Summer 2014

Common Pool Resources and Rural Livelihoods in Stung Treng Province of Cambodia

Pitchaya Boonsrirat

COMMON POOL RESOURCES AND RURAL LIVELIHOODS IN STUNG TRENG PROVINCE OF CAMBODIA

A Dissertation Presented

by

PITCHAYA BOONSRIRAT

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2014

Department of Economics

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Approved as to style and content by:

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James K. Boyce, Chair

____
Michael Ash, Member

____
James A. Hafner, Member

____
Michael Ash, Department Chair
Department of Economics

DEDICATION

To my grandmother, who will always be close to my heart.

ACKNOWLEDGEMENTS

I am grateful to my dissertation chair, Dr. James Boyce, for all his guidance, kindness, and support in every process of this dissertation. I would also like to extend my gratitude to Dr. Michael Ash and Dr. James Hafner, my dissertation committee members.

I would also like to thank Dr. Eric Baran for introducing me to the Lower Sesan 2 hydropower project and connecting me with the Challenge Program on Water and Food (CPWF) Mekong team. My meeting and conversation with Dr. Ian Baird in Laos was a helpful step for this dissertation. A big thank you to Ms. Yumiko Kura of WorldFish Center Cambodia, project leader of the CPWF Mekong-MK 2: Water Valuation Project, for introducing me to the works of CPWF Mekong and supporting me in undertaking the Lower Sesan 2 hydropower project as a case study. Also, I am grateful for all her help in sponsoring me to the International Forum on Water and Food in South Africa, arranging my field visit to Stung Treng province, and recommending me as a grantee for the Mekong Program on Water, Environment and Resilience (M-POWER) fellowship. I want to thank Dr. Claudia Ringler of the International Food Policy Research Institute (IFPRI) for sending me the spreadsheet of primary data. Thank you to Mr. Samonn Mith who helped me with translation and coordination of my field visits in Cambodia. I would also like to thank Dr. Sokhem Pech, my mentor under the M-POWER fellowship program. I am grateful for the opportunity and financial supports I got in my PhD study from the

Royal Thai Government scholarship, M-POWER fellowship, and the Political Economy Research Institute (PERI) fellowship.

During my PhD study, I was very lucky to live with people who shared with me a sense of family. I would like to thank my former housemates, Martin Rapetti, Avanti Mukherjee, Joao Paulo De Souza, Benjamin Storrow, Joshua Finn, and Mittens. The wonderful memories you all created when we lived together will always be with me. I am very fortunate to develop friendships with three wonderful friends who always shared with me a good laugh, and always were there for me during my tough times: thank you Jooyeoun Suh, Jessica Carrick-Hagenbarth, and Anilyn Diaz. I also want to thank Thai students of UMass Amherst for all the fun, the food, and the laughs we had, thank you *Thai Mafia*. Josh Arond helped me go through the last two years of my dissertation stage; his words always assured me that things will get better whenever I had a bad day. I also want to thank the Arond family for welcoming me into their lives. Lastly, I cannot express how lucky and grateful I am to have the love and support from my parents during all these years.

ABSTRACT

COMMON POOL RESOURCES AND RURAL LIVELIHOODS IN STUNG TRENG PROVINCE OF CAMBODIA

SEPTEMBER 2014

PITCHAYA BOONSRIRAT, B.S., KASETSART UNIVERSITY

M.S., KASETSART UNIVERSITY

Ph.D., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor James K. Boyce

This dissertation assesses the contribution of fish and forest products in the livelihoods of villagers in Strung Treng province of Cambodia, as these two common pool resources are threatened by the construction of the Lower Sesan 2 hydropower project. Household survey data collected under the Challenge Program on Water and Food (CPWF) are used in the analysis. It is found that, in general, fish accounts for a higher overall contribution in household's livelihoods compared to forest products. Fishery products are most important for direct consumption, while forest products are more important for cash income. Across the study area, the households that most heavily extract and depend most on these resources are the relatively poorer households. The households that highly depend on forest products are distinct, however, from the households that highly depend on fish. The results indicate that these households' livelihoods are vulnerable to changes in the quality of common pool resources or restriction in access to them due to implementation of the Lower Sesan 2 hydropower project. Compensation and income generation

programs that can ensure food security and substitute for losses of common pool resource-based income are a necessity for impacted households. In addition, further restrictions on accessing common pool resources should be minimized in order to secure rural livelihoods and reduce poverty.

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LIST OF ABBREVIATIONS

BOT	Build-Operate-Transfer
CEPA	Cultural and Environment Preservation Association
CGIAR	Consultative Group of International Agricultural Research
CPRs	Common Pool Resources
CPWF	Challenge Program on Water and Food
EDC	Electricité du Cambodge
ELC	Economic Land Concession
FSL	Full supply level
GDP	Gross Domestic Product
GMS	Greater Mekong Subregion
HH	Household
ha	Hectare
IA	Implementation Agreement
IFPRI	International Food Policy Research Institute
KCC	Key Consultant Cambodia
kg	Kilogram
km	Kilometer
kWh	Kilowatt hour
M-POWER	Mekong Program on Water, Environment, and Resilience
MW	Megawatt
NTFP	Non-Timber Forest Product
PECC1	Power Engineering Consulting Joint Stock Company
PPA	Power Purchase Agreement
SLC	Social Land Concession

CHAPTER 1

INTRODUCTION

1.1 Motivation and objectives

"I grew up having the forest and the river to depend upon, it was always like that. They (the government) already took the forest away from us, and now they want to take the river away as well. I understand that we need energy for the country, but how about us? How can we live without the river and fish?"

Mr. Sai, a seventy year old villager of Sre Kor Mouy village in Stung Treng province of Cambodia said this to me in the Lao language when I visited his village in June 2012. It is a response to my question on how he feels about the proposed Lower Sesan 2 hydropower project, which will be built on the Sesan River. The reservoir area will inundate his village and will cause him and other fellow villagers to resettle in an area farther away from the Sesan River.

I walked from Sre Kor Mouy village to the adjacent Sre Kor Pi village. This village will also be flooded by the Lower Sesan 2 hydropower project. There I met with Mr. Heng, who is in his fifties. He drew a map of the two villages and told me about some important landmarks. His map shows a community forest which is shared between two villages, and an area next to it that he called, as related by my translator, "private company forest'', which used to be part of village's community forest. Mr. Heng was referring to the Economic Land Concession that was granted to a Vietnamese company for a rubber plantation. This is what Mr. Sai meant when he said ''they already took the forest away from us''.

Both Sre Kor Mouy and Sre Kor Pi villages are located at the bank of the Sesan River. The Sesan River is one of the main tributaries of the Mekong River, a transnational river that runs through six riparian countries in Southeast Asia. Currently, the governments of the Mekong countries have focused on harnessing the hydropower potential of the river to generate more electricity supply and pursue energy security. The increase in overall energy demand in the Mekong countries, the attempt to reduce energy poverty in the rural areas, and the global pressure on energy resources have become main arguments for hydropower development in the Mekong River Basin. Several dams and hydropower projects are already built in the basin and more of them are proposed.

The Lower Sesan 2 hydropower project, proposed to be built on the Sesan River in Stung Treng province, in northeast Cambodia, is expected to generate the greatest impact in terms of fishery losses. It is estimated that it will reduce the amount of fish stock in the Mekong River Basin by 9.3% (Ziv et al., 2012). Construction of this project thus will have a major impact on important common pool fishery resources of the Mekong River Basin. It will impact the livelihoods of thousands of basin inhabitants, since fishing is an integral activity for the rural pool as it can directly feed the family and also generate cash income. However, these benefits of Mekong fish for the rural poor are often devalued in efforts to justify the hydropower project.

In addition to the Lower Sesan 2 hydropower project, community forests in Stung Treng province on which the rural poor depend are already threatened by the Cambodian government's Economic Land Concessions policy. The hydropower project will aggravate this problem by inundating thousands of hectares of forest land, including community forest areas that are utilized by thousands of villagers. However, the significance of community forests in the livelihoods of villagers situated around the Lower Sesan 2 hydropower project area has not been adequately recognized by the project developer and the Cambodian government.

Using the Lower Sesan 2 hydropower project as an entry point, this dissertation explores the rural livelihoods of villagers in parts of Stung Treng province of Cambodia that will be affected by the project, and assesses the contribution of fish and forest products to household income and consumption. The level of livelihood dependence on fish and forest products not only indicates the importance of such common pool resources to the lives of the locals, but also implies the vulnerability of household livelihoods when such common pool resources are degraded or reduced, or when the rights to access and utilize the resources are restricted. This information is essential when reducing rural poverty and protecting the livelihoods of the poor are the goals of development policy.

1.2 Chapter summaries

This dissertation is arranged into six chapters. In Chapter 2, I provide background information about the hydrological nature of the Mekong River Basin, as well as brief socio-economic information of the Mekong countries and the state of hydropower development in the basin. The concept of pro-poor development and the roles of common pool resources in sustaining rural livelihoods are also discussed in this chapter.

Details about the case study, the Lower Sesan 2 hydropower project in Stung Treng province of Cambodia, are provided in Chapter 3. Primary data used in this dissertation come from the household survey conducted under the Challenge Program on Water and Food (CPWF). I classify surveyed households into three communities based on their location in relation to the site of Lower Sesan 2 hydropower project. Sampled villages and communities are described using information both from the household survey and from the dialogues with villagers during my field visit to Stung Treng province in June 2012.

In Chapter 4, I focus on the contribution of fishery in rural livelihoods, as this is the main threatened common pool resource from the construction of the Lower Sesan 2 hydropower project. I calculate amounts and values of fish caught, consumed and sold by households, and create fish dependence variables along with assets, income, and demographic variables. Descriptive statistics of all variables are reported. I pose the main question: who depends most on the fishery? To answer this question, first I look at all households across the Lower Sesan 2 hydropower project area and use the values of four fish dependence variables, one by one, to categorize them into different strata. After identifying characteristics of households in each stratification, I find that the groups of households that rely heavily on fishery for their income and their consumption tend to be relatively the poorest groups among all the households situated across the study area. In the next step, I examine patterns among households situated within each of the three communities. Correlation coefficients are used to identify the association among selected pairs of variables. I find that, in every community, the group of households that highly depends on fish for cash income is distinct from the group that highly depends on fish for direct consumption, and there is negative association between total cash income from all sources and level of fish consumption dependence. I then estimate four OLS regression models for each community. Details of the regression results are different for each community; nevertheless, the results from two communities suggest that the poorer households depend more on fish for self-consumption than the relatively richer households within the same community. At the same time, the richer households in two communities are found to depend more on fish for income generation than the poorer households.

Evidence from Chapter 4 also indicates that the group of households that catches the most fish and generates the highest average cash income from fishery also has the highest average cash income generated from forest products. Also, the decreasing of community forest in the study area due to the Economic Land Concession policy is a concern voiced by several villagers. Hence, I focus on the contribution of forest products in household livelihoods in Chapter 5. Firstly, I look at the history and policies that shape the current forest sector in Cambodia. Forest areas that will be directly impacted by the construction of Lower Sesan 2 hydropower project are discussed. I report types of forest products extracted by households across the study area. Households' consumption values for selected forest products are calculated, and four additional forest dependence variables are created. My main question for this chapter is similar to that I posed in the previous chapter: who depends most on forest products? I create four forest dependence stratifications in order to shed light on the characteristics of households across the study area that depend differently on forest products. This stratification exercise reveals that, across the study area, households that depend highly on forest products for income generation, self-consumption, or for both tend to be poorer than households that depend less on forest products in each respect. I calculate correlation coefficients for each community, and find that, in every community, low total cash income is negatively associated with high forest consumption dependence. Furthermore, with the poorest community, there is also a negative association between low total cash income and high dependence on forest product for income generation. Four OLS regression models again are estimated for each of the three communities. The regression results, though different in details for each community, confirm that, in two out of three communities, it is the poorer households that depend most highly on forest products for consumption. In addition, poorer households in the poorest community also depend on forest products for income generation more than the richer households.

Main findings and conclusions drawn from this dissertation, along with policy recommendations, are presented in Chapter 6.

CHAPTER 2

HYDROPOWER DEVELOPMENT AND COMMON POOL RESOURCES IN THE MEKONG RIVER BASIN

2.1 Geography and hydrology of the Mekong River

The Mekong is the eighth largest river in the world and the longest river in Southeast Asia. It is also a transnational river shared by six developing countries. The Mekong River's headwaters are in the Tibetan Plateau, more than 5,000 meters above sea level. The river flows southeast across the Yunnan province of the People Republic of China where it is called the Lancang River, then forms the boundary between Myanmar and the Lao's People Democratic Republic (Laos) and also the short boundary between Laos and northern Thailand. Then it flows eastward into Laos, continues toward the south, and again forms the boundary between Laos and northeastern Thailand before entering Cambodia. In Cambodia, the Mekong River connects with the Tonle Sap Lake, the largest freshwater lake in the Southeast Asia, through the Tonle Sap River. Finally, the Mekong River flows into the Mekong Delta in southern Vietnam and empties into the South China Sea (Jacobs, 2002) (See map, Figure 2.1).

The Mekong River and its tributaries create the vast river basin, with the total area of 795,000 km^2, that covers most of Laos and Cambodia, one-third of Thailand's total area, one-fifth of Vietnam's total area, and some parts of Myanmar and China (see Table 2.1). The basin often divided into two parts: the Upper Mekong Basin and the Lower Mekong Basin (see Figure 2.2). The Upper Mekong Basin, which is in China and Myanmar and covers 24 percent of the total area of the whole basin, experiences high mountain cool temperate conditions, especially at the head water which has permanent snow cover. The Lower Mekong Basin is mostly under the tropical weather and subject to the monsoon's influence.

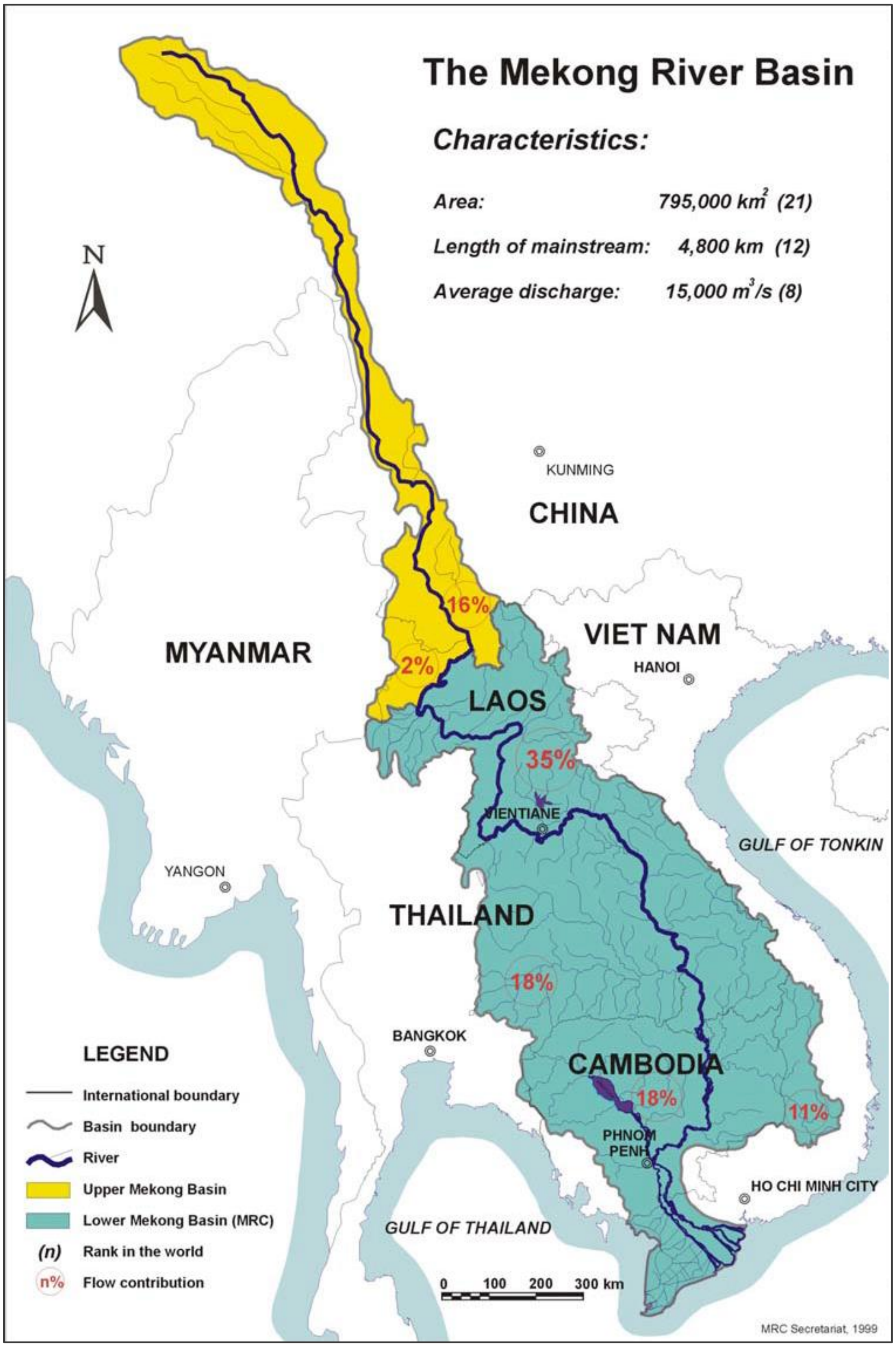
Figure 2.1 Map of the Mekong River

Table 2.1 Country areas in the Mekong River Basin

Country:	Area of country in basin (km²)	As % of total area of the basin	As % of total area of the country
China	165,000	21%	2%
Myanmar	24,000	3%	4%
Laos	202,000	25%	85%
Thailand	184,000	23%	36%
Cambodia	155,000	20%	86%
Vietnam	65,000	8%	20%

Source: http://www.fao.org/nr/water/aquastat/basins/mekong/index.stm (retrieved on April 15, 2014)

Figure 2.2 Hydrographic map of the Mekong River Basin, with indication of the Mekong River and main tributaries, and flow contribution by country



Source: World Bank and Asian Development Bank (2006)

The annual flooding cycles of the river and the sediment loads from the upper catchment are the two main factors that make the Mekong River Basin one of the richest biodiversity sites in the world. The river system supports the flooded forests of southern Laos and Cambodia, several lakes and swamps in the basin (Blake, 2001). The unique annual flood pulse creates about 84,000 km^2 floodplains, equal to the surface area of Ireland, during the monsoon season from May to November (Baran and Myschowoda, 2009). Agriculture and fisheries activities in the basin area are sustained by the river and the basin's rich ecosystem.

The wet season floodplains and seasonal flood pulse are crucial for the lifecycle of the Mekong fish, many of which are migratory. Kang et al. (2009) and Baran and Myschowoda (2009) explain that seasonal changes of water level trigger fish to travel between their breeding grounds, mostly located in the upstream tributaries, and feeding grounds, mostly located on downstream floodplains. The migratory fish found in the Mekong Basin include both long-distance migration fish which travel longitudinally in the mainstream Mekong, and short-distance migration fish which travel between tributaries and floodplains (Peterson and Middleton, 2010).

2.2 Socio-economic aspects and demand for energy of the Mekong countries

2.2.1 Mekong countries economy

All six countries in the Mekong River Basin are developing countries. Table 2.2 presents data on the population, unemployment rate, Gross Domestic Product (GDP), GDP per capita, and current account balance of each Mekong country in

2013. Roughly 73 million people lived in the Mekong River Basin in 2002 and the number is expected to be 120 million by 2025 (Jacobs, 2002). The basin area is mainly rural with population density range from 10 inhabitants/km^2 in the hill area to more than 500 inhabitants/km^2 in the Mekong Delta area (Walling, 2008).

Table 2.2 Key economic indicators of the Mekong countries in 2013

Country:	Population (million)	Unemployment rate (% of total labor force)	GDP (billion US$)	GDP per Capita (US$)	Current account balance (% of GDP)
China	1,360.76	4.10	8,939.33	6,569.35	2.50
Myanmar	64.95	4.02	59.43	914.95	-4.34
Laos	6.78	n/a	10.10	1,490.31	-30.80
Thailand	68.20	0.65	400.92	5,878.75	0.11
Cambodia	15.41	n/a	15.64	1,015.28	-10.63
Vietnam	89.69	4.47	170.02	1,895.58	5.62

Note: All numbers are estimated.
Source: International Monetary Fund, World Economic Outlook Data Base, October 2013 (retrieved on April 17, 2014)

Approximately 90 percent of the population who live along the Mekong River are involved in agriculture, mainly in rice production, which significantly depends on the irrigation from the river (Blake, 2001). The Mekong Delta in southwestern Vietnam is the largest rice- growing area in this region. It is estimated that more than 16 million metric tons of rice are produced annually in the Mekong Delta, going to both domestic consumption and export[1]. The percentage of rural households involved in inland fisheries varies from 64 to 93 percent, depending on the location, throughout the Lower Mekong Basin (Fox and Sneddon, 2007). The hydrology of the

[1]Online at http://www.internationalrivers.org/files/WRR Mekong Map.pdf, retrieved on November 22, 2010.

