. There were many injuries and deaths, especially of fishers from Chroy Svay Kach. There was anarchy and a lot of violence during this time.

During the 1990s, the problem of illegal fishing boats continued to worsen. There were still a lot of fish in the 1990s, but they were less compared to the 1980s. Conflict between fishers remained high despite interventions by Ta Yi Hay, the former commune chief of Chroy Svay, and by the district governor. There continued to be many deaths from the fighting, even after there were no more military in the villages. By 2000, many traditional fishers in Chroy Svay commune had stopped fishing because of problems with trawlers, push boats, and robbers. In Saray village, nearly 80-90 percent stopped fishing. When the locals stopped fishing, they cleared flooded forest for rice cultivation and upland forest for plantations. Many men had to leave to find work in other places, so women and children had more work to do at home. The villagers in Chroy Svay Lech and Nisat, however, were more dependent on fishing – 80-90 percent continued to fish, but they dared not go far from the shore. Whenever the villagers went fishing, their nets would be removed or ruined by illegal boats after only one or two days. Many of the villagers owed money to middlemen because they had to borrow money to buy nets, but they earned no income when the nets were lost. From 1998-2003, those who were clearing forest were less affected by the conflict. Notwithstanding the fact that the government outlawed forest logging in 1999, the local villagers continued to clear land because they were still unable to practice traditional fishing. They began fishing again in 2003 only because there were no more forests to cut. But for those who never quit fishing, the fighting continued to get worse and more people were killed. By now, there were less and less fishery resources and it was difficult to support the villagers' respective families. More and more illegal trawlers from Stung Hav came. Cha Eurt Community was patrolling their area, so illegal boats came to Chroy Svay instead.

In 2003, the villagers heard about the establishment of the community-based fishery in Chikor Krom commune. They also heard about fresh water fisheries being established on the Tonle Sap. They never thought that a community fishery could be established in the area because there were so many illegal boats and conflicts. They could not manage a solution between the traditional fishers and illegal trawlers on their own so they needed help from the outside.

3.3 Methods

The sample size was composed of 210 fishing families randomly and equally selected from the two fisheries communities. The survey targeted all types of fishermen; large scale, medium scale and small scale. Large scale defined for those who used motor boat with horsepower higher than 30, medium scale referred those who used motor boat in between 5 horsepower to 30 horsepower, while small scale defined the motor less than 5 horsepower. Each community is composed of three fishing villages whose composition varied from 30 to 32 fishing families per fishing village. Data of fish catch per fishing family has been recorded as a series data since 2005 to 2009. Data on fish catch was composed of volume, time to catch, weather, place, species, name of fisher, type of boat, and gears used. Besides fish catch data, there were around 30 other related variables included in the fish catch records. These question variables present in a structural and non-structural format. Test normality of data is required to see trends of data; how much the disparity in the variation of means is from one to another.

Fish catch monitoring was conducted in the areas in the two communities where there are strong fisher associations. The data were used to support advocacy initiatives of the two fisher organization (e.g., stricter enforcement of laws in municipal fishing grounds and livelihood assistance). Data collected and analyzed in a systematic manner and formally presented to government and other sectors could be impressive and influential. All 210 fishers were trained during the early stages for training and analysis). Those fishers were provided with fish identification materials (picture book), data sheet and pencils, logbook, weighing scales, and calculator. The ruler used is a locally designed fish measurement board. Data record sheet consists of many questions eliciting time to catch fish, place to catch fish, and fish volume and were provided to guide all the fishers when they record information. Initially, trend of data were recorded in Excel form and each factors related to fish catch had separate graphs. Analysis of Variance of a time series data of seasonal family fish catch was conducted in order to compare means in the period of 2002-2009. Pos Hoc of ANOVA was the parametric test selected to see the differences in fish catch volume individually.

3.4 Results

The results of this chapter presented in figures and tables as general findings. They are focused mainly on percentage and frequency of the practical status of fishermen. It is also importantly indicated a trend of series data of fish catch over last couple years. The statistic data obtained from both archival documents and provided by department of fisheries administration.

3.4.1 Current Fishing Performance

Two types of fishermen were found in the study area; small scale fishermen and medium scale of fishermen (Table 3.1). Small scale of fishermen dominated in the area, while most people were not used motor boat to catch fish. As described in the methodology section on the definition of fishermen large scale, medium scale, and small scale. All thought large scale of fishermen were not found during the study, but they were available in the deep sea water of the large where inaccessible. Small scale and medium scale were found during field data collection as described in Table 3.1.

Table 3.1: Type of fishermen

Type of fishermen	Frequency	Percentage
Small scale of fishing	152	72.4
Medium scale of fishing	58	27.6
	210	100

There are two types of fishers in the area: small scale and medium scale. Medium scale fishers account for 27.6% of the 210 fishing families, while small scale fishers comprise 72.4% of the total fishers. 33.3% of the fishers in the Chhroy Svay Community are small scale fishers and 9.6% are medium scale fishers. In the Cha Eurt Community, 39% are small scale fishers while 18.1% are medium scale fishers (Table 3.2). Notwithstanding the fact that there was still a small number of large scale fishers in the area, the 210 sampled households do not include large scale fishers because it was difficult to reach them for record-keeping. Moreover, those large scale fishers are not local residents often referred to as outsiders.

Table 3.2: Percentage of fishermen in the two fishery communities

Type of fishermen	Cha Eurt Fishery Community	Chroy Svay Fishery Community
Small scale of fishing	33.3	39.0
Medium scale of fishing	9.6	18.1
	42.9	57.1

3.4.2 Type of Fishing Gear

There are four categories of fishing gears. Crab nets and push nets comprise 6.7% and 9.5% of the fishing gears used by the 210 respondents in the Chroy Svay and Cha Eurt Community respectively, while drift nets and seabass nets are used by 12.4% and 18.1% of the respondent fishers in the Chroy Svay and Cha Eurt Community respectively. The rest of the gears used are trawl and purse nets are used by 1.4% and 1.9% in the Chroy Svay and Cha Eurt Community respectively. Encircling seine, anchovy encircling seine, mackerel gill nets, clupea gill nets and others are used by about 22.4% and 27.6% respondents in the Chroy Svay and Cha Eurt respectivly (Table 3.3).

Table 3.3: Percentage of fishing gear using in the two fishery communities

Type of fishermen	Cha Eurt Fishery Community	Chroy Svay Fishery Community
Crab net and Push net	9.5	6.7
Drift net and sea bass net	18.1	12.4
Encircling seine, anchovy encircling seine, and mackerel gill net	27.6	22.4
Trawl and purse net	1.9	1.4
Total	**57.1**	**42.9**

3.4.3 Number of Gears per Fishing Trip

Table 3.4 shows the number of gears used per fishing family per effort of fishing. 31.9% and 39.5% of the fishing families used 1 to 3 fishing gears per effort in the Chroy Svay and Cha Eurt Communities respectively. 8.1% and 15.2% of fishing families in the Chroy Svay and Cha Eurt Community respectively used 3 to 5 gears per effort. A small number of fishing families use more than 5 gears, 2.9% in Chroy Svay and 2.4% in Cha Eurt Community (Table 3.4).

Table 3.4: Percentage of number of fishing gear used per fishing effort

Class of number of fishing gear	Cha Eurt Fishery Community	Chroy Svay Fishery Community
Less than 3 gears per fishing effort	39.5	31.9
3 – 5 gears per fishing effort	15.2	8.1
Higher than 5 gears per fishing effort	2.4	2.9
Total	**57.1**	**42.9**

3.4.4 Household Seasonal Fishing Trips and Catch Volume vs. Number of Trips

The number of seasonal fishing trips per family varies from a minimum of 50 trips to 110 trips per season. Less than 80 trips were accounted for by 32.9% of the 210 total fishing respondents in the Chroy Svay Community while 41.4% was recorded in the Cha Eurt Community. 5.7% of each community recorded a fishing trip of 80 to 90 times per season while 4.3% and 10% in Chroy Svay and Cha Eurt Community put forth more than 90 trips respectively (Table 3.5).

Table 3.5: Percentage of fishing trips per household fishing (Nov-May)

Class of fishing trips	Cha Eurt Fishery Community	Chroy Svay Fishery Community
Less than 80 trips per season	41.4	32.9
80 – 90 trips per season	5.7	5.7
Higher than 90 trips per season	10.0	4.3
Total	**57.1**	**43.9**

Catch volume shows the relationship between the volume of fish catch and the number of trips per season. The more efforts the fishers put forth per season the more volume of fish they caught (Figure 3.1)

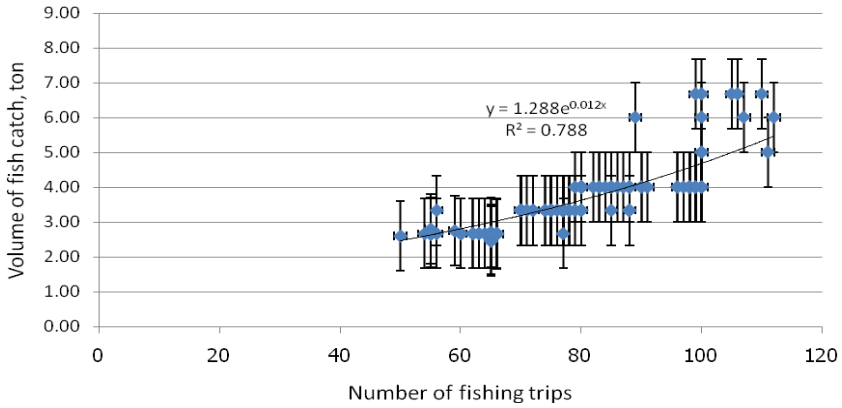

Fig. 3.1 Household seasonal volume of fish catches vs. number of fishing trips

3.4.5 Length of Boat versus Volume of Fish Catch

The length of the boat used by the fishers varies from 8m to 15m long. The length of boat used is an important indicator to consider in looking at fish catch. The findings show that the bigger the boats used the greater the volume of fish catch (Figure 3.2).

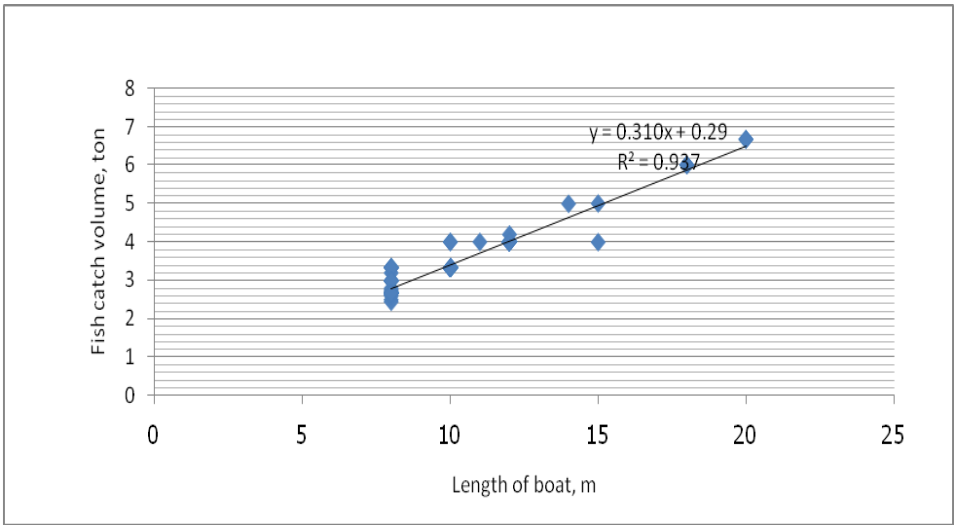

Fig. 3.2 Volume of fish catches vs. length of boat

3.4.6 Power of Boat versus Volume of Fish Catch

Fish catch volume is likewise directly related to capacity of boat power (Table 3.6). The capacity of the boat's power used by the fishers varies from 6 horsepower to 30 horsepower. Boats with less than 10hp usually catch approximately 1.7 tons, while boats with power higher than 25hp are usually able to catch more than 2.7 tons.

Table 3.6: Fish Catch vs. Horsepower

Capacity Distribution of Power of Engine (horsepower)	Mean of fish catch in tons
Less than 10hp	1.7142
11hp - 15hp	2.7258
16hp - 20hp	2.7657
21hp - 25hp	3.0963
Higher than 25hp	3.7712
Total	2.7078

3.4.7 Fisher's Education versus Volume of Fish Catch

Education of fisher is an indicator which influences catch volume as well. The higher the education they obtained, the more volume of fish they caught (Figure 3.3).

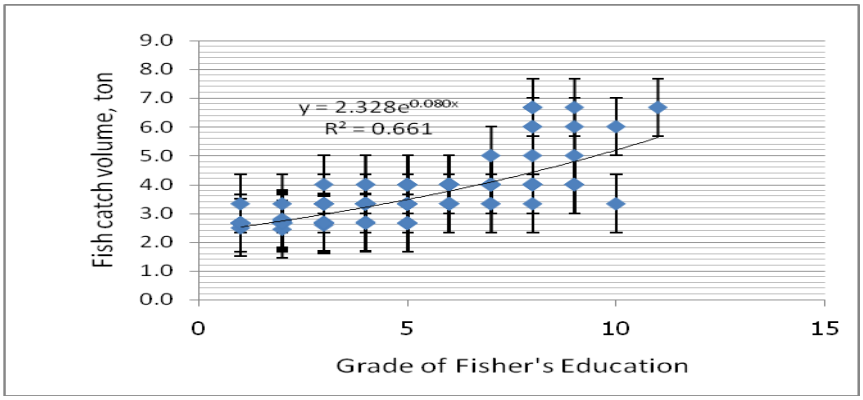

Fig. 3.3 Volume of fish catches in relation to fisher's education

3.4.8 Volume of Fish Catch in relation to Water Depth Where Fish was caught

The average water depth is about 6 m and it also varies from one fishing ground to another. About 500m from the shore, water depth is approximately 2m. The highest volume of fish is usually caught where water depth is approximately 2m to 3m. The catch decreases where the water depth is high (Figure 3.4).

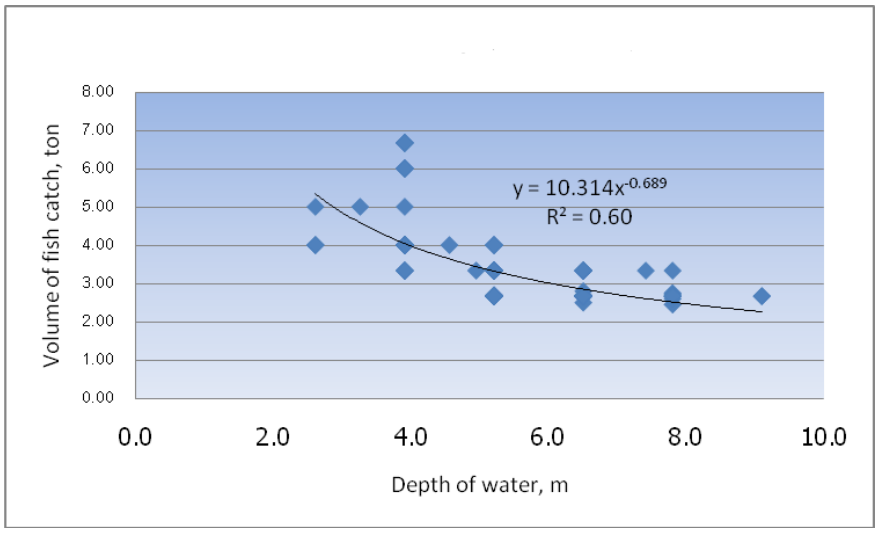

Fig. 3.4 Volume of fish catches in relation to water depth

3.4.9 Temperature Measurement

Temperature was measured from four stations surrounding the area at 6h30 pm. Calibration was recorded since 2005 until 2009. Table 3.7 shows the average changes.

Table 3.7: Surface Water temperature in daytime

Year	2005	2006	2007	2008	2009
Temperature (^{o}C)	30.63	30.93	31.09	32.25	32.25

Source: Provincial department of hydrology

3.4.10 Changes in Fish Catches over the Years

Average Change in Household Fish Catch over the Years: Analysis shows a linear trend in fish catch that has been steadily declining from 2005 to 2009. The decline in fish catch is counted in average per family for all fishing types (large, medium, and small scale). Figure 3.5 shows a decline of catch volume for the last five years in both fisheries communities. In 2004, fish catch per family was about 5 tons per season starting from November to June. It declined drastically in 2009, dropping to 2.7 tons per family. However, fish catch volume appeared to be constant during 2008 and 2009 with a slight decline of about 0.1 ton only. The next section provides a detailed description of the changes over the years.

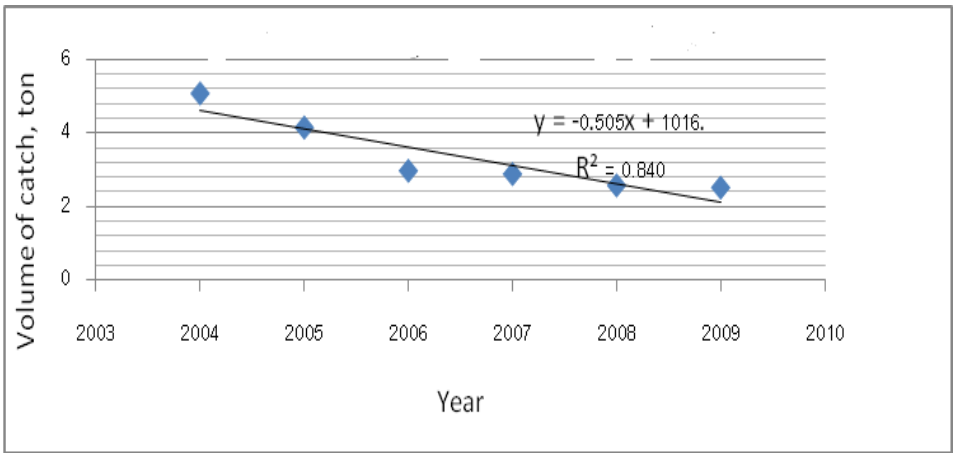

Fig. 3.5 Seasonal Trend of Average Household Fish Catch (Nov-May)

Changes in the Number of Fishing Gears Used Over the Years: Both communities registered an increase in the number of fishing gears used over the years, including fishing gears that come from other surrounding areas. The increase in fishing gear use varies from 40 gears to a maximum of 71 gears in Chroy Svay, and from 80 gears to a maximum of 114 gears in 2009 Cha Eurt Community in 2005 (Figure 3.6). The average increase in the use of fishing gears in the Cha Eurt Community appeared much higher than that of the Chroy Svay Community.

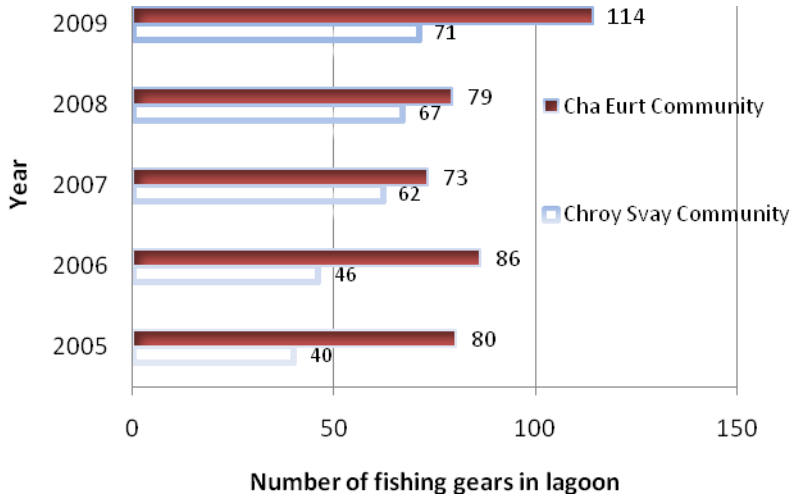

Fig. 3.6 Increase in the use of fishing gears in the area

Fisheries Statistics of Sre Ambel Coastal Fisheries: Landings in the Sre Ambel coastal area of Koh kong province, a distinct coastal lagoon where the study site is located, contributed 25.8% of the entire provincial landings (17.400 tons) (DoF, 2005). Interestingly, records show that landings in this area decreased from 898 tons in 2005 to 525 tons in 2009. The trend shows a steady decline since 2005: 767.8 tons were caught in 2006, 721 tons in 2007, and 653.6 tons in 2008 (Figure 3.7). Total effort in the area decreased from 11900 trips in 2005 to 4875 trips in 2009. Trips are known as a relationship

unit of effort to the increase in the use of of fishing gears in the area (Figure 3.6). Along with the decrease in fishing trips (efforts), a decrease in motorization was noted as well (Figure 3.8) from high horsepower to low horsepower which result in the loss of profit due to the increase of fuel costs and other law restrictions. The valuable fish species showed a significant decline over the period of 2005-2009, with remarkable absence of auto-correlation in the annual landings (Table 3.8). Information relevant to the status of individual fish species in Sre Ambel, however, was lost at the regional level where annual totals for the province of Koh Kong were further aggregated among 21 common fish species in 12 fisheries sites of the province (Jensen & Try 2002). Surveys conducted at the Sre Ambel coastal fishing points revealed that 185 fishing units operated each day within the 10,000 km2 of the Sre Ambel coastal area, most (70%) of which used mackerel gill nets, anchovy encircling seine, fish gill nets, and shrimp gill nets (first category of fishing gears) to catch all kinds of fish species (Table 3.8). Medium-scale lift net units (20% of total effort) (second category of fishing gears) aimed at small pelagic fish from 10 – 20 m long motorized boats, while the remaining units used crab gill nets, crab traps, squid traps, and fish stake traps, explosives, and long lines hooks (third category of gears). The low average catch rate of the first category of fishing gears was about 22kg/effort. The second category of fishing gears registered a catch of 75kg/effort, while the third category of fishing gears was able to catch only 10kg/effort). The selection of fishing locations by fishers was limited by the permission of the community authorization which issued permits depending on the size of the boat length as well. CPUE was significantly higher in the less intensively fished areas. Fishers could hardly perceive differences in CPUE at a small spatial scale within their individual resources species, where they nevertheless reacted to high catches, they could not conclude on such large-scale patterns. This was particularly so for lift net fishers, who in theory could reach every location inside the Lagoon, but who experienced high variability in their catch rates (0 – 105 kg/effort) due to the migratory and schooling behavior of their target fish.

Table 3.8: Name of fish species that declined over the period of 2005-2009

No.	Scientific name	Common name	Khmer name	Price (Riel/Kg)
1	*Cromileptes altivelis (Valenciennes, 1828)*	Humphack grouper	Trey Tok Ke Chrouk	24,000-28,000
2	*Pomacanthus annularis (Bloch, 1787)*	Bluering angelfish	Trey Me Ham Boa	23,000-25,000
3	*Epinephelus coioides (Hamilton, 1822)*	Orangespotted grouper	Trey Tok Ke Koa	22,000-28,000
4	*Pampus argenteus (Euphrasen, 1788)*	Silver pomfret	Trey Chab Sor	20,000-26,000
5	*Epinephelus faciatus (Forsskål, 1775)*	Blacktip grouper	Trey Tok Ke Kra horm	18,000-20,000
6	*Plectropomus oligocanthus (Bleeker, 1854)*	Highfin grouper	Trey Tok Ke Uch Kiev	18,000-25,000
7	*Epinephelus quoyanus (Valenciennes, 1830)*	Longfin grouper	Trey Tok Ke Para	11,000-16,000
8	*Diagramma pictum (Thumberg, 1792)*	Yellowdot sweetlips	Trey Ka chii	10,000-15,000
9	*Pampus chinensis (Euphrasen, 1788)*	Chinese silver pomfret	Trey Chab Khmao	4,000-6,000
10	*Atelomycterus marmotatus (Bennett, 1830)*	Coral catshark	Trey Chhlam Khla	2,000-3,000
11	*Chiloscyllium punetatum Müller & Henle, 1838*	Brown-banded catshark	Trey Chham Chhmar	2,000-3,000
12	*Scarus quoyi Valenciennes, 1840*	Quoy's parrotfish	Trey Sek Khiev	2,000-2,500
13	*Himantura imbricata (Bloch & Schneider, 1801)*	Scaly whipray	Trey Bor Bel	1,500-2,000
14	*Sargocentron rubrum (Forsskål, 1775)*	Redcoat	Trey Kror horm sraka tom	1,500-2,000

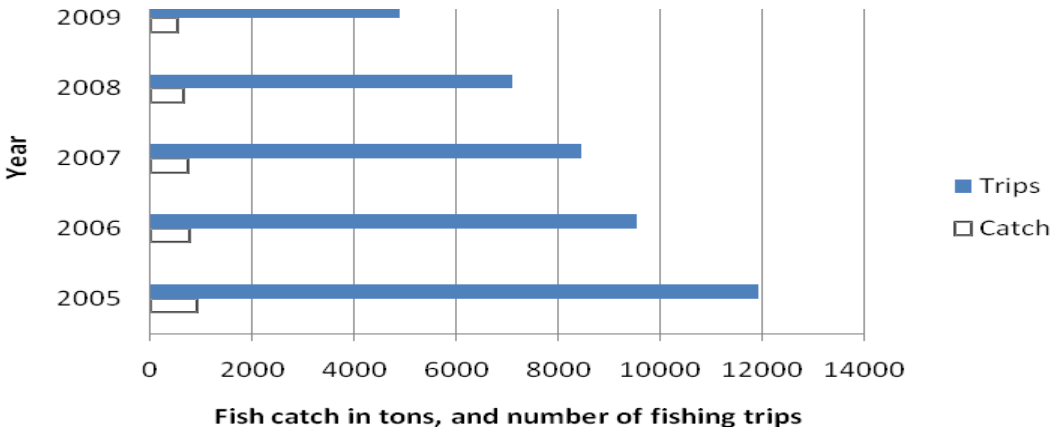

Fig. 3.7 Trend of total fish catch and fishing trips in the whole area of two communities from 2005 – 2009

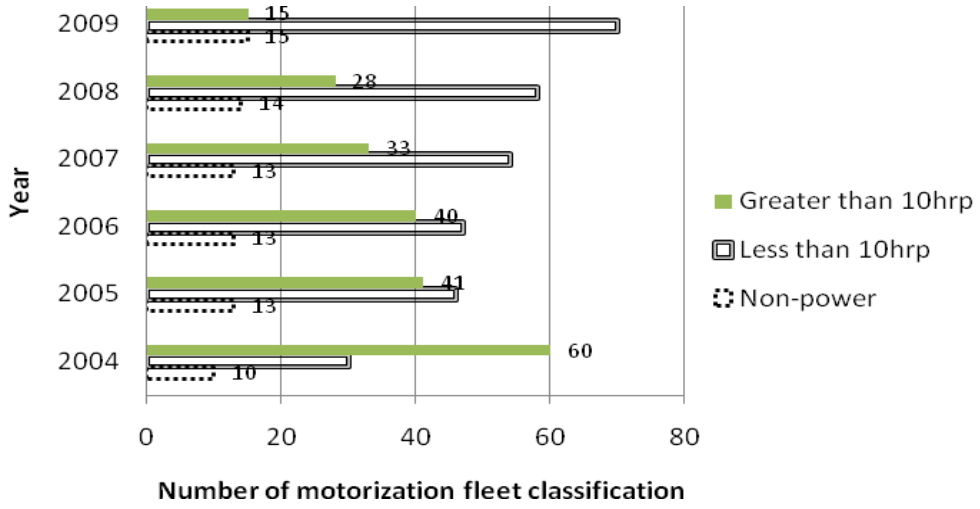

Fig. 3.8 Trend of motorization and use of motorized fishing fleet from 2005 – 2009

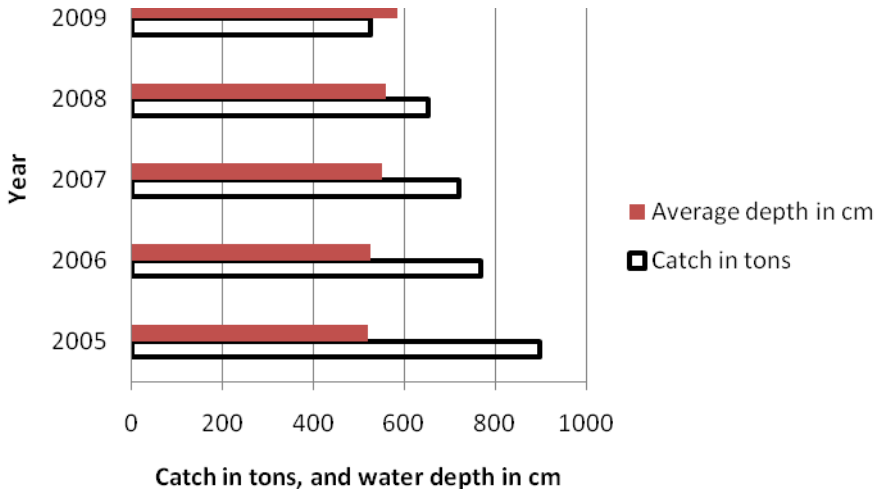

Fig. 3.9 Trend of total fish catch vs. water depth from 2005 – 2009

Test Homogeneity of Variance of Annual Seasonal Household Fish Catch: There are 2 target groups of families whose fish catch was seasonally recorded (Chroy Svay Community Fisheries, and An Cha Eurt Community Fisheries). The test was to look at any differences between those groups of fishers by year. Table 3.9 shows the homogeneity of variance of seasonal families fish catch in average in the last eight years since 2002. Test shows Leven Statistics value is higher than 0.05. Thus, the conclusion is there is equality of variance assumed of all data obtained. Significant value of statistics is higher than 0.05. Therefore, the hypothesis of equal variance within the groups is not rejected.

Table 3.9: Volume of Fish Catch per Family

	Year of Family Fish Catch per Season	N	Subset			
			1	2	3	4
Tukey HSDa	Y2008	210	2.46			
	Y2009	210	2.55	2.55		
	Y2007	210	2.72	2.72		
	Y2006	210		2.85		
	Y2005	210			3.93	
	Y2004	210				4.81
	Y2002	210				4.94
	Y2003	210				4.99
	Sig.		.355	.139	1.000	.807

Description of Annual Seasonal Family Fish Catch: The resulting mean of seasonal family fish catch from 2002 to 2009 showed a small standard error of 0.82. Lower bound in 2002 was 4.7±0.08 tons per family and upper bound was 5.10±0.08 tons per

family. The results also showed the lower bound in 2009 about 2.39±0.82 tons per family and upper bound was about 2.71 tons per family. On the average, the mean of fish catch varied from 4.94±0.08 tons to 2.55±0.08 tons per seasonal family fish catch (Table 3.10). The overall mean of family fish catch in Chroy Svay Community Fisheries was 3.68±0.08 tons, while it was 3.63±0.08 tons for An Cha Eurt Community Fisheries (Table 3.11).

Table 3.10: Household's Fish Catch Yearly

Year of Family Fish Catch per Season	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Y2002	4.943	.082	4.781	5.104
Y2003	4.979	.082	4.817	5.141
Y2004	4.821	.082	4.660	4.983
Y2005	3.932	.082	3.770	4.094
Y2006	2.855	.082	2.694	3.017
Y2007	2.722	.082	2.560	2.884
Y2008	2.467	.082	2.305	2.629
Y2009	2.551	.082	2.389	2.713

Table 3.11: Average fish catch per household of the two fishery communities

Community Fisheries	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Chroy Svay Community Fisheries	3.684	.044	3.598	3.770
An Cha Eurt Community Fisheries	3.634	.038	3.559	3.708

Comparison of Seasonal Family Fish Catch Yearly: The result showed that there is no significant difference among the target group variable ($p > 0.05$). There is a significant difference of yearly fish catch per family ($p < 0.05$), even significant at 99% confident interval (Table 3.12). Tukey HSD test showed the differences of multiple comparisons among family fish catch during the period of 2002-2009 (Appendix - A). It was not differentiated between 2002 and 2003, between 2003 and 2004, between 2002 and 2004, between 2006 and 2007, between 2006 and 2009, and between 2007, 2008, and 2009. However, the results (p-value < 0.05) showed strong significant differences between the most current family fish catch in comparison with the catch in 2006 backward (Appendix - A).

Table 3.12: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1894.267a	15	126.284	90.251	.000
Intercept	22030.546	1	22030.546	1.574E4	.000
Target Group	1.049	1	1.049	.749	.387
Yearly Family Fish Catch	1849.274	7	264.182	188.802	.000
Target Group * Yearly Family Fish Catch	1.531	7	.219	.156	.993
Error	2328.356	1664	1.399		
Total	26667.831	1680			
Corrected Total	4222.622	1679			

a. R Squared = .649 (Adjusted R Squared = .644)

3.5 Discussions

Current Fishing Performance: Generally, fish catch has declined during the last few years due to many factors. Those factors have been outlined in the next chapter. The decline of fish landing resulted from the decline of individual fish catch volume. Statistical p-value showed significant at 0.01 confident intervals of the differences among family fish catch per season between the current fish catch practices and the last couple years. Test of analysis of variance showed the significant difference among means of the time series data recorded during 2002-2009 ($p < 0.05$) at 95% confident interval. Pos Hoc of parametric test has indicated the level of differences among means. According to the results, seasonal family fish catch declined from 5.00±0.08 tons for every fishing family in 2002 to 2.58±0.08 tons for every fishing family in 2009. The decline of fish catch has been blamed to current fishing practices in the area.

Many types of small-scale or artisanal, middle-scale and some large-scale or commercial fishing gears were used in the Sre Ambel Lagoon. According to a proclamation made by the Ministry of Agriculture, Forestry and Fisheries, small-scale or artisanal and middle-scale fishing gears were distinguished by the capacity of boat engines and the size of fishing gears. The term commercial fishery was used only for inland fisheries and was rarely used in relation to Cambodia's marine fisheries, particularly in the Sre Ambel Coast. However, the study found only two types of fishing in the coast of Sre Ambel: small scale or artisanal scale and middle scale fishing. Only a few numbers of fishers were engaged in large scale fishing, a rare few of whom were encountered during the field study. Small scale fishing accounted for about 72.4% of the total number of fishers, while 27.6% were engaged in medium scale fishing. Cha Eurt Fishery Community shared the highest amount of fishing types than Chroy Svay Fishery Community. Of these numbers 39% small scale fishers and 18.1% middle scale fishers were found in Cha Eurt Community, while 33.3% and 9.5% of small and middle scale fishers respectively were found in Chroy Svay Fishery Community. The proportion of fishing types does not relate to the number of fishing population in the area, but to the fish population habitat available in the fishing ground of each fishery community.

Marine capture fisheries in Sre Ambel were likewise divided into two categories: middle-scale fisheries and small-scale or artisanal fisheries. Middle-scale fisheries refer to those utilizing highly efficient fishing gears and vessels with capacity to fish both offshore and inshore using all fishing gears, with the exception of trawling in inshore waters. These fisheries were required to pay tax to the government. After the government declared a reform of the fisheries sector in October 2000, middle-scale inland fisheries were not required to pay tax anymore. However, fishers operating middle-scale fishing gears in the marine waters of Sre Ambel were required to pay tax as usual, albeit at rates lower than those prior to the government reform. The study categorized the fishing gears into four groups, of which crab nets and push nets comprise about 6.7% and 9.5% of the total 210 fishing sample size in Chroy Svay and Cha Eurt fishing ground respectively. Drift nets and seabass nets make up about 12.4% and 18.1% of the fishing gears used in the Chroy Svay and Cha Eurt fishing ground respectively. Encircling seine, anchovy encircling seine, mackerel gill nets, clupea gill nets and the others make up about 22.4% of the fishing gears used in the Chroy Svay fishing ground and 27.6% in the Cha Eurt Fishing ground. Illegal fishing gears such as trawl and purse nets were used by about 1.4% in the Chroy Svay fishing ground and about 1.9% in the Cha Eurt fishing ground.

