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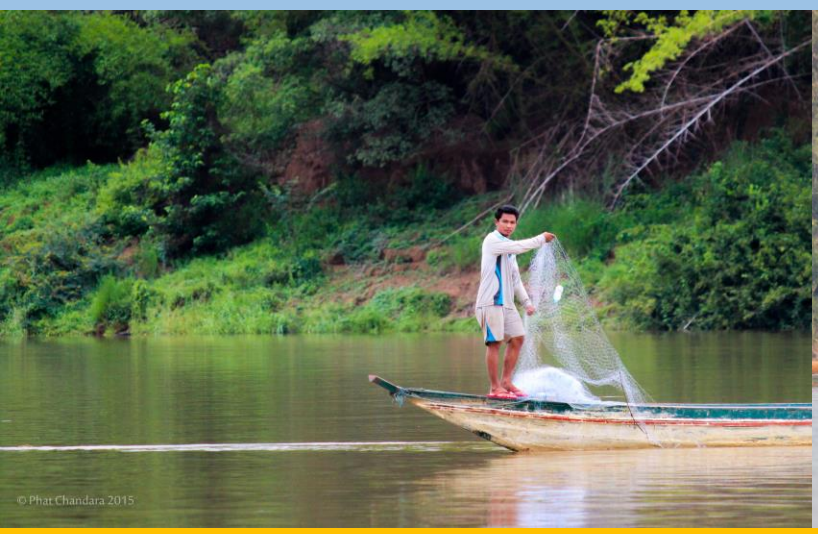
Natural Resource Governance in Cambodia



Editors

Seak Sophat

Gary Morrison

NORWEGIAN PEOPLE'S AID

Wildlife Conservation Cambodia

The research paper volume contains part of research findings of PEACE project, a program supported by the ICCO and NPA with the aims of (i) to promote the dialogues between government, private sector, NGOs and Communities on natural resources management aiming at improving environmental governance and livelihoods of local resource dependent communities; (ii) to promote a collaborative research on environmental issues and problems affecting the communities aiming at supporting the dialogues between government, private sector, NGOs and communities, and the advocacy campaign on improving access to natural resources for local communities; (iii) to influence national policies and decision-making on natural resources management and poverty reduction in rural natural resource dependent communities; and (iv) fostering an exchange of information and establishing networks among scholars, researchers, NGOs, government agencies, and media workers working on natural resource and environmental governance, and development related issues in Cambodia. These papers are written by researchers who, and also by those carry out research under NRMD research projects and collaborative research projects.

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Photos: Seak Sophat & Phat Chandara
Design and Layout: Horn David

Published in Phnom Penh 2015 by: Department of Natural Resource Management and Development (NRMD), Faculty of Development Studies, Royal University of Phnom Penh Contact Address: Room 216B, Building A Department of Natural Resource Management and Development (NRMD), Faculty of Development Studies, Royal University of Phnom Penh Russian Federation Boulevard, Toul Kork, Phnom Penh, Cambodia
Tel: 855-23-883-640
Fax: 855-23-880-116

Preface

This publication brings together into one volume some of the work carried out by the Department of Natural Resource Management and Development at the Royal University of Phnom Penh (RUPP) in Cambodia over the last 5 years, an important period for environmental issues within the country.

The papers in this volume tackle a range of issues at the heart of the debates taking place in Cambodia today, from the granting of land concessions and the impacts of hydropower dams, to mining activities and the impacts of development on local livelihoods – particularly those related to fishing. The papers also highlights the high level of dependence local people still have on the natural resources around them.

All the papers explore how people living in rural areas of Cambodia are being impacted often adversely – by the interests of those from 'outside', and in one case, from those in another country, with these interests almost exclusively driven by the desire to 'develop' at a rapid pace along market driven lines, a desire made stronger due to the long period of war and stagnation that took place in the country in the 1970s and 1980s.

As with many other developing countries around the world, local people are rarely included in the consultation process when development activities take place in their local area, either because it is not in the interests of those introducing the change to do so (in the case of economic land concessions (ELCs) and sand dredging (along Cambodia's coast), because they are far removed from the activities shaping their lives (such as those living around Tonle Sap Lake), or even because they live in a different country to where the activities are taking place (the Vietnamese dam on the Sesan River).

One paper in this volume highlights in particular the close relationship that exists between rural dwellers in Cambodia and the natural resources around them (forest ecosystems), sending the message that as the charge towards a market economy gathers pace, with its associated exploitation of oceans, rivers and forests, so local people whose livelihoods depend on such resources are likely to lose out, leading to the loss of unique ways of life (to be replaced by homogeneity), sustainable livelihoods (to be replaced by exploitative methods) and diversity – particularly in terms of ecosystems' services.
The underlying message of this volume is that in Cambodia, as in other developing countries, the changes introduced in the name of development come at a price, one that in the longer term may be too high to pay.

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The Socio-economic Contributions made by Coral Reefs: Research findings from Koh Sdech Commune in Kirisakor District, Koh Kong Province, Cambodia

Khan Lyna* and Ouch Mara

Abstract

Coral reefs represent one of the most crucial habitats for marine resources, including fish, which live and produce offspring within reef areas. In this study, the authors explore the significance of coral reefs to the local livelihoods of those living in Koh Sdech Commune, Kirisakor District, Koh Kong Province in Cambodia, focusing on the socio-economic contributions that coral reefs make and the conflicts that arise over the allocation of coral reef resources. It also describes the perceptions of local villagers regarding the significance of the coral reefs around them. The research reveals that: (1) Coral reefs are a key resource for local people's livelihood development, (2) Coral reef resources are not equally distributed among the poor and better-off households, (3) The level of awareness on local fishing rules is limited, and that, (4) The main role of women in the study area is to support the men, collect coral reef resources and carry out other resource-related management activities.

Keywords: coral reef, marine resources, socio-economic contribution, conservation, community development, and ecotourism

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*L. Khan ( )

Department of Natural Resource Management and Development

Faculty of Development Study, Royal University of Phnom Penh

E-mail: khanlyna@gmail.com

1. Introduction

In developing countries, coral reefs provide ecosystem-related goods and services, and so contribute to the social and economic welfare of hundreds of millions of people (Moberg and Folke, 1999). Coral reefs are the most diverse marine ecosystems globally, playing host to millions of species, but they are now also among the most threatened ecosystems (Knowton and Jackson, 2013). Coral reef communities face unprecedented pressures due to climate change and anthropogenic disturbance taking place at the local, regional and global levels (Xu and Zhao, 2014; Rinkevich, 2014). Risk *et al.* (2009) suggest that a lack of scientific consensus has been responsible for poor management decisions in relation to coral reefs, resulting in their degradation. In the Maldives, almost the entire population depends on coral reefs, and their direct and obvious economic significance has led to greater accountability developing there in terms of the protection and management of coastal areas (Jaleel, 2013).

As coral reefs in general have become increasingly over-exploited, so scientists and practitioners have advised countries to reduce their dependence on this resource type (Cinner, 2014). A number of studies on coral reefs have looked at their general vulnerability (Darling and Côté, 2013), and the impacts of climate change (Ateweberhan *et al.*, 2013) and sea-level change on such reefs (Woodroffe and Webster 2014), as well as the impacts of community-based management activities (Amar *et al.*, 1995) and food security (Cruz-Trinidad *et al.*, 2014). More integrated forms of management involving various stakeholders have been introduced in the Philippines in order to protect coral reefs (White *et al.*, 2000). In Indonesia; meanwhile, research suggests more attention should be paid to the involvement of communities in the implementation of coral reef management activities if marine protection areas are to continue to be a useful resource management tool (Elliott *et al.*, 2010). Govan (2009) points out that the inclusion of coral reef ecosystems within community-based marine

protected areas has gained ground in recent decades. Based on experiences from a number of developing countries, the effective management of coral reefs is possible with the support of local communities (Pollnac *et al.*, 2010).

In southeastern Cambodia, coastal areas provide people with resources which are extremely important for sustaining their livelihoods in terms of the utilization of fish, seaweed and mangrove forests (Bith, 2011). In addition, coral reef landscapes are potential tourist attractions, providing supplementary income sources to local people (Bauld, 2005). However, natural resources in Cambodia's coastal zones are under threat from over-exploitation, the increasing demands of development activities and population growth (Krell *et al.*, 2011). Some key reasons for the degradation of coastal resources in Cambodia include a lack of public awareness, weak and ineffective coastal law enforcement, a lack of institutional cooperation, and a lack of authority among local, community-based organizations (Bith, 2011). Community-based natural resources management is a method used to protect and conserve natural resources in a sustainable way, but to succeed in its aim of conserving natural resources and raising the living standards of local communities, it requires the full involvement of such communities (Nong and Marchke, 2006). Establishing community-based natural resources management frameworks can help to improve local people's socio-economic conditions by helping them to maintain ecosystem services; providing additional income sources and a strong local labor market (Bith, 2011).

Coral reefs can form the basis of tourism and recreation activities, though in recent years coral resources across the globe have been heavily degraded by both natural factors and human activities. In Cambodia, natural damage to coral reefs has increased in recent years due to storms, huge sea swells and climate change (Buddemeirer, *et al.*, 2008; Wilkinson,

2004). The increased amount of Carbon Dioxide in the atmosphere has led to an increase in coral diseases and an invasion of alien species, leading to yet further coral degradation (Wilkson, 2004). Human activities are also harmful to coral reefs, in particular overfishing, the use of illegal fishing gear, soil degradation caused by deforestation, poor land use planning, increasing agricultural pollution, industrial development in coastal area and tourism activities (Eakin *et al.*, 2010; Moberg and Folke, 1999; Wilkinson, 2004). In this paper, we explore the importance of coral reefs to the livelihoods of villagers in the study commune, focusing on: (1) The socio-economic contributions made by coral reefs and the conflicts taking place over their allocation, and, (2) The study villagers' perceptions of the significance and importance of coral reefs for their daily lives.

2. Study area and Research Methods

Both quantitative and qualitative approaches were used for the data collection activities, which took place across three villages: Koh Dach, Phe and Peam Kay, all of which are in Koh Sdach Commune (Figure 1). The selection of the study area was based on the socio-economic and marine natural resource usage activities that take place there, plus due to the fact that the study commune is a focal point for marine pollution and its members carry out illegal fishing activities. Koh Sdach is located on an island and has a total land area of 3km^2. In 2008, roads to the village were surfaced, providing better access to the rest of the island. The community is approximately 280 kilometres west of Phnom Penh, and can be reached by boat (Data gathered from meetings with the Commune Chief and the local community). The study village is surrounded by nine islands, these being Koh Mnose, Koh Kbong, Koh Domloung, Koh Smach, Koh Ampel, Koh Khmauch, Koh Chhan, Koh Tor Teung and Koh Andeuk. The island hosts several types of seaweed and a number of coral reefs, and these reefs provide a natural habitat for marine species and a variety of ecosystems, leading to high

levels of marine species diversity. All of this provides significant potential for ecotourism and conservation activities to be developed. In general, the village has reasonable infrastructure facilities, including health care services and schools. There is a health centre, several small general health clinics and a dentist, all of which serve villagers. In addition, there are two schools; a primary and a secondary/high school.

Our research explored the villagers' socio-economic conditions in Koh Sdach. Based on the Yamen calculation – a formula used to generate samples – 103 households from throughout the village were invited for an interview, plus a group discussion was held and 13 key informants took part in a household survey. The primary data was taken from the household survey, for which the key informants were drawn from key institutions, such as the Fisheries Administration, Commune Councils and Wildlife Conservation Cambodia, and also included village heads and members of the fishing community. The group discussion was held with villagers and village heads, the aim being to ascertain the most important issues being experienced in the study village. Some secondary data was taken from existing sources, including international journals, UN reports and government statistics.

Figure 1: Map of Koh Sdach Village

3. Findings and Results

Socio-economic contributions and conflicts over the allocation of coral reef resources

Living as they do on an island, for local people the nearby coral reefs are the most important livelihood resource. The areas surrounding the island have abundant coral reefs and seaweed, and these provide space for the growth and regeneration of marine fisheries. All the villagers interviewed during our field work are fishermen, meaning their lifestyles and income sources are closely linked. Out of the total number of villagers interviewed, 60% are involved in collecting fish, crabs and crayfish as their primary food and income sources, and 40% are

engaged in fishing activities as a supplementary source of food and income. Other primary occupations among the villagers include aquaculture (3%), tourism (37%) and self-employment (60%). Tourism activities depend closely on the sea and surrounding islands, all of which form a part of the marine ecosystem. Some villagers, and especially women, are self-employed business owners, running grocery stores and guest houses.

Obviously, the surrounding coral reefs provide both economic and non-economic value to the villagers living on Koh Sdach . With abundant coral reef resources and a beautiful landscape, the area has a very high potential for economic activities. In particular, Koh Sdach has well-connected roads, comfortable accommodation and other key infrastructure features which attract both national and international tourists. The island has a number of tourist attractions, guest houses, restaurants and markets, and all of these facilities support eco-tourism. Moreover, the island's port plays an important role in helping to transport fish, seafood and tourists. The beaches are used for swimming and sunbathing, and as mentioned, the island is surrounded by many other islands. Moreover, local fruit farms have helped create a landscape perfect for tourism. In terms of non-economic value, the coral reefs are not used for producing souvenirs, and this helps support ecosystem protection. In the interviews and group discussions held, villagers stated that the reason there are so many fisheries in the study area is because of the coral reefs, which act as fish habitats and breeding areas. Furthermore, they said that the coral reefs protect the shore from the wind and large waves, so reducing the risks faced by fishermen during storms and rough weather.

The interviews held revealed that the sea currents around the island tend to be weak, with only small waves created, allowing the coral reefs to grow and help clean the sea by removing small particles. In addition, the coral reefs provide the villagers with the resources

they need to make medicines, those used to help cure diseases. These resources include starfish and many kinds of coral reef species. The coral reefs also have a high cultural value, as villagers believe they bring good luck to their businesses and jobs. In particular, the coral reefs ensure that the quality of the sea water is good, and help to attract tourists. In total, 57% of the interviewed villagers said that fishing without an appropriate management plan in place, or with no control on the gear used, would likely lead to the disappearance of their traditional fishing activities. In fact, the illegal fishing activities carried out by both local people and outsiders is a key concern among the general population; 67% of those interviewed said that natural resources in the area will be destroyed within the next five to seven years. Already, traditional fishing is hardly practiced due to the decline in fish resources. Over-fishing has severely damaged the coral reefs, based on practices such as dynamite fishing and the use of chemicals and large-scale gear, all of which are banned by law.

The villagers revealed that marine resources are not equally distributed among the population in the study area; there is a very big gap between the poor and better-off households in terms of being able to benefit from the available marine resources. The reason for this is that the poorer households do not have sufficient money to invest in good quality fishing gear and materials, nor to buy bigger boats and nets. Furthermore, those from poorer households are often involved in accidents caused by the big, commercial-scale boats. The villagers reported having had their fishing gear and instruments damaged by such boats in the study areas. Some villagers have fallen into debt, having taken out loans from microfinance institutions and commercial banks in order to buy bigger boats and fishing gear, only to have their boats damaged in accidents or fall into disrepair. During the interviews, villagers stated that marine resources are in decline due to illegal fishing activities, especially those carried out by

outsiders. Fishermen from other villagers use well-equipped and large fishing boats to catch fish using sonar and computer-aided technology. As a result, they are able to catch large amounts of fish, and often damage the coral at the same time. Although not used locally, parts of the coral reef are collected for export to Vietnam. Such illegal activities have been reported to local police officers and Fisheries Administration officials, but have not been stopped because the relevant offices are located a long way from where the activities take place.

Villagers' perceptions of the significance of the local coral reefs

The results of the interviews indicate that the level of local awareness regarding fishing conditions and rules is relatively limited. Of the total number interviewed, 45.4% of villagers said they know about some of the rules and procedures regarding coral reef management activities; usually the most important laws and regulations for their communities' activities, including the punishments given for illegal fishing. The villagers said they find it hard to understand some of the laws and regulations; for example, those related to the conservation of the protected areas and the size of fishing gear able to be used. Also, the villagers are not fully cognizant of the fishing boundaries in place. However, this lack of knowledge is rendered less important by the fact that the villagers are able to ignore the laws to a certain extent by making informal payments to local officers when carrying out illegal fishing activities.

Those who carry out illegal fishing are mostly outsiders, and they do not follow the local laws and regulations. For instance, Article 9 of the Fisheries Law states that a "fishing boundary is determined by the sub-decree [a] A fishing boundary may cover state property or private property during any inundation season", but in reality local people don't know where

the boundaries lie for family fishing. In another example, point 14 under Article 20 of the Fisheries Law prohibits all new fishing technology harmful to fish and fish ecosystems from being used, in accordance with the Ministry of Agriculture Forestry and Fishery (MAFF). According to the interviews held; however, villagers do not understand clearly what types of fishing gear are prohibited. The local villagers claim that they do not fully understand the regulations regarding community-based development activities, because there have been few awareness raising campaigns held in the study commune. At the same time, 14.4% of those interviewed said they have not received any information about the laws and regulations regarding marine resources management.

There are no government institutions working proactively and specifically on coral reef conservation and protection, though the sustainability of the coral reefs remains a big issue. The provincial Fisheries Administration and Department of Environment occasionally send staff to the area, but the Fisheries Administration, which is based on Koh Sdach Island, has insufficient staff and skills available to carry out coral reef management effectively. However, non-governmental organizations (NGOs) such as Wildlife Cambodia Conservation (WCC) are actively involved in coral reef community and marine resources protection activities. As part of their community development activities, the establishment of a coral reef community has been crucial, though in reality it has proved very hard for the community to establish a community fishery, as there are several steps required and many stakeholders to consult in order to make it happen. In recent years, some NGOs such as WCC have worked in liaison with the local government and villagers to try and establish a coral reef community, but as yet is has not happened. In general, NGOs have only been able to help the communities and local people establish elected committees and regulations. Furthermore, the

communities are supposed to carry out daily operations, but cannot mobilize the resources needed for the implementation of these.

In general, women in the study villages play a key role in helping to generate household income, with 89% of women respondents saying their primary occupations are the largest income sources. The women are involved in a variety of different occupations, including fishing, running businesses, working in factories and acting as housewives. For the widows, they tend to go fishing on their own, while others support their husbands with the fishing activities. In general, the women defer to their husbands in terms of decision-making activities; only 16% of the women interviewed said they contribute towards decisions regarding their families and social activities. Instead, they support their husbands collecting and processing the fish, plus work very hard preparing and maintaining the fishing gear. When it comes to finances (including taking out loans) and looking after the children and elderly; however, the women play a key role. Occasionally, the women participate in coral reef community activities when their husbands are busy with work, and as such act as substitutes for the men when they are absent. Overall, even if the role of women is not officially recognized in the community rules, they do contribute towards decision making in the study communities.

4. Conclusion

Based primarily upon the authors' findings in Koh Sdech village, it can be concluded that: (1) Coral reefs are a key resource in terms of local people's livelihoods on the study island. Out of the total questioned, 60% of the villagers stated that their primary occupations depend on the reefs, while the other 40% have collecting fish, crabs and crayfish as their secondary occupations. Moreover, the local coral reefs have both economic and non-economic value, as

they provide marine resources, medicines and a beautiful landscape, (2) Coral reef resources are not equally distributed among the villagers; there is a gap between the poor and better-off households in terms of benefiting from the reefs. The better-off households can invest in fishing gear and materials, while the poorer households are frequently involved in accidents caused by the larger, commercially run boats, with a number of villagers reporting damage to their fishing gear as a result of such incidents. (3) The level of awareness among villagers of the official fishing laws and relations is very limited, with less than half the villagers being aware of the rules regarding coral reef management. However, the establishment of a coral reef community could be crucial in helping to protect the reefs, though due to the complexities involved it will be difficult for the community to establish such a community, and (4) Women in the community support the men in helping to collect and process coral reef resources, as well as with resources management activities in general, yet only 16% of the women contribute to decision making activities related to family matters and social activities.

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A Trade-off between Conservation and Fisheries-dependent Livelihoods around Tonle Sap Lake in Cambodia

Seak Sophat*, Ouch Mara, Khan Lyna and Thou Reno

Abstract

In Cambodia, fish taken from Tonle Sap Lake play a very important part in the livelihoods of rural fishers. This paper explores the trade-off that needs to take place between conservation efforts and fishery dependent livelihoods around Tonle Sap Lake, focusing in particular on: (a) the importance of fishing to local people's livelihoods, (b) the influence of illegal fishing activities, and (c) the local people's involvement in patrolling for and reporting on these illegal fishing activities. The findings of the research reveal that: (1) Fishing is an important source of food and income for fishers, (2) Only a few fishers report on illegal fishing activities and are involved in patrols, due to concerns over safety and their ignorance of the legal actionsthat can be taken against offenders, and (3) Fishers would not fish illegally within the local fish sanctuary if they were provided with information about the fishing ban in place there.

Key words: Conservation, fishery-dependency, livelihood, Tonle Sap Great Lake

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*S. Seak(□)
Department Head, Department of Natural Resource Management and Development, Faculty of Development Studies, Royal University of Phnom Penh E-mail: seaksophat@gmail.com

1. Introduction

The inland fisheries of Tonle Sap Lake contribute a huge amount to Cambodian culture, livelihoods and lifestyles. Also, these fisheries have long been depicted as the centre of food security foraround 1.25 million Cambodian people who reside around the lake (Navy *et al.*, 2006). Interestingly, fish resources in the lake rank number one in the world in terms of productivity,[1] and fourth in terms of catch sizes[2] (Baran *et al.*, 2007). In addition, Baran (2005) stated that fisheries on Tonle Sap Lake contribute 60% towards total fisheries production in the country, and that local people fish and farm its rich fishing grounds, floodplains and forests in seasonal cycles. Added to this, Tonle Sap Lake is the largest freshwater body in Southeast Asia and exhibits unique hydrological phenomenon, plus is the breeding ground for many Mekong River species and mediates the river's flood system. As a result, it can be seen that the significance of the lake reaches far beyond Cambodia (UNDP-GEF, 2002).

The communities situated alongside Tonle Sap Lake are generalized as "fisheries-dependent", with the people living in them relying heavily on fish resources (Rab*et al.*, 2005). According to the categorization used by Baran (2005), fishing on Tonle Sap Lake can be categorized into three different types: small-scale; medium-scale and large-scale. Large-scale fishing areas, or fishing lots, were originally auctioned-off by the Royal Government of Cambodia (RGC) to the highest bidder **(**Navy *et al.,* 2006). The winners of this process gained exclusive rights to fish over a two-year period,and were able to use large-scale fishing gear such as *seine* nets and bamboo barrage traps (Van Zalinge *et al.,* 2000, Navy *et al.,*

[1]The catch per fisher amounts to 20 kilogrammes (kg) per person per year (compared to 4.5 kg/person/year in Bangladesh and 0.5kg/person/year in India). The natural productivity of the Tonle Sap's floodplains ranges from 130 kg to 230 kg/hectare/year, the highest globally.

[2]Research suggests that production ranges from 290,000 tonnes to 430,000 tonnes per year.

2006, Baran, 2005). Medium-scale or *dai* fishing is based on a kind of bag net or stationery trawl, which is positioned in a river to capture fish migrating downstream. This form of fishing is allowed commercially between October and May, a time during which the water level in Tonle Sap Lake drops; October being the high point, and under current regulations, no license is required to operate this scale of operation. In general, small-scale fishing, also called family or 'survival'fishing is employed by those whose livelihoods rely entirely on Tonle Sap Lake and its resources, and it is usually practiced by family members using small-scale fishing gear such as bamboo fences traps and gill nets. It is also true that small-scale fishing is more significant in terms of supporting livelihoods, food security and national income than most people realize (FAO, 2000).

Gum (2000) pointed out that accessibility to common property resources such as fisheries is significant for villagers who wish to cover the risk inherent in their agricultural activities. As a result, the recent decrease in access to fisheries resources due to ineffective management and illegal fishing has badly affected the livelihoods of poor, rural villagers, those who have limited land available to carry out agriculture. In particular, fish are the main source of animal protein for poor villagers living around Tonle Sap Lake, a group which represents 15% of Cambodia's total population (Gum, 2000, Kaing *et al.,* 2003). Due to the current population growth rate in the country of 2.49% (MoP, 1998), there is a need to expand fishing grounds and increase fisheries' productivity levels; however, influential leaseholders are increasingly restricting access to fishing grounds and causing conflicts with small-scale subsistence fishers. The main reasons for these conflicts include abuses of power, the unequal distribution of benefits and the restriction of access to fishing grounds (Kaing *et al.*, 2003).

In 2012, the RGC introduced a fisheries policy reform; transferring the bulk of fishing rights from the large-scale commercial fishers to small-scale subsistence fishers.As a result 56%, or 500,000 hectares of the former fishing lot areas previously assigned to the commercial sector, was released for local communities to manage[3]. In addition, in March 2012 the RGC decided to cancel all fishing lots nationwide, also handing them over to local communities – for them to use, manageand conserve. Many of the studies of Tonle Sap Lake carried out by academic scholars have focused on governance (Sokhem and Sunada, 2006; Sok *et al.*, 2013), community-based management (Sok *et al.*, 2012), the socio-political context of resource management (Mak, 2014; Thol and Jin, 2014), ineffective integrated water resources management (Varis and Keskinen, 2006), and also physical, ecological and social system interactions (Neou and Lane, 2002).

In this paper, we will examine the trade-off that exists between conservation and fisheries-dependent livelihoods around Tonle Sap Lake in Cambodia. In particular, our study focuses on (a) the importance of fishing to local people's livelihoods, (b) illegal fishing activities and the local people's involvement in patrolling for these activities, and (c) the involvement of fishers in reporting on illegal fishing activities.

2. Study Areas and Methods

In this research, a household survey was used to obtain quantitative data, while social science tools were applied to gather qualitative data during the field work and data collection period. Data was collected in September 2014 across two communes adjoining Tonle Sap Lake: Chhnock Trou in Kompong Thom Province and Pat Sandai in Kompong Thom Province (see

[3]Keynote address given by Samdech Hun Sen, Prime Minister of Cambodia, at the National Forum on the Tonle Sap Initiative, Hotel Inter-Continental, Phnom Penh on 5thMarch 2007.

Figure 1). Administratively, Chhnock Trou is one of 11 communes in Boribour District, and has a total population of 895 households. As for Pat Sandai, it is one of 11 communes in Kompong Svay District and has a population of 975 households (Commune Database Online, 2014). In accordance with Yamane's (1967) recommendations, our survey sample consisted of 346 fishers; 170 in Pat Sandai and 176 in Chhnock Tru. At the individual level, each fisher was contacted in order to gain his or her consent to be interviewed. For the qualitative data, group discussions were held among the fishers and with several key informants such as commune heads, village heads and NGO staff. For the quantitative analysis, a Chi-square test (x^2) was used to uncover any relationships between (1) those participating in illegal fishing patrols and their personal safety, (2) those informing about illegal fishing activities and their personal safety, and (3) the level of awareness of any fishing bans inside the fish sanctuaries[4] and the carrying out of fishing activities there. For the qualitative analysis, academic journals and other published documents acted as the main sources of secondary information.

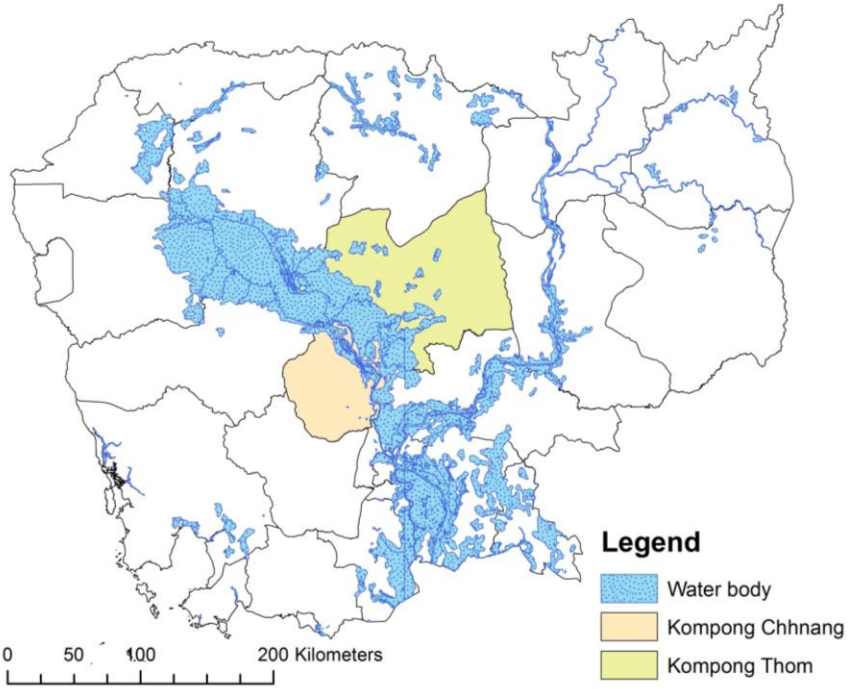

Figure 1: Map of Cambodia showing the Study Provinces

[4] Inside fish sanctuaries, all fishing activities are prohibited, allowing fish reproduction activities to carry on unhindered. They are also used for research and for scientific study.

3. Findings and Results

3.1 Importance of fishing to local people's livelihoods

In the communities around Tonle Sap Lake, fishing is a key part of the people's culture and lives, and every household is involved in this activity in one way or another, whether it is the primary or secondary livelihood activity (Village Head in Chhnock Tru, pers. comm. in September 2014). In the two study areas, fish are eaten and sold every day, and overall, 65% of the fishers in this study stated that fishing is vital for their livelihoods (68% in Pat Sandai and 61% in Chhnock Tru; see Figure 2).

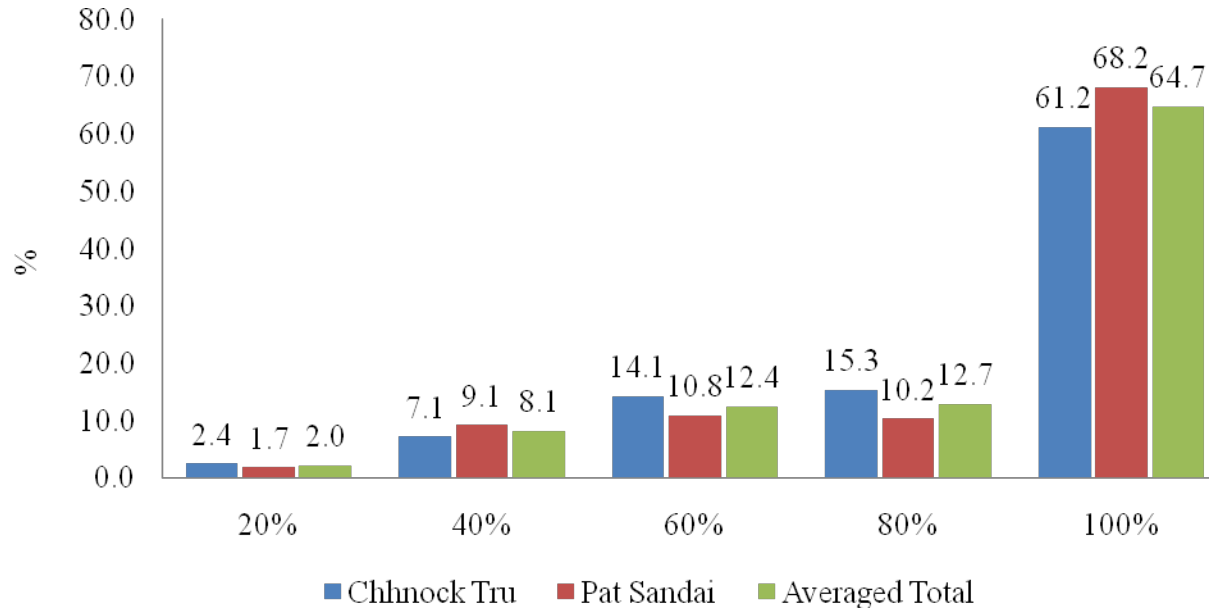

Figure 2: Importance of Fishing Activities to the Livelihoods of the Study Villagers

In the wet season, Pat Sandai Commune is a fully floating community, and it is quite a long way and expensive to travel by boat to the nearest river. At this time, the residents depend mainly on fishing for their livelihoods, while in the dry season they undertake agricultural activities (Village Head in Pat Sandai, pers. comm. in September 2014). Many residents in Chhnock Tru can travel fairly easily to the provincial town of Kompong Chhnang for work and to carry out business activities; some work in the private sector to supplement their incomes and support their households (Village Head in Chhnock Tru, pers. comm. in

September 2014). Commercial fishing is vital to the households in both study communes (see Figure 3), and the villagers sell their fish catches in two key ways: (1) using middlemen who visit the fishing areas, and/or (2) through middlemen who operate at the local markets.