Mekong River has a strong influence on fish migration, breeding and spawning. Fishery products are the main source of protein for the poor in the basin area. Both rice production and the inland fishery, which are sustained by the healthy Mekong River, contribute to food security for the vast majority of the people in the Mekong River Basin. On average, basin inhabitants are less well-off than the people of the region who live outside the basin (www.fao.org). Presented in Figure 2.3 is the poverty map of the Mekong River Basin, and the extended area of the Greater Mekong Subregion (GMS)[2], that shows the percentage of population in each province whose income is below the poverty line. The map shows that there is widespread poverty in the basin area, especially in Cambodia and Laos. Percentages of population living below the national poverty lines for each Mekong country, except China, are presented in Table 2.3.

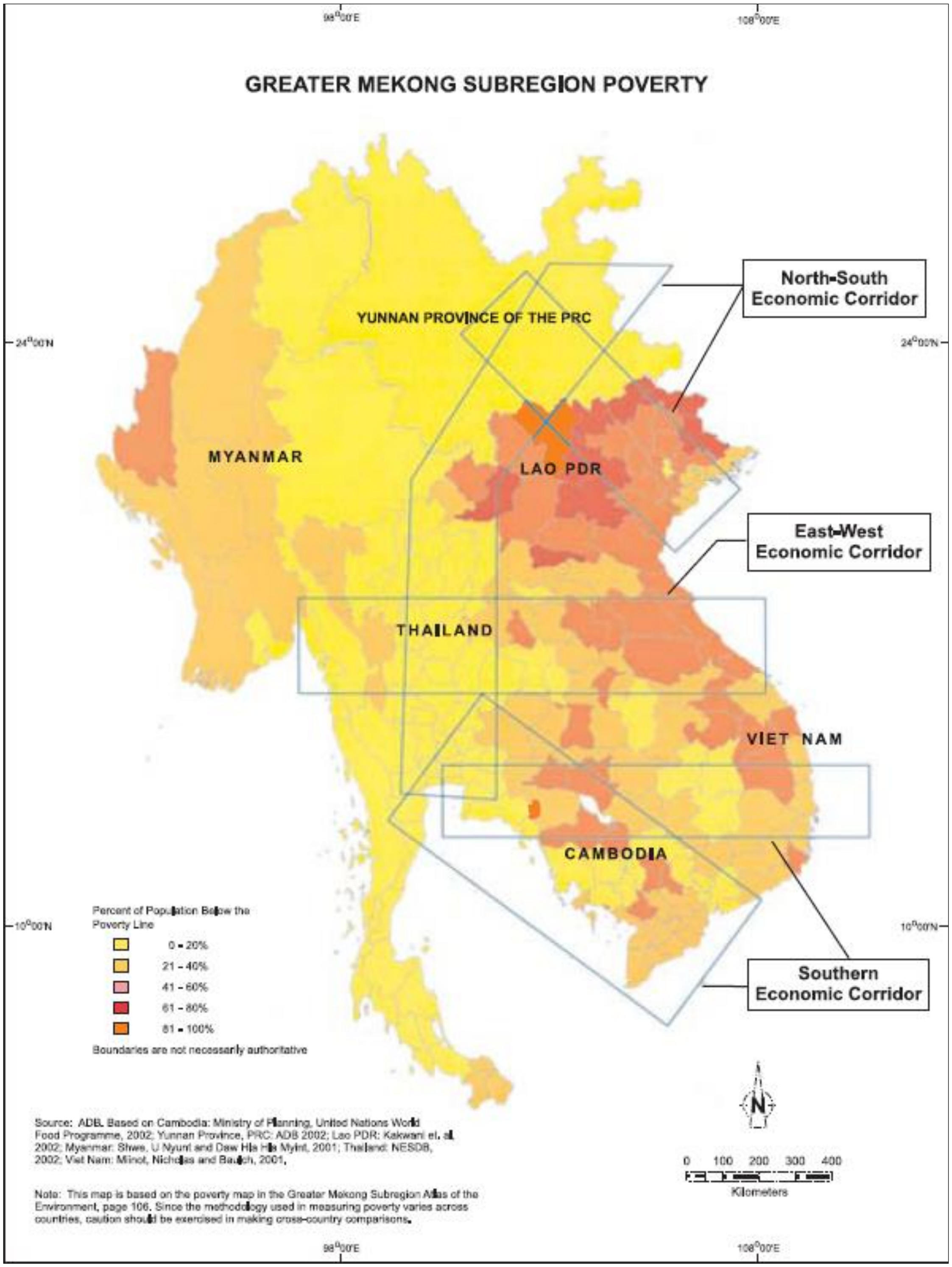
Table 2.3 Poverty head count ratio of five Mekong countries

Country:	Poverty head count ratio (%)		
	2008	2009	2010
Myanmar	25.60	25.60	25.60
Laos	27.60	27.60	27.60
Thailand	8.95	8.12	7.75
Cambodia	29.30	27.40	25.80
Vietnam	13.40	14.20	14.20

Source: http://www.gms-eoc.org/gms-statistics/overview/poverty-rate (retrieved on April 16, 2014)

[2]The Greater Mekong Subregion (GMS) is comprised of Cambodia, Laos, Myanmar, Thailand, Vietnam, and the Guangxi Zhuang Autonomous Region and Yunnan Province of China.

Figure 2.3 Greater Mekong Subregion (GMS) poverty map



Source: http://www.adb.org/Documents/CSPs/GMS/2004/gms-poverty.pdf (retrieved on March 30, 2010)

As the main source of fresh water in this region, water from the Mekong River and its tributaries is also used for drinking, bathing, and domestic sanitation. Presented in Tipping (2001), additional beneficial uses of Mekong River water include livestock watering, commercial navigation and transportation, wastewater disposal, tourism activities, and water recreation (i.e. boating and swimming). The competition between countries for dry-season abstraction of the Mekong water can be found especially among Thailand, Cambodia and Vietnam. As of now, no comprehensive water allocation mechanism has been set up for the Mekong River Basin yet (Baran et al., 2007). In a study done by Ringler (2001), the trade-offs and complementarities in water usage are considered to find the optimal allocation of water resource, and a baseline scenario of water allocation is proposed. Two main conclusions about the allocation of water resource in the Mekong River Basin are also drawn in the study. The first is that the largest portion of the water in the basin should be allocated to the purpose of agricultural irrigation. The second conclusion is that the Mekong Delta in Vietnam is the area that uses the largest portion of river water, and also the most economically benefited area, which implies that this area is especially vulnerable to the water management activities undertaken upstream.

2.2.2 Demand for energy in the Mekong countries

Described in ADB (2009), the overall demand for energy in the Mekong countries has increased in the past decade. One reason is structural change, in which the manufacturing and service sectors in each country expand as economy becomes more modernized. These sectors are more energy-intensive compared to the agricultural sector. At the same time, income growth leads to rising demand for modern energy.

The existence of many communities in the Mekong countries with limited access to modern energy is another reason for energy development. Roughly 80 percent of Laotian households, 83 percent of Cambodian households, and more than 50 percent of Vietnamese households still use fuel wood and other traditional energy sources for cooking. Both Laos and Myanmar have very low electrification rates, 20 percent and 11 percent respectively (ADB, 2009). Table 2.4 presents the per capita electric power consumption of the Mekong countries from 2009 to 2011.

Table 2.4 Electric power consumption per Capita of Mekong countries

Country:	Electric power consumption per Capita (kWh/person)		
	2009	2010	2011
China	2,633	2,944	3,298
Myanmar	97	121	110
Laos	369	409	402
Thailand	2,120	2,335	2,316
Cambodia	127	144	164
Vietnam	917	1,035	1,073

Source: http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC (retrieved on April 16, 2014), except Laos' data is from http://www.gms-eoc.org/gms-statistics/overview/electricity-consumption-per-capita (retrieved on April 16, 2014).

The pressure of the energy crisis that threatens almost every part of the world also makes each Mekong country aware of the need to increase its energy security so that they can continue pursuing economic expansion. At the same time, the global concern on climate change also put more concern towards clean and renewable energy as a favorable choice over the carbon-based energy. These reasons lead to attention to the enormous potential of the Mekong River Basin in hydroelectricity generation. Several dams and hydropower projects are planned, as well as the plans for cross-border electricity trade among the Mekong countries.

2.3 Overview of hydropower projects in the Mekong River Basin

Most of the hydropower projects proposed in the Mekong River Basin involve more than one country, either as an investor or an electricity buyer. Joint investment between two countries is often found, and some investors are also from countries outside the Mekong region.

Regional and international organizations are also involved, either directly or indirectly, in the hydropower development. The Mekong River Commission (MRC) is one such organization. The MRC[3] has the development paradigm of promoting more international cooperation, more integrated and scientifically based programs for environmental preservation, and more equitable use of basin resources. About its role in hydropower development, it is stated that "the MRC is working with Mekong governments to develop coordinated and integrated impact assessments, consistent and fair mitigation measures, and hydropower development strategies and policies" (online at http://www.mrcmekong.org/ish/ish.htm, retrieved on November 22, 2010).

Key international development agencies such as the Asian Development Bank (ADB) and the World Bank, are also involved with the hydropower

[3]Mekong River Commission is a river basin management organization directed by the representatives from the governments of Laos, Thailand, Cambodia and Vietnam, while Myanmar and China joined as dialogue partners.

development in the basin. In 1992, the Asian Development Bank (ADB) suggested and assisted the establishment of a subregional economic cooperation program in the Mekong River Basin under the name of the Greater Mekong Subregion (GMS). Development in the energy sector is one important aspect of the cooperation, and the integrated development of energy sector is expected to "enhance efficiency of the entire subregional energy system by exploiting the economies of scale and scope" (ADB, 2009: p. xix). Hydroelectric development and cross-border electricity trade are the main objectives of energy sector integration. In 2008, the members of the GMS endorsed the Vientiane Plan of Action, which includes the construction of 14 hydropower projects on the Mekong tributaries.

The World Bank is also involved in water resource management and hydropower development in the basin. Its first channel of participation is through the MRC, by giving direct assistance, financial support, and collaboration in studies. It also directly finances some projects in the Mekong countries, such as the GMS power trade project in Cambodia which will facilitate that country's hydroelectricity trade with Laos, Thailand and Vietnam (online at http://web.worldbank.org/, retrieved on November 22, 2010).

The lists of existing and proposed dams and hydropower projects in the Mekong Basin vary across references. The most complete list that can be found right now, though it is still a work in progress, seems to be the inventory and database presented in King et al. (2007), which compiles the information from several sources. Some important information from this list is summarized in Table 2.5. It shows that 43 dams already exist, which means that they are either operating or being constructed, and 78 more dams are proposed to be built. Laos and Cambodia are the two countries that have the highest number of proposed projects, with 32 projects planned to be built in Laos and 26 projects in Cambodia. It is not only because of the geographical possibilities, but also for economic reasons that these two countries have come up with so many hydropower projects. Both countries plan to become the main electricity producers and exporters in this region; and, both expect to generate more foreign currency through this channel (ADB, 2009). Presented in Figure 2.4 is a map showing the dams/hydropower projects in the Mekong River Basin. It should be noted that the information in Figure 2.4 may not exactly match the information in Table 2.5, due to different sources.

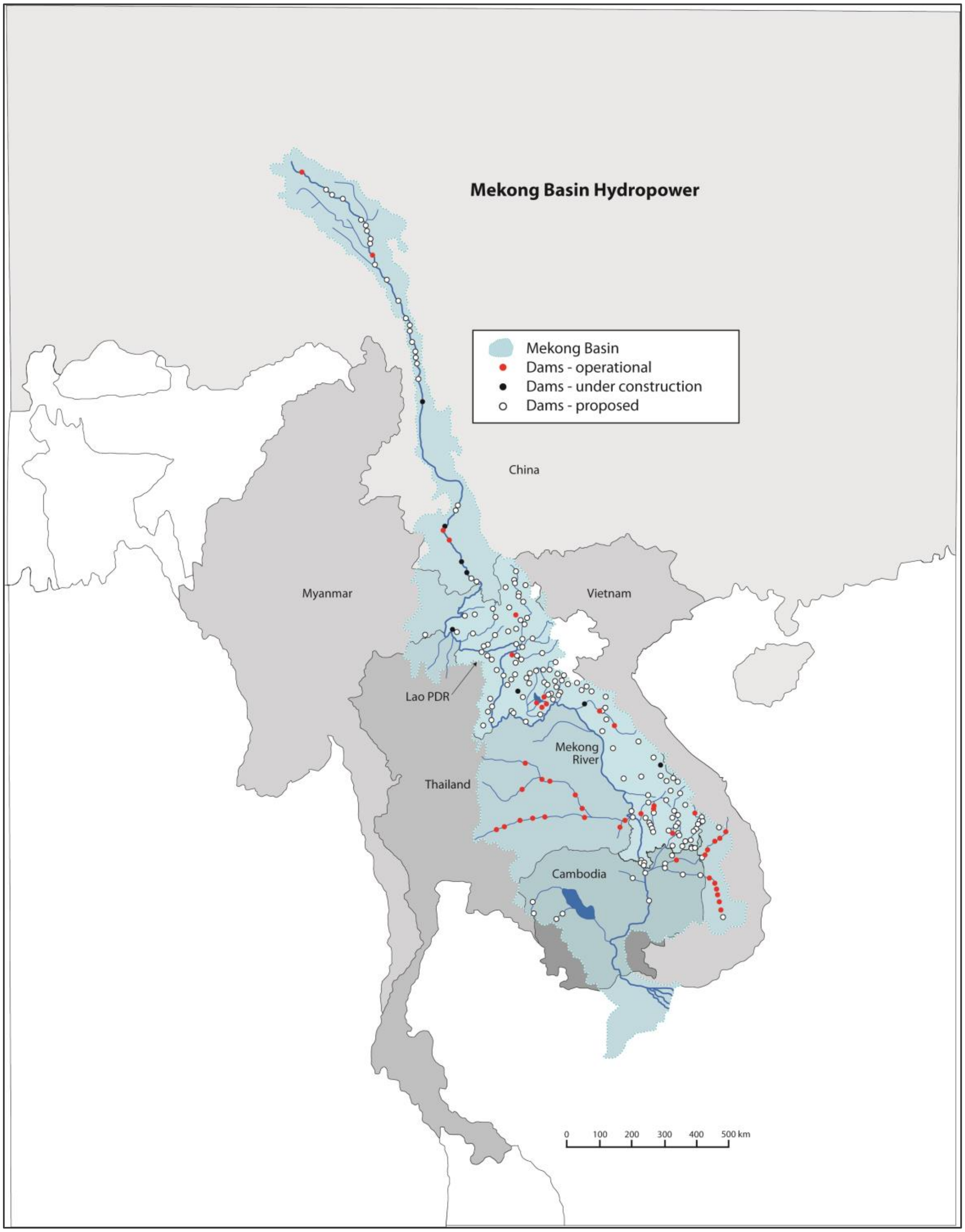
Table 2.5 Summary of existing and proposed dams and hydropower projects

Country:	Existing dam/hydropower project		Proposed dam/hydropower project	
	Number of project	Total installed capacity (MW)	Number of project	Total installed capacity (MW)
China (Yunnan)	4	8,550	10	13,560
Myanmar	0	0	1	550
Laos	11	1,779	31	5,788
Thailand	10	743	0	0
Cambodia	1	1	26	7,264
Vietnam	17	1,209	9	1,018
Total	43	12,282	78	28,180

Note: Existing dam/hydropower projects are comprised of (i) the projects that are completed and operated, and (ii) the projects that are under construction

Source: Summarized from King *et al.* (2007)

Figure 2.4 Mekong River Basin hydropower map



Source: http://mekong.waterandfood.org/app/webroot/mekong/downloads/
MB_Hydropower_map.jpg (retrieved on November 3, 2011)

The projects in the Upper Mekong Basin bring concern about the power of China as an upstream country able to impact the hydrology and the amount of water downstream, while the projects on the lower reach of the Mekong River Basin bring concern about benefit sharing among the Lower Mekong countries and how the projects will affect the rich ecosystem of the Lower Mekong Basin.

2.4 Pro-poor development and common pool resource dependence

Poverty alleviation is an important goal in economic development. In order to tackle poverty, the development paradigm of the 1950s and 1960s relied on rapid growth and the hope that higher employment and real wages will ultimately create the 'trickle-down' effect and alleviate poverty. The logic of the trickle-down effect is that even if the rich will benefit from economic growth first, the poor will benefit in the second round through the vertical flows as the rich start spending and investing (Kakwani and Pernia, 2000). However, it has been found that the pursuit of so-called 'pro-growth' policies often led to higher inequality, or even to what can be called 'immiserizing growth', and that the expected trickle-down effect may be very weak or may not exist.

Recognition of the limitations of the pro-growth policies shifted development policy to place poverty reduction as the main objective in development. Bourguignon (2004), for example, argued that reducing absolute poverty should be the main purpose of development, and that this requires effective combinations of growth and distribution policies. By directly targeting the employment rate and income of the poor, and also reducing inequality through the explicit policies during the process of pursuing growth, the approach of ‘pro-poor’ growth or ‘pro-poor policies’ is now the focus of the international community and many national governments. According to Asian Development Bank (ADB, 1999), “Growth is pro-poor when it is labor absorbing, and accompanied by policies and programs that mitigate inequalities and facilitate income and employment generation for the poor, particularly women and other traditionally excluded groups.”

The rich typically get proportionally higher benefits from economic growth than the poor, due to the advantages that they have in the market system in terms of human capital and material capital (Kakwani and Perina, 2000). Moreover, government policies sometimes tend to favor the rich, which makes the difference of well-being between the rich and the poor persist or widen over time. To alleviate poverty and increase overall well-being, pro-poor growth therefore must include pursue policies that reduce inequality.

A good example of why pro-growth economic policy alone, without putting the poor as the target of development, may not be sufficient to tackle poverty reduction is the case of policies that overlook the link between rural livelihoods and common pool resources (CPRs). Several empirical studies from around the world have found that the rural poor are more dependent upon CPRs for their livelihoods compared to the rich, and that restrictions on accessing the CPRs would affect the well-being of the poor significantly. Without recognizing and understanding this relationship thoroughly, development policies may end up degrading the environment and CPRs on which the poor’s livelihoods are depend, or displace and/or restrict their rights to access and utilize the CPRs. As a result, the development policy worsens differences of well-being between the rich and the poor, instead of narrowing the inequality gap.

Ostrom (2011, p.30) defines a common pool resource as a "natual or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use". Examples of CPRs are groundwater basins, grazing areas, fishing grounds, forest, irrigation canals, bridges, the atmosphere, lakes, oceans, rivers, and other bodies of water.

Using data from more than 80 villages located in dry tropical districts in seven states of India to measure the contribution of CPRs in the rural economy, Jodha (1986) found that CPRs are significant contributors to the rural poor's employment and income generation, as well as providing a safety net for them during times of crisis. Moreover, the poor were found to derive relatively more benefits from CPRs than the rich, implying that CPRs have an important role in reducing rural inequalities. The contribution of CPRs to the rural poor households in India is estimated in Beck and Ghosh (2000), of which it is roughly US$ 5 billion per year, equal to 12% of household income for the rural poor households.

Reddy and Chakravarty (1999), in a study on forest dependence in northern Indian state of Uttar Pradesh and its impact on rural poverty, constructed several measurements of poverty and compared poverty indices with and without forestry income. The results indicated that without forestry income, there would be an increase in poverty, and that the poorest of the poor are most dependent on forestry income. This finding elucidates the potential problem from the restriction of common property rights under the forest conservation policy being implemented at the time. Moreover, the study also shows that an increase of income from non-forestry income sources, i.e. agricultural labor, artisan work, and business, may not sufficiently substitute losses of forestry income.

Beck and Nesmith (2001) review several other empirical studies done in India and West Africa that assess the link between CPRs and rural poverty. Despite the differences in gender roles, land tenure systems, and rural differentiation across the two regions, it is found that CPRs are pivotal resources for the poor in both places, especially during the pre-harvest season, when other sources of income are unavailable, and in other times of stress. The share of CPRs in the poor people's income is usually found to be larger than that of the rich, again implying the redistributive effect of CPRs. It is also found that women in particular play important role in harvesting and utilizing CPRs, but usually not in managing CPRs. Degrading or privatizing the common resources thus not only threatens to worsen the rural poor's livelihoods, but also to worsen the position of women within the household.

Béné et al. (2010) advance an alternative view on the function and contribution of small-scale fisheries to economic development and poverty alleviation. The dominant 'wealth-based model' in fishery economics focuses on making small-scale fisheries become more economically efficient via restriction on fishing access in order to prevent overfishing, as well as to maximize the resource rent form fishery sector. Béné et al. argue that benefits of small-scale fisheries should not be viewed only in terms of economic surplus. As opposed to the 'wealth-based model', they use an alternative 'welfare model' to defend the proposition that small-scale fisheries, due to their common-pool-resource nature, function as a 'labor buffer' for resource-poor households. Fishing activities allow rural poor and marginalized households, with limited access to capital and other production resources, to sustain their livelihoods. Using the reviews on small-scale fisheries in Vietnam, Indonesia and Mozambique, Béné et al. conclude that, though there are some contrasts among these case studies, there is consistent evidence that small-scale fisheries play a role of absorbing unskilled workers, especially in the rural areas, and of providing them minimum subsistence.