Every fishing family used at least two to three fishing gears per fishing effort (trip). Only a few of the fishers in the two communities used more than three fishing gears. However, qualitative information and data gathered showed that the number of fishing gears used declined in comparison with the previous five years due to the high cost of repairing gears and the cost of buying new gears. It became no longer efficient and economical for the fishers to spend money on fishing gears when daily income from selling fish decreased.

Table 3.13: Commercial fishing gears used in the coastal waters of Sre Ambel

No.	Type of Fishing Gear		No.	Type of Fishing Gear	
	English Name	Khmer name		English Name	Khmer name
1	Trawl	Uon Ohs	7	Scomberomorus gill net	Mong Trey Beka
2	Purse seine/Ring net	Uon Tith	8	Mackerel gill net	Mong Trey Kamong
3	Anchovy encircling seine	Uon Ka Koeum	9	Shrimp gill net or Trammel net	Mong Bang Kear
4	Beach seine	Uon Khow	10	Crab gill net	Mong Kdam
5	Encircling seine	Uon Houm	11	Horizontal longline	Santouch Ro Noung
6	Gill net	Mong Paehk	12	Clupea gill net	Mong Trey Kbork

(Source: DoF 2002)

The number of fishing gear units used in any given area varies according to the distribution and abundance of natural resources, as well as socioeconomic and market conditions. For example, dredging for short-neck clam began in Sre Ambel at the end of 1999 following identification of a market for this species in Thailand. Similarly, the intensity of small trawl fisheries increased in 1997, leading to the perceived

overexploitation of fisheries resources and conflicts over resource use between small-scale and middle-scale fishers, found in this study.

The use of trawl nets, mackerel encircling seines, and short-neck clam dredges was most common in Sre Ambel and other neighboring places since the last 5 years as these areas have deep-water areas suitable to these gear types, but the use of trawl nets seemed to have decreased since the measure to ban the use of such nets was enacted by the government. In the study area, traditional fishing gears, including gill nets, crab nets and long lines were still commonly used, especially for those fishing for household or personal consumption.

Small-scale fisheries in the study area were those utilizing traditional or low efficiency fishing gears (Table 3.14), non-power boats, or power boats with a capacity lower than 5 hp (horse power). Generally, these fisheries operated in inshore waters up to 3 nautical miles from the shore and were not required to pay tax. The result of analysis showed there were a variety of motorized machines used in the study area. Table 3.6 shows the horsepower varies from less than 10hp to higher than 25hp. Most of those who used motorized boats with capacity higher than 25hp were outsider fishermen who used gears such as trawl nets and push seine nets. Even the volume of fish catch was the positive linear function of boat power; the high power boats consumed much fuel. Therefore, local resident fishermen opted to use motorized boats with the power of less than 10 hp.

Table 3.14: Small-scale or artisanal fishing gears used in the coastal, Cambodia

No	English Name	Khmer name	No	English Name	Khmer name
Gill net (Mong Paehk)					
1	Crab gill net	Mong Kdam	3	Fish gill net	Mong Paehk
2	Shrimp gill net	Mong Bang Kear	4	Seabass gill net	Mong Trey Spong
Stationary Gear					
5	Squid trap	Lop Meuk	8	Bamboo crab	Lop Kdam
6	Fish trap	Lop Trey	9	Small winged	Pong Pang
7	Crab trap	Lop Kdam	10	Circular net	Lop Mong Kdam
Mobile gear					
11	Push net	Thnorng Os Ky	13	Drift gill net	Mong Bandet
12	Hook	Santouch			

(Source: DoF 2002)

During the last five years, the number of efforts to catch fish was very high. A single fishing family during fishing season caught fish more than 100 times. They used small boats to catch fish, and majority of them were not of high capacity horse power. Therefore, we concluded that the catch method was using motorized horse power that is less than 5 hp. Marine fish catch in 2005 was very high inside the area. Statistically, fish catch in the two fisheries communities reached up to 898 tons seasonally. Meanwhile, the efforts (trip) of fishing in 2005 were also high (11,900 trips). However, the number of trips and volume of fish landing in the area gradually declined during the last five years. In 2009, the fishing efforts were about 4875 trips for the first 6 months of open access (November-May). Thus, the fish landing also declined to about 525 tons, one third less than the catch in 2005 (Figure 3.7). Possibly, the decline of fish catch in 2009 was a result of the decline in

fishing efforts (trips decline), but the decline of fishing efforts may have been caused by some factors such as socioeconomic evolution in the area, cost of fishing raw materials, enforcement of laws and regulations, or even a decline in the volume of single catch effort. For instance, it was reported that sometimes only 5 kg of fish was caught per effort (trip), notwithstanding the fact that a whole day was spent on site (according to the chief of fisheries community). However, an analysis of the data showed that the volume of seasonal fish catch is a function of fishing efforts (trip), i.e. the more trips the fishers were to make, the greater the volume of fish catch. Based on the data collected, a single family's fish catch declined from about 4 tons per trip in 2005 to about 2 tons per trip in 2009. Depending on the gear they used, if they used large intensive fishing gears such as trawl nets and push seines for instance, it was still possible to catch a huge volume of fish per trip. Ironically, although these two kinds of gears have been banned by the government, they were still being used in the fishing grounds of the two fisheries communities. Significantly, fishers that used trawl and push seine had never landed the fish that they caught in the area to avoid any public criticism. The analysis also showed that there was a significant difference in family catch volume between the two fishery communities at 95% confidence interval (p-value < 0.05). It also showed that the volume of fish caught per single-fishing effort in Chroy Svay was less than the volume caught in Cha Eurt Community. There have been some impact factors that influenced these results and these are presented in next chapter.

Volume of fish catch was also related to the length of fishing boats used. The analysis showed that the boat's length varied from 8m to 15m long. Regression showed the relationship model; $y = 0.308x + 0.389$ with r2 of 0.774, where x presents the length of the boat in meters. This result showed that there is a strong correlation between the length of the boat used and the volume of catch. Normally, fishers who used big boats also used a greater number of fishing gears (3 to 5 gears per trip) because they employed more crews than the small boats (according to the chief of Cha Eurt Community). Currently, local fishers do not want to use big boats with lengths longer than 10m because they consume a lot of fuel. This is the reason why the volume of fish catch declined along with the decline of total trips per season. On the other hand, small boats cannot be used to catch fish in places where water depth is high. Ideally, they may be optimally used only in places where water depth is from 2 to 5 meters. The fishing grounds are normally allocated or assigned by the local fisheries administration to prevent conflicts between the fishermen as well as between the resident fishers and outsider fishers. Because of this, some fishers with small fishing boats had no choice but to fish in grounds where the water depth was high. Therefore, it can be said that the change in the volume of fish landing in the area was also affected by the local management authority.

Statistically, the annual volume of fish landing in the Sre Ambel coastal area has been declining from 2005 to 2009. In 2005, the whole fishing ports of Sre Ambel had about 898 tons of fish catch, while it declined to about 525 tons in 2009. The decline was likely linear regression for the last five years. In 2006, the fish landing at the ports was about 767.8 tons, and approximately 721 tons in 2007. The decline in fish landing resulted from the decline of individual fish catch per fisherman. The catch per fishing effort (trip) per family was about 4 tons in 2005, while it was just down to 2.1 tons in 2009 (Figure 3.5). Result of fish catch per family was linear regression. However, fish landing in Sre Ambel also resulted from the decline of fishing effort numbers. Figure 3.7 shows that the number

of fishing efforts has declined from 11,900 trips per season in the whole area to just 4,875 trips per season in 2009. The decline of efforts may result from many factors such as the management of the lagoon, socioeconomics evolution, other physical factors and the changes in types of fish boat from high motorized fishing fleet to low motorized fishing fleet (Figure 3.8).

3.6 Conclusions

Fishing in the Sre Ambel lagoon has three types of scale: small, large and medium. Small scale fishing was predominant during the last five years, followed by medium scale fishing. Few fishers were involved in large scale fishing in the lagoon, and most of them are foreigner vessels that fished in the lagoon, but landed in areas outside the lagoon, some exported directly to neighboring countries. The large scale fishing was not met during the survey because they were located in offshore area so far from the community centre down to deep sea. Most complaints referred to resources exploitation of large scale, but there was not sufficient to confirm this is really the case due to insufficient information.

Many types of fishing gears were found in the area and there are 12 common fishing gears in the Sre Ambel Lagoon. The most common fishing gears were anchovy encircling seine, encircling seine and gill net. Shrimp gill net and crab gill net comprise about 15% of the total 210 fishing gears in the area. Although the government has already banned the use of certain types of fishing gears such as trawl and purse seine net and other explosive materials, these were still found in the area, especially in the offshore where water depth is less than 20 meters. The illegal fishing gears still being used in the area comprise 2% to 5% of the total number of fishing gears used. Notwithstanding its seemingly negligible number, such illegal gears affected the supply of fish in the whole lagoon.

Fishing has many functions, the most common of which was related to the types of fishing boats used, the length of boat, motorized machine, and the number of fishing efforts (trips). Fishers who used big boats are able to catch a larger volume of fish than those who use small boats because big boats are able to bring in many gears per trip. However, the trips of efforts could not be increased seasonally unless the machine capacity of boats was big enough (high than 10 horsepower). Thus, fishing unit (trips) has also a function of boats (capacity of machine). Nevertheless, the physical condition of the lagoon would also affect the volume of fish catch because small boats with less fishing gears do not have the capacity to reach deeper waters since it can only fish in places where water depth was about 2 to 5 meters. Fish resource depletion may probably cause the decrease of fishing household fishing trip seasonally. Some converted from medium scale fishing to small scale fishing because small boat consumes less fuel.

The whole lagoon was also deeply affected by sanding excavations which has increased for the last three years. Every sand shipment that came from the excavation was approximately 20 to 30 tons of sand, exported either locally or abroad. Because of the excavations many places in the lagoon have become deeper making them unsuitable for small scale fishers using small fishing gears.

Seasonal household fishing unit (tons) had declined drastically during the last 5 years. Fish catch volume per fishing season decreased from 4 tons in 2005 to 2 tons in 2009. While statistical volume of fishing landing in Sre Ambel decreased one third in comparison with the fish landing in 2005. The decrease of fish landing in all ports of Sre Ambel was the result of the decrease of the total number of fishing trips in the area as well. The total decrease of fishing trips in the area was the result of the decrease of fishing raw materials such as price of gear, labours, maintenance, and especially price of fuel for those who use motorized fleets. Local fishers have shifted from using high capacity and high-powered boats to low capacity and low-powered boats because fuel has become quite expensive. Nowadays, most fishers commonly use motorized boats with a capacity of 6 hp. The change in the capacity of the fishing boats caused the changes in the size of fishing fleets as well and inevitably the decline of fish landings at the Sre Ambel coast.

Finally, it can be concluded that fishing performance has changed over the last five years. This in turn caused some changes in the fish landing in the area as well. The drop of fishing efforts caused the decrease in seasonal fish landing at all ports of Sre Ambel. The change in the motorization of fishing boats also affected the seasonal fish catch per family, which resulted in the decrease of fish landing in the area. On the other hand, physical changes in the fishing ground, such as the change in water depth, also affected the efficiency of fish catch per family in the fishery community. Meanwhile, the measures of the local government to ban illegal fishing gears were not effectively enforced since trawl and push seines were still used in the area.

Do the laws and regulations affect the fisheries activities in the area?
What are the real factors affecting the decline of fish catch?

Chapter 5 will answer these questions using the Component Factor Analysis.

CHAPTER 4
SOCIOECONOMIC GROWTH IN RELATIONSHIP TO MARINE FISH CATCHES

4.1 Introduction

It is often argued that the ultimate goals of natural resources management should be ecological sustainability, economic efficiency and social justice (intra- and inter-generations). In order to propose or reformulate management rules and policies to achieve these ultimate goals, natural resources managers should understand how ecological and socio-economic systems interconnect and change over time as they constantly co-evolve. For this purpose, the ecological economics view of systems interaction can provide a useful analytical framework. Ecological economics acknowledges that "human preferences, understanding, technology and cultural organization all co-evolve to reflect broad ecological opportunities and constraints" (Costanza et al. 1997, p.337). The Earth is seen as materially finite and a closed system; hence, technical advances do not create new resources (i.e., human-made capital is a complement to rather than a substitute for natural capital) (Daly, 1977). Surprises and uncertainty are considered part of any ecosystem although they may have exogenous origins (Holling, 1986).

Ecological economics differs from conventional neo-classical economics in that the latter typically "assumes that society is simply the sum of its individuals, the social good is the sum of individual wants, and markets automatically guide individual behavior to the common good." Ecological economics, on the other hand, acknowledges that "community relations define who people are, affect what they want, [and] facilitate collective action" (Costanza et al. 1997, p.24).

Using theories, concepts and instruments from different disciplines and rethinking their applicability, ecological economists investigate co-evolutionary processes between environment, technology, knowledge, institutions and values, to develop tools (e.g. policy instruments) that are able to promote sustainable governance of resources (Constanza et al. 1997). Policy instruments can be used to incorporate environmental uncertainty and the real value (including the long run ecological costs) of natural capital (including both materials and services) into the economic system. As well, they can be used to minimize the differences in income distribution and resource access, both inter- and intra-generationally.

Concerning coastal and ocean management in the world, some marine ecological economists suggest six principles that should be applied when formulating policies to promote sustainable governance of the oceans (Costanza et al. 1998, 1999). These principles concern:

- the responsibility of individuals or corporations to use environmental resources in an ecologically sustainable, economically efficient and socially just manner (Responsibility principle);
- the importance of assigning decision-making to the scale of governance which has the most relevant ecological information, which considers ownership and actors, and which internalizes costs and benefits (Scale-matching principle);

- the need to take uncertainty about potentially irreversible environment impacts into account (Precautionary principle);
- the requirement to continuously monitor social, economic and ecological information because resource management systems are dynamic and have some level of uncertainty associated with them (Adaptive management principle);
- the need to identify and allocate all internal and external costs and benefits (social and ecological) of alternative uses of environment resources (Full cost allocation principle);
- the importance of full stakeholder participation in the formulation and implementation of decisions about environmental resources (Participation principle).

Because two-thirds of the world's population live in coastal areas and human welfare is highly dependent on the oceans (Costanza, 1999), disruption of coastal ecosystems is one of the major threats, both to the oceans (Antunes and Santos, 1999) and to humans themselves. Hence, appropriate governance of coastal areas and management of coastal resources must be a high priority policy for any state with coastal area. Ideally, effort shall be made to promote sustainable governance of coastal areas at the global scale. However, such global effort can be very costly in time and money. Actions taken locally are more likely to be effective in the short run as "local level institutions are generally better able to identify the recipients of both costs and benefits and assign responsibilities that internalize both" (Costanza et al. 1999).

In this context, the aim of this chapter is to use an ecological economic approach to investigating management strengths and shortcomings of a coastal ecosystem in order to propose more appropriate policy instruments and management rules. The study focuses on the co-evolution of local communities and the Sre Ambel Lagoon in the Southern Cambodian coast. This area was chosen because it is a micro-watershed where most environmental impacts are locally generated and can be locally addressed. That is, there is no 'exportation' of problems downstream or 'importation' from upstream in the watershed, although Lagoon problems may be exported to the ocean and vice-versa. The specific objectives of the study are (a) to examine interactions between changes in the local economy and the evolution of the shrimp market; (b) to understand how the local economy affects and are limited by the Lagoon ecosystem; and (c) to propose some management alternatives based on the principles above.

Technological resources change is an important factor in economic growth and development. Historical experience suggests that technology, by raising productivity of factors (e.g. labor, capital, land and other natural resources), plays an important role in economic growth. Though developed counties, being the forerunner in technological innovations, benefited most from technical change particularly in industrial technology, developing countries also benefited from the technological innovations, particularly in agriculture.

Fisheries resources constitute the major source of livelihood in Cambodia. The fisheries sector accounts for more than 30 percent of the national income and employs thousands of rural people for its labor force. Being one of the most densely populated

countries of the world, the land-man ratio is starting to decrease while population is growing. Therefore, continued agricultural growth is deemed pivotal in alleviating poverty and raising the standard of living for the whole population. However, because of the burgeoning population vis-à-vis the decrease in available land for agriculture rice cultivation has been less productive. Fisheries products play a very essential role in the national economy in order to ensure that food security is enhanced. Over the past five years, the major trusts of national policies were directed towards transforming the fisheries sector via the route of rapid technological progress. The purpose of this study is to examine the distributional consequences and sustainability of this rapid technological progress in Cambodia's coastal fisheries within the context of the region's economic development. Specifically, the distributional consequences of modern coastal fishery technology were evaluated in terms of its impact on productivity, employment, income, income distribution and poverty. Sustainability is evaluated in terms of its impact on selected components of environment and trend in long-term productivity growth.

4.2 Marine Fish Resources Change: Related to Developmental Issues

It has been widely recognized (Tisdell, 1988; Clapham, 1980) that a high level of interconnection exists among technological change, economic development, environmental quality, population growth, natural resources change, and social change. Tisdell (1988) also noted that, new technology (it's availability and application) is vital not only as a factor of economic growth and development, but also as a determinant of the nature and structure of society and as a contributor to changes in fish resources, especially marine fish species. Previous researchers suggested that the major reason for sustained economic growth commenced in the eighteenth century in Great Britain was the new inventions and their application rather than the high level of savings and capital accumulation (in Tisdell, 1988). Some researchers (Denison, 1962) claimed that for most of the developed countries, qualitative factors (such as improved technologies and their adaptation) served as a major source of economic growth than the quantitative factors (such as increase in savings and capital accumulation). Such line of reasoning goes against the views of Rostow (1952) who prescribed that the necessary condition for an economy to reach the take-off stage in economic growth is to achieve a high level of savings and capital accumulation. Though economists and social scientists now recognize the critical role of technological change in these respects, its importance has not been fully appreciated.

4.3 Research Objectives

The general objective is to find out the extent that the dynamic changes of socioeconomic growth over time has affected marine fish catch in the lagoon fisheries of Sre Ambel.

There are some specific objectives which are linked to the particular problems under research and inherent to exploration, evaluation, comparison and analysis. The specific objectives of the study are;

- To examine the changes in the local economy and the evolution of the shrimp market;

- To understand how the local economy affects and are limited by the Lagoon ecosystem; and
- To propose some management alternatives.

This chapter presents the marine fish economics approach for lagoon resource management, focusing on the case study of the Sre Ambel Lagoon fisheries management in Cambodia. First, the fishery ecological economic approach is introduced; second, the socio-economic and the history of the area is presented; third, the socio-ecological incentives and constraints to development are discussed; fourth, the major socio-economic events and their effects on the management system is addressed, and finally an alternative management design for the Lagoon fisheries system is proposed.

4.4 Results

4.4.1 Historical Overview on the Changes of Socioeconomics Overtime

The Sre Ambel Lagoon is located in the Koh Kong Province (pop. 133,000 in 2007), along the southern part of the Cambodia coast. There are seven communities around the Sre Ambel Lagoon. Most of the local people are Khmer descendents with a small proportion of Khmer Muslim and Vietnamese. Most fishery communities in the area were quite isolated from each other, living on household agriculture and subsistence fishing. Many socio-economic and ecological changes have occurred since then, and as of year 2000, tourism-related activities had come to dominate the economy of most communities; yet fishing continues to be an important source of cash or in-kind household income.

As of the year 2004, there were about 22 professional (licensed) fishers, and several unlicensed fishers living in the seven communities around the Lagoon. Legally, any Cambodian who has a professional fishing license can catch fish in the Lagoon as large scale fishers. Those with no licenses cannot perform as medium and large scale fishers. Professional fishing licenses, in law, are supposed to be issued only to those who obtain their main source of income from fishing. But in reality, they are issued to almost anyone who requests them. The main requirement for a professional license is the testimony of two professional fishers that the requester makes his living from fishing. Thus, there is no effective legal access restriction to the Lagoon. This is a shallow lagoon; most of its area is between 0.50 m and 6.0 m deep, with a few points reaching about 8 m deep along channels running through the Lagoon area. The lagoon has a mainly sandy bottom and brackish water. Freshwater input is mainly through rainfall and springs which feed the Lagoon at nine or more points. The water level in the Lagoon system rises as the season progresses. Through most of the year, there is a sandbar between the Lagoon and the sea.

To understand the interactions over time between the local socio-economic system and the Lagoon ecosystem, it firstly investigates the Lagoon's major fishing resources. Second, it then examines the socio-economic evolution of local communities. Third, it is described changes in the Lagoon management in response to changes in the local and regional socio-economy. Fourth, it studies the evolution of Lagoon's shrimp and fish market. Finally, it is analyzed some of the major socio-economic factors affecting resource stocks, allocation, and sustainability.

4.4.2 Lagoon's Major Fishing Resources

The Sre Ambel Lagoon's main fishing species are shrimp (*Farfantepenaeus brasiliensis and F. paulensis*), fishes and crab (*Callinectes spp.).* Of these, shrimp is the most valuable and commercialized. Mullet is seldom sold, and crab is only for one's own domestic consumption. The Lagoon shrimp and fish stocks are mainly determined by the season's months, by the opening season of fish catch, and by fishing activities. The season when the water flows from the mountain catchments has an effect on species diversity that may enter the Lagoon. During the period of June to September most shrimp larvae and post-larvae, as well as young and adult mullet, enter the Lagoon to grow in its warmer waters. Mature fish and shrimp return to the sea in October to March which can vary from a few weeks to several months, depending on rainfall. Adult mullet in spawning migration (those with higher economic value) usually appear along the ocean shore in the winter, from May to August. A major recruitment peak for shrimp at Sre Ambel Lagoon occurs during spring months and a minor one occurs during fall. Seasons may also influence growth rate of some species. For instance, shrimp grow from post-larvae to young individuals more quickly (usually two or three months) during hot months (October to March) and more slowly (about four months) during cold months (May to August).

The major determinant affecting the Lagoon's stocks is fishing activities. The capture of small individuals from fish and shrimp stocks reduces the potential harvest of larger (and better-priced) individuals in the future. This effect is characteristic of all fisheries, but is particularly true of a temporarily closed system such as the Sre Ambel Lagoon. In other words, fishing rules (formal or informal) and their enforcement are critical for sustainable yields from the fishery. Fishing rules (or lack of them) specify permissible gear types, mesh-sizes, and restrict access. The evolution of fishing activities and their influence on the Lagoon's stocks and harvests is investigated in a later section of this chapter.

4.4.3 Socio-economic Evolution of Local Communities

Over the last five decades of the 20th Century, communities around the Sre Ambel Lagoon experienced major socio-economic changes. Although each community had its own particularities, the overall picture for the area shows that the local economy moved from household-level agriculture during the 1950s to a mix of agriculture and small-scale commercial fishery during 1970s and to tourism-related activities during the 1990s. The main driving forces influencing such changes seem to be road access in the case of fisheries and proximity to the sea in the case of tourism. I expand on these issues.

In the 1975 and the early 1979, there were relatively few, but quite small families living in the communities around the Lagoon. No people living this area were allowed to catch fish, rice plantation was the only livelihood activity allowed. Every activity was controlled by the military headed by Pol Pot. Fish and shrimp resources seemed abundant in the area, but no one was able to catch any even for household consumption. As a result, the ecology in the area was much healthier than in the present time. Until the 1980s these communities still had no road access to other localities, none had electricity, all villages had no general store, and none had a fish market because of the constant fighting between the

state's forces and the Khmer Rouge. Transport of people and goods among some communities was usually through pole canoes along the Lagoon or through ox and cart along trails. Household-level agriculture was the main source of income for most families, and fishing was mainly for subsistence. There were no local employment opportunities for young people who often migrated to big cities for work. Men were usually in charge of both farming and fishing, and women were responsible for housekeeping, although they also helped men with farming, crab fishing and production of manioc flour and sugar.

In the early 1980s, cultivated crops included cassava, corn, beans, watermelon, potato, rice, chili pepper, banana and sugarcane, among others. Crops and/or their products were sometimes traded among locals (for example, rice was bartered with goods in the local market), since there was no currency used at that time. In this system, middlemen provided clothes, shoes and other basic goods to local families in exchange for freshly harvested rice and livestock products. That is, there existed a patronage system. Some families, however, were able to stock their rice products while waiting for better prices.

During the 1990s, roads were constructed and electricity became available in most communities. These infrastructure improvements facilitated the development of a shrimp market and access to the region by tourists and outside fishers. From the mid-1990s onwards, tourists started to explore the Sre Ambel region, first by camping and later by buying property from the locals and building summer cottages. Outside fishers came from the city of Preah Sihaknouk and other nearby districts.

The money generated by the shrimp fishery improved local fisher welfare. Some fishers reported that they were able to buy a foam mattress (replacing the hand-made natural fiber mattress), a refrigerator, a gas stove (replacing firewood stove), etc. As the fishery became an important source of cash income, some local residents became fulltime fishers and the importance of household-level agriculture in the economy of some communities started to decline. In addition, the development of industrial activities during the late 1990s and 2000s generated more local job opportunities and precipitated the return of villagers who had migrated to big cities. The local population increased, more markets and retail outlets were created (including fish/shrimp stores), and guesthouse and summer cottages were built. Public transportation became available for most communities during the 2000s and some local residents started to commute daily to work at industries and other businesses in Sre Ambel twon or Kompong Seila District (a nearby town).

In 2005, large fishery-related activities had dominated the economy of most communities. Fishing became a part-time activity for most fishers who previously worked for subsistence agriculture. These fishers increased their fishing efforts from 30 times to 80 times per season. 30% of men and young women were employed in the construction of summer cottages, guesthouses, and restaurants. Some became house-sitters for summer cottages. Others opened their own businesses such as bars and restaurants. Most guesthouses and fancy restaurants in the area, however, were owned and managed by outsiders. Fishing became a part-time activity, shrimp and fish were still considered an important source of income and most local fishers sold shrimp and fish, and bought beef to supply their diet with protein as beef became cheaper than shrimp. This happened because

the price of shrimp came to exceed that of beef as a result of the dynamics of the shrimp and fish market.

As of 2008, the local economy was totally integrated into the regional economy and had become significantly influenced by the latter. For example, pollution of other lagoons in the region has pushed many outsider fishers into Sre Ambel. The area surrounding the Lagoon and the nearby beaches on the sea became a popular fishing place for other Cambodians and even those from other countries, especially Thailand. The local population has grown at an accelerated pace during the past two decades despite the fact that the number of children per family has decreased considerably (estimates vary from one to five children in 2000). This population growth is due in part to the growth in the building industry which is drawing new residents to the Lagoon communities to open fish and goods businesses. Although population numbers by village are not available from the government census data, a population estimate can be made from the data on households and the average number of people per household. For the seven villages in the Lagoon area, this estimate comes to about 4,698 families in 2006. Judging by the number in current year, which is higher, the number of resident households, the population of the area is estimated to reach about 7,899 people in the peak fishing season.

The picture of socio-economic changes just described encompasses aspects of most communities around the Lagoon. Each community, however, has its own particularities and economic history (Table 4.1). It seems that the two major factors influencing economic changes in each community were (1) road access and (2) proximity to market's demand of fish resources. Road access allowed for the development of small businesses (starting in Sre Ambel) while fishing-related activities expanded mainly in communities close to the sea beaches (Thmar sar, Trapeang Roung, and Sre Ambel).

Table 4.1: Changes in the local economy of three communities in the Sre Ambel region

Communities	**Basis of local economy**			
	1960s	**1980s**	**1990s**	**2000s**
Chhroy Svay	Upland crop	Seasonal Paddy rice	Seasonal Paddy rice	Seasonal Paddy rice
Roads: 1990s	Fishing	Fishing	Fishing	Fishing
beaches: a bit far	No business	No business	Small business	Small business
		Public services	Public services Waged-labor	Public services Waged-labor
An Cha Eurt	Agriculture	Sugarcane farm	Fishing	Fishing
roads: in 1990s	Fishing	Fishing	Fishing	Small business
beaches: near		Small business	Small business Tourism Waged-labor	Industry growth

Thmar Sar	Agriculture	Agriculture	Extensive sugarcane	Paddy and extensive sugarcane
roads: in 2000s	Fishing	Fishing	Fishing	Fishing
beaches: far			Small business Waged-labor	Small business Waged-labor

Indeed, several interviewees associated the development of local communities with road construction. They also associated road access with an increase of outside fishers and decline of fish and shrimp stocks in the Lagoon. As expounded in the next section, road construction allowed for the development of a shrimp market, which in turn, furthered an increase in fishing efforts and a decrease in the stocks. The history of Sre Ambel communities shows, therefore, both the positive and negative impacts of 'development'. For instance, several interviewees emphasized the contrasting scenario of the local economy in the late 1990s compared to the 1950s and 1960s when they were young. They usually talked about how difficult life was before roads were built, electricity became available, local markets emerged and tourism began; and what hard work it was to cultivate crops and produce its rice. On the other hand, some locals also recognized the negative impacts of the local 'progresses. One old fisher mentioned that after electricity became available, major destruction of the area occurred and the community he lives in (Sre Ambel) grew tenfold in number of households between 1990 and 2000. Examples of environmental destruction include several sand dunes that were removed, forest areas and resting vegetation that were wiped out, and pollution problems that arose. Some of these issues are addressed in a later section of this chapter.

4.4.4 Interaction of Socio-Economy and Lagoon Management

During the 1990's and 2000's, the main fishing strategies in the Lagoon included the use of cast-nets and gillnets (used as setting-nets, encircling-nets or seine-nets) to catch fish, and cast-nets with boat lamps to catch shrimp. Although the local fishers' communities and district governance's fishery agency already existed, they did not play any important role in the local management of the Sre Ambel Lagoon. Local rules and traditional practices were sufficient to manage the Lagoon fisheries. According to fishers, during these decades, they captured mainly large fish and shrimp, and harvests were quite good for four main reasons. First, the two main fishing gears, gillnets and cast-nets, were made of natural fibers which limited their mesh to large size. Second, there were relatively few families living around and fishing from the Lagoon, i.e., low use. Third, fishing was mainly a part-time activity for subsistence purposes only. Fourth, fishers respected the practices and rules of long-term fishers regarding where, when and how to fish or not to fish (i.e., the traditional management system). The fishers interviewed viewed these four factors as being responsible for the large sustainable individual harvest of fish and shrimp enjoyed by fishers during the 1990s.

Socio-economic changes during the late 1990s and the 2000s led, however, to several periods of resource over-exploitation during this time. Two main factors were

responsible for these periods of over-harvest: technological improvements, and road construction which led to the emergence of markets for Lagoon fish and shrimp.

First, technological innovations in fishing gears and strategies resulted in more efficient fishing. The improved gear included monofilament nylon nets, smaller mesh-size nets, and motor lamps which attracted significantly more fish and shrimp than kerosene lamps. A new strategy was the use of gillnet as beach seine along the Lagoon shore. As a result of the introduction of these gears and strategies, fishers harvested larger quantities of, albeit smaller, fish and shrimp, in a shorter time. Fishers also spent less time fixing or making nets as nylon nets were more resistant than natural fiber nets. These technological innovations also intensified the frequency and gravity of conflicts between the two major user-groups, gill-netters and cast-netters, over resource access. Such conflicts had existed for decades but were often expressed in forms of complaints with few episodes of physical confrontations. Since technological innovations resulted in an increase of size and amount of gill-nets set in the Lagoon, which in turn led to over-harvest, some physical confrontations occurred, the police were involved in many cases, and some fishers were arrested.

Second, road construction allowed for the emergence of a shrimp market, which shifted fishing activities from subsistence to commercial fishing in response to outsiders' demand for Lagoon products. As well, roads brought outside fishers to the Lagoon, increasing the number of users harvesting resources. Roads also brought tourists, increasing the demand for fish and shrimp. As a fish and shrimp market emerged, profit-oriented fishers started to disregard traditional rules governing access and gears (i.e., how, when, and where to fish) and began to fish in areas not allowed before and to use smaller-mesh cast-nets. By the late 2007, all fish and shrimp stocks in the Lagoon were caught within about two or three months of closing season. This meant that there was almost no harvest in the Lagoon for several months before the next opening. In contrast, during the 1950s and 1960s, fish and shrimp stocks in the Lagoon lasted from one closure until the next opening. During the late 1960s and 1970s, governmental regulations existed limiting the net mesh-size, gillnet length, and types of nets allowed in the Lagoon. However, the rules were not effectively enforced.

Declining fish and shrimp stocks, fishers' economic dependence on fishing, and conflicts between user-groups triggered several changes in Lagoon fishery management during the 2005 and early 2006. First, a new leader with credibility and willingness to promote changes was elected for the local fisher communities in 1991. Second, the government approved three regulations demanded by local fishers which reduced fishing effort and led to more equitable resource allocation among fishers. These regulations included (a) banning of gillnets in 2007; (b) banning of the motor lamps which were being used with a new fishing gear (a hand-held shrimp tong) to catch small shrimp in the stock areas; and, (c) banning of shrimp cast-nets with mesh smaller than 3.0 cm stretched measure in 2009. Third, the municipal government issued a regulation prohibiting any type of engine, which disturbed fishing in the Lagoon in 2009; only dugout canoes with poles or paddles were allowed. Fourth, rule enforcement became effective as two state fishery inspectors were designated to the area. Most of these changes served to improve shrimp and fish stocks and harvest.

Despite the recovery of the Lagoon's shrimp and fish stocks, the natural shrimp production became insufficient to supply the local market since 2005 to date due to increased shrimp demand as tourists, the local population and the number of outside fishers increased. Since 2008, a shrimp-stocking project took place in the Lagoon increasing the overall shrimp production considerably. For instance, a report estimates the shrimp harvests in the first two years of the Koh Kong Province to have been as follows: 72,699 kg of pink-shrimp (*F. paulensis*) and 10,198 kg of white-shrimp (*P. schimitti*) (DOF, 2009). This project improved fishers welfare (better houses, appliances, etc.) by bringing more money to them as well as to middlemen. Because it was a research project, shrimp post-larvae were financed by research funds. That is, fishers profited from an increase in the Lagoon's shrimp stock. Fishers said that, once the individual project was underway, they could get a lot of shrimp year round, while before the individual project; shrimp catches during the winter were usually low. The project ended due to a lack of funds. Currently, the fishery inspector positions were extinguished, probably due to budget constraints. In the absence of local fishery inspectors, the newly implemented rule enforcement structure proved to be ineffective presently. As a result, several unregulated fishing activities took place during this period, including the use of banned gears and new destructive gears. These activities negatively affected shrimp and fish stocks. At the same time, there were emerging challenges to the Lagoon fishery from the increase of industry, whose sailing and sport fishing interfered with professional fishing (i.e., fishing carried on by part-time and full-time local fishers). As well, there was an increase of outside fishers, and the unregulated growth of summer cottages, guesthouses and restaurants. Excessive development was destroying vegetation on the Lagoon edge which, in turn, increased erosion, siltation, and mudslides, filling the fish migration channels and destroying fish and shrimp feeding habitat. In addition, drainage of sewage into the Lagoon by the large number of tourists and illegal constructions (with poorly constructed septic tanks) was polluting the Lagoon.

Various Lagoon communities responded to the lack of rule enforcement in various ways. A subset of local fishers decided in 2000 to organize themselves into groups to patrol the Upper Lagoon. Nonetheless, this activity did not last long because the fishers lacked legitimacy. Indeed, they were sometimes threatened with shotguns by those fishers using illegal gears. Likewise, to deal with the impacts of unregulated tourism, three of the seven communities surrounding the lagoon have re-activated their community councils in 1999/2000. The results of their actions are still yet to be verified. To tackle the siltation problem, the fisher organization, in cooperation with state and municipal governments, implemented a Lagoon dredging project whose effects remain uncertain.