Most fishers prefer to sell their fish directly to the middlemen in the fishing areas, because they do not want to have to pay to travel to the market, even though they fetch a relatively low price locally. However, those who catch larger amounts of fish prefer to sell to the middlemen at the markets, as they can obtain a better price there (Committee Member, Community Fishery in Pat Sandai, pers. comm., September 2014). In the study areas, about 47% of fishers in both communes said they sell around 70% of their fish catches and keep the remaining 30% for household consumption. Of the total number of fishers in the study, 27% in Pat Sandai said they sell 60% of their fish catches directly to the middlemen who visit the communities; however, in Chhnock Tru only 13% said they sell their fish catches to these middlemen, as they prefer to sell at the local market.

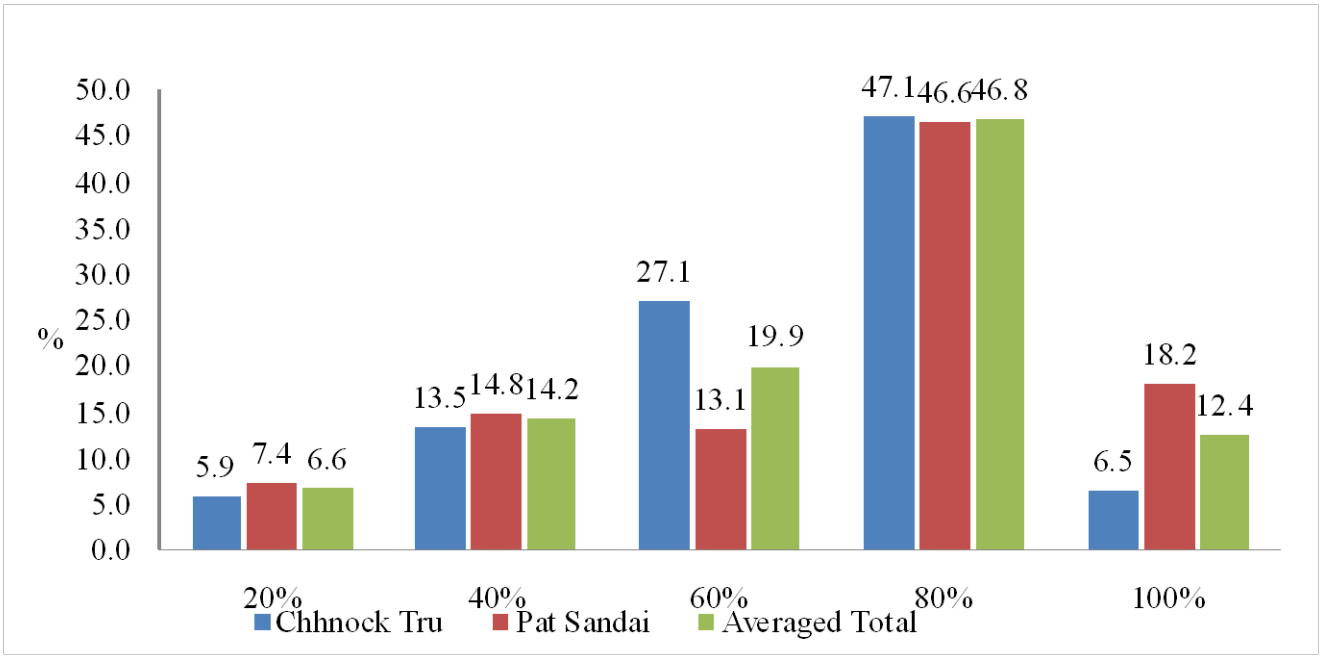

Figure 3: Proportion of Fish Catch used for Commercial Purposes by the Study Fishers

3.2 Illegal fishing and villagers' involvement in patrols

Sub-decree 37 issued on March 2012 was the last important reform to be introduced by the RGC, as it cancelled all the fishing lots in Cambodia, handing them over to local communities – for them to manage and protect. In the communities, fishers were given an important role in helping to inform relevant officers at the Provincial Office of Fisheries, the Provincial Office of the Environment and in the police of any illegal fishing activities they came across in their areas. Figure 3 shows fishers' level of involvement in patrolling for and informing on illegal fishing activities in the study communities. These fishers were also asked how safe they feel when carrying out these tasks.

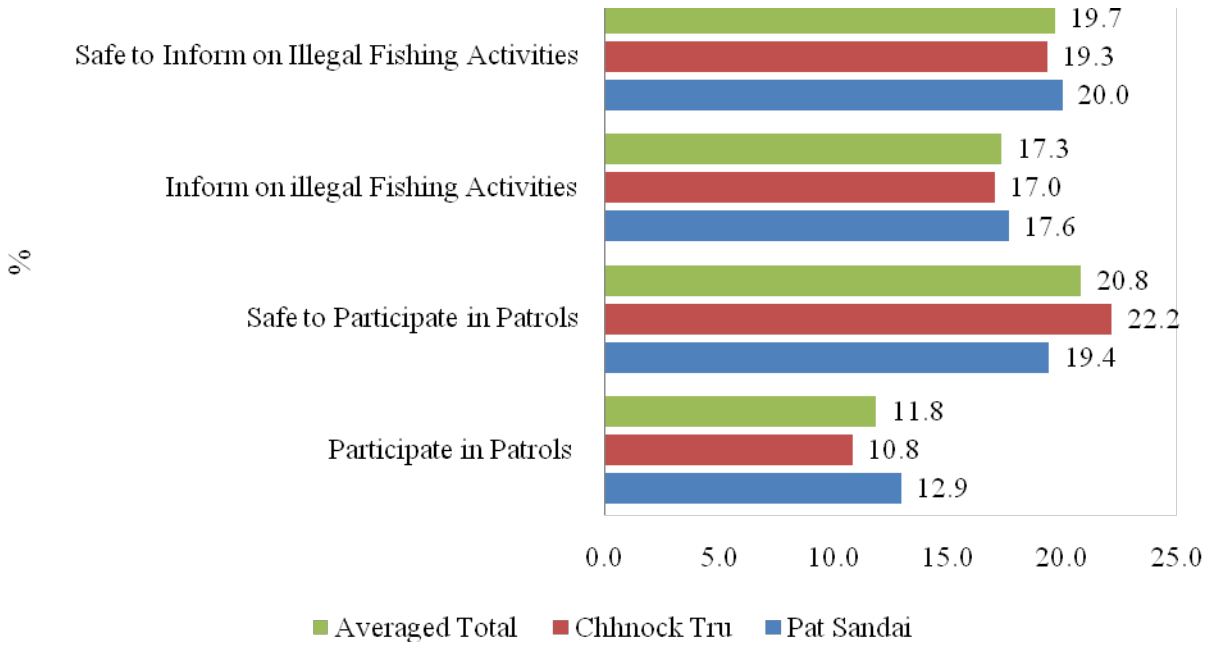

Figure 4: Study Fishers' Participation in Patrolling for and Reporting on Illegal Fishing Activities

Overall, only around 18% of fishers said they report on illegal fishing activities and only 13% said they participate in illegal fishing patrols, due to concerns over their safety. In both communities fishers said that patrols are not carried out unless support is received from NGOs such as WorldFish and the Asian Development Bank. Currently; therefore, fishers do

not feel safe enough to inform the Provincial Office of Fisheries, the Provincial Office of Environment or the police if they witness illegal fishing activities, particularly aslittle action is taken against the perpetrators afterwards (Community Fishery in Pat Sandai, pers. comm. in September 2014). In general, the fishers said that community fisheries and NGO focal points are actively involved in a campaign to identify illegal fishing activities, but that their personal safety is not assured (NGOs Focal Point in Chhnock Trou, pers. comm. in September 2014).

Picture 1: Middlemen Waiting to Buy Fish from the Fishers

3.3 Involvement of fishers in patrolling for and informing on illegal fishing activities

A Chi-square test (x^2) was employed to discover if there is any relationship between: (1) fishers' participation in illegal fishing patrols and their safety concerns, (2) fishers informing on illegal fishing activities and their safety concerns, and (3) fishers' level of awareness of the fishing ban inside the sanctuary and whether they go fishing there or not. The same Chi-square analysis confirmed that all of these relationships were significant (*P= 0.000*'; see

Table 1). Fishers do not wish to join patrols, nor do they wish to inform the authorities of illegal fishing activities, because they fear for their safety; however, in general they actively participate in community meetings, group discussions and workshops organized by the government and NGOs about fisheries management. On a positive note, the test revealed that those fishers who are aware of the fishing ban inside the sanctuary do not tend to fish there.

Picture 2: Fishers Arriving Home from their Fishing Trip

Illegal fishing takes place throughout Tonle Sap Lake due to weak law enforcement by the Provincial Office of Fishery, the Provincial Office of Environment and the police (NGOs Focal Point in Chhnock Tru, pers. comm. in September 2014). Little if any legal action is taken by the relevant officers, even if they have been provided with information by local fishers (Village Head in Chhnock Tru, pers. comm. in September 2014). Moreover, fishers stated that they are not comfortable either joining-in with patrols or providing information on illegal fishing activities to the authorities (Fishers in Chhnock Tru, pers. comm. in September 2014). In relation to patrols, the fishers are reluctant to get involved because they feel it is not their responsibility to have to deal with the illegal fishers, plus they have insufficient funds to

join-in anyway, given that they have to pay for gasoline themselves (Committee Member, Community Fishery in Pat Sanday, pers. comm. in September 2014).

Table 1: Fishers' Views on (i) Participation in Patrols/Informing on Illegal Fishing Activities and Safety Concerns, and (ii) Fishing inside the Sanctuary and their Knowledge of the Fishing Ban

Fishers' Views on Participation in Illegal Fishing Patrols and Safety Concerns					
Variables			Safe to Patrol	X^{2a}	p^b
		N	Yes	No	
Join-in with Patrols	Yes		19	22	17.804	.000 [b]
	No		54	251		
	Total		73	273		
Inform on Illegal Fishing Activities/Safety Issues for Fishers					
			Safe to Inform		
Inform on Illegal Fishing	Yes		39	30	41.077	.000[b]
	No		30	247		
	Total		69	277		
Fishing Activities inside the Sanctuary/Awareness of the Fishing Ban					
			Know about the Ban		
Catch Fish inside theSanctuary	Yes		99	2	234.225	.000[b]
	No		219	22		
	Total		318	24		

[a]X^2: Critical Chi-square values were 17.804, 41.077 and 234.225 with 1 degree of freedom. The Chi-square distribution table provided similar P values of 0.000. This meant that the test results for the three variables were significantly different.
[b]*P*: Significant at 1%.

Fishers' lack of willingness to carry out the two key monitoring and reporting activities has given illegal fishers the opportunity to fish inside the sanctuary and/or use large-scale fishing gear, that banned by the law (Fishers in Pat Sandai, pers. comm. in September 2014). It is unlikely small-scale fishers will survive this situation for long, because fish resources are under threat from so much illegal fishing (Committee member,community fishery in Pat Sandai, pers. comm. in September 2014).

Conclusion

Based on the findings described here, we can conclude that: (1) Fishing is vitally important in helping support the incomes and daily food consumption activities of fishers in the study communities. Of the total fishers questioned, an average of 65% said they are completely dependent on fish resources; 68% in Pat Sandai and 61% in Chhnock Tru. Almost half of the fishers said they use 70% of their fish catch as an income stream and retain 30% for daily household consumption purposes. The fishers sell their fish in two key ways: through middlemen who visit them in their fishing areas and/or through middlemen based at the local markets. (2) Only a few fishers monitor illegal fishing activities and report such activities to the relevant officers. In terms of the fishers' involvement in patrolling activities, they said that safety issues and their lack of knowledge of the legal actionstaken against offenders by relevant officers are the main reasons why they do not participate in patrolling activities, even though they know that such patrols are key to the conservation and management of fish resources. From the survey, it was also found that only 18% of fishers inform on illegal fishing activities, while even fewer (13%) participate in fishing patrols. And (3), those fishers who know about the ban confirmed they do not go fishing inside the sanctuary.

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The Cancellation of Fishing Lots on Tonle Sap Great Lake in Cambodia: Changes in fish productivity and livelihood development

Seak Sophat*, Khan Lyna, Ouch Mara and Thou Reno

Abstract

The Royal Government of Cambodia (RGC) has given a strong political commitment to improve the livelihoods of those who depend on fishing for a living in the country, based primarily on the implementation of effective fisheries management and conservation policies. Since the 2000s, there have been several policy reforms introduced by the RGC, with sub-decree 37 introduced in March 2012 being the most recent reform, one which cancelled the use of fishing lots throughout Cambodia, and handing these areas over to local communities for them to manage, the aim being to conserve fisheries resources. This paper presents the impacts of this withdrawal of the fishing lot system on the fish production and livelihood development activities of those who live around Tonle Sap Great Lake. The study focuses on changes in fish production levels and fishing areas used, and those factors which have influenced fishers' livelihoods since use of the fishing lots ended. The results show that: (1) Fisheries are now less productive than they were prior to cancellation of the fishing lots, (2) Access to fishing areas is now open to people from throughout Tonle Sap Great Lake, and that this open-access has led to more illegal fishing activities taking place, and that (3) The active participation of fishers and the introduction of local community fishery initiatives are both vital for the development of sustainable livelihoods in the study area.

Key words: Fishing lots, fishery production, Tonle Sap Great Lake, Cambodia

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*S. Seak (□)
Department Head, Department of Natural Resource Management and Development, Faculty of Development Studies, Royal University of Phnom Penh E-mail: seaksophat@gmail.com

1. Introduction

The Mekong River Basin (MRB) can be divided into two parts: the Upper Mekong Basin (UMB) – which includes China and Myanmar, and the Lower Mekong Basin (LMB) – which includes parts of Cambodia, Lao PDR, Thailand and Vietnam. The LMB, which is home to more than 60 million people and covers 78% of the MRB's total area, contains a wide range of water-based ecosystems, such as rivers, lakes, ponds, swamps and streams (MRC 2010a). The water, fish and aquatic resources to be found in the LMB have long played a vital role in supporting the food consumption, income and livelihood activities of millions of people. In particular, the LMB contains one of the largest and most important freshwater fisheries in the world: Tonle Sap Great Lake (MRC, 2002). In terms of economic value, the fisheries sector contributes about 12% to Gross Domestic Product (GDP) among the LMB countries, and provides most people there with vital sources of animal protein, calcium and vitamin A (MRC, 2004). Recent estimates by Hortle (2009) found there are around 850 fish species in the LMB; most of which support the rural dwellers' way of life, emphasizing their reliance on fish and the habitats that support them (Halwart, 2008). In 2002, the Mekong River Commission (MRC) estimated that the annual fish catch in the MRB as a whole is around 1.5 million tonnes, with 0.5 million tonnes also caught in reservoirs and through other forms of aquaculture (MRC, 2003). In terms of its monetary value, this fish catch was estimated to be worth 2.6 billion USD, with the value of other aquatic animals such as frogs and crabs adding up to 249 million USD (MRC, 2009).

Tonle Sap Great Lake represents the heart of the LMB. It is the largest freshwater lake and most significant wetland in Southeast Asia, supporting fisheries and other living aquatic resources. The lake's fisheries contribute significantly to the livelihoods and lifestyles of those who live in Cambodia, with its fish and other aquatic resources long being depicted as

the centre of the country's food security, directly supporting around 1.25 million Cambodian people who live around its shores (Hap *et al.*, 2006). Cambodia is home to the world's most productive inland fishery (Baran and Kura, 2007), with the annual catch conservatively estimated to be 400,000 tonnes, two-thirds of which is contributed to by the lake itself. The majority of those who live in the Tonle Sap Great Lake[5] area are low-income, small-scale and subsistence fishers who live in fishing villages and can be generalized as being "fishing-dependent" (Hap *et al.*, 2006). The fisheries sector makes a vital contribution to the national economy, accounting for 10% to 12% of the nation's GDP (MRC 2010b). A recent estimate showed that the average person in Cambodia consumes 52.4kg of fish per year, representing more than 80% of their total animal protein intake (Hortle, 2007).

Given the lake's significance to the livelihoods of millions of Cambodians, as well to the region's environmental conversation and resource management activities, a number of scholars have linked their research work to fisheries governance (Sok *et al.*, 2014; Sokhem and Kengo 2008, Thol and Sato 2014), community fisheries and natural resource management around the lake (Bonheur and Lane, 2002; Sok *et al.*, 2012), as well as declines in the lake's fisheries (Baran and Myschowoda, 2008), socio-economic development (Hap *et al.*, 2006), and the impacts of livelihood and climate change in the area (Nuorteva, 2010). The central studies of Tonle Sap Great Lake have focused on conservation, management and livelihood development activities among the fishers there. The first fisheries policy reform[6] in

[5] The six provinces located around the lake have a population of nearly three million people (about 30% of the country's total population), about one-third of which lives in floating villages around the lake and within the inundated forests (Nao Thuok *et al.,* 1996). Among the fishing communes: 58% can be classified as primarily fishing districts, home to 2.4 million inhabitants (1995). Actually, when Kandal and Kompong Cham provinces are removed from such statistics, as they are not located around the Great Lake, this leaves 161 communes out of 307 that can be classified as fishing communes (52%), with a population of 1.2 million (1995).

[6]Keynote address by Samdech Hun Sen, Prime Minister of Cambodia, at a National Forum on the Tonle Sap Initiative, held at the Inter-Continental Hotel in Phnom Penh on 5 March 2007.

2000 was vital in terms of giving the poorer communities access and user rights to, as well as management responsibility for, fisheries and inundated forests in the country, including Tonle Sap Great Lake, the aim being to improve livelihood opportunities and food security among communities. In 2000, the RGC decided to transfer the majority of fishing rights from the large-scale commercial fishing operators to the small-scale subsistence fishers. As a result 56% (500,000 ha) of the former fishing lot areas allocated to the commercial sector was released to the local communities at that time; for them to manage. The most recent and important policy reform introduced by the RGC in March 2012 cancelled the remaining fishing lots throughout Cambodia, handing them over to communities carrying out small-scale fishing activities.

This paper examines the impact of this cancellation of the fishing lots on fish production activities and livelihood developments around Tonle Sap Great Lake, focusing particularly on changes in fish production activities and the fishing areas, and also those factors influencing the livelihoods of people dependent on fish since the fishing lots were removed.

2. Study Areas and Methods

After the policy reforms were introduced in 2000, many communities around Tonle Sap Great Lake were empowered with regard to resource management and conservation activities, due to the establishment of community fisheries. The number of these fisheries had increased to 440 by 2005, increasing in number at an average 28.5% each year (see Figure 1). Out of this total, about 266 community fisheries (60%) have by-laws, 135 (31%) have maps, 57 (13%) have their own action plans, and 74 (17%) have fish sanctuaries (ADB, 2012).

Table 1: Characteristics of the Study Communes

Chhnock Trou Commune	Phat Sanday Commune
• Live in a floating commune the whole year	• Live in a floating commune during the wet season only.
• No community fishery due to a lack of fishing grounds	• Community fisheries established after 2007
• Most fishers go fishing in other districts or provinces	• Some fishers fish in the commune community fishery
• Few opportunities for communities to get involved in patrols looking for illegal fishing activities	• Some patrols carried out by the community fishery looking for illegal fishing activities

According to Cambodia's sub-decree on community fisheries management published in 2005, a community fishery is a group of Cambodian people living in one or more villages in Cambodia who voluntarily agree to cooperate and participate with each other for the purpose of: (i) participating in the sustainable management, conservation, development and use of fisheries resources in their local areas, and (ii) protecting the rights and interests of Cambodians in accordance with all legal instruments related to the fisheries sector (MoFF, 2010).

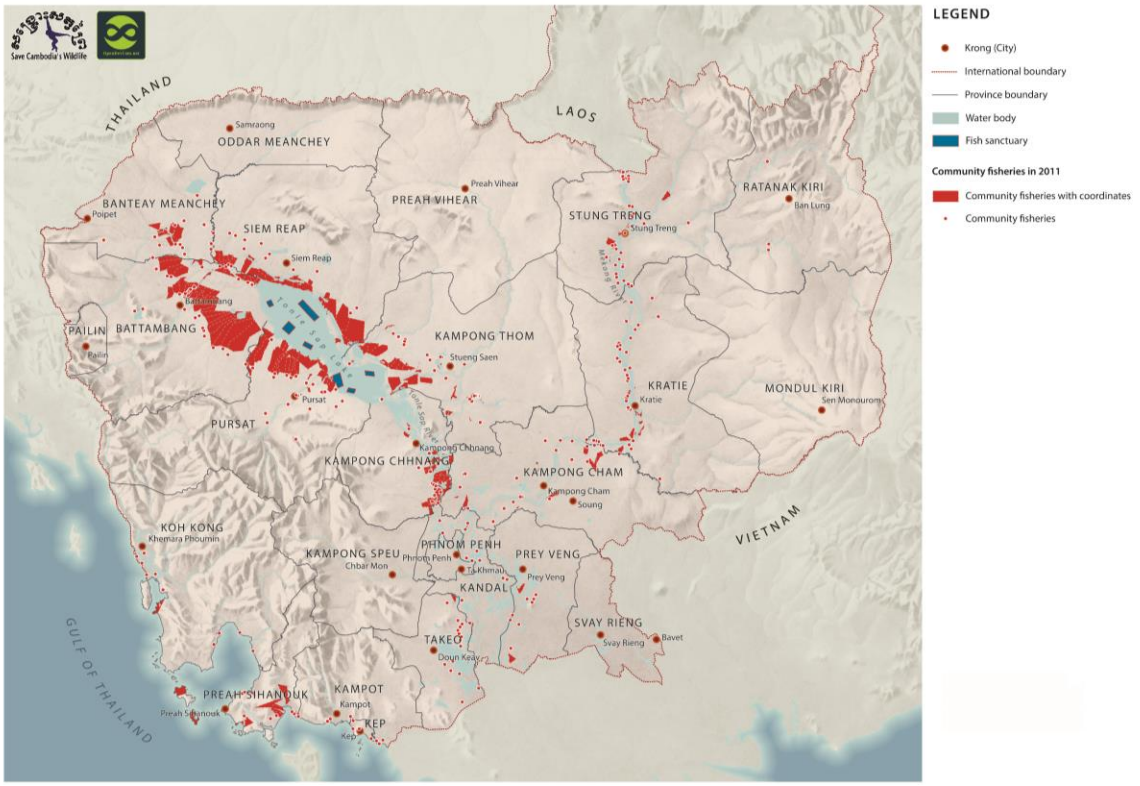

Figure 1: Map of Community Fisheries and Sanctuaries in Cambodia

Source: Open Development Cambodia, 2014

The research project included a household survey to obtain the quantitative data, and used participatory approaches to obtain the qualitative data. Field work was conducted during September 2014 across two communes: Chhnock Trou in Kompong Chhnang Province, and Phat Sanday in Kompong Thom Province (see Table 1). Chhnock Trou is one of 11 communes in Boribour District, Kompong Chhnang Province, and has a total of 895 households. As for Phat Sanday, it is one of the 11 communes in Kompong Svay Districtm, Kompong Thom Province, and has 975 households (Commune Database Online, 2014). The study survey sample contained 346 fishers: 170 in Phat Sanday and 176 in Chhnock Trou, in line with Yamane's calculations (1967). Each person selected was invited for an interview. Also, group discussions were held among the fishers and village heads in each commune, and key informants chosen from among commune and village heads, as well as staff of local non-

governmental organizations (NGOs). For the purposes of quantitative analysis, logistic regression was used to predict whether the suggested variables were significant in contributing to people's livelihoods. Also, a t-test was used to investigate any differences and similarities among the variables related to fish production activities before the fishing lots were withdrawn, and since. For the qualitative analysis, academic journals and other published documents were used as the key sources of secondary information (Table 1).

3. Findings and Results

3.1. Changes in fish production activities since closure of the fishing lots

Fisheries share a similar importance for the villagers in the two study communes, with any changes in the quality and quantity of fish directly affecting daily food consumption, income generation and livelihood development activities among the villagers. In Chhnock Trou; for example, the villagers highlighted the significance of fisheries for their income generation and daily food consumption activities, plus expressed significant concern for the recent decline in production levels within the fisheries. Table 2 shows the average fish catch before and since the fishing lots ceased operating in Phat Sanday and Chhnock Trou. The fish catch is shown to be larger in the dry season (36.7kg) than in the wet season (21.6kg), but since the fishing lots were closed, fishers have caught less fish in both seasons. Fishers in Phat Sanday and Chhnock Trou said that the number and diversity of fish has declined since 2013, and that this trend began in 2005. In Phat Sanday, fishers complained about the extensive illegal fishing that takes place, the water pollution caused by the use of agro-chemicals in neighbouring districts, and the destruction of the flooded forests. The absence of any community fisheries was one of the key reasons given for the decline in the fisheries around Chhnock Trou (Phat Sanday Community Fishery; personal communication in September 2014).

Moreover, fishers spend longer collecting fish in the wet season (5.1 months) than in the dry season (4.3 months), but said there is no significant difference between the time spent now and prior to closure of the fishing lots. In general, fishers in both communes go fishing all-year-round if they do not have any other business or do not migrate to urban areas or other provinces in search of work (Chhnock Trou village head; personal communication in September 2014). During group discussions in the two communes, the fishers confirmed that fishing is their life; they spend most of their time on Tonle Sap Great Lake – fearing the arrival of storms, especially in the wet season – catching fish for food and to earn an income. In the dry season, some fishers in Phat Sanday settle on land, while others move their homes along with the falling water levels. Some fishers then become involved in rice or cropping cultivation activities around their houses, or on land in other districts. In contrast, fishers in Chhnock Trou said they move their houses with the water level, and seem to engage in fishing all-year-round, as they do not have land on which to practice agriculture.

Picture 1: A Small-scale Fisher Gathering Fish in Chhnock Trou Commune

However, fishers in the two study communes confirmed that despite rapid declines in fish catches, investment has remained relatively high. Some fishers got into debt when their fishing gear was confiscated by officers from the Provincial Office of Fishery, the Provincial Office of Environment, and the police. One fisher stated that costs have risen but that the fish catches have fallen in recent years (Fisher in Chhnock Trou; personal communication in September 2014), though the price of fish has also risen; fish are particularly expensive in the wet season. During a group discussion conducted in Phat Sanday, fishers said that fish can be sold at a higher price when they are scarce. Also, according to a commune head in Chhnock Trou, fishers sell their fish to middlemen who work around Tonle Sap Great Lake. The fishers could probably sell directly to the dealers for a better price, but would have to spend a lot on gasoline when travelling by boat to the dealers' trading locations.

Table 2: Fish Production before and since Closure of the Fishing Lots

Attributes	Since Closed	Before Closed	Overall	*P-value*
	Fishing Lot Operations			
Mean fish catch in the dry season (*kg*)	24.8	48.7	36.7	***.000****
Mean fish catch in the wet season (*kg*)	14.1	29.0	21.6	***.000****
Fishing period in the dry season (*Months*)	4.4	4.3	4.3	.202
Fishing period in the wet season (*Months*)	5.1	5.1	5.1	.782
Mean fish price/kg in the dry season (*Khmer Riels*)	2505	2009	2257	***.000****
Mean fish price/kg in the wet season (*Khmer Riels*)	2913	2254	2584	***.000****
Mean investment in fishing gear (*Khmer Riels*)	2,035,064	2,425,717	2,230,390	.057

Notes: *bold font indicates significance

3.2. Fishing areas since cancellation of the fishing lots

Before March 2012, many villagers could not even fish close to their houses because such areas were part of the fishing lot system, and specifically fishing lots 2, 3 and 4. The head of the community fishery in Phat Sanday said that fishing lot 1 was first handed over to the community in 2008/9 (head of Phat Sanday community fishery; personal communication in September 2014), after many years of advocacy (with financial and technical support coming from NGOs) had shown the government that fishing lots were seriously and negatively affecting the security and livelihoods of fishers (Community Fishery Committee member in Pat Sanday; personal communication in September 2014). Fishers said they had to pay the fishing lot owners to go fishing within the lots, and for those fishers not willing or able to pay, they could not go fishing within 500m of the lot boundaries. In March 2012, the

government decided to close all the fishing lots country-wide, handing the former lot areas over to local communities, for them to use, manage and conserve. During the interviews, the majority of fishers (80.9%) said that they can now catch fish anywhere on Tonle Sap Great Lake, though the numbers varied slightly between Phat Sanday (83.5%) and Chhnock Tru (78.4%). However, though they are allowed to fish, the fishers in both communities are required to take their fishing gear (such as nets) to the Provincial Office of Fishery to have the mesh sizes checked. More often than not, they then have to pay a bribe to the relevant government officers, or sell their fish to the officers' wives/relatives at a cheaper price. Those fishers who do not want to pay; therefore, say that the areas within which they can fish are just as restricted as they were when the fishing lots operated.