The concept of CPR dependence can help to explain the failure of narrowly-growth-centric policy in solving the challenge of poverty reduction. At the same time, it suggests an alternative pathway of development, in which sustainable CPRs and environmental protection can be used as the keys to improve rural livelihoods and reduce poverty (Narain et al., 2008). This development path puts the poor as the main actors and poverty alleviation as the main goal, in keeping with the purpose and framework of pro-poor development.

CHAPTER 3

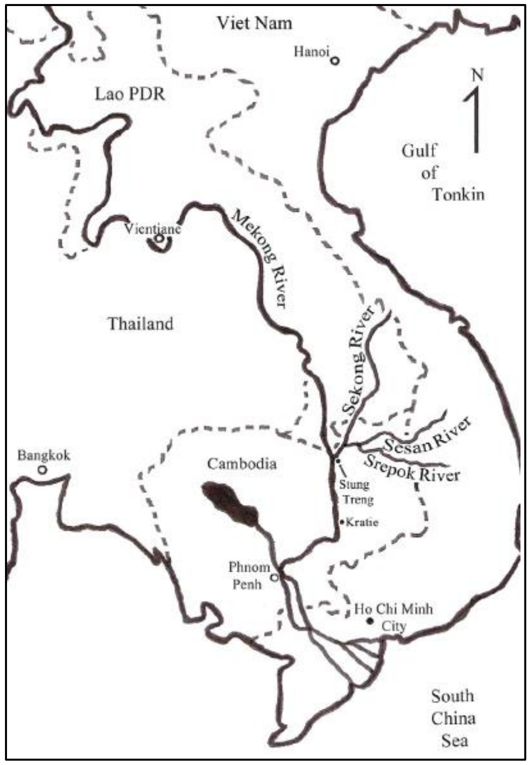
THE LOWER SESAN 2 HYDROPOWER PROJECT: A CASE STUDY

3.1 Overview of the Lower Sesan 2 hydropower project

The Sesan River, one of the largest tributaries of the Mekong River, originates in the Central Highlands of Vietnam. The river flows to northeast Cambodia through Ratanakiri and Stung Treng provinces. In Stung Treng province, the Sesan River is first joined by the Srepok River, which also originates in Central Highlands of Vietnam, then continues towards the west to merge with the Sekong River, which originates in Vietnam and flows through southern Laos before entering Cambodia. The Sekong River flows into the Mekong River in Stung Treng town, ten kilometers after it joins with the Sesan River (see Figure 3.1). It is estimated that the Sesan, Srepok, and Sekong rivers contribute about 19% to the total annual flow of the Mekong, measured at Kratie town (Baird and Mean, 2005; Rutkow et al., 2005).

The plan to construct the Lower Sesan 2 project started following a 2004 study on hydropower development in the lower Sesan basin. In 2007, the Electricity of Vietnam International Joint Stock Company, the main investor of the project back then, subcontracted the Key Consultant Cambodia (KCC) and the Power Engineering Consulting Joint Stock Company (PECC1) to conduct the feasibility study of the project. The feasibility study suggested that this project would be economically effective and would create significant benefit to Cambodia. Hence the project was approved, in principle, by the Royal Government of Cambodia.

Figure 3.1 The Sesan, Srepok and Sekong Rivers



Source: Baird and Mean, 2005

On November 2, 2012, the Cambodian Council of Ministers formally adopted the Lower Sesan 2 hydropower project with the Hydro Power Lower Sesan 2 Co., Ltd. now as project developer. The company's 90% stake is owned by the Royal Group Company, Cambodia's largest company, in collaboration with the Hydrolancang International Energy Co., Ltd. from China. The remaining 10% stake is owned by the state-owned Electricity of Vietnam International Joint Stock Company, the former sole investor. On November 26, 2012, the Implementation Agreement (IA) and the Power Purchase Agreement (PPA) were signed. As part of these two agreements, the Cambodian government is required to give two warranties of payment to the project developer. The first warranty is to purchase the power if the buyer, Electricité du Cambodge (EDC), a fully state-owned enterprise, fails to pay. The second one is a warranty of payment for purchase of project, meaning to pay for the cost of the project if the project cannot be implemented by the project developer because of political force majeure. The Letter on Government Guarantee of Payment was given to the project developer on December 12, 2012, and the 'Law on Authorization of Payment Warranty of the Royal Government of Cambodia for the Hydro Power Lower Sesan 2 Company' was approved by the Cambodian government in February 2013.

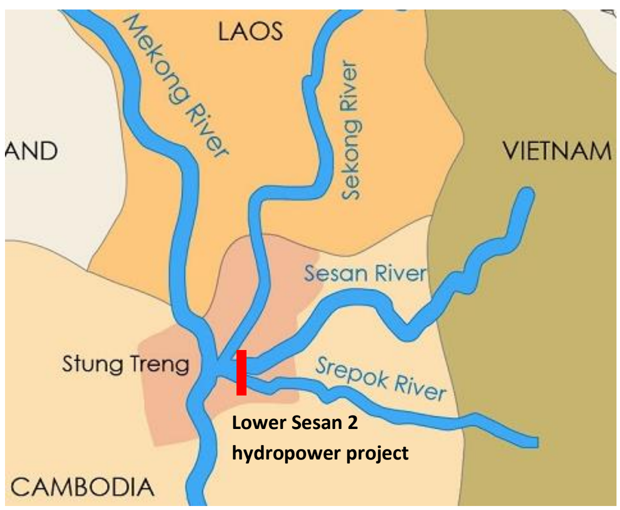
The Lower Sesan 2 hydropower project is a Built-Operate-Transfer (BOT) project, with a concession period of 45 years, consisting of 5 years of construction and 40 years of business operation. The project's total cost is estimated to be US$ 781.5 million, of which 30% of the cost is financed by the developer's capital and 70% from bank loans. Main project expenditures, as listed in the Law on Authorization of Payment Warrantee, are presented in Table 3.1.

Table 3.1 Main expenditures of the Lower Sesan 2 hydropower project

Expenditure:	Value (million US$)
Building	246.47
Machinery, equipment, tools	232.63
Interest for 5-yesr construction period	90.33
Contingency	55.74
Consultancy and monitoring	44.59
Compensation for impacts	41.42
Project development	16.72
36 kilometer of power transmission line	14.67
Clearance of reservoir areas	14.42
Project management	11.15
Insurance	5.58
Mine clearance	5.05
Environmental protection	2.23
Total	781.52

The project will be located just 1.5 km downstream from the confluence of the Sesan and the Srepok rivers, and 25 km east of the confluence of the Sesan and the Sekong Rivers near Stung Treng Town (see Figure 3.2). It will have an 8 km long earth-fill dam on the Sesan River, which will create a big reservoir with a flooded area of 33,560 ha, and storage capacity of 1.79 million m^3 when the water in the reservoir reaches the full supply water level (FSL) at 75 m. The electricity output from the 400 megawatts (MW) installed capacity of the project is expected to be 1.912 million kilowatt hours (kWh) per year on average[4].

Figure 3.2 Location of the Lower Sesan 2 hydropower project



Source: http://www.rfa.org/english/news/laos/sekong-06252013190742.html
(retrieved on July 7, 2013)

[4]Installed capacity refers to the maximum amount of electricity that the electricity generating station can produce at any given point in time. The amount of electricity produced within one hour is often measured by the unit of kilowatt hour (kWh), which is also commonly used as the billing unit for electricity delivered to consumers.

The clearing for dam's reservoir started in March 2013, with the resettlement and construction expected to begin sometime in 2014[5]. However, it has never been made clear to the public how the electricity output will be distributed. In early 2011, the Vietnam Foreign Investment Agency stated that half of the electricity output will be exported to Vietnam[6]. In mid-2011, officials from Cambodia's Ministry of Environment commented that the electricity output will be distributed for local use in Stung Treng Province of Cambodia first and the left-over will be exported to Vietnam, while providing no details about the share between domestic use and export[7]. Dr. Ian Baird, a Mekong fisheries expert and Assistant Professor of Geography at University of Wisconsin-Madison, estimates that the Stung Treng Province might need less than 1% of the electricity generated from the Lower Sesan 2. Transferring electricity to other parts of Cambodia is impossible at this point of time since there are not enough national electrical grids. Moreover, if there were an electrical grid to transfer electricity to Phnom Penh, the Lower Sesan 2 electricity output would exceed current power use by the capital city[8]. So it appears

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[5]According to International Rivers' website (http://www.internationalrivers.org/campaigns/lower-sesan-2-dam, retrieved on August 26, 2013).

[6]http://www.intellasia.net/news/articles/infra_resources/111314247.shtml, retrieved on November 5, 2011.

[7]http://www.intellasia.net/news/articles/business/111327063.shtml, retrieved on November 5, 2011.

[8]In 2008, electricity consumption in Cambodia is 1,348 GWh (http://www.tradingeconomics.com/cambodia/electric-power-consumption-kwh-wb-data.html, retrieved on November 30, 2011). Phnom Penh shares roughly 80% of national electricity consumption, which is equal to 1,078 GWh (http://agmhp. aseanenergy.org/focus-countries/2009/10/30/current-status-of-electricity-sector-of-kingdom-of-cambodia, retrieved on November 30, 2011). The 1,912 GWh from the Lower Sesan 2 is almost double the amount of electricity consumed by Phnom Penh.

certain that most of the power will be exported to Vietnam[9]. Nonetheless, after the structure of project developer has changed in November 2012, there is still no new information about the plan to distribute electricity.

3.2 Surveyed households and villages

To analyze the livelihoods and common pool resource dependence of households located around the Lower Sesan 2 hydropower project, I use the primary data obtained from the household survey conducted for the 'Water Valuation Project' under the Challenge Program on Water and Food (CPWF) in the Mekong Basin. The CPWF is a research program launched in 2002 by the Consultative Group on International Agricultural Research (CGIAR), a global research partnership whose works focus on advanced agricultural research for food security. The CPWF has more than 400 research partners and has carried out over 100 research-for-development projects that address the challenges of poverty, food security and water scarcity in several river basins around the world. The 'Water Valuation Project' is one of the research projects under CPWF in the Mekong Basin. It focuses on estimating the costs and benefits of different water uses at reservoir and catchment level.

Eighteen villages located around the Lower Sesan 2 hydropower project in Sesan District were selected for the household survey, which was conducted during April to May 2011. From the 300 surveyed households, I dropped one household

[9]http://www.intellasia.net/news/articles/business/111327063.shtml, retrieved on November 5, 2011 and from the interview in Pakse, Laos on August 15, 2011.

due to an ambiguous identification problem and use 299 households for the analysis. The 299 surveyed households are categorized into three groups, here termed three communities, based on the location of their villages and whether the villages are officially listed to be relocated due to the reservoir inundation. Figure 3.3 shows locations of 8 surveyed villages located downstream of the project, called here the 'downstream community'. Figure 3.4 shows location of 10 surveyed villages located upstream of the project, of which 5 surveyed villages are listed to be resettled, here called the 'relocated community', and 5 surveyed villages are not listed for resettlement, here called the 'upstream community'.

Figure 3.3 Locations of eight downstream villages in the survey

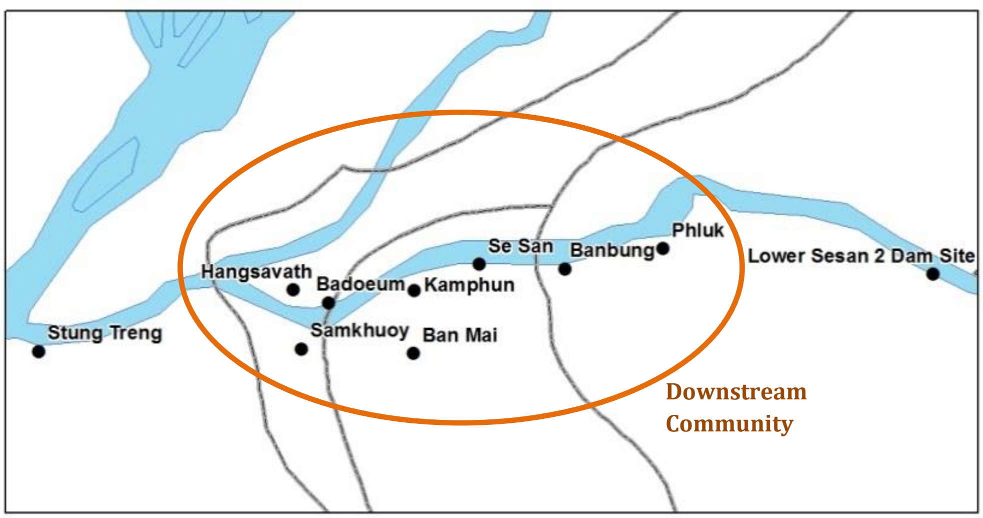
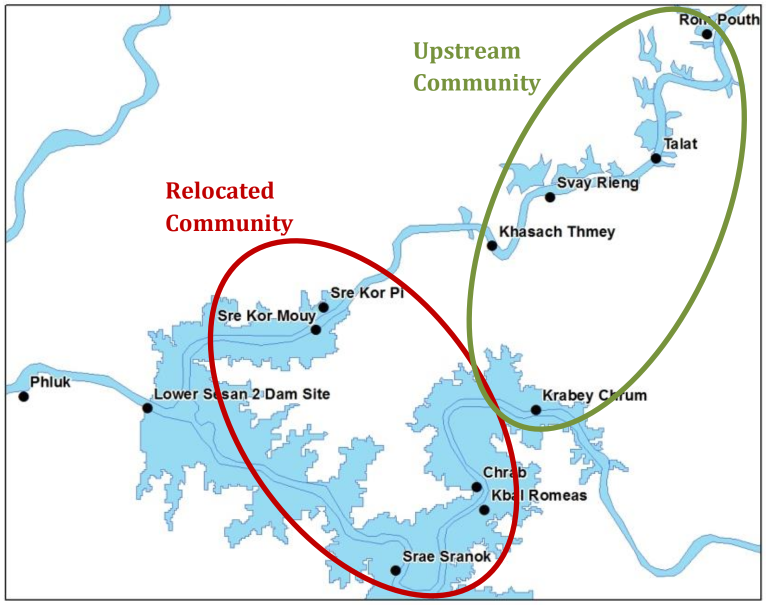


Figure 3.4 Locations of ten upstream villages in the survey



1. The downstream community

There are 150 surveyed households from eight selected downstream villages. These villages are located between the project site and the confluence of the Sekong and Sesan Rivers. Table 3.2 shows the village names, number of surveyed households in each village, and other selected details.

Table 3.2 Details of surveyed villages in the downstream community

No.	Village name	Commune name	Distant to Strung Treng town	Number of households in village	Number of surveyed households
1	Phluk	Phluk	22.4 km	255	24
2	Banbung	Phluk	19.7 km	60	11
3	Kamphun	Kamphun	14.2 km	498	46
4	Banmai	Kamphun	13.2 km	108	10
5	Se San	Kamphun	16.7 km	77	10
6	Badoeum	Samkhouy	10.3 km	152	18
7	Samkhuoy	Samkhouy	8.2 km	124	14
8	Hangsavath	Samkhouy	13.6 km	144	17

All of these eight downstream villages are easily accessible by road, and the condition of the roads is better than those of the upstream villages. During the field visit in June 2012, I was able to visit Phluk village, Banmai village and Kamphun village.

Phluk village is located immediately downstream, around 8 km, from the Lower Sesan 2 hydropower project site. Villagers grow rice once a year by using rain water, and the rice is mainly for household consumption. Fishing is also an important activity. Whether the fish will be consumed or sold depends on the type of fish. The village faces the challenge of decreasing availability of community forest due to a land concession granted by the Cambodian government. There are 27 households of Phluk village that are located closer to the project site, very close to the entrance to Srekor Mouy and Sre Kor Pi villages located upstream of the project that will be inundated, and this area can be accessed only by boat. This group of 27 households is poorer than the other households in Phluk village, and they will have to evacuate since their houses will be flooded. The former main investor once informed the villagers that this group of 27 households will get only lump sum compensation, not the same resettlement package as other resettled households; however, it is still not clear whether this offer remains the same under new project developer.

Kamphun village and Banmai village are very close to each other, in the same commune[10]. Several households in this commune are able to afford electricity,

[10]The primary administrative division in Cambodia is province and autonomous municipality. The secondary subdivision is district, which is further divided to communes, and then subdivided to village.

which is imported from Laos. Villagers also grow rice for consumption, and sell only if there is any excess. Though the villages are not far from the river, the steep banks of the river make it hard to obtain river water for their daily usage; so, ground water is used during the dry season (from December to April) and rain water is used during the wet season (from May to November). The river is used mainly for fishing, and villagers usually go to the upstream of Phluk village near the project site for fishing, because there are more fish at that location.

The concerns that villagers have about impacts from the Lower Sesan 2 hydropower project are very similar among these three villages. First of all, there is a concern about flooding when the dam releases water, which might create some damage to their rice fields. As of now, there is no discussion about compensation in case the rice fields are flooded. The second concern is about the quality of the water, especially during the construction period and while the reservoir is filled up. So far, the villagers have not yet been informed about how the water quality will change. The third concern is about the rapid changes of water lever when the dam starts operating, which might be dangerous for people downstream who use the river for transportation. The fourth concern is about a decline in fish stocks. Villagers report that a decline of fish has happened since the Yali Falls Dam, located further upstream on a tributary of the Sesan River in Vietnam, was constructed in the mid-1990s. Now they wonder what will happen to the fish when the Lower Sesan 2 hydropower project is built close to them.

It should be noted that, apart from 27 households in Phluk villages that live close to the project site, there is no compensation package specifically offered to villages located downstream of the Lower Sesan 2 hydropower project.

2. The relocated community

From the Law on the Authorization of Payment Warranty, five upstream villages are listed as the impacted area and will be evacuated to the new resettlement areas. Every household in these five villages will lose their current assets that cannot be easily or affordably moved. The household survey covered all of these five villages, with 74 surveyed households. Table 3.3 lists the village names, number of surveyed households in each village, and other selected details.

Table 3.3 Details of surveyed villages in the relocated community

No.	Village name	Commune name	Distant to Strung Treng town	Number of households in village	Number of surveyed households
1	Sre Kor Mouy	Sre Kor	69.4 km	178	15
2	Sre Kor Pi	Sre Kor	71.35 km	172	14
3	Srae Sranok	Kabal Romeas	61.6 km	123	11
4	Chrab	Kabal Romeas	71.4 km	237	22
5	Kbal Romeas	Kabal Romeas	72.55 km	121	12

In June 2012, I visited Sre Kor Mouy and Sre Kor Pi villages. Both villages are located next to each other and adjacent to the Sesan River. The rice fields of both villages are on another bank of the river, in which they grow rice once a year using only rain water, mostly for household consumption. The villages are quite easy to access by cars in the dry season, but during the wet season the only dirt road that leads to the villages becomes too muddy for cars and only motorcycles are used for transportation. There is no electricity in the villages, but several households have invested in a power generator and battery. Households in both villages depend on similar economic activities: growing rice, fishing, and getting timber and non-timber forest products from the community forest that located next to the villages. Here the area of community forest has been decreased by a land concession to a private company. Most households keep small herds of chickens, ducks, or pigs under their houses, which are raised above the ground to avoid flooding in wet season. Buffaloes and cows are kept away from the house, and the community forest is used for grazing land. Households usually sell their livestock to the middlemen who come to the villages.

The villagers in both Sre Kor Mouy and Sre Kor Pi villages are well aware about the construction of the Lower Sesan2 hydropower project, also the fact that they will have to leave their villages to new resettlement areas. Their main concern is about the new resettlement. It will be farther away from the Sesan River (3 km), which will make fishing harder than it used to be. Also, they say that the quality of soil in the resettlement areas is not suitable for growing rice.

My plan to visit Srae Sanok and Kbal Romeas village, which are located on the bank of the Srepok River, was canceled due to the heavy rain at the end of May 2012 which prevented access to them. However, I was able to meet with the village leader and committee members of Kbal Romeas village in Stung Treng Town and got some information from them. The villagers explained that their village is hard to access, due to the bad condition of the village's dirt road. Though the village is adjacent to the river, there is no irrigation system, so the villagers depend on rain water for rice growing. Rice production is just enough for household consumption, due to the limitation of arable land in the village. Raising and selling livestock is an important activity for cash generation. The villagers are very well informed about the plan to construct the Lower Sesan 2 hydropower project, also are well aware that their village will be flooded and they will all have to move to a new area. Similar to the situation in Sre Kor Mouy and Sre Kor Pi villages, Kbal Romeas villagers are concerned that the proposed resettlement area has poor quality land for agriculture. They would prefer to either move to a better location in terms of soil quality, or to a location that is closer to the highway so that it can be easier for them to reach the town.

The Law on the Authorization of Payment Warranty expects that there are 797 affected households to be resettled in 2014[11]. Each of the resettled households will be provided one 80 m^2 house, built on a land area of 1,000 m^2. Five hectares of farm land will be provided for each household as well. The new resettlement area will also have infrastructure and public services; such as roads, commune office, police station, school, health center, irrigation system, well, etc. The provision of allowance and rice for one year is also mentioned, though there are no details in terms of value. Compensation money is also mentioned to be given to each resettled household, of which the value will depend on their crops, size of farm land or plantations, and houses affected by the project. Compensation for fishery loss is not specifically mentioned in the Law on the Authorization of Payment Warranty.

[11]This number already includes 27 households in Phluk village.