The scenario at the end of 2006 indicated that a new resource crisis was emerging. It is noteworthy, however, that at that time, very few fishers (less than 60% of fishers) were strictly dependent economically on fishing (i.e., full-time fishers). 40% local fishers were part-time fishers, working in industry-related activities, and fishing shrimp at night to supply the local market and supplement their incomes. In contrast, most outside fishers were mainly large scale fishers. Consequently, as a fisher stated, if another big production crisis occurred in the Lagoon, this crisis would not be as disruptive to fisher well-being as those of the end of the 1960s and 1970s, because fishers are less dependent on fishing in the late 2007 than then. On the other hand, because the Lagoon is one of the major attractions

of the region, a large disruption in its ecosystem, for instance caused by pollution, would negatively impact sand excavation activities, and consequently, fisher well-being.

Fishing activities in the late 1990s: species, gears, and fisher-groups during fieldwork, several fishing gears were observed. Table 4.2 presents these and other methods that are used but were not observed during the fieldwork for this research. For each fishing method, Table 4.2 identifies the target species, gears used, legitimacy, main season, fishing time, user-groups and fishing purposes. Shrimp is the major target species and it is caught largely for sale but also for the fisher's home consumption. Crab is captured mostly for home consumption. Large marine fish and small fish, (*Eucinostomus spp.)* are the main target fish species. The former is used either for home consumption or for sale; the latter is mainly for home consumption. Other fish target species include small blue-fish (*Pomatomus saltatrix*), small grouper (*Epinephelus sp*.), and sardine (*Clupeidae*, e.g., *Opistonema oglinum*) which were caught exclusively for fishers' home consumption.

Significant use of illegal fishing gears and methods is apparent in the Lagoon (Table 4.2). Illegal methods were used by sport, part-time and full-time fishers, and by both local and outside fishers. In spite of the large diversity of fishing methods, shrimp is mainly caught with cast-net and kerosene lamp when the channel connecting the Lagoon to the ocean is closed, and with trap-nets and hoop-nets set in the channel soon after it is opened (for about one week or so).

Table 4.2: Small-scale or artisanal fishing gears used in the Sre Ambel Lagoon

No	English Name	Khmer name	No	English Name	Khmer name
Gill net (Mong Paehk)					
1	Crab gill net	Mong Kdam	3	Fish gill net	Mong Paehk
2	Shrimp gill net	Mong Bang Kear	4	Seabass gill net	Mong Trey Spong
Stationary Gear					
5	Squid trap	Lop Meuk	8	Bamboo crab	Lop Kdam
6	Fish trap	Lop Trey	9	Small winged	Pong Pang
7	Crab trap	Lop Kdam	10	Circular net	Lop Mong Kdam
Mobile gear					
11	Push net	Thnorng Os Ky	13	Drift gill net	Mong Bandet
12	Hook	Santouch			
1	Trawl	Uon Ohs	7	Scomberomorus	Mong Trey Beka
2	Purse seine/Ring	Uon Tith	8	Mackerel gill	Mong Trey
3	Anchovy	Uon Ka Koeum	9	Shrimp gill net	Mong Bang Kear
4	Beach seine	Uon Khow	10	Crab gill net	Mong Kdam
5	Encircling seine	Uon Houm	11	Horizontal	Santouch Ro
6	Gill net	Mong Paehk	12	Clupea gill net	Mong Trey Kbork

(Source: DoF 2002)

Trawl gill nets and purse gill nets are illegal because they prevent shrimp and juvenile fish species from leaving the Lagoon and reaching the sea to reproduce. One trawl gill net can capture up to 60 kg of shrimp per night while a fisher throwing a cast-net usually catches only about 2 kg per night in a reasonable night (up to 10 kg per night in a rare very good night). The amount of shrimp captured by each cast-netter in one night may

vary considerably according to (a) a fisher's ability and knowledge about shrimp behavior; (b) shrimp movements inside the Lagoon; (c) time spent fishing. Shrimp movements inside the Lagoon depend on several factors such as moon phase, wind direction, rapid temperature change, tides, and presence of luminescent algae. Time spent fishing usually alters according to the purpose of and dependence on fishing. The peak number of shrimp cast-netters is in the first hours of the night when full-time fishers and most part-time fishers are still fishing (Figure 4.1). Late in the night only few fishers, probably full-timers, still keep fishing.

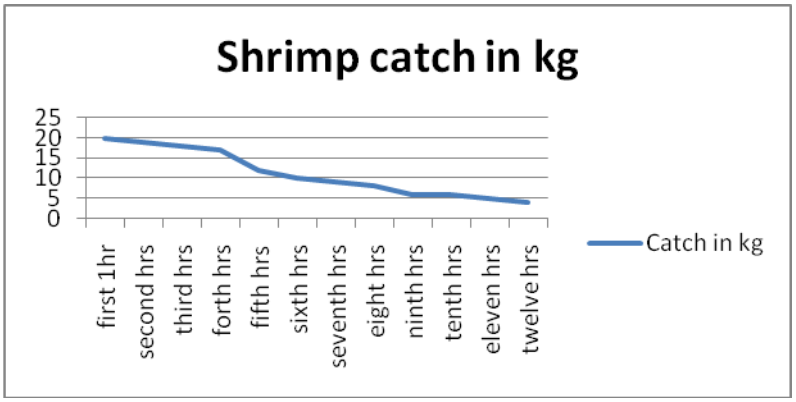

Fig. 4.1 Shrimp cast-net fishery activity in Sre Ambel Lagoon in April 2007. Numbers of kerosene lamp at different night hours. (First lamp lighted at 6:15 pm. Calm wind, full moon, temperature about 22 ºC.) Source: Chhroy Svay Community.

4.4.5 Evolution of Markets for the Lagoon's Shrimp and Fish

Although fishing was mainly for subsistence during the 1990s and 2000s, fishers sometimes sold shrimp by transporting it on their backs along the beach (about 15 km) to Sre Ambel District's market. Fish was seldom sold and only inside local communities. To store fish, many families sun-dried it with salt or hard-pressed it with salt; however, it was usually sold fresh. Shrimp was sold either fresh or salted and dried, and either through direct middlemen or port owner. They had to adopt the standard unit, kilograms (kg), used in regional and national markets.

In the early 1990s, the local middlemen started to use cars and started to buy shrimp from the Lagoon and sell it in the regional market (fish continued to be sold by fishers within local communities only). This shrimp trade became possible due to road construction (i.e., giving access to remote communities) and available electricity (i.e., shrimp could be preserved in refrigerators). As a result of resettlement development from the mid-1990s on, a local market for fish and shrimp emerged, increasing demand and prices, especially for shrimp. In the late 1990s, at least five middlemen were already involved in the Lagoon's shrimp market and fish seller.

The shrimp market evolved through a patronage system similar to that for agricultural products. During 2005, middlemen provided fishers with materials to make gears (e.g., cast-nets and gillnets), money to buy canoes and medicines, and transport for

family members to doctors and hospitals. Fishers, in turn, were obliged to sell all of their catch to the particular middleman who had helped them before. Since1990, middlemen exported the Lagoon's shrimp to the regional market. However 30% of fishers at current time, due to high local and regional demand and population growth, sold their catches directly to consumers (both locals and outsiders), local restaurant owners or grocery retailers, which paid better prices than middlemen did. As well, most, if not all, middlemen focused on supplying the local market, where demand exceeded the Lagoon's fish and shrimp supply, especially during the peak tourist season. Indeed, during the peak seasons of the late 2000s, middlemen imported shrimp and fish from the regional market to supply the local market demand.

As some fishers started to sell their catches directly to consumers, especially during peak tourist seasons in Preah Sihanouk Ville and Koh Kong Province, the patronage system weakened. As a punishment for breach of informal contracts, middlemen diminished or stopped loaning money to fishers. Currently, some middlemen said that they no longer gave fishers money to buy canoes or gears, but only helped them in the case of illness. Two middlemen affirmed that they gave money to only a few fishers because most of the other fishers were not as loyal as they used to be; they were selling their catch to the buyers who paid the best prices, regardless of whether the buyers were consumers, restaurants, retailers or other middlemen. From this study, it appears that the role and prominence of the middlemen declined as fishing declined in importance as a source of income for fishers. In the Lagoon communities currently, the fishers who are still most engaged with the middlemen were those who still fished full-time. Part-time fishers who relied less on fishing for income and income stability could afford to assume the risk of abandoning the patronage system and seeking the highest-paying buyer. However, it is noteworthy that after a particularly good harvest, even full-time fishers would risk selling to the higher-paying buyers rather than to their patrons. The few full-time fishers seemed to still rely heavily on middlemen support, especially during low tourist seasons and non-productive months (e.g., they borrowed money from middlemen in an informal credit system). Although full-time fishers could be better off selling shrimp directly to consumers during high seasons, they had to ensure having a buyer during low tourist seasons in the neighboring municipalities and provinces.

Whether middlemen take advantage of (wrest surplus from) fishers in the patronage system is unclear. One full-time fisher said that middlemen do not charge interest rates for loans, and do not pay less for shrimp and fish when fishers are repaying their debts. On the other hand, another full-time fisher mentioned that middlemen underpaid when fishers are repaying debts. Perhaps this might occur in some but not all cases. What is clear is that some middlemen pay less for shrimp than others. One full-time fisher described patronage relations as a positive thing, although he made it clear that he sometimes sold shrimp directly to consumers. It was interesting to note that some fishers, especially full-time fishers, tried to create a relationship with middlemen, by inviting middlemen to baptize their children. This can be seen as a way to ensure economic safety.

4.4.5.1 Shrimp/Fish Market in 2000

Fishers may sell their catch to consumers (both residents and tourists), local grocery stores (retailers), local and non-local restaurants, and middlemen. Sellers of shrimp may be local fishers, outsider fishers, middlemen, or retailers. Sellers who sold to non-local restaurants were outsider fishers. Middlemen sold to both consumers and local restaurants. When middlemen accumulated surplus, they sometimes sold to other local middlemen or to the regional market. Retailers sold directly to consumers. A smaller portion of local fishers' catch was sometimes used for their families' own consumption. During fieldwork, seven middlemen, five local grocery stores and seven local restaurants in Sre Ambel Lagoon were observed buying shrimp directly from fishers. Retailers are distinct from middlemen in that the former do not put any effort in searching for shrimp because of the high opportunity cost of the search in terms of the value of other goods that can be sold using the same effort. That is, retailers buy shrimp only when fishers come to them to offer it, while middlemen actively search for both sellers and buyers. Of the seven middlemen identified around the Lagoon area, five also had a fish/shrimp store; that is, they were middlemen-retailers and had to divide their time between these activities. Of these middlemen-retailers, only one had other sources of income, which allowed him to open his shop only during high tourist season – the most profitable time. Indeed, this middleman is an entrepreneur – one of the first two who started marketing shrimp from Sre Ambel to the regional market in the early 1990s. At present, he has some other businesses and seemed to be the wealthiest middleman in the region. Despite the fact that his fish/shrimp shop had the largest storage capacity (freezers), this middleman was the least active in buying directly from fishers. This may suggest that for the size and diversity of his business, the opportunity cost to buy directly from fishers was too high, and he probably imported shrimp from the regional market or bought from other local middlemen. Of the two middlemen who did not own a store, one was not very active and had only one buyer (a restaurant); that is, although he did spend time searching for shrimp sellers, he spent no time searching for buyers. The other middleman without a store was one of the most active middlemen in the area, and spent most of his time searching for shrimp and selling it to local restaurants. The tradeoffs between having a shrimp shop and spending time searching for sellers is, thus, not clear-cut. On one hand, there are certain operating costs involved in running a shop; on the other, there are costs in terms of time, gasoline, and car repairs associated with searching for buyers. In the latter case, however, the middleman also uses his time and instruments to trade, to a lesser extent, some other farm products and animals, such as manioc flour, poultry, and cow.

During quantitative data collection on shrimp commercialization, due to the need to guarantee fishers' anonymity (and to avoid conflicts), it was not possible to identify specifically which fishers sell to which middlemen or retailers and under what circumstances. However, some middlemen mentioned that there was an informal division of areas around the Lagoon where fishers lived, from which middlemen bought shrimp. As these middlemen described it, a middleman drives to fishers' houses to buy shrimp, usually two or three times in a week. During peak shrimp season, the middleman might expand to six trips per week. During low-productive season, the opportunity cost of each trip increases, thus the middleman makes only one trip a week, which is possible because all fishers own refrigerators in which to store shrimp.

Although most fishers were free to sell their catch to any middleman, sometimes there seemed to be a semblance of loyalty between a fisher and a particular middleman, and this relation seemed to be respected by other middlemen. From time to time, this loyalty was broken when another middleman offered better prices for shrimp or for some reason a middleman could not work temporarily. For instance, one middleman complained that another offered much better prices for shrimp soon after the Lagoon channel was opened (during a highly productive part of the season), which the first middleman was unable to match. This occurred because the business of the first middlemen was much smaller than that of the second one. Hence, the first middleman lost all 'his' fisher loyalty. Despite some isolated examples like this, there seemed to be no open conflict among middlemen. Indeed, sometimes one helped another, for example, when one bought another's surplus (i.e., when all his freezers were full) during a peak shrimp season that fell outside a high in the tourist season. It is important to note that middlemen's importance as buyers varies with the season. Most fishers sell their catches to middlemen mainly during winter because in summer (the high tourist season) they prefer to sell directly to tourists because of the higher prices tourists pay. In conclusion, the dynamic relations between middlemen and fishers might be explained either by a weak patronage system (see above section) or by price-driven factors. Before investigating shrimp prices, however, it is important to understand the relationship between that of the quantity of shrimp marketed (supply) and Lagoon ecosystem dynamics, including shrimp life cycles.

The price fishers receive for each kilogram of shrimp may vary according to shrimp size, supply and demand factors (e.g., tourist season: peak versus off-season), and whether fishers transport their product to middlemen (higher prices) or middlemen have to travel to fishers' houses (lower prices due to the operation cost that middlemen incur) (Table 4.3). Shrimp size is usually classified as follows: (a) large: from 25 (or fewer) to 40 individuals per kg; (b) medium: from 45 to 70 individuals per kg; (c) small: from 75 to 150 (or even more) individuals per kg; (d) assorted: large, medium and small shrimp are mixed and sold together. Small shrimp are rarely sold separately; they are usually mixed with medium and/or large shrimp and sold as assorted. This explains the absence of a "small" category in Table 4.3.

Table 4.3: The prices of marine fisheries products in three communities of Sre Ambel, 2009.

Fishery Community	Fish(Riel/ Kg)	Crab(Riel/ Kg)	Mud crab (Riel/Kg)	Shrimp (Riel/Kg)	Squid (Riel/Kg)
An Cha Eurt	2,500-8,000	8,500-10,000	8,500 – 20,000	7,000-55,000	1,500-5,500
Chhroy Svaiy	2000-8,500	8,000-15,000	8,000-15,000	9,000-56,000	1000-10,000
Thmar Sar	3000-9,000	7,000-12,000	8,000-25,000	7,000-57,000	5,500

Note: (1 Thai Baht = 100 Riel)

An attempt was made to collect information on shrimp prices received by fishers, as well as the profits earned by middlemen and retailers from trading shrimp. However, because these are sensitive issues to businessmen, the number of observations was small and data should be taken as potentially illustrative rather than wholly representative. The range of prices for Lagoon shrimp during the 28 weeks of data collection is presented in Table 4.3. Prices are delineated according to shrimp size, supply, demand, and buyer type. Not surprisingly, large-shrimp prices were higher than medium-shrimp prices, and prices for assorted-shrimp tended to fall between large-shrimp and medium-shrimp prices. Prices paid varied fairly consistently according to who the buyers were. Middlemen usually paid less than retailers, and much less than restaurants. As can be seen in Table 4.3, shrimp prices also varied over time, due to fluctuations in demand (tourist season) and Lagoon ecosystem cycles. Shrimp prices tended to increase as a result of: (a) the approach of the high tourist season (beginning at Christmas) when buyers wanted to stockpile shrimp; and (b) the drastic drop in supply soon after the Lagoon closed (June to Sept). However, because shrimp size varies within a single size category (e.g., large shrimp usually range from 25 to 40 individuals/kg), an increased price may also be captured for larger shrimp within a given category (i.e., a decreased number of individuals per kg). Lower shrimp prices corresponded to the ending of the high tourist season (soon after carnival – Ash Wednesday) as well as to times of increased supply. The profits earned by middlemen and retailers in shrimp trading seemed to range from 10% up to 50% of the price at which shrimp were sold.

Table 4.4 presents the quantities of Lagoon shrimp purchased by Lagoon area middlemen, retailers, and restaurants during the 28 weeks of study. Of the total 4,339 kg of Lagoon shrimp sold in the Lagoon area, during these 28 weeks, 68% was bought by middlemen, 9% by retailers and 23% by restaurants. It is interesting to note that 50% of the total amount was bought by only three middlemen. Moreover, these three middlemen accounted for 74% of the shrimp bought by middlemen. In other words, three middlemen dominate the local shrimp market. As well, only three restaurants accounted for 70% of the Lagoon shrimp bought by all seven of the restaurants which buy directly from fishers. Interestingly, these three restaurants were the only ones located adjacent to ocean beaches. It is important to note that, with one exception, the owners of all of the restaurants studied were local residents. The exception, however, is someone who is a part-time fisher himself and interacts with many local fishers. Therefore, it appears that fishers sell their shrimp solely to those restaurant owners who are familiar to them.

According to some middlemen, the Lagoon shrimp production is not sufficient anymore to supply local shrimp demand, especially during summer. When supply exceeds demand during a few weeks in winter, middlemen export shrimp to the regional market. To supply the local market during summer, middlemen usually import shrimp from other nearby lagoons (Tatai, and Thmar Sar Lagoon). In these cases, they might buy shelled shrimp, something that never happens in the case of Sre Ambel Lagoon shrimp. According to one middlemen, Sre Ambel shelled shrimp is not competitive with imported shelled shrimp because Sre Ambel shrimp are more expensive than shrimp from nearby lagoons. This results from the fact that Sre Ambel shrimp is locally recognized as the best shrimp in the region (and according to some, in Cambodia) because it comes from a non-polluted lagoon. What is interesting to note is the fishers' and middlemen's pride about the high

quality of Sre Ambel shrimp. Nevertheless, problems generated by excessive development, such as sewage drainage into the Lagoon and poorly constructed septic tanks, are likely to affect shrimp quality in the non-too-distant future if no preventive action is taken.

The prices which middlemen, retailers and restaurants paid for Lagoon shrimp varied from 7USD to 12USD per kg. Lagoon mullet was much less valuable, however; fish prices only varied from 2USD to 2.50USD per kg. The costs of fishing for fish and shrimp were quite similar: both species were caught with cast-nets, and fishers could not use a polling canoe. The difference in fishing costs was the price of kerosene used to attract shrimp (2USD for an entire fishing night). This cost was relatively small as it would probably represent less than 10% of shrimp prices. That is, shrimp was more valuable from a profit standpoint than fish. As shrimp generates much greater returns for fishers than fish, most fishers prefer to invest their time in shrimp fishing rather than catching fish. What sets subsistence fishers from full-time fishers is that the latter must keep fishing even during the shrimp off-season. These fishers usually sell their catches directly to consumers, local restaurants or small retail outlets. As a result, middlemen wanted to buy shrimp rather than fish from the Sre Ambel Lagoon. They do however buy fish (valuable fish) captured in large fisheries in front of beaches near the Lagoon. Sometimes because of insufficiency of shrimp catch, middlemen import shrimp and crab meat from the regional market (nearby the lagoon) to supply the local market.

Changes in management institutions may create incentives or constraints to resource sustainability, ecosystem dynamics, and social welfare. For instance, the history of the Sre Ambel Lagoon management illustrates that new regulations based on fishers' ecological knowledge and concerns and an appropriate enforcement system proved to restore the Lagoon's structure and dynamics, to reduce user-group conflicts, to promote more just resource allocation, to increase people's safety, and to avoid pollution. On the other hand, a lack of regulation enforcement led the system to an open access situation. In the face of a lack of constraints (e.g., lack of regulation enforcement), resource users do not have any incentives to use appropriate gears, to avoid over-harvesting, or to prevent pollution. Hence this open access situation can disrupt ecosystem natural dynamics, lead to over-harvesting, increase the risk of pollution and directly affect the well-being of resource users. Often, most people bear the cost of the actions of just a few cheaters. This situation calls for some new management measures including enforcement of regulations, restriction on the number of resource users and environmental education.

Creating new management institutions may help mediate the influences of local socio-economic factors in the social-ecological management system. In this sense, it probably requires to propose the establishment of a co-management Forum for the Sre Ambel Lagoon, in which government agencies, resource users and other stakeholders would be involved. The Forum may address the six Lisbon principles concerning: participation, responsibility, scale-matching, precautionary, adaptive management, and full-cost allocation (Costanza et al. 1998, 1999). *To incorporate such principles within the Lagoon fisheries management, it is proposed the creation of an extractive reserve and a combination of fisheries regulations and a license system to pursue sustainable use of fishing resources*. A detailed explanation of these measures is presented in Chapter VII.

Table 4.4: Lagoon shrimp and fish sold to local middlemen, retailers and restaurants from October 2005 to April 2009

Group of buyers	Total Fish sold in ton	Total Shrimp sold, ton	Shrimp sold, ton	Fish sold, ton	% total amount of fish sold	%total amount of shrimp sold
Middleman A (Chhroy Svay)			273	756	9	13
Middleman B (Chhroy Svay)			252	756	9	12
Middleman C (Chhroy Svay)			315	1260	15	15
Middleman D (Chhroy Svay)			357	1008	12	17
Middleman E (Chhikar Kraom)			126	840	10	6
Middleman F (Chhikar Kraom)			147	1008	12	7
Middleman G (Chhikar Kraom)			105	756	9	5
Restaurant A (at Sre Ambel)			105	420	5	5
Restaurant B (at Sre Ambel)			84	252	3	4
Restaurant C (at Koh Kong)			126	504	6	6
Restaurant D (at Sihanoukvill)	8400		105	420	5	5
Other related retailers		2100	105	420	5	5
Total sold			2100	8400	100	100

4.4.5.2 Current Proportion of Job Occupation

Job occupation in the study area is divided into six categories: fisheries job, wage labor, salaried jobs, small trades, agriculture, and household chores. Fisheries comprised approximately 77.5% of all the occupations, followed by 22.3% in agriculture, 6.1% in small trades, 5.9% in wage labor, and 2.6% in salaried jobs (Table 4.5). Unemployment rate stands at 18.9% of the total 2135 people in the two communities. Most of those who were unemployed were female, which accounted for 21% of the total unemployment rate, while 16.9% were male. 49% of the men were engaged in fisheries, while 27% were women.

Table 4.5: Major occupation of the male and female population aged ten years and above

Activity / Occupation	Age Group								Total		
	10 – 14				31 – 59		> 59				
	M	F	M	F	M	F	M	F	M	F	Total
Fisheries	8	5	331	149	152	101	59	22	550	277	1654
	4.7	3.3	65.5	33.5	45.0	31.1	57.3	22.2	49.3	27.2	77.5
Wage labor	0	0	16	35	34	33	8	0	58	68	126
	0.0	0.0	3.2	7.9	10.1	10.2	7.8	0.0	5.2	6.7	5.9
Salaried Jobs	0	0	2	9	43	2	0	0	45	11	56
	0.0	0.0	0.4	2.0	12.7	0.6	0.0	0.0	4.0	1.1	2.6
Small Trades	0	0	35	59	5	29	2	0	42	88	130
	0.0	0.0	6.9	13.3	1.5	8.9	1.9	0.0	3.8	8.6	6.1
Agriculture	1	2	99	100	102	92	30	51	232	245	477
	0.6	1.3	19.6	22.5	30.2	28.3	29.1	51.5	20.8	24.0	22.3
Household Chores	0	10	0	56	0	34	0	16	0	116	116
	0.0	6.7	0.0	12.6	0.0	10.5	0.0	16.2	0.0	11.4	5.4
Working Subtotal	9	17	483	408	336	291	99	89	927	805	1732
	5.3	11.3	95.6	91.7	99.4	89.5	96.1	89.9	83.1	79.0	81.1
Not Working	161	133	22	37	2	34	4	10	189	214	403
	94.7	88.7	4.4	8.3	0.6	10.5	3.9	10.1	16.9	21.0	18.9
Total	170	150	505	445	338	325	103	99	1116	1019	2135
	100	100	100	100	100	100	100	100	100	100	100

M = Male, F = Female

Note: Figures in the second line of each row show column proportions

Two attributes related to people were taken into consideration. The first is the intervening and highly controversial variable of population group, distinguishing between caste-orientation, ethnic-orientation, and group in transition. It was observed that there was no significant variation in the number of activities or sources of income. The number of households engaged in one activity or source of livelihood fall between 10% and 14% of the sample population. Households engaged in only one activity was mostly occupied with household chores. Those involved in two activities earned most of their income from the field of fisheries, agriculture, and waged labor (Table 4.6).

Table 4.6: Number of Activities or Sources of Earnings and Income by Family Size and Sources of Earnings or Income

Frequency	Family Size			Source of earning income				
Category	Unitary	Small	Medium	Wage	Fishery	Agri.	Trade	HH.Chore
	N = 32	N = 58	N = 120	N = 15	N = 137	N = 30	N = 20	N = 8
One	5	10	10	10	14	12	11	98
Two	80	75	78	72	86	80	55	2
Three	15	15	12	18	0	8	34	0

Note: Figures are in percentage.
Pearson's Chi-Square value: 20 for family size at degree of freedom of 3, and 33.08 for sources of earnings or income at degree of freedom of 8, both significant at 0.001 levels.

4.4.5.3 Explanation to Fish Production

The most important and major source of income in the whole area of Sre Ambel was fisheries and it has three types: large scale fishing, medium scale fishing, and small scale fishing. However, those who were engaged in large scale fishing were mostly outsider fishers who land fish catches outside the area as well. Medium scale and small scale fishing were exercised mostly by the local fishers in the area. Before 2005, the average catch of all types of scale were 4.2 tons, 7.5 tons, 10.8 tons for small, medium, and large scale respectively. However, after 2005 particularly during the last few years, there was a change in both proportion of fishing scale and yield of catch (Table 4.7).

Table 4.7: Proportion of fish catch in 2005 and 2009

Fishers in 2005	Proportion of Household (N=210)		Average Catch	Fishing landing
	Frequency	Percentage	Ton / trip	
Small Scale	170	81	4.20	Inside
Medium scale	30	14	7.50	Inside
Large scale	10	5	10.80	Outside
Fishers in 2009	Proportion of Household (N=210)		Average Catch	Fishing landing
	Frequency	Percentage	Ton / trip	
Small Scale	130	62	2.10	Inside
Medium scale	8	4	5.00	Outside
Large scale	72	34	10.50	Outside

To analyze the underlying factors affecting the total catch of fish per type of scale per trip, regression analysis were done, assuming the catch yields were the function of the variables discussed in the immediately following subsection.

4.5 Discussion

The Sre Ambel case provides useful information for marine fish ecosystem management planning based on an ecological marine resources economics approach. The case shows several interactions among the local socio-economic system, the Lagoon management, and the Lagoon fish shrimp market through a historical perspective. In the following sections I first investigate

how the Lagoon shrimp and fish market was/is influenced by social-ecological incentives and constraints; then, how the Lagoon ecosystem and the local social system were influenced by socio-economic events; and finally, I discuss a potential alternative for the Lagoon management based on the six core principles proposed by Costanza et al. (1999).

4.5.1 Fish and Shrimp Market: Social-Ecological Incentives and Constraints

It is clear that the Sre Ambel fish and shrimp market only started when the costs of fish and shrimp storage and transportation to regional markets diminished due to technological improvements. In other words, the market really emerged once transaction costs decreased sufficiently to ensure that sellers could profit from commercial shrimp production. Additionally, this market development depended on the efforts of two entrepreneurs. As Wang (1999, p.801) puts it, "the provision of the market is costly and requires entrepreneurial efforts". The initial shrimp market institution was based on a similar local institution for agricultural products - a patronage system. In both cases, middlemen provided money or basic goods for local families, who in turn, were constrained to sell all their products (manioc flour or fish/shrimp) to their patrons. Nevertheless, patronage institutions were weakened when the local socio-economic system expanded, became influenced by outsiders' values and ideas, and offered alternative jobs to fishers and new buyers for their shrimp. Most fishers who formerly needed informal credits as a form of insurance against risk of natural hazards and economic uncertainty (Platteau and Abraham 1987) became less dependent on fishing as they got other jobs. Moreover, they tried to maximize their expected income by selling shrimp directly to consumers or restaurants for better prices. From the middlemen's point of view, giving credits to fishers as a way to ensure access to their catches – credit as an output-securing device (Platteau and Abraham, 1987) – also became a risky transaction: as local communities have lost most of their 'traditional' identity, social sanctions of credit arrangements were not likely to occur and 'moral hazard' (i.e., cheating) became uncontrollable.

Wang (1999) asserts that changes in the institutional structure of a market are determined mainly by transaction costs. The Sre Ambel fish and shrimp market illustrates this. The shift of the local Sre Ambel fish and shrimp market from being export-oriented to import-oriented reflected changes in transaction costs. For instance, the increased local demand for shrimp reduced the operating costs of marketing shrimp within local communities relative to the regional market (at Koh Kong and Preah Sihanouk Ville). Indeed, as a result of such modification, the regional market now seems to have almost no influence on the local fish and shrimp market (although further research is needed to confirm this). Sre Ambel fish and shrimp prices came to reflect mainly local demand, supply, and ecological uncertainties, fish and shrimp size and shrimp quality (i.e., source being an unpolluted lagoon).

The relationship between supply and demand forces in the Sre Ambel fish and shrimp market does not match the predictions of neoclassical economic theory. Sre Ambel fish and shrimp demand is mainly determined by the stage of the tourist season (peak versus off-season). Shrimp supply is highly dependent on the Lagoon channel-opening management, which in turn depends on rainfall and the movements of shrimp larvae and post-larvae in the ocean. Hence, fish and shrimp supply is subject to ecological uncertainties and shocks. Generally under these conditions one would expect potential negative supply shocks to drive up the market price for a commodity. In this case, however, ecological uncertainties do not add economic value to the product; instead, they decrease shrimp prices and fishers' profits. I suggest here that this happens

because the Lagoon shrimp market is dominated by only three middlemen, who usually pay less for shrimp than retailers, restaurants and probably tourists, but who purchase shrimp year-round instead of buying it only during the tourist season. Because shrimp harvests may peak during the tourist off-season, some fishers prefer to sell shrimp to middlemen for reduced prices even during the tourist season to ensure that they will have a buyer during the off-season – the period when tourism-related jobs decrease. If this is the case, then the dynamics between demand and supply in the Sre Ambel fish and shrimp market can be viewed as operating to provide an "income-insurance mechanism".

Since prices increase as shrimp size increases and the Lagoon is a closed system for most of the year, one may ask why fishers do not wait to capture large fish and shrimp later in the season (i.e., avoid using small-mesh cast nets). Doing so would generate more financial benefit and the added ecological benefit of increasing the chances that part of the pre-adult shrimp stock would return to the ocean for reproduction. The problem is that lack of regulation enforcement (concerning how, where and when to fish, and who is allowed to fish) makes the Lagoon a common property resource but an open-access situation. Individuals have privilege but no rights in using the resource (Bromley, 1989). In the late 1990s, locals harvested shrimp primarily for commercial purposes, while, for most outsiders, fishing served mainly as entertainment. Since most outsiders and sport-fishers had no economic dependence on the Lagoon resource, they had no economic incentives to use large mesh nets and prevent overfishing. In the face of an open-access system where anyone holding a professional fishing license could fish, local fishers, both full-timers and part-timers, also had no social or economic incentive to use large meshes and prevent overfishing. In addition, there also existed some profit-maximizing local fishers whose private interests dismiss all possible social goals, and whose implied rate of time preference must be sufficiently high to shrink future earning streams from a sustained shrimp stock. Hence, in order to increase the size (and price) of fish and shrimp marketed and avoid overfishing, new incentives and constraints are needed. In other words, a new institutional arrangement should provide fishers with signals that incorporate the costs of their fishing activities. Charging a user fee of some sort could accomplish this.

The idea that the Lagoon use is costly to others extends to "use" the Lagoon as a receptacle for waste. The open-access situation resulting from a lack of control (by governments) of the sewage drained into the Lagoon by illegal constructions (with poorly constructed septic tanks) and garbage dumped in the Lagoon margins by tourists and local residents started to compromise the quality of the Lagoon water. The good quality of the Lagoon water accounts for the higher prices of fish and shrimp compared to shrimp from nearby lagoons. The sustainability of the Lagoon ecosystem and fisheries relies on preventing further pollution of its water and surroundings. If no effective action is taken to monitor sewage and garbage disposal and to construct proper sewer systems, the quality and price of Srea Ambel fish and shrimp is likely to decrease in the near future. Creating a mechanism to enforce the already existing (and often appropriate) environmental regulations is one possible solution. Another solution is to propose some voluntary mechanisms to stop polluting through environmental education.

4.5.2 The Effects of Socio-Economic Evolution on Lagoon Fish Resources

This section summarizes the impacts of major evolutionary events on the Lagoon's goods and services and on stakeholder well-being over the past five decades. Although it did not

attempt to calculate the monetary costs or benefits of each impact, it has been delineated their positive and negative effects on the ecosystem and stakeholder well-being.

The major evolutionary events in the Sre Ambel region in the last five decades of the 20th Century were described throughout the previous sections of this chapter. They include: innovations in fishing technologies from the late 1990s onwards; some infrastructure improvements such as road construction and electric power availability especially during the 2000s; development of a fish and shrimp market in 2005; an overfishing crisis in the late 2005; the creation of new fisheries regulations and the establishment of a strong rule enforcement between 2006 and 2008; the breakdown of the enforcement structure in 2003 leading to illegal sewage disposal into the Lagoon and the use of illegal fishing gears and vessels in the following years; and the implementation of a shrimp-stock project from 2003 to 2005.

Technological innovations may result in more efficient fishing, but if not properly used, they may cause overfishing and ecosystem disruption. In addition, technological innovations might promote unfair resource distribution, as some technologies are not affordable to all users. Increasing market demands may lead to species by-catching (which may cause ecosystem disruption) and may put primacy on fishers' private interests (i.e., profit-maximization) over social goals (i.e. sustainable resource use). Overfishing causes ecosystem disruption and may reduce fishers' and middlemen's welfare in the long-run. As a result, some technological restrictions may prevent overfishing and promote better resources distribution (see next section).

Official regulations based on fishers' ecological knowledge and concerns (see Chapter VII) and an appropriate enforcement system has been proven to restore the Lagoon's structure and dynamics, reduce user-group conflicts, promote more just resource allocation, increase people's safety, and avoid pollution. On the other hand, lack of rule enforcement may disrupt the ecosystem's natural dynamics and lead to overfishing, increase the risk of pollution and human health problems, and decrease people's safety on the water. Often, most people bear the cost of the actions of just a few cheaters.

Infrastructure improvements (e.g., roads, electricity) may increase the local population's well-being, but it may also expose the local society to immigrants' social and cultural values. The introduction of different values may cause a breakdown in the local authority system and disruption of social life, resulting in a 'community failure' of resource management (McCay and Jentoft 1998). Depending on the type of infrastructure 'improvement', it may either relieve pressure on the ecosystem or exacerbate ecosystem destruction. Excessive (and usually unplanned) development often results in ecosystem degradation, increased pressure on resources, and conflict of interests between outsiders and the local population holding some sense of place. 'Development' projects, such as the shrimp stocking project and the Lagoon-dredging project, focus mainly on human benefits, disregarding the side-effects on ecosystem structure and resilience. Some projects may result in positive impacts on the ecosystem; others may have negative impacts. As well, some stakeholders may benefit from development projects, while others may not. Hence, all the socio-economic-ecological benefits and costs of a project must be investigated a priori.