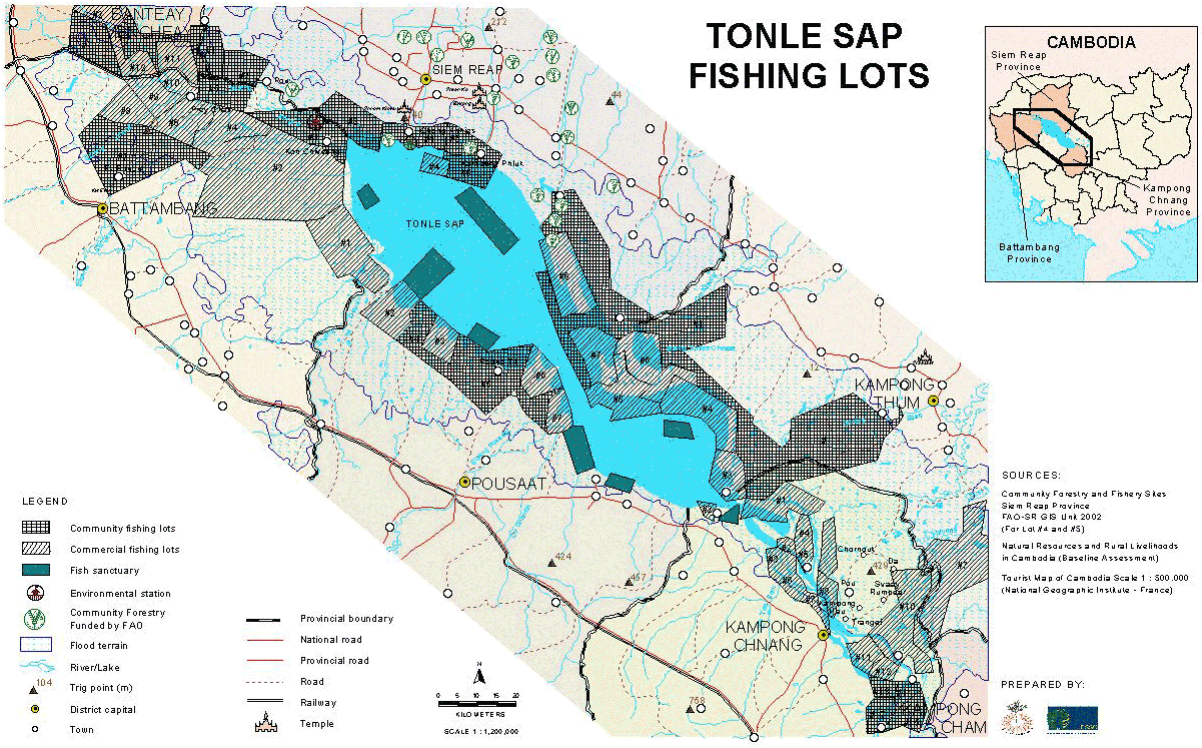

Figure 2: Fishing Areas Used before and since Closure of the Fishing Lots

Figure 2 shows that many fishers now go fishing in other provinces, and especially those from Chhnock Tru, who travel to nearby districts or to Kompong Thom or Pursat provinces, because there is no community fishery in their commune. Fishers in Chhnock Trou;

meanwhile, have asked the Commune Council and the Provincial Office of Fishery for a community fishery to be set up there to conserve the local flooded forests, as there are no fishing grounds (NGO Focal Point in Chhnock Trou; personal communication in September 2014). Members of the discussion groups mentioned that because there is no community fishery, they have to travel to other districts or provinces to go fishing, which sometimes brings them into conflict with the restrictions imposed by the other fisheries and the involved agencies. Since the fishing lots were closed, the fishers in Phat Sanday have extended their fishing area into Pursat Province. Most of the fishers in Phat Sanday use traditional, bamboo *cylin* nets, which are banned, while those in Chhnock Trou use ordinary nets to catch fish, which are not banned. However, the fishers in Phat Sanday do not wish to change the methods they use to catch fish, even though the nets are banned, as it is their tradition (NGO Focal Point in Chhnock Trou; personal communication in September 2014).

Picture 2: A Fisher's Boat and Gear before going Fishing

Before the fishing lots were closed, fishers had to pay the lot owners to use their fishing grounds, while now they have to pay bribes to the local officers in order to fish illegally. One fisher complained in a group discussion:

> "We cannot go fishing without paying bribes to the relevant agencies, because we can never use the legal fishing gear required by current laws

> and regulations. We have to pay around two or three million Khmer Riel per year to be allowed to use our illegal gear. When the fishing lots were open, we could catch more fish and had to pay less to the lot owners. Before, fishers paid the lot owners in order to go fishing, but now we pay the Provincial Office of Fishery, the Provincial Office of Environment and the police. As a result, there is little or no difference between the situation now, and that which existed before the fishing lots were closed. The closure of the fishing lots was a good thing, as it has since allowed us to fish anywhere, and there are no lots owners to put pressure on us. However, poor management has led to extensive illegal fishing and bribery. Nowadays, those who can afford to invest in gear and pay bribes are able to catch more fish" (committee member, community fishery in Phat Sanday; personal communication in September 2014).

One fisher said that with no restrictions on the activities of the large-scale fishers, the fish will soon be gone. He added that illegal fishing is now out of control; run as it is by the local elite and by villagers from other areas.

3.3. Factors influencing fishing livelihoods since the fishing lots were closed

Based on the group discussions held, without effective management and conservation of the community fisheries, the fishers' livelihoods are not likely to remain sustainable. There is no doubt that fish are very important to the villagers, meaning that the legal and management framework surrounding the fisheries has a significant influence on their livelihoods. Based on logistic regression analysis of a combination of variables, we estimated those factors significantly influencing the contribution of fish to people's livelihoods in the study area

since the fishing lots were closed. The results show that eight out of the 12 attributes used contributed to all the predictions. Table 3 (page 49) reveals those factors influencing people's fishing-based livelihoods in the study area. These factors include the local authorities' actions, the use of patrols to police illegal fishing activities, mean fish catches during the dry season, involvement with NGO officers in fish management activities, household member details such as age, and the impacts of illegal fishing.

Other attributes, such as mean fish catch in the wet season, the decision to close the fishing lots, having to inform local officers of the use of illegal fishing gear and working with the fishery officers on management activities, were found not to have a significant influence on the fishers' livelihoods. In general, the fish catch is larger in the dry season and the fisheries are at their most productive for only a few months each year (fisher in Chhnock Trou; personal communication in September 2014). In the group discussions, fishers said that the impacts of fishing lot closures remain hidden to an extent, because: (1) The payment of bribes to the relevant agencies in order to continue to use illegal fishing gear is very common, and (2) The fish catch has continued to decline. When fishers or the community fishery inform the authorities about the use of illegal fishing gear, little effective action is taken, while in contrast, the authorities pay close attention to the actions of the small-scale fishers who use illegal fishing gear in the communities in order to survive. In both communities, the fishers work quite closely with the Commune Councils (CoCs) and NGOs, but deal little with the government officers.

Based on the results of the group discussions, interviews and key informant meetings held during the research, attributes influencing the livelihoods of the fishers include the level of involvement with the local authorities over fisheries management activities, the level of

participation in the illegal fishing patrols and the level of involvement with NGOs over fisheries management activities. When the fishers are more closely involved in such activities, it helps them manage and conserve fisheries resources in a sustainable way, as well as increase small-scale fishing production levels. Furthermore, our research found that illegal fishing has a very negative impact on the livelihoods of the small-scale fishers, because those who have the resources can maximize their fish catch. In addition, some demographic attributes such as age and number of household members are significant when wishing to establish the contribution fishing makes to the fishers' livelihoods. Younger fishers also tend to be able to work longer hours and further away from their village, especially in the productive zones within Kompong Thom and Pursat provinces.

Table 3: Factors Influencing Fishers' Livelihoods

Attributes	**B**	**SE**	**Odds ratio**	**P-value**
Attributes Contributing to Fish-related Livelihoods				
Age of Household Members	-.597	.282	.551	**.034***
No. of Household Members	-.180	.063	.835	**.005****
Significance of Fishing to their Livelihoods	3.171	.732	23.839	**.000*****
Mean Fish Catch Rates in the Dry Season	.231	.110	1.260	**.036***
Mean Fish Catch Rates in the Wet Season	.032	.099	1.032	.747
Illegal Fishing Activities	-.733	.304	.480	**.016****
Supported Decision to Cancel the Fishing Lots	-.045	.311	.956	.885
Inform Officers of Illegal Fishing Activities	-.081	.391	.922	.836
Participate in Patrols to Catch those Fishing Illegally	1.196	.523	3.307	**.022****
Involved in Management Activities with Fisheries Officers	.154	.350	1.166	.660

Attributes	B	SE	Odds ratio	P-value
Attributes Contributing to Fish-related Livelihoods				
Involved in Management Activities with NGO Officers	-.707	.344	.493	**.040***
Involved in Management Activities with the Local Authorities	1.208	.334	3.347	**.000*****

Notes: *Significant beta data shown in **bold** font

Furthermore, the size of the fish catch was also found to be dependent on the number of household members involved in fishing activities; the more labour there is available, the more fish can be caught. In addition, the mean dry season fish catch size, plus the impact of illegal fishing activities, contribute significantly to the fishers' livelihoods. In both study areas, fishers catch more fish in the dry season, and their catch sizes are directly affected by the amount of illegal fishing taking place. During the group discussions held, the fishers accused the government officers of not taking appropriate action over illegal fishing, and not adjusting the existing regulations to enable communities to earn a sufficient income from fishing activities, as well as ensure food security. The ineffective policing of illegal fishing and the continuation of regulations that prevent small-scale fishers making a proper living, remain the key negative impacts of the government's efforts to hand over control of fisheries management activities to local communities by withdrawing the fishing lots system across Tonle Sap Great Lake.

4. Discussion

4.1. Open access and the growth in illegal fishing activities

The ultimate goal of cancelling the fishing lots system in provinces surrounding Tonle Sap Great Lake, as well as in other provinces across the country, was to ensure communities could use and conserve their local fisheries. Under sub-decree 37 issued in March 2012, all fishing lots disappeared and the fishers were given the right to fish everywhere except in

protected areas. From a situation where fishers could not work within 500m of fishing lot boundaries, the majority of fishers (80.9%) can now travel throughout the Tonle Sap Great Lake in order to fish. All the fishers we spoke to applauded the efforts and political will of the government in cancelling the fishing lots in support of community management and conversation purposes. This sub-decree also increased the size of the zones within which fishers could fish whose communities have no community fisheries established.

As a result of these changes, fishers in Chhnock Trou are now able to go fishing in other districts or provinces, and the fishers are no longer required to pay lot owners to use the fishing grounds. In Phat Sanday; for example, fishers can also use the fishing zones found in other districts of Kompong Thom and Pursat provinces, as most of the zones are concentrated in these areas. This open access situation allows the fishers to go fishing elsewhere across Tonle Sap Great Lake, except in the protected areas. However, fishers know that the fisheries are becoming less productive when compared to before the sub-decree was introduced. Some reasons behind this decline in fish productivity include: (1) Weak law enforcement, (2) Insufficient resources and a lack of authority among communities regarding fisheries management and conservation activities, (3) The payment of bribes to government officers; allowing illegal fishing to take place, and (4) The current laws and regulations which do not allow small-scale fishers to support their livelihoods. Based on the group discussions held among the fishers in the study villages, as well as the key informant interviews held with village and commune heads, and with community fishery committee members, the existing laws are not strictly enforced due to the bribes taken by officers from the Provincial Office of Fishery, the Provincial Office of Environment and the police. The fishers complained that there are many overlapping government institutions that claim to have as their role the monitoring and conservation of the fisheries. The staff at these institutions uses their

authority to obtain bribes from fishers in exchange for allowing illegal fishing to take place. Obviously, it is impossible for the fishers to obey the current laws, because the limitations placed on the gear used mean they cannot sustain their livelihoods.

At the same time, communities do not have enough resources, nor the authority, to fully own abd utilize their own fisheries resources. In Phat Sanday; for example, the community does not have sufficient funds to carry out regular patrols in search of illegal fishing activities. For two years from 2007, the Asian Development Bank (ADB) provided this community fishery with equipment to support its patrols (such as motorized boats), community meetings and other related administrative work. However, the present community fishery has only just resumed operations after a number of years not working due to insufficient funds to cover the costs of petroleum for regular patrols; once the ADB support stopped. A newly-elected committee is trying to restart its activities, so as to be accountable to the community over fisheries management issues. However, the community fishery and fishers have limited scope to deal with illegal fishing activities in their communities; for example, they only have the power to report such activities to the government officers, and cannot confiscate gear or stop the illegal activities prior to the arrival of the officers. In particular, no strict action is ever taken over illegal fishing, especially among those who use large-scale and destructive equipment, as such people are supported by those in positions of power.

4.2. Effective fisheries management and the importance of fish to people's livelihoods

The introduction of appropriate and effective fisheries management activities and the development of sustainable livelihoods among fishers are closely related. In reality, fisheries management activities are limited in the two study villages for two key reasons: (1) Weak law enforcement, and (2) Insufficient resources and levels of authority among the study

communities in relation to fisheries management activities. Obviously, committee members in Phat Sanday, with the support of the Commune Council, could play a very important role in the effective management of fisheries in their community and of the protected areas. However, the community fishery does not have the resources required to carry out regular patrols. As a result, it is unlikely the communities there will be able to carry out regular patrols until they receive support from external parties, including NGOs such as WorldFish or the ADB. If they receive the resources needed to carry out regular patrols, at least illegal and larger-scale fishers might be afraid of being reported to government officers or of having information related to their activities passed to the media or the Fisheries Administration. Because the fishers cannot work within the current legal framework and survive, they end up paying bribes and trying to maximize their catch, without considering the sustainability of their actions. In both communes, small-scale fishers said that the younger generations will not be able to live-off the fisheries if illegal fishing continues as is. Population growth and a lack of alternative livelihood options will also place more and more pressure on the fisheries.

Although there is no official up-to-date data on annual fish catch trends in the study area, the local fishers said they catch less now than they did in previous years, and that this development is affecting their livelihoods. In the not-too-distant future; therefore, communities in the area need to be given sufficient funds and authority to help improve the accountability and effectiveness of fisheries management activities in the area. There is no community fishery in Chhnock Trou, but some NGOs such as WorldFish and the Fisheries Action Coalition Team (FACT) have set-up focal points in the community to help raise awareness of the fishery laws and regulations that are in place. An existing community fishery in Phat Sanday is well-established, but also has insufficient funds and lacks the authority to make decisions and enforce laws. With many years of experience operating this

community-based organization (since 1997), the committee members in Phat Sanday are planning to divide-up the community fishery into three zones: (1) A protected area, (2) A *Chrung Nor* (a fishing lot for the fishing communities) to generate income for the community fishing operation, and (3) Fishing areas set aside for use by the local fishers. In October 2014, the Fisheries Administration worked with the community fishery and the commune councils to demarcate the proposed areas.

This could be the first ever local initiative linking the management and conservation of the community fishery with the livelihoods of local fishers. A key challenge; however, is the lack of funds needed to start-up the *Chrung Nor*, the income from which could be used over the long term to carry out regular fishing patrols and to make the community fishery self-sufficient. Members of the committee in the community have proposed two options in order to achieve these aims: (1) Establish a community savings group, or (2) Invite private companies and/or interested businessmen to invest in the community fishery. The second option would be similar to the previous situation with the fishing lot owners, but under the management of the community fishery. However, this is not the preferred option as it would mean returning to the past. However, for the first option it is unlikely the community fishery would be able to mobilize the funds required itself to invest in the *Chrung Nor* operation. As a result, a further option could be to link local initiatives with a combination of savings funds, NGO support and commune/*sangkat* funding. To do this; however, the community fishery may have to work closely with Commune Councils and NGOs in order to mobilize the resources needed to run the operation effectively.

5. Conclusion

It can be concluded that: (1) Fish catches are lower now in the study area than during the fishing lots period. Some key factors leading to this decline in fisheries yields include: (i) weak law enforcement, (ii) insufficient resources and authority among the communities regarding fisheries management and conservation activities, (iii) the use of bribes to persuade local government officers to allow fishers to operate, and (iv) laws and regulations that do not facilitate small-scale fishers' activities. Fishers in the study area have also recently had to battle against a rapid decline in fish catches and high levels of investment in fishing gear. (2) Fishing areas are now open across Tonle Sap Great Lake. Overall, 80.9% of the fishers interviewed said they are able to catch fish in locations throughout the lake, though this response was more common in Phat Sanday (83.5%) than in Chhnock Tru (78.4%). Unfortunately, open access has led to widespread illegal fishing activities and so to an unsatisfactory conclusion regarding the closure of the fishing lots, and that (3) The active participation of fishers and the development of local initiatives will be vital if sustainable livelihoods are to be created in the study fishing communities.

Furthermore, the livelihoods of fishermen in the study area are significantly influenced by: (1) the involvement of the local authorities in fisheries management activities, (2) the villagers participation in regular illegal fishing patrols, (3) a lack of fish in the dry season, (4) the involvement of NGOs officers in fisheries management activities, (5) household structures in terms of member profiles, (6) the ages of household members, and (7) the impacts of illegal fishing activities.

A plan to zone the community fishery in Phat Sanday and raise funds locally to run it represents the first initiative in the area aimed at becoming self-sufficient in terms of

managing and funding fisheries management activities. The aim is to obtain such funding from savings funds, NGOs and the commune itself.

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Reducing Mercury Emissions and their Impacts during the Process of Artisanal and Small-scale Gold Mining in Roveing District, Preah Vihear Province, Cambodia

Sereivathanak Reasey Hoy* and Dararith Kim

Abstract

In Cambodia, poor communities inhabited by indigenous people are often dependent on mineral resources extraction activities to earn supplementary income on a seasonal basis. In the country's Preah Vihear Province, gold ore is often extracted using traditional methods, and this is referred to as Artisanal and Small-scale Gold Mining (ASGM). In this paper, the authors conclude that: (1) residents are unofficially allowed to carry out ASGM activities using traditional methods, (2) miners know that by using a mercury amalgam, they can extract more gold from the crushed gold ores, (3) gold miners only take limited health protection measures, and (4) using fume hoods and amalgamation retorts to reduce mercury emissions will be an effective and relatively cheap way to protect the health of the miners while carrying out ASGM activities.

Keywords: Artisanal and Small Scale Gold Mining (ASGM), Mercury, Health Prevention, Fume hood and Amalgamation retorts

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*S.V.R. Hoy (□)
Department of Natural Resource Management and Development, Faculty of Development Studies, Royal University of Phnom Penh E-mail: reasey@mail.com

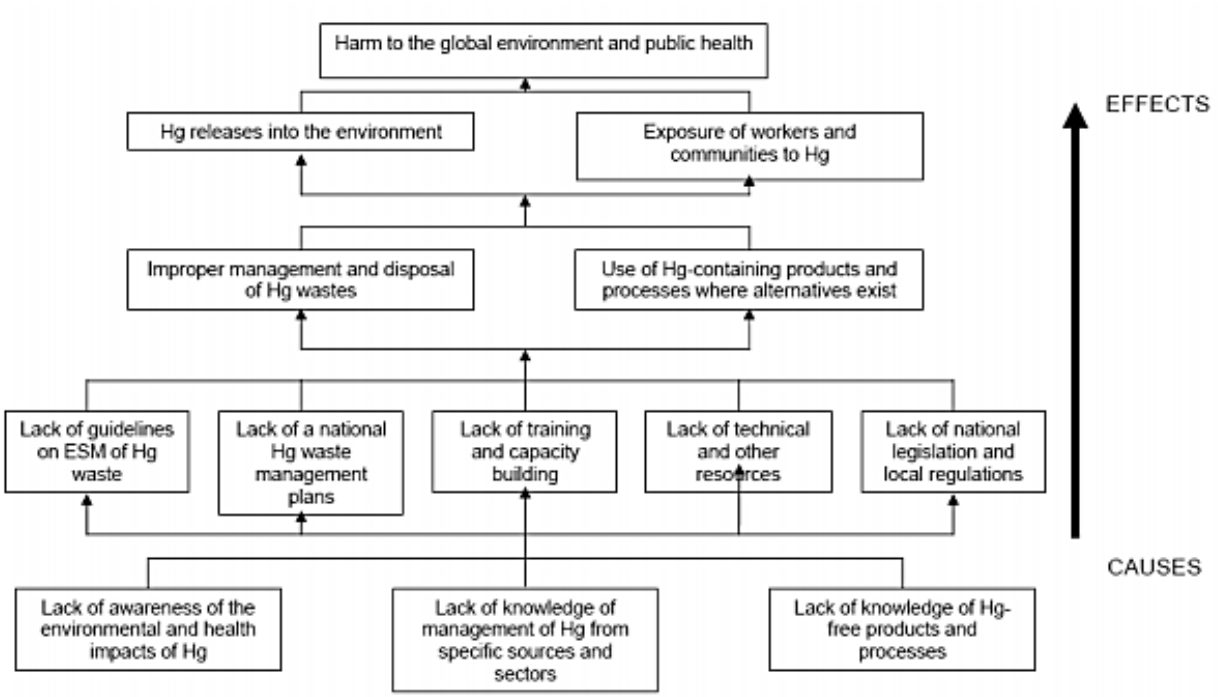
Introduction

Artisanal and small-scale gold mining (ASGM) is an important segment of the rural economy in a number of developing countries (United Nations, 1996). In rural sub-Saharan Africa; for example, it has become an important economic activity in recent years (Hilson, 2009), growing at an exponential rate over the past two decades. These ASGM activities tend to occur in remote areas and are participated in by the poorest sections of populations (Carmody and Owusu, 2007). Aubynn (2009) points out that ASGM activities provide incomes to many thousands of people, both directly and through the creation of downstream industries. For example, they are now significant for the livelihoods of an increasing proportion of Africa's rural population, and are being recognized by African governments for their crucial role in national development processes (Jønsson and Fold, 2011).

The International Labor Organization (ILO) has suggested that there is a positive correlation between the presence of rural poverty and ASGM activities, though the ASGM sector is estimated to provide employment for between 10 and 15 million people across Africa, Asia and Latin America (ILO, 1999). Globally, these operations span more than 70 countries and produce in the region of 350 tonnes of gold per annum (Telmer and Veiga, 2008). A number of delegates at the International Roundtable on Artisanal Mining hosted by The World Bank in 1996 argued that, to a large extent, informal mining is a poverty driven activity (Barry, 1996, p. 1), and has significant environmental consequences. For example, in the 1990s, environmental monitoring surveys showed extensive mercury pollution in the water and sediment of the Naboc River (Appleton *et al.*, 1999), as caused by ASGM activities.

ASGM has had a positive impact on populations in Burkina Faso from a socio-economic development point of view, but has had negative impacts at the environmental and governance levels (Andriamasinoro and Jean-Michel, 2012). Hilson *et al*. (2007) suggest that the majority of small-scale gold miners depend on mercury to amalgamate gold. Once used; however, this mercury is often discarded into the natural environment, where it transforms into methylmercury, a toxic substance which bio-accumulates in organic tissue with devastating ecological consequences.

Figure 1: Global Significance of ASGM Activities



Note: Hg is the chemical symbol for Mercury

Source: UNEP/DTIE Chemicals Branch, June 2010

The number of gold miners worldwide is expected to increase in future years as mining the metal becomes increasingly lucrative. The price of gold on the world market has increased dramatically in recent years; for example, it rose to over US$1500/oz in April 2011, having been just $260/oz in March 2001 (UNEP, 2011) (see Figure 1). Overall, 37% of mercury vapour emissions come from ASGM activities, and it has been estimated that artisanal miners

consume one-third (1400-1600 tons per annum) of all mercury produced in the world (UNEP, 2010a). According to Watch (2010), Cambodia releases 7.5 tonnes/annum of mercury vapour into the atmosphere as a direct result of ASGM activities.

As a result of this, some serious and long-term environmental health hazards affect local residents in areas where ASGM activities take place. At a meeting of the United Nations Industrial Development Organization (UNIDO) in 2010, it was stated that almost 50% of miners display unintentional tremors. At the same time, the World Health Organization (WHO) has estimated that the incidence rate for mild mental retardation is as high as 17.4 per 1000 among infants born within subsistence fishing populations located close to gold mining activities in the Amazon (UNEP, 2010a).

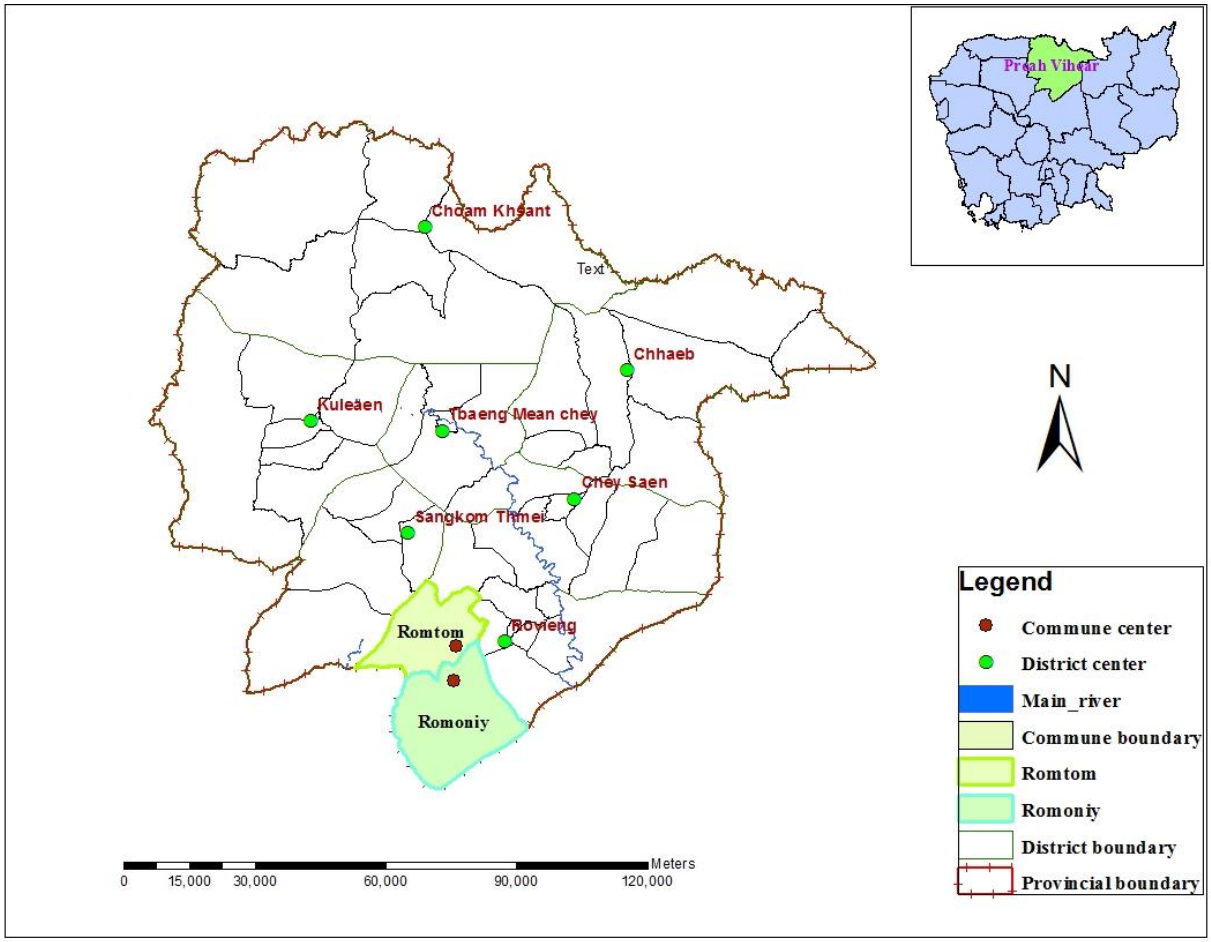
In Cambodia, ASGM activities are in the early stages of development (Browne *et al.*, 2011); however, it is very clear that Cambodia's environment is being exposed to mercury levels in excess of WHO guidelines. The management of waste containing mercury is necessary in order to reduce the serious risks it poses to human health and the environment (UNEP, 2010a). With the Southeast Asia region having a vibrant exploration sector, Cambodia has an opportunity to lay the foundations for a responsible mining sector, both environmentally and socially. The Ministry of Environment (MoE) and United Nations Environment Program (2011), as well as Development and Partnership in Action (DPA; 2012) reported that ASGM activities in Cambodia have become an increasingly important part of the economy in recent years, with people from all over the country migrating to become gold miners. This expansion of ASGM activities has brought with it an increase in the use of chemicals; to process and recover the gold, and particularly mercury and cyanide, which are harmful to all living organisms, including humans.

In Cambodia, unregulated and uncontrolled utilization of these chemical processes has already resulted in significant adverse environmental impacts in and around areas where artisanal mining activities take place. Furthermore, a number of social risks are faced by indigenous groups working on mining activities, due to breaches in the health, safety and labour standards usually applied to those who work in the mineral extraction industry (CCC, 2010). As Spiegel (2010) stated at the International Conference on Mining in Cambodia, held in Phnom Penh on 26-27th May 2010**,** many miners do not know how to apply for a mining license. Also, many individuals and small groups have become involved in gold mining activities over recent years, though the number of these is decreasing in the face of increasing competition from concessionaires, large companies and wealthy miners (MoE, 2011). In this paper, we will examine the ASGM processes used in the study area, and explore ways of reducing the adverse impacts of mercury vapour emissions there, focusing on, (1) ASGM practices, (2) the health impacts of mercury usage and the ways in which miners can protect themselves from such impacts, and (3) the most appropriate and safest mercury processing technologies that may be used by the gold miners.

Study Area and Methods

For this research, we used both qualitative and quantitative methods to collect our primary data and information. The study survey was conducted in two communes: Romoneiy and Romtum, which are both in Roveing District, Preah Vihear Province in northern Cambodia (see Figure 2).

Figure 2: Map of Preah Vihear and the Study Communes



Preah Vihear Province is recognized as having some of the largest gold deposits in Cambodia, and migrants living in Rum Chek, O Por, Chi Ouk, Phnum Dek and Sre Tnung villages all practice ASGM activities. Seasonal gold mining work is a key source of income for the local people, all of whom use traditional mining methods. In the Phnom Dek and Anlung mountain areas, which are located near to the study communes, people practice ASGM using traditional manual and semi-automated processes. In order to collect quantitative data for the study, we interviewed 100 households across the two communes whose members are engaged in ASGM activities. To collect the qualitative data, we contacted the relevant government officers, commune council members and village heads, as well as local villagers, and asked them to be our key informants, all of whom were then invited to participate in group discussions. The survey; meanwhile, targeted those who use mercury during their ASGM activities. In addition, a rule-of-thumb method was used to

ascertain the number of households needed to create the appropriate number of households for the interviews; in this case 30, representing 30% of the total number of ASGM families in the study area.

Results and Discussion

Summary of ASGM practices

The respondents we interviewed work in the ASGM sector and were between 30 and 49 years-old at the time. In terms of education level, 13.8% had completed high school, 51.7% lower secondary school and 13.8% upper secondary school. A large number of the respondents (79.3%) were migrants from various provinces throughout Cambodia (see Table 1); only 20.7% were local people. As water is a key resource for most ASGM activities, 55.6% of the respondents said they engage in ASGM activities using mercury only during the wet season, while another 17.2% said they take part in ASGM activities only when water is available to support the processes. In some cases, the respondents said they use water pumped from a well to extract gold in their area.

Some 27.2% of the respondents said they are involved in ASGM activities throughout the year, and almost all of these respondents were local residents. None of the respondents own the land on which they carry out agriculture, so ASGM work is their main source of income. During the group discussions, a lack of rural employment opportunities and an unproductive agricultural sector were cited as having driven many households to move to the study area and switch to the non-agricultural sector to work on ASGM activities. According to the interviews held, there are two types of miner: owners of ASGM businesses and labourers for such businesses. Those who have migrated to the area are basically labourers who earn a

daily wage. In order to extract gold from the gold-mercury amalgam, the workers heat the amalgam themselves, meaning they can work either at home or at the mine.

Table 1: Profile of those who Practice ASGM Activities

No.	Attributes	%
1	***Involved in mining***	
	Local residents	20.7
	Migrants	79.3
2	***Periods over which ASGM activities using mercury are carried out***	
	Whole year	27.2
	Wet season only	55.6
	Only when water is available	17.2
3	***Location of gold-mercury amalgam heating activities***	
	At home	55.2
	Processing area at the mine	44.8

In Preah Vihear Province, local residents are allowed to carry out ASGM activities using traditional tools. There is no clear definition of the traditional tools which should be used for such activities, nor the machinery or chemicals to be used, such as mercury (DPA, 2012). Unregulated ASGM activities are engaged in by local migrants, who follow the deposits from place to place, exploiting them in an unsustainable manner. A 2002 report by the DPA states that full-time, professional, migrant ASGM miners in Cambodia often form communities consisting of hundreds, and in some cases thousands of people, and such miners re-process the residues from larger mechanized operations using a mercury amalgam and cyanide leaching. Economic problems among the migrant miners' families force women and children to become involved in the mining process also. As mentioned at the International Conference on Mining held in Cambodia in May 2010 **(**Spiegel 2010), among the Asia-Pacific countries,

miners vary greatly in terms of their genders and ages, with women, men and children working on land (reef mining), in forests and along rivers (alluvial gold panning). In addition, children can often be seen working at mines in areas where educational opportunities are limited (DPA, 2012).