However, lump-sum money to compensate for one year of fishery losses was mentioned in the early draft of environmental and social impact assessments conducted by KCC (Baird, 2009).

3. The upstream community

There are 75 surveyed households from 5 upstream villages that will not be relocated. Table 3.4 lists the village names, number of surveyed households in each village, and other details.

Only the Krabey Chrum village is located on the Srepok River, while other four surveyed villages are located on the Sesan River. These five upstream villages are not listed to be impacted by reservoir area in the Law on the Authorization of Payment Warranty. Some reservoir maps produced during the project feasibility study, done by former main investor, show that some of these villages might be at risk of flooding; however, there is no plan of evacuation for these 5 villages so far. This inconsistency of information has created confusion and is the main challenge for this group of villagers.

Table 3.4 Details of surveyed villages in the upstream community

No.	Village name	Commune name	Distant to Strung Treng town	Number of households in village	Number of surveyed households
1	Rom Pouth	Talat	103.1 km	60	4
2	Svay Reang	Talat	91.2 km	294	23
3	Khasach Thmey	Talat	79.5 km	295	25
4	Talat	Talat	97.5 km	89	7
5	Krabey Chrum	Kabal Romeas	83.6 km	195	16

Krabey Chrum village is an important example, since it is shown to be flooded in every reservoir map, but the latest resettlement plan still does not include this village. During my visit to Krabey Chrum village in June 2012, villagers expressed their main concern that they don't know what to do if the village ends up being flooded by the project. Some households plan to move to the forest area nearby if that situation happens, but they expect that it will be chaos since there is no system on how to distribute the forest area among them. Also, there is still a possibility that the forest area they plan to move into might be under land concession in the future. So the villagers want at least a guarantee from government authority that there will be land reserved for all households in the village in case their village is flooded.

Apart from being at risk of flooding without any formal plan of resettlement, this group of villages also faces the unclear situation about the impacts of the Lower Sesan 2 hydropower project. One might expect to see the decline of fish stocks in both the Sesan and Srepok Rivers, since the project will block the migration of fish between the Mekong River and the Srepok River, also the migration of fish between the Srepok River and the Sesan, Sekong and the Mekong Rivers.

None of the villages located upstream of the Lower Sesan 2 hydropower project are mentioned to be compensated in the Law on the Authorization of Payment Warranty. However, according to the early draft of environmental and social impact assessments, only upstream villages located adjacent to the Sesan and Srepok Rivers are to be compensated for one year of fishery losses, while other upstream villages located within the Sesan and Srepok Basins, but not adjacent to the rivers, are not recognized as impacted villages (Baird, 2009).

Villagers in these three communities are considerably poorer than the average Cambodian. Table 3.5 presents the National per Capita Income, as reported in Table 2.2, and values of per Capita Income for each community, of which calculated from the primary data used in this dissertation[12].

Table 3.5 National per Capita Income and calculated per Capita Income of three communities

Income:	US$
National per Capita Income (year 2013)	1,015.28
Calculated per Capita Income for downstream community	335.82
Calculated per Capita Income for relocated community	327.42
Calculated per Capita Income for upstream community	217.05

Ethnicity of the population in the surveyed villages is also important information worth pointing out. During my field visit in 2012, I was able to communicate with several villagers directly using Thai and Lao languages. This is because while the majority of Cambodia's population is Khmer, Lao is the dominant ethnicity in Stung Treng province. This province used to be part of Laos under the period of French protectorate until December 6, 1904 when French transferred it to Cambodia (Braid, 2010). Apart from ethnic Lao, other minority ethnic groups are also found in Stung Treng province. Baird (2009) provides ethnicities of population in some selected villages of northeast Cambodia, of which the ethnicities of the people who live in the surveyed villages are presented in Table 3.6.

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[12]Details of the primary data are discussed in Chapter 4.

Table 3.6 Dominant ethnicity in eighteen surveyed villages

Community:	Village	Ethnicity
Downstream	Phluk	Lao
	Banbung	Lao, some Khmer
	Kamphun	Lao, Khmer
	Banmai	Lao
	Se San	Khmer
	Badoeum	Lao
	Samkhouy	Lao
	Hangsavath	Lao, some Khmer
Relocated	Sre Kor Mouy	Lao
	Sre Kor Pi	Lao
	Srae Sranok	Khmer Khek, Bunong, Brao
	Chrab	Khmer, Lao
	Kbal Romeas	Bunong
Upstream	Rom Pouth	Kreung
	Svay Reang	Khmer Khek
	Khasach Thmey	Khmer Khek, Lao
	Talat	Khmer Khek
	Krabey Chrum	Lao

Source: Adapted from Baird (2009)

CHAPTER 4

FISH AND RURAL LIVELIHOOD DEPENDENCE

4.1 Introduction

In the drive for economic growth, some economic policies and projects can aggravate the existing problems of poverty and income inequality. An important example is when the policy or development project overlooks the significant contribution of common pool resources in the livelihoods of the rural poor, and ends up either degrading those resources or restricting rights to access and utilize the resources. Both impacts can worsen the situation of rural poverty and income inequality.

The state-led hydropower development projects now being implemented in the Mekong River Basin may be a case in point. The construction of several hydropower dams on the mainstream and the tributaries of the Mekong River could put millions of local people at risk of losing their access to fisheries resources, which are crucial element in rural livelihoods in the basin. This chapter aims to assess the dependence of rural poor on the threatened Mekong fisheries, via a case study of households situated around the proposed Lower Sesan 2 hydropower project in northeast Cambodia.

The chapter consists of seven sections. Section 2 reviews literature on the impacts of hydropower dams on fish biodiversity and fish migration in the Mekong River. In section 3, the data used in the analysis of this chapter are discussed, along with the details of variables and descriptive statistics. Section 4 puts forward four different ways to measure the household's fish dependence. Section 5 presents a statistical analysis of the relationship between the fish dependence variables and other socio-economic variables. The results are discussed in more depth in section 6, and the conclusion is presented in section 7.

4.2 Fish and dams

There is abundance of fish species in the Mekong. A global fish database used to compare rivers and lakes around the world shows that the diversity of fish species in the Mekong River is second only to that of the Amazon River (Baran, 2010)[12]. The Tonle Sap Lake in Cambodia, which is the largest freshwater lake in Southeast Asia and connects to the Mekong River system, is ranked fourth among the world's lake ecosystems for its fish diversity, with 197 recorded fish species. Throughout the whole Mekong Basin, the area that has the most fish diversity is the lower Mekong fish migration zone[13], in which 669 fish species are found. This lower Mekong fish migration zone covers the area of Khone Falls in Southern Laos, mainstream Mekong in Stung Treng and Kratie province in Cambodia, the Sekong-Sesan-Seprok Rivers system, Tonle Sap Lake, and the Mekong Delta in southern Vietnam.

The richness of fish biodiversity has made the Mekong River system the world's largest inland fishery (Dugan et al., 2010). Estimates of fish catch in the

[12]The number of fish species found in the Mekong River is listed at 781 species, while there are 1,217 fish species in the Amazon. The Mississippi River in the United Stated is ranked eleventh for its fish diversity among the top 15 rivers with 226 fish species (Baran, 2010: p.6).

[13]Note that the lower Mekong fish migration zone is only a part of the Lower Mekong Basin.

Mekong Basin and in the Mekong countries vary in the literature. Baran (2010) presents several estimates gathered from national data and different fishery surveys. According to the national statistics, the inland fisheries from four countries in the Lower Mekong Basin produce 755,000 tons per year, which is 7% of the world's catch from freshwater fisheries. A synthesis from field surveys and scientific estimations yields the most robust assessment of freshwater fish production in the four Lower Mekong Basin Countries as 2.1 million tons per year, or approximately 18% of the world's production. Among the four countries, Laos produces around 5% of total catch, while Cambodia, Thailand and Vietnam each produce approximately one-third of the rest. The calculations from Baran (2010) also show that the average freshwater fish catch per capita in the four Lower Mekong countries ranges from 5 to 29 times more than the world's average. Cambodia is the country with highest freshwater fish catch per capita.

Freshwater fish resources are significant for both income and food security of the Lower Mekong countries. Peterson and Middleton (2010) report that fisheries contribute roughly 8% of Laos' GDP and 16% for Cambodia's GDP. In terms of the contribution of fisheries to the region's food security and nutrition, freshwater fish consumption per capita in the Lower Mekong countries is 56.6 kg on average (Baran et al., 2007; Peterson and Middleton, 2010). According to Baran (2010), the share of freshwater fish in total animal protein consumed in the Lower Mekong countries ranges from 2.2 to 8.6 times the world average.

Currently, the governments of the Mekong countries have focused on using the hydropower potential of the river system in generating more electricity to support economic development. Combining existing dams, dams under construction and planned dams together, there are nearly 200 dam projects on the mainstream Mekong and tributaries (Ferguson et al., 2011). This situation raises the concern about the potential impacts of hydropower on the environment and livelihoods of the people in the basin area, especially through the fisheries impacts.

The construction of dams could generate crucial impacts on the Mekong River fish. As explained in Baran and Myschowoda (2009), the most evident impact of a dam is that it will block the migratory routes of fish and hence their natural lifecycle cannot be completed. In general, adult fish move upstream to breed, and the larvae drift back downstream. Hence, a dam located downstream, near floodplains habitats, would create greater ecological impacts on longitudinal fish migration networks compared to an upstream or tributary dam. Moreover, fish that depend on the species that migrate long distance will also be affected if their prey cannot travel past the dam.

Dams will also change the natural flows and the flooding period in the basin. In general, downstream of the dam locations will experience lower water level and delayed seasonal flood peak, as well as a shorter flood period in the wet season, and an increase in average discharge during the dry season (Kummu and Sarkkula, 2008).

The Mekong River Commission (2010) suggests that these potential hydrological changes would benefit aquaculture downstream, because more water in the dry season and less flood peak in the wet season would be favorable to caged fish in the river. The sediment loads will be trapped by the dam, which will make the released water cleaner and good for aquaculture, although this would have a negative impact for wild fish downstream. Loss of sediment means loss of the associated nutrients, affecting the conditions of the feeding grounds downstream and leading to declines of fish productivity (Kummu and Varis, 2007). Also, the increase of water level during the dry season can relax the problem of water shortage for the water users downstream, which would benefit agricultural production. However, on the other hand, dams could also create irregular water releases and flow variability as well, leading to problems for downstream users.

In terms of the impacts on wild fish, the potential hydrological changes would definitely affect the quality of breeding and feeding grounds for wild fish, as well as blocking migration between them. With lower flood levels, the surface area for fish to feed would be smaller. Shorter flood period means that fish will have less time to grow and thus the size of fish caught will be smaller. Also, fish larvae and juveniles will have lesser chance to survive if the timing of flood is delayed (Baran and Myschowoda, 2009). Kang et al. (2009) explain that fish species with stronger adaptability, higher breeding and shorter reproduction cycle are likely to survive better under these changes in the post-dam period. Hence, it is not only the stock of fish in the Mekong Basin that would be affected; the diversity of fish species is also vulnerable to the dam development.

These potential fishery impacts brought by hydropower dams will definitely affect the livelihoods of local people who live around the dam areas. However, the impacts of dams would be unevenly distributed among households. In part, this depends on location. The impacts on downstream households and upstream households are likely to be different. As for the fishery impacts created by the Lower Sesan2 hydropower project in particular, Baird (2009) breaks down the fishery impacts, and the population in Cambodia that would face those fisheries impacts, into several groups as follows:

1. Fisheries impacts upstream from the project site in the Sesan River and Srepok River in Stung Treng, Ratanakiri and Mondulkiri provinces

In the early rainy season, between May to July, it is found that several fish species migrate from downstream to upstream of the proposed dam site to spawn and feed. Then their larvae float back downstream during the peak of the rainy season. Long-distance migratory fish are also found in both the Sesan and the Srepok Rivers. Baird (2009) mentions that at least 30 fish species migrate from the Tonle Sap River up the Mekong River and farther up to the Sesan and Srepok Rivers every year between December and February. This finding matches up with the statement provided in the EIA of the Lower Sesan 2 hydropower project that, in the dry season, fish mostly move to and spend time in the deep pools areas of both Sesan and Srepok Rivers.

It is also found that there are more fish migrations in the Srepok and Sekong Rivers than in the Sesan River. This is because the Srepok and Sekong Rivers have more deep pools and adjacent wetlands than the Sesan River. In terms of diversity of fish species, the Srepok River also has a higher diversity than the Sesan River, due to more deep pools and less migration barriers.

Since the Lower Sesan 2 project will be located down the confluence of the Sesan River and the Srepok River, it will block the migration of fish between the

Mekong River and the Srepok River, also the migration of fish between the Srepok River and the Sesan, Sekong and the Mekong Rivers. The study conducted under the EIA finds that, of 87 fish species caught during the study period[14], 58 fish species were found in upstream and downstream of the proposed Lower Sesan 2 site. This suggests that approximately 66% of the fish species around the proposed Lower Sesan 2 area might have movements that will be blocked by the dam.

Human populations living upstream of the Lower Sesan 2 dam reservoir can be categorized into three groups as follows:

1.1 People who live adjacent to the Sesan River and Srepok River

Several villages located directly adjacent to the Sesan River and the Srepok River above the Lower Sesan 2 site would be directly impacted by losing access to migratory fish. It is estimated that there are 22 villages directly adjacent to the Srepok River upstream from the Lower Sesan 2 site that would lose all fish that currently migrate between the Mekong River and the Srepok River, and that approximately 65 villages living directly adjacent to the Sesan River upstream from the Lower Sesan 2 site would lose all fish that presently migrate between the Srepok River and the Sesan, Sekong and Mekong Rivers[15].

1.2 People who live not adjacent to the Srepok River but in the Srepok River Basin

Since fish do not only live in large rivers but also travel along other water bodies such as smaller streams and seasonally inundated areas, blocking the

[14]Information about fisheries for the EIA was collect during the dry season of 2008.

[15]For 22 upstream villages located adjacent to the Srepok River, 4 villages are in Stung Treng province, 4 villages are in Mondolkiri province, and 14 villages are in Ratanakiri province. For 65 upstream villages located adjacent to the Sesan River, 6 villages are in Stung Treng province and 59 villages are in Ratanakiri province.

migration of fish in the large rivers also will affect the number of fish that can be found in the smaller streams. In the Srepok River Basin, there are at least 42 villages located near the large streams that flow into the Srepok River that would face fisheries loss due to the blocking of migratory fish by the Lower Sesan 2 project[16]. It should be noted that these villages are not recognized in the EIA as potential impacted villages.

1.3 People who live not adjacent to the Sesan River but in the Sesan River Basin

There are at least 44 villages, all of them are in Ratanakiri province, located near the streams that flow into the Sesan River that would face fisheries loss due to the blocking of migratory fish by the Lower Sesan 2 hydropower project. It should also be noted that these villages again are not recognized in the EIA as potential impacted villages.

2. Fisheries impacts in the reservoir area in Stung Treng Province

People who once live in the reservoir area and have to be resettled will also face the major fisheries impacts in terms of the changes in their income and food supply. The Lower Sesan 2 project would create a big reservoir in which approximately covers the surface area of 335 km^2; however, reservoir fishery would not be very productive. Baird (2009) explains how the characteristics of the reservoir itself would make it not be an attractive place for aquatic life:

> First, the reservoir would be euthrophic (algae blooms), since it would flood a lot of non-cleared vegetation in the inundation area. Secondly, much of the reservoir would constitute very deep inactive storage, thus creating a large quantity of anoxic water, a habitat where few fish can survive. Third, this reservoir, like most others, would include a 'draw down zone' surrounding

[16]For these 42 villages, 3 villages are in Mondolkiri province and 39 villages are in Ratanakiri province.

> the reservoir. The unusual changes in water levels in the reservoir are likely to result in this area being non-vegetated. Therefore, there would be very little vegetative habitat along the edge of the reservoir. As Baird (2007)[17] has shown for the Mekong River in southern Laos and northeastern Cambodia, terrestrial forests and other riverbed tree and shrub species are important sources of food for many fish species, especially in the rainy season. (Baird 2009: p.53-54)

Thus, it is not likely that the native fish would be able to adapt themselves to the reservoir conditions; and hence it is plausible that the reservoir fishery would not be very productive, which can affect the income and food supply of people live nearby the reservoir in the post-dam period.

3. Fisheries impacts downstream from the Lower Sesan 2 in Stung Treng Province

Though the EIA mentions that some negative impacts might happen downstream of the project during the construction period, it does not sufficiently recognize the impacts that would occur during the operation period of the project. As reviewed in Baird (2009), the operation of dam would change the hydrological conditions and water quality downstream, which will affect ecology of the river and fishery. It is estimated that 19 villages located downstream along the Sesan and the Sekong River would face downstream fishery impacts from the Lower Sesan 2 project.

4. Wider regional fisheries impacts in the Lower Mekong Basin

It is recognized in the EIA that the fisheries impact of Lower Sesan 2 hydropower project are likely to spread as far as the Tonle Sap in Cambodia and the Mekong Delta in Vietnam. Moreover, other countries sharing the Lower Mekong

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[17]Refer to Baird, I.G. 2007. "Fishes and Forests: The Importance of Seasonally Flooded Riverine Habitat for Mekong River Fish Species". *Natural History Bulletin of the Siam Society* 55(1): 121-148.

River Basin which located upstream of the project, i.e. Laos, may see fisheries impacts as well if the migration of fish is severely affected.

In one recent study published in the *'Proceedings of the National Academy of Sciences of the United States of America'*, Ziv et al. (2012) use an ecological model of fish migration to estimate the losses of fish biodiversity and biomass regarding different scenarios of Mekong mainstream and tributary dams, and calculate the potential loss of fish production generated by the construction of each tributary dam. The results show that, among 27 proposed tributary dams, the Lower Sesan 2 hydropower project would create the greatest impact, with 9.3% drop of fish biomass in the entire Mekong Basin**.** The results from Ziv et al. (2012) are reproduced in Table 4.1.

Among all impacted households, households that probably face the most direct and extreme changes in their livelihoods are those that will be evacuated due to the inundation of the dam's reservoir. In addition, households within the same communities would bear different costs from fishery impacts, depending on how much the household's livelihood relies on fisheries. The more the household depends on fisheries, for income generation or self-consumption, the greater fishery impacts it will have to face. To identify the households that would be hit hardest by the dam via fishery impacts, we need information on their 'fish dependence'. The purpose of this chapter is to shed light on the fish dependence of households and how this varies across different economic status groups in the dam area of the Lower Sesan 2 hydropower project in Cambodia.

Table 4.1 Impact of individual dams on fish productivity and biodiversity

Dam:	Average Δ (migratory biomass) (%)	Rank (impact on fish biomass)	Average Δ (number of newly endangered species)	Rank (impact on fish species richness)
Lower Sesan 2	9.29	1	56.29	1
Se Kong 3d	2.29	1	9.42	2
Se Kong 3up	0.90	3	3.47	3
Se Kong 4	0.75	4	3.02	4
Nam Ou 1	0.49	5	1.99	5
Nam Kong 1	0.35	6	1.77	6
Nam Ngiep-regulation dam	0.28	7	1.76	7
Nam Ngiep 1	0.28	8	1.70	8
Nam Theun 1	0.26	9	1.43	9
Nam Ou 2	0.26	10	0.86	12
Se Kong 5	0.25	11	0.93	11
Nam Tha 1	0.22	12	1.33	13
Nam Lik 1	0.22	13	0.89	10
Nam Ou 3	0.16	14	0.46	15
Nam Suang 1	0.13	15	0.76	17
Xepian-Xenamnoy	0.11	16	0.36	18
Nam Suang 2	0.10	17	0.49	14
Nam Beng	0.07	18	0.49	20
Xe Katam	0.06	19	0.19	16
Nam Pha	0.06	20	0.40	22
Nam Ou 4	0.05	21	0.15	19
Nam Phak	0.03	22	0.23	21
Houay Lam phan	0.03	23	0.10	25
Nam Ou 5	0.03	24	0.06	23
Nam San 3	0.02	25	0.13	24
Nam Ou 6	0.01	26	0.02	26
Nam Ou 7	0.01	27	0.01	27

Source: Ziv et al. (2012)

4.3. Data

4.3.1 The survey and questionnaire

Data used for the analyses in this paper come from the primary data collected under the 'Water Valuation Project', one of the six projects launched under the Challenge Program on Water and Food (CPWF). Several research groups work together under this project, which studies reservoir water utilization and people's livelihoods regarding three dams in Laos, Vietnam, and Cambodia. The main research organizations that are responsible for the study of the Lower Sesan 2 household resettlement survey are the Culture and Environment Preservation Association (CEPA)[18], together with the International Food Policy Research Institute (IFPRI)[19] and the WorldFish Center[20].

The survey was conducted during April to May 2011 in the selected 18 villages located in Sesan district, Stung Treng province, Cambodia. A questionnaire was used as a survey tool. The eight modules of questionnaire are summarized as follows:

1. Module 1: Roster

List of household members, gender, age, level of education.

2. Module 2: Housing, housing assets, and water use

Data on construction materials of the house (i.e. floor, wall, roof), source of lighting, type of toilet facility.

Data on assets owned by the household, number of years that each asset is owned, value of each asset at the time it is purchased, and current value of each asset.

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[18]CEPA is a local NGO in Cambodia, whose works focus on sustainable natural resource management.