4.6 Conclusions

What can we learn from the interactions between the Sre Ambel Lagoon's ecological and Socio-

Economic systems? How can we improve the Lagoon management?

Agrawal and Yadama (1997, p.457) suggest that although "socio-economic forces are important in influencing resource management and the condition of renewable resources … their influences [can] usually [be] mediated through community institutions." The Sre Ambel case shows that in the late 2000s, there was almost no local resource management institution influencing the Lagoon system. In fact, the system was being negatively affected by State policies (e.g., weak rule enforcement, no access restriction), technological factors (e.g., inappropriate fishing gears, development projects), market pressures (e.g., high demand for shrimp) and population pressures (e.g., large number of local residents, outsiders and tourists).

In order to craft community institutions to mediate the negative effects of such factors, to create social and economic incentives for better Lagoon management, and to incorporate the six principles into a new management plan, it is suggested the establishment of a Sre Ambel Lagoon Management Forum through a co-management process. The Forum may be a long-lasting institution able to deal with the current problems and to actively respond, through an adaptive management approach (Holling 1978, Walters 1986), to future socio-economic-ecological problems.

The Forum could be a joint effort from all the stakeholders, state and municipal government agencies holding any responsibility for the Lagoon management and most, if not all, of the other Lagoon stakeholders (e.g., local fishers, outside fishers, local residents, tourists, and tourism businessmen). Some scientists and natural resource managers may also join the Forum. In designing and implementing management strategies, all parties should be involved in decision-making to increase the process's transparency and subsequent rules compliance (participation principle). Non-governmental stakeholders may create one or more local non-governmental organizations (NGOs) to represent them in this Forum. To encourage stakeholder participation in the Forum, there is a need to develop environmental education programs to reach them. These programs might use examples from the present case-study to demonstrate that human-made impacts on the Lagoon ecosystem and its surroundings emerge later as impacts on humans themselves. That is, the responsibility principle may be realized from the beginning, and a mechanism that indoctrinates the community according to this principle must be implemented very early on.

Any 'development' project or management regulation may be planned so that it adheres to three conditions. First, the plan should internalize as many local monetary and non-monetary costs and benefits as possible. Second, people holding local ecological knowledge (e.g., old fishers) should be involved in planning and decision-making. Third, representatives from governments from different political scales should be involved because some costs and benefits may affect other socio-ecological systems (scale-matching principle). Because the long-term impacts of water pollution, deforestation, overfishing, and shrimp stocking are uncertain, a cautious approach to management design and implementation should be the rule rather than the exception (precautionary principle). That is, some mechanisms could be developed to incorporate the long-term ecological value of the Lagoon ecosystem services and goods into their current prices.

As the Sre Ambel case clearly demonstrates, socio-economic and ecological systems co-evolve in a non-linear, uncertain way. Hence, in designing and implementing any management

plan, effort must be made to continuously monitor the social, economic and ecological systems (adaptive management principle). Although it is quite difficult to do so, effort must also be made to identify and allocate all of the internal and external costs and benefits (social and ecological) of alternative management plans (full cost allocation principle).

It is necessary to propose that the Sre Ambel Lagoon Management Forum may initially address at least the following major issues: fishing activities, other related activities (agricultural farm extensive scale), management of seasonal catches of marine resources, sewage systems, garbage dumping, irregular buildings close to the Lagoon margins, and deforestation along the Lagoon margins and along springs that drain freshwater into the Lagoon. For each of these issues, feasible policy instruments can be established. As Jacobs (1993, p.162) puts it: the appropriateness of any particular instrument in any given circumstance will clearly depend on which of the criteria [ideology, effectiveness, motivation, administrative cost, efficiency, political acceptability and distributional impact] are regarded as most important, and on the particular context and nature of the environmental damage to be prevented. In Chapter VI, it presents a policy alternative and some policy instruments that may be used to approach sustainable fisheries management at the Sre Ambel Lagoon and that may exemplify how the six principles may be addressed.

CHAPTER 5
FACTORS RESPONSIBLE FOR THE LOW FISH CATCH RATE IN ARTISAN MARINE FISHERIES OF SRE AMBEL LAGOON

5.1 Introduction

Many indicators are available to identify the problem of overexploitation and threats to marine fisheries resources. These include increases in fishing effort, decreases in the annual catch, changes in the species composition of catch, and increases in the percentage of trash fishes in the catch. Scientists know the causal relationships between these indicators and overfishing, however, there remains a need to extend such information to the general community.

Many fishers in Sre Ambel Lagoon do not realize that high levels of fishing effort can lead to negative outcomes, including stock depletion, instead blaming such situations on mistakes made by government or managers. However, it is becoming clear that both fishers and government officials have played important roles in the creation of fisheries problems. In Lagoon level, questions such as "why is the production of fish decreasing?" and "how can we solve this problem?" are frequently asked by fishers and members of the general community.

Typical answers to these questions in the lagoon have referred to fishers breaking fisheries laws, and the use of illegal fishing gears. However, changes in the distribution and abundance of natural resources, such as fisheries, are often a result of natural variation in the environment, as well as the impacts of fishing and other human activities. Examples of phenomena driving this natural variation include climate change, global warming, El Niño, and sea level rise. According to Ibrahim (1999), human activities with potential to negatively affect fisheries and other resources include:

- destruction of habitats for spawning, nursing and feeding due to rapid development of coastal areas and development of new, efficient fishing technology and population growth;
- land and sea-based pollution that tends to reduce fish recruitment and increase mortality; and
- Overcapitalization and exploitation of coastal marine living resources.

As highlighted previously, there is a paucity of information regarding the status of the Lagoon's marine fisheries resources. There are concerns about stock depletion in the marine fishery, although with no substantial stock assessments conducted, the status of the resource is largely unknown. Catch statistics have varied substantially, reporting 1,200 tonnes in 1980, 39,900 tonnes in 1990, and 29,800 tonnes in 1997. While the DoF collects harvest data from commercial fisheries, there are concerns relating to the accuracy of these figures, as they do not include catches from illegal fishing vessels, both foreign and domestic. Similarly, they do not include catches from fishing vessels that did not land their catches at Sre Ambel ports. Finally, there are no reports of the amounts caught by subsistence fishers.

The main threats to fisheries production in Sre Ambel are habitat destruction, overfishing, and pollution, which have led to the rapid decline of coastal fish stocks, and the degradation of the marine environment and other coastal resources. Increased fishing effort, as evidenced by

increasingly high numbers of large fishing boats, has contributed to the recent trend of increasing annual catches.

5.2 Results and Discussion

5.2.1 Principal Component Analysis of Fisheries Performance in Sre Ambel

The topics listed below describe the principal of factor analysis, and how it can be applied towards these two purposes. There are several correlated variables of fish decline in the Sre Ambel Lagoon. The results of correlated variables are presented in Table 5.1. The component martrix (Table 5.1) consists of 21 correlated variables which resulted from data reduction of huge measured variables related to fisheries performance during the last 5 years in the area. The following discussion presents some of the standard results from a principal components analysis. This is the result of extracting factors (fish decline, and practices) that account for less and less variance. To simplify matters, it usually starts with the correlation matrix, where the variances of all variables are equal to 1.0. Therefore, the total variance in that matrix is equal to the number of variables. The variance accounted for successive factors is summarized as in Table 5.2. The results described here, combine seven correlated factors in component 1, such as fishing unit (CPUE) factor, factor of non social and environmental safeguards mechanism, factor of top-down approach for fisheries management, socio-economic growth, factor of raw material cost increase, factor of lagoon's morphological changes, and the factor of using capacity of motorized boat. Component 2 combines four factors such as length of boat, locally illegal fishing gear, fuel cost, and fishing experiences. Component 3 combines three factors such as factor of invasion of foreigner fishing vessels, factor of use of illegal fishing gear (outsider), and factor of sand excavation and navigation. Component 4 describes three factors: factor of local industrial growth, factor of considerable extensive farm increase, and factor of changes in water quality. Component 5 combines two factors: factor of global economic crisis, and factor of local credit.

Table 5.1: Rotated Component Matrix a

Factors	Component				
	1	2	3	4	5
Fishing unit (CPUE)	.754	.100	.079	.338	.342
No social and environmental safeguard mechanism	.744	.106	.083	.309	.339
Top-down approach management for lagoon's resource control	.732	.006	.048	.017	.169
Socio-economic growth	.661	.062	.052	.167	.076
Cost of materials (increase)	.614	.148	.011	.430	.199
Morphological condition (changes)	.582	.349	.084	.540	.089
Motorized boat usage (changes)	.573	.063	.034	.044	.393
Boat's length	.111	.924	.018	.131	.021
Use of illegal fishing gear (local fisher)	.168	.874	.011	.129	.012
Fuel cost (increase drastically)	.020	.847	.049	.126	.019
Experiences of fishers	.136	.663	.134	.035	.014
Foreigner vessels	.047	.095	.920	.178	-.011
Use of illegal fishing gear (outsider)	.005	.071	.901	.215	.073
Sand excavation and navigation	.027	.091	.813	.193	.060
Industrial growth	.139	.035	.068	.781	.017
Increase of extensive agro-farm	.264	.258	.003	.505	.000
Changes of water quality	.046	.278	.197	.497	.101
External demand	.038	.297	.120	.451	.324
Level of education to understand law	.031	.003	.101	.144	.034
Global economic crisis	.093	.044	.165	.055	.730
Local credit	.191	.044	.237	.194	.424

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 13 iterations.

Eigenvalues: The second column (Eigenvalue) above, presents the variance on the new components that were successively extracted. In the third column, these values are expressed as a percentage of the total variance (21 variables). Factor 1 account for 20.8 percent of the variance, Factor 2 for 13.4 percent, and so on. It was found that the sum of the Eigenvalues is equal to the number of variables. The third column contains the cumulative variance extracted. The variances extracted by the factors are called the Eigenvalues. This name derives from the computational issues involved. The factors with Eigenvalues close to 1 or greater than 1 can be retained and the other factor extracts can be reduced. This criterion was proposed by Kaiser (1960). The Eigenvalues loadings are plotted in the Scree Test of graphical method below. According to this criterion we can only retain about seven factors from component 1 to component 7 for further analysis because those factors have Eigenvalues approximately or greater than 1.

Table 5.2: Total Variance Explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.379	20.853	20.853	3.339	15.902	15.902
2	2.822	13.440	34.293	3.207	15.271	31.173
3	2.656	12.647	46.939	2.516	11.982	43.155
4	1.501	7.147	54.086	2.260	10.761	53.916
5	1.271	6.051	60.137	1.306	6.221	60.137
6	1.237	5.890	66.027			
7	.998	4.750	70.777			

Extraction Method: Principal Component Analysis.

Statistically, it was found that landings have declined during the last five years due to various factors such as the decline of family fishing efforts as well as the increase of fuel cost. Many local fishers were forced to give up fishing because notwithstanding the daily increase of fuel, their monthly incomes have decreased.

Component 1 shows the effect of fishing unit (CPUE) and changes of lagoon morphological condition on the decline of fish catch with the coefficient of factor loading at about 0.754 and 0.614 respectively. Local individual fishing effort (trip) declined during the last 5 years due to the decline of fish catch and low fish price in the local market. On the other case, the physical changes of the lagoon are likely to cause the changes of fish catch as well. Most people confirmed about the increase of water depth in the lagoon where are not suitable to fit with their fishing gear (small boat, old seine). Activity of mangrove access has been confirmed to the damage of fishing ground where fish community accumulated.

Some local fishers complained about the increase in the cost of raw materials such as seine, hook, and string, etc. Socioeconomic growth in the urban and city were likely to increase of the demand of fish catch in form of large scale. Large scale fish supplies were much more from large scale fishermen, especially foreign fishing vessels. However, local socioeconomic growth does not much effect to the decline of fish catch in the lagoon. The decrease in the monthly family income has actually affected the number of fishing trips, and caused the decrease of fishing landings in the entire area. Local fishermen acquired the use of money from local credit to buy materials and their equipment maintenance. Factor loading are at about 0.66 and 0.61 of socioeconomic growth and cost of material increase respectively. Aside from these factors the current management of fishing control (top-down approach), and unavailability of social and environmental safeguards for lagoon's resources have also contributed to the decline of fish catch, while factor loading provided in most high at 0.73 and 0.74 respectively. Most of respondents revealed that they are not satisfied with the current management of the lagoon. Because the lagoon is an open access resource, illegal outsider fishers can also come to catch fish in the area. Conflicts were found in many types such as fighting, shooting, and on the ground debate. No any social measures or environmental mechanism to protect users from these problems. On the other hand, sand excavation activities severely affected water depth in the area such that even small-scale local fishers were unable to catch fish effectively. Water depth has

been increasing over the last five years since the local authorities' permitted sand excavation in the lagoon area for commercial purposes. Normally, the most optimum depth for local fishers varies from 2m to 3.5m. Currently though most of the areas have depths of more than 5 m. Therefore, it can be said that the sand excavation activities also caused fish decline.

Component 2 shows the four factors of local fishermen such as condition of boat's length, illegal fishing gear, fuel cost, and experiences of fishermen. Comparison of experiences between local fishermen and outsider fishermen showed significant differences. Local fishermen experiences are quite less than those who come from outside. Outsider fishermen can understand well the place of fish community and they even can predict weather as well. Therefore, much experience does not contribute to the conservation of fish resources, but overexploited through their huge catch seasonally. The increase of fuel cost allowed local fishermen are not able to catch fish because of insufficient money, but outsiders can have good opportunity to catch. In these challenges, it forced local people to use illegal fishing gears for either their daily consumption or small commercial purpose as well. The component 2 shows factor loading higher than the other six components (Table 5.1).

Component 3 shows the main factors that are associated with each other (increase of foreigner vessels, outsider's use of illegal fishing gears, and commercial sand excavation and navigation inshore and offshore of the lagoon). Currently, there is a significant increase in the number of outsiders fishing in the lagoon. They come from different places surrounding the lagoon. Most outsider fishers used illegal fishing gears and fished all year round. Some of them used trawl fishing gears and operated big boats, to the detriment of the local small-scale fishers. The other outsiders were authorized by the local government to explore sand resource transporting inside the lagoon to the urban and regional demand. This causes to the damage of lagoon's morphology, mangrove and fish resources.

Component 4 shows the increase of tourist and garment industry in associated with other factor such as changes of water quality, and enlargement of extensive farming system. Industrial growth in the area does not very much to build up local social capital, but the produced much liquid and solid waste to the lagoon. Water pollution becomes worst from year to year since the population growth of local industry. On the other hand, sugar cane and bean farming system have been emerged surrounding the lagoon. It counted for at least 15,000 ha of sugar cane and bean, as well as other cash crops. Farming used huge of chemical fertilizers for the improvement of yield. Local farmers and fishermen claimed the changes of water quality identified by color changes since the growth of large scale farming system in the area. However, they will not be affected the lagoon if they use organic fertilizer.

5.2.2 The Related Factors Affecting Fish Catch

Aside from the factors discussed above, industrial growth in the area, increase of solid waste, and navigation also brought about the decline of fish catch in the area. The construction of industrial buildings in the area such as a sugar plantation, hotel and guest house, food processing company and garment factory, caused solid and liquid waste to be drained into the lagoon. In addition, the further expansion of an already extensive sugar cane plantation in An Cha Eurt Community Fisheries caused the changes in water color inshore for the last 5 years. Most of the local fishers complained that the amount of inshore crab declined significantly. Some opined that the decrease of inshore crab was the result of the extensive use of chemical fertilizers by the

sugar cane plantation. This was somehow confirmed by workers at the sugar cane plantation who reported that the chemical fertilizers applied in the plantation were ten times more than that normally used by the farmers.

5.3 Conclusions

One of the main factors that affect fish catch is the style of fisheries management. Currently, several guidelines and regulations are being enforced inside and around the areas of the lagoon. Nonetheless, these guidelines and regulations did little to improve the volume of fish catch in the area. As a result, the volume of fish landings has steadily declined from year to year, according to government records. Management which applies the top-down approach was ineffective in ensuring the conservation of the natural resources in the area or the increase in the volume of fish catch. The existing mechanism proposed by the government was ineffective in ending the conflicts among stakeholders which continued to escalate.

The secondary factors affected include changes in the number of fishing trips per family, change in the depth of fishing grounds, and changes in the capacity of fishing boats from high to low horsepower. Socioeconomic changes had a concomitant change on the volume of fish catch. Aside from this, climate variation and agricultural practices have also affected the volume of fish in the lagoon. The fishers claimed that because of the large amount of fertilizers used by the large sugarcane plantation adjacent to the lagoon to increase the yield of sugarcane, the quality of water along the shoreline has severely declined. This claim, unfortunately, is not backed by any scientific research. Notably, fishers who catch fish in shallow depths were able to catch a greater number of fish than those who fish in places where water depth is high because of the fishing gears that they use. The exploitation and excavation of marine sand resources has likewise affected the shore and offshore morphologies of the lagoon, inevitably affecting the volume of fish catch.

The management of the Sre Ambel lagoon must be improved and the "bottom-up" approach should be adopted, so that the stakeholders themselves are given a voice in its administration. A change from the current open access system to a common resources property regime can be a good alternative extractive reserve system for the conservation of the lagoon's resources. The institution of a controlling mechanism at the lagoon level would also be necessary to protect the area from the use of illegal fishing gears by outsiders.

CHAPTER 6
STAKEHOLDER CONFLICTS AND SOLUTIONS ACROSS POLICY LEVELS

6.1 Introduction

Sre Ambel Lagoon is the largest estuarine ecosystem in the coastal area of Cambodia. It is influenced by freshwater from the continent during the rainy season. There are two streams influencing this estuary: Sre Ambel Stream and Trapeang Roung Stream. This estuary has a large delta approximately 60,000 ha in area and is covered by a mangrove forest. The species diversity of the estuary is high (74 species). *Rhizophora mucronata* and *Rhizophora conjugata* are particularly important because their roots are the main habitats of green mussels, mangrove oysters and hermit crabs. *Seagrass*, especially *Enhalus sp*., is present at the delta of Trapeang Roung Stream and the muddy beaches of the eastern part of the bay. *Halodule sp*. occur in the area between the shoreline and Koh Kong Island, especially during the dry season. These areas are important habitat for mud crabs, cuttlefishes, and *Penaeus* and *Metapenaeus* shrimp. Shallow water mammals, including the Irrawaddy dolphin (*Orcaella brevirostris*), utilize this habitat almost year round. The collection and culture of the green mussel (*Perna viridis*) takes place in Peam Krasob, Koh Kong Bay. Fishers harvest hard-shell clams (Meretrix spp.) and the short-neck clams (*Paphia undulate*) in Thmor Sor. Currently, there are challenges to the use of marine resources in the area of Sre Ambel Lagoon, particularly regarding marine fish catches, leading to various conflicts in the area. These conflicts have resulted from the depletion of marine resources, especially a yearly decline in marine fishes. There have been claims by the local government to address four main conflicts between resource users. These conflicts are between: 1) medium-scale fishers and small-scale fishers; 2) users of illegal fishing gear and small-scale fishers; 3) medium-scale and large-scale fishers with the local administration officer; and 4) local fishers and outsiders. There may have been other serious conflicts, however, which have not been addressed by the local government. To date, there has not been a solution proposed to solve the conflicts in resource use in this area.

User-participation management of fisheries resources "is a way of broadening the knowledge base on which management decisions rest and thus improving the science of management" (McCay and Jentoft 1996). Therefore, an important objective towards an integrated and participatory marine fishery management plan is to build a common knowledge base upon which management decisions can be made. Such a knowledge base could include scientific knowledge and practical knowledge from resource managers and resources users. It could also include socio-economic and ecological information at local, district, provincial and national levels. Such an information base may serve at least three major purposes: 1) provide a large set of information for decision-makers; 2) minimize differences in stakeholder understanding of problems; and 3) provide information to coordinate management at a larger scale.

6.2 Research Objectives

The aim of this paper was to investigate stakeholder conflicts in the Sre Ambel coastal area of Cambodia in order to propose a participatory resource management approach that takes into account stakeholder concerns, fishers' knowledge and government institutional frameworks. This paper also examined a small-scale coastal fishery at the Sre Ambel Lagoon, Sre Ambel District of Koh Kong Province, and Southern of Phnom Penh Capital. Analytical tools from common-property theory were used to investigate stakeholder conflict interactions among

management institutions across political scales, administrative sectors, and organizational spectra. Additionally, the role of these institutions to help minimize or exacerbate conflict was investigated. Insights from common-property theory were explored to propose some mechanisms to integrate different types of knowledge.

6.3 Methods

Fieldwork was conducted from January 2009 to October 2009. Research methods included interviews, archival research and participant observation. Interviews were carried out in several formats, including structured interviews, semi-structured interviews with key informants and small groups, and resource mapping. These formats were used to elucidate fisher knowledge, stakeholder conflicts, stakeholder concerns, major management problems, actors and organizations responsible for and affected by such problems, and the main changes in the local socio-economic and ecological system in the last four decades. Archival research was done to trace changes in fisheries legislation, government organization and the local socio-economic system. Participant observation was carried out to monitor fish and shrimp catching activities and the fishing methods used, and to understand the role of fishers, tourists, tourism entrepreneurs, resource managers, fishers association, government agents, and community councils. Data analysis was based on triangulation of data from field notes, transcribed interviews, and from external sources including documents and literature. In addition, the main findings were verified by key people including fishers, local residents, local school teachers, head of fishery communities and a governmental fishery administration agent working in the area.

In addition to frequency estimates derived by SPSS analysis, scales and indexes were used for the quantitative interpretation of qualitative data. Scaling and indexing can be used to measure or assess attitudes and other forms of qualitative reactions to questions. They are commonly used in social sciences, and are particularly useful because they provide quantitative measures that are amenable to greater precision, statistical manipulation, and interpretation (Miller 1983, p.174).

Because questions differed according to the specific purpose of the interview, an index of scaling tool was applied to assess the reasons, reactions, preferences, restrictions and opinions regarding:

- Willingness to participate in lagoon management
- Satisfaction with the existing management of the lagoon
- Satisfaction with the change in management of the lagoon
- How to make management of the lagoon successful
- Agreement with the actions of the co-management team
- Agreement with co-management practical and scientific knowledge
- Satisfaction with the establishment of a forum for conflict resolutions
- Satisfaction with the proposed alternative management for the lagoon

To measure the perceived satisfaction on variables including the existing management of the lagoon and establishment of a forum for conflict solution, the formula of scaling index was as follows:

IPS = VD (0.1) + DS (0.4) + ST (0.7) + VS (1.0) / n
Where IRR = Index of Perceived Satisfaction
VD = Very dissatisfied

` DS = Dissatisfied
ST = Satisfied
VS = Very satisfied
n = Number of observations

To measure the fulfillment of expectation regarding the variables associated with participation in the management of lagoon in the future (IEF), the formula of scaling index was as follows:

IEF = NF (0.10) + HF (0.40) + MF (0.70) + GF (1.0) / n

Where IEF = Index of Expectation fulfilled
NF = Not fulfilled
` HF = Hardly fulfilled
MF = Moderately fulfilled
GF = Highly fulfilled
n = Number of responses related to each attribute

To measure the change of the current situation in the management of the lagoon, the formula was:

ICS = BD (0.10) + DG (0.30) + MT (0.50) + IM (0.75) + SI (1.0) / n

Where ICS = Index of change in situation
BD = Badly degraded
` DG = Degraded
MT = Maintained
IM = Improved
SI = Sustainably improved
n = Number of responses related to each attribute

To measure the feelings of stakeholders regarding the proposed activities to manage the lagoon, the formula used was as follows:

IST = N (0.00) + I (0.33) + J (0.67) + E (1.0) / n

Where IST = Index of Desired State of Proposed Alternative Activities to Manage the Lagoon
N = None
` I = Insufficient
J = Just sufficient
E = Excellent Agreed
n = Number of responses related to each attribute

The index is used to indicate full rejection of the proposed activities and express perceptions of insufficiency or sufficiency, or full agreement with the proposed activities.

6.4 Theoretical Review

First, user knowledge may supplement scientific information, especially in areas where scientific knowledge is scarce, as in most developing countries (Berkes et al. 2001). This approach is feasible since resource users have ecological knowledge about marine fish species and ecosystem processes especially in their area. Moreover, using fisher knowledge and scientific knowledge together has improved management systems in several localities (Corsiglia and

Snively 1997). Second, conflicts among user-groups and between them and other stakeholders (including government agencies), are often a result of very different management goals, which reflect different worldviews rooted in different knowledge bases (Hanna and Smith 1993). Building a common and reliable knowledge base may help reshape, to some extent, stakeholder views of management problems and their management goals. Third, sharing a locally developed knowledge base across political scale and localities (geographical scale) may lead to a better coordination and outcome of integrated marine resources management at provincial, regional, and national scales. More often than not, fisheries measures, which are usually based on scientific research performed in relatively small areas, are implemented in much larger areas disregarding the socio-economic context and ecosystem particularities affecting fisheries systems at local levels.

Coastal resources are often managed by more than one agency (such as different authorities of the government, private and community organizations) at different political levels (local, district, community, provincial, national and international) and in distinct sectors of the economy (fisheries, tourism, urban development, maritime transportation, and mining exploration). For instance, fisheries departments at any government level usually deal with regulations concerning only access to, and use of, fish stocks; little attention is given to the fact that fishing areas and fishers' livelihoods are affected by other economic activities taking place at the same time and locality. This lack of coordination among different efforts to manage coastal areas usually results in conflict among user-groups, environmental degradation and resource over-exploitation. Such situations call for an improvement in both cross-scale and cross-sector efforts to develop integrated coastal management.

Efforts towards integrated coastal management may occur at different scales from the national to the local level. An example of a national and district level effort is the measures program in or surrounding the lagoon that included representatives of several fisheries administration and provincial officers and non-governmental organizations, the provincial environmental department, and some internal and international university programs as well. These representatives assessed Sre Ambel coastal problems, inadequate development of human resources involved in management, and training needs at the local/national level. The objective of this program was to build the capability of Sre Ambel coastal fishery communities at the local level to devise a strategy for the development of the coastal zone as an integrated system. There was no doubt, however, that such a program crossed over political levels, administrative sectors, and organizational spectra - key factors for successful management in this area. What is often missing in these nation-wide efforts, however, is input from resource users and other stakeholders.

Theoretically, according to Costanza et al. (1998, 1999), full stakeholder participation in formulating and implementing decisions about environmental resources is one of the key principles for promoting sustainable governance of the oceans and coastal areas (Table 6.1). This is particularly true in the case of multifaceted conflicts about resource use, which require a participatory resolution process (Hanna and Smith 1993). User-participation in decision-making helps to increase the transparency of the process (and legitimacy) and subsequently, rule compliance (McCay and Jentoft 1996).

Although acknowledging that nation-wide efforts towards integrated coastal fishery management are very important, solutions to specific problems should be tackled at the scale that

matches the problem to be solved. Thus, efforts focusing on a particular locality using participatory approaches are likely to solve local fishery management problems more effectively than regional or national approaches. The present study has focused on using participatory approaches at the local level and suggests that identification of stakeholder conflicts and their origins, together with stakeholder concerns, may be a first step towards an integrated marine fish resources management. Conflicts and concerns usually indicate a weakness in current management arrangements, the main organizations involved, as well as their capacities and vulnerabilities, and the major issues that have to be addressed.

Berkes (2002) identified some promising institutional forms for cross-scale linkages in natural resource management to take stakeholder concerns and user knowledge into account through a participatory resource management process. They included: co-management linking communities and government; multi-stakeholder bodies; development, empowerment and co-management arrangements; institutions for linking local users with regional agencies; research and management approaches to enable cross-scale linkages; and 'citizen science' or 'people's science movements. There is not a general model that can be universally applied as the best solution. The most appropriate approach or combination of approaches for each case will depend on the political and cultural history of the area as well as on its geographical and ecological characteristics.

The fisheries management of the Sre Ambel Lagoon started in 1988 through a readjustment of the existing law of marine fisheries in 1987. The majority of the fish catch activities received capital budget from Thailand in order to absorb marine fish catch production from Cambodia's coastal areas, particularly Sre Ambel Lagoon. The marine fisheries products were sometimes replaced by other products from Thailand. The credit investment of Thailand in the lagoon, however, has so far decreased. For the past five years, the marine fish products have been exported to neighboring countries.

The major economic activities in each of the two communities varied slightly, but overall, with respect to the entire region, tourism-related activities seemed to be the third main source of income for most people next to the main income from marine fishing and rice field activities. Small-scale fishing and household agriculture, which were the major sources of income since the 1980s, became less representative in the local economy by late 2005. Fishing activities, which evolved from subsistence-oriented activities in the 1990s to market-oriented in the 2000s, became both a commercial and consumption activity during the 1990s. Household agriculture changed from market-oriented since the 1960s mainly to subsistence-oriented in the 2000s.

The Lagoon fishery was a resilient communal management system in early 1997 at a time when management practices were based on local ecological knowledge and enforced by governmental rules (Ratha el al. 2007). The Department of Fishery had initially established its policies and guidelines on marine fish resources conservation based on the current demand. The national regulations of the marine fisheries conservation focused on how to allocate enough quantity and ensure that the lagoon stock had met sustainability. To reflect the aim of these goals, the local administration at the lagoon level had three planning processes: a one-year based planning process of stock recruitment, a five-year based planning process of stock recruitment, and a ten-year based planning process of stock management in the Sre Ambel Lagoon. The medium term five-year based process was incorporated from 1999 to 2003 and specifically focused on the rising awareness of conservation and management of marine fisheries resources,

which importantly focused on the local ecological impact of fish catch. The planning process had also assessed illegal use of fishing gear as well as the procedure of complaints in a conflict of interest. During 2002, the Lagoon became an open-access and less resilient system due to several changes in the local socio-economy, including the development of a shrimp market, a very popular activity in 2003. The resilience that was rebuilt into the system had some key factors (Table 6.2); these key factors have to be considered in any Sre Ambel Lagoon Management plan. Co-management arrangements triggered by local fishers allowed for the incorporation of local knowledge and fisher concerns into government regulations (i.e., good cross-scale communication and political space for experimentation). These regulations served to optimize catch size while maintaining the stock for the future and minimizing conflict among user-groups by promoting equity in resource access. During this period, through an agreement between the local administration and fishery authority administration (government), the government appointed a few officers as fishery inspectors for that region (i.e. strong rule enforcement). In 2005, these appointed inspectors were not very effective in enforcing fisheries rules, probably due to budget constraints (small salary), and enforcement became sporadic. The lack of personnel and equipment supplied by the central fishery administration authority and the provincial department of environment with local administration (commune councils) led the Sre Ambel Lagoon to a mix of state-property, communal-property and open-access situations during 2007.

6.5 Results

Although there are plenty of established laws and regulations in the area of fisheries within the Lagoon of Sre Ambel, there was still a diversity of serious conflicts among resource users at the lagoon level. A summary of the types of conflicts as disclosed by all 210 respondents is compiled below. The percentage of the conflicts is shown in Figure 6.1.

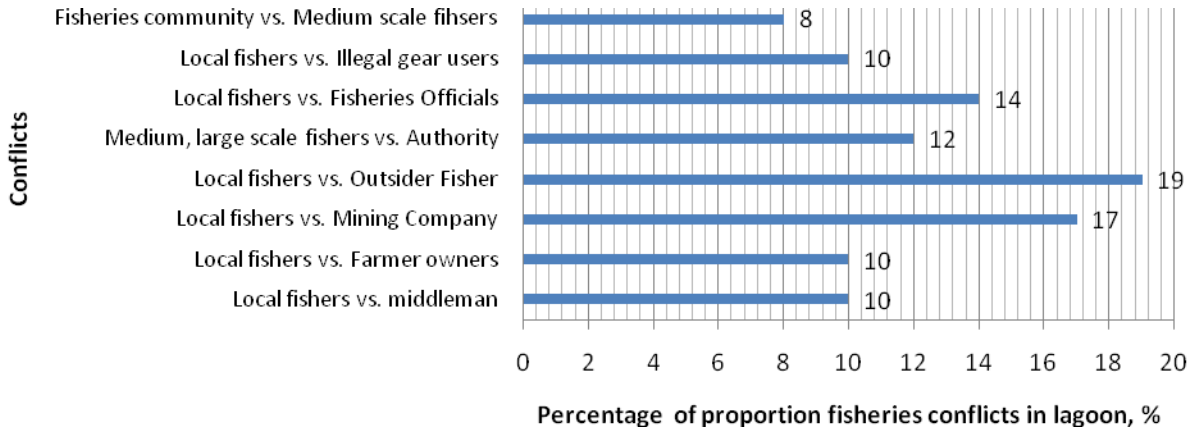

Fig. 6.1 Proportion of fisheries conflict in the area

Marine fish resources declined gradually subsequent to an increase in the demands of a growing population, both locally and regionally. This has caused conflicts of interest for marine fishing at the lagoon level. Moreover, there have been observations of increased use of illegal fishing gear and modern fishing technology in the area as well. The conflicts among fishers result from the use of modern technology in fish catches and collusion among fishers using illegal fishing gear and the local fisheries administration. The decline of marine fish resources and collusion in management resulted in disappointment among most of the fishers and residents in

the area with the poor management by the local fisheries administration. When questioned whether they were satisfied with the existing management of the lagoon, only 24% said they were satisfied, with the Index of Perceived Satisfaction estimated at 0.32.

Results of the field research and the triangulation of field notes in particular, indicate that there are eight major types of lagoon fishing conflicts as follows:

- Conflicts between the fishery community and medium-scale fishers;
- Conflicts between small-scale fishers and illegal fishing gears users;
- Conflicts between small-scale fishers and the local fisheries administration, which includes community administration;
- Conflicts between medium- and large-scale fishers and the marine fisheries administrations;
- Conflicts between local fishers and outsiders (foreign vessels or Cambodian medium-scale fishers);
- Conflicts between local fishers and mining exploration companies;
- Conflicts between local fishers and large farm investment of agriculture (Lagoon management problem); and
- Conflicts between local fishers and marketing middlemen.

The three most common and serious conflicts that occurred in the coastal areas differed from place to place. Respondents from the Chroy Svay Fishery Community revealed that the most common fishing conflicts in this area were conflicts between community management and medium-scale fishers who use trawl (*Oun Os, and Chepyon*). The second most common conflicts in this community fishing ground were between small-scale fishers and medium-scale fishers, while the third most common conflicts were conflicts between fishers and local fishery administration. According to the results of workshop at the lagoon following the data collection however, there appears to be another serious conflict between fishers and a mining exploration company (Sand Excavation).

In the second community, Chikor Kraom, the most serious conflicts were conflicts between fishers and large-scale investment of agriculture, followed by conflicts between small-scale and medium-scale fishers, and conflicts concerning the use of illegal fishing gear. As indicated in the field notes, the two major causes of conflict in the lagoon were the use of fishing gear in all scales of fish catch, and the permitted area of fishing.

6.5.1 Fishery Community vs. Medium-Scale Fishers

Although the community has its own regulatory system to manage the fisheries activities in its own coverage area, conflicts still exist. The majority of the fishers in Chroy Svay Community replied that they have not been equally treated by the community. Figure 6.1 illustrates that 8% of the respondents reported that conflicts sometimes arose because of collusion. In some cases, the fishery community allowed their members to fish even in banned areas, especially during the closure period, whereas other fishers were not permitted. The head of the community, however, revealed that there had been strict control of fishing activities during the fish spawning periods (closure periods), but the illegal individuals, small-scale consumption fishers in particular, have always ignored the rules by fishing during the night. According to the research, it was difficult for the community to manage the area because they do not have much

power and equipment to control the fishing grounds, especially during the night. Monitoring during the closure period pursuant to this research has also shown that poor fishing families still fish during the closed period for the purpose of daily consumption only.