ASGM methods used

Based on field observations and informal focus group discussions, there are two types of ASGM method carried out in the study area. The most common method used among local indigenous communities is the so-called traditional or manual method (see Table 2), which is a basic physical method. This process can be divided into three stages: exploring for deposits, then extracting the gold and finally purifying it.

A semi-automated ASGM process as also used, as described in Table 3, and this process has seven stages: exploration, preparation of equipment, ore crushing, separation, extraction, smelting and purifying.

In the study area, the most common traditional method used is a physical practice applied by local indigenous people in the community. They use their hands and simple equipment to extract the gold ore, and during this process do not use toxic chemicals, as to do so would cost money. However, less gold ore can be extracted using this common method, as some is lost in the slurry. In addition to this traditional manual method, a semi-automated process is also practiced by the migrant miners, who use a crushing machine if they can afford it. In this process, mercury is used to concentrate the gold over several stages, and this mercury leaches into the soil and water.

Table 2: The Basic Manual ASGM Process

Stages	Exploration	Extraction	Purification
Activities	-Find gold ore quartz veins -Dig a one square metre hole, three to four metres deep	-Crush rocks -Grind rocks -Sieve/shake (gravity)	-Wash gold ore -Dry
Mining Tools and Equipment	-Shovels -Pick axes -Crowbars -Hoes -Water pumps	-Hammers -Pans	-None
Labor Involvement	-Men -Women -Children	-Men -Women	-Men -Women
Chemicals used	-None	-Water	-Water
Outputs	-Ground ore	-Minerals: gold and iron	-Gold ore

More than 55.2% of the respondents said that they carry out the smelting activities at home, usually in the presence of the whole family and with the mercury vapour released into the open air. The smelting stage is the most dangerous for people's health, because mercury vapours released during the gold amalgamation process are inhaled by the miners and others in close proximity, with women and children particularly vulnerable (Mwaipopo *et al.*, 2004). Furthermore, and according to Macello and Veiga (2009), when mercury is used to amalgamate gold, some escapes directly into local water bodies, either as elemental mercury droplets or adsorbed onto the surfaces of sediment grains. Also, the mercury used to form the gold amalgam is emitted into the atmosphere when the amalgam is heated – if a fume hood or retort is not used.

Table 3: Semi-automated ASGM Process

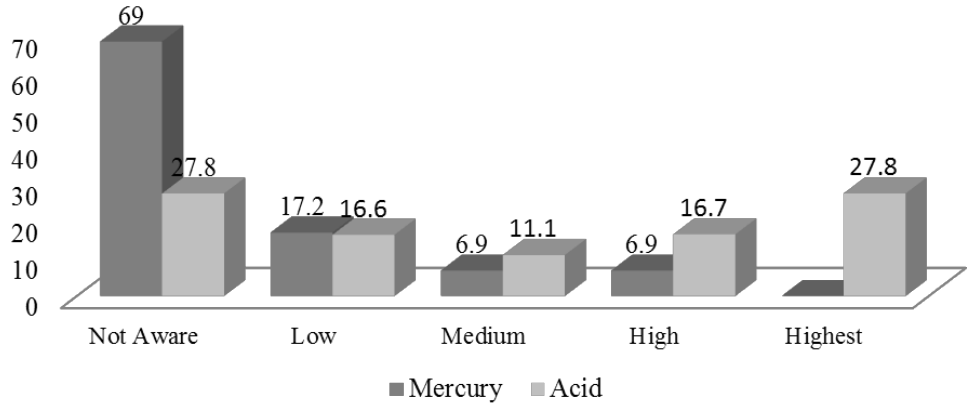
Stages	Exploration	Equipment Preparation	Ground Ore Crushing	Concentration	Extraction	Smelting	Purification
Activities	- Look for gold ore quartz veins - Dig a one square meter hole, three to four meters deep	-Coat mercury on to aluminum plates	-Crush the ore -Crushed ore slurry passed over mercury plates	-Recover the gold mercury amalgam from aluminum plate -Amalgam concentrate	-Wash and sort concentrate -Twist, and squeeze-out mercury and water	-Heat gold-mercury amalgam (releasing mercury vapour into the air)	-Melt
Mining Tools/Equipt Used	-Shovels -Pick axes -Crowbars -Hoes -Water pumps	-Mercury plates -Crushing machine	-Crushing machine -Sluice box -Water pipe -Mercury coated aluminum plates -Sluice carpet concentrate	-Rubber slipper -Iron bowl -Plastic saucepan -Plates -Wooden board	-Nylon cloth	-Clay pieces, crucible or rice bowl -Tongs	-Torch
Labour Used	-Women -Men	-Women -Men	-Men	-Men	-Men	-Men	-Men
Chemicals Used	-None	-Mercury -Water	-Water -Mercury	-Soap or alum -Mercury	-Soapy water or alum -Mercury	-Acid -Water	-*Aqua regia* (gold polish)
Outputs	-Finely ground ore	-Aluminum plates covered with mercury	-Heavy gold particles	-Gold-mercury amalgam	-Gold dust	-Sponge gold	-Gold ore

Source: Field Survey 2013

Impacts of mercury usage on human health

From the miners' point of view, the amount of mercury used during the ASGM activities impacts upon the quantity of gold which can be extracted, with 82.8% of respondents saying that the more mercury they use, the more gold they can extract. Meanwhile, only 17.2% of respondents said that large amounts of gold can be extracted using just medium amounts of mercury (see Table 3). The majority of respondents said that little or no gold can be extracted unless some mercury is used. When using the semi-automated process, almost all the respondents said they use 100 grams of mercury to coat four to six aluminum plates, which will be used for just five or six days. In terms of their awareness of the environmental and human health impacts of using mercury during their ASGM activities, 69% of respondents said they are not aware of any adverse impacts arising from the use of mercury, either on the environment or on human health. Meanwhile, 27.8% said that the acid they use during the process has a direct impact on human health, with the same percentage saying that they are very aware of the adverse impacts this has.

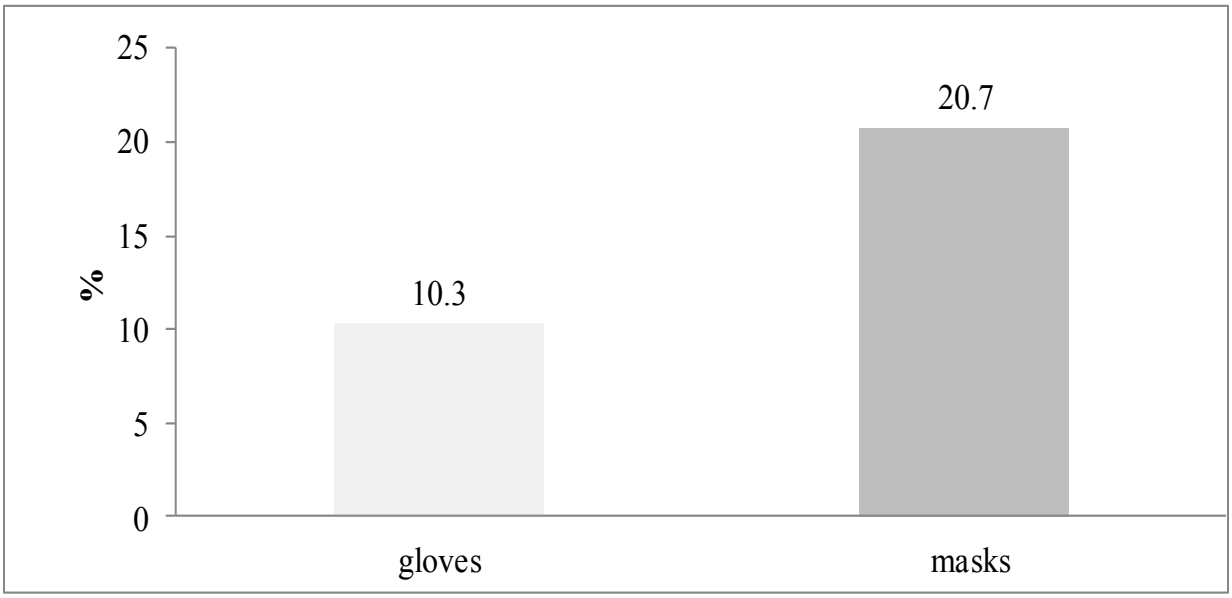
Figure 3: Awareness of the Health Impacts of Using Mercury and Acid during ASGM Activities



In order to obtain effective gold concentrations, miners use their traditional practices without understanding the harmful effects using mercury, cyanide and acid can have during the process. In fact, 82.2% of the respondents said they believe mercury amalgam extracts much more gold from the crushed gold ores, while only 13.8% said that sufficient gold can be extracted without using mercury. According to research conducted by Oxfam America, the untrained handling and

improper use of mercury and cyanide at mining sites can result in environmental pollution, and can also cause illness and death among humans, fish, cattle and other wildlife (DPA, 2012). In contrast to these findings, only 6.9% of the study respondents said that mercury has a medium to high impact on human health, while 69% said they are not aware of this issue at all. In fact, only the use of acid was cited by the respondents as having a harmful and poisonous effect. During a group discussion, the miners described these harmful effects based on their experiences and visual observations. For example, acid causes the skin and eyes to itch, inflammation of the hands and eyes, and also sore throats. However, when it comes to using mercury, during the interviews the miners simply said that unpleasant fumes are given-off when the gold-mercury amalgam is heated.

Figure 4: Protection Measures used by the Gold Miners



According to our interviews, ASGM activities are not officially legal in the study area, so little action is taken in terms of raising awareness of the safety, health and environmental protection measures required for these gold mining activities, and this means the risks faced by the miners are high. At the International Conference on Mining in Cambodia mentioned previously, Spiegel

said that even though some countries recognize small-scale mining activities in terms of licensing local nationals, ASGM activities in general remain illegal. Figure 4 shows that the respondents pay little attention to health protection, with only 20.7% and 10.3% saying they wear masks and gloves respectively. The most likely scenario is that the respondents are not aware of how to protect themselves from the impacts of mercury poisoning, including from breathing-in mercury vapour released into the atmosphere during smelting.

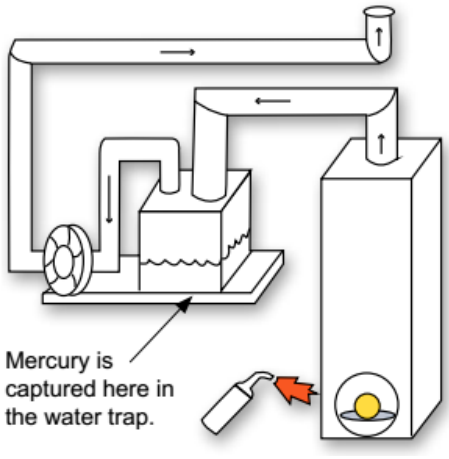
Appropriate health prevention approaches

In principle, the adverse impacts of mercury vapour could be avoided through the adoption of safer methods, those common to ASGM activities. A guidebook was published by the United Nations Environment Programme (UNEP) in 2012 entitled 'Reducing Mercury Use in Artisanal and Small-Scale Gold Mining', and this recommends two types of equipment for use with ASGM activities among local communities, namely fume hoods and amalgamation retorts, as detailed below.

- Fume hoods

Fume hoods are mercury capture systems which reduce mercury emissions and so operators' level of exposure to mercury fumes. They can be built using easy-to-find materials such as wooden boards, PVC water pipes and plastic water boxes. as illustrated below:

Figure 3: Fume Hood Design



Source: UNEP, 2012

- Amalgamation Retort

With a retort, the heated amalgam is cooled and condensed, meaning the mercury vapour is turned back into a liquid, allowing the mercury to be re-used.

In more detail, the cooled amalgam is placed in a stainless-steel retort, which is then clamped tight and placed on a gas burner. Mercury vapour leaves the amalgam, condenses in the steel tube, and drips into the vessel containing cool water. The retort is then allowed to cool, and can then be opened to recover the gold (see Figure 4).

Figure 4: Amalgamation Retort

Source: UNEP 201

Study Findings

According to our research, some of the key issues and findings in relation to ASGM activities in Cambodia are outlined below:

- As part of its policy to reduce mercury emissions, The Ministry of Industry, Mines and Energy's (MoIME) now uses mercury reducing equipment during its training and extension activities. However, our key informants at the Provincial Office of Mines and Energy, and from the Commune Councils, stated that ASGM activities are illegal and cannot be controlled because they operate outside the registration and licensing system. They also stated that environmental issues are not being addressed within this sector in terms of

prevention and conservation. As a result, this training could be extended to include the informal sector.

- During focus group discussions, the ASGM miners said they live in poverty and have limited knowledge of the dangers posed by their work. This is especially true of those indigenous people who have worked in this sector over a number of generations. In their view, traditional ASGM practices should be protected by law, as environmental, health and safety issues are not being addressed.
- Mining activities adversely affect the environment, both underground and on the surface, by polluting the air and water. The consequences of further, uncontrolled releases of mercury are likely to include food supply contamination and deterioration, adverse impacts on human and animal health (both aquatic and land-based animals), and a reduction in plant species abundance (Murphy *et al*., 2013). Only a few of the gold miners who took part in the study said they use health protection equipment such as mesh and plastic gloves, because of their limited awareness of the need for such equipment and its cost. Oikawa (1983) points out that most ASGM human health issues are caused by the inhalation of mercury vapour into the lungs, but in general, the gold miners are not aware of the health risks posed by this.
- We found that the workers carelessly expose themselves to mercury, but have no choice, as in most cases they do not have an alternative (Telmer and Veiga, 2009). The UNEP (2012) advises that ASGM miners are generally not aware of the risks they face, nor do they have access to the capital and capacity required to adopt even the most basic health protection practices. Based on our assessment of ASGM activities in the study area, including what solutions might be introduced, the practices there can be broken down into three categories, as follows: (1) poor practices, (2) better practices and (3) best practices, shown in Table 3.

Table 3: Ranking of Practices during ASGM Refining Operations

Quality	Activities
Poor Practices	• Do not use fume hoods • Poor chemical management activities • Poor assay purification techniques
Better Practices	• Do not use fume hoods • Some chemical management activities used • Some assay purification techniques used
Best Practices	• Fume hoods used • Effective chemical management activities used • Formal assay purification techniques used

Source: UNEP, 2012

- ASGM miners in the study area carry out poor practices due to their lack of knowledge as to the solutions available to them, and due to their poverty. In its 2012 guidebook, the UNEP describes the equipment and methods that may be used to minimize risk during such operations. During our group discussions, it was agreed that the use of fume hoods and amalgamation retorts could be adopted as common practice within the study community, as these methods are easy to put into practice. However, the miners were still hesitant over the use of such measures due to their limited financial capacity, their worries over how to use the equipment and how useful it would be in terms of rendering mercury harmless.

Also, at a National Consultation Workshop on Academic Research Funding held at the Royal University of Phnom Penh (RUPP) in Cambodia on 30 December 2013 concluded, a representative from the Department of Geology at the General Department of Mineral Resources (MIME) noted that amendments to existing laws should be considered in accordance with the situation on the ground, and especially with regard to ASGM activities.

Conclusion

Based on the study findings, it can be concluded that: (1) local residents are unofficially allowed to engage in ASGM activities using traditional and semi-automated tools. Among the study respondents, 79.3% of those involved in ASGM activities were migrants from provinces across Cambodia, and over half engage in ASGM practices using mercury only during the wet season, while 17.2% take part in ASGM activities only when sufficient water is available. (2) The majority of the gold miners (82.2%) said that when using mercury amalgam they are able to extract much more gold from the crushed gold ores; however, only a few miners said they know that gold can be removed without using mercury, and 6.9% of the minders said that mercury has a medium to high impact on their health. (3) The gold miners' approach to health protection is haphazard at best. Only 20.7% said they use masks and 10.3% said they use gloves during their ASGM activities. In general, they are not aware of how to prevent mercury being released into the atmosphere during the ASGM smelting process, for which they use little or no protection, and (4) Two pieces of equipment – a fume hood and amalgamation retort, may be utilized to reduce mercury use and mercury vapour inhalation; however, this will require improvements in both the miners' basic level of knowledge regarding ASGM activities and their financial situation.

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Can a Small-scale Irrigation Scheme Reduce Exposure to Climate Variability and Sustain Agricultural Production Levels? A case study of the Roleang Chrey irrigation scheme in Chbar Mon City, Kampong Speu Province

Chou Phanith*

Abstract

In this paper, the contribution of a small-scale irrigation scheme towards reducing the impact of climate variability in Cambodia is investigated, the aim of the scheme being to sustain farmers' agricultural production levels. The author focuses on the issues of climate change, rainfall and temperature variability, as well as other natural hazards, and the role irrigation can play in helping to reduce the local communities' level of vulnerability to these issues. Based on a detailed study of the Roleang Chrey irrigation scheme in Chbar Mon City, Kampong Speu Province, the paper concludes that: (1) Farmers have found it hard to adapt to water shortages in terms of their agricultural activities, due to the recent, high levels of rainfall variability, (2) Increased temperature variability has led to prolonged droughts in the study area, (3) Floods and droughts are the key natural hazards caused by climate variability in the two study villages, (4) The Roleang Chrey irrigation scheme is only able to partially irrigate the paddy fields used by farmers in the two study villages, and (5) A reduction in water usage fees in Roleang Chrey has reduced management costs, but the villagers cannot afford the ongoing maintenance costs. In future, better irrigation infrastructures could be constructed based on contributions from the government and private sector, and from the local communities themselves, in terms of finances, cooperation and capacity building, the aim being to improve agricultural production and reduce the impacts of climate variability.

Keywords: Climate change, small-scale irrigation, adaptation, rice production

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*P. Chou (✉)

Department of Community Development,

Faculty of Development Studies, Royal University of Phnom Penh

E-mail: chou.phanith@rupp.edu.kh

1. Introduction

In developing countries, irrigation systems have always played a key role in helping to maintain and enhance agricultural food production levels (Albertson and Bouwer, 1992), though many unproductive agricultural regions of the world still have untapped water resources due to a lack of irrigation facilities (Van Den Berg and Ruben, 2006). In a number of Asian countries, small-scale irrigation schemes play a diverse role, and such schemes often reflect the varying relationships that exist between the government sector and farmers. As a result of these relationships, the use of irrigated agricultural practices varies widely across the continent (Ambler, 1994). According to García-Bolaños *et al.* (2011), the typical irrigated land area able to be managed by an individual household is 0.2ha to 1ha, an area suitable for rice cultivation purposes. In support of this, over recent decades the government of the Philippines has supported the implementation of locally managed, small-scale irrigation systems (Bagadion and Korten, 1980).

Some scholars (i.e., Burney and Naylor, 2011; Dillion, 2011; Gebregziabher *et al.*, 2009) have focused on the contribution irrigation systems can make to poverty reduction. In rural areas, a small-scale irrigation scheme can help to reduce the risk behaviours of water users (Burney and Naylor, 2011); for instance, the use of portable, motorized pumps on small-scale irrigation schemes in southern Malawi has been promoted to mitigate the effects of climate change (Chidanti-Malunga, 2011). In recent years, studies on the assessment, privatization and increased productivity of small-scale irrigation schemes have shown how such schemes can help to enhance incomes and mitigate the impact of climate change among poor communities in developing countries (García-Bolaños *et al.*, 2011; Giordano and de Fraiture, 2014).

The impacts of climate change on agricultural activities are current and visible (Bobojonov and Aw-Hassan, 2014), so there is an urgent need to adapt agricultural activities to suit (Bryan *et al.,* 2013). Similar to other developing countries, in Cambodia extreme events such as floods, droughts and storms, as well as changes in temperature and rainfall, and rising sea levels, are becoming more frequent and unpredictable due to climate change (UNFCCC, 2007). Over the period 1960 to 2005, the average temperature in Cambodia increased by 0.8°C, and this is expected to have increased by another 0.3°C to 0.6°C by 2025 (MRC, 2010). Changes in temperature such as these can also lead to water supply and water quality problems, in particular for rural people located in high-risk zones (McCarthy *et al.*, 2001; UNFCCC, 2007; Sarker *et al.*, 2012). Climate change has had an obvious and negative impact on the productivity of both wet and dry rice activities in Cambodia over recent decades (Wokker *et al.*, 2011; Sim *et al.,* 2012), and irrigation systems can help reduce water shortages among such activities (MOWRAM, 2012). As a result, the Royal Government of Cambodia (RGC) has recently prioritized the adoption of irrigation systems as a key response to climate change (MOWRAM, 2012).

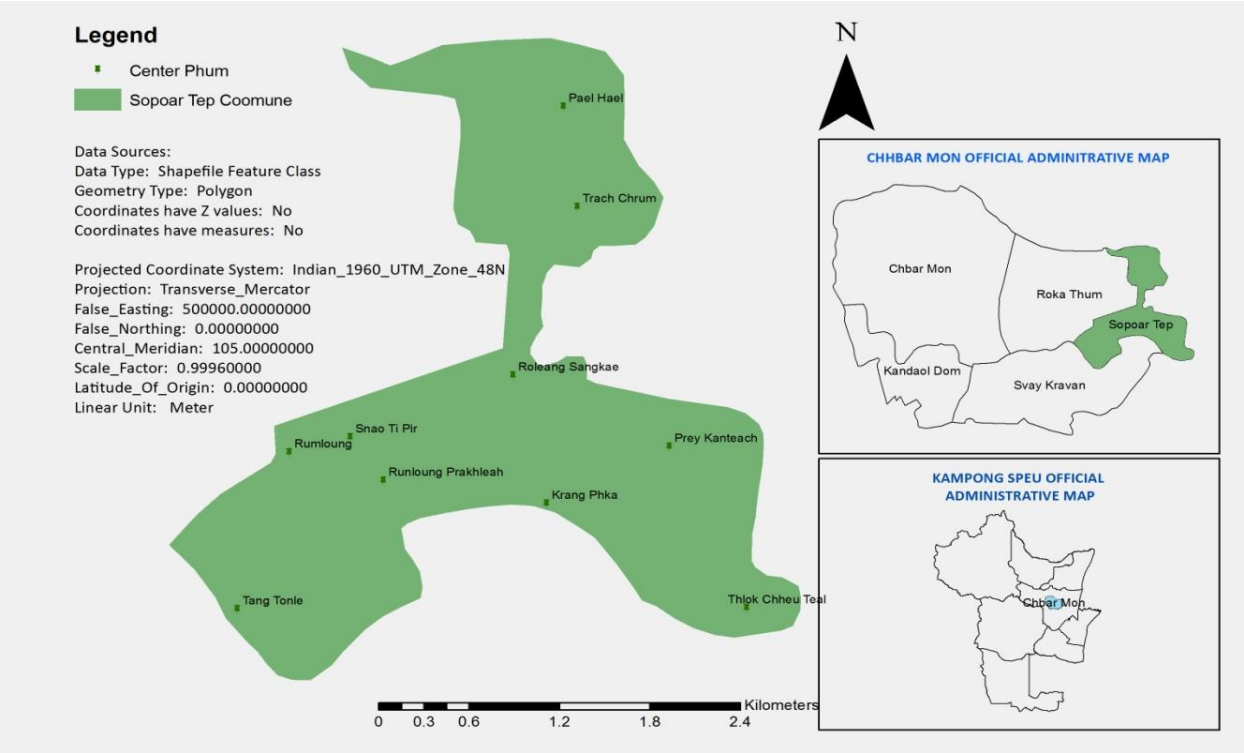
In this article, the contribution of small-scale irrigation towards reducing the impacts of climate variability will be investigated, the aim of such schemes being to maintain agricultural production levels among Cambodian farmers. This study will take a close look at climate change in general, as well as rainfall and temperature variability and natural hazards in Cambodia, plus the role irrigation can play in reducing farmers' vulnerability to climate variability.

2. Study Areas and Methods

One of the areas most vulnerable to climate change, not only in Cambodia but also in Southeast Asia as a whole, is Kampong Speu Province, due to its population's low adaptation capacity (MoE, 2006;

Yusuf and Fransisco, 2009), and so this research study focuses on two villages in the province, those located in Sopoar Tep Commune, Chbar Morn city (see Map 1). These villages were selected due to their high levels of exposure to the impacts of climate change (NCDM, 2010), and also the varied risks and impacts experienced by agricultural production activities there. Every year, Pael Hael village is affected by droughts, while Thlok Chheu Teal village suffers floods, being as it is located along the Prek Thnot River. Both villages utilize the Roleang Chrey irrigation system for their agricultural activities. According to the village head of Pael Hael, there are 147 households in the village, all of which are dependent on agriculture, while in Thlok Chheu Teal village, a total of 149 households, or around 47%, are dependent on subsistence agriculture.

According to my key informants within the Sopoar Tep Commune Council, Thlok Chheu Teal village's total paddy land area is 63ha, though only 10ha of this is supplied by the Roleang Chrey irrigation system. Farmers of the remaining 53ha depend on both rainfall and water which comes directly from the Prek Thnot River. As for Pael Hael village, 20ha of paddy fields are fed by the irrigation system, while the remaining 38ha are completely dependent on rainfall. The source of the Roleang Chrey irrigation system is in nearby Oral Mountain, and the system was built during the Khmer Rouge period (late 1970s), before being restored and improved in 2000. Roleang Chrey irrigation system has two key zones; the northern and southern zones. The northern zone of the Roleang Chrey system is mainly used to supply water for dry rice farming in Pael Hael village (20km in length), while the southern zone supplies water to the dry rice farmers of Thlok Chheu Teal village, to reduce their dependence on water from the Prek Thnot River during the wet season (30km in length). Access to the irrigation system is free-of-charge.



Source: JICA 2003

Map 1: Administrative Map of Sopoar Tep Commune

Qualitative data was gathered from key informants, who included representatives from government agencies, non-governmental organizations (NGOs) and the commune councils, as well as village heads and villagers. The data was gathered using interviews and focus group discussions. For the qualitative analysis, academic papers, journals and other, relevant published documents were used as the key sources of secondary data. To identify the extreme events caused by climate change, rainfall and temperature data for Chbar Mon City was used to create assumption parameters for climate variability. The study used district level rainfall data provided by the Ministry of Water Resources and Meteorology (MOWRAM) for the period 1990 to 2010. Only flood and drought events, and temperature changes, were analyzed, as these are the most extreme events that take place in the study area.

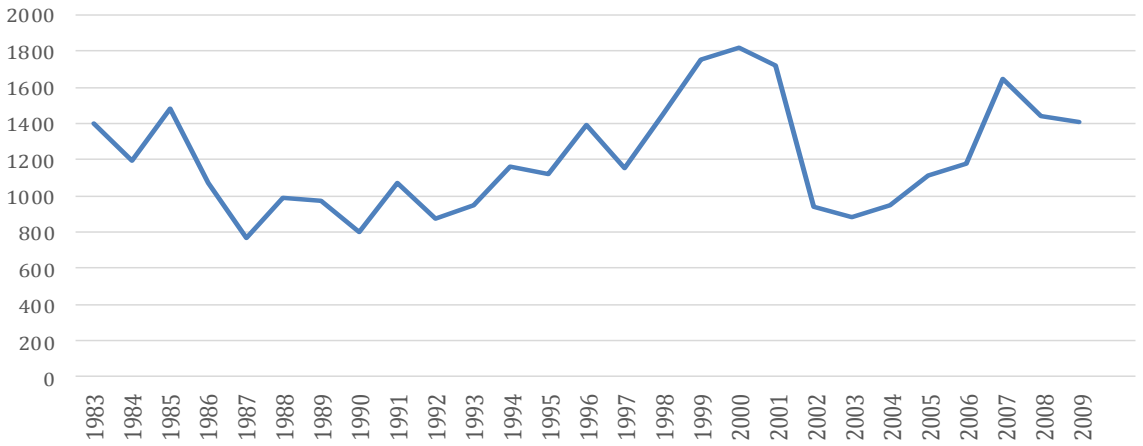
3. Findings and Results

3.1. Climate change and rainfall variability

In the Mekong region, the impact of climate change is becoming more visible, and has recently led to more extreme events, including temperature changes, rainfall variations and sea level rise (McCarthy *et al.*, 2001; Kurukulasuriya and Rosenthal, 2003). In the two study villages, three key events regularly affect agricultural production levels: droughts, and significant rainfall and temperature variability. As Balasubramanian and Kumar (2010) point out, the amount of water supplied by both rainfall and the irrigation system has a considerable impact on rice yields in the study area. Figure 1 illustrates the variations in rainfall that take place in Chbar Mon City between 1983 and 2009 – based on the data available from MOWRAM, while Figure 2 provides average monthly rainfall figures (mm) over the same period. Overall, the rainfall trend is a fluctuating one, but reaches a peak in 2000 of approximately 1800mm. On average, rainfall fluctuated by 200mm or less over the years 1983 to 1985 (i.e., 1400mm in 1983, 1200mm in 1984 and 1400mm in 1985).

Rainfall levels fell from 1400mm in 1983 to 900mm in 1992, but then stabilized for 1987 and 1988. Notably, rainfall rose and then fell every consecutive year between 1990 and 1995, but was also consistently below 1200mm per year over the period. Significant rainfall in 1999, 2000 and 2011 led to extensive flooding in the area, particularly in 2000. This provides obvious evidence that farmers who were not able to access irrigation over this period faced significant uncertainty due to fluctuating rainfall levels. Rainfall then declined rapidly over the period 2001 to 2003, from around 1700mm per annum in 2001, to 1000mm per annum in both 2002 and 2003. Those changes created major difficulties for farmers, who found it hard to adapt their livelihoods and farming activities to the resulting water shortages. In addition, such fluctuating rainfall levels affected the farmers' decision-making processes with regard to technology selection. In 2013, farmers in the two villages were provided with

agricultural extension training by the Ministry of Agriculture, Forestry and Fishery (MAFF) and the Centre d'Etudeet de Développement Agricole Cambodgien/Cambodian Center for Study and Development in Agriculture (CEDAC). This training instructed them on how to choose the right crop varieties to deal with both wet and arid conditions. However, although these crops help reduce the risk of major losses occurring, some farmers still do not use these methods due to the resulting, intensive labour requirements.

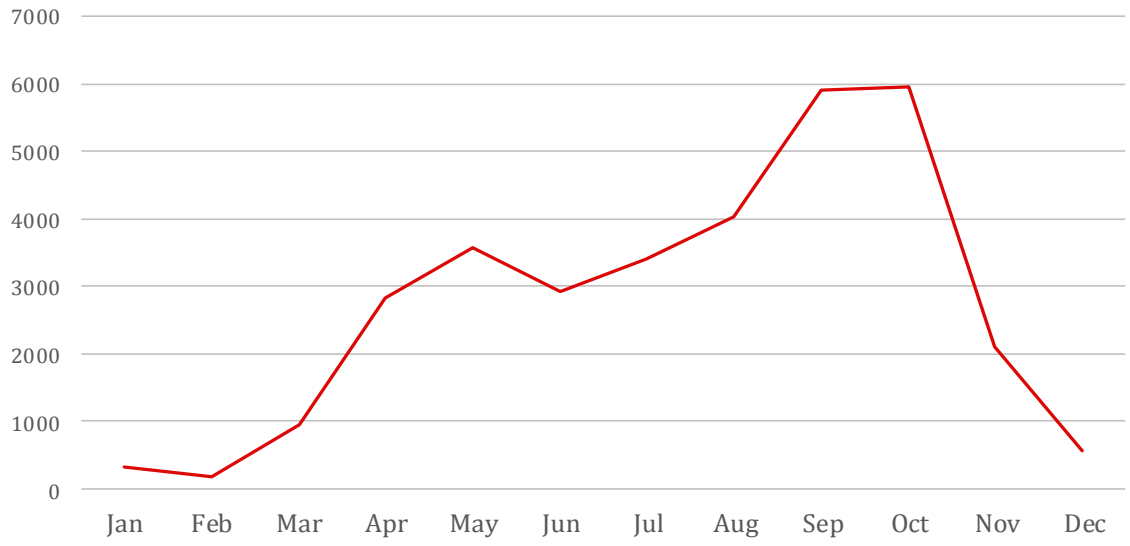


Source: MOWRAM 2010

Figure 1: Average Annual Rainfall Levels (mm) in Chbar Mon, 1983-2009

Based on the average monthly rainfall data shown in Figure 1, those farmers traditionally involved in the cultivation of long-term rice varieties faced water shortages over the study period, as the available water sources − the Roleang Chrey irrigation scheme and the Pek Thnot River and its tributaries − were not able to supply sufficient water to the paddy fields in the two villages (see Figure 2). Between 1983 and 2009, rainfall variability between April and June was relatively moderate, but there was a lot of water available between September and November. In general, when the wet season starts in April and May, farmers prepare their land for planting, but during the study period the water supplied by rainfall in June was insufficient, leading to unproductive agricultural activities. Those farmers able to access

water from the Roleang Chrey irrigation system were able to continue with their cultivation activities, while those who could not access the irrigation system faced crop failures at this time, as there was insufficient rain.