[19]IFPRI is an international research organization with a mission on seeking sustainable solutions to end hunger and poverty in developing countries, and providing research-based global food policy knowledge. The research team that is responsible for the 'Water Valuation Project' is based in Washington DC, USA.

[20]WorldFish is an international nonprofit research organization whose missions are improving livelihoods of the poor who depend on fisheries and aquaculture, also accomplishing environmental sustainable solutions to make fish accessible and affordable for the poor in developing countries. The WorldFish office in Cambodia is the leader for the 'Water Valuation Project'.

Data on sources of water used in the house in each season, amount of water used in each season and in a day, percentage of water used in different activities, sources of water, time and effort spent in getting water, and the importance of river and other water sources in different activities.

3. Module 3: Land use/farming activities

Data on total amount of farmed land, area of the plot cultivated, types of irrigation used in farmed land, and whether the farmed land be lost to the reservoir.

Lists of crops cultivated, amount of each crop harvested in the last 12 month, amount of the harvests that are sold and consumed, and money earned from sales.

4. Module 4: Livestock activities

Data on types and number of livestock owned 12 months ago, types and number of livestock bought in the past 12 months and the average price of each one, types and number of livestock sold in the past 12 months and the average price of each one, types and number of livestock lost/killed/given away in last 12 months, types and number of livestock owned today, total sales value of livestock owned today, and whether livestock require regular watering by the household.

5. Module 5: Fisheries activities

Data on total earnings from fish sales in the past 12 months, number of fishing trip in each month and number of days in one fishing trip, amount of catch in one day/week/month, percentage of catch for consumption and for selling in each month, average selling price in each month, amount of fish purchased in each month and average price, and amount of shellfish/snails collected in one day/week/month.

6. Module 6: Forestry activities

Data on types and quantity of products collected from forest, locations and types of forest each product is collected, value of each product in the past 12 months and total money earned from selling each forest product, amount of each forest product consumed in the household, and amount of each forest product given away.

7. Module 7: Nonagricultural income sources

List of nonagricultural activities done by each household member, the month that each activity occurs, money earned from each activity in one year, and whether travelling to another town/village is required for each activity.

8. Module 8: Household expenditures

Data on types and value of each household's expenditure in the past year and in the past month.

CEPA was the main group in charge of conducting the field survey and transcribing the information obtained from the questionnaires into a spreadsheet, while IFPRI is in charge of processing and analyzing the data. I was able to acquire the spreadsheet of data from IFPRI. For several modules, the data needed to be cleaned and processed in order to obtain the appropriate variables for this analysis. Because I had no access to the hard copy of the questionnaires to help me clarify ambiguities found in the spreadsheet, I used related information found in the spreadsheet to crosscheck answers. When data anomalies were found, the affected entries were treated as missing values.

4.3.2 The variables

The variables constructed for this analysis from the primary survey data can be categorized into four groups.

1. Fishery and fish dependence variables

The six variables in this category reflect the importance of fish as source of income and food for each household:

1.1 Total Fish Catch (Catch)

Amounts of fish catch in each month are reported by the households that participate in fishing. The value of this variable is calculated by combining the amounts of fish catch for all 12 months. For the households that do not participate in fishing, there total fish catch values are zero. The unit for 'Total Fish Catch' is Kilogram (kg).

1.2 Amount of Fish Consumed (Food)

This variable is calculated by combining the amounts of catch that are consumed by households for all 12 months. For the households that do not participate in fishing, the value of this variable is equal to zero. The unit for 'Amount of Fish Consumed' is Kilogram (kg).

1.3 Amount of Fish Sold (Sale)

This variable is calculated by combining the amounts of catch that are sold by households for all 12 months. For the households that do not participate in fishing, the value of this variable is equal to zero. The unit for 'Amount of Fish Sold' is Kilogram (kg).

1.4 Fish Income Dependence (FID)

The Fish Income Dependence is a ratio between two variables: 'Fishery Income' and 'Total Cash Income'. Definition and the calculation of these two variables are explained below under the Income Variables. This FID ratio ranges from 0 to 1.

1.5 Fish Consumption Dependence (FCD)

The Fish Consumption Dependence is a ratio between two variables: 'Value of Fish Consumed' and 'Total Cash Income'. 'Value of Fish Consumed' is calculated using these following steps:

(i) Divide 'Fishery Income' by 'Amount of Fish Sold' to obtain 'Unit Price of Fish Sold' ($/kg).

(ii) Find the median values of 'Unit Price of Fish Sold' for each of the three communities. The results are $1.87/kg for the downstream community, $1.69/kg for the upstream community, and $2/kg for the relocated community.

(iii) In my interview in the villages, villagers report that they normally sell bigger fish which have higher market values, and consume smaller fish which have lower market values. The 'Unit Price of Fish Consumed' thus will be less than the 'Unit Price of Fish Sold'. For this analysis, I assume that 'Unit Price of Fish Consumed' is half of the 'Unit Price of Fish Sold'. Hence the values for 'Unit Price of Fish Consumed' are $0.93/kg for the downstream community, $0.85'/kg for the upstream community, and $1/kg for the relocated community.

(iv) For each household, I multiply its respective 'Unit Price of Fish Consumed' by 'Amount of Fish Consumed' to obtain 'Value of Fish Consumed'.

The FCD ratio is calculated by dividing 'Value of Fish Consumed' by 'Total Cash Income'. Unlike the value of FID, the values of FCD can be greater than 1. The FCD equals to zero for households that do not participate in fishing, and also for households that participate in fishing but do not consume any of their catch.

1.6 Total Fish Dependence (TFD)

The Total Fish Dependence is calculated by adding 'Fish Income Dependence' and 'Fish Consumption Dependence' together. Households that have information on only one of these two combinations, as well as households that missing both combinations, are treated as missing values.

2. Income variables

The income variables refer to cash income that each household obtains from different sources in one year. There are six variables in this category. The unit of currency is the US dollar. Where necessary, the exchange rate of 4,020 Cambodian riels to US$1 is used to convert local currency into US dollars.

2.1 Fishery Income (YFish)

The data on fishery income for each household come from the question under Fishery Activity Module in the questionnaire, which directly asks 'How much were your total earnings from fish sales in the past 12 months?'

2.2 Farm Income (YFarm)

Under the Land Use/Farming Activity Module in the questionnaire, households are asked about crops grown. For each crop reported grown and sold by each household, there is a question which directly asks 'how much money was earned from this quantity sold?' The value of farm income is calculated by combining the earnings that household obtains from each crop.

2.3 Forestry Income (YForest)

Under the Forestry Activity Module in the questionnaire, forest products are categorized into 3 main groups: Timber Forest Products, Non-Timber Forest Products, and Wildlife Products. A list of forest products are provided in each group, together with a direct question that ask the total money earned from sales of these items. The value of forestry income is calculated by combining the earnings that household obtains from each forest product.

2.4 Livestock Income (YLives)

There are eight types of livestock listed under the Livestock Activity Module in the questionnaire. There is no direct question asking about money earned from livestock sold in the past 12 months, but there are questions asking about (i) number of each livestock sold in the past 12 months; (ii) average price of each livestock sold during the past 12 months. Money earned thus can be calculated by multiplying number of livestock sold with average price for each livestock. However, the information for large livestock (i.e. cattle, buffalo and pig) is less consistent than the information for small livestock (i.e. chicken, goose, bird and duck), with reported earnings poorly correlated with reported sales, resulting in an implausibly wide range of implied prices. Hence, while the values of small livestock are calculated directly using the household information, a different approach is used to obtain the values of large livestock. For each type of large livestock, the prices from households that report selling only one animal are used to find the mean value of the selling price. This price is used to calculate the earnings from large livestock sales, by multiplying it by the number of animals sold. Livestock Income for each household is calculated by combining the money earned from all types of small and large livestock.

2.5 Other Income (YOther)

Apart from the four main sources of income from resource-based activities discussed above, several other types of activities are also listed under the Nonagricultural Income Module in the questionnaire, together with amount of money households earned from each activity in the past 12 months. Examples of activities listed are carpentry, construction, shop-keeping, government employment, renting equipment, craft work, etc. The value of 'Other Income' is calculated by combining money earned from these activities, except the earnings from paddy credit and loans/cash credit.

2.6 Total Cash Income (YTotal)

The value of 'Total Cash Income' for each household is calculated by combining together 'Fish Income', 'Farm Income', 'Forestry Income', 'Livestock Income', and 'Other Income'.

3. Asset variables

There are three variables in this category. Asset variables reflect the living standards of each household, and provide an alternative to using cash income as the only criterion to distinguish the poorer households from the richer households.

3.1 Household with Latrine (Latrine)

Different types of toilet facilities are listed under the Housing and Housing Assets Module in the questionnaire. To create this dummy variable, households that use 'open land/forest/bush' as their toilet facility are considered to be households with no latrine, and are assigned number 0. Households with latrine, which are assigned number 1, are households that have these following types of toilet facility: (i) toilet with pour flush (or flush); (ii) latrine with slab (closed/covered); (iii) latrine without slab (open); (iv) latrine over field or water.

3.2 Size of Farm Land (Farm)

Total size of farm land that each household owns is asked under the Land Use/Farming Activity Module. The unit of farm land is Hectare.

3.3 House Quality Index (HQI)

The House Quality Index is constructed using the information about materials that each household uses for the wall, roof, and floor of the house. Information about the construction materials is provided under the Housing and Housing Assets Module. Numbers are assigned according to the quality of the construction materials used, in which 1 represents good quality materials, 0.5 represents medium quality materials, and 0 represents poor quality materials. The Wall Quality Index, Roof Quality Index, and Floor Quality Index are first constructed for each household; then are combined to achieve the House Quality Index. The details are as follows:

- *House Quality Index (HQI) = Wall Quality Index + Roof Quality Index + Floor Quality Index*

- *Wall Quality Index:* 1 = Good quality wood,
  0.5 = (i) Medium quality wood; (ii) Tin, metal, corrugated iron,
  0 = (i) Poor quality wood; (ii) Bamboo, thatch, grass

- *Roof Quality Index:* 1 = Good quality wood,
  0.5 = (i) Medium quality wood; (ii) Tin, metal, corrugated iron,
  0 = (i) Poor quality wood; (ii) Bamboo, thatch, grass;
  (iii) Makeshift, mixed materials

- *Floor Quality Index:* 1 = Good quality wood,
  0.5 = (i) Medium quality wood; (ii) Tin, metal, corrugated iron,
  0 = (i) Poor quality wood; (ii) Plywood; (iii) Bamboo, thatch, grass; (iv) Makeshift, mixed materials

4. Demographic variables

There are two variables in this category. Demographic variables reflect the character of each household based on the members of household itself.

4.1 Female Headed Household (Fem)

'Female Headed Household' is a dummy variable, in which households with a male as head of household are assigned number 0 and households with a female as head of household are assigned number 1.

4.2 Number of Adult Equivalents (AdultE)

Number of adult equivalents is constructed to measure household size. Regarding consumption and income generation, having a child as a household member is different from having an adult as a household member. To calculate number of adult equivalent, each child (age 0 to 9) in a household is assigned the weight of 0.5, while each teenager (age 10 to 17) and adult (age 18 and above) are assigned the weight of 1. Hence, number of adult equivalent in each household is calculated as follows:

*Number of Adult Equivalents = number of adults + number of teenagers + (0.5 * number of children)*

4.3.3 Descriptive statistics

In order to compare differences across the three different communities, the descriptive statistics of all variables are calculated separately for each community.

When we look at the volume of fish catch (Table 4.2), and the amounts of catch that go to household consumption and sale (Table 4.3 and 4.4, respectively), households in the upstream community have highest average total fish catch and amount of fish consumed. Similarly, its average value of Fish Consumption Dependence (FCD) and Total Fish Dependence (TFD), reported in Table 4.6 and Table 4.7 respectively, is highest among the three communities by a substantial margin. The relocated community has the highest average amount of fish sold (Table 4.4) and average value of Fish Income Dependence (Table 4.5), and the highest Fishery Income (Table 4.8).

Table 4.2 Total Fish Catch (Catch)

Community:	Observations	Mean	SD	Min	Max
Downstream	140	258.2	522.1	0.0	4800.0
Relocated	64	323.3	455.2	0.0	2,659.0
Upstream	68	370.3	524.8	0.0	2,129.0
All	272	301.5	508.3	0.0	4,800.0
Unit: kg/household/year					

Table 4.3 Amount of fish consumed (Food)

Community:	Observations	Mean	SD	Min	Max
Downstream	124	163.2	280.3	0.0	1,960.0
Relocated	52	163.6	233.5	0.0	1,240.0
Upstream	56	210.5	395.4	0.0	2,065.0
All	232	174.7	302.5	0.0	2,065.0
Unit: kg/household/year					

Table 4.4 Amount of fish sold (Sale)

Community:	Observations	Mean	SD	Min	Max
Downstream	124	28.0	129.6	0.0	1,120.0
Relocated	52	107.8	368.8	0.0	2,300.0
Upstream	56	105.9	342.7	0.0	1,890.0
All	232	64.7	261.7	0.0	2,300.0
Unit: kg/household/year					

Table 4.5 Fish Income Dependence (FID)

Community:	Observations	Mean	SD	Min	Max
Downstream	136	0.07	0.22	0.00	1.00
Relocated	63	0.10	0.20	0.00	0.73
Upstream	66	0.06	0.20	0.00	0.94
All	265	0.08	0.21	0.00	1.00

Table 4.6 Fish Consumption Dependence (FCD)

Community:	Observations	Mean	SD	Min	Max
Downstream	120	0.39	1.88	0.00	19.69
Relocated	51	0.23	0.69	0.00	4.68
Upstream	54	1.01	4.91	0.00	36.05
All	225	0.50	2.79	0.00	36.05

Table 4.7 Total Fish Dependence (TFD)

Community:	Observations	Mean	SD	Min	Max
Downstream	120	0.44	1.89	0.00	19.69
Relocated	51	0.29	0.70	0.00	4.68
Upstream	54	1.06	4.90	0.00	36.05
All	225	0.55	2.79	0.00	36.05

The descriptive statistics for income variables suggest that the relocated community is the richest regarding its average total cash income and the upstream community is the poorest (Table 4.13). When we look at each income component, not only does the relocated community have the highest fishery income, as noted above, it also has highest average forestry income and farm income. The upstream community has the lowest average farm income, livestock income, and non-agricultural income. The downstream community falls into the middle, with the highest average non-agricultural income and livestock income.

Table 4.8 Fishery Income (YFish)

Community:	Observations	Mean	SD	Min	Max
Downstream	140	68.8	216.5	0.0	1,480.6
Relocated	63	249.1	617.6	0.0	3,010.0
Upstream	68	141.9	497.6	0.0	2,865.7
All	271	129.0	422.4	0.0	3,010.0
Unit: US$/household/year					

Table 4.9 Farm Income (YFarm)

Community:	Observations	Mean	SD	Min	Max
Downstream	150	180.3	319.2	0.0	1,343.3
Relocated	73	298.0	827.9	0.0	4,975.1
Upstream	75	94.1	269.5	0.0	2,005.0
All	298	187.5	490.5	0.0	4,975.1
Unit: US$/household/year					

Table 4.10 Forestry Income (YForest)

Community:	Observations	Mean	SD	Min	Max
Downstream	150	91.4	408.7	0.0	3,965.2
Relocated	73	422.5	840.2	0.0	4,218.9
Upstream	75	366.6	611.3	0.0	2,985.1
All	298	241.8	609.5	0.0	4,218.9
Unit: US$/household/year					

Table 4.11 Livestock Income (YLives)

Community:	Observations	Mean	SD	Min	Max
Downstream	150	537.5	867.9	0.0	4,333.7
Relocated	73	390.9	607.8	0.0	3,313.1
Upstream	75	317.2	721.2	0.0	4,133.1
All	298	446.1	778.6	0.0	4,333.7
Unit: US$/household/year					

Table 4.12 Other Income (YOther)

Community:	Observations	Mean	SD	Min	Max
Downstream	150	1,000.9	1,725.6	0.0	10,398.0
Relocated	73	826.9	1,239.3	0.0	7,462.7
Upstream	75	466.8	1,397.5	0.0	9,975.1
All	298	823.8	1,549.4	0.0	10,398.0
Unit: US$/household/year					

Table 4.13 Total Cash Income (YTotal)

Community:	Observations	Mean	SD	Min	Max
Downstream	140	1,954.4	2,056.7	0.0	10,622.8
Relocated	63	2,260.8	1,933.6	102.5	8,367.7
Upstream	68	1,299.1	1,576.5	0.0	7,539.1
All	271	1,861.5	1,942.7	0.0	10,622.8
Unit: US$/household/year					

In terms of quality of assets, almost half of the downstream households have some sort of latrine, while the majority of households located in two communities upstream still use open land/forest/bush as their toilet facility (Table 4.14). On the other hand, the quality of housing materials is not much different among three communities (Table 4.16).

Relocated households have biggest size of farm land on average, by a substantial margin (Table 4.15). It is interesting to compare the descriptive statistics of farm size and farm income together. While the difference of the average farm size between downstream households and upstream household is less than 0.1 hectare, the average Farm Income of the downstream households is almost twice of that of the upstream households, suggesting poorer land quality and/or poorer market access in the latter community.

Table 4.14 Household with latrine (Latrine)

Community:	Observations	Percentage
Downstream	149	45.6%
Relocated	74	13.5%
Upstream	75	10.7%
All	298	28.9%

Table 4.15 Size of farm land (Farm)

Community:	Observations	Mean	SD	Min	Max
Downstream	149	2.89	2.44	0.00	16.00
Relocated	74	3.90	3.08	0.00	14.00
Upstream	75	2.81	2.12	0.00	8.25
All	298	3.12	2.57	0.0	16.00
Unit: hectare/household					

Table 4.16 House Quality Index (HQI)

Community:	Observations	Mean	SD	Min	Max
Downstream	147	1.40	0.69	0.00	3.00
Relocated	73	1.58	0.66	0.00	2.50
Upstream	72	1.33	0.63	0.0	2.50
All	292	1.43	0.67	0.0	3.00

In terms of demographic variables, the downstream community and relocated community have higher percentages of female-headed households than the upstream community (Table 4.17). As for household size, which is represented by ‘Number of Adult Equivalent’, it is almost the same for all three communities (Table 4.18).

Table 4.17 Female headed household (Fem)

Community:	Observations	Percentage
Downstream	148	9.5%
Relocated	74	9.5%
Upstream	73	8.2%
All	295	9.2%

Table 4.18 Number of adult equivalent (AdultE)

Community:	Observations	Mean	SD	Min	Max
Downstream	148	4.91	1.99	1.50	10.00
Relocated	69	5.32	2.20	2.00	10.00
Upstream	75	4.86	2.09	2.00	11.00
All	292	4.99	2.07	1.50	11.00

4.4 Who depends most on the fishery?

4.4.1 Fish dependence variables and stratifications

In this section, instead of comparing communities, the surveyed households within each community are categorized by their levels of fish dependence. The aim is to shed light on the characteristics and the differences among households that depend differently on the fishery. Three variables are used to construct three separate stratifications of fish dependence.

One straightforward way to observe the importance of fishing in household's livelihood is by looking at the amount of fish harvested. Hence, the first fish dependence stratification is created simply by using the 'Total Fish Catch' variable. The surveyed households are grouped as follows:

(i) *Low Fish Catch Group*: Households with value of 'Total Fish Catch' less than 100 kg.

(ii) *Moderate Fish Catch Group*: Households with value of 'Total Fish Catch' equal to or greater than 100 kg, but less than 500 kg.

(iii) *High Fish Catch Group*: Households with value of 'Total Fish Catch' equal to or greater than 500 kg.

The numbers of households belonging to each group, categorized by community, are shown in Table 4.19. Note that the Low Fish Catch Group includes households that do not participate in fishing, of which there are 106 out of the total 299 households[21].

Table 4.19 Number of households categorized by community and Total Fish Catch (Catch)

Community:	High Fish Catch Group	Moderate Fish Catch Group	Low Fish Catch Group	All
Downstream	19	52	69	140
Relocated	14	23	27	64
Upstream	18	20	30	68
All	51	95	126	272

[21]From 193 households that participate in fishing, I can calculate the value of 'Total Fish Catch' for only 166 households. I treat this variable as a missing value for the other 27 households in this group, because they do not report their amounts of fish catch in some months, hence the yearly catch cannot be calculated.

The second fish dependence stratification is created using the 'Fish Income Dependence' variable. This variable, which is a ratio between 'Fishery Income' and 'Total Cash Income', reflects the significance of fish as household's source of cash income. The higher the value of 'Fish Income Dependence', the more dependent household is on fishery. The surveyed households are grouped according to their value of 'Fish Income Dependence' variable as follows:

(i) *Low Fish Income Dependence Group*: Households with value of 'Fish Income Dependence' variable less than 0.05.

(ii) *Moderate Fish Income Dependence Group*: Households with value of 'Fish Income Dependence' variable equal to or greater than 0.05, but less than 0.5.

(iii) *High Fish Income Dependence Group*: Households with value of 'Fish Income Dependence' variable equal to or greater than 0.5.

The numbers of households belonging to each group, again categorized by community, are shown in Table 4.20. Note that the Low Fish Income Dependence Group also includes households that do not participate in fishing.