6.5.2 Small-Scale Fishers vs. Fishers Using Illegal Gear

At least 10% of respondents reported this conflict in the lagoon (Figure 6.1). At the Sre Ambel Lagoon, illegal fishing gear refers to gear that is banned according to fishery law. Banned gear consists of purse seines with a mesh size of 1 cm and an artificial light used to lure schools of fish. The main species caught by purse seines are pelagic fishes such as mackerel, sardines and other small fishes, although mackerel comprises around 80 to 90% of the total catch. Banned gear also includes seines with a mesh size smaller than 1 cm, and explosive and chemical materials.

The conflict between illegal gill-netters and cast-netters has existed at least since 1999. The conflict was, and still is, about resource allocation since gill-netters (a few individuals backed by a local administration body) captured much more resources with less human effort than cast-netters (most individuals). During 2000 and 2003, this was also a conflict among local communities as illegal gill-netters were concentrated on the inshore of the Lagoon (close to the beach) and most cast-netters lived on the eastern, more isolated sides. In 2003, an attempt was made to solve this conflict by allowing gillnet fishing in only two of the three basins of the Lagoon. For about three years, a volunteer fishery inspector enforced the informal agreement. After his resignation, however, the conflict restarted as gill-netters started to fish in prohibited areas, and during the closed seasons. By the end of 2005 when fishing became a market-oriented activity, the conflict reached a peak; intense use of several gillnets attached together and used as beach seines along the Lagoon shore, and other destructive gears, caused the fishery system to collapse. According to some informants, at that time there was a clear difference in the socio-economic status of gill-netters (richer) compared to cast-netters (poorer). After gillnet use was banned by government regulations in 2006 as a result of cast-netters' requests, the conflict between gill-netters and cast-netters became rare from 2006 to 2007 due to strong regulation enforcement provided by state and federal agencies. The conflict flared up again as enforcement became weak from 2008 to 2009.

As of 2009, gill-netters were mostly outsider fishers. According to some fishers, however, they mainly originated across all of the Lagoon communities. Of interest, local cast-netters can name local gill-netters although gillnet fishing is an illegal activity. For instance, there were about ten gill-netters fishing at the Upper basin, eight of whom have major sources of income other than fishing. To avoid verbal or physical confrontations, gill-netters often run away when they are approached by cast-netters. Over the past few years, most conflicts appeared in the form of verbal exchanges, with few episodes of physical confrontation and shotgun threats.

No movement towards the legalization of a gillnet fishery was observed, although a few individuals suggested legalization. Low support for a gillnet fishery probably occurred because even former gill-netters admitted that the unrestricted use of gillnets was the major cause of the fishery collapse. In addition, a former fishery administration agent who researched the area, argued that the small depth of the Sre Ambel Lagoon does not sustain a gillnet fishery, particularly in the face of an increased number of fishers. Hence, this conflict is essentially a result of the lack of strong regulation enforcement and penalties for cheaters (i.e., gill-netters).

Until now, penalties basically consist of the confiscation of illegal gears and sometimes the imposition of a small fine, which encouraged fishers to take risks. Since then, under fishery laws, fines were increased and their fishing materials have to be burned. The problem was that many fishers were still taking risks in the face of a weak enforcement at the Lagoon, i.e., penalties were heavy but transgressors were not being caught.

6.5.3 Fishers vs. Local Fishery Administration

This conflict was one of the top four conflicts in the lagoon and accounted for 14% of the respondents. Conflict between fishers and the local administration body has only emerged in the last five years as a result of a major increase in conflict of interests in the communities around the Lagoon. The major points of conflicts are listed below in the section "Lagoon management problems …" Briefly, lagoon fisheries have been impacted several times through mistreatment by the power of the local fishery authority and community authority, especially in the last couple of years. Local fisher understanding of how the Lagoon and its surroundings should be managed (to improve fishery production, for example) is quite different from central decision making that incorporates the permission of the local authorities to allow industrial growth and large farm investment. This conflict is frequently expressed in the form of complaints by local fishers. The biggest problem in this situation is that local fishers feel powerless against local administration bodies that usually have a higher degree of education, socio-economic status, and arguing skills. Moreover, in the past when fishers and a local community council complained about irregular constructions on the Lagoon shore they were threatened by sand exploration entrepreneurs.

Overall, this situation is a result of conflicting goals and a different degree of dependence on resources. Ultimately, it expresses a lack of empowerment of fishers and local fishery communities to improve the Lagoon management, a lack of government personnel and equipment resources to enforce regulations, and a mismatch of scale of Lagoon management problems (i.e., local level) and the regulatory and enforcement agencies.

6.5.4 Medium- & Large-Scale Fishers vs. Local Fisheries Administration

Although the medium- and large-scale fishers followed regulations of the local fishery administration, these conflicts still existed. Conflicts with the local fisheries administration usually stem from the fact that the local fishery administration allowed outside fishers to catch fish within areas where local residents fished. Approximately 12% of the respondents expressed this conflict during 2009. Since there is little evidence from interviews with medium- and large-scale fishers, proof of this conflict needs to be supported by the local fishers. The evidence is that those medium- and large-scale fishers have to regularly pay administration fees to the local administration agents for personal security and conflict resolution. Sometimes, however, the conflicts between small-scale fishers and medium-scale fishers cannot be resolved. This kind of conflict has also been confirmed by the local people surrounding the lagoon.

By paying money to the administration, large- and medium-scale fishers expect some lee-way with regards to being allowed to catch fish during the closed season. On the contrary, this did not happen as expected. Since the catch restrictions were implemented in the lagoon, particularly for trawls and seines with light sources to ban the illegal fishing gear in 2006, disappointment between medium-catch fishers and the fisheries administration increased.

6.5.5 Local Fishers vs. Outside Fishers

Outside fishers started to come to the Lagoon about two or three decades ago when access to its shore became available due to the construction of access roads. The conflict only increased when there was an increase in large-scale fishers using trawls (mainly outsiders), especially in 2004. The conflict between locals and outsiders, however, is quite minor as all local fishers acknowledge the outsiders' rights to fish at the Lagoon – a communal property – and physical confrontations rarely occurred. From the point of view of most outsiders interviewed, there seemed to be no conflict among them and the local fishers. Nevertheless, many locals had complaints about outsiders. First, some locals argue that outsiders are the ones who usually introduce new, destructive (and more efficient) and large fishing gears into the Lagoon, which are later used also by some locals and other outsiders. Second, some locals say that outsiders account for most of those using banned gears such as gas lamps, small-mesh cast-nets and shrimp small-trawls. Third, local fishers respect each other's fishing activities more than outsiders, especially concerning fishing spots and first-comers' rights.

Therefore, the conflict in this case is about fishing rights, dependence on fishing, and resource allocation. Again, the weak enforcement of regulations contributed to the conflict because it allowed for the use of banned gears.

6.5.6 Local Fishers vs. Mining Exploration Company

Sand excavation inside the lagoon of Sre Ambel emerged in 2006. There is one sanding port with many vessels to carry sand from the pitch. From a conservation point of view, sand resources are the most suitable shelter habitats of crab, crustaceans, mollusks, and sea grasses. Nevertheless, the sands have been extensively excavated since 2006. As discussed in the previous chapter, sand excavation activities increased with the increase of water depth inside the lagoon. Conflicts occurred for two reasons. Fishers complained that the decrease in sand at the bottom part of the lagoon has caused a decrease of crab and mollusk catches. In addition, vessels carrying sand to the ports and other big ships in the sea may have produced oil pollution in the lagoon.

6.5.7 Local Fishers vs. Lagoon Management

Resource users are quite aware of the major environmental and management problems affecting their livelihoods. According to some Sre Ambel Lagoon fishers and local residents, intensification of large-crop plantations and lack of enforcement of environmental regulation on the use of chemical fertilizers resulted in several problems during the late 2004s, as presented in Table 6.3. Water quality has changed in color since the establishment of a large investment in agriculture on the shores of Sre Ambel Lagoon. 99% of the local residents in Chikor Kraom Fishery Community observed that the water quality had become very different within the last five years. Currently, the water is very dirty and grey in color.

First, illegal gear (e.g., gillnets banned since 2004) and fishing methods (e.g., cast-net fishing at the channel mouth, which prevents fish from entering the Lagoon) were commonly used in the Lagoon, affecting resource stocks and triggering conflicts among fisher groups. Second, motor vessels (banned since 1999 to avoid oil spills and noise that disturbed fishing) and windsurf boards were being used by mining exploration and other administration agents and

interfering with fisheries, causing conflicts between fishers and local controllers. Third, the Lagoon started to be polluted due to an increase of industrial growth and agricultural plantations and fishers, who used the Lagoon margins as garbage dumps. Fourth, the increase in the number of summer cottages with poorly constructed septic tanks that led to contamination of the water table, or that drained sewage directly into the Lagoon, aggravated pollution. Fifth, pollution became a problem during the rainy season. Fishers, on the other hand, wanted to open the channel at different periods to improve the Lagoon fish and shrimp stocks, as traditionally practiced. Sixth, unplanned development and unregulated construction were also causing deforestation along the Lagoon margins, along springs that drain freshwater into the Lagoon, and on the rest of the secondary forest present on the hills surrounding the Lagoon area. Seventh, both unplanned construction and deforestation around the Lagoon were causing siltation of shrimp/fish migratory channels inside the Lagoon and affecting fisheries. Eighth, communal trails up and down nearby hills to access the Lagoon margins were being closed by landowners from outside.

Demonstrates several agencies from different political scales and sectors in charge of environmental and management problems affecting the Sre Ambel Lagoon and its surrounding area. It is worth noting, however, that this was not an attempt to map the entire institutional framework affecting resource management in this region. The purpose here was to record some institutions and organizations related to the Lagoon environment and management problems pointed out by fishers. Mostly, the problems resulted from a lack of coordination among these many management agencies and their ineffective management capabilities. For instance, the Provincial Environmental Department – whose jurisdiction encompassed the lagoon – had, since 2005, only a few personnel and one vehicle to monitor all fisheries communities and protected areas in the whole province of Koh Kong concerning deforestation and water quality, among other issues. Another example is the local community administration as well as the fishery community itself – a jurisdiction that encompassed the lagoon – who, since early 1993, did not have enough power and facilities to monitor fisheries issues in all the fishery communities in their own area.

There were several stakeholders who caused or intensified management problems and those who were most affected by such problems. What is clear is that all these problems are common dilemmas leading to collective action problems – “a situation where there is a divergence of interests between what is rational for the collective and for the individual”. They exist because the current institutional arrangement allows free-riding and cost externalization of problems to a third party; that is, individual rational behavior generates communal problems.

6.5.8 Fishers vs. Market Middlemen

An unstable value of fish prices at local and regional markets caused problems between medium- and small-scale fishers and the middlemen. Of 210 respondents, 90% indicated that the price of fish depended on the decision of middlemen. In months that the catches were small, the fish prices offered by the middlemen were high enough for the fishers. On the contrary, during times of high fish catches, especially during December and January, the price of fish dropped to a minimum that was not acceptable to the fishers.

In this case, both medium- and small-scale fishers suffered financially, whereas the cost of maintenance and repair remained substantially high. Middlemen, who owned the port for fish landing, have provided loans to their fishers if they do not have enough money to buy or repair

fishing gears. The loan was actually provided with the condition that they must sell the fishes in their ports at the price recommended. No fishers who have loans from middlemen break these informal rules. Therefore, the conflicts between them were the set price of fish during the fish landing. Notably however, 15% of the fishermen have their own ports to land fish and transport to the local markets.

6.5.9 Stakeholders Mobilization

To resolve conflict, the Lagoon fishers have been grouped according to their origin and dependence on fishing (full-timers, part-timers, semi-fishers or subsistence fishers). There were a wide range of participants and interested stakeholders in the Sre Ambel marine fisheries. Community members, large- and middle-scale fishers, processors, traders, transporters, provincial and national government staff, local and international NGOs, and scientists were increasingly being involved in government decision-making processes (Ing T. and Kathe R. Jensen, 2005). However, it may be important to include the participation of small-scale commercial fishers as well as subsistence fishers in the future. It appears that most private sector stakeholders, including large and middle scale fishers, are mostly interested in getting maximum profits in a short time, even if they know that this will damage the environment and eliminate their future possibilities of utilizing these resources. With the exception of Koh Kong Province, the marine fishers in coastal zones of Cambodia have not yet formed fisher associations, and so it is up to each individual to make decisions about when and how much to fish, as well as appropriate times to take up loans for investing in improved technology. However, even if the Koh Kong Province has established fishery organizations throughout the province, the function of these organizations are still limited, especially since they do not have much power to control illegal fishing by outsiders. The majority of fishers, including rice farmers, fully agreed that they would commit to or participate in the management process planning in the future if there is a management approach introduced to improve the current situation. 76.6% agreed strongly to participate with a strong IEF Index scale of 0.79 (Table 6.4), whereas a minority of them showed moderate commitment. Therefore, the co-management approach at the lagoon level would be a successful model in this coastal area of Cambodia.

There are many legislative instruments and regulations currently in force for the management, conservation, and sustainable development of Sre Ambel's fisheries resources. These include:

- Fishing permits for commercial fishing
- Boat licenses
- Licenses for foreign vessels fishing inside Sre Ambel Lagoon
- Prohibition of illegal fishing gear such as electro-fishing, explosives and poisons
- Prohibition of trawling in water less than 20 m deep
- Protection of mangrove areas and fish sanctuaries (spawning areas)
- Enforcement of a closed season during the spawning season of mackerels from 15 January to 31 March

After assessment of the conflicts between stakeholders, all participants of the workshop at the lagoon level brainstormed the most practical approach to solve the marine resource management issues. The majority (61.0% with an IPS index scale of 0.69; Table 6.4) agreed with solving collective problems in the area prior to dealing with other complaints. A total of 16.2% supported a decentralization of resources to the local management as the best solution, whereas

30.5% indicated that they need co-management planning process compliance with the existing rules and regulations; 4.3% of participants indicated that decision making should be from the local fishers.

Results from measurement of expected situation changes provided an index scale IEF of 0.79 at a proportion of 82.3%. The responses were strongly optimistic about the ability to effectively manage lagoon resources if there was an effective co-management strategy of the lagoon with revised regulations and adoption of the alternative management strategy proposed below.

The majority of respondents (84%) were supportive of the establishment of a forum for conflict resolution. The Index of Perceived Satisfaction IPS was 0.75. The desired state of the proposed alternative management approach had an IST of 0.77, estimated from 79.9% of the 210 observations (Table 6.4).

6.6 Discussion

6.6.1 Solving Collective Action Problems

If individual responses cannot solve a common dilemma, the task for the group is to organize themselves and to change from a situation of individual action to one of collective action. Such a strategy will provide joint benefits but lower joint costs (Berkes et al. 2001, p.181). Solutions to collective action problems involve the establishment of rules constraining individual behavior. How management rules should be created depends on the scale and scope of each problem (e.g., political and ecological boundaries of an area, the property-rights regimes, ability to limit access, and the size and diversity of fishery communities). According to Acheson (1998, p.51), collective action problems may be solved by decentralized solutions, in which "people may cooperate to provide rules by informal agreements" (i.e., community-based management) or by centralized solutions, in which people ask "the government to provide such regulations". The former may occur as a result of distributional conflicts, but "the nature of boundaries, ability to limit entry, political entrepreneurship, group size and social capital all play a role" (Acheson 1998, p.51). The latter may occur when there is a lack of access control, insufficient property rights and large and heterogeneous user-groups. It is important to note, however, that centralization and decentralization, in the above sense, are only two ends of a continuum of possible arrangements, and trade-offs exist among them.

However this is to remark that: If management is too centralized, valuable information from the resource, in the form of feedbacks [from users to decision-makers], may be delayed or lost because of the mismatch in scale. If management is too decentralized, then the feedback between the user-groups of different resources, or between adjacent areas, may be lost (Berkes 2000, p.1).

Considering the above, it seems the fishers and other farm owners have agreed as a reasonable guidance to argue that the principle of subsidiary may be an appropriate guide to solving conflicts resulting from collective action dilemmas. This mechanism of conflict resolution has been satisfactorily accepted and proposed by the local workshop upon the finalization of data collection at the community level. The mechanism shows that any decision-making should be made by the lowest organizational level (Fishery Community or at least

Community Councils) capable of solving the problem. For example, conflicts involving only local people and non-migratory resources may be solved at the district or provincial level, whereas conflicts involving outsiders or migratory resources may be solved at higher provincial political levels (e.g., by the province or ministry of government).

6.6.2 Proposing an Alternative Management Plan for the Sre Ambel Lagoon

Following discussion and approval at the local community level, it has been discussed institutional instability at higher political levels, the great diversity of ineffective management agencies, and the lack of coordination among government agencies from different levels and sectors. This has resulted in stakeholder conflicts, environmental degradation and resource overexploitation at the Sre Ambel Lagoon and the surrounding area. As well, it has been observed that stakeholder conflicts reflect a divergence in management goals, a degree of dependence on resources, disagreement about fishing rights and resource allocation, a lack of personnel and equipment resources to enforce regulations, a mismatch of scale of problems and regulatory and enforcement agencies, the lack of empowerment of fishers and local councils, and different understandings of Lagoon ecosystem dynamics. It is now time to answer to the question "What may be done to overcome such problems in order to develop an integrated and participatory management plan for this area?"

Any promising solutions to these problems depend first upon the political commitment of government at different political administration scales to deal with the issues. This may require the government to modify their current structures in order to: 1) coordinate actions at different levels to minimize discrepancies in management goals and policies; 2) allow stakeholder concerns to be addressed; and 3) to incorporate user knowledge into management. The first task may be initiated by efforts such as Integrated Issues Dialogue in the Whole Coastal Area of Cambodia, which helps build the capability of coastal managers at different scales. Tasks 2 and 3 may be accomplished by initiating a participatory management process for the Sre Ambel Lagoon.

It is suggested that the establishment of a workshop at Sre Ambel Lagoon to address stakeholder concerns and conflicts (as combined issues above), and to build a knowledge base upon which management decisions can be made through a co-management process, be a shared responsibility among governments, non-government organizations and resource users (Figure 6.1). The Forum could be a long-lasting institution able to deal with current problems and to actively respond, through an adaptive management approach (Holling 1978, Walters 1986) to future socio-economic and marine fish resource problems. As well, this could be a joint effort among all NGOs, districts and provincial authorities, governmental agencies holding responsibility for Lagoon management and all the other Lagoon fishery communities that include local fishers, outside fishers, local residents, tourists, and tourism businessmen. Some scientists and natural resource managers may also join the Forum in order to provide information, methods and tools to be used in each one of the co-management phases: planning, implementation, monitoring, evaluation and adaptation.

The Forum may search for promising conflict resolution measures across different political scales. For instance, it may work to empower community councils and other local organizations or it may work to set up agreements between groups of stakeholders. Additionally, the Forum may promote co-management between local resource users and government agencies.

It may also serve to mediate discussions about resource use among local users and community councils, and the district and provincial authorities may legitimize agreements reached in such discussions (i.e., it may turn an informal agreement into a central government by-law). In other instances, the Forum may encourage the central government to promote decentralization of enforcement from the central sector to the district and community level, or even to the fishery community and the Forum itself. This could result in a more effective, and possibly less expensive, enforcement regime, as local inspectors are more familiar with the local conditions than are outsiders.

6.6.3 Establishing a Forum for Conflict Resolution at Lagoon Level

Much has been written about co-management and participatory management processes, especially concerning fisheries management (Jentoft 1989, Pinkerton 1989, Hanna 1996, McCay and Jentoft 1996, Sen and Nielsen 1996, Pomeroy and Berkes 1997, Singleton 1998). These studies have reported on the positive and negative experiences with fisheries co-management, and the major issues that need to be addressed in such arrangements, such as: questions of representation of participants and their motivations; relationship building; power in decision-making; process legitimacy; local socio-political and cultural context; stakeholder values, interests, and conflicts; boundaries; resource condition; goals; costs, funding and budget allocation; capacity-building; institution-building; time-frame; information gathering; monitoring, enforcement and compliance; evaluation measures; and adaptive learning.

All of these issues may be addressed when establishing the Sre Ambel Lagoon Forum (SLF). In this section, however, I propose a way to build a knowledge base that will bridge user concerns and knowledge with manager concerns and knowledge. The major point here is that conflict resolution can be based on a common understanding of environmental and management problems. As Hanna and Smith (1993, p.66) pointed out, "a discussion of the various perceptions of the problem [is needed] to arrive at a consensus of the true nature of the problem and on a common principles that will structure the [co-management] process. The consensus includes recognition by each group that the other group's objectives are viable and thus supportable."

To create the Sre Ambel Lagoon Forum and a knowledge base, it is to build a governance model (Figure 6.2) based on the local community fisheries management structure in 2003. The central office of the Fisheries Administration Authority – the provincial authorities - was responsible for approving all changes in fisheries regulation, whereas local fisheries agent offices at the district level were in charge of presenting proposals of new regulations but did not have any power in decision-making. Finally, 210 outside and local stakeholders participated in a workshop on the Sre Ambel Lagoon. A majority of these participants were satisfied with the establishment of a conflict solution forum at the lagoon level. Managers working at the district level office need to have the necessary skills to enter into a co-management process. Capacity-building is needed for managers to understand the important contribution stakeholders may have in management design, implementation, monitoring, evaluation and adaptation, and to learn tools and techniques to conduct workshops, to assess stakeholder concerns and user knowledge, and to manage conflicts among user-groups (or even between themselves and users).

It is important to clearly recognize that each knowledge system is valuable in providing different kinds of knowledge and different perspectives. Making resource users confident of their knowledge can increase user participation in decision-making and in providing local solutions for

management problems. Solutions to problems, based on local knowledge, are more likely to be accepted by local communities (Antweiler 1998). In addition, increasing resource users' confidence in their knowledge may even strengthen their ability to "co-operate with external institutions on an equal basis" (Antweiler 1998, p.490).

Capacity-building may be provided by specialists or scientists working with local knowledge and social organizations in local coastal systems. Scientists may also play a role in providing scientific information to complement user and manager practical knowledge. Hence, local fisheries administration agents may invite both natural and social scientists from local universities or research institutes (such as CDRI, CARDI…) to be a part of the co-management process. After partnerships are established between fisheries administration agents and natural and social scientists, the identification of stakeholders may be undertaken. To help establish a co-management forum at the lagoon, fishery agents may describe each step of the process and the actors involved in it, and point out the benefits, costs and risks of such a process for each stakeholder group and for the society in general. In many cases, stakeholders are not well organized, and therefore managers may need to encourage them to get organized in order to be a part of the process. Stakeholder representation and the decision-making process could then be negotiated. Stakeholder misrepresentation may create bias in the decision-making process (Jentoft et al. 2001) and a consequent lack of compliance to management measures.

It is important to understand that not all management decisions can be made locally by the Forum. Indeed, in many cases the Forum will only provide a knowledge base and suggestions for promising solutions to government agencies at higher political levels, which in turn will make decisions while taking into account matters involving other areas and groups of people – the subsidiary principle.

6.6.4 Co-Managing Practical and Scientific Knowledge

If the Sre Ambel Lagoon Forum can be created, there will be a need for a 'working team' to build a knowledge base upon which decisions can be made. Initially, the team can define research tools, techniques, and samples to search and compile information about the Lagoon management system, including stakeholder concerns and user knowledge. Information-gathering techniques and sampling strategies may vary according to the local socio-political context and diversity of fish resource uses. In fisheries, for example, "the complex range of factors that probably influences fishers' [knowledge] means that reliance on a small sample could result in limited and perhaps biased data" (Neis et al. 1999, p.222). The literature provides several techniques (e.g., semi-structured interviews, focus groups, ethno-mapping, participant observation, etc.) and sampling methods (e.g., most knowledgeable users, users from different user-groups, gender, etc.) which may be used individually or complementarily to collect user local knowledge (e.g., Neis et al. 1999, Usher 2000, Berkes et al. 2001).

The team would need to be involved in data collection, organization and communication, as well as the discussion of such data with the public. The knowledge base would incorporate three main sources of information. These would include: 1) marine resource users, who would provide practical local knowledge; 2) managers, who would provide practical knowledge at local and/or regional scales, and scientific knowledge; and 3) scientists, who would provide scientific knowledge (Figure 6.3). To integrate user and management practical knowledge with scientific knowledge, all information must be collected, organized and communicated in a comparable way.

User and manager practical knowledge can be organized in a systematic way, and distinction must be clearly made between observations and inferences. Moreover, the process of collecting and organizing information must also include techniques of validation (e.g., data triangulation). Particular attention may be given to information directly relevant to conflicts among fishery communities, since user statements may be 'politicized' (Neis et al. 1999). Practical information provided by users and managers must be accountable on an equal basis to scientific information.

All compiled information, including both practical and scientific knowledge, may be presented to all actors involved in the co-management process. Additionally, sufficient time may be provided for the groups to digest or verify information. For instance, resource users need time to assimilate external knowledge by testing it in their everyday practices. As Antweiler (1998, p.489) pointed out,

"Communities must have the opportunity in terms of time and social institutions to discuss the given information and integrate it into their system. They need to gain their own experiences with the application of external knowledge along the lines of their socialization practices. This normally demands an adequate time frame and has often led to impatient reactions of practitioners, who need to achieve quick results, particularly in the case of an endangered natural environment."

Giving time to marine fish resource users, managers and scientists to assimilate information about an entire fishery system (including socio-economic and fish resources information at the local and regional scale) may also encourage their search for more creative and viable management strategies and solutions to problems. As well, this may reduce the time stakeholders spend arguing with one another about their own, often limited, views of the system. Information gathering may take place during several phases of the co-management process, including: 1) defining management goals; 2) building an initial knowledge base concerning the economic, social and ecological aspects of the system; 3) compiling suggestions for, and decisions about, management and conflict resolution measures while considering its costs, benefits and risks; 4) compiling suggestions for, and decisions about, ways of implementing and enforcing such measures; 5) compiling new data (through monitoring) to evaluate the implemented measures; 6) compiling new suggestions about how to improve the implemented measure; and so on. Ideally, the Forum could work towards an adaptive management, in which new information could be incorporated into the knowledge base and help decision-makers to propose more appropriate management measures (learning-by-doing).

The continuous process of planning, implementation, monitoring and evaluation is necessary because resource systems are 'non-linear in nature, cross-scale in time and in space, and have an evolutionary character' (Holling et al. 1998). Moreover, resource systems are complex in behavior, unpredictable, and in some cases, chaotic (Wilson et al. 1994). Therefore, management measures have to be adjusted in order to adapt to changes in the resource system. As well, measures also have to adapt to changes in the socio-economic system, especially when stakeholder conflicts arise.

The key idea of such a co-management forum is to present and discuss knowledge and the values and concerns of users, other stakeholders, managers and scientists. This is done in order to propose and decide upon viable socio-economic and marine fish resource solutions for the existing management problems, and to improve the Lagoon management system. Such a process

is a multi-way interaction pattern for providing information and decision-making that may result in learning and knowledge adaptation for users, other stakeholders, fishery agents and scientists.

A co-management forum along the lines summarized above is one way new Lagoon governance may be conceived and structured. In reality, the interactions among government agencies and other stakeholders may result in a different kind of multi-stakeholder body with a different mandate or structure. Indeed, co-management is an interactive process that may arise from negotiation, joint problem-solving and mutual learning (e.g., Kendrick 2000, Blann et al. 2002).

Conflict management has many aspects. The aspect dealt with in this chapter is to build a knowledge base to help find a common ground among stakeholders. It is possible that stakeholder interactions may never emerge out of interest-based politics, to build such a knowledge base. The point, however, is that if a common knowledge base can be built, this would help resolve or manage conflicts more effectively.

6.7 Conclusions

Sre Ambel Lagoon is the largest estuarine ecosystem in the Cambodia's coastal zone. The lagoon has a large diversity of marine species, especially fish species. From year to year, some fish species have disappeared in the catches with a decline in total volume of catch as well. The decrease in fish catch and fish species has led to user conflicts in this famous ecosystem area. The conflicts remained unsolved by both the local administration and central fisheries administration. Therefore, user-participation in fishery resource management may be the best approach to solve the problem. A successful solution to these problems will involve thorough investigation of stakeholders' interests and their goals for livelihood improvement. What is the best approach to solve the problem?

Interviews with 210 respondents from fisheries households including key informants from various governmental sectors and fisheries communities in the area were conducted. The questions were developed to acquire information on knowledge, conflicts, concerns, and regulations across the lagoon. They were also used to obtain information about the background of the area, ecosystem resources, and fish catch and fish landing, and especially the management and mechanism required to conserve the resources at the lagoon level. The notes from the field could best be used in comparing the experiences of the inhabitants of the study area with other similar events in various countries.

Citations from more than 20 papers across the world were influential in developing the proposed solution for this area. The citations were related to a feasible approach and included resource users, ecological knowledge, ecosystem processes, and especially the mechanism to solve specific conflicts. Political commitment by the local authority of Sre Ambel Lagoon was also presented in some proclamations by the local government, and this was important for communicating that the central government was concerned about resource depletion and conflicts.

The investigation found eight conflicts between stakeholders inside and outside the lagoon. These conflicts included conflicts between the fishery community and medium-scale fishers, conflicts between small-scale fishers and users of illegal fishing gear, conflicts between

medium-scale fishers and marine fishery administration, conflicts between local fishers and outsiders, conflicts between local fishers and outsider fishers, conflicts between fishermen and mining exploration enterprises, conflicts between fishers and large farm investment in agriculture, and conflicts between local fishers and marketing middlemen. The conflicts differed in nature and origin of cause, and varied from one village to another. The availability of fishery laws and regulations indicated that there have been plenty of legislative documents since 1995 to present. The application of those laws and regulations, however, has been limited because of the gradual increase in conflicts of interest.

There is a need for an alternative management plan for the lagoon. The proposal of this alternative approach, however, is still dependent on the extent of political commitment of the government at different administration levels. The proposed solution has to modify the current management structure on the basis of coordination and actions at all different levels in the area of management and policies, development of a mechanism to allow all stakeholders to have good opportunities to address their concerns and conflicts at the forum, and incorporation of user knowledge into management under consensus from all stakeholders. To proceed with this proposed lagoon management approach there is a need to build an outstanding forum with the support of central governmental legislative framework and policies.

Table 6.1: Key Principles to Promote Sustainable Governance of Cambodia's Coastal Areas

Cambodia's Coastal Management Principles	
Responsibility principle	the responsibility of individuals or corporations to use environmental resources in an ecologically sustainable, economically efficient and socially just manner
Scale-matching principle	the importance of assigning decision-making to the scale of governance that has the most relevant ecological information, that considers ownership and actors, and that internalizes costs and benefits
Precautionary principle	the need to take uncertainty about potentially irreversible environment impacts into account
Adaptive management principle	the requirement to continuously monitor social, economic and ecological systems because they are dynamic and have some level of uncertainty
Full cost allocation principle	the need to identify and allocate all internal and external costs and benefits (social and ecological) of alternative uses of environment resources
Participation principle	the importance of full stakeholder participation in the formulation and implementation of decisions about environmental resources

Table 6.2: Key Factors that have affected the management of social and marine ecological resources of the lagoon. These are also key Factors affecting the social and marine ecological resources of the Sre Ambel lagoon in Cambodia.