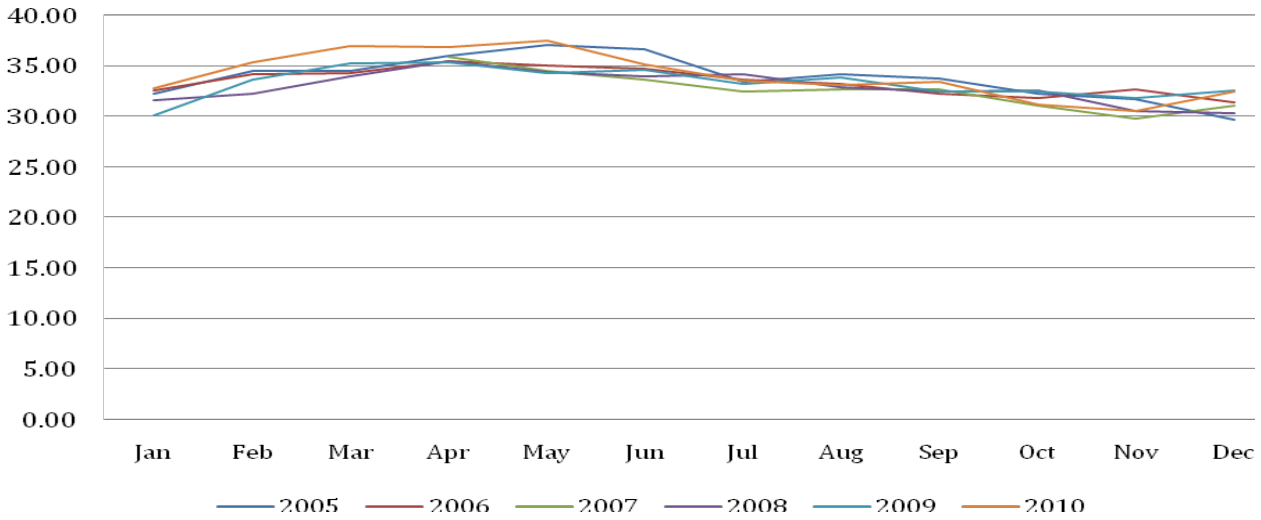
Source: MOWRAM 2010

Figure 2: Average Monthly Rainfall Levels (mm), 1983-2009

3.2 Climate change and temperature variability

Temperature is one of the most important factors affecting agricultural yields. Over the last few decades, the weather in Cambodia has become warmer, and temperature rises such as the ones seen can destroy crops when irrigation is absent. According to data from MOWRAM (2010) for the period 2005 to 2010, the average monthly temperature in the study area varied little; between 29°C and 38°C (see Figure 3). The highest average temperature occurred in 2010, leading to a prolonged drought. During focus group discussions with the key informants, the farmers in the two study villages revealed that droughts are particularly damaging to their rice yields.

In the two villages, the hottest period is normally between April and early May each year, and during the study period, temperatures were found to be normal for the rest of the year; between; 29°C and 38°C. However, although farmers normally start to plant their rice around this time, over the study period rain often did not fall until mid- to late May. In general, the temperatures in Chbar Mon did not cause the famers many difficulties in terms of their agricultural activities, but the absence of an irrigation system along with the late arrival of the rains led to water shortages.



Source: MOWRAM, 2010

Figure 3: Average Monthly Temperatures (°C), 2005-2010

3.3. Climate change and natural hazards

In Kompong Speu Province, droughts and floods have become quite common in recent years, having a negative impact on agricultural yields almost every year. According to a National Committee for Disaster Management (NCDM) report published in 2010, droughts have become the most prevalent natural hazard in the study villages over recent years, even more so than floods. During a group discussion held among the villagers and village heads, they said that the droughts and water shortages of 1990 and 1993 reduced rice productivity significantly, though the impacts were more severe in Pael

Hael village than Thlok Chheu Teal. Added to this, during the meeting, farmers also raised concerns about the impacts of floods on their rice production levels. A representative from NCDM said, "if the paddy fields do not get enough water during the crop growing season over a period of seven to ten days, productivity will decrease." Furthermore, if a drought lasts 20 to 30 days, rice crops are likely to fail completely. When droughts occur during April and May, farmers can still secure their crop yields by extending the planting period. However, during the study period, droughts occurred regularly during the most productive period for rice cultivation, in July. When this happened, rice yields were severely affected by water shortages. During these events, only some farmers in Thlok Chheu Teal village were able to mitigate the impacts of climate change because they were able to access water from the irrigation system and from the Prek Thnot River.

Table 1: Impacts of Droughts and Floods in the Study Villages, 1990-2010

Year	**Droughts**		**Floods**	
	Pael Hael	Thlok Chheu Teal	Pael Hael	Thlok Chheu Teal
1990	Severe impact	Little/no impact	Little/no impact	Severe impact
1993	Severe impact	Little/no impact	Little/no impact	Moderate impact
1994	Moderate impact	Little/no impact	Little/no impact	Little/no impact
2000	Little/no impact	Little/no impact	Little/no impact	Moderate impact
2001	Little/no impact	Little/no impact	Little/no impact	Moderate impact
2002	Little/no impact	Little/no impact	Little/no impact	Severe impact
2003	Moderate impact	Moderate impact	Little/no impact	Little/no impact
2008	Moderate impact	Moderate impact	Little/no impact	Little/no impact
2009	Moderate impact	Moderate impact	Little/no impact	Moderate impact

Year	Droughts		Floods	
	Pael Hael	Thlok Chheu Teal	Pael Hael	Thlok Chheu Teal
2010	Moderate impact	Moderate impact	Little/no impact	Moderate impact

The two study villages are prone to both flash floods and seasonal river floods, and these events killed villagers and damaged private and public property during the study period; Pael Hael village was less affected by floods but suffered from droughts due to its higher elevation, while floods occurred in Thlok Chheu Teal village every year. In fact, according to a group discussion held among farmers there, severe floods occurred in 1990, 2000, 2001 and 2002, when water inundated the paddy fields for up to 15 days during the September to October period. During 1993 and 2000, the floods inundated the paddy fields for more than two weeks, destroying the entire rice crop, killing livestock and damaging household assets. In Cambodia, when floods or heavy rainfall occur during September and October, rice productivity levels tend to decrease (Jennings and Magrath, 2008), and if the annual floods occur during the rice flowering period – around September, October or November – significant rice productivity losses can be recorded, especially among those farmers cultivating long-term or traditional rice varieties.

3.4. Role of irrigation in reducing vulnerability to climate change

Sustainable water management through the use of irrigation systems has, over the years, played a very important role in terms of poverty reduction in Cambodia (Bhattarai *et al.,* 2002), as irrigation helps to increase agricultural productivity by increasing yields and lowering the risk of crop failures (MOWRAM, 2010; Wokker *et al.*, 2011). In the two study villages, only those paddy fields using irrigation receive sufficient water to carry out dry rice cultivation, though pumping services have to be

used; for which farmers pay approximately one kilo of rice per 0.01ha (meaning that for every hectare of rice grown, farmers have to pay 100kg after the harvest). To manage the Roleang Chrey irrigation scheme, two committees have been established under MOWRAM; the South of Roleang Chrey and North of Roleang Chrey committees. In both these committees, technical assistance is provided by the village heads. MOWRAM covers the maintenance costs, and the farmers make a contribution of 1kg of rice per $100m^2$ of irrigated land (0.01ha). Unfortunately, irrigation only partially covers the agricultural land in the two villages, meaning 38ha in Pael Hael village and 53ha in Thlok Chheu Teal village are not able to use irrigation for agricultural purposes during the dry season.

As a result, the farmers reported that during the study period, although paddy fields located on higher ground received more rainfall, they also managed to avoid any flooding. Due to the limited extent of the irrigation scheme, the majority of farmers still depend on rainfall for their cultivation, and droughts have become more frequent and intense during the rice growing/wet seasons in recent years. In some years during the study period, water levels both rose quickly leading to floods, and also decreased rapidly, causing droughts. The gates to the Roleang Chrey irrigation system can be opened to mitigate the impacts of flash floods, and in Thlok Chheu Teal village, this helps reduce flooding from the Prek Thnot River. Located on low land close to the river, this village is well suited to agricultural activities. The main water sources in this village are the Prek Thnot River and Oral Mountain, so the catchment is normally full during September and October. Rainfall levels reach their peak between October and November, so the floods affect the rice growing areas most during these months. Obviously, the Roleang Chrey irrigation system normally plays a significant role in helping to mitigate floods in Thlok Chheu Teal village, so lowering the level of risk in the area.

According to an MAFF representative, floods are not always destructive, in fact they sometimes improve soil quality. With the Roleang Chrey irrigation system available to them, farmers have been able to utilize knowledge on new agricultural technologies passed on to them by the provincial government, agricultural extension services and NGOs. In general, the farmers in Thlok Chheu Teal village who can access irrigation have been able to adopt the technology transferred by CEDAC in terms of the variety of crops and the planting techniques used. Previously, the farmers used 'Kantom' rice, a traditional Cambodian variety, but recently have changed to using 'Reang Chey', another traditional Cambodian variety, but one more resistant to climatic changes. This use of a new rice variety, as well as the use of technological knowledge, has helped increase rice productivity in the study villages. Those farmers cultivating rain-fed wet rice can produce around two to three tonnes per hectare per cropping season, while those who have selected the new variety 'IR66' for their dry rice farming are able to produce around four tonnes per hectare per cropping season.

3.5. Economic impact assessment of rice production risk due to limited irrigation facilities

Data collected over the study period shows that 53ha of paddy field in Thlok Chheu Teal and 38ha in Pael Hael are at risk from climate variability, and in particular droughts and floods, because the farmers there cannot access the Roleang Chrey irrigation system. Even though some paddy fields can be cultivated through the use of water pumps, productivity levels tend to be adversely affected due to the high investment costs. Also, these paddy fields can only be saved when the farmers are able to access water sources, so many are still at risk from both a lack of water and flooding. When looking at the rice productivity data retrieved for this study, for both dry season and rain-fed rice cultivation, one can see how much production and income levels are put at risk by droughts and floods if no preventive action is taken. In Thlok Chheu Teal, farmers produce around 3.5t/ha for dry season rice and 3.25t/ha for rain-fed rice, but as already mentioned, around 53ha of the paddy fields have very uncertain productivity

levels; this uncertainty amounting to around 357.75 tonnes of rice per year, which has a value of 357,750,000 Riel (USD89,437.50 at 4000 Riel/USD). So, if the farmers were able to access irrigation for the entire paddy field area of around 63ha per village, they could achieve a total rice production figure of around 425.25 tonnes per year; generating 425,250,000 Riel (USD106, 312.50) in income, a 19% improvement on current levels.

Table 2: Rice Crop Productivity vs Risk

Village	Average Productivity/ Hectare (ha)		Price/ Kg (Riel)	Paddy Area at Risk	Rice Productivity at Risk
	Dry Season Rice	Rainfed Rice			
Thlok Chher Teal	3.5 tonnes	3.25 tonnes	1000	53 ha	357.75 tonnes
Pael Hael	2 tonnes	1 tonne	800	38 ha	114 tonnes

For Pael Hael village, only 20ha out of 58ha of farmland utilize the Roleang Chrey irrigation system, and those farming the irrigated land are able to produce around 2t/ha for dry season rice and 1t/ha for rain-fed rice. This means that the 38ha with no access to the irrigation system could produce another 114 tonnes per year, generating 91,200,000 Riel (USD22,800) in income if it did have access. So, if the irrigation system was able to supply the whole village, this would allow rice productivity levels to reach around 174 tonnes per year, generating an income of around 139,200,000 Riel (USD348,000). Therefore, if the irrigation system supplied both villages, the farmers could generate a combined total productivity of 599.25 tonnes over 101ha, generating a total income of around 564,450,000 Riel (USD141,112.5). This raises the question: What would production levels be like across the country if the total area of cultivated rice land (around three million hectares in 2011 according to MAFF) were

supplied with water using an irrigation system? Such levels could then be further enhanced, by two or three times, if farmers were to change to short-period crops.

How much irrigation would be required to achieve the above targets? Is water management through the use of irrigation so costly that the country cannot afford to enhance its rice productivity in this way?

It is likely that the cost of such a development to the government, private sector and farmers would be worth paying to reduce the risks posed to rice production activities. However, according to Ehrlich and Becker (1972), and Muermann and Kureuther (2007), people need to choose an optimal combination of prevention and insurance when dealing with natural risk, that is, they need to invest to reduce the likelihood of significant losses occurring.

However, in this case, expansion of irrigation systems on the scale required would need significant investment to be made, so who would pay for this? The common answer to such a question is "the government", as the private sector and local people always think that public goods should be provided by the government. However, such a scenario would place a significant cost pressure on Cambodia, a relatively poor country, and particularly if the national budget was used. However, such an initiative should be an absolute priority for the Cambodian government.

Another view says that market mechanisms based on contributions from the private sector should be used, as shown in many cases across the developed world, though in such situations the allocation and coordination process is not simple.

However, Elinor Ostrom has provided an alternative to the market and government models in relation to prevention investment. In many rural areas of developing countries, collective actions are often called-upon to overcome social dilemmas that are typically beyond government capacity. Communal protection against natural disasters, such as common refuge sites situated along river banks, is, in many cases, characterized by interdependent risk. If one individual invests in collective protection, that individual's and others' risks are reduced. Successful joint contributions reduce risk to a targeted degree. Empirical research on cooperative behaviour regarding an uncertain outcome, such as disaster risk, is typically based on individual decisions (Keser and Montmarquette, 2008). Decision units in developing countries; however, are not always individual – decisions can be made by groups such as households or communities, and groups tend to behave differently from individuals with regard to cooperation (Insko *at al.*, 1987), risk and uncertainty (Charness *et al.*, 2007). Hence, investment for self-insurance is not only a state obligation, for communities and individuals also need to base their actions on the strategic need to enhance their incomes within an uncertain climatic situation.

4. Conclusion

This study found that a small-scale irrigation scheme has helped reduce exposure to climate variability within two Cambodian villages, helping to maintain their rice production levels. Based primarily on the study's findings in the two villages, it can be concluded that: (1) Rainfall variability fluctuates in the study area, meaning the local farmers struggle to adapt to the water shortages they face as part of their agricultural activities. For example, over the study period, the availability of rainfall was found to be moderate between April and June, but high between September and November, while farmers in the two study villages faced water shortages in June, causing them to shift from low and unproductive agricultural activities, (2) Increased temperatures as a result of climate change have led to prolonged droughts occurring in the area in recent years, with the hottest time of year being April and early May.

For example, over the last six years of the study, the highest average temperature occurred in 2010, at 38°C , leading to a prolonged drought, (3) Floods and droughts are the major natural hazards being caused by climate change in the two villages. Over the study period, Pael Hael village was often affected by droughts in May and June, while Thlok Chheu Teal village suffered particularly from floods each year during August and September. (4) The Roleang Chrey irrigation scheme has a limited capacity; supplying an average of just 24.8% of paddy fields in the two study areas (34.5% in Pael Hael village and 15.8% in Thlok Chheu Teal village). However, the irrigation scheme plays a significant role in mitigating floods and reducing the impacts of water shortages in both Thlok Chheu Teal and Pael Hael villages, and (5) Greater investment in public goods such as irrigation schemes should be considered by the Cambodian government nationwide, in order to reduce the risk of low rice production levels brought-about by climate change.

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Identification of Deforestation Drivers in Cambodia

San Vibol*

Most forests in Cambodia are located in the north, east and southwest of the country, areas where population densities are lower. Forests are important in terms of the support they provide for subsistence livelihoods, and for economic production and environmental service activities. Understanding the drivers of deforestation and degradation is fundamental for the development of policies and measures aimed at altering current forest usage patterns in favour of more climate- and biodiversity-friendly outcomes. Moreover, granting of land concessions and the conversion of forest land into agricultural plantations and also human settlements, plus illegal logging for commercial and domestic purposes – to make charcoal and household woodfuel, can all be considered key drivers of deforestation in the study area. Large-scale land concessions have already been granted by the government, and only political factors can resolve this problem. This means that the issues of forest land conversion and illegal logging can only be effectively addressed based on a strong commitment coming from the government; to strengthen and enforce forest laws.

*Vibol. S (✉)

Department of Natural Resource Management and Development, Faculty of Development Studies, Royal University of Phnom Penh E-mail: sanvibol@gmail.com

Introduction

Most forests in Cambodia are located in the north, east and southwest of the country, areas where population densities are lower. Forests are important in terms of the support they provide for subsistence livelihoods, and for economic production and environmental service activities. Forests are a source of food for local people, provide fuel for domestic and commercial use, timber for both construction and export activities, and also produce a wide variety of non-wood forest products supplying both domestic and foreign markets. Forest cover in Cambodia has declined in recent decades; for example, from 11.3 million ha or 61% of the total land area in 2002, to 10.9 million ha or 59% in 2006. The net annual rate of deforestation is estimated to be 0.5% (Technical Working Group Forestry & Environment, 2007). These changes in forest cover are related to population growth, as the rapid increase in the country's population has led to an increase in demand for fuel and construction materials, and also for agricultural land (Kim Phat *et al.*, 1998).With respect to Oddar Meanchey Province in northwest Cambodia, Poffenberger *et al.* (2008) identified economic land concessions, migration encroachment, land speculation, agricultural expansion, illegal logging, and the collection and consumption of wood for fuel purposes as the main drivers of deforestation.

Understanding the drivers of deforestation and degradation is fundamental for the development of policies and measures aimed at altering current forest usage patterns in favour of more climate- and biodiversity-friendly outcomes. Addressing the drivers of deforestation and forest degradation has been part of the REDD+ discussions and UNFCCC negotiations over many years. Decision 2 of COP 13 developed in Bali in 2007 encourages parties "...to explore a range of actions, identify options and undertake efforts, including demonstration activities, to address the drivers of deforestation." Decision 1 of COP 16; meanwhile, reiterates the need for all parties, including developing countries, to take actions to address the drivers of deforestation and forest degradation when developing and implementing their national strategies and action plans. In addition to the discussions on policy incentives and measurement, reporting and verification modalities (MRV), the issue of identifying the drivers of and activities leading to forest carbon changes at the national level, for REDD+ monitoring and implementation purposes, has received increasing attention as part of the REDDC debate in recent times (Bedort *et al.*, 2007; UNFCCC, 2010).

The dynamics and causes of deforestation and forest degradation are multi-faceted, complex and vary from place to place, and quantitative national-level information available on the drivers and activities leading to these outcomes is scarce. This study aims to identify and quantify the drivers of deforestation in a key forested area of Kampong Thom Province, Cambodia.

Methodology

Study Site

Kraya Commune is located in Satuk District, Kampong Thom Province, and is home to 1743 families and 8311 people (2010) (NCDD, 2010). Forested land covers 486,588 ha. Kraya Commune was selected as the study site in line with the following criteria:

1. Woodfuel production capacity in this area is similar to other production sites throughout Cambodia.
2. A direct and causal relationship between woodfuel production and deforestation can be identified in the study area, because some people living near the forest collect wood for daily use as fuel and to make charcoal, especially during the dry season. Other causes of forest loss are also significant.
3. The area studied was small enough for the researcher to conduct a thorough assessment.

Survey Design

Before starting the data collection activities, a reconnaissance survey was carried out to gather general information about the study site, the drivers of deforestation and the other variables mentioned in this study. This pre-survey allowed the questionnaires to be modified and the sample respondents to be selected. For the purpose of the study, villages near forested areas in Kraya Commune and containing charcoal makers and woodfuel consumers (households) were chosen. Charcoal makers and households represented the strata in each village. The number of households and charcoal makers was obtained among the selected samples during the reconnaissance survey, and this number was also used as the sampling frame. The respondents were then chosen using a systematic random sampling method.

Data Collection Instruments

Having been reviewed, the secondary data was used to prepare the data collection instruments used in the study. The questionnaire was designed in line with four key sectors, as follows:

- The residential sector,
- The charcoal producing sector,
- The commercial woodfuel collection sector, and
- The woodfuel and charcoal sales sector.

When applied to the residential sector, the questionnaire was comprised of four broad headings: a survey form, background information, socio-economic data and household energy consumption – which consisted of questions related to energy sources for lighting, cooking, boiling water and animal protection, as well as energy bills and the use of appliances. The questionnaires used for the charcoal producing and commercial woodfuel collection sectors consisted of questions related to wood transportation, the types of stove and kiln used, collection patterns, woodfuel prices and the types of wood collected.

Key Informant Interviews

Though the empirical parts of this research were based mainly on the collection of primary data from the sample households, key informant and in-depth interviews were also applied. Concerned stakeholders included heads of households, woodfuel collectors, charcoal producers, woodfuel and charcoal sellers, government officials and local expatriates. Key informant and in-depth interviews were used to validate and cross-check the information provided by the respondents.

To identify the drivers of deforestation in the study area, focus group discussions (FGDs) were carried out. However, because forest issues are very sensitive, information obtained from the FGDs could have been biased, because government officers such as communal and village chiefs also participated in the discussions. Therefore, key informant interviews and individual discussions with local people, such as charcoal producers, wood collectors and woodfuel sellers, were also conducted in the study area.

Sampling Size

The sample size for the study was not determined using a specific equation, and randomization was maintained to avoid bias. Villages in the study area were selected for the household interviews based on information regarding the number of households, charcoal producers, commercial woodfuel collectors, and woodfuel and charcoal sellers in each village. The number of respondents selected for interview, by sector, was as follows:

- Residential sector: 158 respondents
- Charcoal producers: 15 respondents
- Commercial woodfuel collectors and sellers: 10 respondents
- Forest dependent people: 50 respondents

Units and Conversion

Only woodfuel and charcoal are commonly used in the study area. The domestic consumption units used for these fuels are a 'stere' (1 x 1 x 1m of stacked wood, or 360kg) for firewood, and a kilogramme or sack (55kg) for charcoal. One stere of woodfuel used to produce charcoal is equal to approximately 450kg in weight (Gorse, 1998). Top *et al.*, (2003) reported that the conversion factor between oven dried weight (ODW) and air-dry weight is 0.71 (using 20 firewood samples from ten tree species) and using these results, one stere of firewood is equivalent to 255 kg ODW. Based on a study conducted by RWEDP (1998), one-tonne of charcoal represents 7.3 stere of firewood on average, and; therefore, one tonne of charcoal is equivalent to 1.862 tonnes of firewood ODW. Gorse (1998) studied the woodfuel production process in Kampong Chhnang Province, Cambodia, and reported that one cubic meter of wood is equal to 604 kg.

Results and Discussion

Socio-economic Conditions

Table 1 shows the socio-economic status of the study households by household size. The households are categorized into five family sizes: very small (2-3 persons), small (4-5 persons), medium (6-7 persons), large (8-9 persons) and very large (>10 persons). Table 1 shows that family size and education status play an important role in shaping woodfuel usage activities. Nearly 40% of the households (63 households) is in the small household category, while only 1.3% is very large. The illiteracy rate among the very small households is lower than for the medium-size households, while the overall illiteracy rate is 22.9%. Over 70% of the households said they received a formal education, to primary or secondary level, or above.

It should be noted that average annual incomes vary with the household size. The lowest average annual income (USD1048.19±119.87) can be found among the very small households; whereas, the highest annual income, estimated as USD1727.40±178.90, is found within the medium-size household category. According to my statistical analysis, there is a significant difference within the very small household group, and also the medium and large household groups ($p>0.05$). The overall average annual income is USD1429.68±78.78 (Table 1).

Average household size is 5.02±1.85 (Mode = 4). In terms of household age composition, **63.3%** of the sample population is in the five to 18 years-old age bracket, **98.7%** in the 19 to 59 age group – so of working age, and **22.2%** is 59 or over. People within the lower and upper age brackets do; however, contribute their labour, although not to the same extent as those in the 19 to 59 age group. Family labour is the basis of both on- and off-farm employment activities, and is often shared reciprocally among neighbors and relatives, to offset potential labour shortages during peak agricultural production periods.

Table 1: Household Socio-economic Conditions by Household Size (Mean±SE)

Family Size	Number of Families	Education (%)				Average Annual Income (USD)
		Illiteracy Rate	School			
			Primary	Junior	Senior	
Very Small	34(21.5%)	17.6	61.8	17.6	2.9	1048.19±119.87[a]
Small	63(39.9%)	25.4	58.7	11.1	4.8	1365.23±113.28[ab]
Medium	47(29.7%)	23.4	59.6	14.9	2.1	1727.40±178.90[b]
Large	12(7.6%)	16.7	66.7	8.3	8.3	1720.50±246.58[b]
Very Large	2(1.3%)	50	-	50	-	1203.75±38.75[ab]
Total/Mean	158(100%)	22.9	59.9	14.0	3.2	1429.68±78.78

Economic Land Concessions

Since the 1990s, land concessions have been granted in Cambodia for a variety of reasons and purposes. The 2001 Land Law formalized the legal framework for granting concessions for economic purposes. An economic land concession, or ELC, is a long-term lease that allows the beneficiary to clear land in order to develop industrial agriculture. According to the Ministry of

Agriculture, Forestry and Fisheries (MAFF) website (updated in May 2010), 86 valid economic land concessions have been granted since 1995. The concessions cover a land area of about 1,041,144 ha across 18 provinces throughout the country. However, according to the NGO Forum database, which uses information collected from different sources, 229 economic land concessions have been granted in Cambodia (Table 2).

Table 2: Economic Land Concessions in Cambodia, 2010

Province	**Total No. (NGO Forum database)**	**Total No. (MAFF)**	**Total Land Area (ha) (MAFF)**	**No. of Foreign Owned Companies (MAFF)**
Banteay Meanchey	4	0	0	0
Battambang	2	2	13,200	0
Kampong Cham	26	5	12,070	0
Kampong Chhnang	1	1	315,028	0
Kampong Speu	13	6	43,181	5
Pursat	4	1	3,000	0
Kampong Thom	37	6	48,161	3
Kampot	3	3	35,800	0
Koh Kong	14	4	79,300	2
Kratie*	28	18	102,591a	13
MondulKiri*	17	10	65,258	6b
Otdar Meanchey	13	4	27,736	4
Preah Vihear	11	1	14,752	0
Siem Reap	9	3	19,235	0
Ratanakiri*	14	9	61,959a	4
Sihanoukville	2	2	12,800	0
Stung Treng*	30	11	187,073	4
Svay Rieng	1	0	0	0
Total	**229**	**86**	**1,041,144**	**41**

Notes: (a) Approximate figure owing to limited detailed information on some companies, (b) Two companies added which do not appear on the MAFF website. Information was collected from hard copies of the company investment contracts. *Northeast provinces. All concessions listed were valid as of May 2010. *Source*: www.elc.maff.gov.kh.

In the study area, 36,687.5 ha of forest land under the management of the Forestry Administration in Kror Year Commune has been granted to ten rubber plantation companies. According to the 2014 annual report for Kro Yea Forestry Administration, 27,141.89 ha of forest land have been cleared by these companies (Table 3).

Table 3: Economic Land Concessions in the Study Area, 2013

Company	Total Land Area Granted (ha)	Total Area of Cleared Land (ha)
Barear	5,914	5579.699
Mean Rith Group (Phea Var)	9784	7916.4
Tan Bean	7571	7200
Nupheap Sophy Investment (Siv Gech)	488	488
An Sophy Farming Investment	967	355
Farmer Investment (Cambodia Farmer	939	415
Golden Farming Investment)	925	290
CCV	5730	1530
Gold Foysion	2163	2163
Rith Mony Samnang Leap	1678.5	1255
Total	**36,687.5**	**27,141.89**

Woodfuel Collection for Commercial Purposes

In Cambodia, wood is the main energy source, not only for people living near forests, but also for those living in provincial towns and further away from forests. Wood is collected from natural forest areas and from agricultural plantations converted out of forest land. To obtain wood from the agricultural plantations, the collectors pay the landowners 1000 Riel (USD~2.5 to 3.5) per ox cart containing 5$m^3$of wood. Then, the collected wood is transported and sold to local wood sellers or retailers in the district towns. The city of Phnom Penh is also a final destination for such wood, where it is sold to retailers and households, and to the services sector (Fig. 1).

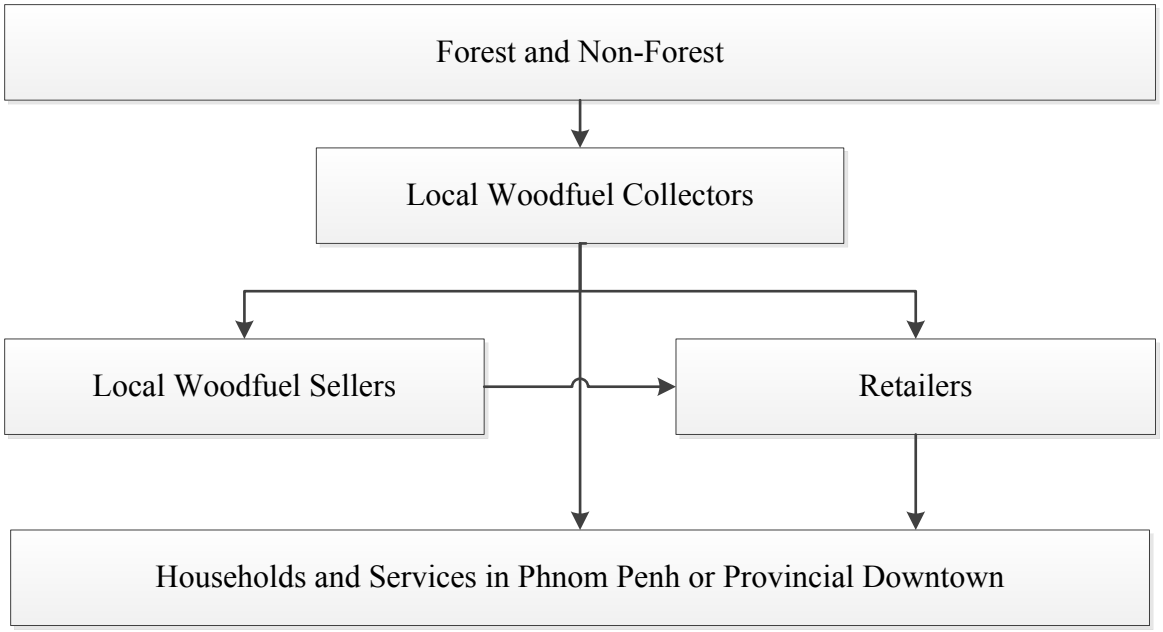

Figure 1: Commercial Woodfuel Supply Process in the Study Area

According to the results of the study, wood collection activities over the course of a year for the household and services sector can be divided into three collection periods: peak, medium and low collection periods. Usually, the peak collection period lasts for approximately six months over the course of the dry season, while medium-scale collection activities are conducted over four months in the early and late wet season. Only a small amount of wood is collected in the middle of the wet season, as it is difficult to collect and transport wood at this time due to the rain. In the peak season, a wood collector will usually gather wood five times a month, collecting a total of 19.33±3.35 tonnes. In the medium and low collection periods; meanwhile, a collector will gather 12.75±0.07 tonnes and 9.23 ± 0.05 tonnes of wood respectively. The average amount of wood collected by a family over the course of a year is 66.10±10.62 tonnes^{-1} (Table 4).