Table 4.20 Number of households categorized by community and Fish Income Dependence (FID)

Community:	High FID Group	Moderate FID Group	Low FID Group	All
Downstream	11	8	117	136
Relocated	5	14	44	63
Upstream	4	5	57	66
All	20	27	218	265

Since fish harvested are also consumed within household, it is thus important to look at household's dependence on fish as food as well. The third fish dependence stratification is created using the ‘Fish Consumption Dependence’ variable, which is a ratio between the ‘Value of Fish Consumed’ and ‘Total Cash Income’. The surveyed households are grouped according to their value of this variable as follows:

(i) *Low Fish Consumption Dependence Group*: Households with value of ‘Fish Consumption Dependence’ variable less than 0.05.

(ii) *Moderate Fish Consumption Dependence Group*: Households with value of this variable equal to or greater than 0.05, but less than 0.50.

(iii) *High Fish Consumption Dependence Group*: Households with value of this variable equal to or greater than 0.50.

The numbers of households belonging to each group are shown in Table 4.21. Note that the Low Fish Consumption Dependence Group includes households that do not participate in fishing.

Table 4.21 Number of households categorized by community and Fish Consumption Dependence (FCD)

Community:	High FCD Group	Moderate FCD Group	Low FCD Group	All
Downstream	13	39	68	120
Relocated	6	16	29	51
Upstream	12	13	29	54
All	31	68	126	225

The last fish dependence stratification uses ‘Total Fish Dependence’ as a measure. The surveyed households are grouped according to their value of this variable as follows:

(i) *Low Total Fish Dependence Group*: Households with value of ‘Total Fish Dependence’ variable less than 0.1.

(ii) *Moderate Total Fish Dependence Group*: Households with value of this variable equal to or greater than 0.1, but less than 1.0.

(iii) *High Total Fish Dependence Group*: Households with value of this variable equal to or greater than 1.0.

The numbers of households belonging to each group are shown in Table 4.22. Note that the Low Total Fish Dependence Group includes households that do not participate in fishing.

Table 4.22 Number of households categorized by community and Total Fish Dependence (TFD)

Community:	High TFD Group	Moderate TFD Group	Low TFD Group	All
Downstream	11	33	76	120
Relocated	2	21	28	51
Upstream	7	19	28	54
All	20	73	132	225

4.4.2 Descriptive statistics for the four fish dependence stratifications

For each of the three fish dependence stratifications, the descriptive statistics of sixteen variables are calculated. Tables 4.23, Table 4.24, and Table 4.25 report the mean values (or percentage in the case of dummy variables) for each variable.

In the 'Total Fish Catch Stratification', Table 4.23, the High Fish Catch Group has the highest average value of 'Fish Income Dependence' and 'Fish Consumption Dependence', as one might expect. This group also has highest average 'Total Cash Income'. When comparing the mean values of income components among three groups, the result shows that the High Fish Catch Group depends less on non-agricultural income, while the story is in the opposite direction for the Low Fish

Catch Group. It should also be noted that the High Fish Catch Group also has highest values of average 'Fishery Income' and 'Forestry Income'. These two components of income are generated from common pool resources, unlike the 'Farm Income' and 'Livestock Income' which based more heavily on private properties. Taken together, these results suggest that among those who rely most on common pool resources for their livelihoods, those with higher cash incomes tend to catch the most fish, perhaps because they are better able to afford fishing gear.

Table 4.23 Total Fish Catch Stratification: Descriptive statistics

Variables:	High Fish Catch Group	Moderate Fish Catch Group	Low Fish Catch Group
Total Fish Catch	1,073.2 kg *(51)*	275.5 kg *(95)*	8.9 kg *(126)*
Amount of Fish Consumed	604.3 kg *(51)*	253.6 kg *(75)*	7.9 kg *(123)*
Amount of Fish Sold	385.7 kg *(34)*	25.3 kg *(75)*	0.0 kg *(123)*
Fish Income Dependence	0.23 *(48)*	0.10 *(95)*	0.001 *(122)*
Fish Consumption Dependence	2.37 *(31)*	0.51 *(75)*	0.01 *(119)*
Total Fish Dependence	2.56 *(31)*	0.58 *(75)*	0.01 *(119)*
Fishery Income	$543.33 *(51)*	$75.78 *(95)*	$0.47 *(125)*
Farm Income	$197.11 *(51)*	$218.78 *(95)*	$178.03 *(125)*
Forestry Income	$412.46 *(51)*	$180.33 *(95)*	$202.58 *(125)*
Livestock Income	$641.72 *(51)*	$497.21 *(95)*	$356.63 *(125)*
Other Income	$298.59 *(51)*	$680.96 *(95)*	$1,187.60 *(125)*
Total Cash Income	$2,093.21 *(51)*	$1,653.06 *(95)*	$1,925.31 *(125)*
Latrine	27.5% *(51)*	27.7% *(94)*	34.1% *(126)*
Farm Size	3.04 ha *(51)*	3.21 ha *(95)*	2.92 ha *(125)*
HQI	1.49 *(50)*	1.36 *(94)*	1.46 *(121)*
Female Headed Household	6.1% *(49)*	5.3% *(94)*	14.4% *(125)*
Adult Equivalent	5.02 *(51)*	5.47 *(92)*	4.56 *(124)*

Note: number of observations in parentheses.

The 'Fish Income Dependence Stratification', Table 4.24, classifies households not according to the absolute amount of fish caught, but rather according to the share of fish in their total cash incomes. In this case, descriptive statistics show that even though the average 'Fishery Income' of the High

Dependence Group is much higher than that of the other two groups, it is the poorest group based on its average 'Total Cash Income'. Moreover, the average size of farm land for this High Fish Income Dependence Group is also the smallest among all three groups. These findings suggest that the group which depends the most on common pool resource (fish) for income generation is the poorest group judging by both cash income and assets.

Table 4.24 Fish Income Dependence Stratification: Descriptive statistics

Variables:	High FID Group	Moderate FID Group	Low FID Group
Total Fish Catch	844.4 kg *(20)*	625.4 kg *(27)*	211.6 kg *(218)*
Amount of Fish Consumed	82.2 kg *(11)*	197.1 kg *(12)*	174.0 kg *(202)*
Amount of Fish Sold	597.8 kg *(11)*	559.7 kg *(12)*	8.5 kg *(202)*
Fish Income Dependence	0.75 *(20)*	0.20 *(27)*	0.00 *(218)*
Fish Consumption Dependence	0.09 *(11)*	0.09 *(12)*	0.55 *(202)*
Total Fish Dependence	0.87 *(11)*	0.31 *(12)*	0.55 *(202)*
Fishery Income	$993.18 *(20)*	$554.92 *(27)*	$0.56 *(218)*
Farm Income	$65.96 *(20)*	$273.94 *(27)*	$203.55 *(218)*
Forestry Income	$90.46 *(20)*	$612.12 *(27)*	$207.12 *(218)*
Livestock Income	$193.87 *(20)*	$903.48 *(27)*	$441.61 *(218)*
Other Income	$49.07 *(20)*	$605.47 *(27)*	$968.08 *(218)*
Total Cash Income	$1,392.54 *(20)*	$2,949.93 *(27)*	$1,820.91 *(218)*
Latrine	36.8% *(19)*	29.6% *(27)*	30.7% *(218)*
Farm Size	2.05 ha *(20)*	3.36 ha *(27)*	3.13 ha *(217)*
HQI	1.42 *(19)*	1.41 *(27)*	1.44 *(213)*
Female Headed Household	10.0% *(20)*	0.0% *(27)*	10.7% *(214)*
Adult Equivalent	4.74 *(19)*	5.19 *(26)*	4.95 *(215)*

Note: number of observations in parentheses.

The 'Fish Consumption Dependence Stratification', Table 4.25, classifies households based on the ratio of the imputed values of their fish caught for their own consumption to their total cash income. In this case, the high dependence group is clearly the poorest one among all three groups. Its average total cash income is considerably lower than that of the other two groups, a pattern that holds for every income component as well. Fishery income for this group is zero, implying that they consume all of the fish they catch. Descriptive statistics for asset variables tell a similar story: the High Fish Consumption Dependence Group has the smallest average size of farm land and the lowest percentage of households with latrines. Conversely, the richest group in this Fish Consumption Dependence Stratification, based on total cash income, is the low dependence group. The main contribution for its high income is from the non-agricultural income sources. This group also seems to have better living conditions on average, since it has the highest percentage of households with latrine.

Table 4.25 Fish Consumption Dependence Stratification: Descriptive statistics

Variables:	High FCD Group	Moderate FCD Group	Low FCD Group
Total Fish Catch	603.8 kg *(31)*	376.8 kg *(68)*	72.1 kg *(126)*
Amount of Fish Consumed	603.8 kg *(31)*	264.0 kg *(68)*	13.8 kg *(126)*
Amount of Fish Sold	0.0 kg *(31)*	112.8 kg *(68)*	58.3 kg *(126)*
Fish Income Dependence	0.00 *(31)*	0.08 *(68)*	0.05 *(126)*
Fish Consumption Dependence	3.25 *(31)*	0.18 *(68)*	0.003 *(126)*
Total Fish Dependence	3.25 *(31)*	0.26 *(68)*	0.05 *(126)*
Fishery Income	$0.00 *(31)*	$121.10 *(68)*	$111.98 *(126)*
Farm Income	$59.22 *(31)*	$190.68 *(68)*	$268.12 *(126)*
Forestry Income	$105.30 *(31)*	$303.19 *(68)*	$193.38 *(126)*
Livestock Income	$124.93 *(31)*	$597.39 *(68)*	$474.91 *(126)*
Other Income	$146.83 *(31)*	$599.74 *(68)*	$1,323.37 *(126)*
Total Cash Income	$436.29 *(31)*	$1,812.10 *(68)*	$2,371.76 *(126)*
Latrine	16.1% *(31)*	26.5% *(68)*	34.9% *(126)*
Farm Size	2.66 ha *(31)*	3.46 ha *(68)*	3.06 ha *(125)*
HQI	1.48 *(31)*	1.34 *(67)*	1.48 *(122)*
Female Headed Household	3.4% *(29)*	5.9% *(68)*	13.7% *(124)*
Adult Equivalent	5.34 *(31)*	5.30 *(64)*	4.72 *(125)*

Note: number of observations is in parentheses.

From both the 'Fish Income Dependence Stratification' and 'Fish Consumption Dependence Stratification', there is a consistent story that the High

Dependence Groups, which depend highly on fish either as income generation or as food, are relatively poorer than the Moderate or Low Dependence Groups. Also, these two High Fish Dependence Groups seem to have less opportunity to generate income outside the agricultural sector, as suggested by their relatively low values of average 'Other Income'.

Lastly, 'Total Fish Dependence Stratification' is presented in Table 4.26. The High Dependence Group has highest average value of 'Fish Consumption Dependence', but not the highest average value of 'Fish Income Dependence'. Descriptive statistics of this stratification also show similar patterns as in the 'Forest Income Dependence Stratification' and the 'Forest Consumption Dependence Stratification', of which the High Dependence group is relatively the poorest one among all three groups.

Table 4.26 Total Fish Dependence Stratification: Descriptive statistics

Variables:	High TFD Group	Moderate TFD Group	Low TFD Group
Total Fish Catch	636.2 kg *(20)*	495.2 kg *(73)*	34.4 kg *(132)*
Amount of Fish Consumed	605.5 kg *(20)*	306.24 kg *(73)*	29.9 kg *(132)*
Amount of Fish Sold	30.8 kg *(20)*	189.0 kg *(73)*	4.55 kg *(132)*
Fish Income Dependence	0.10 *(20)*	0.13 *(73)*	0.0002 *(132)*
Fish Consumption Dependence	4.64 *(20)*	0.26 *(73)*	0.01 *(132)*
Total Fish Dependence	4.74 *(20)*	0.39 *(73)*	0.01 *(132)*
Fishery Income	$44.65 *(20)*	$293.00 *(73)*	$0.47 *(132)*
Farm Income	$53.86 *(20)*	$180.58 *(73)*	$260.05 *(132)*
Forestry Income	$77.30 *(20)*	$314.86 *(73)*	$179.67 *(132)*
Livestock Income	$20.65 *(20)*	$562.30 (73)	$476.31 *(132)*
Other Income	$57.38 *(20)*	$444.29 (73)	$1,352.26 *(132)*
Total Cash Income	$253.83 *(20)*	$1,795.03 *(73)*	$2,268.76 *(132)*
Latrine	20.0% *(20)*	21.9% *(73)*	35.6% *(132)*
Farm Size	2.72 ha *(20)*	3.23 ha *(73)*	3.13 ha *(131)*
HQI	1.48 *(20)*	1.39 *(72)*	1.47 *(128)*
Female Headed Household	5.3% *(19)*	4.2% *(72)*	13.8% *(130)*
Adult Equivalent	5.30 *(20)*	5.41 *(70)*	4.70 *(130)*

Note: number of observations is in parentheses.

4.5 A statistical analysis of fish dependence

This section presents statistical analyses of the relationship between fish dependence and livelihoods of households located around the Lower Sesan 2 hydropower project. Two main approaches are used here, namely correlation analysis and multiple regression analysis.

4.5.1 Correlation analysis

A correlation matrix is generated for each community in order to observe the correlation coefficients among all 17 variables[22]. Table 4.27, Table 4.28, and Table 4.29 present the matrixes for each of the three communities. Noteworthy correlation coefficients include the following:

(i) Correlation between 'Fish Income Dependence' (FID) and 'Fish Consumption Dependence' (FCD)

This correlation coefficient equals -0.03 for downstream community, -0.07 for the relocated community, and -0.06 for the upstream community. The weakly negative value of the coefficients means that the group of households that highly depends on fish for cash income is distinct from the households that highly depend on fish for consumption. Hence, we need to look at these two groups separately in order to understand whose livelihoods will be worst impacted by the dam via the changes in the fishery. Hence, in the next section the regression model will be estimated separately for Fish Income Dependence and for Fish Consumption Dependence.

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[22]Correlation coefficient, which range from -1 to 1, measures the strength and direction of a linear association between two variables.

Table 4.27 Correlation matrix of the downstream community

Downstream (n = 113 HHs)		Fish Dependence						Income						Asset			Demographic	
		Catch	*Food*	*Sale*	*FID*	*FCD*	*TFD*	*YFish*	*YFarm*	*YForest*	*YLives*	*YOther*	*YTotal*	*Latrine*	*Farm*	*HQI*	*Fem*	*AdultE*
Fish Dependence	*Catch*	1.00																
	Food	0.84	1.00															
	Sale	0.60	0.08	1.00														
	FID	0.25	-0.06	0.56	1.00													
	FCD	0.49	0.64	-0.04	-0.03	1.00												
	TFD	0.54	0.60	0.11	0.24	0.96	1.00											
Income	*YFish*	0.28	-0.07	0.62	0.77	-0.04	0.17	1.00										
	YFarm	0.08	0.15	-0.07	-0.08	-0.07	-0.09	-0.03	1.00									
	YForest	-0.02	-0.01	-0.03	-0.03	-0.04	-0.05	-0.03	-0.06	1.00								
	YLives	0.16	0.06	0.20	-0.12	-0.16	-0.19	-0.06	0.38	0.12	1.00							
	YOther	-0.26	-0.23	-0.14	-0.15	-0.20	-0.23	-0.13	-0.09	-0.09	-0.002	1.00						
	YTotal	-0.13	-0.15	-0.01	-0.14	-0.26	-0.30	-0.07	0.23	0.14	0.50	0.84	1.00					
Asset	*Latrine*	-0.14	-0.21	0.05	-0.09	-0.10	-0.12	0.01	-0.05	0.04	0.15	0.17	0.21	1.00				
	Farm	-0.03	0.01	-0.08	-0.09	-0.06	-0.08	-0.08	0.32	0.07	0.33	0.03	0.23	0.01	1.00			
	HQI	-0.15	-0.18	-0.01	0.06	-0.15	-0.12	0.04	0.14	0.18	0.35	0.04	0.24	0.25	0.10	1.00		
Demographic	*Fem*	-0.16	-0.15	-0.07	-0.08	-0.10	-0.12	-0.07	-0.03	-0.05	0.02	-0.03	-0.04	-0.02	0.15	-0.05	1.00	
	AdultE	0.03	0.07	-0.04	0.05	0.02	0.03	0.002	0.18	0.01	0.06	0.04	0.09	0.08	0.38	0.15	0.13	1.00

Table 4.28 Correlation matrix of the relocated community

Relocated (n = 47 HHs)		Fish Dependence						Income						Asset			Demographic	
		Catch	*Food*	*Sale*	*FID*	*FCD*	*TFD*	*YFish*	*YFarm*	*YForest*	*YLives*	*YOther*	*YTotal*	*Latrine*	*Farm*	*HQI*	*Fem*	*AdultE*
Fish Dependence	*Catch*	1.00																
	Food	0.56	1.00															
	Sale	0.86	0.06	1.00														
	FID	0.55	0.08	0.62	1.00													
	FCD	0.14	0.39	-0.08	-0.07	1.00												
	TFD	0.26	0.40	0.07	0.16	0.97	1.00											
Income	*YFish*	0.77	0.04	0.91	0.75	-0.08	0.10	1.00										
	YFarm	-0.07	-0.06	-0.05	-0.09	-0.11	-0.13	-0.03	1.00									
	YForest	0.26	-0.02	0.33	0.17	-0.13	-0.09	0.37	-0.14	1.00								
	YLives	0.18	0.26	0.06	-0.05	-0.09	-0.10	0.07	0.16	-0.11	1.00							
	YOther	-0.18	-0.16	-0.12	-0.17	-0.16	-0.20	-0.17	-0.02	-0.09	0.07	1.00						
	YTotal	0.25	-0.05	0.32	0.12	-0.27	-0.24	0.35	0.44	0.39	0.41	0.58	1.00					
Asset	*Latrine*	0.40	0.26	0.32	0.42	-0.02	0.07	0.29	-0.13	0.27	-0.11	0.02	0.12	1.00				
	Farm	-0.09	-0.02	-0.09	-0.08	-0.12	-0.13	-0.04	0.43	-0.10	0.20	0.17	0.32	-0.12	1.00			
	HQI	-0.01	-0.00	-0.01	-0.13	-0.05	-0.08	-0.07	-0.10	-0.01	0.11	0.11	0.03	0.00	-0.03	1.00		
Demographic	*Fem*	0.19	-0.14	0.31	0.11	-0.11	-0.08	0.21	-0.08	0.04	-0.11	-0.08	-0.05	0.10	0.05	-0.05	1.00	
	AdultE	0.34	0.34	0.20	0.10	0.11	0.14	0.22	0.13	0.01	0.15	0.04	0.20	0.03	0.25	-0.17	0.05	1.00

Table 4.29 Correlation matrix of the upstream community

Upstream (n = 50 HHs)		Fish Dependence						Income						Asset			Demographic	
		Catch	*Food*	*Sale*	*FID*	*FCD*	*TFD*	*YFish*	*YFarm*	*YForest*	*YLives*	*YOther*	*YTotal*	*Latrine*	*Farm*	*HQI*	*Fem*	*AdultE*
Fish Dependence	*Catch*	1.00																
	Food	0.72	1.00															
	Sale	0.61	-0.11	1.00														
	FID	0.35	-0.13	0.65	1.00													
	FCD	0.42	0.58	-0.07	-0.06	1.00												
	TFD	0.43	0.58	-0.05	-0.03	0.99	1.00											
Income	*YFish*	0.38	-0.13	0.70	0.94	-0.07	-0.03	1.00										
	YFarm	0.29	-0.03	0.45	0.17	-0.06	-0.06	0.37	1.00									
	YForest	-0.03	0.10	-0.16	-0.13	-0.10	-0.11	-0.15	-0.14	1.00								
	YLives	0.20	-0.06	0.35	0.13	-0.09	-0.09	0.33	0.56	-0.21	1.00							
	YOther	-0.11	-0.16	0.02	-0.07	-0.09	-0.09	-0.03	-0.08	-0.12	0.21	1.00						
	YTotal	0.23	-0.13	0.48	0.35	-0.16	-0.15	0.53	0.54	0.05	0.79	0.55	1.00					
Asset	*Latrine*	0.20	0.08	0.19	0.35	-0.03	-0.02	0.36	0.33	-0.08	0.21	0.19	0.38	1.00				
	Farm	0.51	0.33	0.35	0.01	0.02	0.02	0.11	0.46	0.02	0.45	-0.02	0.36	0.21	1.00			
	HQI	0.27	0.36	-0.03	-0.08	0.28	0.28	-0.09	0.15	-0.10	0.16	-0.18	-0.04	0.08	0.35	1.00		
Demographic	*Fem*	-0.18	-0.13	-0.11	-0.01	-0.03	-0.03	-0.10	-0.10	-0.08	-0.05	-0.05	-0.13	-0.11	-0.20	-0.08	1.00	
	AdultE	0.12	0.21	-0.07	-0.09	-0.04	-0.04	0.02	0.28	0.02	0.24	-0.08	0.15	0.24	0.17	0.23	0.08	1.00

(ii) Correlation between 'Total Cash Income' (YTotal) and 'Fish Consumption Dependence' (FCD)

This correlation coefficient equals -0.26 for the downstream community, -0.27 for the relocated community, and -0.16 for the upstream community. The negative sign confirms the low values of the 'Total Cash Income' are associated with high values of 'Fish Consumption Dependence'. This finding is consistent with the descriptive statistics obtained in the Fish Consumption Dependence Stratification.