Build resilience	Weaken resilience
Strong institutions (leadership and rule enforcement)	Breakdown of locally-devised institutions and authority system
Good cross-scale communication (co-management of scientific and local knowledge)	Rapid technological changes leading to more efficient resource exploitation
Political space for experimentation	Rapid changes in the local socio-economic system
Equity in resource access	Institutional instability at higher political levels negatively affecting local management
Use of (local people's) memory and knowledge as source of innovation and novelty	

Table 6.3: Major marine resource management problems affecting the lagoon

Problems	Regulatory/enforcement agencies	State agency	Stakeholders responsible	Most affected stakeholders
1. Use of illegal fishing gear and methods affecting marine fish stocks and triggering fisher conflicts 2. Motorized vessels in the lagoon 3. Garbage dumping along the shoreline 4. Sewage drainage into the Lagoon 5. Sand excavation 6. Large farm investment in agriculture with utilization of chemical fertilizers that damage sea water quality	1. Fishery administration agents with district policies 2. Local administration and local governmental sector 3. Commune Administration and district 4. Local governmental sectors 5. Local government sector 6. Provincial administration	1. Provincial level 2. District and Provincial level 3. District level 4. Provincial level 5. Provincial level and District level 6. Provincial level	1. Local fishers, outside fishers, medium fishers 2. Businessmen & medium scale fishers 3. All residents in the lagoons 4. Businessmen, port owners, industrial building 5. Sand port owner, 6. Farm owner, fishers	1. Full-time and part-time, local fisher 2. Fishers 3. Fishers, local residents, tourists 4. Fishers 5. Fishers (crabs and bivalve catch) 6. Fishers, local residents

Table 6.4: Results of Scaling Index

Preferences	Expectation to participate in lagoon management in the future (IEF)	Change in the existing management of the lagoon (ICS)	Satisfaction with the actions of co-management of the lagoon (IPS)	Satisfaction with the existing management of the lagoon (IPS)	Satisfaction with the establishment of a forum for conflict solution (IPS)	Index of Desired State of the proposed alternative affairs (IST)
Index of Perceived Satisfaction	0.79	0.79	0.69	0.32	0.75	0.77
Proportion (%)	76.6%	82.3%	61%	24%	84%	79.90%
Observations	n = 210	n=210	n=210	n=210	210	n=210

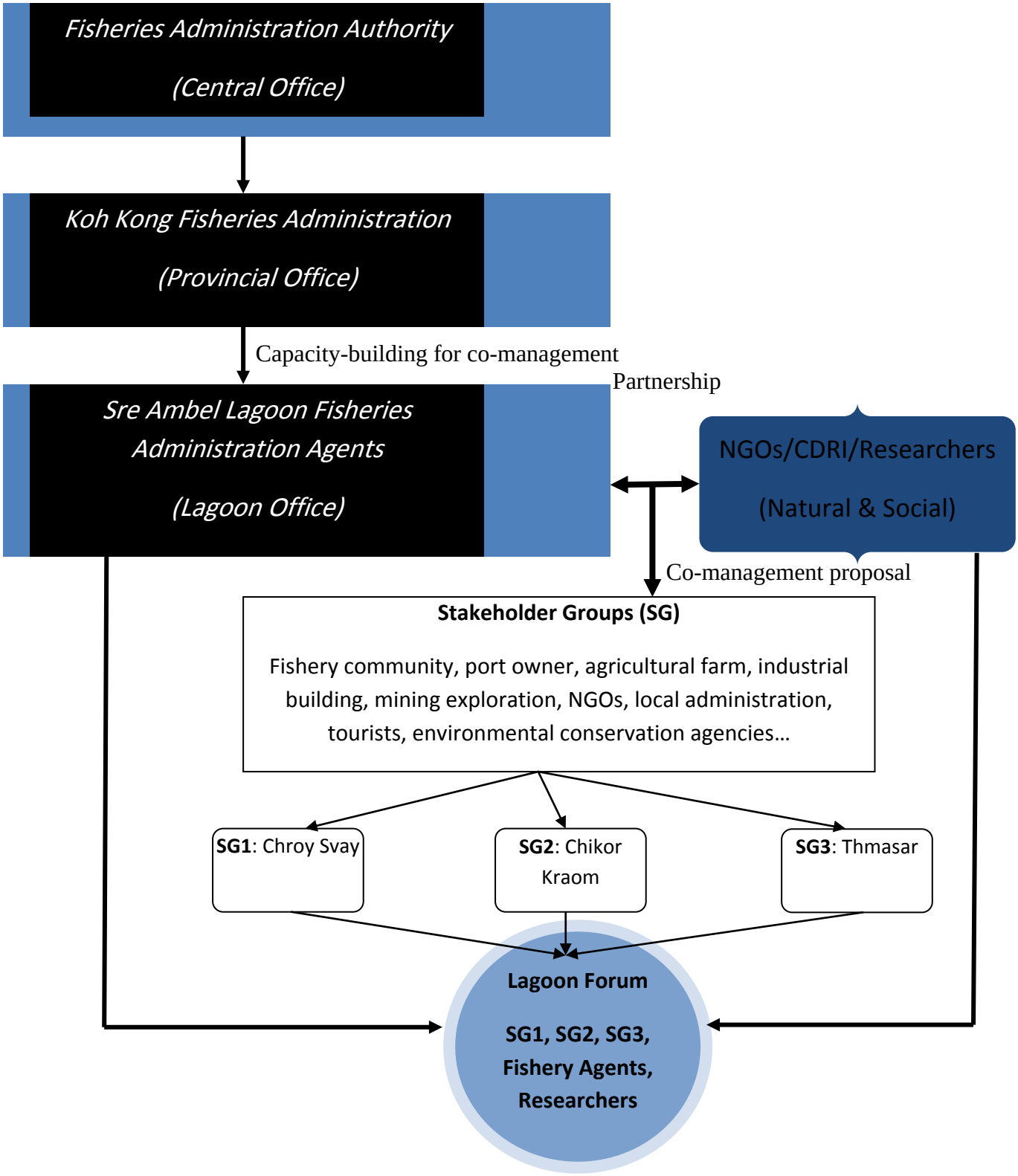

Fig. 6.2 Establishing the Sre Ambel Lagoon Co-Management Forum

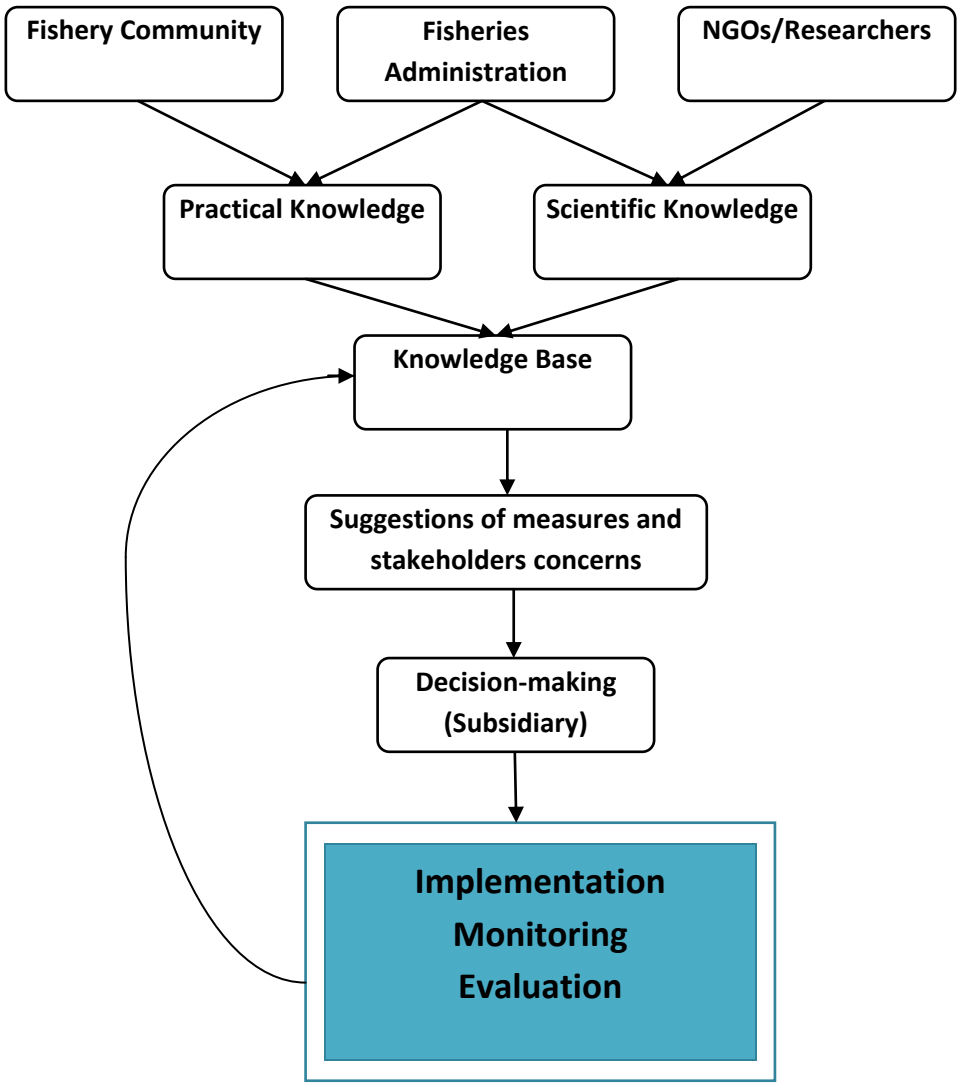

Fig. 6.3 Building a Knowledge Base for Co-Management

CHAPTER 7
A POLICY ALTERNATIVE FOR LAGOON MANAGEMENT

7.1 Introduction

There are numerous definitions for Marine Protected Areas (MPAs) that allow a wide range of coastal and marine areas to be categorized as MPAs. Terminology and understanding of what constitutes a Marine Protected Area depend mainly on the level of protection associated with them and the diverse interests of their various proponents. Accordingly, the main purposes of Marine Protected Areas (MPAs) vary with the interest of different interest groups:

- to protect a certain species
- restore depleted species
- to benefit fisheries management
- to protect full ecosystems,
- rare and/or critical habitat
- spawning and nursing grounds for fish
- to protect historical sites as shipwrecks and important cultural sites such as aboriginal fishing grounds

Thus, a wide variety of marine areas that are under some form of management and protection have been proposed and implemented in various parts of the world (NRC, 1999). Cambodia claims that it maintains the finest marine protected areas in Southeast Asia which harbour a rich wildlife (DoF, 2008). After decades of civil war, Cambodia established 23 protected areas in 1993 across the country to rehabilitate the natural environment. The national parks and the marine fish sanctuaries and reserves cover 43,000 km², roughly 23% of the country (MOE, 2002a). The main purpose of these wildlife reserves is to protect and restore a certain animal/plant species, a critical habitat, and an ecosystem, or to benefit fisheries through protecting spawning and nursing grounds or to manage an area as an extractive reserve (MOE, 2002b). Sre Ambel Lagoon, located in Southwestern Cambodia (Figure 7.1), is one of those marine extractive reserves which were established to conserve multiple use resources, particularly marine fish resources. However, limited awareness of the purpose of conservation and lack of alternative livelihood opportunities have resulted in continuation of the illegal resource extraction activities (ADB, 1999). The responsible management authorities have spent a considerable effort raising the ecological awareness among the local population (DoF, 2008) without much success.

There are several unanswered questions about the potential use of extractive reserves as effective MPAs. First, it is not clear what kind of extractive reserve instruments can be applied in Sre Ambel Lagoon. Second, how effectively can the extractive reserves model be used for marine fisheries conservation in Sre Ambel? Finally, to what extent can fishing communities in Sre Ambel Lagoon comply with fishing laws and regulations?

7.2 Research Objectives

To date, there has been little discussion of the Cambodian coastal management extractive reserves' potential as MPAs. To address these questions, it is necessary to introduce the concept of extractive reserves, then to present some cases of extractive reserves for marine fisheries conservation, and finally to address some issues and problems from these experiences. This chapter will explore the idea of extractive reserve as a policy alternative for the Sre Ambel area management system in a coastal area of Cambodia, and propose some policy instruments to manage this reserve. Finally, it will explore the ability of the fisheries' communities to apply rules and policies.

7.3 Theoretical Overview

The idea of extractive reserves was initially proposed during the 1970s and 1980s by the 'rubber tappers' or 'extractives men' social movements in the Brazilian Amazon as a way to promote social justice and environmental protection (Brown and Rosendo, 2000; Diegues 2001). It emerged in response to the development model for the Amazonian region proposed by the Brazilian government during the 1970s (Cunha, 2002). The government's development model was based on deforestation and expansion of cattle ranches into cleared areas to promote regional economic growth. This kind of 'development' displaced forest people, reduced biodiversity, and proved to be unsustainable (Barbira-Scazzochio, 1980; Fearnside, 1983; Diegues, 2001). The idea of extractive reserves, by contrast, was based on the sustainable use of forest products by local people (Diegues, 1993).

Extractive reserves are defined as "territorial spaces destined for self-sustained exploitation and conservation of renewable natural resources by extractivist populations". Thus, an extractive reserve is an area in which access to the marine fish resource is controlled. The local population has 'use rights' in the area, while entry by outsiders is regulated. Marine fish resource management is a joint effort between government and the local population. Local knowledge, rules, and institutions may be used in such management (Begossi, 1998).

What distinguishes extractive reserves from other types of conservation units, such as State and National Parks and Marine Protected Areas, is that the former are based on the use and conservation of resources, while the latter focus on the preservation of ecosystems. Extractive marine reserves are unique in that they contemplate the active involvement of fish resource users in the planning, implementation, monitoring, enforcement, and evaluation of management plans, and help ensure the permanence of extractive persons in their traditional areas (Cunha, 2002). Using extractive reserves as part of institutional environmental policy started in 1990. Since then, 16 extractive reserves have been created in the Amazon, and the establishment of 20 others is being considered (Cunha, 2002).

In addition to forest conservation, the idea of extractive reserves has also been applied to marine fish resource conservation. In 1992, the first marine extractive reserve was established in Latin America, on the coast of Brazil. Since then, five other marine extractive reserves have been created, and 34 other sites are being investigated by local administration agencies (Cunha, 2002).

The process of creating a marine extractive reserve is sometimes facilitated in cases where the reserve encompasses only ocean waters and coastal areas owned by the government, and no expenditure is needed to expropriate land. This, in fact, was the case of a reserve created to manage small-scale artisanal fisheries on the coast of Cambodia, as well as the case of another potential reserve in a nearby area (FAO, 1996).

The Chilean Fishing and Aquaculture Law of 1993 presented a concept similar to the Brazilian marine extractive reserves under the name "Management and Exploitation Areas (MEA)" (Castilla and Fernandez, 1998). These MEAs are reserved for small-scale (artisanal) fisheries only, and were created to resolve the conflict between artisanal and industrial fleets. Accordingly, the Chilean government confers exclusive fishing rights in defined areas to registered organizations (e.g., fishers' unions) or communities of artisanal fishers. A management plan for each MEA must be developed by the local fishers or their organizations and approved by the government. That is, this is a co-management arrangement as in the case of the Brazilian extractive reserves.

The effectiveness of MEAs as a conservation measure for marine policy is discussed by *Castilla and Fernandez* (1998). In their study, a comparison between an MEA and an open-access fishing ground showed that more benthic resources were captured inside the MEA, and that the mean catch per unit of effort (CPUE) was also higher inside the MEA. The authors call attention, however, to differences underlying the conscious values and concerns about conservation between resource users and scientists:

> *Of course, the [fishers'] main motivation to avoid overexploitation is to obtain the maximum revenue from the MEA, even if it implies perturbation of the system. One of the major problems we may face in the Chilean small-scale fishery is that although fishers have some idea of ecosystem functioning (through experience), their objectives are completely different from those of scientists. Fishers, if allowed, will try to modify the system in order to obtain the maximum revenue: for instance, the removal of predators of the target resource (p. 129).*

A similar argument is presented by Almeida (1994), who observes that some extractivists, such as rubber tappers, are not only driven by a conservation ethic, but also by economic opportunities which may lead them to violate such an ethic. This means that in elaborating a management plan for an extractive reserve, issues concerning the economic viability of such management must be addressed. Sustainable Livelihood Approach (SLA) is the approach which very strongly relates to reserve measures in marine resources conservation, particularly fish resource management and conservation. SLA has been applied in many areas of the world, particularly in coastal zone management.

Concerning the success of an extractive reserve as a conservation measure, Brown and Rosendo (2000, p. 36) point out that "the legal provisions for the establishment of extractive reserves have by no means guaranteed their effective implementation." A good example of this is presented by Pinho (2001), who analyzed the 10-year management history of a marine reserve in Brazil, and found several current problems. These include, among others, a lack of knowledge by extractivists about their rights to engage in decision-making and enforcement activities; a misrepresentation of users on the local decision-making association (the board of the association was filled only by part-time extractivists

instead of full-time extractivists); and lack of effective rule enforcement, which in turn created other problems such as pollution in the mangrove area and over-harvesting of some plant and animal species. That is, if sustainable management is to be achieved, the incorporation of the extractivists as *real* actors is essential (Castilla and Fernandez, 1998).

Appropriate fisheries management mechanism should be developed in conjunction with the institutional building exercises by of Community-Fisheries Management Organizations (CFMOs). The participatory mechanism as a tool of co management should be developed along line with the legal provisions at both central and local levels (SEAFDEC, 2008). Another key factor to achieving sustainability is the ability of resource users to learn from their experiences and to adapt the appropriate policy instruments for each scenario. The following sections address these and other key factors to sustainability by proposing the establishment of an extractive reserve for the Sre Ambel Lagoon management system in the coastal area of Cambodia.

7.4 Methods

Sre Ambel Lagoon is located in the Province of Koh Kong (pop. 33,000 in 1991) along the southern part of the Cambodian coast (Figure 7.1). This is a brackish water lagoon, intermittently connected to the sea by three open spaces. The lagoon has three basins and an area of approximately 15,000 hectares. Fish, crab, and shrimp are the main fishing resources, followed by molluscs and bivalves. The area consists of two fisheries communities, Chhroy Svay Fisheries Community and An Chha Eurt Fisheries Community.

Fig. 7.1 Sre Ambel Region

This paper uses both qualitative theoretical review of various papers and questionnaire responses from field interviews to achieve its objectives. Papers which describe extractive reserves for marine fish conservation were selected from international journals. Synthesis of the papers and field interviews was based on ***Situation Analysis***.

To explore the ability of the fisheries communities to observe the rules and policies, some indicators were selected from the field interviews:

- Fishers' education
- Awareness of legislation and fishing framework
- Awareness of trawl fishing gear use

- Ability to identify illegal fishing gear
- Ability to identify threatened fish species
- Degree of preferences for existing laws
- Ability to identify lagoon issues
- Ability to read and understand fishing laws, and
- Co-management in Sre Ambel Lagoon.

The research had also conduced local workshop to present the current data observation and find out local preferences on the management of lagoon. All 210 interviewers attended the workshop. Workshop addressed about mechanism of existing management style and the proposed extractive reserve in conjunction with their ability to apply laws and regulations. Quantitative data were computed by weight average index (WAI). This was required to score the question variables in accordance with the level of replies. Most data collected were indicated as ordinal data. Weight Average Index (WAI) is calculated based on the scoring and frequency of the respondents' replies. The WAI is the result of total weight divided by total frequency in each reply of variable (Table 7.1). The overall performance (OP) is judged in accordance with the value of WAI. For instance, a WAI value of by or less than 0.5 is poor (P) or even very poor (VP), while WAI values of 0.6 and 0.7 are average (A) and good (G) respectively. A value exceeding 0.7 is very good (VG).

SPSS Statistical frequencies were selected in the analysis of instrumental preferences of the new extractive reserve to manage the lagoon. There were several variables asked the respondents to show their preferences. Of which, they included all indications of the current laws and regulations.

7.5 Results

Owned by the public, the government has not imposed any effective measures to restrict access to its resources. Under this open-access regime, there are only few licensed fishers and many unlicensed fishers living in seven communities around the Sre Ambel Lagoon. Many of the fishers have local origins, including some indigenous people and some foreign citizens who arrived in the area about 10 to 20 years ago. Fishers from other communities and provinces or other parts of Koh Kong Province also frequently fish in this lagoon.

The Lagoon fisheries system has experienced several management cycles since the 1960s: it has gone from a community-based management regime during the 1960s to an open-access situation from 1980 to 1993, then to a co-management system between local fishers and the federal government during the 1999-2003 period, and finally, to a mix of state-property regime, communal-property regime, and open-access during the 2005-2009 period. The latest scenario is due to a lack of regulation enforcement, an increase in the number of outside fishers, and several conflicts caused by various activities interfering with the fishery system during the 2000s. Currently, there are various laws and regulations applying inside the lagoon; principle (principal as in main or principle as in guiding line of actions) fisheries law, management of community natural resources, local community fisheries regulations, procedures of conflict resolution, illegal fishing restrictions, and the

responsibilities of local fisheries communities in fisheries control. These policies and regulations were introduced by the central fisheries management in conjunction with state sectored institutions, and communities themselves. Below results shows fishers' knowledge to understand these existing laws and regulation is quite low.

Both ccommunities showed levels of understanding of existing guidelines and of general education is 0.5 to 0.6 respectively. Level of satisfaction with existing guidelines is poor (0.5). However, the majority of people have strong willingness to further discuss any new guidelines (Extractive Reserve) and strong willingness to propose workshops for an initiative of new guidelines, if established (Figure 7.2). If new guidelines are established, majority committed to deploy their valuable times for learning as well and applying. Therefore, they suggested strongly having a workshop for the establishment of the new extractive reserve in the area. Overall performance (OP) of proposed new extractive reserve workshop is 0.8 higher than the others. Furthermore, some perspectives of understanding of mangrove impacts, illegal fishing gear impacts, and period of fish spawn are also high, which over average of weighting index, except trawl gear that the overall performance is 0.5 (under average) (Figure 7.2). Statistically, the variable of willingness to propose new guidelines and satisfaction of existing guideline show not significant difference among the respondents at *p-value >0.05* (Table 7.1).

Qualitative data were observed from the respondents relevant to historical background of the lagoon and their perspectives on the new proposed extractive reserve. The history of lagoon fisheries management shows in two instances that *there is a demand to improve fisheries management by local fishers*. First, during the 1981-1994 periods, fishers organized themselves and demanded three different gear restrictions, which were approved by the Department of Fisheries (DoF) and helped to restore the Lagoon's stocks. Second, facing a lack of enforcement by provincial and central governments, local commune and district levels organized themselves into groups to patrol the Lagoon in 1995. However, this did not last long because fishers did not receive the legal support to continue. On several occasions, they called the commune councils and the communal police to stop illegal fishing, but to no avail. Moreover, monitoring groups were sometimes threatened with shotguns by fishers who used illegal gear. These two examples demonstrate that Sre Ambel fishers can and do engage in fisheries management of the new extractive reserve, and are able to work jointly with government officers – two key factors to establishing an extractive reserve. 95% of respondents claimed the existing policies and regulations do not work effectively because the lagoon is open-access which allow majority of outsiders to fish illegally. More than 75% of respondents in Chroy Svay Commune revealed that new extractive reserve must address ecological issues, marketing/economical constraints, and capacity building at both communities and lagoon level. Most respondents showed their abilities in local resources use which is a combination of scientific knowledge and practical knowledge for the local-base knowledge application. More than 90% of both communities (*p-value >0.05*) shows a common property regime is needed, that is for new extractive reserve for the whole resources use. The majority claimed also co-management mechanism is needed to process planning of the new extractive reserve. The top-five significantly important instruments were preferred by the local fishers. Of which, 41% of local fishers addressed instrument of user rights with restrictions of outsiders, 21% and 15.2% preferred to have enforcement of regulations and financial incentives under responsibility of the

government, while 11.4% addressed the need of mitigate mining explorations impacts and market/economic knowledge improvement (Figure 7.3).

Shrimp and Fish Market Behaviour in the late 1990s: Sre Ambel fish and shrimp are marketed locally, directly to consumers or through middlemen, while small fish, crab, and other fish are used mainly for subsistence family consumption. The relationship between supply and demand forces in the Sre Ambel market does not match the predictions of neoclassical economic theory. Sre Ambel shrimp demand is mainly determined by season-long need. Shrimp supply is highly dependent on its seasonal catch management, which in turn depends on rainfall and the movements of shrimp larvae and post-larvae in the Gulf of Thailand. Hence, the shrimp supply is subject to ecological uncertainties and shocks. Under these conditions, one would generally expect potential negative supply shocks to drive up the market price for a commodity. In this case, however, ecological uncertainties do not add economic value to the product; instead, they decrease shrimp prices and fishers' profits. This is probably because the Lagoon's shrimp market is dominated by only three middlemen, who usually pay less for shrimp than do retailers and restaurants. Because shrimp harvests may peak during the tourist off-season in cities and municipalities near Koh Kong, some fishers prefer to sell shrimp to middlemen for reduced prices during the tourist season to ensure that they will have buyers during the off-season, the period when tourism-related jobs decrease. If this is the case, then the dynamics between demand and supply in the Sre Ambel shrimp market can be viewed as operating to provide an "income-insurance mechanism".

Since prices increase as shrimp size increases, one might ask why fishers do not wait to capture large shrimp later in the season (i.e., avoid using small mesh nets). Doing so would generate more financial benefit and the added ecological benefit of increasing the chances that part of the adult shrimp stock would return to the Gulf of Thailand for reproduction. The problem is that lack of regulation enforcement (concerning how, where, and when to fish, and who is allowed to fish) makes the Lagoon a common property resource in an open-access situation. Individuals have privileges but no rights in using the resource (Bromley, 1989). Since most outsiders had no economic dependence on the Lagoon's resources, they had no economic incentives to use large mesh nets or to prevent overfishing. In the face of an open-access system where anyone holding a professional fishing license could fish, local fishers, both full-timers and part-timers, also had no social or economic incentive to use large meshes and prevent overfishing. In addition, there were also some profit-maximizing local fishers whose private interests dismissed all possible social goals, and whose implied rate of time preference was sufficiently high to shrink future earning streams from a sustained shrimp stock.

Hence, in order to increase the size (and price) of shrimp marketed and to avoid overfishing, new incentives and constraints are needed. A new institutional arrangement should provide fishers with signals that incorporate the costs of their fishing activities, such as a user fee of some sort. Indeed, a new arrangement could incorporate policies based on both property rights and market instruments.

Moreover, regional workshop following the completion of field research rose up some issues concerning the application of new extractive reserve. More than 90% of local

attendants explored big picture of extractive reserve policy for lagoon management, policy instruments, defining groups and use rights, and the way to implement a licensing system in the lagoon. They had also concerned about the administrative costs to run new projected guideline, enforceability, effectiveness, and policy adaptations to approach sustainability of lagoon.

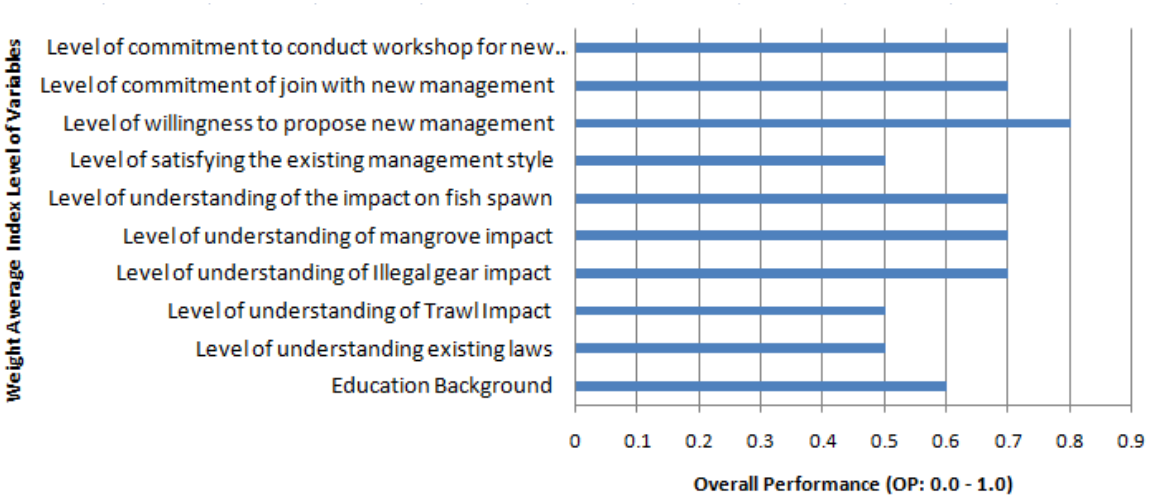

Fig. 7.2: Level of Satisfaction and Understanding of Laws and Regulations at Lagoon Level

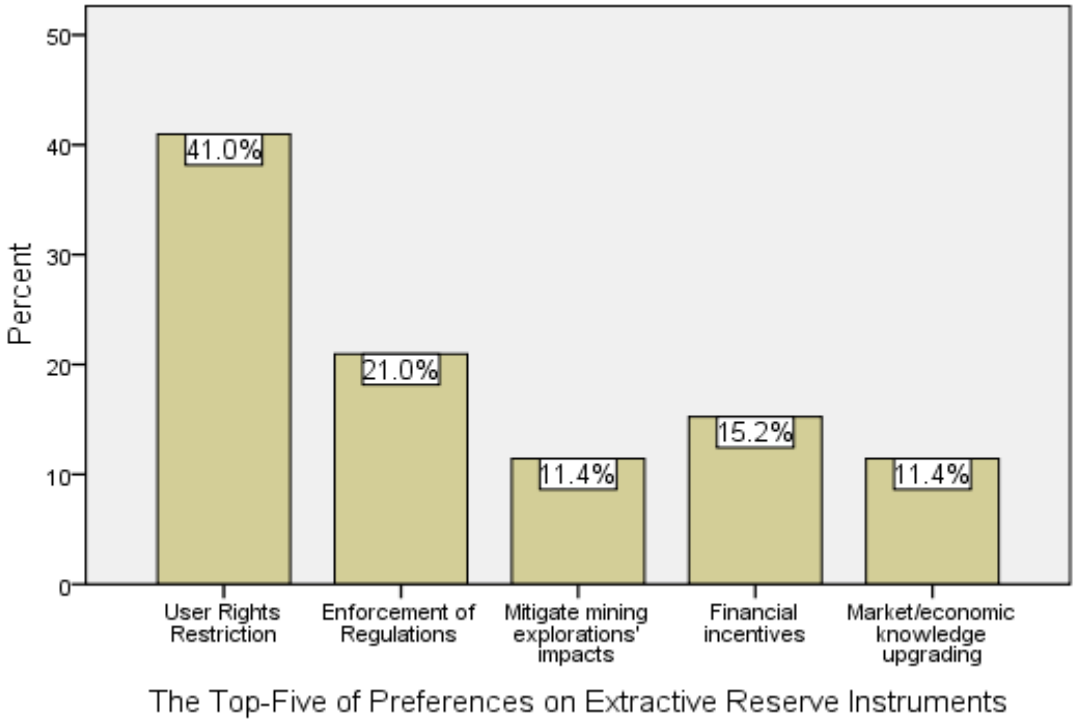

Fig. 7.3: Percentage of top-five preferences on the proposed new extractive reserve

7.6 Discussion

7.6.1 Ability of Community Fisheries to Apply Laws and Regulations

Existing policies and regulations do not currently function in the lagoon fisheries management. Regulations show very much relevance to centralization rather than empower the local fisheries communities to establish, manage, and control local resources. Because the community are not satisfied with the existing management style, they are reluctant to study and learn anything in the guidelines and other regulations. General education of the local people is sufficient to apply an appropriate law and regulation. Results show their abilities to identifying illegal fishing gears, they have strong purposes to engage, plan, and implementing any appropriate rules and regulations. It is an evident that community fisheries have strong willingness to establish new extractive reserve in the applicable way that will benefit them better than existing guidelines and regulations. The community desire to have common property regime to replace current open-access regime. The most appropriate management system of the lagoon is to increase access restrictions avoiding either local illegal fishing gears or outsiders on overexploitation. In establishing the new system capacity building should be considered to carry along the generality of the community for all-inclusive benefit. How can the new Extractive Reserve Policy work for Sre Ambel Lagoon?

7.6.2 Extractive Reserve Policy for Sre Ambel Lagoon

It is unlikely that the Lagoon system will ever approach sustainable use in an open-access situation (i.e., unrestricted number of fishers). This is because lack of access restrictions is a probable cause for overexploitation, even when 'how to fish' rules are appropriate and effectively enforced. Since the extractive reserve concept seems to be an appropriate instrument for marine conservation, and is relevant to part of the government's environmental policy, it seems feasible to create an extractive reserve at Sre Ambel Lagoon as a way to: (a) restrict the number of fishers with 'use rights', (b) seek better enforcement of regulations, and (c) mitigate mining explorations' negative impacts on the Lagoon. By creating an extractive reserve, the Sre Ambel Lagoon system may be transformed from an open-access situation into a common property regime, where 'use rights' are controlled by a fishery community and other parties (e.g., local administration agents) (Begossi, 1998). Indeed, extractive reserves provide a combination of common-property and state-property regimes (Begossi, 1998). In such a co-management arrangement, responsibility for resource management is shared by organizations of fishers and the government.

To develop and implement a management plan for the Sre Ambel Lagoon Extractive Reserve (SLER), a co-management forum could be created. This forum could serve as an arena for negotiation, joint problem-solving, and mutual learning among local fishers, government agencies, researchers, and other stakeholders. The co-management forum should address the major categories of policy instruments for sustainable fisheries management as presented. Since the majority (*OP=0.8*) of local people have willingness to change style of management, specific policy instruments that are discussed regarding the extractive reserve are addressed during the field work through local workshop. Potential issues in the design of this policy, such as administrative costs, enforceability,

effectiveness, distributional effects, and use of revenues, will also be addressed.

7.6.3 Major Categories of Policy Instruments

Jacobs (1993) outlines four classes of policy instrument for natural resource and environmental management: (1) regulations, (2) financial incentives (also known as market mechanisms), (3) voluntary mechanisms, and (4) government expenditures. In fisheries, *regulations* may encompass standards concerning 'where', 'when', and 'how' (technological standards) to fish as well as 'how much' to fish (e.g., fishing quotas). Monitoring, enforcement, and punishment (by fines or imprisonment) are imperative for the effectiveness of regulations. Acheson and Wilson (1996) argue that controlling 'how' people fish reduces information and enforcement costs relative to controlling 'how much' people fish.

Financial incentives use price mechanisms to obtain management goals. In fisheries, at least two types of financial incentive may be applied: resource depletion taxes and tradable permits (or their variant, licenses). By increasing the costs associated with resource use, taxes encourage less and more efficient use of the resource and its conservation. *A depletion tax* levied on the fishery harvest "is set at the rate which reduces extraction to the sustainable (or otherwise defined) level" (Jacobs 1993, p.139), though governing authorities may have to iteratively adjust the tax rate from year to year to approach this theoretical ideal. In a *tradable permit system*, the governing authority fixes the aggregate fishery harvest (presumably at the sustainable level), and then allocates rights to the aggregate harvest by issuing permits among fishers. Fishers can reallocate rights to portions of the harvest by buying and selling permits among themselves. Fishers who buy permits take on a cost associated with harvesting above the level represented by their initial permit allocation. The information needed to establish Total Allowable Catch (TAC) is quite costly, as is the monitoring and enforcement of the permit system. *A license* is a type of permit that may be tradable but which has no defined TAC attached to it. License prices may be used to exclude ineffective fishers from the system, thereby reducing the number of fishers. A comparison between two types of tradable permits, fishing quotas and fishing licenses, is presented in a following subsection.

Voluntary mechanisms cause "actions unenforced by law and un-persuaded by financial incentives, which individuals, groups and firms take to protect the environment" (Jacobs 1993, p.134). The most prevalent form of voluntary mechanisms is the provision of information, often in a persuasive manner, with the idea that economic agents will behave sustainably when informed about the effects of their behaviour. Another common form of voluntary mechanisms is the allocation of property rights to people close to a resource, in the hopes that they will then voluntarily manage the resource sustainably. In fisheries, voluntary mechanisms may include environmental education of resource users who may be interfering with or negatively affecting fishing activities and the ecosystem itself (e.g., aquatic sports performers and water polluters). Voluntary mechanisms may also appear in fisheries when 'ownership' and control of fisheries management is transferred to the local population, who "are likely to regard the environment as a source of long-term survival, which therefore needs protection" (Jacobs 1993, p.136).

***Government expenditure*s** are monies spent to manage resources in a sustainable way. In fisheries, government expenditures may include information costs to define TAC and appropriate regulations on 'how to fish,' enforcement costs, other management costs, and subsides for fishers to engage in alternative livelihoods. Government expenditures differ from regulations and financial incentives in that "the cost of environment protection is borne by the taxpaying community as a whole", while in the latter cases, the cost is borne by primary resource users (Jacobs 1993, p.137).

To design fisheries management policies, a combination of policy instruments is often needed to achieve the desired management goals. The appropriateness of each instrument will depend on the social-political context in which it will be implemented and on the goal(s) it will be expected to achieve. Of these four classes of policy instruments, this study focuses on regulations and financial incentives including licensing.

7.6.4 Policy Instruments to Manage the Lagoon's Fisheries

A co-management forum is one option for running the Sre Ambel Lagoon Extractive Reserve (SLER). Because any change in fishing regulations has to be approved by the Fisheries Administration (FA), the Forum may present the FA with more appropriate suggestions about how, where, and when to fish in the Lagoon. Decisions about how regulations can be enforced and about earmarking expenditures could be made by the Forum. That is, there will be a need for devolution of decision-making power from the central offices of FA to the Sre Ambel Lagoon Forum (which should have at least one FA officer). The Forum may also decide who may or may not fish (regulations), and at what 'price' (financial incentives). This will be further explored in the next section.

7.6.5 Defining Fisheries Groups and 'Use Rights'

Lagoon fishers can be classified according to their legitimacy (professional licensed fishers, sport licensed fishers, or unlicensed fishers), their dependence on fishing (full-timers, part-timers, or subsistence fishers) and their origins (locals or outsiders). Rights to use the SLER should be given only to local fishers holding a professional fishing license. Locals are likely to encompass all full-timers, most part-timers, some subsistence fishers, and very few, if any, recreational fishers. Indeed, the baseline differentiating local subsistence fishers (who fish for domestic consumption) from local sport fishers (who fish for entertainment) is very unclear; in both cases, fishers are forbidden to sell their catches. Based on the result of field interview, it is reasonable to include local subsistence fishers in the local sport licensed fishers category. Fishers from outside represent most sport fishers, licensed or not. Fishers from outside should not have usage rights to the SLER.

Basing use rights on a distinction between local fishers and fishers from outside requires defining 'local fisher'. To determine this, survey should be conducted in each of the seven communities to identify full-time, part-time, and sport fishers. To determine which of these fishers is local, the criterion may then be the testimony of three other local, non-relative fishers. Another criterion may be birth, or a minimum of ten years of residence in one of the seven communities, or marriage to a local person in the past five years. Of course, the specifics of the design must be defined by the Forum; the above are only

suggestions.

One important question about use rights is how they are to be transferred from one generation to another. While this decision rests with the Forum, some considerations are suggested here. Use rights should initially be vested in local individuals and may only be transferable to other local individuals with the Forum's approval. If all descendents of those who hold the first 'use rights' were eligible to inherit the same rights, the Lagoon system would again be overwhelmed by a large number of local fishers in a short time.
Based on the case of a Sri Lanka shrimp fishery (Amarashinghe et al., 1997), it is suggested that, to avoid this situation, each use rights holder be allowed to bequeath those use rights to only one descendent. In the absence of a descendent, the right of inheritance is automatically discontinued with the death of a fisher.

7.6.6 Implementing a licensing system

Although the SLER may limit the number of fishers with use rights, this may not be sufficient to ensure sustainable fishing. This section proposes a combination of regulations and financial incentives to achieve sustainability. In addition to these, two other policy instruments may be used to manage the SLER. First, the transfer of control of resources, at least in part, to the local population, is expected to induce local users to voluntarily conserve those resources, as they are likely to see the long-term benefits of doing so. Second, government expenditures should occur, especially to build ability, in the process of creating a Forum to manage the SLER.