Table 4: Wood Collection Periods and Amounts for Households and Services

Wood Collection Periods	Duration (months)	Frequency of Collections (months^{-1})	Amount Collected (Monthly) (tonnes/family^{-1}/month^{-1})	Amount Collected (Annually) (tonnes/family^{-1}/year^{-1})
Peak	6.77 ± 0.77	5.55 ± 0.91	19.33 ± 3.35	115.83 ± 17.13
Medium	4.22 ± 0.89	3.66 ± 0.55	12.75 ± 0.07	48.52 ± 10.28
Low	2.71 ± 0.47	2.71 ± 0.60	9.23 ± 0.05	24.76 ± 6.91
Mean/Total	12.00	4.08 ± 0.67	14.13 ± 1.64	66.10 ± 10.62

Charcoal Production

For Cambodian people, charcoal is a key energy source, and especially for those who live in Phnom Penh, where 40% of the population depends on charcoal for its cooking activities. However, the act of producing charcoal is considered illegal, because it is one of the main drivers of deforestation.

Wood Collection and Charcoal Sources

In the study area, charcoal producing activities are mainly concentrated in or near to forested areas, where it is easy to collect wood to supply the local charcoal kilns. Some of the wood used for charcoal is collected from former forest land that has been converted to agricultural land, while the rest is cut from trees. Some charcoal producers buy their wood from local farmers who need to clear their land to cultivate crops. However, the charcoal producers cannot collect enough wood from agricultural land to feed the charcoal kilns over a long period; therefore, some producers illegally cut-down trees in forested areas. According to the results of the study, approximately 60% of producers obtain their charcoal wood from forested areas and agricultural plantations, while only 33% said they collect wood from natural forests alone (Fig. 2). Wood collection is mostly carried out by men, and particularly those aged between 18 and 59. Households without male members buy their wood or collect it themselves from nearby forest land.

There are different types of charcoal producer. Some producers living far away from the forest land build their charcoal kilns within the forested areas, with stand wood collected to feed the kilns. These producers stay in the forests for around one to two months while collecting the wood to feed their kilns, and after feeding their kilns, leave them for about one-and-a-half months until the charcoal is ready to collect. This group is considered the main charcoal producer in the study area. Other producers who live near to the forest construct their kilns close to their houses, with small trees gathered from their agricultural land and from nearby forested areas used to feed the kilns. Such producers are not considered large-in-scale, because they produce only a small amount of charcoal when local tree wood is available. Generally, charcoal is produced during the dry season because it is the agricultural off-season. In addition, producers can easily access forests at this time, to collect wood and feed their kilns.

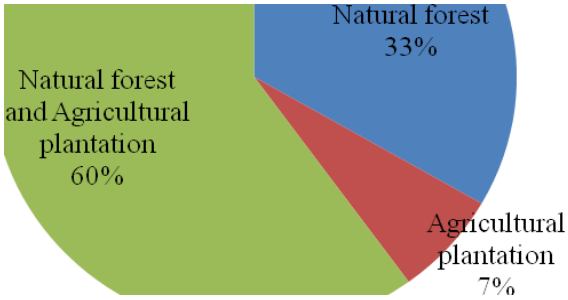

Figure 2: Sources of Charcoal Wood

The collected wood is mostly transported from the forest using a power tiller and cart of 5m^3 capacity (Fig. 3). For households without their own power tiller, the wood is collected manually and a power tiller hired to transport it to their kilns.

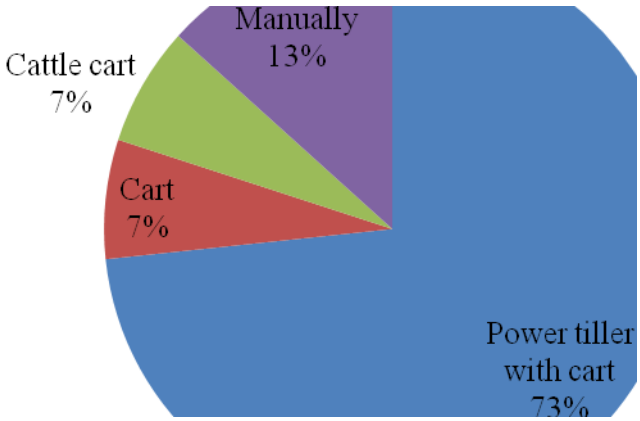

Figure 3: Methods used to Transport Charcoal Wood

Tree and Plant Species used to Produce Charcoal

Various parts of different species of tree and shrub are collected from the forests and agricultural plantations. The species preferred for producing charcoal is shown in Table 5. The most popular tree species used are Khrorkhoh (*Sindoracochinchinensis*), Chambak *(Irvingiamalayana)* and Thnao *(Borassusflabellifer)*. Charcoal producers always carefully select the plant species they use to feed their kilns, because some species do not produce high quality charcoal, making it difficult to sell the final product. However, due to the scarcity of trees and the limited access rights for collecting plants, the producers don't care so much about choosing the best tree species; they prefer to cut all the species available in a given forest area.

Table 5: Tree Species used to make Charcoal in the Study Area

N^0	Local Name	Scientific Name (species)
	Khrorkhoh	*Sindoracochinchinensis*
	Chambak	*Irvingiamalayana*
	Thnao	*Borassusflabellifer*
	Lngieng	*Cratoxylonprunifolium*
	Trosek	*Peltophorumferrugineum*
	Kray	*Kayeaeugenicefolia*
	Thlork	*Parinarium spp.*
	Pring	*Eugenia spp.*
	Troyeung	*Diospyroshelferi*
	Knong	*Pterocarpusindicus*
	Trosek	*Peltophorumferrugineum*
	Smarch	*NA*
	Porpel	*Hopearecopei*

Note: NA means the information is 'not available'

Wood Consumption when Making Charcoal

Charcoal is the main energy source for people living in the provincial towns and Phnom Penh, and its production is a key income source for rural people. However, the making of charcoal consumes a large amount of standing wood from the natural forests. In the study area, where charcoal making is a key income generating activity, each family collects approximately 6.17 ± 1.52 tonnes of standing wood each month, in order to feed the charcoal kilns (Table 6).

Table 6: Amoubt of Wood Consumed to make Charcoal

Wood Consumption	Number of Months	Wood Consumption (tonnes/family^{-1}/month^{-1})	Woodfuel Consumption (tonnes/family^{-1}/year^{-1})
Mean	8.47 ± 1.04	6.17 ± 1.52	44.41 ± 6.97

Charcoal Flows and Income

Figure 4 below shows the production and distribution process flows for the charcoal production sector in the study area. Most of the charcoal is purchased by traders and then transported to

retailers in provincial centres or in Phnom Penh – the largest city in the country and so the preferred location for selling charcoal to households and businesses such as small- to medium-sized restaurants. A second group of traders is also involved in the flows, as this group purchases charcoal from the first group of traders in the provincial towns and transports it to Phnom Penh The charcoal is also sometimes purchased by local transporters, who then transport it to local markets where it can be purchased by local traders, retailers, households or small restaurants, though most of the charcoal is taken to Phnom Penh by transportation companies who sell it on to these same customers.

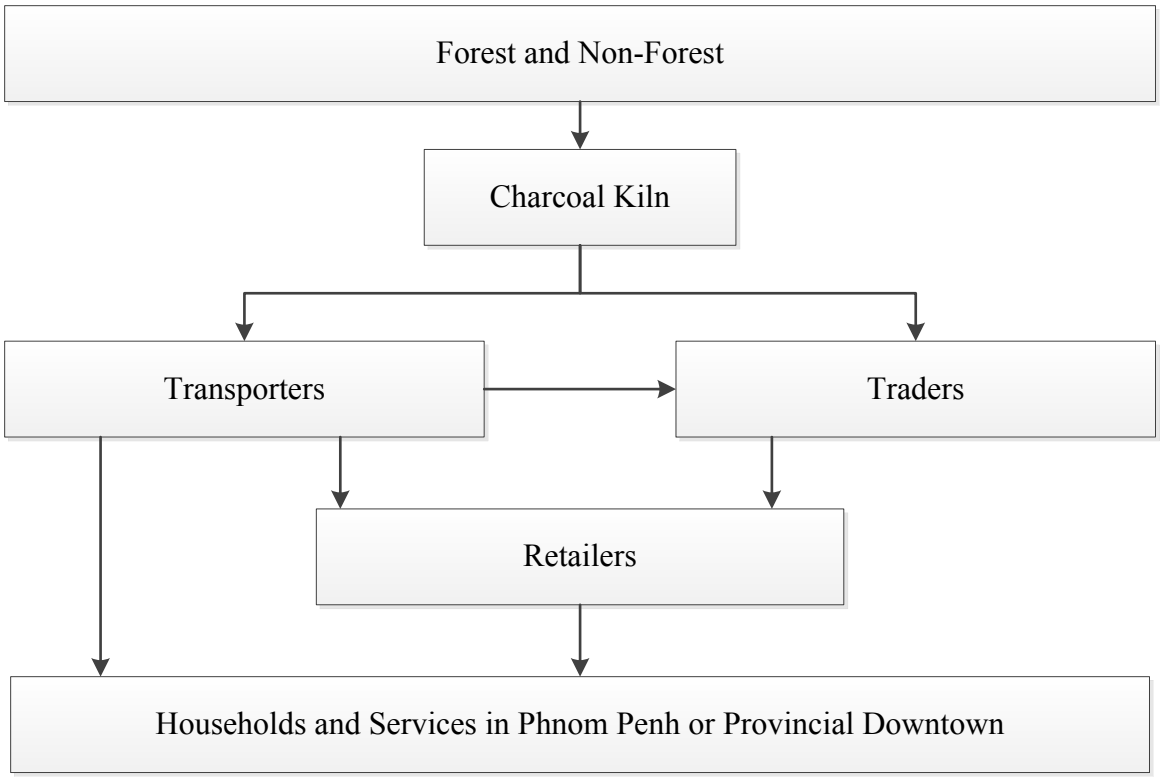

Figure 4: Charcoal Production and Distribution Process

According to the results of the survey, average charcoal production per family is 10.57 ± 2.23 tonnes per year^{-1}. At a price of USD0.11 ± 0.058 per kg^{-1}, a charcoal producer can earn approximately 1260.55 ± 283.21 USD per year, accounting for about 59% of the income generated by the charcoal-producing households (Table 7). The relationship between the income made from charcoal production and total household income is a strong and positive one (R^2 = 0.6969; p = 0.000; n = 15), and this reflects the importance of charcoal production activities to total household incomes (Fig. 6), even though such activities are considered illegal.

Table 7: Incomes Derived from Charcoal Production Activities

Forest-based Activity	Charcoal Production (one family^{-1}per year^{-1})	Unit Price (USDkg^{-1})	Average Cash Generated by Product Sales (USD/year^{-1})	Average % Contribution to Total Household Cash Income
Charcoal Production	10.57 ± 2.23	0.11 ± 0.058	1260.55 ± 283.21	59.10 ± 7.56

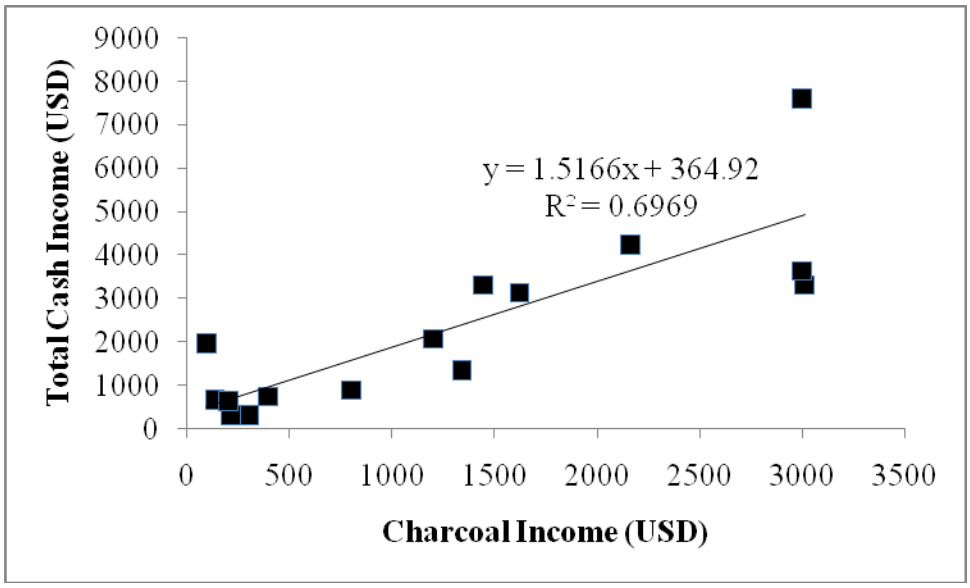

Figure 5: Total Annual Cash Income and Charcoal Production Income in the Study Area

Charcoal Kilns

Clay kilns of different capacities are used in the study area. A large capacity kiln is approximately 12m^3, while the medium and low capacity kilns have an area of 5m^3 and 2m^3 respectively. Charcoal producers tend to construct the same type of charcoal kiln; a traditional enclosed kiln. One production cycle takes an average of 25 days. The results of the study reveal that most charcoal producers own only one kiln; only 7% of the total charcoal producers sampled said they own two kilns, while 21% of producers own three kilns (Fig. 7).

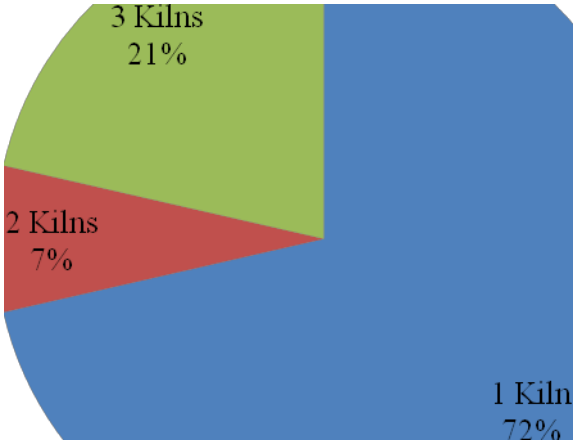

Figure 7: Number of Kilns Owned by Charcoal Producers in the Study Area

Woodfuel Consumption

Collecting wood for use with cooking, boiling water and other daily activities alone would not lead to deforestation in the study area. However, the incomplete combustion of wood when using low efficiency traditional stoves does result in high wood consumption levels, and this leads to

more wood having to be collected from the forests. Although the collection of wood for domestic usage – such as with cooking, for boiling water, to protect against insects and to prepare animal feed – is not a major cause of deforestation country-wide, it may be a major cause in certain areas, and the constant rate of wood removal may be having a negative effect on the structure of natural forests in Cambodia. Due to the rapid pace of population growth, more wood is needed to meet the demands of local people and city dwellers; therefore, woodfuel is harvested in an unsustainable way. Also, in terms of greenhouse gas emissions, using traditional cooling stoves has some serious implications.

Eighty-eight percent of the sampled households said they obtain wood for fuel by collecting from a variety of sources, while only 12% of the sampled households said they purchase wood from sellers or collectors in their village (Fig. 8). The lower proportion of woodfuel purchased is due to the proximity of local forests from where wood can then be collected for free, and because the commercial wood can be transported directly to the district town and Phnom Penh. Top *et al.* (2004) reported that in highly forested areas, less wood is purchased from markets than in areas of sparser forest cover, while people in areas with a lot of forest cover are less likely to purchase wood, as they can easily collect it locally, for free.

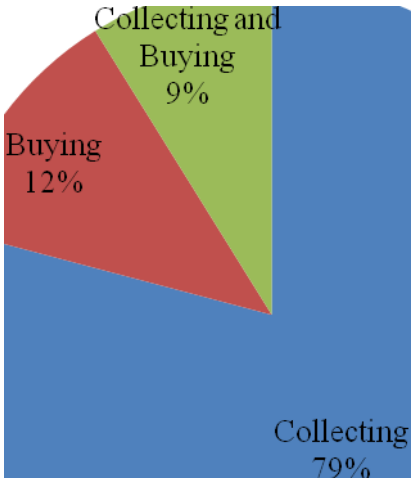

Figure 7: Sources of Wood used to make Charcoal

The study revealed that local people collect wood from four different sources: (i) from the forest around their homes, (ii) from the natural forest, (ii) from wasteland, and (iv) from agricultural land (Fig. 8). Usually though, local people collect wood for daily consumption from the forests around their homes. Top *et al.* (2003) carried out research in Kampong Thom Province, and estimated that 51% of wood originated from forested areas and 32% from non-forest sources, while a year later in 2004, these same sources represented respectively 49% and 39% of wood collected.

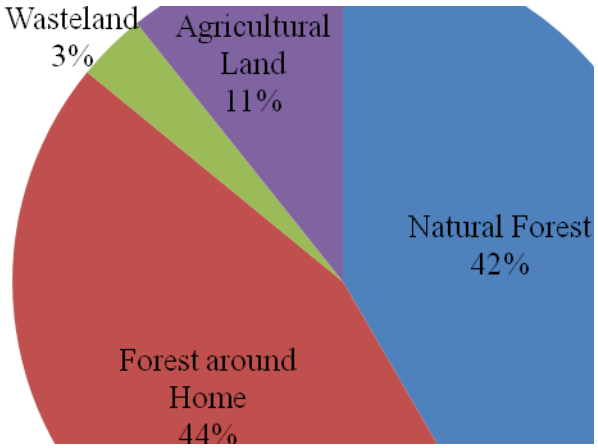

Figure 8: Sources of Wood Collected by Villagers for Daily Consumption Purposes

Table 8 shows the woodfuel consumption rate by household size, with the household size groupings used being the same as those shown in Table 1 (page 5). The average consumption rate is 5.12±0.14kg per day^{-1} per family^{-1} (Mean±SE), while the lowest and highest average consumption levels are 4.49±0.37 kg and 7.00±0.00 kg per day^{-1}per family^{-1}for the very small and very large households respectively. According to my statistical analysis, the average wood consumption rate for the very small households is significantly different from that of the other household groups ($p<0.05$). The analysis also indicates that there is a significant difference in woodfuel consumption rates between the medium, large and very large households; however, there is no significant difference between the small and medium-sized households (Table 8).

For this survey, the households were divided into five different income groups (million Riel): Group 1 (G1) 1-5, Group 2 (G2) 6-10, Group 3 (G3) 11-15, Group 4 (G4) 16-20 and Group 5 (G5)>20. It was found that about 55% of the total households are in income Group 1 (G1), while 31% are in Group 2 (G2), followed by Groups 3, 4 and 5, with only a few of the households in the higher income groups. The variations seen in woodfuel consumption levels are due to differences in income levels. The results clearly show that the average woodfuel consumption rate among those households with the highest incomes is higher than for those households at other income levels. Overall average woodfuel consumption for cooking is 5.12±0.14 kg per day^{-1}per family^{-1}, but in Group 5 it is7.00 kg per day^{-1}per family^{-1} (<20). Meanwhile, in Group 3 it is 4.45±0.55 kg per day^{-1}per family^{-1} (Table 9). According to a one-way ANOVA analysis, the average woodfuel consumption for Group 1 and Group 2 is not significantly different ($p>0.05$). However, the analysis also reveals that average woodfuel consumption levels in these two lower income groups are significantly different from those in Groups 3, 4 and 5 ($p<0.05$).

Table 8: Average Woodfuel Consumption for Cooking Purposes, by Household Size (Mean±SE)

Household Size	Number of Families	Average Woodfuel Consumption ($kg/day^{-1}/family^{-1}$)	Average Woodfuel Consumption ($kg/day^{-1}/capita^{-1}$)
Very small (2-3)	34	4.49 ± 0.37^{a}	2.23 ± 0.18^{a}
Small (4-5)	63	5.08 ± 0.20^{b}	1.76 ± 0.07^{b}
Medium (6-7)	47	5.40 ± 0.26^{bc}	1.31 ± 0.7^{bc}
Large (8-9)	12	5.75 ± 0.49^{c}	1.16 ± 0.09^{bc}
Very large (>9)	2	7.00 ± 0.00^{d}	0.83 ± 0.04^{c}
Mean	158	5.12±0.14	1.67±0.06

The letters a, b and c are used to show the significant difference (p = 0.05) between the values within a column, according to the contrast test in the one-way ANOVA. Values in the same column followed by the same letters are not significantly different.

Table 9: Average Woodfuel Consumption for Cooking Purposes, by Income Group (Mean±SE)

Annual Income (million Riel)	Number of Families	Average Woodfuel Consumption ($kg/day^{-1}/family^{-1}$)
Group1 (1–5)	88	5.05 ± 0.20^{a}
Group 2 (6–10)	49	5.34 ± 0.23^{a}
Group 3 (11–15)	16	4.45 ± 0.55^{b}
Group 4 (16–20)	4	6.20 ± 0.45^{c}
Group 5 (>20)	1	7.00 ± 0.00^{d}
Mean	158	5.12±0.14

The letters a, b and c are used to show the significant difference (p = 0.05) between values within a column, according to the contrast test in the one-way ANOVA. Values in the same column followed by the same letters are not significantly different.

Conversion to Agriculture and Settlement

Until recently (before 2014), migrants moved to the study area in search of agricultural land. While these migrants may have participated in clearing the forest to facilitate future land sales and to create agricultural plantations, land speculation is most often driven by business-people, officials and local villagers who claim and clear the forest in order to allow for agricultural plantations to be set up. With populations in the rural areas growing rapidly, the demand for agricultural land is increasing year-on-year. As well as pressure on forests from migrants, local communities are experiencing population expansions and so require an increasing amount of farmland to grow cassava and help support their families. Encroachment on to forest land by migrants, local people and private companies is taking place every year. According to Kraya Forestry Administration in Kraya Commune, 4243 ha of forest land has been claimed and cleared by local people and migrants over recent years for settlement and agricultural activities, and especially for growing cassava.


Picture1: Agricultural Land Conversion Activities

Illegal Logging for Commercial Sale and Local Use

Based on the growing domestic and overseas demand for high-value luxury wood, illegal logging now contributes significantly to deforestation in the study area. Illegal timber is smuggled out of the area during the night, to avoid being seen by local people and the local authorities. These illegal timber smuggling activities are usually organized by private operators or powerful government officers, with support coming from the local military. The amount of illegal timber smuggled cannot be accurately estimated because it is a very sensitive issue, meaning no one wants to talk about it in the study area.

As well as illegal logging for commercial sale, timber is harvested for house construction purposes, but this is carried out by local people. However, timber is also harvested by local people for commercial sale, for use as housing materials by people outside the study community.

Conclusion

To conclude, the granting of land concessions and the conversion of forest land into agricultural plantations and also human settlements, plus illegal logging for commercial and domestic purposes – to make charcoal and household woodfuel, can all be considered key drivers of deforestation in the study area. Large-scale land concessions have already been granted by the government, and only political factors can resolve this problem. This means that the issues of forest land conversion and illegal logging can only be effectively addressed based on a strong commitment coming from the government; to strengthen and enforce forest laws. Due to the ongoing demand for charcoal from local people and those living in urban areas, charcoal producing represents a key activity, one difficult to stop, especially as it makes such a large contribution to the total incomes of the charcoal producers. To deal with the issue, the demand for wood-based charcoal in the provincial towns and Phnom Penh could be reduced by promoting the use of clean charcoal produced out of agricultural residues. In addition, the use of more efficient charcoal kilns and cooking stoves should also be promoted, to help reduce wood consumption levels among households and small service businesses, not only in rural areas but also in provincial towns and cities. Finally, new and alternative energy sources should be introduced in the study area, such as solar energy and biogas fuels.

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Using Contingent Valuation to Measure the Willingness to Accept by Fisheries Communities for Voluntary Waterbird Nest Guarding: Case Studies at Stung Treng and Ratanakiri Provinces, Cambodia

Phat Chandara & Seak Sophat
Department of Natural Resource Management and Development,
Royal University of Phnom Penh

Editor: Andrea Claassen
Conservation Biology Graduate Program
University of Minnesota, USA

Introduction

Ecosystem services have been studied by a number of researchers, providing valuable analyses as to the benefits they can generate for local people's livelihoods; however, there has been less research carried out into the non-calculable or invisible value of such resources (Berbés & Marta., 2012). National Parks (NPs) support fauna and flora that sustain and provide services to billions of people around the world. Protected Areas (Pas), including NPs, are commonly established to conserve biodiversity, protect ecosystems, and maintain ecological processes; many NPs are also expected to contribute to sustainable development and poverty reduction.

The greatest threat to the survival of populations of plants and animals is due to illegal harvest (Manel et al., 2002). The World Conservation Union (1996, 1997, 2000) predicts that over the next few decades approximately 10-20% of all vertebrate and plant species are at risk of extinction. Furthermore, human exploitation and disturbance often threaten nesting wildlife, including waterbirds (Wright et al., 2013). There are a variety of reasons that nests fail, such as natural predation, starvation, adverse weather, and exploitation for food or trade. Moreover, wildlife and their products is the third greatest illegal traffic after drugs and arms (Robber, 2000).

Improving nest success is a fundamental and principle conservation measure for many kinds of threatened species, including birds, reptiles, turtles and others wildlife (Bell & Merton, 2002). Willingness to Accept compensation (WTA) is therefore an effective measure of the social and economic costs to communities of losses associated with conservation of natural resources. A Nest guarding scheme is being implementing by the Department of Natural Resource Management and Development of the Royal University of Phnom Penh for six waterbird species along the 3S Rivers, Cambodia including River Tern (*Sterna aurantia*), River Lapwing (*Vanellus duvaucelli*), Great Thick-Knee (*Esacus recurvirostris*), Small Pratincole (*Glareola lactea*), Little Ringed Plover (*Charadrius dubius*) and Mekong Wagtail (*Motacilla samveasnae*). This scheme employs local communities to prevent human exploitation (harvest of eggs and chicks) and disturbance at nesting sites. This project provides guard salaries as an incentive to local communities to report a nest site and ensure its success, rather than harvesting its contents.

Specifically, the aim of this study was to measure the value maximum WTA as compensation for voluntary waterbird nest guarding along the 3S Rivers (Sekong and Sesan Rivers), Cambodia.

Research Methods

Contingent Valuation (CV) is an economic method of assessing the value of non-market resources. The use of CV in developing countries is now widespread (Whittington, 2002). In particular, CV has been established for the valuation of environmental resources arising from national parks in developing countries. CV has been studied from developed countries as well. CV is often used to assess Willingness to Accept (WTA) compensation for a loss to (or Willingness to Pay to maintain) environmental resources such as biodiversity. The use of CV and WTA can be applied to any kind of conservation approaches including to induce land use changes, protected area conservation, and also waterbird conservation and protection of nesting as well. In this study, we used CV and WTA to assess various scenarios related to potential compensation payments to communities for waterbird nest protection.

In the WTA approach, the provision point is the total amount of money available for compensating all affected individuals in a group for the loss of access rights to waterbird nests and nesting sites along the 3S Rivers, Cambodia. Individuals are asked to make a claim or bid for compensation from this fund. If the sum of all claims exceeds the money available in the fund, no compensation payments are made and the status quo is maintained. If the sum of claims is less than or equal to the provisioning point of WTA, individual claimants receive their claim. The access regulations are then imposed.

To be specific, we define *Bi* , *Bj* as individual claims on the compensation fund, *PP* as the total amount available in the fund, and *N* as the number of claimants. It follows that

- if $\sum_{j=1}^{N} Bj > PP$, the sum of claims exceeds the available funds, then no new regulation or enforcement is put in place, and no compensation is paid; however,
- if $\sum_{j=1}^{N} Bj = PP$, the sum of claims exactly equals the amount available, so enforcement is put in place, compensation is paid, and people receive exactly the individual amount of their claim.

In this study, based on the Rule of Thumb, 30% of the total number of families from five target communities in the study area were selected to participate in a survey of WTA compensation for waterbird conservation; hence, 256 people were interviewed (see Appendix 1 for the interview questionnaire).

We conducted a binary logistic regression to investigate how WTA was affected by level of potential payment for nest protection. WTA was the response variable (1=respondent was willing to accept the specified level of payment and 0=respondent was not willing to accept the payment). Level of payment was the explanatory variable; 10 levels of payment were investigated: 5.0, 4.5, 4.0, 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, and 0.5 US dollars per day. SPSS software program was used to conduct this analysis.

Results and Discussion

Respondent's Profile

Along the Mekong River, there are about 65 million people, with about two-thirds of them living in rural areas and depending mainly on fisheries for their livelihoods (Ziv et al., 2012). In Cambodia, the 3S River Basin covers three provinces namely, Mondulkiri, Ratanakiri, and Stung Treng. Among all study locations of this survey, Kao Pang commune has the lowest population of approximately 200 households/families (see table1). Sdau commune has the highest population with the greatest number of total families/households among the 5 communes in the study area.

Table 10: The demographics of the study area

Province	*River*	*Commune*	*Village*	*Families in 2010*	*Population(persons) in 2010*
	Sekong	*Sdau*	Sdao	620	1,364
Stung Treng	*Sekong*	*Thma Kaev*	Nheang Sum	260	982
	Sekong	*Ta Lat*	Svay Rieng	403	1,233
			Khsach Thmei	258	1,300
	Sesan	*Hat Pok*	Hat Pok	215	929
Ratanakiri			Veun Hay	88	432
	Sesan	*Kaoh Pang*	Pa Tang	92	311
			Lam Av	50	286
			Pa Hay	65	224

Source: National Institute of Statistic, 2010

Villagers' primary sources of income included: agriculture, animal (non-chicken) husbandry, chicken husbandry, and fishing (Table 2). Although 87% of villagers primarily depend on agriculture, their livelihoods also rely on natural resources such as timber and non-timber forest products, and aquatic resources along the 3S Rivers.