(iii) Correlation between 'Total Cash Income' (YTotal) and Asset Variables

The correlation coefficient between 'Total Cash Income' and the three asset variables – latrine, farm size, and housing quality index – are mostly positive and tend to be strongest for latrine and farm size, suggesting that these may be better proxies for household wealth.

4.5.2 Regression analysis

The purpose of the regression analysis is to estimate more precisely the correlation of fish harvest and levels of fish dependence in each of the three communities, controlling for the influence of multiple independent variables. The dependent variables for the regression models are chosen from the group of Fishery and Fish Dependence Variables. The independent variables are chosen from the group of Income Variables, Asset Variables, and Demographic Variables.

Four regression models are estimated as follows:

(i) *Catch* = f (*Fem*, *AdultE*, *Latrine*, *Farm*, *HQI*, *YTotal*)

(ii) *FID* = f (*Fem*, *AdultE*, *Latrine*, *Farm*, *HQI*, *YTotal*)

(iii) FCD = f (Fem, $AdultE$, $Latrine$, $Farm$, HQI, $YTotal$)

(iv) TFD = f (Fem, $AdultE$, $Latrine$, $Farm$, HQI, $YTotal$)

Each model is tested separately for the households in each community. Using the Ordinary Least Square (OLS) method and starting with the initial model, the least significant independent variables (with the highest p-values) are dropped, one by one. Tables 4.30, Table 4.31, and Table 4.32 report the estimated coefficients of independent variables from the initial models and from the best-fit models; i.e. regression models with highest adjusted R-square, for each community.

For the downstream community, none of the independent variables are statistically significant in the first regression model that has 'Total Fish Catch' as dependent variable. The second regression model, with 'Fish Income Dependence' as dependent variable, also has no statistically significant independent variable in both the initial model and the best-fit model. In the third regression model, the results from both the initial model and the best-fit model suggest that it is the poorer households with less 'Total Cash Income' that depend more on fish for self-consumption. In the last regression model of 'Total Fish Dependence', the results show statistically stronger effect of the 'Total Cash Income' variable, with negative coefficient.

In the first regression model for the relocated community, in which the initial model is also the best-fit model, three variables are statistically significant. The results suggest that households with higher 'Number of Adult Equivalent' and 'Household with Latrine' harvest greater amounts of fish; at the same time, it also shows that poorer households, judging from smaller 'Size of Farm Land', tend to catch more fish as well. In the second regression model, of 'Fish Income Dependence', the results suggest that the better-off households, judging from having 'Latrine', have higher Fish Income Dependence. In the third regression model, of 'Fish Consumption Dependence', both the initial model and the best-fit model suggest that the poorer households with less 'Total Cash Income' depend more on fish caught for household consumption than do the richer households. The coefficient for 'Total Cash Income' is still statistically significant with negative value in the best-fit model of the 'Total Fish Dependence' regression, though with a lower confidence level.

For the upstream community, both the initial model and the best-fit model for the 'Total Fish Catch' regression show a strongly significant effect of 'Size of Farm Land', with positive values of the coefficient. This result suggests that the better-off households, with larger size of farm land as an indicator, harvest greater amounts of fish. In the 'Fish Income Dependence' regression, the best-fit model has three statistically significant independent variables. It shows that households with smaller 'Number of Adult Equivalent' have higher Fish Income Dependence. Also richer households, using 'Latrine' and 'Total Cash income' as indicators, depend more on fish as source of income. For the 'Fish Consumption Dependence' regression, the results suggest that better-off households, judging from better 'House Quality Index', have higher 'Fish Consumption Dependence'. This is similar to the result found in the 'Total Fish Dependence' regression.

These four regression models were then re-estimated using only the households that participate in fishing. That is, households that do not participate in fishing at all are treated as missing values. This is done not only to check on the robustness of the results, but also, by leaving households that do not participate in fishing out of the analysis, to see if we find stronger relationships between the dependent and independent variables. The results of this second set of regressions are shown in Tables 4.33, Table 4.34 and Table 4.35.

Starting with the downstream community, the best-fit model of the 'Total Fish Catch' regression still has no statistically significant independent variable, similar to the result in the first set of regressions. The results for the 'Fish Income Dependence' regression show some differences from the first regression, in that the 'Size of Farm Land' and 'Total Cash Income' variables are now negatively significant. This suggests that the poorer households depend more on fish for income generation. For the third regression model, of 'Fish Consumption Dependence', the coefficient on 'Total Cash Income' is still negative and statistically significant, similar to the result from the first regression, though with a higher confidence level. Moreover, the 'Size of Farm Land' variable shows a significant negative sign as well. Hence, the results from this regression are consistent with the finding that poorer households depend more on fish for self-consumption than do the richer households. Changes in the 'Total Fish Dependence' regression are similar to what is found in the 'Fish Consumption Dependence' regression, of which the 'Size of Farm Land' variable is also found statistically significant with negative coefficient while the 'Total Cash Income' variable is still strongly significant with positive coefficient.

For the relocated community, the 'Total Fish Catch' model in this second set of regression has three statistically significant independent variables. From the demographic aspect, larger households catch more fish, which is similar to the result from the first set of regressions. From the economic aspect, households with more cash income tend to catch more fish, as well as households with smaller size of farm land. Notice that 'Size of Farm Land' is significant in both the first and the second set of regressions while 'Total Cash Income' is significant only in this second regression. In the 'Fish Income Dependence' model, the coefficient on 'Household with Latrine' is still positive and statistically significant at the same confidence level. Moreover, 'Number of Adult Equivalent' is also significant here, with a negative sign such that household with smaller number of adult equivalent depends more on fish for income generation. The 'Fish Consumption Dependence' regression shows the same results as in the first regression, in which the poorer households, with less total cash income, depend more on fish for self-consumption. Finally, in the 'Total Fish Dependence' regression, the coefficient of 'Total Cash Income' variable is still statistically significant with negative value, as found in the first set of regression, though with higher confidence level here.

The 'Total Fish Catch' model for the upstream community has more statistically significant independent variables than the results in the first set of regressions. 'Size of Farm Land' is positive and statistically significant in both sets of regression with the same confidence level. 'Number of Adult Equivalent', 'Household with Latrine', and 'House Quality Index' variables also become statistically significant in this second set of regressions. The results suggest that better-off households, with latrines, better house quality, and larger size of farm land, as well as households with smaller number of adult equivalent, catch a greater amount of fish than the poorer households. The ‘Fish Income Dependence’ model shows similar results to the first set of regressions, except that ‘Total Cash Income’ is not significant here. Overall this model suggests that better-off households that have latrines, as well as smaller households, tend to have higher levels of ‘Fish Income Dependence’. For the model with ‘Fish Consumption Dependence’ as the dependent variable, the coefficient on the ‘House Quality Index’ is still positive and statistically significant, as in the first set of regressions, with a higher confidence level. Lastly, in the ‘Total Fish Dependence’ regression, the coefficient of ‘House quality Index’ variable is still statistically significant with positive value.

4.6. Discussion of the results

The descriptive statistics from four different ‘Fish Dependence Stratifications’ shed light on the characteristics of households across the Lower Sesan 2 hydropower project area that depend differently on the fishery. The results show that households that depend heavily on fish for income generation and for self-consumption tend to be relatively the poorest in the area. We can also see some hint that the households that catch the most fish also tend to depend more on the forest for their livelihoods at the same time. These two findings suggest the importance of common pool resources (fish and forest) for the poor in the study area.

Table 4.30 Regression results for downstream community

Downstream Community								
Dependent Variables:	**Total Fish Catch**		**FID**		**FCD**		**TFD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	-117.500 (0.440)		0.017 (0.787)		-0.272 (0.183)	-0.242 (0.217)	-0.320 (0.124)	-0.302 (0.115)
- Adult Equivalent	22.031 (0.362)		0.008 (0.389)		0.022 (0.471)		0.031 (0.328)	
Economic Variables								
- Latrine	-107.624 (0.258)	-138.422 (0.121)	-0.044 (0.261)		-0.041 (0.738)		-0.072 (0.570)	
- Farm Size	-16.252 (0.415)		-0.009 (0.277)	-0.010 (0.207)	-8.84E^{-4} (0.974)		-0.007 (0.795)	
- HQI	29.884 (0.671)		0.024 (0.410)		-0.092 (0.330)	-0.085 (0.339)	-0.062 (0.517)	
- Total Cash Income	-0.023 (0.301)		-1.3E^{-5} (0.159)	-1.56E^{-5} (0.101)	-7.2E^{-5}** (0.015)	-7.05E^{-5}** (0.012)	-8.42E^{-5}*** (0.005)	-8.85E^{-5}*** (0.001)
Constant	253.236* (0.080)	323.561*** (0.000)	0.061 (0.300)	0.134*** (0.000)	0.452** (0.018)	0.518*** (0.000)	0.473** (0.015)	0.483*** (0.000)
Observations	132	139	128	135	113	116	113	118
R-squared	0.0368	0.0175	0.0490	0.0397	0.0960	0.0857	0.1188	0.1011
Adjusted R-squared	-0.0094	0.0103	0.0018	0.0251	0.0448	0.0612	0.0689	0.0855
Prob > F	0.5744	0.1205	0.4041	0.0691	0.0915	0.0179	0.0337	0.0022
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

Table 4.31 Regression results for relocated community

Relocated Community							
Dependent Variables:	**Total Fish Catch**	**FID**		**FCD**		**TFD**	
Independent Variables:	*Initial Model and Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables							
- Female Headed HH	118.599 (0.529)	-0.037 (0.678)		-0.301 (0.388)		-0.262 (0.457)	
- Adult Equivalent	65.380** (0.026)	-0.007 (0.610)		0.064 (0.230)	0.059 (0.224)	0.069 (0.202)	0.065 (0.187)
Economic Variables							
- Latrine	353.661** (0.040)	0.173** (0.036)	0.172** (0.022)	0.027 (0.939)		0.234 (0.513)	
- Farm Size	-41.297** (0.041)	-0.008 (0.422)		-0.013 (0.703)		-0.018 (0.622)	
- HQI	9.688 (0.913)	-0.039 (0.357)	-0.032 (0.410)	-0.018 (0.910)		-0.048 (0.769)	
- Total Cash Income	0.054* (0.079)	$6.63E^{-6}$ (0.647)		$-9.86E^{-5}$* (0.076)	$-1.02E^{-4}$** (0.041)	$-9.13E^{-5}$ (0.103)	$-9.38E^{-5}$* (0.064)
Constant	-44.423 (0.843)	0.198* (0.070)	0.131* (0.053)	0.253 (0.547)	0.170 (0.533)	0.313 (0.462)	0.181 (0.514)
Observations	59	59	62	47	48	47	48
R-squared	0.2724	0.1146	0.0918	0.1226	0.1022	0.1220	0.0925
Adjusted R-squared	0.1884	0.0124	0.0610	-0.0090	0.0623	-0.0097	0.0522
Prob > F	0.0088	0.3630	0.0584	0.4832	0.0885	0.4866	0.1125
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.							

Table 4.32 Regression results for upstream community

Upstream Community								
Dependent Variables:	**Total Fish Catch**		**FID**		**FCD**		**TFD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	-121.802 (0.569)		-0.043 (0.623)		-0.288 (0.909)		-0.309 (0.903)	
- Adult Equivalent	-17.741 (0.602)		-0.020 (0.147)	-0.024* (0.058)	-0.231 (0.552)		-0.247 (0.526)	
Economic Variables								
- Latrine	217.82 (0.309)		0.175** (0.047)	0.154** (0.041)	0.417 (0.877)		0.597 (0.825)	
- Farm Size	107.819*** (0.001)	121.848*** (0.000)	-0.017 (0.187)	-0.018 (0.128)	-0.075 (0.848)		-0.086 (0.825)	
- HQI	92.590 (0.367)		-0.029 (0.489)		2.403* (0.064)	2.178** (0.046)	2.403* (0.064)	2.160** (0.048)
- Total Cash Income	0.015 (0.741)		$2.77E^{-5}$ (0.144)	$3.2E^{-5}$* (0.056)	$-4.16E^{-4}$ (0.434)	$-4.52E^{-4}$ (0.270)	$-3.81E^{-4}$ (0.473)	$-4.17E^{-4}$ (0.308)
Constant	6.901 (0.971)	31.281 (0.730)	0.199** (0.012)	0.165** (0.012)	-0.271 (0.907)	-1.250 (0.463)	-0.175 (0.940)	-1.225 (0.473)
Observations	63	68	62	66	50	52	50	52
R-squared	0.2941	0.2542	0.1862	0.1625	0.1101	0.1020	0.1070	0.0974
Adjusted R-squared	0.2184	0.2429	0.0974	0.1076	-0.0141	0.0653	-0.0176	0.0606
Prob > F	0.0026	0.0000	0.0683	0.0266	0.5130	0.0717	0.5328	0.0812
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

Table 4.33 Regression results for downstream community, consider only households that participate in fishing

	Downstream Community							
Dependent Variables:	**Total Fish Catch**		**FID**		**FCD**		**TFD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	-176.426	-54.987	0.045		-0.417	-0.443	-0.503	-0.520
	(0.482)	(0.108)	(0.689)		(0.256)	(0.220)	(0.147)	(0.125)
- Adult Equivalent	14.297		0.011		0.052	0.042	0.068	0.064
	(0.729)		(0.517)		(0.355)	(0.431)	(0.199)	(0.205)
Economic Variables								
- Latrine	-96.222		-0.032		0.108		0.088	
	(0.534)		(0.627)		(0.613)		(0.659)	
- Farm Size	-69.372*	-54.987	-0.032**	-0.040***	-0.112*	-0.104*	-0.146**	-0.142**
	(0.070)	(0.108)	(0.036)	(0.008)	(0.069)	(0.081)	(0.013)	(0.013)
- HQI	109.916	151.836	0.045		-0.109		-0.045	
	(0.346)	(0.153)	(0.355)		(0.504)		(0.771)	
- Total Cash Income	-0.044		$-4.33E^{-5}$*	$-5.03E^{-5}$**	$-2.77E^{-4}$***	$-2.78E^{-4}$***	$-3.24E^{-4}$***	$-3.21E^{-4}$***
	(0.415)		(0.063)	(0.026)	(0.001)	(0.000)	(0.000)	(0.000)
Constant	557.707**	417.312**	0.186*	0.333***	1.127***	1.056***	1.239***	1.221***
	(0.025)	(0.029)	(0.081)	(0.000)	(0.002)	(0.001)	(0.000)	(0.000)
Observations	76	80	74	79	59	59	59	59
R-squared	0.0809	0.0573	0.1222	0.1351	0.2666	0.2578	0.3625	0.3595
Adjusted R-squared	0.0009	0.0328	0.0436	0.1123	0.1819	0.2028	0.2890	0.3120
Prob > F	0.4250	0.1031	0.1742	0.0040	0.0104	0.0025	0.005	0.0001
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

Table 4.34 Regression results for relocated community, consider only households that participate in fishing

Relocated Community								
Dependent Variables:	**Total Fish Catch**		**FID**		**FCD**		**TFD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	499.734 (0.145)	532.606 (0.112)	-0.088 (0.659)		0.064 (0.960)		0.241 (0.849)	
- Adult Equivalent	71.035* (0.072)	73.557* (0.059)	-0.036 (0.121)	-0.044* (0.026)	0.138 (0.275)	0.092 (0.270)	0.105 (0.403)	0.084 (0.313)
Economic Variables								
- Latrine	290.03 (0.174)	256.786 (0.205)	0.300** (0.021)	0.280** (0.010)	-0.396 (0.590)		-0.019 (0.979)	
- Farm Size	-123.663*** (0.002)	-118.343*** (0.002)	-0.015 (0.502)		-0.048 (0.670)		-0.048 (0.670)	
- HQI	-61.567 (0.570)		-0.107 (0.101)	-0.093 (0.126)	0.043 (0.883)		-0.056 (0.848)	
- Total Cash Income	0.132*** (0.002)	0.127*** (0.002)	$2.93E^{-5}$ (0.216)	$2.11E^{-5}$ (0.294)	$-2.07E^{-4}$* (0.087)	$-2.21E^{-4}$** (0.020)	$-1.83E^{-4}$ (0.127)	$-2.04E^{-4}$** (0.030)
Constant	284.325 (0.292)	172.438 (0.340)	0.471*** (0.005)	0.461*** (0.005)	0.311 (0.700)	0.454 (0.340)	0.662 (0.415)	0.573 (0.230)
Observations	38	38	38	38	26	26	26	26
R-squared	0.5221	0.5170	0.2576	0.2439	0.2340	0.2154	0.2055	0.1895
Adjusted R-squared	0.4296	0.4415	0.1139	0.1522	-0.0078	0.1471	-0.0455	0.1190
Prob > F	0.0005	0.0002	0.1332	0.0499	0.4730	0.0615	0.5689	0.0893
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

Table 4.35 Regression results for upstream community, consider only households that participate in fishing

Upstream Community								
Dependent Variables:	**Total Fish Catch**		**FID**		**FCD**		**TFD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
<u>*Demographic Variables*</u>								
- Female Headed HH	-9.510 (0.978)		-0.027 (0.877)		0.962 (0.886)		1.034 (0.879)	
- Adult Equivalent	-70.208* (0.068)	-72.547** (0.038)	-0.028 (0.155)	-0.035** (0.043)	-0.714 (0.229)	-0.695 (0.176)	-0.757 (0.209)	-0.710 (0.167)
<u>*Economic Variables*</u>								
- Latrine	368.814 (0.101)	378.239* (0.062)	0.170 (0.139)	0.187* (0.080)	1.901 (0.622)		2.172 (0.576)	
- Farm Size	136.949*** (0.000)	138.007*** (0.000)	-0.021 (0.247)	-0.022 (0.178)	-0.163 (0.776)		-0.274 (0.643)	
- HQI	258.419* (0.064)	258.255** (0.048)	-0.057 (0.428)		6.833** (0.019)	6.055** (0.011)	6.469** (0.026)	5.982** (0.012)
- Total Cash Income	0.002 (0.968)		$3.3E^{-5}$ (0.205)	$3.5E^{-5}$ (0.122)	$-3.88E^{-4}$ (0.612)		$-3.05E^{-4}$ (0.701)	
Constant	108.298 (0.637)	115.777 (0.589)	0.312** (0.012)	0.259*** (0.008)	-3.294 (0.455)	-3.245 (0.397)	-2.400 (0.586)	-2.973 (0.437)
Observations	42	43	41	43	29	30	29	30
R-squared	0.4680	0.4739	0.2392	0.2202	0.2546	0.2256	0.2527	0.2235
Adjusted R-squared	0.3768	0.4185	0.1050	0.1381	0.0513	0.1682	0.0489	0.1160
Prob > F	0.0007	0.0001	0.1324	0.0460	0.2419	0.0317	0.3245	0.0329
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

The households in the relocated community, which will be evacuated from the villages to the new resettlement area, and will be most likely to lose their current fishery activities, tend to be relatively richer compared to households in the other two communities. They sell the most fish, earn the most fishery income, and have the highest Fish Income Dependence value. The regression result from Fish Income Dependence model points out that in their community it is the better-off households, with better quality of asset (toilet facility), that depend more on fish for income generation. However, it is the poorer households with low cash income that depend more on fish for consumption, as seen in the regression results for the Fish Consumption Dependence model. These regression results suggest the importance of distinguishing between households that depend on fish for income and those that depend on fish for consumption. In sum, the statistical analysis suggests that within this community the better-off households will be most affected via the loss of cash income, while the poorer households are more likely to be affected via the loss of food.

Apart from being the community that has highest fishery income, the descriptive statistics also show that this community has the highest forestry income and farm income. It is still not clear whether there will be community forest near the new resettlement area for these households to rely on; also, the forest products may be different from what they can collect in their community forest at the present. Hence, their ability to generate income from forestry activities in the new resettlement area is uncertain. In terms of farming activities, it has been officially announced that five hectares of farm land will be given to each resettled household, which is bigger than the average size of farm land that the households in this community have now. However, from conversations with villagers during the field visit, they are not happy about the bad quality of soil in the new area, which eventually will have adverse impacts on farm production and farm income. The challenge that this community will face in terms of livestock activities may prove to be another issue. Currently, villagers have middlemen who bring their livestock to the market. Once all these villages are moved to the new resettlement area, it is important that they will still have the channel to connect to the livestock market, and that the new location will not adversely affect their power to negotiate for the reasonable prices.

Households in the upstream community are located furthest from the provincial capital, Stung Treng Town. The descriptive statistics show that this group of households catches the most fish on average, and use fish mostly for self-consumption. They have the highest average amount of fish consumed, the highest average Fish Consumption Dependence value, and the highest average Total Fish Dependence value. In terms of cash income, this community is the poorest among three communities. Its average farm income is the lowest, even though the average size of farm land is not that much different from that of the downstream community. This suggests the possibility that farming activities here may also mostly for self-consumption, similar to fishery activities. The community also has the lowest livestock income, as well as the lowest average income from non-agricultural activities, which might due to the longest distance from the market. This community generally appears to have more self-sufficient livelihoods when compared to the other two communities.