By only awarding use rights to local fishers, the extractive reserve will limit the number of fishers, but the reduced number may still represent a very large fishing effort for the size of the Lagoon and its stocks. One way to solve this problem is by further limiting the number of fishers through a licensing system specific to the SLER. In the proposed SLER licensing system any fisher must *buy a* SLER fishing license to fish in the Lagoon. That is, holding a right of use is necessary but not sufficient to permit someone to fish in the Lagoon; local fishers with use rights must still buy a license to legally fish in the Lagoon, but under their use rights designation they will be guaranteed a license (provided they pay for it). License prices and purchase eligibility criteria can restrict the number of fishers using the Lagoon, and license prices can fluctuate annually according to resource conditions and environmental and market uncertainties.

There could be two types of fishing licenses in the SLER licensing system: annual fishing licenses and daily fishing licenses. Fishers holding an annual license may be allowed to fish for shrimp, mullet, crab or other species. Daily licenses, on the other hand, may be specific for each species and priced accordingly. In the first attempt to restrict fisher numbers, the system may account for both fishers with use rights and fishers with no use rights. That is, outsiders would still be allowed to purchase any leftover daily licenses to fish at the Lagoon. However, only local fishers would be allowed to buy annual licenses. Additionally, outsiders would pay higher prices than local fishers for daily licenses. (The higher payment works to incorporate the dynamic costs of fishing activity into outsiders' decision about whether to fish).

The proposed SLER licensing system may work to accomplish sustainability goals. The fact that fishers can be charged a significant price to fish (instead of fishing for free (except for their equipment and time costs)) leads us to believe that only those who can profit from fishing or who are willing to pay for entertainment would buy a license. Inefficient commercial fishers (i.e., full-timers and part-timers) who could not profit from fishing after paying the license fee would probably not enter the system. Commercial fishers holding annual licenses would have an incentive to wait and fish for large (high-priced) shrimp, crab or bivalves instead of catching small individuals early in the season. Moreover, commercial fishers (either locals or outsiders) who bought daily licenses would probably risk fishing only after being convinced that large (high priced) individuals were present in the Lagoon. Thus, capturing small individuals could be reduced by this licensing system. However, recreational fishers might still fish for small individuals as they have no economic incentive to fish for large individuals.

Based on the above discussion, the pricing of different types of licenses could follow certain principles. First, prices could be tied to target species. Daily licenses for each target species (shrimp, fish, or crab) could reflect market prices for these species. Second, pricing could be fair. Daily licenses could be accessible to local subsistence fishers, and annual licenses should ensure fishers enough profits to maintain their livelihoods. Third, prices could discriminate between locals and outsiders. Daily licenses for locals (who hold use rights) should be cheaper than for outsiders. Fourth, prices could vary with resource conditions. License prices in one year may be higher or lower than the year before based on monitoring of Lagoon stocks in the year before (see below). Fifth, prices could account for environmental and market uncertainties. Part of a license price could be a type of insurance against a year of very low production or of very low market prices. This is further explained in the section on earmarking license revenues.

An alternative way of limiting fishing effort in the SLER may be the establishment of an annual or seasonal total allowable catch (TAC), which could then be implemented through the allocation of fishing quotas such as Individual Transferable Quotas (ITQs) among fishers. ITQ is a type of tradable permit that specifies catch amounts and may, according to Hartwick and Olewiler (1998), lead to an optimal amount of effort and harvest.

However, the licensing system, proposed here, is more appropriate to Sre Ambel Lagoon than the often-advocated ITQ system because ITQs must be established based on a TAC. Determining TAC for Sre Ambel Lagoon is not feasible due to three factors. First, the Lagoon's production is highly dependent on environmental factors and season opening; hence, there is a high degree of uncertainty in each season – the TAC could vary widely from season to season, and it would be impossible to know this (at a reasonable cost level) in time to set the TAC each season. Second, as most of the Lagoon margins are easily accessible to anyone, surveying all fisher landings would be difficult, thus making monitoring and enforcement of an ITQ system overly costly. Third, because many fishers sell shrimp directly to consumers, estimating the Lagoon's total production from middlemen's booklets is inaccurate. These last two factors also make a resource depletion tax inappropriate for maintaining the Lagoon resource at a sustainable level.

7.6.7 Potential Issues Concerning the SLER Policy

In designing any policy, some issues must be discussed. The remainder of this section addresses issues relating to administrative costs, enforceability, effectiveness, adaptations to approach sustainability, distributional effects, and use of revenues at the SLER.

7.6.8 Administrative Costs

The administrative costs for managing the SLER will probably be high at first because of the costs of establishing the co-management Forum. However, after a while, if the policy is well designed, the system may be financially self-sustaining. That is, revenues from selling licenses and charging fees to transgressors may be able to cover all administrative costs. Initial costs for setting up a Forum may include costs related to building the ability of both government and non-government personnel (including fishers), administrative infrastructure (including physical space and technological resources), and preliminary research to define who are the local fishers and other major stakeholders. Government expenditures could be used for these purposes. Annual administrative costs would encompass costs of resource monitoring and other information gathering to decide upon license prices and policy design from year to year, costs of regulation enforcement, and costs of running the Forum and its meetings.

7.6.9 Enforceability

The proposed policy design is based mainly on two instruments: fisheries regulation and a licensing system. Enforcement of regulations concerning 'how to fish' and 'who is allowed to fish' is one of the first problems the Forum might have to deal with. Heavy penalties for transgressors, including stiff fines and imprisonment, already exist in the case of regulations concerning 'how to fish' (DoF, 2006). The problem to date has been a lack of resources and personnel to enforce them. One possible solution to this problem may be achieved by creating two fishery inspector positions for the SLER. Inspectors should be familiar with the region and its fisheries problems. They should gain legitimacy through their official ties to the competent, local authority (the Forum). This would make enforcement more effective. It will be essential to pay inspectors adequately to remove any temptations they may face to accept payoffs for not reporting or penalizing transgressors. In addition to controlling 'how to fish', inspectors may also control 'who is allowed to fish' and penalties to transgressors can be stipulated concerning the licensing system.

7.6.10 Effectiveness

Although result shows high commitment of local fishers to participate with the new policies (OP=0.7), guidelines, to assess the effectiveness of policy design, some criteria should be defined *a priori*. For instance, to adjust license prices accordingly over time, what will be considered as a sustainable level of resource use? Because monitoring fishing efforts and assessing stocks in the Lagoon are not feasible (as explained earlier), a workable solution might be to ensure that enough stock exits the Lagoon at the end of a harvest season to generate offspring that will return to the Lagoon. It is clear that some research

will have to be undertaken to calculate the amount of stock. Monitoring this criterion seems feasible; for example, data collection may take place in the channel connecting the Lagoon to the ocean during the first five days after channel opening (the period when most shrimp and fish leave the Lagoon). Of course, the Forum may devise other criteria.

7.6.11 Policy Adaptations to Approach Sustainability

The local fishers understand well the impacts of mangrove, illegal fishing gear, except trawl, and the period of fish spawn. Furthermore they should be offered trainings on the operation of license system, and the benefit of license system at lagoon level. The persistence of overfishing after the first year of management would indicate that the number of licenses issued was too large (i.e., their prices were too low) or that regulations were inadequate (e.g., mesh size of nets were too small), and that fishing in the Lagoon needs to be further reduced. One way to reduce fishing is to increase license prices for the next season. At higher prices, fewer fishers will be willing to pay for licenses; that is, only very efficient or wealthy fishers will buy licenses.

A second way to further reduce effort is to decrease the number of annual licenses available in each year, and the number of daily licenses available for locals and for outsiders in each month. Moreover, daily licenses for outsiders may not be available during certain months because local fishers have priority in fishing at the SLER. Limiting the number of licenses available demands an auction scheme in which fishers can bid for a license. All annual licenses could be sold at once and daily licenses could be sold monthly in two steps: first local fishers apply for licenses, and then outsiders can apply for any remaining licenses. In all cases, licenses should have a minimum price, but the price paid by a fisher will depend on the number of fishers entering the competition and on each fisher's confidence in his ability to profit or on how much he is willing to pay for entertainment. Again, this mechanism is likely to exclude inefficient fishers from the system (see the shrimp fishery case at a Sri Lankan estuary presented by Amarashinghe et al. 1997).

A third way to reduce fishing effort is changing fisheries regulations on how, where, and when to fish. For instance, fishing seasons may be shortened. Shrimp fishing may only be allowed two months after closing period, which is the minimum time needed for shrimp to grow from post-larvae to young adult. Fish harvests may only be allowed during closed channel seasons, as the practices used in this fishery may repel fish back into the ocean during open channel season. In proposing new fisheries regulations, both fishers' ecological knowledge and scientific knowledge may be used.

7.6.12 Distributional Effects

The capacity of local people in the lagoon is likely suitable enough to share equal benefits among beneficiaries. Therefore, they indicated strongly their perceptions on the new system application. Even thought majority of local people propose a new strong extractive reserve, but they should think about the distribution of effects from the system. What are the probable distributional effects of the proposed policy design? Charles (1988, 281) reviews some critiques of limited entry regulatory mechanisms in fisheries and points

out that "there may be losses as well as gains from limited-entry programs" concerning their social consequences. It is clear that some people's well-being will decline when implementing an extractive reserve, but the cumulative decline may be at least compensated for by the corresponding cumulative welfare gains received by other people. For example, some local fishers may directly benefit from this management approach through increased incomes, while other local residents, tourists, and fishers from outside may indirectly benefit from it through the improved long-term ecological sustainability of the Lagoon. In the case of Sre Ambel Lagoon, it is likely fishers from outside are the ones whose well-being will decrease. The majority of fishers from outside do not make their living from fishing (i.e., recreational fishers) and are often wealthier than full- and part-time local fishers. Therefore, though more socio-economic research needs to be conducted on the distributional effects, it is expected that limiting access to the Lagoon in the proposed manner will improve local fishers' well-being without decreasing the welfare of fishers from outside by an amount that is harmful and thus unfair.

If the minimum license prices, established by the Forum, are constantly increased in order to reduce fishing effort, they might reach a price that only relatively wealthy fishers are able to pay, excluding local, subsistence, and commercial fishers who depend on fishing from the system. In this case, the management system will flip from a market-oriented shrimp fishery to a consumption-oriented fishery. The Forum then could direct revenues from fishing license sales toward finding alternative livelihoods for those local fishers who are highly dependent on fishing.

To avoid such a flip in the fishery system, restriction of licenses issued and a bid mechanism is proposed above. The distributional effect of this new design in comparison to the extractive reserve alone is not quite clear. As licenses will be limited, fewer local fishers will directly benefit from the system; however, the same number of local and outside people will indirectly benefit from the sustainable use of the Lagoon. Fishers from outside are likely to lose even more well-being in this new design. However, what the new design offers is a better chance of increasing the well-being of future generations by ensuring sustainable resource use, without decreasing the welfare of the present generation to an amount that may threaten people's livelihood.

7.6.13 Use of Revenues

Since the abilities of local farmers are above moderate of education background (Table 1), there will be most effective way to operate revenue systems. Revenue from selling fishing licenses and from charging regulation infraction fees could be earmarked to improve both Lagoon management and local fisher welfare. For instance, it could be used to fund the Forum's administration, pay fishery inspectors, and monitor resource use. Part of this revenue could be used as a form of insurance against environmental and market uncertainties, by providing small loans to full-time fishers during shrimp and fish off-seasons. This would reduce their dependence on middlemen and give them the freedom to trade their product for the best prices year-round. License sales revenues may also be used to investigate economic alternatives for fishers who reduce their fishing in and therefore their income from, the Lagoon (as in the case of San Miguel Bay in Philippines). In addition, license sales revenues may be used to investigate potential markets for the

Lagoon's other fish and crabs.

7.7 Conclusions

The level of education of the community is above moderate; therefore the community are able to understand regulations and guidelines. However, they are not satisfied with existing guidelines and regulations. For this reason, are the willingness of local people is very strong to propose new style of management of extractive reserve. According to their experiences, common property regime of resources management is very much appreciated by all local people. *Can the extractive reserves model be used for marine fish conservation*? This paper has shown that the extractive reserves concept, by definition, restricts the number of resource users and may help implement policies leading to sustainability. The implementation of an extractive reserve, however, is insufficient to guarantee its sustainability. Several policy instruments must be used jointly to achieve such a goal.

In the case of Sre Ambel Lagoon, this paper discusses an alternative policy consisting of the establishment of an extractive reserve to restrict the number of fishers and a combination of regulations and a licensing system to operate such a reserve. The reasons for using licenses to regulate the number of fishers and to improve management are that license prices can exclude inefficient fishers, can account for resource conditions as well as environmental and market uncertainties, and can generate revenues that can be used to improve management, and to improve the living standards of fishers. The licensing system is a complement, and not a substitute, for other management regulations concerning how, when, and where to fish.

Although there is no optimal management alternative, the best alternative is developed collaboratively among all stakeholders in a way that incorporates all, or at least most, of the Lisbon principles (Constanza et al., 1998). These are: participation, responsibility, scale-matching, precautionary, adaptive management, and full-cost allocation. Specifically, a highly representative Forum with management rights should be created.

Finally, unless government supports local actions, by creating political space for experimentation, and provides legal mechanisms for access restriction, Sre Ambel Lagoon will never approach sustainability.

Table 7.1: Weighting Average Index (WAI), ability of fishers to apply guidelines and regulations in Sre Ambel Lagoon

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Target Area	Community Fisheries, Sre Ambel Lagoon																			
Overall Performance	Very Poor			Just Poor			Average			Good			Very Good			Total weight	frequency	WAI	OP	t-test
Variables	score	F	weight	score	F	weight	score	F	weight	score	F	weight	score	F	weight					
Education background to apply guidelines	0.2	11	2.2	0.4	27	10.8	0.6	33	19.8	0.8	3	2.4	1	16	16	51.2	90	***0.6***	A	0.010
Ability to understand guideline	0	0	0	0.33	45	14.85	0.66	18	11.88	1	7	7	0	0	0	33.73	70	***0.5***	P	0.000
Ability to understand trawl fishing gear	0	0	0	0.33	69	22.77	0.66	46	30.36	1	5	5	0	0	0	58.13	120	***0.5***	P	0.000
Ability to understand illegal fishing gear	0	0	0	0.33	43	14.19	0.66	31	20.46	1	46	46	0	0	0	80.65	120	***0.7***	G	0.003
Ability to understand mangrove protection	0	0	0	0.33	29	9.57	0.66	47	31.02	1	44	44	0	0	0	84.59	120	***0.7***	G	0.000
Ability to understand fish spawning period	0	0	0	0.33	29	9.57	0.66	47	31.02	1	44	44	0	0	0	84.59	120	***0.7***	G	0.000
Level of satisfaction with existing guidelines	0.25	43	10.75	0.5	49	24.5	0.75	22	16.5	1	6	6			0	57.75	120	***0.5***	P	0.207
Level of Satisfaction to propose new guideline	0.2	1	0.2	0.4	18	7.2	0.6	20	12	0.8	42	33.6	1	49	49	102	130	***0.8***	G	0.052
Level of agreement that they have sufficient time to learn guidelines	0	0	0	0.33	9	2.97	0.66	75	49.5	1	36	36	0	0	0	88.47	120	***0.7***	G	0.000
Level of agreement with suggestions for year-end guideline refresher workshop	0	0	0	0.33	8	2.64	0.66	81	53.46	1	31	31	0	0	0	87.1	120	***0.7***	G	0.000

Remark: F – Frequency, OP – Overal Performance, VP – Very Poor, P – Just Poor, A – Average, G – Good, VG – Every Good

CHAPTER 8
SUMMARY, CONCLUSION AND RECOMMENDATIONS

8.1 Summary

This dissertation is a study of the marine fisheries assessment in a common-pool resource management system and the linkages between factors affecting fish decline and the current management aspects of such a system in order to contribute to the efforts for sustainable natural resources and environmental management. The study focused on the history of the Sre Ambel Lagoon management system in Cambodia. In particular, we addressed five major issues in this research including: (a) the significance of local knowledge for participatory management; (b) the key factors that build or threaten the marine resources degradation in the lagoon; (c) the evolution of socioeconomics growth in the area; (d) some possible solutions for stakeholder conflicts across policy levels; and (e) the use of extractive reserves model for marine conservation.

Two types of fishing were dominated in the area; small scale and medium scale. But majority of fishing are small scale. For those fishers who have high general education and experieces can catch much more than those who have less experiences and low education. The medium length of fishing boat is about ten meters long. It is also functional with the volume of catch as well. Although trawl is banned to fish in the area, they were still found, especially fishing in the depth fishing ground. This perhaps can cause the decline of fish catch as well. However, fish decline is the result of the decline from fishing trip in the area. Fishers dropped their amount of fishing trips per season due to high cost of fuel. Moreover, sand excavation is the activity affecting lagoon's morphology and changing depth of water which cause the decrease of individual family fish catch.

Socioeconomics growth does not provide better result for the area, in term of lagoon conservation, but large scale fishers put their fishing efforts to maximize the catch to support the demand. Restaurants, markets, industries, and tourism are quickly increased with the increase of food demand, specially shrimp and other valuable fishes. This case, is the result in the increase of large scale suppliers (large scale fishers).

This chapter summarizes the key concluding points of each of the five main chapters in order to present the major theoretical, methodological and policy contributions of this dissertation to literature.

Which incentives and constraints have affected the development of the marine resources system?
That is, what is the socioeconomics of the area?

Chapter IV investigates the socioeconomics of Sre Ambel communities. This study shows several feedback interactions between the socio-economic system and the marine system. The local socio-economic system can be intensively influenced by (a) the values and ideas brought by outsiders (e.g., changes in market institutions, decrease of social sanctions, and disruption of social life), and (b) the new economic opportunities that

outsiders create. In addition, fluctuations in resource availability and in resource markets may also influence socio-economic institutions. For example, the existence of middlemen in the Sre Ambel shrimp market provides an "income-insurance mechanism" for fishers in the face of ecological uncertainties and the dynamics between demand and supply in this market. Socio-economic incentives and constraints may affect resource management systems in several ways. First, an increase in market demand for fishing products may lead to species by-catching (which may cause ecosystem disruption) and to an unsustainable use of resources because it may prioritize fishers' private interests (i.e., profit-maximization) to the detriment of social goals (sustainability). Second, a community's infrastructure improvements and development projects, if not well planned, may result in ecosystem degradation, increased pressure on resources, and conflict of interests between locals and outsiders. Therefore, all the socio-economic and ecological benefits and costs of any development intervention must be investigated a priori. Third, technological innovations may have either a positive or a negative effect in resource management. Technological innovations may promote unfair resource distribution, as it may not be affordable by all users. Alternatively, technological restrictions may promote a more just resource distribution. Technological innovations may likewise result in a more efficient resource use, but if not properly used, they may cause over-harvesting and ecosystem disruption.

What are the key factors that help build social-ecological resilience in the lagoon management structure, and what are the key factors that threaten it?

Factors affecting fish decline is human illegal activities and the extensive use of fertilizers in agriculture, increase of raw materials at the market, and the decline of family fishing trips per year.

The Sre Ambel Lagoon case study demonstrates that it is possible to analyze the dynamics of integrated social-ecological systems. Chapter V reveals that although the cycles of changes in the social system and the ecological system may occur at different places, they are intimately related to one another and feedback interactions can be clearly observed. Management practices concerning the release and renewal phases of ecosystem dynamics may trigger critical marine resources processes. For example, practices that produce small-scale disturbances may help prevent larger-scale disturbances later. This is the case with some of the Sre Ambel Lagoon management practices based on local knowledge. These practices help to avoid ecological surprises, performing as insurance mechanisms for maintaining the Lagoon biodiversity. In addition, four key factors that weaken resilience were detected. They include: the breakdown of local institutions, rapid technological change, rapid socio-economic change, and institutional instability across political scales. Other comparative studies would probably come up with other factors. Although we attempt to analyze the resilience of the marine resources system according to the property regime under which it was managed, resilience may be viewed in a longer time scale as the ability of a system to turn successive resource crises into opportunities for a new round of institutional renewal. This is the case of the Sre Ambel Lagoon management system in the past four decades.

What policies across organizational scales may help solve stakeholder conflicts over resource use?

Chapter VI demonstrates that institutional instability at higher political levels, the great diversity of ineffective management agencies, and the lack of coordination among government agencies from different levels and sectors result in stakeholder conflicts, environmental degradation and resource overexploitation at the Sre Ambel Lagoon and its surrounding areas. These stakeholder conflicts reflect: a divergence in management goals; a degree of dependence on resources; disagreement about fishing rights and resource allocation; a lack of personnel and equipment resources to enforce regulations; a mismatch in the scale of problems and the scale of regulatory and enforcement agencies; the lack of empowerment of fishers and local councils; and different understandings of Lagoon ecosystem dynamics between government managers and local fishers.

To overcome management problems and stakeholder conflicts the establishment of a Sre Ambel Lagoon Management Forum is suggested. This Forum could address stakeholder concerns and conflicts, and build a knowledge base upon which management decisions could be made through a co-management process. This knowledge base could bridge user concerns and knowledge with manager concerns and knowledge. Details about this co-management process are presented in Chapter VI. The key idea of such a Forum is to present and discuss knowledge and the values and concerns of users, other stakeholders, managers and scientists so that conflict resolution can be based on a common understanding of environmental and management problems. Of course, conflict management has many other aspects, but if a common knowledge base can be built, this may help to solve or manage conflicts more effectively. As well, resource governance has several aspects.

The proposed co-management Forum is only one possible way that new lagoon governance may be conceived and structured. Effective co-management arises from negotiation, joint problem-solving and mutual learning (e.g., Kendrick 2000, Blann et al. 2002) when political space for experimentation is created. Simply having a structure or arrangement is no guarantee of effective co-management. Rather, co-management may be seen as an interactive process, a "tango" (Pomeroy and Berkes 1991). The dynamics of institutions across scales in distinct periods of time may create different political spaces, which lead to different management arrangements.

What is the significance of local knowledge in participatory management?
Is it useful in designing, assessing and implementing management plans?

Chapter VII shows that local knowledge may play an important role in designing, implementing and assessing adaptive management plans. This is not to say that local knowledge can replace scientific knowledge in adaptive management; they should be complementary. Indeed, this case study shows that the effective fishing regulations implemented were based on the co-management of local and scientific knowledge.

Local knowledge has several aspects. Local resource users may provide a valuable set of information about ecosystem dynamics and the resources they use (e.g., species diversity, species life cycles, species interactions, and environmental factors affecting species development). Moreover, local management practices may provide insightful information about the concerns, values, and ethics of resource users. Understanding local social values and ethics is necessary before proposing official regulations in order to

increase compliance. This case study indicates that when user knowledge and concerns are incorporated into official regulations, these regulations are more likely to succeed.

Local management practices may serve different purposes. Not all practices may promote conservation. For instance, some practices may serve to minimize conflicts among users or optimize catches. It is worth noting that some practices that may promote conservation in the eyes of local resource users may not be seen as conservation measures in the eyes of many western-trained researchers. This happens because the two groups may have a different understanding of both the resources and the ecosystem dynamics. In these cases, a close investigation of the marine resources benefits (and costs) of each measure is recommended.

Resource users are not a homogenous group nor are the local knowledge they provide. Moreover, local knowledge is not a static set of information. It is constantly reshaped by the users' own experiences and by scientific information and practices brought to them by government agents, researchers, or even by local individuals who are more interested in scientific approaches. Hence, it is difficult to separate knowledge gained through experience and information acquired from outsiders.

Just as local knowledge is reshaped, local management practices also tend to be reshaped to adjust to new management demands. One important contribution of this research is to show that both user knowledge and local management practices can, and do, usually adapt in response to crises or the perception of crises. Hence, they may serve as an important source of information for participatory adaptive management.

8.2 Conclusions

The major cause of the decline in fish resources is the inadequate lagoon fisheries management due to the lack of an appropriate extractive reserve and weak law enforcement. Even though fishers have enough capacity to comply with laws and regulations, but they do not comply and even try to understand the laws and regulations because they are not satisfied with all introduced laws and regulations. Non-compliance with laws and regulations and wrong engagement of the local governmental officers, especially local police administration officials, commune administration officials have caused the degradation of natural resources in the area, particularly marine fish resources.

There are two major factors affecting the decline of marine fish, which are external and internal factors. External factors consist of sand excavation, foreign vessels fishing in the local fishing ground, and intensive farming systems which pollute water quality due to chemical fertilizers utilization. Internal factors involve with management style, illegal fishing gears being used in the lagoon, compliance of individual fishers on laws and regulations, and decreasing number of fishing trips due to cost of raw materials and fuel.

Current laws and regulations do not effectively work in controlling lagoon's resources, while people who execute these laws and regulations are committing illegally such as patroller, policemen, and fisheries administration officials. Replacing the current laws and regulations with adaptive measures was strongly suggested by the majority of

fishers including some stakeholders as well. However, lessons learned from the previous experiences and from other countries of the world show that lagoon system required proper management measures through an appropriate extractive reserve and well-function institutions as introduced in Chapter 7. Workshop of new proposed management style of common property use regime has been participated with all stakeholders and landslide support with these new ideas for marine resources conservation. Officials of central government showed their satisfaction on this establishment and it would be best, if the top key policy-makers from the governmental side bring them into consideration for future policy establishment and other proclamation.

8.3 Recommendations

Alternative Policy for Lagoon Management: The government shall adopt this new policy and management style for the whole marine resources management. The government staff and focal points should read and familiar with all elements of the proposed mechanism and share this context to the grassroots for further joint cooperation. All stakeholders which include non-governmental organization should get involved with the new proposed management and help the communities to take actions swiftly.

Establishment of Local-Base Knowledge for Lagoon Management: This paper has identified some major gaps in scientific knowledge that could help solve the problems concerning marine fisheries resources. This highlights the importance of initiating collaborative researches in the Sre Ambel Lagoon in Cambodia. Areas of specific importance are reproductive biology, population dynamics, and ecology of commercial fish species. In addition, quantitative studies of benthic and pelagic invertebrates, which constitute food for commercial fish species, should be given high priority. The recommendation is that the government should subsidize the resources and willingness to create one effective-local base knowledge for the future marine conservation in the area.

Monitoring and Patrolling: Fish resource trawling and seining should be conducted at regular intervals to assess CPUE for commercially important species. Where possible, this should be carried out in collaboration with Thai, Vietnamese, and regional fisheries research institutions. A regular monitoring program should be established to check water quality parameters, hydrograph, phytoplankton production, and zooplankton biomass. In order to carry out all these activities, a marine research facility should be established in the coastal area of Cambodia.

The DoF needs to change the recording system for official fisheries statistics. Records of catches need to be separated according to species (for the most abundant ones) or groups of species. In addition, the value for each of these categories needs to be recorded.

The DoF should also allocate qualified technical staff with specific responsibilities for the marine fisheries sector. Problems and issues within this sector differ from those of the freshwater fisheries sector, and with the current staff rotation system, knowledge gained by some staff members “disappears” when they are promoted to other duties.

Management measures should be implemented to conserve endangered species, and protocols should be established for the handling of accidentally captured cetaceans, dugongs and sea turtles.

UNEP & GEF should assist Cambodia's DoF in creating and implementing marine fisheries sanctuaries (MFS). The institutional overlap mentioned above should be resolved. There is a National Steering Committee for Coastal Zone Management, but so far, this committee has not addressed this problem.

Capacity Build Up: The educational level of fishers and their families is typically low. It is important that information about marine ecosystems and biodiversity be disseminated to these people. Increased community participation in fisheries management requires that stakeholders make informed decisions, and this is only possible if the stakeholders have all the available information. Due to the prevalence of illiteracy among subsistence fishers, all information should be given as visual presentations, such as videos. Fishers should also be offered training about boat handling, safety, and navigation. It is important that the educational level of the staff of the provincial fisheries offices be improved. Junior staff with reasonable English skills can receive formal training abroad if scholarships are available. However, senior staff members often have little or no command of English, and will need to be trained locally. Special training should be given to technical staff in connection with implementation of a monitoring program, for handling accidental catches of endangered species and other special issues. There is also an urgent need to change the catch recording system in order to ensure the reliability of fisheries statistics. This will probably require international assistance as well as special training of technical staff, especially in the provincial offices and the Marine Fisheries Inspection Unit.

Join-Collaboration Measure: As overfishing is already rampant in Cambodian waters, measures should be taken to regulate catches. This can be done through the implementation of closed periods, during which fishing is prohibited, closed areas ("no-take zones"), or regulation of the number of licenses issued. All the parts of the Gulf of Thailand should be encouraged to prohibit pair-trawlers and fishing gears operated in combination with light.

Law enforcement: At present, there is little compliance with existing regulations. Trawling takes place in shallow waters, illegal gears are used, and catches are landed outside the country. It is therefore important that measures be taken to ensure that offenders are caught and punished according to the law.

Economic measures

To control or reduce the number of subsistence fishers, alternative income sources should be explored. The establishment of processing facilities for marine fisheries products should be promoted. Presently, most of the fisheries products are exported fresh, chilled or frozen. Processing generally adds value to a product and it creates local employment opportunities.

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Appendix 1 – Comparison of Annual Measurement of Water Depth

Table A1 : Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Measurement of water depth in 2005 - Measurement of water depth in 2007	-.262	.660	.046	-.352	-.173	-5.762	209	.000
Pair 2	Measurement of water depth in 2007 - Measurement of water depth in 2009	-.332	.822	.057	-.444	-.221	-5.862	209	.000
Pair 3	Measurement of water depth in 2008 - Measurement of water depth in 2009	-.240	.757	.052	-.343	-.137	-4.593	209	.000

Table A2: Between-Subjects Factors

		Value Label	N
Community Fisheries	1	Chroy Svay Community Fisheries	720
	2	An Cha Eurt Community Fisheries	960
Year of Family Fish Catch per Season	1	Y2002	210
	2	Y2003	210
	3	Y2004	210
	4	Y2005	210
	5	Y2006	210
	6	Y2007	210
	7	Y2008	210
	8	Y2009	210

Table A3: Descriptive Statistics

Community Fisheries	Year of Family Fish Catch per Season	Mean	Std. Deviation	N
Chroy Svay Community Fisheries	Y2002	4.97	1.507	90
	Y2003	4.93	1.444	90
	Y2004	4.88	1.729	90
	Y2005	3.97	1.395	90
	Y2006	2.87	1.036	90
	Y2007	2.77	.962	90
	Y2008	2.50	.980	90
	Y2009	2.58	.755	90
	Total	3.68	1.642	720
An Cha Eurt Community Fisheries	Y2002	4.92	1.365	120
	Y2003	5.02	1.260	120
	Y2004	4.76	1.510	120
	Y2005	3.89	1.238	120
	Y2006	2.84	.941	120
	Y2007	2.67	.752	120
	Y2008	2.43	.745	120
	Y2009	2.53	.842	120
	Total	3.63	1.543	960
Total	Y2002	4.94	1.424	210
	Y2003	4.99	1.339	210
	Y2004	4.81	1.605	210
	Y2005	3.93	1.305	210
	Y2006	2.85	.981	210
	Y2007	2.72	.847	210
	Y2008	2.46	.852	210
	Y2009	2.55	.804	210
	Total	3.66	1.586	1680

Table A4: Multiple Comparisons

	(I) Year of Family Fish Catch per Season	(J) Year of Family Fish Catch per Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Y2002	Y2003	-.05	.115	1.000	-.40	.30
		Y2004	.13	.115	.958	-.22	.48
		Y2005	1.01*	.115	.000	.66	1.36
		Y2006	2.09*	.115	.000	1.73	2.44
		Y2007	2.22*	.115	.000	1.87	2.57
		Y2008	2.48*	.115	.000	2.13	2.83
		Y2009	2.39*	.115	.000	2.04	2.74
	Y2003	Y2002	.05	.115	1.000	-.30	.40
		Y2004	.17	.115	.807	-.18	.52
		Y2005	1.06*	.115	.000	.71	1.41
		Y2006	2.13*	.115	.000	1.78	2.48
		Y2007	2.27*	.115	.000	1.92	2.62
		Y2008	2.52*	.115	.000	2.17	2.87
		Y2009	2.44*	.115	.000	2.09	2.79
	Y2004	Y2002	-.13	.115	.958	-.48	.22
		Y2003	-.17	.115	.807	-.52	.18
		Y2005	.89*	.115	.000	.54	1.24
		Y2006	1.96*	.115	.000	1.61	2.31
		Y2007	2.10*	.115	.000	1.75	2.45
		Y2008	2.35*	.115	.000	2.00	2.70
		Y2009	2.26*	.115	.000	1.91	2.62
	Y2005	Y2002	-1.01*	.115	.000	-1.36	-.66
		Y2003	-1.06*	.115	.000	-1.41	-.71
		Y2004	-.89*	.115	.000	-1.24	-.54
		Y2006	1.07*	.115	.000	.72	1.42
		Y2007	1.21*	.115	.000	.86	1.56
		Y2008	1.46*	.115	.000	1.11	1.81
		Y2009	1.38*	.115	.000	1.03	1.73
	Y2006	Y2002	-2.09*	.115	.000	-2.44	-1.73

		Y2003	-2.13*	.115	.000	-2.48	-1.78
		Y2004	-1.96*	.115	.000	-2.31	-1.61
		Y2005	-1.07*	.115	.000	-1.42	-.72
		Y2007	.14	.115	.932	-.21	.49
		Y2008	.39*	.115	.016	.04	.74
		Y2009	.31	.115	.139	-.04	.66
	Y2007	Y2002	-2.22*	.115	.000	-2.57	-1.87
		Y2003	-2.27*	.115	.000	-2.62	-1.92
		Y2004	-2.10*	.115	.000	-2.45	-1.75
		Y2005	-1.21*	.115	.000	-1.56	-.86
		Y2006	-.14	.115	.932	-.49	.21
		Y2008	.25	.115	.355	-.10	.60
		Y2009	.17	.115	.833	-.18	.52
	Y2008	Y2002	-2.48*	.115	.000	-2.83	-2.13
		Y2003	-2.52*	.115	.000	-2.87	-2.17
		Y2004	-2.35*	.115	.000	-2.70	-2.00
		Y2005	-1.46*	.115	.000	-1.81	-1.11
		Y2006	-.39*	.115	.016	-.74	-.04
		Y2007	-.25	.115	.355	-.60	.10
		Y2009	-.09	.115	.996	-.44	.26
	Y2009	Y2002	-2.39*	.115	.000	-2.74	-2.04
		Y2003	-2.44*	.115	.000	-2.79	-2.09
		Y2004	-2.26*	.115	.000	-2.62	-1.91
		Y2005	-1.38*	.115	.000	-1.73	-1.03
		Y2006	-.31	.115	.139	-.66	.04
		Y2007	-.17	.115	.833	-.52	.18
		Y2008	.09	.115	.996	-.26	.44
Games-Howell	Y2002	Y2003	-.05	.135	1.000	-.46	.36
		Y2004	.13	.148	.990	-.32	.58
		Y2005	1.01*	.133	.000	.61	1.42
		Y2006	2.09*	.119	.000	1.72	2.45
		Y2007	2.22*	.114	.000	1.88	2.57
		Y2008	2.48*	.115	.000	2.13	2.83
		Y2009	2.39*	.113	.000	2.05	2.74
	Y2003	Y2002	.05	.135	1.000	-.36	.46

	Y2004	.17	.144	.931	-.27	.61
	Y2005	1.06*	.129	.000	.67	1.45
	Y2006	2.13*	.115	.000	1.78	2.48
	Y2007	2.27*	.109	.000	1.94	2.60
	Y2008	2.52*	.110	.000	2.19	2.86
	Y2009	2.44*	.108	.000	2.11	2.77
Y2004	Y2002	-.13	.148	.990	-.58	.32
	Y2003	-.17	.144	.931	-.61	.27
	Y2005	.89*	.143	.000	.45	1.32
	Y2006	1.96*	.130	.000	1.56	2.35
	Y2007	2.10*	.125	.000	1.72	2.48
	Y2008	2.35*	.125	.000	1.97	2.73
	Y2009	2.26*	.124	.000	1.89	2.64
Y2005	Y2002	-1.01*	.133	.000	-1.42	-.61
	Y2003	-1.06*	.129	.000	-1.45	-.67
	Y2004	-.89*	.143	.000	-1.32	-.45
	Y2006	1.07*	.113	.000	.73	1.42
	Y2007	1.21*	.107	.000	.88	1.54
	Y2008	1.46*	.108	.000	1.14	1.79
	Y2009	1.38*	.106	.000	1.06	1.70
Y2006	Y2002	-2.09*	.119	.000	-2.45	-1.72
	Y2003	-2.13*	.115	.000	-2.48	-1.78
	Y2004	-1.96*	.130	.000	-2.35	-1.56
	Y2005	-1.07*	.113	.000	-1.42	-.73
	Y2007	.14	.089	.781	-.13	.41
	Y2008	.39*	.090	.000	.12	.67
	Y2009	.31*	.088	.012	.04	.57
Y2007	Y2002	-2.22*	.114	.000	-2.57	-1.88
	Y2003	-2.27*	.109	.000	-2.60	-1.94
	Y2004	-2.10*	.125	.000	-2.48	-1.72
	Y2005	-1.21*	.107	.000	-1.54	-.88
	Y2006	-.14	.089	.781	-.41	.13
	Y2008	.25*	.083	.049	.00	.51
	Y2009	.17	.081	.431	-.08	.41
Y2008	Y2002	-2.48*	.115	.000	-2.83	-2.13
	Y2003	-2.52*	.110	.000	-2.86	-2.19

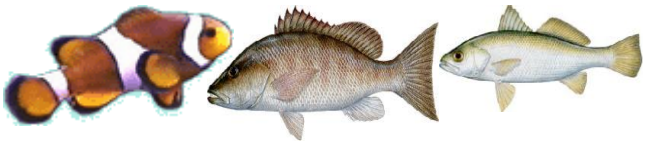
		Y2004	-2.35*	.125	.000	-2.73	-1.97
		Y2005	-1.46*	.108	.000	-1.79	-1.14
		Y2006	-.39*	.090	.000	-.67	-.12
		Y2007	-.25*	.083	.049	-.51	.00
		Y2009	-.09	.081	.964	-.33	.16
	Y2009	Y2002	-2.39*	.113	.000	-2.74	-2.05
		Y2003	-2.44*	.108	.000	-2.77	-2.11
		Y2004	-2.26*	.124	.000	-2.64	-1.89
		Y2005	-1.38*	.106	.000	-1.70	-1.06
		Y2006	-.31*	.088	.012	-.57	-.04
		Y2007	-.17	.081	.431	-.41	.08
		Y2008	.09	.081	.964	-.16	.33

Based on observed means. The error term is Mean Square (Error) = 1.399.