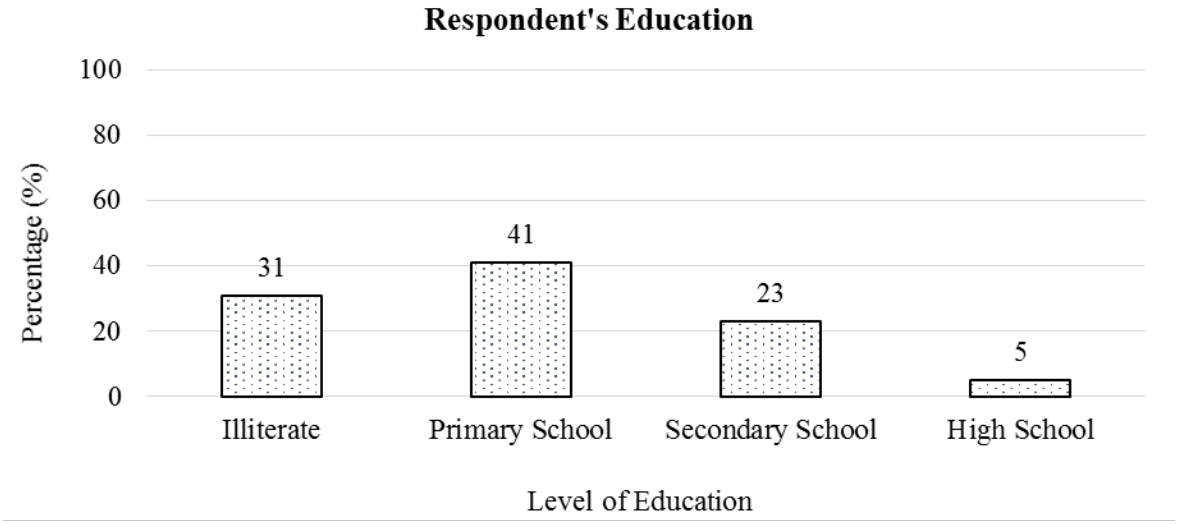
Table 11: Sources of monthly income

Source of Income	***No. Respondent***	***Percentage (%)***
Agriculture	222	87
Animal Husbandry	61	24
Chicken Husbandry	86	34
Aquaculture	5	2
Fishing	56	22
Self-Farming	1	0.5
Short-term/Vocational	4	2
Selling	22	9
Government Assistant	3	1

Source: Field Survey, 2015

As shown in figure 1, the smallest number of local people interviewed have a high school degree (5%), followed by those with a secondary school level (23%), and primary school level (41%); 31% were illiterate (non-education or dropped school).

Figure 5: Respondent's education level



Source: Survey, 2015

Descriptive Analysis

As shown in table 3, the monthly income for total respondents was ranked into 6 categories: 1) less than 100 dollars, 2) in between 100-200 dollars, 3) in between 250- 350 dollars 4) in between 400-550 dollars, 5) in between 550-650 dollars, and 6) over 650 dollars. After the analysis, the study found that the majority of respondents (60%) are earning in less than 100 US dollars per month, followed by 100-200 US dollars per month (34 %). Furthermore, this table also shows that less than 1% of total respondents earned over 400 US dollars per month.

Table 12: Monthly income for individual (US dollars)

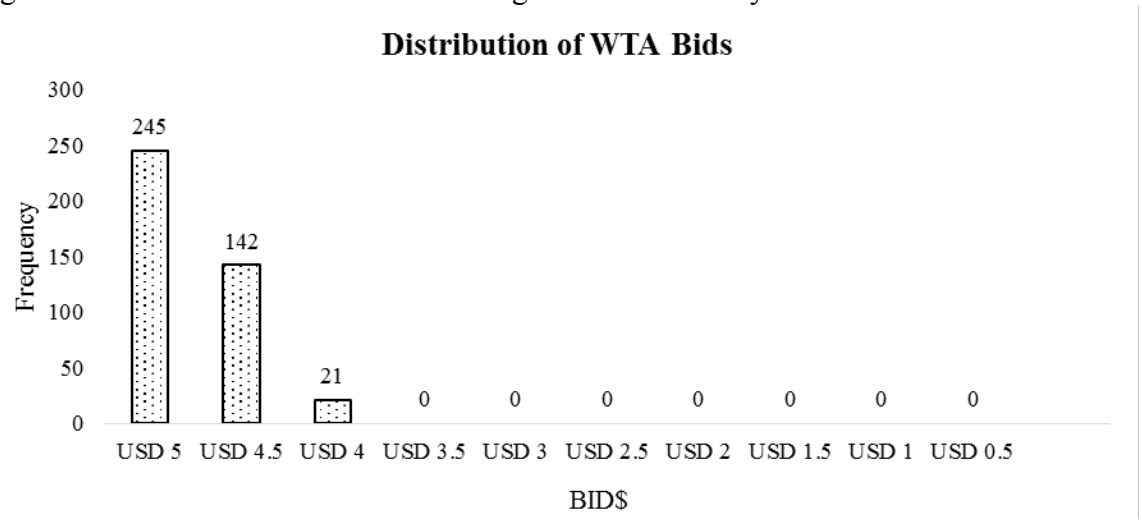
Income Level	*Frequency*	*Percentage*
Less than 100	153	60
100-200	88	34
250-350	12	5
400-550	1	0.4
550-650	1	0.4
Over 650	1	0.4

Source: Survey, 2015

Analysis of CV Responses

Figure 2 shows that 245 respondents out of 256 were willing to accept 5 US dollars per day for nest guarding along the sandbar at 3S Rivers, Cambodia. Significantly, 142 out of 256 respondents revealed that they were willing to accept 4.5 US dollars per day for nest guarding along the 3S Rivers. However, results from this survey indicated that respondents were not willing to accept less than 4 US dollars per day.

Figure 6: Distribution of WTA Bids among Local Community



Note: Respondents were not willing to accept 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, or 0.5 (US Dollars)
Source: Survey, 2015

According to table 4, low income families were significantly more willing to accept 5 US dollars per day as a payment for nest guarding along the 3S Rivers, Cambodia than families with higher monthly incomes. As result, 134 out of 256 respondents from low income families (less than 100 US dollars per month) were willing to accept 5 US dollars as payment for nest guarding, followed by 78 low income households willing to accept 4.5 US dollars per day. Additionally, 84 households with a monthly income of 100-200 US dollars were willing to accept 5 US dollars per day as a guarding fee to protected bird nests along the 3S Rivers (table 4). These results suggest that total household income had a significant impact on households' WTA compensation. Households with lower monthly income were willing to accept compensation from the project, as long as the compensation was at least 4 US dollars per day; however, households with higher monthly incomes were less willing to participate in this project.

Table 13: Distribution of WTA Bidding among Monthly Income Levels

Acceptance Level (USD)	**Monthly Income Levels (USD)- Frequency**					
	Less than 100	100-200	250-350	400-550	550-650	Above 650
5	134	84	19	3	2	3
4.5	78	46	13	2	-	3

4	16	1	3	-	-	-
3.5	-	-	-	-	-	-
3	-	-	-	-	-	-
2.5	-	-	-	-	-	-
2	-	-	-	-	-	-
1.5	-	-	-	-	-	-
1	-	-	-	-	-	-
0.5	-	-	-	-	-	-
0	-	-	-	-	-	-

Note: Currency is reported as US Dollars ($). Respondents were not willing to accept 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, or 0.5 (US Dollars) per day as compensation for bird nest protection.
Source: Survey, 2015

Based on our results from the logistic regression, the only payment level variable that was significant was 5.0 US dollars per day (table 5). These results were influenced by the fact that respondents who had been involved in the nest guarding project since last year (2014) were higher more willing to accept 5 US dollars per day than respondents who recently participated (2015), as their fee than one of the lower payment alternatives that were offered during the bidding process; in 2014 the payment was 5 US dollars per day and so participants were less likely to accept a lower payment than they had received previously.

Table 14: Results of the Binary Logistic Regression Model (N=256)

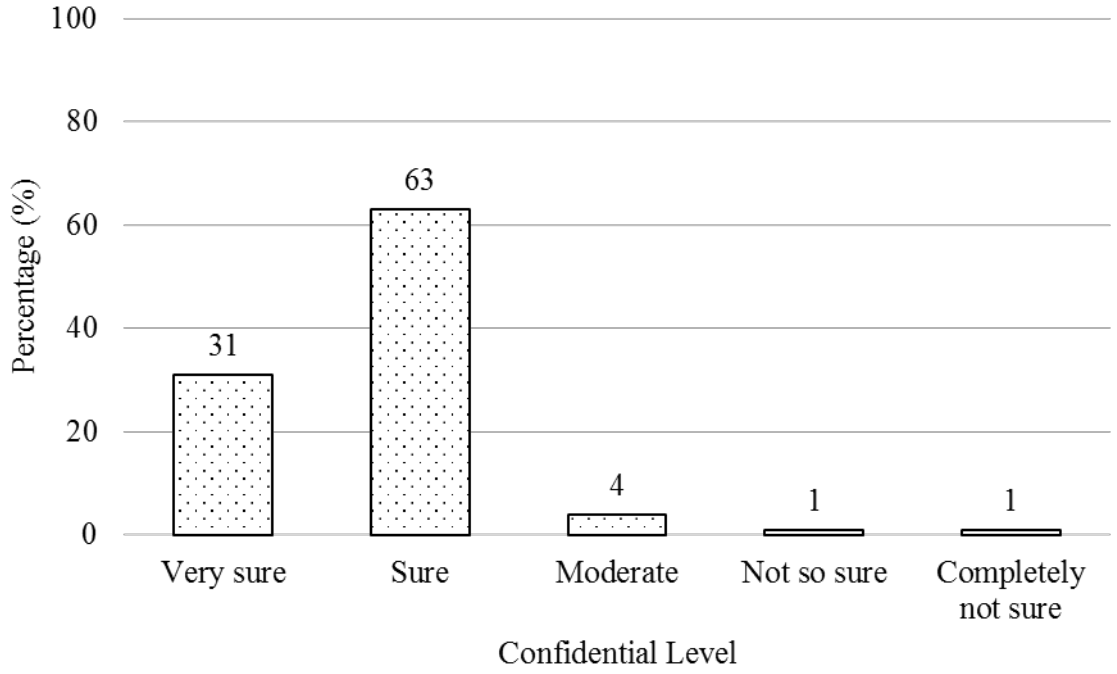
Variable Name	B	S.E.	Wald	Df	Sig. (*p* value)	Exp(B)	95% C.I. for EXP(B) Lower	Upper
$ 5	3.388	1.073	9.971	1	0.002	29.615	3.615	242.607
$ 4.5	0.024	0.309	0.006	1	0.938	1.024	0.558	1.879
$ 4	0.337	0.594	0.322	1	0.570	1.401	0.437	4.491
$ 3.5	-	-	-	-	-	-	-	-
$ 3	-	-	-	-	-	-	-	-
$ 2.5	-	-	-	-	-	-	-	-
$ 2	-	-	-	-	-	-	-	-
$ 1.5	-	-	-	-	-	-	-	-
$ 1	-	-	-	-	-	-	-	-
$ 0.5	-	-	-	-	-	-	-	-
Constant	-5.196	1.528	11.563	1	0.001	0.006	-	-

a. Variable (s) entered on step 1: $ 5, $ 4.5, $ 4, $ 3.5, $ 3, $ 2.5, $ 2, $ 1.5, $ 1, $ 0.5

Note: Respondents were not willing to accept 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, or 0.5 (US Dollars) per day as compensation for bird nest protection.
Source: Survey, 2015

The results from figure 3 suggest that 63% of respondents were sure or very sure of their decision to accept a specific payment amount as compensation for nest guarding. Only 2% of respondents were not sure of their decisions to accept a specific payment level.

Figure 7: Level of respondent confidence in their Willingness to Accept a specific payment amount.



Source: Survey, 2015

According to the survey, a minority of respondents were not willing to accept 5 US dollars per day as the compensation for nest guarding. Several reasons were identified during the survey for the unwillingness to accept the 5 US dollar per day payment. 53% of respondents did not participate in the nest guarding program because they believed the payment amount was too low, while another 29%responded that they would participate if the payment was increased to 7 US dollars per day.

Table 15: Factors effected to the participation of local villager with nest guarding project

Factors Limited on Local Participation	***Percentage***
The amount payment for nest guarding is too low	53
The amount of payment for nest guarding is too low, but if you increase up to 7 US dollars per day, I will join	29
I thought that community will manage and conserve the nest by themselves, and no need any participation from villager	9
I thought that this project will not stop running ever	6
I thought that this project will not happen (I don't believe on the project)	4

Source: Survey, 2015

Conclusions

This analysis of CV to assess WTA of fisheries communities for voluntary waterbird nest guarding produced interesting and useful results. In addition to the bidding price, communities were willing to accept 5 dollars per day. Also, WTA was influenced by level of monthly income; lower income households had higher willingness to participate in the project, as long as the payment was at least 4 US dollars per day, while higher income households were less willing to participate in the project even at the higher payment levels. Among the three payment levels (5, 4.5, and 4 US dollars per day) that communities were willing to accept as compensation for nest guarding, 5 US dollars per day had the most significant positive affect on WTA (Table 5), and the majority of respondents were WTA 5 US dollars per day to participate in the project (Figure 2).

It is likely that respondents were the most willing to accept 5 US dollars per day as the compensation for nest guarding, because this payment level represents an amount that is satisfactory to support respondents' livelihoods. Furthermore, the higher payment amount of 5 US dollars per day may provide for the well-being of respondents significantly more than the lower alternative payment amounts. As such, this may explain why respondents who previously participated in the nest guarding project last year (2014), and who were then asked about their willingness to accept a lower payment than they had received previously, were generally more concerned with the sustainability of funding support for this program than respondents who had not previously participated in the project.

In conclusion, the local communities along the 3S Rivers, Cambodia are highly appreciative of the waterbird nest conservation project implemented by the Department of Natural Resource Management and Development of the Royal University of Phnom Penh (Phat & Seak, 2014). The results of this survey indicate that compensation (5 US dollars per day) for nest guarding is also highly accepted by the local communities along the 3S Rivers, Cambodia. This information will be useful for future implementation of the waterbird nest protection project, as well as for other similar conservation projects in Cambodia. Moreover, our approach to assessing communities' WTA compensation for participating in the conservation project can be applied to other similar participatory, community-based conservation programs.

Acknowledgements

We would like to express our sincere thanks to the MacArthur Foundation and the Critical Ecosystem Partnership Fund for providing us with funding support for the project since 2012. Additionally, we are grateful to all of the local communities along the 3S Rivers who participated in this survey and in the waterbird nest protection project.

Appendix Lists

Appendix 1: Questionnaire for Household Survey- Willingness to Accept for Fisheries Communities for Voluntary Waterbird Nest Guarding

Name of Respondent……..
Household No: ……..... Village…….Commune: ……..……..
District: ……..... Province: …… Contact No.……..…
Name of Interviewer: ……..
Date of Interview: ……...
Day of week of interview: ……...
Remarks: .....……...

I. Interviewee Information

<table>
<tr><td colspan="3">Are you Head of Household</td></tr>
<tr><td colspan="2">☐ No</td><td>☐ Yes</td></tr>
<tr><td colspan="2">Are you the person who decide the expenses</td><td rowspan="2">Age of Household (…….Years old)</td></tr>
<tr><td>☐ No</td><td>☐ Yes</td></tr>
<tr><td>Thank you for your time. Stop interview</td><td colspan="2">Gender ☐ Male☐ Female
Marital status ☐Single ☐ Married ☐ Divorced</td></tr>
</table>

II. Socio-Economic Profile

1. Educational Qualification of the Respondent
   ☐ Illiterate ☐ Primary ☐ Secondary ☐ High school ☐ University
   ☐ Master degree ☐Other (specify……)

2. Occupation of the Head of Household
   ☐ Government Staff ☐ Salaried Employee ☐ Craftsman ☐ Self-employed
   ☐ Student ☐ Trader ☐ Retired ☐ General Worker
   ☐ Other (specify……)

3. The total number of Household members Adults .....
4. Children below 15 Years of age .....
5. How many people can generate earning? .....

6. Income Level of the Respondent's (USD)
   ☐ Lower 100 ☐100-200 ☐250-350 ☐ 400-550
   ☐550-650 ☐Over 650

7. Individual income of family members .....
   Income earner number 1. (USD)
   ☐ Lower 100 ☐100-200 ☐250-350 ☐ 400-550
   ☐550-650 ☐Over 650
   Income earner number 2 (USD)

☐ Lower 100 ☐100-200 ☐250-350 ☐ 400-550
☐550-650 ☐Over 650

Income earner number 3. (USD)

☐ Lower 100 ☐100-200 ☐250-350 ☐ 400-550
☐550-650 ☐Over 650

8. Total Household income (USD).

☐ Lower 100 ☐100-200 ☐250-350 ☐ 400-550
☐550-650 ☐Over 650

III. Payment Card

Assume that you were offered protection bird nest at the sandbar nearby your house location. The protection of water-bird nest will help to improvement the environmental welfare and enhance ecological system which important to help human system on earth. Recently, you receive 5 US Dollars as seasonality payment for protecting water-bird nest on a sandbar. This small amount of money will contribute somehow on your family's economics. Let think that those sandbars will protected by community for upcoming year as conservation zone for those water-bird, but everything such management plan and actions will led by community. Therefore, when the project ended, the payment of 5 US Dollar will no longer exist for your household as usual. But, the activities of nest protection still continues by community funded. Generally, community funded is not much as the current funded by the project, therefore your fee for nest protection should be lower than 5 US Dollar. The below pricing will let you know how much you willing to accept for nest protection after the current project has been stop. When you decide an amount, also think about what you would be willing to pay for a similar nest on other sandbars by WWF where they give 5 US Dollar per day for protection of the nest of giant ibis. The amount you state will not be used to decide compensation for your protected, but will give an idea about how much conservation would cost in total."

Payment Card-Amount (USD Dollar)

5.0	☐ Yes	☐ No
4.5	☐ Yes	☐ No
4.0	☐ Yes	☐ No
3.5	☐ Yes	☐ No
3.0	☐ Yes	☐ No
2.5	☐ Yes	☐ No
2.0	☐ Yes	☐ No
1.5	☐ Yes	☐ No

1.0	☐ Yes	☐ No
0.5	☐ Yes	☐ No
Not Accept	☐ Yes	☐ No (why, specific reason……)

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Contribution of Local Ecological Knowledge and Practices to Waterbird Conservation along the Sekong and Sesan Rivers IBA, Cambodia

Phat Chandara & Seak Sophat
Department of Natural Resource Management and Development
Royal University of Phnom Penh

Editor: Andrea Claassen
Conservation Biology Graduate Program
University of Minnesota, USA

Introduction

The 3S Rivers, including the Sekong, Sesan and Srepok, have played a very important role in providing diverse sources of hydrology, biodiversity and livelihoods for millions of people of riparian countries. According to Ziv *et al.* (2012), the 3S Rivers are home to many endemic and endangered species, such as fish, birds and other wildlife, and they provide critical habitats like deep pools for fish. The Rivers cover 78,650 km^2 and are shared between Vietnam (38%), Cambodia (33%), and Laos (29%) (Piman *et al.*, 2012). In particular, the Rivers nourish the Lower Mekong Basin (LMB) and the Tonle Sap Lake in terms of the pool of natural resources, for example water, fisheries and forestry; they greatly contribute to socioeconomic development, culture and the environment, and account for up to 20% of the annual flow of the Mekong River (Piman *et al.,* 2012; Ziv *et al.*, 2012). Approximately 3.5 million people inhabit the areas surrounding the 3S Rivers; many of them are from ethnic minority groups and their livelihoods wholly depend on these rivers.

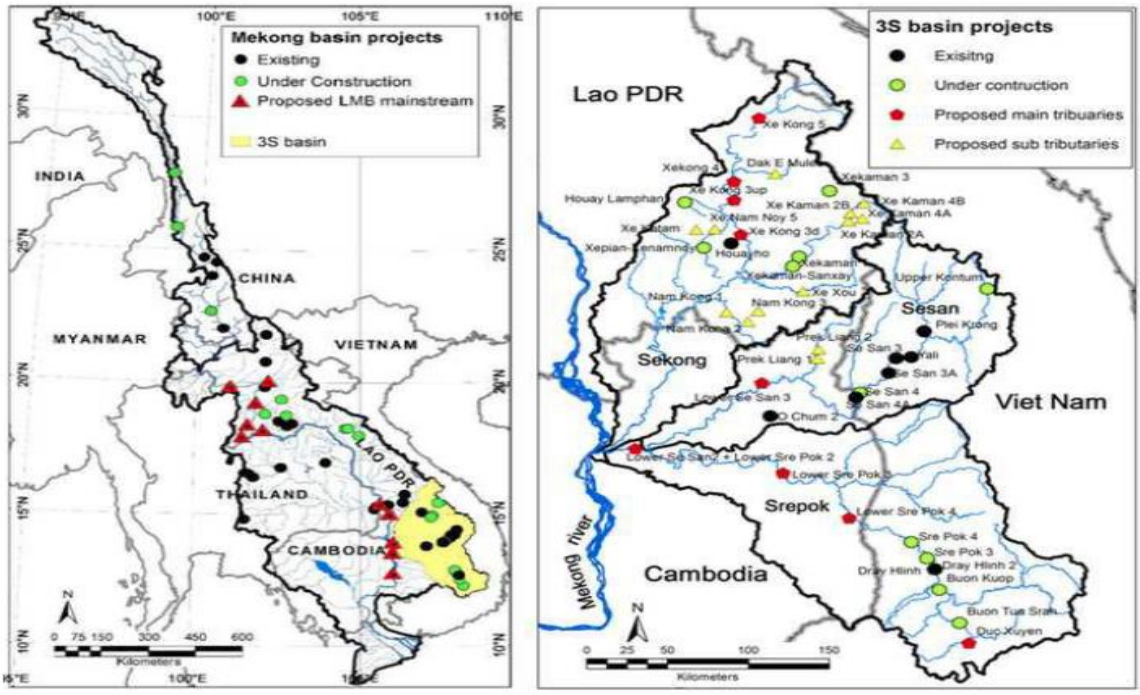

Figure 8: Maps of the Mekong River and 3S River Basin
Source: Piman et al., 2012

The 3S Rivers provide critical habitat for wildlife and support many threatened species. In particular, the Sesan and Sekong Rivers are regarded as Important Bird Areas (IBAs), which recognizes their exceptional avian diversity and the fact that they contain critical habitat for threatened bird species (Seng *et al.* 2003). The 3S Rivers also have high fish diversity; for example, there have been more than 133 and 204 species of fish recorded in the Sesan and Srepok Rivers respectively (Grimsditch, 2012). In Cambodia, over 20% of the 3S basin is currently designated as protected areas; they include a national park, wildlife sanctuaries, biodiversity conservation areas, and protected forests.

However, due to recent economic development and high demand for energy production, more than 20 hydropower dams have been built on the 3S Rivers; additionally, more than 26 dams have been planned for construction (Piman *et al.*, 2012). Although all of the existing dams are located in upstream countries (i.e., Vietnam and Lao PDR), one – the Lower Sesan 2 Dam – is currently under construction near the confluence of the Sesan and Srepok Rivers. Overall, the potential for hydropower production in the 3S River basin has been estimated to be as much as 6,400 MW (MRC, 2009).

In response to the situation on the 3S Rivers, we established a participatory, community-based conservation programme for threatened birds. The goal of this research was to assess the communities along the Sesan and Sekong Rivers in terms of their knowledge, attitudes, and practices regarding the bird conservation programme, and to use the results of this research as an educational and diagnostic tool to assess the effectiveness of the programme to meet community needs, and to be able to improve this or other such community-based programmes in the future.

Research Methods

During this research, both qualitative, quantitative, and content analyses were employed to gather all necessary documents and information regarding: social-economic development, current status of villagers supporting water conservation projects, and further vision to improve the effectiveness of the bird conservation programme.

The survey was designed as a Knowledge, Attitudes and Practice (KAP) survey to be utilized to assess a community-based conservation project. Knowledge was considered to be the level of understanding of local people on conservation activities and tactics for waterbird and riverine species along the 3S Rivers, Cambodia. Attitude was considered to be a way of being; it refers to the feelings and perceptions of local people about the conservation activities. The local community's attitude is an intermediate variable between the situation of waterbirds along the 3S Rivers and the community's response to this situation. Practice was considered to be the observable response of an individual or community to a situation, and refers to how individual or communities demonstrate their knowledge and attitudes through their actions and behaviors. In this study, we were interested in their actions and behaviors regarding the situation of waterbirds and the conservation programme. We considered factors such as their participation related to conservation activities, and any related activities that local communities had implemented. The KAP survey was conducted by designing a questionnaire and conducting interviews. It included questions around knowledge of and perceptions of waterbird conservation and protection on the

3S Rivers, Cambodia (see Appendix 1). Based on the Rule of Thumb, 30% of the total number of families were selected to participate in the survey; hence, 256 people were interviewed.

General Information about Respondents

Along the Mekong River, there are about 65 million people, with about two-thirds of them living in rural areas and depending mainly on fisheries for their livelihoods (Ziv et al., 2012). In Cambodia, the 3S River Basin covers three provinces namely, Mondulkiri, Ratanakiri, and Stung Treng. This study included 9 villages in 5 communes (Table 1).

Table 16: The demographics of study areas

Province	*River*	*Commune*	*Village*	*Family in 2010*	*Population in 2010/person*
	Sekong	*Sdau*	Sdao	620	1,364
Stung Treng	*Sekong*	*Thma Kaev*	Nheang Sum	260	982
	Sekong	*Ta Lat*	Svay Rieng	403	1,233
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Ratanakiri			Veun Hay	88	432
	Sesan	*Kaoh Pang*	Pa Tang	92	311
			Lam Av	50	286
			Pa Hay	65	224

Source: National Institute of Statistic, 2010

Villagers' primary sources of income included: agriculture, animal (non-chicken) husbandry, chicken husbandry, and fishing (Table 2). Although 87% of villagers primarily depend on agriculture, their livelihoods also rely on natural resources such as timber and non-timber forest products, and aquatic resources along the 3S Rivers.

Table 17: Sources of monthly income

Source of Income	***No. Respondent***	***Percentage (%)***
Agriculture	222	87
Animal Husbandry	61	24
Chicken Husbandry	86	34
Aquaculture	5	2
Fishing	56	22
Self-Farming	1	0.5
Short-term/Vocational	4	2
Selling	22	9
Government Assistant	3	1

Source: Field Survey, 2015

There is a high level of ethnic diversity within the study area (Table 4). Because the majority of people cannot speak Khmer (national language of Cambodia), this led to language difficulties while conducting the survey, and may have affected the survey results. .

Table 18: Ethnic groups in the study area

Ethnic Group	No. Respondent	Percentage (%)
Ethnic Lao	58	22.7
Prov	16	6.3
Other Ethnic Minorities	182	71.1

Source: Field Survey, 2015

Results and Descriptive Analysis

According to the survey, 51% of respondents who were involved in the conservation project as nest guards and patrollers live approximately 2 Km from the conservation sites (i.e., protected sandbars), which is about 30 minutes travel time by motor boat. This short distance from home to the sandbar made it easier and more convenient for them to access conservation sites in order to effectively protect nests on sandbars and to patrol the areas around the conservation sites. However, 49% of those patrollers live approximately 8 Km from the sandbars. This longer distance between their home and conservation sites required about 1 hour travel by motor boat, which was less convenient and more difficult for them to effectively protect and patrol conservation sites.

Table 19: House and distant from sandbar

Distant	No. Respondent	Percentage (%)
Close to Sandbar (2-3 Km)	127	50.8
Far from Sandbar (about 8 Km)	123	49.2

Note: Close to the island sandbar is approximately 2 Km by boat, and locating a bit far is approximately 8 Km

Source: Field Survey, 2015

Education level of respondents likely affected survey results; because education level and literacy rates were low, respondents may not have understood some of the questions or technical details of the survey. Based on the commune data record, only 10% of adults registered in secondary school, and 30% in primary school. Of surveyed adults, the middle-aged group (35-45 years old) had the lowest level of education.

As shown in the Table 6 (below), a large proportion of people in all communes had awareness about rare bird species under protection and conservation of national and international agencies. As results from this survey indicate, 87% of respondents knew that river lapwing and vultures are endangered or rare species, while 76% also said that river tern is also protected (Table 6). Interestingly, in western Siem Pang Forest which is located within the boundary of Thmor Keo Commune, researchers found a large population of endangered ibis.

However, there was misunderstanding regarding what organization was protecting these species; respondents said that species in Table 6 were not protected by NRMD/RUPP, but by related

NGOs working closely with this conservation programme such as Birdlife International, Save Cambodia Wildlife, WWF, and CEPA[7].

Table 20: Types of rare bird species known by local people

Bird Species	No. Respondent	Percentage (%)
River Lapwing	222	87
River Tern	194	76
Great-Thick-Knee	127	50.8
Small Pratincole	146	57
Giant Ibis	182	71.1
Vulture	225	87

Source: Field Survey, 2015

Furthermore, respondents were unclear about which bird species were under protection of the NRMD Department. Some respondents said that some species under protection (first seven species listed in Table 7) were not protected by the program. Other respondents listed species that are not in fact protected by the program (last two species in Table 7). For instance, only 57% of respondents said that river lapwing, and 56% said river tern are under protection by the project. Interestingly, 99% of respondents said that a variety of bird species are under protection not only by NRMD, but by several NGOs, likely Birdlife International and WWF. For example, Birdlife International is protecting vultures, and WWF is protecting Giant Ibis.

Table 21: Riverine bird species under protection

Bird Species	No. Respondent	Percentage (%)
River Lapwing	146	57
River Tern	142	56
Great Thick-Knee	134	52
Small Pratincole	132	51
Mekong Wagtail	129	50
Black Bellied-Tern	129	50
Little Ringed Plover	122	48
Little Egret	88	34
Cattle Egret	94	37
Others	**254**	**99**

Source: Field Survey, 2015

As shown in Table 8 (below), 76% of respondents indicated that local participation has positively contributed to water bird conservation. Likewise, participation from local people in the conservation project is important to ensure the stability of bird populations through local practice, and patrols along the sandbars. However, 1% of respondents said that the involvement

[7] CEPA is a local NGO working with local communities in Stung Treng Province since 2002.. CEPA is a provincial partner organization of NRMD/RUPP.

caused a negative impact on the bird population due to the disturbance to birds caused by community monitoring and patrol activities. 23% of total respondents replied that they did not know; we believe this was due to their limited understanding of the question.

Table 22: Impact of local participation on bird nests & population

Level of Impact	No. Respondent	Percentage (%)
Positive	194	76
Negative	1	1
Don't know	59	23

Source: Survey, 2015

This survey found that 68% of the total population at Talat commune said that waterbird populations had decreased, based on their observations during the last several years. Moreover, 14% of villagers at Thmor Keo commune had the same answer regarding the current status of bird populations (Table 9). On the other hand, respondents at all study locations answered that populations of waterbirds increased, as a result of several years of project implementation. Likewise, 39% of respondents in Talat Commune said that they have observed the bird's populations increase since their participation in the project. 15% and 24% of respondents from Hat Pok and Thmor Keo Communes also had the same answer. In total, 39% of all respondents said that bird populations increased, 27% said they decreased, and 88% said they do not know (Table 9).

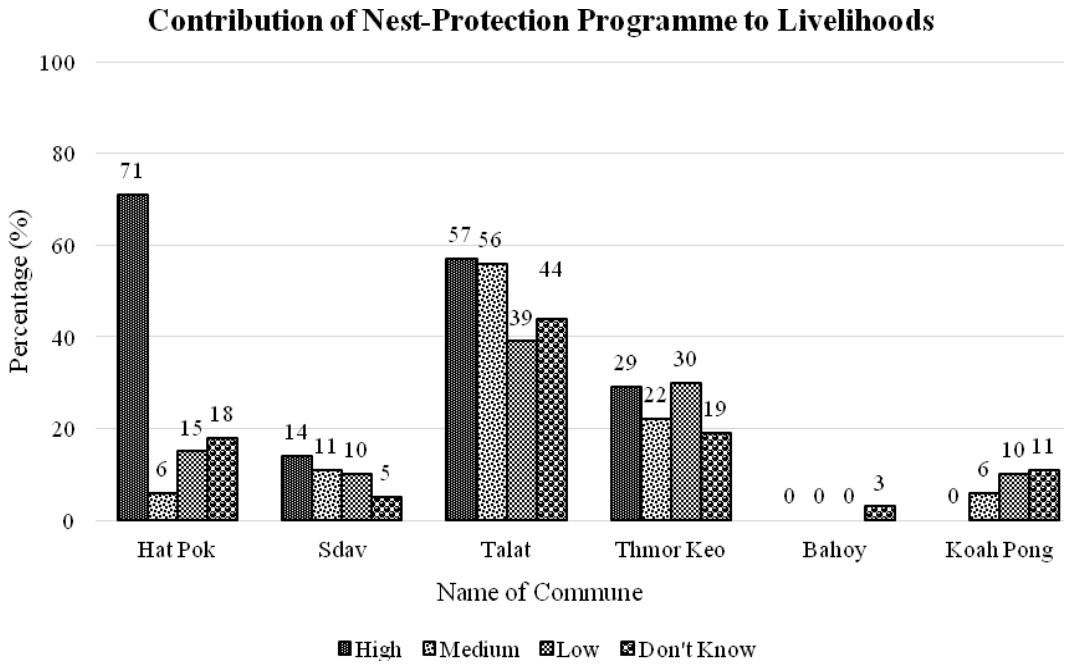
Table 23: Perception on the population of water-birds along the 3S Rivers, by villages

Villages	*Don't know*	*Percentage (%)*	*Increase*	*Percentage (%)*	*Decrease*	*Percentage (%)*
Hat Pok	23	**26**	15	**15**	6	**9**
Sdav	1	**1**	10	**10**	4	**6**
Talat	28	**32**	39	**39**	47	**68**
Thmor Keo	19	**22**	23	**24**	10	**14**
Bahoy	3	**3**	2	**2**	1	**1**
Koah Pong	14	**16**	10	**10**	1	**1**
Total	**88**	**34**	**99**	**39**	**69**	**27**

Source: Survey, 2015

Figure 2 illustrates the contribution of the nest-protection programme to people's livelihoods within the project area. This survey has found that 71% of respondents at Hat Pok village agreed that the nest-protection programme provided significant benefits, and highly contributed to their livelihood. Likewise, 57% and 29% of respondents from Talat and Thmor Keo village also had the same answer (Figure 2). However, 39% and 30% of respondents at Talat and Thmor Keo communes indicated that benefits from the nest protection programme from NRMD/RUPP to their livelihoods were low due to the limitation of payments for nest protection. Meanwhile, local villagers said that livelihood support in these communities is low because the project is focused more on strengthening capacity and conservation activities (see Table 10).

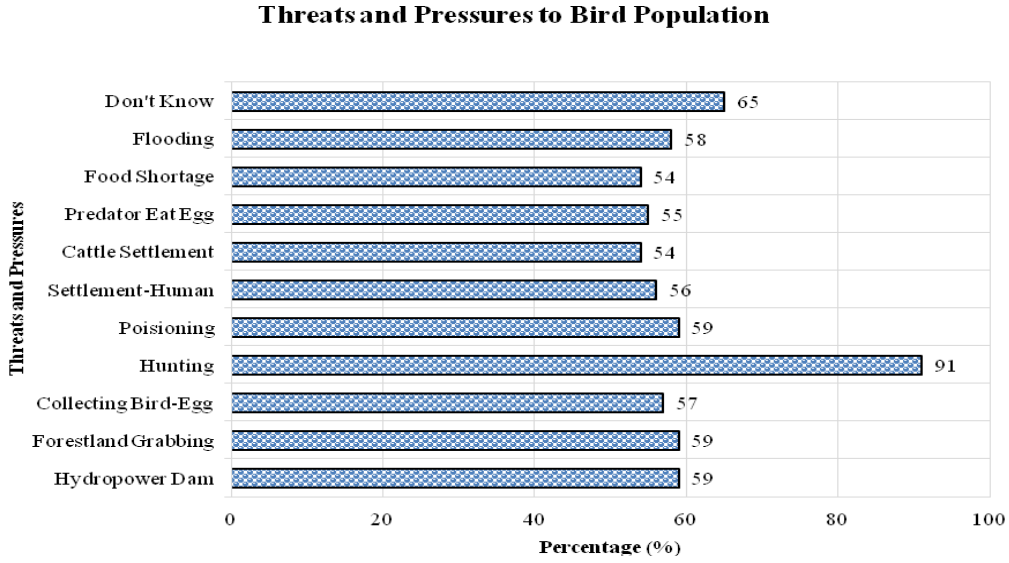
Figure 9: Perception of the contribution of the nest protection program to communities' livelihoods



Source: Survey, 2015

On average, 50% of respondents said that both natural and human activities are threats to and pressures on waterbird populations. 59% and 58% of respondents explained that the development of hydropower dams, poisoning, and natural flooding are critical causes of decreasing bird populations (Figure 3).

Figure 10: Perceptions of threats and pressures to bird populations

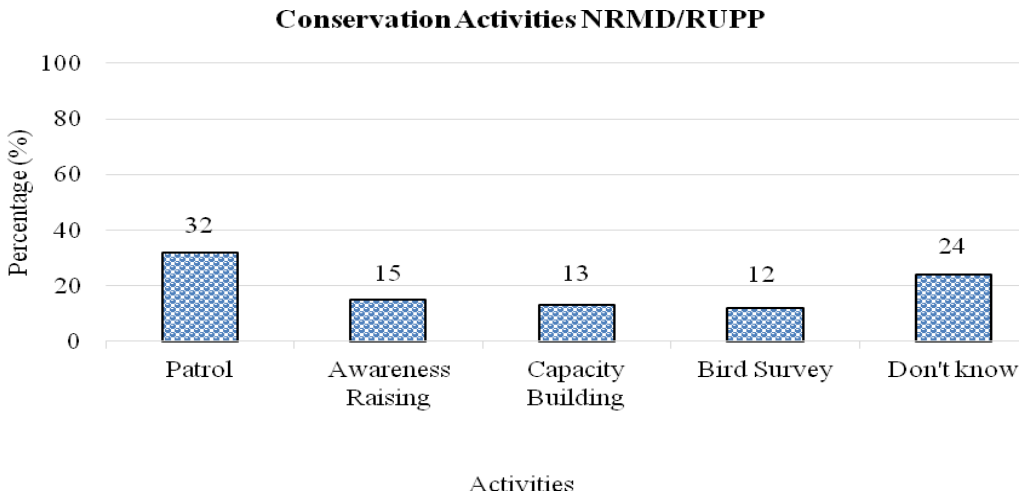


Source: Survey, 2015

Interestingly, 54% of all respondents in the study areas were aware that there is a conservation programme implemented by Department of Natural Resource Management and Development, Royal University of Phnom Penh (NRMD/RUPP), since 2012. However, 39% stated that they had never heard about any conservation programme on water-bird species before, while 7% were sure that there is no conservation programme implemented by NRMD/RUPP.

Although, the majority of respondents knew about the conservation project run by NRMD/RUPP since 2012, only a few of them are understood the details of the conservation activities shown in Figure 4.

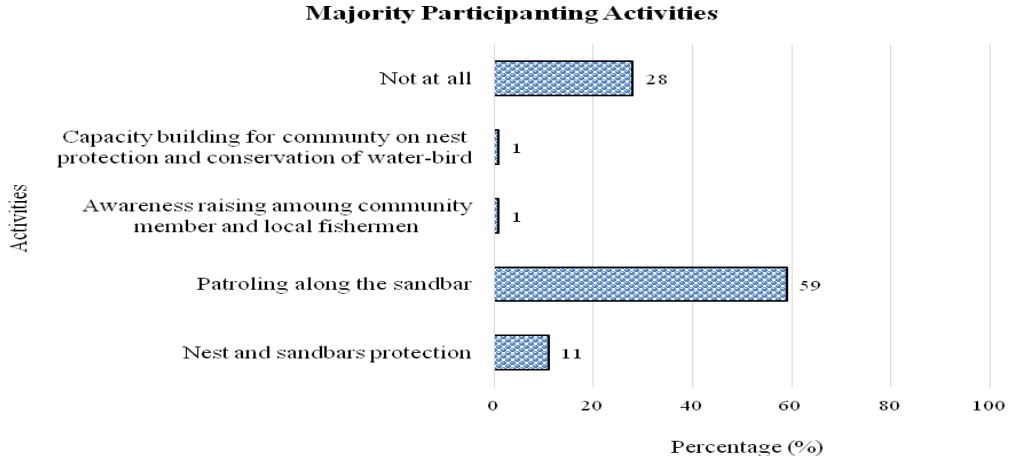
Figure 11: Conservation programmes/activities implementing by NRMD/RUPP



Source: Survey, 2015

Furthermore, this survey found that 72% of the total population had participated in at least one of the above conservation activities, while only 28% had not yet contributed any effort to this project.

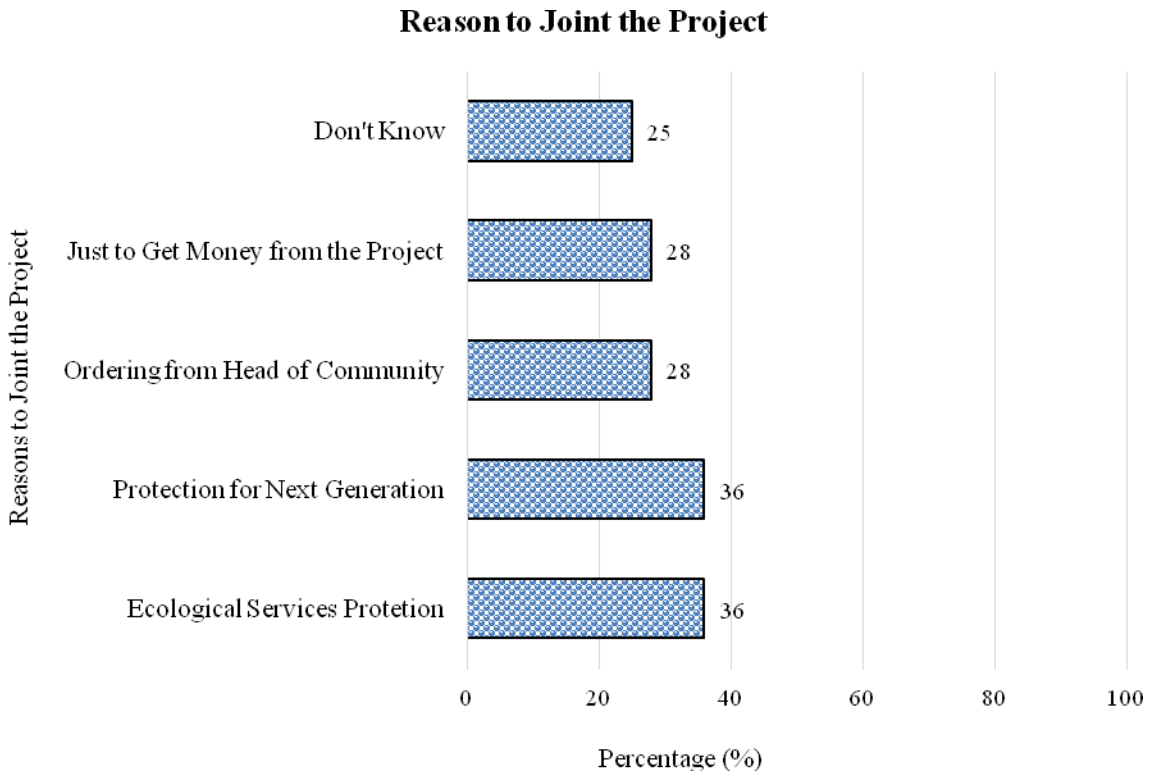
Figure 12: Activity which involving majority participation



Source: Survey, 2015

Moreover, this survey also found that nest and sandbar protection was the predominant activity, with 11% of respondents participating in this activity. However, 85% of people acknowledged that they did not participate in any particular conservation activity that was related to the project. Several reasons for participating in these conservation activities were found (see Figure 6):

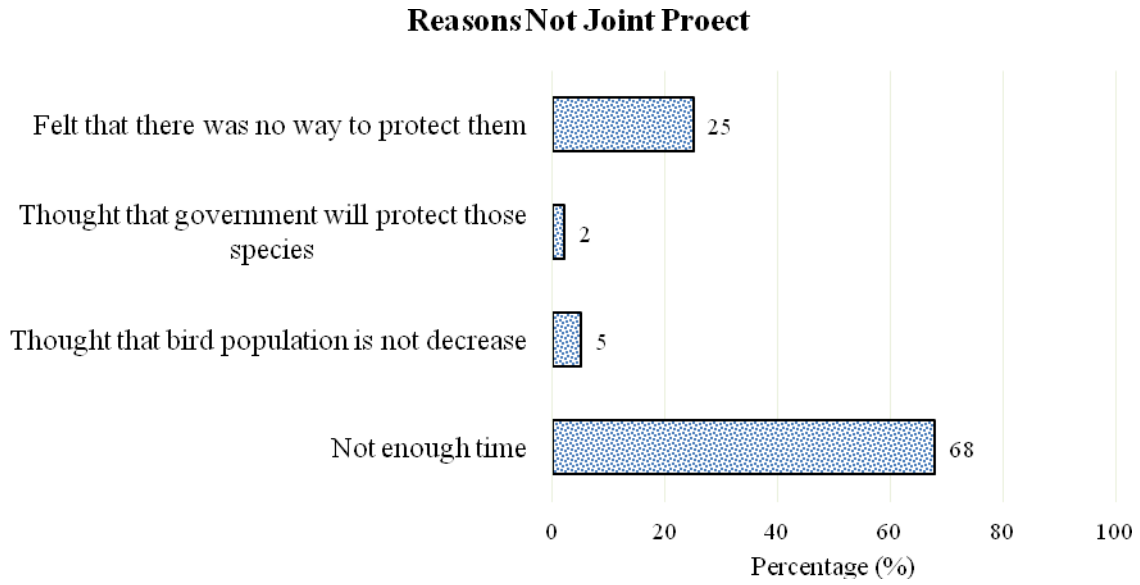
Figure 13: Particular reason to join the conservation project's activities



Source: Survey, 2015

Based on Figure 6 (above), the primary reasons that respondents participated in protection and conservation of waterbirds, were to enhance ecological functions and services (36%), and to protect rare bird species for future generations (36%). Furthermore, 28% of total respondents said that they participated in these activities for financial benefits from the nest protection and conservation programme, while another 28% responded that the head of the community called for their participation.

Figure 14: Particular reason that respondents did not participate in the Conservation Activities

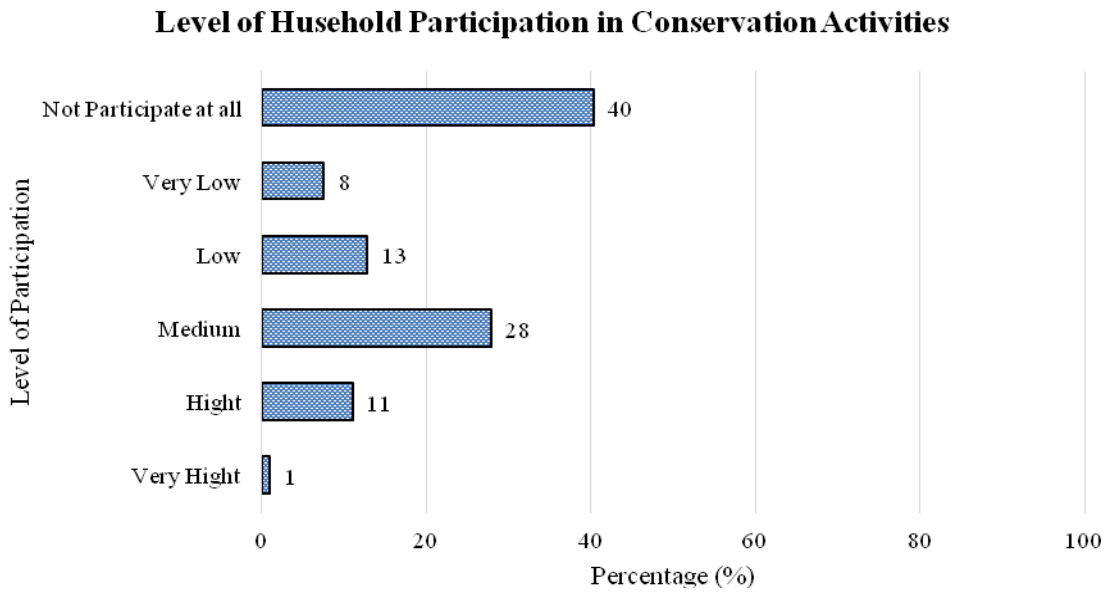


Source: Survey, 2015

Among respondents who did not participate in any particular conservation activities, 68% of respondents said that they did not participated because they did not have enough time (Figure 7). Interestingly, livelihoods of those respondents (respondents who did not participated in any particular activities) depend on forest products. In addition, 25% of the total respondents who did not participate in this conservation programme said that they did not join because they felt that the decreasing of bird's populations naturally happen, and the program would not be successful in stopping the bird population decline (Figure 7).

Participants stated that they relied upon forest products for their everyday lives. This includes timber and non-timber forest products; hence participants would not be able to join the project effectively. As seen in Figure 8 (below), 11% of respondent perceived that participation from their family for protecting and conserving the population of waterbird was relatively high, while 28% said that the contribution of each household into the conservation programme was medium, and 8% said it was very low.

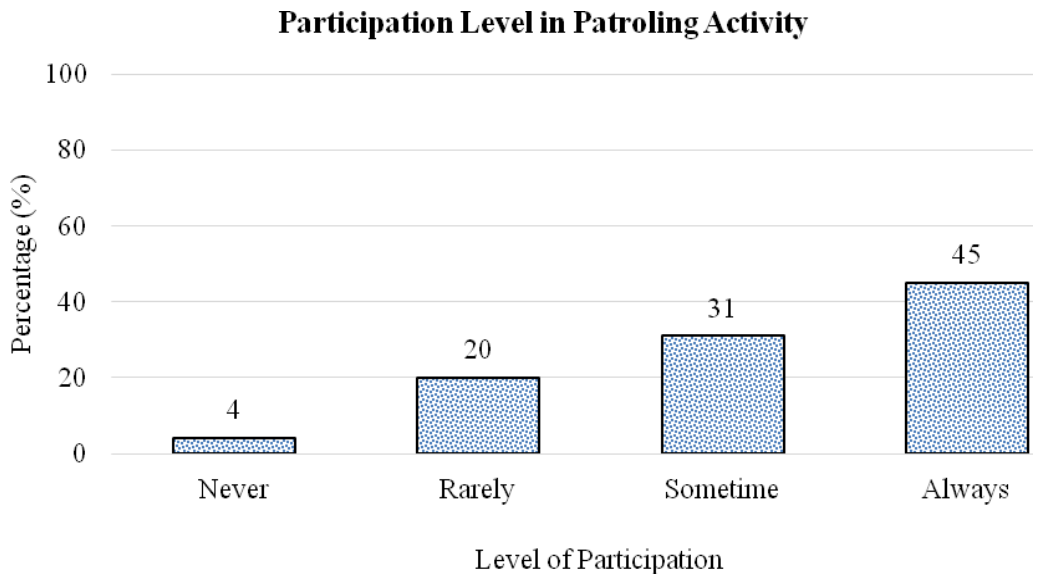
Figure 15: Level of household's participation in conservation activities with our project



Source: Survey, 2015

As shown in Figure 9 (below), only 4% of the respondents said that they never participated in patrolling as a core activity in the project, while 31% said that they sometimes participated in patrolling, and 45% said that they always participated in patrolling activities (Figure 9).

Figure 16: Participation level in patrolling activities



Source: Survey, 2015

After several years of implementing the conservation project, respondents have provided positive support, and a high level of willingness to participate in project activities. As shown in Table 10, respondents believe that nest protection is the highest priority, in terms of conserving bird species along the 3S Rivers. Patrolling and awareness raising were also given high priorities, but should be secondary and complementary activities, after nest protection activities (Table 10).

Table 24: Potential conservation activities ranked by respondents

Potential Activities	*Percentage (%)*				
	Very High Priority	High Priority	Priority	Poor Priority	Very Poor Priority
Nest Protection	X				
Patrolling		X			
Awareness Raising and Capacity Building		X			
Bird Survey and Inventory			X		

Source: Survey, 2015

Currently, this survey found that human disturbance has a negative impact on birds, preventing birds from breeding and decreasing their populations. The construction of hydropower dams, humans settling on sandbars during the breeding period, and cattle raising were also given as reasons for the decrease in bird populations along the 3S Rivers. Similarly to the results from group discussions, these issues have respondents very worried, due to the frequency and number of disturbances and developments occurring in the area that could potentially impact bird populations. Moreover, 49% of respondents replied that the ongoing project and activities listed in Table 10 will positively contribute to the conservation of water birds along the Sekong and Sesan Rivers.

However, this survey found that according to respondents, human activities are not the only causes of negative impacts on bird populations along the 3S Rivers, but natural phenomena, such as flooding and drought, also negatively affect bird populations (Table 11). Based on the discussions among community members, critical issues for birds included, (1) hydropower dams, (2) food shortage, (3) fishermen settling on sandbars, and (4) cattle raising on the sandbar (Table 11).

Table 11: Level of potential impacts of disturbances to nest and bird population

Disturbance Factors	*Particular Disturbance Factors*	*Level of Potential Impacts*		
		Very worried	A little worried	Not worried
Natural Disturbance	Predator eat egg		x	
	Food shortage	X		
	Flooding		x	
Human Disturbance	Hydropower dam	X		
	Forestland grabbing		x	
	Hunting		x	

	Poisoning	x
	Fishermen settling on the sandbar	X
	Cattle rising on sandbar	X

Source: Survey, 2015

Several issues have been identified as potential threats to waterbird populations; however, villagers said that since the conservation project has been implemented by NRMD/RUPP, those threats have been reduced. As a result, previous issues that used to be threats to water bird populations, such as hunting, poisoning, predator, and cattle raising no longer happen. These threats have been reduced after the implementation of the nest protection and conservation programme (Table 12). However, there are two issues still challenging and causing the population of waterbirds to decrease: food shortage and construction of hydropower dams (Table 12).

Table 12: Level of impacts after conservation programme took place

Disturbance Factors	*Particular Disturbance Factors*	*Level of Potential Impacts*				
		More higher	Less higher	At the level	about same	Decrease[8]
Natural Disturbance	Predator eat egg			X		
	Food shortage	x				
	Flooding			X		
Human Disturbance	Hydropower dam	x				
	Forestland grabbing					x
	Hunting					x
	Poisoning					x
	Fishermen settling on the sandbar					x
	Cattle rising on sandbar					x

Source: Survey, 2015

Discussion and Conclusion

Based on results from this survey and community discussions, the communities acknowledge that as a result of the conservation program implemented by NRMD/RUPP, populations of waterbirds along the Sekong and Sesan Rivers are increasing. However, some studies have identified habitat loss and food shortage as factors contributing to declines of other threatened bird populations (Kasper & Neth, 2006; UNEP, 2008).

According to NCDD (2010), 57% and 50% of villagers 15-60 years old are unschooled in Hat Pok and Kaoh Pang Communes, respectively. Moreover, 72% and 50% of the total population in Santepheap and Thma Kaev communes are also uneducated (NCDD 2010). With regards to the result from KAP survey, 72% of total interviewees were illiterate and from ethnic minority

[8] Decrease, is means not higher as the same level now.

groups such as Chong, Prov and Lao. The education level and ethnicity of interviewees may have influenced results of the KAP survey if respondents did not fully understand the interview questions. The large percentage of "don't know" responses may have been due to questions being too complicated or technical, or because they were in a language (Khmer) that was not the primary language of interviewees.

Over the last couple of decades, populations of waterbirds along the Sekong and Sesan Rivers have decreased (Timmins & Men 1998, Claassen 2004, Bezuijen et al. 2008). Several reasons have been identified, such as egg harvest, animal predation, poisoning, natural flooding, hunting, and habitat loss. However, bird nest protection programs have been successfully implemented in other regions of Cambodia (Sok et al. 2012, Clements et al. 2013), and offer hope for also providing effective protection for threatened bird species along the Sekong and Sesan Rivers. Although ecosystem services along the Rivers are decreasing, it is still an important source of socio-economic development of millions of people in diversified ethic groups and prospective(Clements et al., 2009; Sophat, 2015). Several conservation programs have been implemented by different agencies including government and non-governmental organizations. Since populations of waterbirds along the 3S Rivers is decreasing, and humans are the primary cause of declines, the primary focus of the project is targeting local communities as key implementers of conservation activities.

The nest protection program provided conditional payment for local people to protect bird nests. Since the beginning of 2015, it has protected 72 nests along the Sekong and Sesan Rivers with 60 nests recorded as successful and 158 chicks hatched. 71% of respondents from Hat Pok village responded that nest protection contributed significant benefits that improved the livelihoods of local people. Similarly, Clements et al. (2013) reported that 71-78% of the costs from nest guarding program were paid directly to local people.

Conversely, 91% of total survey respondents said that hunting and human exploitation were causes of bird population declines, while 55% said they were caused by natural predation. Correspondingly, Wright et al. (2013) reported that nest failures were caused by human exploitation, natural predation, and high winds. Additionally, Clements et al. (2009) also found that predation was a prime cause of nest failure of endangered waterbirds in the Northern Plains of Cambodia. Empirical results from this survey show that 34% of respondents believed that the nest protection programme was effective for waterbird conservation along the Sekong and Sesan Rivers. Moreover, Wright et al. (2013) found that nest guarding improved the number of successful nests of White-shouldered Ibis along the Mekong and Western Siem Pang, Cambodia. Furthermore, nest guarding was found not only to be effective in this study but also effective in the Mekong Region of Cambodia (et al. 2012). Direct payment for nest guarding was also found to be successful for conservation of waterbirds along the Northern Plains of Cambodia (Clements et al. 2013).

In conclusion, this study found that since the project started, populations of waterbirds are increasing, and threats are decreasing. Most significantly, the program has been effective at targeting an important threat to species conservation in this area: collection of nests for eggs and chicks. This study has shown that local participation in nest guarding is a key toward sustainable waterbird conservation along the Sekong and Sesan Rivers. However, this research illustrates

some critical challenges for involving villagers in the project, and their willingness to participate in this project. Interestingly, a large proportion of the local people within the study areas are aware of and participating in the project. In the context of community-based conservation, this program is best viewed as a complement, but not a substitute, to other types of intervention, such as local management of natural resources, and development of sustainable financing for communities.

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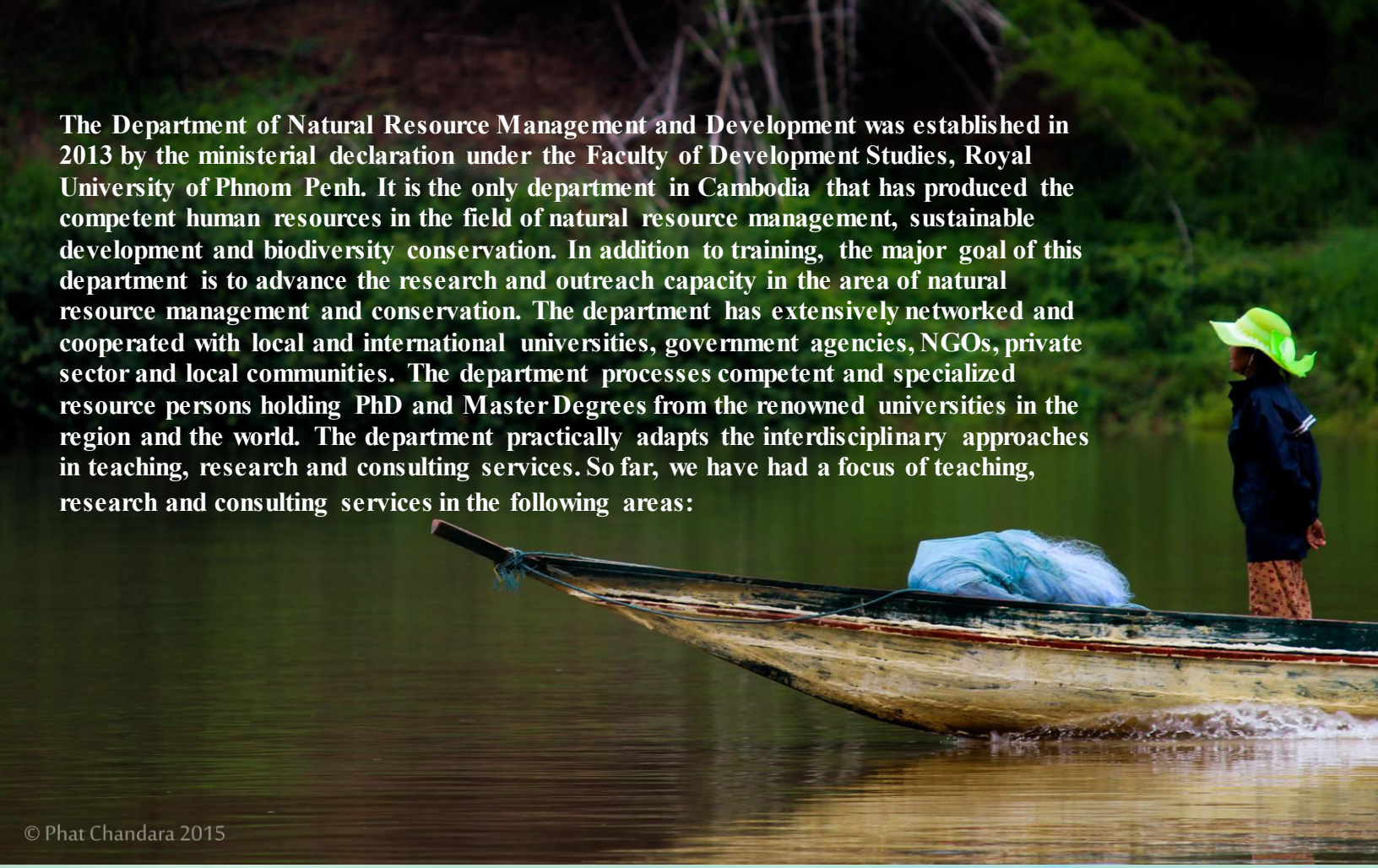
The Department of Natural Resource Management and Development was established in 2013 by the ministerial declaration under the Faculty of Development Studies, Royal University of Phnom Penh. It is the only department in Cambodia that has produced the competent human resources in the field of natural resource management, sustainable development and biodiversity conservation. In addition to training, the major goal of this department is to advance the research and outreach capacity in the area of natural resource management and conservation. The department has extensively networked and cooperated with local and international universities, government agencies, NGOs, private sector and local communities. The department processes competent and specialized resource persons holding PhD and Master Degrees from the renowned universities in the region and the world. The department practically adapts the interdisciplinary approaches in teaching, research and consulting services. So far, we have had a focus of teaching, research and consulting services in the following areas:



- The Socio-economic Contributions made by Coral Reefs: Research findings from Koh Sdech Commune in Kirisakor District, Koh Kong Province, Cambodia
- A Trade-off between Conservation and Fisheries-dependent Livelihoods around Tonle Sap Lake in Cambodia
- The Cancellation of Fishing Lots on Tonle Sap Great Lake in Cambodia: Changes in fish productivity and livelihood development
- Reducing Mercury Emissions and their Impacts during the Process of Artisanal and Small-scale Gold Mining in Roveing District, Preah Vihear Province, Cambodia
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- Identification of Deforestation Drivers in Cambodia
- Using Contingent Valuation to Measure the Willingness to Accept by Fisheries Communities for Voluntary Waterbird Nest Guarding: Case Studies at Stung Treng and Ratanakiri Provinces, Cambodia
- Contribution of Local Ecological Knowledge and Practices to Waterbird Conservation along the Sekong and Sesan Rivers IBA, Cambodia

Contact Address:
Room 317A, Building A Department of Natural Resource Management and Development (NRMD) Faculty of Development Studies
Royal University of Phnom Penh, Russian Federation Boulevard, Toul Kork, Phnom Penh, Cambodia

Email: seak.sophat@rupp.edu.kh
Tel: 855-23-883-640