**. The mean difference is significant at the .05 level.*

Appendix 2 – Questionnaires

PhD Research Topic: Assessment of Marine Fishery Resources and Management
Dok Doma, PhD Candidature at AIT, Thailand 2006 - 2010



Date of Interview: ...../...../..... Sheet Number:.....
Name of Interviewer:....., Name of Location:

1. Name of boat		
2. Name of the fishery community in lagoon		
3. Member of the fishery community	☐Yes	☐No
3. Age of the boat (years)		
4. Length of the boat (meters)		

Engine

5. Age (years)
6. Power (HP)

Crew

7. Number of fishing members in the boat
8. What is the level of share benefit among fishing members?

Costs

9. Required fuel amount (liter) (per active fishing day)
10. Oil cost (per active fishing day)
11. Gear repair cost (per active fishing day)
12. Food cost (per active fishing day)
14. Administrative payment (monthly)
15. Repair and maintenance costs of the boat (monthly)
16. Repair and maintenance costs of engine (monthly)
17. Repair and maintenance costs of fishing gear (monthly)
18. Other costs such as community's member fees (monthly)

Capital-Depreciation-Interest

19. Age and value of boat
20. Value of new boat

21. Age and value of engine
22. Value of new engine
23. Amount of fishing gear
24. Economic life period of fishing gear
25. Value of new fishing gear

Socio-economic characteristics

27. Main occupation of boat owner
28. Other occupations (if any)
29. Age of the owner
30. Education level ☐ Illiterate ☐First school ☐Middle ☐High ☐College ☐University…
31. Marital status ☐ Single ☐Married
32. Number of family members under his/her economic responsibility
33. House owner or renter ☐ Renter ☐Owner
34. Social security ☐ Yes ☐No
35. Fishing experience (Years)
36. Fishing licenses (legalized) ☐ Yes ☐No
37. Give up fishing as an occupation ☐ Yes ☐No
38. Fishing status? ☐Consumption only ☐Commercial only ☐Food processing & commercial
40. Do you borrow money from other sources? ☐ Yes ☐No
41. Reason for engaging in fishery? ☐ no rice field ☐parents do it ☐other
42. Having your own transportation ☐ Yes ☐No
44. Seasonal rest? ☐ Yes ☐No
45. Children willing to become fishermen? ☐ Yes ☐No
46. Number of household population working as fishermen in this place
47. Annual income earned through fishery

Marketing

48. Main marketing shape and size? ☐ Small ☐Medium ☐Large
49. Main problems of marketing
Low fish price
Lack of demand
Lack of preservation facilities
Others
50. Days at the lagoon (active fishing days) January February March April May June July August September October November December
51. Active fishing days without catch?
52. Total catch amount (kg/year) or total annual catch value (US$/year)

No.	Scientific name (a)	Common name	Khmer name	Amount of catch, kg (b)	Value (US$) (c)
1	Chelonia mydas	Green turtle			

2	Eretmochelys imbricata	Hawksbill turtle			
3	Caretta caretta	Loggerhead turtle			
4	Lepidochelys olivacea	Olive ridley			
5	Dermochelys coriacea	Leatherback turtle			
6	Batagur baska	Mangrove terrapin or Royal terrapin			
7	Feresa attenuata	Pygmy killer whale			
8	Grampus griseus	Grey dolphin			
9	Lagenodelphis hosei	Fraser's dolphin			
10	Neophocaena phocaenoides	Black finless porpoise			
11	Orcaella brevirostris	Irrawady dolphin			
12	Sousa chinensis	Indo-Pacific humpback dolphin			
13	Stenella longirostris	Spinner dolphin			
14	Tursiops aduncus	Indian Ocean bottlenose dolphin			
15	Dugong dugon	Dugong			
16	Atelomycterus marmoratus	Coral catshark			
17	Carcharhinus amblyrhynchoides	Graceful shark			
18	Carcharhinus amblyrhynchos	Grey reef shark			
19	Carcharhinus dussumieri	Whitecheek shark			
20	Carcharhinus leucas	Bull shark			
21	Carcharhinus limbatus	Blacktip shark			
22	Carcharhinus longimanus	Oceanic whitetip shark			
23	Carcharhinus melanopterus	Blacktip reef shark			
24	Chiloscyllium indicum	Slender bamboo shark			
25	Chiloscyllium punctatum	Brownbanded bamboo shark			

26	Galeocerdo cuvier	Tiger shark			
27	Isurus oxyrhinchus	Shortfin mako			
28	Prionace glauca	Blue shark			
29	Pristis zijsron	Green sawfish			
30	Rhincodon typus	Whale shark			
31	Scoliodon laticaudus	Spadenose shark			
32	Sphyrna lewini	Scalloped hammerhead			
33	Stegostoma fasciatum	Leopard shark			
34	Triaenodon obesus	Whitetipped reef shark			
35	Aetomylaeus nichofii	Banded eagle ray			
36	Mobula japanica	Japanese devilray			
37	Tæniura lymma	Bluespotted fantail stingray			
38	Hippocampus kuda	Seahorses			
39	Cephalopholis boenack	Chocolate hind			
40	Cromileptes altivelis	Humpback seabass			
41	Cromileptes altivelis (Valenciennes, 1828)	Humphack grouper	Trey Tok Ke Chrouk		
42	Pomacanthus annularis (Bloch, 1787)	Bluering angelfish	Trey Me Ham Boa		
43	Epinephelus coioides (Hamilton, 1822)	Orangespotted grouper	Trey Tok Ke Koa		
44	Pampus argenteus (Euphrasen, 1788)	Silver pomfret	Trey Chab Sor		
45	Epinephelus faciatus (Forsskål, 1775)	Blacktip grouper	Trey Tok Ke Kra horm		
46	Plectropomus oligocanthus (Bleeker, 1854)	Highfin grouper	Trey Tok Ke Uch Kiev		
47	Epinephelus quoyanus (Valenciennes, 1830)	Longfin grouper	Trey Tok Ke Para		
48	Diagramma pictum (Thumberg, 1792)	Yellowdot sweetlips	Trey Ka chii		
49	Pampus chinensis (Euphrasen, 1788)	Chinese silver pomfret	Trey Chab Khmao		

50	Atelomycterus marmotatus (Bennett, 1830)	Coral catshark	Trey Chhlam Khla		
51	Chiloscyllium punetatum Müller & Henle, 1838	Brown-banded catshark	Trey Chham Chhmar		
52	Scarus quoyi Valenciennes, 1840	Quoy's parrotfish	Trey Sek Khiev		
53	Himantura imbricata (Bloch & Schneider, 1801)	Scaly whipray	Trey Bor Bel		
54	Sargocentron rubrum (Forsskål, 1775)	Redcoat	Trey Kror horm sraka tom		
55	Strabozebrians cancellatus (McCulloch, 1916)	Harrowed Sole	Trey An Dat Chhek		
56	Siganus virgatus (Valenciennes,)	Doublebarred spinefoot	Trey Korn Taing Tmor		
57	Cephalopholis formosa (Shaw & Nodder, 1812)	Bluefined grouper	Trey Tok Ke Kroeum		
58	Diploprion bifaciatum Kuhl & Van Hasselt, 1828	Yellow emperor	Trey Sek Loeung		
59	Siganus argenteus (Quoy & Gaimard, 1825)	Silver spinefoot	Trey Korn Tang Pe		
60	Siganus canaliculatus (Park, 1797)	Whitespotted spinefoot	Trey Korn Tang Kro Ub		
61	Siganus guttatus (Bloch, 1727)	Goldenspotted spinefoot	Trey Korn Tang Phoeung		

Marine Crab & Hourseshoe Crab

No.	Crab in Scientific name	Common name	Khmer Name	Amount of Catch, kh	Value (US$)
1	Scylla serrata (Forsskål, 1775)	Giant mud crab	Kdam Thor		
2	Charybdis feriatus (Linnaeus, 1758)	Crucifix crab	Kdam Khlar		
3	Thalamita crenata (Latreille, 1829)	Crenate swimming crab	Kdam Thor Kiev		

4	Charybdis anisodon (de Haan, 1850)	Two spined arm swimming crab	Kdam Dorng Kieb Sor		
5	Portunus pelagicus (Linnaeus, 1758)	Flower crab or swimming crab	Kdam Se		
6	Tachypleus gigas (Müller, 1785)	Triangular-tail horseshoe crab	Balang Kak		
7	Charybdis natator (Herbst, 1789)	Hairy swimming crab	Kdam Neak		
8	Episesarma singaporenes (Tweedie,1936)	Singapore vinegar crab	Kdam Chorr		
9	Episesarma versicolor (Tweedie, 1940)	Violet vinegar crab	Kdam Chorr		
10	Podophthalmus vigil (Fabricius, 1798)	Sentinel crab	Kdam Phneak Vieng		
11	Ozius quttatus Milne Edward,1834	Spottedbelly rock crab	Kdam Pkor lienn		

Gastropods

No.	Scientific name	Common name	Khmer name	Amount of catch, kg	Value (US$)
1	Turbo marmoratus Linnaeus, 1758	Green Turbo or Green snail	Khchorng Prak		
2	Haliotis asinina Linnaeus, 1758	Donkey's ear abalone	Khchorng Pav Hoeur Vieng		
3	Haliotis ovina Gmelin, 1791	Oval abalone	Khchorng Pav Joeur Khey		
4	Turbo petholatus Linnaeus, 1758	Tapestry turban	Khchorng Kror La Proum		
5	Strombus canarium Linnaeus, 1758	Dog conch	Khchorng Choeung Muoy		
6	Babylonia areolata (Link, 1807)	Maculated ivory whelk	Khchorng Pong Krouch		
7	Melo melo (Lightfoot, 1786)	Indian volute	Khchorng Dong		

Bivalves

No.	Scientific name	Common name	Khmer name	Amount of catch, kg	Value (US$)
1	Anadara nodifera (Martens, 1860)	Nodular ark	Kreng Chhiem		
2	Amusium pleuronectes (Linnaeus, 1758)	Asian moon scallop	Khchorng plate		
3	Meretrix lyrata (Sowerby, 1851)	Lyrate hard clam	Kreng Sor		
4	Paphia undulata (Born, 1778)	Undulate venus	Krum Kror Lar Hol		
5	Scapharca inaequivalvis (Bruquière, 1789)	Inequivalve ark	Kreng Chheim Meat Viech		
6	Anadara binakayanensis (Faustino, 1932)	Globose ark	Kreng Chheim Mor Mis		
7	Pteria penguin (Röding, 1798)	Penguin wing oyster	Krum se		
8	Pinna bicolor Gmelin, 1791	Bicolor pen shell	Krum Chorb Chik		
9	Meretrix lusoria (Röding,1798)	Poker-chip venus	Ngeiv Hol		
10	Perna viridis (Linnaeus, 1758)	Green mussel	Krum Cham Puch Tea		
11	Donax cuneatus Linnaeus, 1758	Cradle or cuneate donax	Ngeav Sor		
12	Polymesoda erosa (Solander, 1786)	Common geloina	Ngeav Puok		

Fishes

No.	Scientific name	Common name	Khmer name	Amount of catch, kg	Value (US$)
1	Cromileptes altivelis (Valenciennes, 1828)	Humphack grouper	Trey Tok Ke Chrouk		
2	Pomacanthus annularis (Bloch, 1787)	Bluering angelfish	Trey Me Ham Boa		
3	Epinephelus coioides (Hamilton, 1822)	Orange-spotted grouper	Trey Tok Ke Koa		
4	Pampus argenteus (Euphrasen, 1788)	Silver pomfret	Trey Chab Sor		

5	Epinephelus faciatus (Forsskål, 1775)	Blacktip grouper	Trey Tok Ke Kra horm		
6	Plectropomus oligocanthus (Bleeker, 1854)	Highfin grouper	Trey Tok Ke Uch Kiev		
7	Epinephelus quoyanus (Valenciennes, 1830)	Longfin grouper	Trey Tok Ke Para		
8	Diagramma pictum (Thumberg, 1792)	Yellowdot sweetlips	Trey Ka chii		
9	Pampus chinensis (Euphrasen, 1788)	Chinese silver pomfret	Trey Chab Khmao		
10	Atelomycterus marmotatus (Bennett, 1830)	Coral catshark	Trey Chhlam Khla		
11	Chiloscyllium punetatum Müller & Henle, 1838	Brown-banded catshark	Trey Chham Chhmar		
12	Scarus quoyi Valenciennes, 1840	Quoy's parrotfish	Trey Sek Khiev		
13	Himantura imbricata (Bloch & Schneider, 1801)	Scaly whipray	Trey Bor Bel		
14	Sargocentron rubrum (Forsskål, 1775)	Redcoat	Trey Kror horm sraka tom		
15	Strabozebrians cancellatus (McCulloch, 1916)	Harrowed Sole	Trey An Dat Chhek		
16	Siganus virgatus (Valenciennes,)	Doublebarred spinefoot	Trey Korn Taing Tmor		
17	Cephalopholis formosa (Shaw & Nodder, 1812)	Bluefined grouper	Trey Tok Ke Kroeum		
18	Diploprion bifaciatum Kuhl & Van Hasselt, 1828	Yellow emperor	Trey Sek Loeung		
19	Siganus argenteus (Quoy & Gaimard, 1825)	Silver spinefoot	Trey Korn Tang Pe		
20	Siganus canaliculatus (Park, 1797)	Whitespotted spinefoot	Trey Korn Tang Kro Ub		
21	Siganus guttatus (Bloch, 1727)	Goldenspotted	Trey Korn Tang Phoeung		

		spinefoot			

Main problems

53. Problems regarding fishing grounds?	☐ Yes ☐No If yes, what are they?
54. Problems regarding bank credits?	☐ Yes ☐No If yes, what are they?
55. Problems regarding fishing port?	☐ Yes ☐No If yes, what are they?
56. Conflicts with other fishers?	☐ Yes ☐No If yes, what are they?
57. Problems regarding community?	☐ Yes ☐No If yes, what are they?
58. Conflicts with tourism?	☐ Yes ☐No If yes, what are they?
59. Problems regarding local administration?	☐ Yes ☐No If yes, what are they?
60. Problems regarding security guard?	☐ Yes ☐No If yes, what are they?
61. Problems on using bank credit?	☐ Yes ☐No If yes, what are they?
62. Problems with local regulation and policy?	☐ Yes ☐No If yes, what are they?
63. Problems on finding labor?	☐ Yes ☐No If yes, what are they?
64. Others	☐ Yes ☐No If yes, what are they?

Fishing Member – Community Relationship

65. When did you become a community member?	
66. Have you ever held a position in the management board of the community? ☐ Yes ☐No	
67. If yes, please state in what capacity/position	☐Management board ☐Ordinary member
68. Why did you become a community member?	
☐ to market fish on better price ☐ to provide cheaper inputs ☐ to cope with bureaucratic problems ☐ social reasons ☐ others	
69. Have your expectations been met? If yes which one or ones? ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9	
70. Have you ever caught fish the volume of which exceeded your expectation? If yes which one or ones? ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9	
71. When was the last time you caught fish the volume of which exceeded your	

expectation?
72. How much (quantity) was the surplus catch?
73. Do you attend general assemblies to learn about guidelines and regulations? ☐ Yes ☐No
74. Did you participate in these annual assemblies? ☐ Yes ☐No
75. If you didn't, why?
I don't believe these regulations will help save/conserve marine resources
I don't believe these regulations will improve people's livelihood
I think these regulations or guidelines are hard to implement
I had more important work to do
I was not aware that these annual assemblies were held
Others
76. What are the activities in the community?
Marketing
Supply inputs
Education
Received charge
Control over the use of fishing gears or imposition of sanctions
Others
77. Do you believe that the community is successful? ☐ Yes ☐No
78. Is there a price advantage in marketing fish through the community ☐ Yes ☐No
79. What type of projects should be implemented to improve the livelihood of the community?
☐ Establish fish storage
☐ Supply some inputs to fishermen
☐ Subsidize fuel – oil
☐ Market aquaculture products
☐ Reduce local patrol guards
☐ Equity in the grant/control of fishing applications
☐ Other
80. Do you think the community always has the same management board every where? ☐ Yes ☐No
81. Does the community perform any activity to protect fish stocks? ☐ Yes ☐No
82. What type of activities are they?
4.
5.

83. Do you think the community is successful?

Total annual fish catch since 2002 to date

84. Can you remember the annual average fish catch (in kilograms) from 2002 to date?						
2002	2003	2004	2005	2006	2007	2008

85. What fish species did you catch from 2002 to date? Please provide the five (5) most important species whose sale enhanced your income.

Ranking	2002	2003	2004	2005	2006	2007	2008	2009
First species								
Second								
Third								
Forth								
Fifth								

86. Please provide the significant level of policies or regulation application from 2002 to date.

1 – Strong, 2 – Not so strong, 3 – Weak

Subject	2002	2003	2004	2005	2006	2007	2008	2009
Law								
Policies								
Guideline								
Proclamation								
Other direction								

87. Please provide information about the percentage of illegal fishing gears used from 2002 to date in comparison with the current fishing number.

Type of gear	2002	2003	2004	2005	2006	2007	2008	2009

88. Please provide information about the percentage of fishermen in the area from 2002 to date in comparison with the current fishing number?

Type of gear	2002	2003	2004	2005	2006	2007	2008	2009

89. Please provide information about the scale of sand excavation in the area from 2002 to date?
☐1-Large scale, ☐2 – Medium scale, ☐3 – Small scale, ☐4 – Not excavated

Type of gear	2002	2003	2004	2005	2006	2007	2008	2009

90. Please provide information about the level of crop plantation using chemical fertilizers in the area from 2002 to date? ☐1-Strong use, ☐2 – Medium use, ☐3 – Some use, ☐4 – No use of fertilizers

91. What is the level of inshore water contamination? 1 – very bad, 2 – bad, 3 – quite bad, 4 – normal
☐2002 ☐ 2003 ☐2004 ☐2005 ☐2006 ☐2007 ☐2008 ☐2009
Please tick in your answers to the succeeding questions/statements from the table provided below:

Column1	Column2
1	Aquaculture
2	Crop plantation with chemical fertilizer utilization
3	Commercial fisheries (large scale with illegal fishing gears)
4	Eating delicious seafood
5	Enjoying unspoilt beaches, bays & coastal waters
6	industrial facilities/manufacturing
7	Indigenous cultural & traditional ensaTtamTmøab;
8	Sand excavation
10	Oil & gas exploration & extraction
11	Pearling
12	Ports
13	Recreational boating & sailing
14	Recreational fishing
15	Scuba diving
16	Scenery and aesthetic/spiritual
17	Shipping
18	Solar salt
19	Swimming and snorkeling
20	Tourism, accommodation & services
21	Add any other marine uses:

92. You believe your family and people benefit from
93. Which of these uses and activities do you think could be impacted by waste inputs or pollution?
94. Which of these uses and activities are of concern to you as potential causes of waste inputs and reduced water quality?
95. Please draw rings around the top 5 uses in the table that you most value.
96. Are there areas in the coastal waters of the Sre Ambel that you think should be TOTALLY protected from waste inputs? (tick one) YES NOT SURE NO
97. Are there areas of the coastal waters where you are prepared to accept some effects on marine life from waste inputs in return for important uses and developments? (tick one) YES NOT SURE NO

98. Please provide the number of industrial facilities built surrounding the lagoon from 2002 to 2008.

Facilities	2002	2003	2004	2005	2006	2007	2008
Sand port							
Shipping port							
Sugar cane							
Food processing							
Hotel & guest house							
Annual waste discharge, m3							

99. What is the annual change in water depth of the lagoon (measured at the middle of lagoon)? Where the fishes are caught by fisher?

Year	2002	2003	2004	2005	2006	2007	2008

100. Please provide information about the wave speed from 2002 to date.
1 – very rough, 2 – rough, 3 – calm, 4 – very calm

Year	2002	2003	2004	2005	2006	2007	2008
wave							

101. Please provide information about wind speed during both wet and dry seasons yearly on the basis of the specification table given below?							
Year	2002	2003	2004	2005	2006	2007	2008
Wind	1.3						

Checklist: Wind speed scale

Beaufort number	Description	Wind speed				Wave height		Sea conditions	Land conditions	Sea state photo
		km/h	mph	kts	m/s	m	ft			
0	Calm	< 1	< 1	< 1	< 0.3	0	0	Flat.	Calm. Smoke rises vertically.	
1	Light air	1.1 – 5.5	1 – 3	1 – 2	0.3 – 1.5	0 – 0.2	0 – 1	Ripples without crests.	Wind motion visible in smoke.	
2	Light breeze	5.6 – 11	4 – 7	3 – 6	1.6 – 3.4	0.2 – 0.5	1 – 2	Small wavelets. Crests of glassy appearance, not breaking	Wind felt on exposed skin. Leaves rustle.	
3	Gentle breeze	12 – 19	8 – 12	7 – 10	3.4 – 5.4	0.5 – 1	2 – 3.5	Large wavelets. Crests begin to break; scattered whitecaps	Leaves and smaller twigs in constant motion.	
4	Moderate breeze	20 – 28	13 – 17	11 – 15	5.5 – 7.9	1 – 2	3.5 – 6	Small waves with breaking crests. Fairly frequent white horses.	Dust and loose paper raised. Small branches begin to move.	
5	Fresh breeze	29 – 38	18 – 24	16 – 20	8.0 – 10.	2 – 3	6 – 9	Moderate waves of some	Branches of a moderate size move. Small trees begin to	

					7			length. Many white horses. Small amounts of spray.	sway.	
6	Strong breeze	39 – 49	25 – 30	21 – 26	10.8 – 13.8	3 – 4	9 – 13	Long waves begin to form. White foam crests are very frequent. Some airborne spray is present.	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.	
7	High wind, Moderate gale, Near gale	50 – 61	31 – 38	27 – 33	13.9 – 17.1	4 – 5.5	13 – 19	Sea heaps up. Some foam from breaking waves is blown into streaks along wind direction. Moderate amounts of airborne spray.	Whole trees in motion. Effort needed to walk against the wind. Swaying of skyscrapers may be felt, especially by people on upper floors.	
8	Gale, Fresh gale	62 – 74	39 – 46	34 – 40	17.2 – 20.7	5.5 – 7.5	17.2 – 20.7	Moderately high waves with breaking crests forming spindrift. Well-marked streaks of foam are blown along wind direction. Considerabl	Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded.	

								e airborne spray.		
9	Strong gale	75 – 88	47 – 54	41 – 47	20.8 – 24.4	7 – 10	23 – 32	High waves whose crests sometimes roll over. Dense foam is blown along wind direction. Large amounts of airborne spray may begin to reduce visibility.	Some branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies.	
10	Storm[6], Whole gale	89 – 102	55 – 63	48 – 55	24.5 – 28.4	9 – 12.5	29 – 41	Very high waves with overhanging crests. Large patches of foam from wave crests give the sea a white appearance. Considerable tumbling of waves with heavy impact. Large amounts of airborne spray reduce visibility.	Trees are broken off or uprooted, saplings bent and deformed. Poorly attached asphalt shingles and shingles in poor condition peel off roofs.	
11	Violent storm	103 – 117	64 – 72	56 – 63	28.5 – 32.6	11.5 – 16	37 – 52	Exceptionally high waves. Very large patches of foam,	Widespread damage to vegetation. Many roofing surfaces are damaged; asphalt tiles that have curled up and/or fractured	

								driven before the wind, cover much of the sea surface. Very large amounts of airborne spray severely reduce visibility.	due to age may break away completely.	
12	Hurricane[6]	≥ 118	≥ 73	≥ 64	≥ 32.7	≥ 14	≥ 46	Huge waves. Sea is completely white with foam and spray. Air is filled with driving spray, greatly reducing visibility.	Very widespread damage to vegetation. Some windows may break; mobile homes and poorly constructed sheds and barns are damaged. Debris may be hurled about.	

102. Could you recall the surface water temperature inshore which is about less than 20 meters deep in the lagoon yearly? Fill in the box of the table below.

Year	2002	2003	2004	2005	2006	2007	2008

103. What are the most significant physical changes of mangroves in the lagoon? Please describe as 1 – Intense cutting activity, 2 – Moderate cutting activity, 3 – Less cutting activity, 4 – No cutting activity

Year	2002	2003	2004	2005	2006	2007	2008
Mangrove areas							

104. What are the most aquacultures activities in the lagoon? 1 – Low, 2 – some, 3 – above some, 4 – high.
Please describe these aquaculture species in the table below:

Year	2002	2003	2004	2005	2006	2007	2008
Species							

aquaculture							

105. What kind of boat do you use for fishing? Please tick on the box at the table below.

Year	Boats without engines and less than 5T		Boats with engines								
			<10 HP		10-30 HP		30-50 HP		>50 HP		Total of stock
	Number	Stock	Unit	HP	Unit	HP	Unit	HP	Unit	HP	
2002											
2003											
2004											
2005											
2006											
2007											
2008											
Present											

B. Laws & Regulations

106. In your opinion, is there a law that will best provide a broad legislative framework for management and development of marine capture fisheries in Cambodia?

☐Yes i know ☐No i don't know

If you answered yes, please elaborate……

107. Are new laws and regulations usually explained to you before they are implemented?

☐Yes ☐No Please elaborate…….

108. Are closures for marine fishing announced before they are made/implemented?

☐Yes ☐No Please explain……

109. Can trawl fishing gears be used in inshore areas less than 20 meters deep?

☐Yes ☐No…….

110. Can you make use of explosives and poisons for commercial fish capture?

☐Yes, ☐No…….

111. Are you aware of the requirement to secure fishing permits for commercial fishing?

☐Yes ☐No. Please elaborate…….

112. Are you aware/Do you know of any issuance of licenses for foreign vessels fishing in Cambodia? ☐Yes ☐No

Please describe……

113. Can you describe the kind of instruments which are considered as illegal fishing gears?

☐Trawl less than 20 meters deep ☐Electro-fishing ☐Explosives and poisons ☐Others……

114. Why does the government issue proclamations concerning mangrove protection?.....
115. When was marine fishing generally banned during spawning season of mackerels?.....

116. What kind of nationally threatened marine species are prohibited from being caught?.....

117. Who has introduced the fishing laws and regulations to you?.....

118. What method do they use in explaining the laws and regulations? Do they take the time to teach you the laws, show pictures, or do they just talk to you about them?.....

119. How many years are the licenses issued to fishermen usually in effect?.....

120. Is the marine fishery open access?
☐Yes ☐No……

121. What happens if someone does not have a license for fishing?.....

122. Are all the fishermen in the areas surrounding the Lagoon satisfied with these laws and proclamations?
☐Yes ☐No

123. If no, why?.....

124. Do you think these laws and proclamations are effective in the conservation of fish resources? ☐Yes ☐No…….why?……

125. Do you think these laws and proclamations contribute in improving the local economy? ☐Yes ☐No

126. Can you compare the situation before and after these laws and proclamations came into effect in terms of local livelihood and economic conditions?
Before the laws were enacted and came into effect ☐better ☐no
After laws the laws were enacted and came into effect ☐better ☐no

127. Why do you think these laws and proclamations cannot be practically applied in this area?.....
C. Capability of (Education, Culture, Problem)

128. Level of Education Attained?
1☐Never attended school 2☐Primary 3☐Secondary 4☐High School
☐College ☐Short Trainings

129. Capability to understand laws and regulations?
1☐Cannot read 2☐Read only 3☐Literacy 4☐Read, write and analyze

130. Can local authority help you to understand the law?
1☐Nothing 2☐Low 3☐Medium 4☐High

131. What are the benefits of conservation and management initiatives (laws and proclamation) to the lo
1☐Nothing 2☐Low 3☐Medium 4☐High

132. What are the key issues/problems associated with fisheries in the area?.....
……
……
……
……
……..

133. What is the current capability of each fisherman to read and understand laws and proclamation?
1☐Very low 2☐Low 3☐Medium 4☐High

134. Are you still interested in using traditional methods of fishing that you think is most practical?
☐Yes ☐No

135. How often is there a conflict between fishers? ☐rarely ☐sometimes ☐many times ☐always

136. Is there a conflict between fishers and fisheries authorities?
☐rarely ☐sometimes ☐many times ☐always

137. Are you involved in the management/co-management of the fishery and/or other natural resources?☐Yes ☐No

138. What co-management activities exist in the area?.....

139. What benefits do you get from conservation?.....

140. What can be done to improve the fishery?.....

141. What is the fishing gear that you think can catch a lot of fish for both commercial and consumption u
☐Trawl net ☐Gill net ☐Purse Seine ☐Hook ☐Lift net ☐Others……..

142. Are all fish catch landed in the Cambodia countryside? ☐Yes ☐No If no, where……

Section II. Commune Councils

A. General Information of Marine Capture Fishery

143. Major local occupation in the study area.....

144. Total number of families in the commune.....

145. Size of fishing area in the commune (km2).....

146. Percentage of families who frequently receive education from the commune on fishing roles ……....

147. Do you think marine fish population changes over the years ☐ Yes ☐No
If yes, please provide the reason why.....

B. Marine Fishery Management

148. How difficult was it for the commune to educate the fishermen about fishing roles?
1- hard 2 – normal 3 – easy 4 – very easy

149. Percentage of compliance with laws and local regulations over the years?

Year	2002	2003	2004	2005	2006	2007	2008	2009
%Fishermen								

If you do not have any data or record, please write NA – not available

150. What services are being supplied by the commune to the fishermen yearly? Please describe in the table.

Year	2002	2003	2004	2005	2006	2007	2008	2009

If you do not have any data or record, please write NA – not available

151. Are there any industries and transportation activities present/being conducted in the areas surrounding the lagoon? Do these industries or activities dump solid and liquid waste into the area?

1 – No 2 – Less 3 – Some 4 – Many
If possible, please state the approximate amount of waste discharged into the water.

Year	2002	2003	2004	2005	2006	2007	2008	2009
Industries								

Total in m3								
Transportation								
Total in m3								

Illegal fishing activity monitoring data sheet Date: Recorded by:……. Time: Weighed by:…….... Location:						
Name of illegal fishing gear		Illegal Activity	Most location	No. Of fishermen using	Frequency of use , days a [illegible]	Fish species targeted
In Eng	In Kh					

152. Types of boats used from 2002 until the present?

Year	Boats without engines and less than 5T		Boats with engines									
			<10 HP		10-30 HP		30-50 HP		>50 HP		Total	
	Number	Stock	Unit	HP	Unit	HP	Unit	HP	Unit	HP	Unit	HP
2002												
2003												
2004												
2005												
2006												
2007												
2008												
2009												

Section III. Commercial Fish Seller

153. Fish Landing: Please indicate the aquaculture fish price for each year.
a) Fish landing by perception survey

Table 1: 1 – Low, 2 – above low, 3 – medium, 4 – high

Local market (LM), Regional market (RM), For export only (EO)		2002	2003	2004	2005	2006	2007	2008	2009
Sold species	At								

b) Fish landing by actual record
Table 2.

Recorder:		Date:
Type of boat:		Horse power (HP):
No. of crew		
Type of gear(s):		Mesh size/: No. of hooks:
Area of operation:		
Duration of operation:		
No. of fishing days per month:		
Fish species	Quantity (kg)	Average size (cm)
Number of boats operated on the day:		
Number of fishing days during the month:		
Seasons/month when juveniles are caught for each species		
Type and mesh size of gear used during that time:		
Species of juveniles caught and when:		
Seasonality of fish abundance:		
Seasonality of years used:		

154. What are the constraints to aquaculture?
……
……...……
……
……..……
……
…….……
…….....
.....
155. Do you have any comments or suggestions on the policies and regulations regarding marine fishing?
……
……...……
……
……..……

Section IV. Fish Catch Monitoring

156. What kind of fishing gear do you use for a target group of fish?

Fish Catch Data Sheet
Date: Recorded by:…….
Time: Weighed by:…….....
Location:
Comments:

During noon time☐ During stormy weather☐ Rainy☐ Almost overcast skies☐ Fair Weather☐

Lagoon State: 1 2 3 4 5
Calm Rough

Name of Fishing Gear	2. Fishing Gear in Khmer Name	3. Hours	4. Boat size	5.Location	6. Weight, kg	7. Fish Species	8. Number of fish		9. Motorized	10. Distance from the shore
							8.1 Male	8.2 Female		
Mackerel gill net	Mong Trey Kamong									
Anchovy encircling seine	Uon Ka Koeum									
Shrimp gill net	Mong Bang Kear									
Fish gill net	Mong Trey									
Crab gill net	Mong Kdam									
Crab trap	LopKdam									
Squid trap	Lop Meuk									
Fish stake trap										
Horizontal longline	Santouch Ro Noung									
Push net	Chhep Yun									

157. Temperature and Toxic Substances (Questionnaire for Local Conservation NGOs or Authorities)

Year	2002	2003	2004	2005	2006	2007	2008	2009
Temperature Dissolved Oxygen (DO) Nitrogen (mg/g ds) Phosphorus (mg/g ds) Carbon (mg/g ds) Organic content, % ds Ammonia NH3 NH4+ 8. Metals - Iron (mg/g ds) - Manganese (mg/g ds) - Zinc (ppm) - Chromium (ppm) - Lead (ppm) - Copper (ppm) - Cadmium (ppm) - Mercury (ppb)								

158. cross cutting issues may be merged during field work…….....

……
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……