The regression results for the Total Fish Catch model, the Fish Income Dependence model, the Fish Consumption Dependence model, and the Total Fish Dependence model for the upstream community seem to tell the same story, in which the better-off households are the ones that catch more fish and depend more on fish for both income and food. However, there are two things that are worth remembering while looking at the regression results for this community. Firstly, this community is the poorest community, either judging from the cash income or the asset point of view. Secondly, the differences among households within this community are relatively small compares to those in the other two communities[24]. These two points together suggest that the poor households from this community are likely to be the poorest households among all three communities, and that the rich from this community are likely to be poorer than the rich households in the other two communities. In addition, it also suggests that though the impacts on the richer households will be greater, the impacts on the poorer households might not look much different.

Households in the downstream community have the lowest amount of fish catch, lowest amount of fish sold, and lowest fishery income. In other words, this appears to be the community that engages the least in fishing activities. This community also seems to rely more on non-agricultural activities as income

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[24]Consider the standard deviation and the range of 'Total Cash Income' variable and 'Size of Farm Land' variable in Table 4.13 and Table 4.15, respectively.

generation, in which its average 'Other Income' is the highest among three communities. The location of the community which is close to town and with better road conditions might make it easier for households to seek employment or income generation opportunity outside agricultural sector.

The regression results for the Total Fish Catch model and the Fish Income Dependence model show no statistically significant independent variables. However, for the Fish Consumption Dependence model and the Total Fish Dependence models, the results show that the poorer households, with lower cash income, tend to have higher Fish Consumption Dependence and higher Total Fish Dependence values. Hence, if the construction of the dam causes downstream fish stocks to decline, the poor will face a greater impact than the rich, since they are more depend on fish for self-consumption.

4.7 Conclusion

While several researchers have already analyzed potential fishery impacts of the Mekong hydropower dams, adding the 'Fish Dependence' concept into picture allows us to link the potential fishery impacts to the livelihoods of the rural households in the impacted area of the dam project. Also, it allows us to get a sense about the relative magnitude of the fishery impacts on households with different economic status.

For the case of the Lower Sesan 2 hydropower project, this study finds that the groups of households that rely the most on fishery for their income and their food tend to be the poorest groups among all the households situated across the project area. We can also see that the group that has highest fish harvest intensity also depends heavily on forest for income generation. These findings emphasize the significance of common pool resources in rural livelihoods, especially for the poor.

The impacts and challenges that villagers situated in different locations around the dam project will face are varied. The resettled community will face extreme changes in their livelihoods. Losing their current fisheries activities will affect the richer households greatly via the loss of income, while the poorer households are more likely to face a threat to their food security. Within the upstream community, the statistical analysis shows that the richer households would face greater fishery impacts than the poorer households since they depend more on fish for both self-consumption and income generation. However, the magnitude of the impacts that the poorer households face may not be very different, since the differences among households within this community are not that much. Moreover, this community is the poorest one across the impacted area, with the furthest distance to the city, and it seems relatively more self-sufficient compared to other communities. Households located in the downstream community seem to be in a better place to seek opportunities outside the resource-dependent sector. Their livelihoods are less dependent on fishery activities compared to households in the other two communities. Nevertheless, the poorer households in the downstream community still depend heavily on fish for self-consumption, and any fishery impacts there will affect their livelihoods more than the richer households.

These findings about fish dependence livelihoods in the Lower Sesan 2 hydropower project area are broadly consistent with evidence from different parts of the world that the poorer households depend heavily on CPRs, and would likely to be hardest hit when displaced or restricted from accessing these resources. The findings shed light on the threats and challenges faced by households with different economic status, and situated in different communities, as a result of this particular hydropower project. The attempt to pursue energy security at the national level should be balanced by recognition of the contribution of fisheries to the lives of the local people. This is the first and fundamental step for designing policy to secure the livelihoods of the poor and reduce poverty at the local level.

CHAPTER 5

FOREST AND RURAL LIVELIHOOD DEPENDENCE

5.1 Introduction

This chapter examines forest dependence in the livelihoods of the rural poor situated around the site of Lower Sesan 2 Hydropower project, complementing the previous chapter's analysis of fish dependence. In the study area as a whole, we saw in the previous chapter that households that catch the most fish and generate the highest average cash incomes from fish sales also have the highest average cash incomes from forest product sales. In addition, the relocated community, which has the highest average fishery cash income, also has highest average forestry cash income. And for many households, the forestry income is much higher than fishery income. This information points to the important role of the forest, a common pool resource in the area like fish, in supporting rural livelihoods.

Concerns about the impacts of the Government's implementation of its Economic Land Concession Policy often came up during the dialogues with the villagers in the case study area. Interviewed villagers told stories about harvesting forest products in the community forests since they were children, and lamented the decreasing of community forest areas as private companies were granted concessions for agro-industrial plantations on the lands that used to be villages' community forest. Hence, apart from the impacts of the Lower Sesan 2 hydropower project on forest lands in the case study area, the direction of Cambodia's land and forest policy also affects the rights of rural population in accessing and using forest products.

The chapter consists of nine sections. Section 2 provides a brief introduction to Cambodia's forest sector and relevant forest and land policies. Section 3 presents details about forest areas in the sample villages. In section 4, the variables created and used in the analysis are discussed, along with descriptive statistics of each variable. Section 5 puts forward four different ways to measure the household's forest dependence. Section 6 presents a statistical analysis of the relationship between the forest dependence variables and other socio-economic variables. The results are discussed in more depth in section 7. Section 8 investigates the relationship between forest dependence and fish dependence, and conclusions are presented in section 9.

5.2 Forest sector and forest policies in Cambodia

In the early 1970s, the heavy US bombing during Vietnam War damaged substantial amounts of Cambodia's forest, especially in the north of the country along the Vietnam border. Thousands of people in the rural area fled to Phnom Penh due to the war, leaving their villages and agricultural land behinds (APRODEV, 2011). Under the Khmer Rouge regime in the second half of 1970s, private properties and the land titling system were abolished (Un and So, 2011). There was no explicit forest policy in that period, and instead, a lot of forest areas were cleared for large-scale agricultural production (Sun Tra, 2007). After the Khmer Rouge regime was ended in 1979, the Department of Forestry and Wildlife (DFW)[25] slowly resumed its forest management activities, though without a clear vision on forest development policy (Sun Tra, 2007). Rural population also moved back to their villages and restarted traditional agricultural practices on available lands, which are considered state property (APRODEV, 2011).

The 1980s, were the period of Vietnamese occupation, guerrilla warfare and economic sanctions from the West. In terms of land rights, beginning in the mid-1980s private ownership of land for residential purpose could be claimed by families and individuals based on occupancy (Un and So, 2011; and APRODEV, 2011). There were rising demands for timber and forest products due to domestic reconstruction, but forest exploitation in Cambodia was still limited (Le Billon, 2002). Cambodia launched a reforestation program in 1985, focusing on preventing soil erosion and supplying fuel wood in particular provinces (Sun Tra, 2007). Also, a stricter monitoring system was applied by DFW for the timber transportation inside the country, using international cooperation to monitor the logging operation and timber export, especially with neighboring countries. Most of Cambodia's forests survived the damages from two decades of tragic history, and by the end of the 1980s almost two-thirds of the Cambodia's surface was still covered by forest (Le Billon, 2000).

The era of transitioning to peace and reconstruction in Cambodia began in the early 1990s. The Paris Peace Agreement was signed in 1991 and the United Nations started its operation in Cambodia in 1992. Le Billon (2000) states that this

[25]It is now called Forest Administration.

situation, and the associated uncertainty on political changes, led to each interest group trying to secure its logging concessions before the scheduled national election in the mid-1993. This is because revenues from logging activities and networks played significant role in supporting and maintaining military and political power. The operations of regional logging companies started in Cambodia during this period. At that same time, limits and bans on logging activities also happened in Cambodia's neighboring countries. Commercial logging was banned in Thailand in 1989, Laos adopted more strict control on logging in 1991, and Vietnam banned the export of logs and sawn wood in 1992 (Slocomb, 2002). Resulting from these coincidental situations, Cambodia experienced increasing demands for timber, as well as increasing rate of deforestation after 1991.

According to Neef et al. (2013), more than 30 private forest concessions were allocated after the 1993 general election, which together cover roughly 6.5 million hectares or one-third of the country[26]. According to Le Billon (2002), ''by 1998, all forests outside of protected areas had been granted to concessionaires'' (p. 573). Deforestation rate from 1993 to 1998 hit the record highs (FOA, 2004). Not only domestic companies but also foreign companies were granted logging concessions and export licenses from Cambodian Government, often without bidding or public announcement, as well as without logging quotas. Le Billon provides a good explanation about Cambodia's forestry sector of that period:

> In the absence of effective regulation and large exploitation companies, the forestry sector had remained open to a multiplicity of groups including militaries, local businessmen, farmers and seasonal migrants ... This

[26]Total area of Cambodia is 181,035 km^2, or 18,103,500 hectares.

> seemingly anarchy was not chaos, but rather a spontaneous order resulting from the ability of individuals or groups to control and exploit forests and to trade timber. The illegal character of logging shaped this ordering and reduced the share of profits for many of the less powerful groups, as people in positions of power – high ranking officials and military commanders – were able to extract large benefits for turning a blind eye, protecting, or even organizing these activities. (Le Billon, 2000: p.792-793)

As a result of both illegal logging and widespread petty corruption, the state obtained only a small part of the wealth generated by the logging activity and timber export. Values of timber exports and state revenues presented in Le Billon (2000) are shown in Table 5.1.

Table 5.1 Values of timber exports and forestry revenues of the Cambodia Government

	Year								
	1990	1991	1992	1993	1994	1995	1996	1997	1998
Volume of timber (thousand m^3)	515	848	1,393	1,360	1,495	1,691	992	1,045	1,090
Estimated value (US$ million)	77	170	348	340	374	423	248	188	218
Forestry government revenue (US$ million)	n.a.	n.a.	1.5	3.3	39	27	11	12	5

Note: The volume of timber exported – much of which is smuggled – is only an estimate.
Sources: Le Billon (2000: p.791)

A log export ban was eventually imposed again in 1996[27], but exports were believed still to be substantial, especially from illegal logging (Slocomb, 2002).

[27]"Between 1992 and 1996, a log export ban was declared on five occasions; each ban was lifted within a matter of month if not weeks" (Le Billon, 2002).

While logging concessions and timber exports dominated Cambodia's forestry sector in the 1990s, a new model of forest management in the form of community forests was also introduced in Cambodia in the same period. This 'introduced' community forest is different from the 'traditional/customary' community forest management that was practiced in Cambodia for decades and still continues primarily in the upland remote areas of Stung Treng, Ratanakiri and Mondulkiri provinces (see map, Figure 5.1), where the majority of the population is indigenous and ethnic minorities (FOA, 2004 and Sunderlin, 2006), as are many of the people in the villages studied in this dissertation. The difference in 'introduced' community forest management is that it is initiated from outside the community, by international agencies, local NGOs, government, or some combination of these three. The first initiative of 'introduced' community forest came from international NGOs in the early 1990s, establishing a few pilot sites in Takeo and Kampong Chhnang provinces[28] (Sunderlin, 2006). Much of the community forest initiatives are still supported by international donor organizations, international and local NGOs, while the commitment from central government is widely considered to have fallen short. Also, in the legal framework for community forest management, there are still a lot of conflicts and inconsistencies among different legislations (FOA, 2004).

In 2001, Cambodian government adopted a new Land Law[29], that represents a significant move on forest and land policy in several respects. Firstly, indigenous people are legally recognized for the first time under this Law:

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[28]Takeo province is in the southern Cambodia, while Kampong Chhnang province is in central Cambodia.

[29]The first Land Law was adopted in 1993.

…it was the first law to explicitly recognize the existence of 'Indigenous Peoples' (chuncheat daoem pheak teck in Khmer) in Cambodia, and it was the first piece of legislation to provide those defined as 'Indigenous' with extraordinary land rights apart from what are available to other Cambodians. It gave them the right to establish 'communal land tenure', or the shared land rights of community to a particular piece of land. (Baird, 2013: p.269)

Figure 5.1 Administrative map of Cambodia

Source: http://www.nationsonline.org/oneworld/map/cambodia-administrative-map.htm, retrieved on April 1, 2014.

The 2001 Land Law also grants permission to the Cambodian Government to turn 'state public land' into 'state private land'[30]. Following this new legal category, in 2002 private forest concessions were canceled and those lands were transferred back into 'state public land' (Neef et al., 2013). Government's control over forest was thus enhanced through this aspect of 2001 Land Law.

Lastly, and maybe most important, under the 2001 Land Law the government is allowed to allocate 'state private land' to three main types of concessions: Economic Land Concessions (ELCs)[31]; Social Land Concessions (SLCs)[32]; and others[33] (Neef et al., 2013). Not long after all the logging and forest concessions were canceled and the lands transferred back into state land, the Cambodian government also issued the Sub-Decree on Economic Land Concessions in 2005 which provides the legal framework on the allocation and management of ELCs (APRODEV, 2011). Coinciding with the promotion of agro-industrial business by the government, several land concessions, especially ELCs, have been granted to both local and foreign private companies since then. As cited in Neef et al. (2013), as of February 2012 more than 2 million hectares of land, which is equal to 53% of Cambodia's arable land, were allocated to 227 ELCs. Contrastingly, up until December 2011, fewer than 7,000 hectares of land were allocated to the landless and land-poor farmers under SLCs.

[30]'State private land' can be transferred or sold to private sectors, while 'state public land' is reserved land for public benefit (Un and So, 2011).

[31]The purpose of Economic Land Concessions is for agro-industrial use.

[32]Social Land Concession is granted for residential and subsistence use.

[33]Other types of land concessions are such as industrial development concession, fishing concession, mining concession, port concession.

Many issues have emerged in the implementation and rapid increase of ELCs. A number of ELCs were granted over indigenous community property and forested areas. According to Baird (2013), under the 2001 Land Law the occupied indigenous lands are supposed to be protected against eviction even before the land rights are determined and indigenous lands are registered, but very little protection actually happened. As a result, indigenous minorities had lost approximately 30% of traditional community forest lands by 2007, and the poverty rate rose in the upland provinces of northeastern Cambodia (Neef et al., 2013). The required processes of ELCs management in conducting environmental and social impact assessments, including public consultations, are also not properly enforced. Moreover, in several locations, multiple ELCs are found granted jointly to the same person[34] exceeding the legal limit of 10,000 hectares (APRODEV, 2013: p.10).

Currently, the issue of forced eviction as a result of ELCs has become intense in Cambodia. Forced evictions happen in both rural and urban areas. It is estimated that from 1990 to 2009, 133,000 Phnom Penh residents, or 11% of the capital city's population, were evicted from their homes. In the rural areas, the landless population increased from 13% in 1997 to 20%-25% in 2007, mostly due to forced evictions (APRODEV, 2011). The eviction process has raised concerns from human rights organizations and other international institutions. Forced eviction in Cambodia often occurs with no prior notice and inadequate consultation with those affected, inadequate compensation and without suitable resettlement program, along with violence and the use of excessive force by police and military (APRODEV,

[34]Also, granted to various legal entities which are controlled by the same person.

2011; Un and So, 2011). In August 2011, the World Bank announced the decision to halt its loan disbursements to Cambodia, usually amounting to US$ 50-US$ 70 million per year, until the government can resolve the conflict over evictions in Boeung Kak Lake area in Phnom Penh[35]. The Cambodian government has granted a 99-year lease over this area to a Chinese company and joint venture company owned by a senator from the ruling Cambodia's People Party (CPP)[36], and 10,000 people are facing eviction to make way for a luxury real estate project. The use of violence during forced evictions continued even after the pressure from the World Bank. In May 2012, one month after a local activist was murdered after his investigation on illegal logging in a forest concession, 400 police and soldiers clashed with 200 villagers who refused to leave their farmland in Kratie province to make way for a Russian plantation development, and a 15-year-old girl was shot to dead during the incident[37].

5.3 Forests in the case study area

In the Sesan district of Stung Treng province, the location of the Lower Sesan 2 hydropower project, about 90.5% of the district territory is covered by forests (KCC, 2008). In the process of conducting the Environmental Impact Assessment of the Lower Sesan 2 hydropower project, a forest study was conducted in the project

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[35]Reuters: August 9, 2011 (online at http://www.reuters.com/article/2011/08/09/cambodia-worldbank-idUSL3E7J920D20110809, retrieved on January 24, 2014).

[36]The New York Times: July 18, 2012 (online at http://www.nytimes.com/2012/07/19/opinion/land-grabs-in-cambodia.html?_r=1&, retrieved on January 24, 2014).

[37]The Independent: May 16, 2012 (online at http://www.independent.co.uk/news/world/asia/teenage-girl-in-cambodia-killed-during-violent-eviction-7757221.html, retrieved on March 1, 2014).

area using the combination of aerial photos taken during February to March 2008, and a field survey/count on types of forest. The wildlife habitat in the area was also explored via field survey and literature review.

The construction of the Lower Sesan 2 hydropower project will directly damage two main locations of forest areas. The first location is at the reservoir site, where thousand hectares of forest will be inundated. The second location is at the proposed resettlement sites, in which there will be the clearance of forest areas for the construction of new houses, roads, as well as other infrastructure and agricultural lands.

1. Reservoir site

The reservoir area would flood 330 km^2 of land, and much of the flooded area is forest land. The EIA provides details about types of forest that would be flooded in the reservoir area, as shown in Table 5.2[38].

While visiting Sre Kor Mouy and Sre Kor Pi villages, which are located in the reservoir area, I had a chance to discuss the community forest in the area. These two villages share the same community forest, on which they rely for firewood, non-

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[38]According to the definitions provided by the Food and Agricultural Administration (FAO) of the United Nations, the term *forest* is used to refer to "land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 meters. Young stands that have not yet but are expected to reach a crown density of 10 percent and tree height of 5 meters are included under forest, as are temporarily unstocked areas". The term *woodland* is used to refer to "land that has either a crown cover (or equivalent stocking level) of 5 to 10 percent of trees able to reach a height of 5 meters at maturity; or a crown cover (or equivalent stocking level) of more than 10 percent of trees not able to reach a height of 5 meters at maturity; or with shrub or bush cover of more than 10 percent" (online at http://www.cbd.int/forest/definitions.shtml, retrieved on April 1, 2014). As for *semi-evergreen* type of forest, it is described by the World Wildlife Fund (WWF) that "evergreen forest communities growing under lower rainfall and longer dry seasons contain variable amounts of deciduous trees in the canopy and are therefore termed semi-evergreen forests" (online at http://wwf.panda.org/what_we_do/where_we_work/project/projects_in_depth/dry_forests_ecoregion/about_the_area/habitats/semi_evergreen/, retrieved on April 1, 2014).

timber forest products and various foods, as well as grazing land for buffalos and cows. Villagers told me that before 2005 they could access community forest and harvest forest products freely. In 2005, a company came to the village and observed the community forest area, and in 2007 the company started the process of clearing trees in the community forest area for a rubber plantation. At the time of my field visit in June 2012, approximately 70-100 people from the two villages were hired to work in the plantation.

Table 5.2 Forest types in the reservoir area

Forest Types:	Area (ha)
Deciduous Forest	23,093.03
Semi-Evergreen Forest	3,516.55
Deciduous Woodland	832.63
Evergreen Forest	248.19
Evergreen Woodland	42.07
Total	*27,732.47*

Source: KCC (2008)

Baird (2009) documents that in a meeting with villagers in Kbal Romeas village, which will also be resettled, villagers expressed strong opinions in opposing the construction of the Lower Sesan 2 project. They were able to explain that as ‘indigenous peoples’ they were protected under Cambodian’s 2001 Land Law and had the rights to control their own land.

According to Baird (2009), villagers in the reservoir area that will be resettled will not compensated for forest losses and wildlife habitat losses. This is because the community forest is defined as ‘state land’ according to the 2001 Land Law. Instead, the Cambodian government itself will be compensated by the project developer for the loss of forest lands, as will the companies that hold concessions over the inundated lands in the reservoir area. In the *'Law on the Authorization of Payment Warranty of the Royal Government of Cambodia for the Hydro Power Lower Sesan 2 Company'* , there is no discussion on compensation to villagers based on their losses of forest and forest products.

2. Resettlement areas

There are four proposed resettlement sites upstream of the project to accommodate villagers evacuated from inundated villages, all of them in Sesan district. Two resettlement sites are located along the riverbank of the Srepok River (hereafter, Srepok resettlement site). The other two resettlement sites are located along the riverbank of the Sesan River (hereafter, Sesan resettlement site).

According to the EIA (KCC, 2008), the surrounding forest in the Srepok resettlement area is classified as Deciduous dipterocarp forest, containing shrubs, subshrubs and short bamboo as dominant understory species. Most of the trees in this area are relatively small in circumference. Larger trees, especially those with high market values, were under selective cutting during the time of survey in April 2008. This habitat is large and extends along the southern part of the Srepok River. Upstream the proposed Srepok resettlement site connects to two protected area[39] and one protected forest[40].

[39]Two protected areas, the Lomphat Wildlife Sanctuary in Ratanakiri Province and the Phnom Prich Wildlife Sanctuary in the Mondulkiri Province, are managed by Cambodia's Ministry of Environment (KCC, 2008). According to the United Nations Environment Program, "Protected areas are internationally recognized as regions set aside primarily for nature and biodiversity conservation and are a major tool in managing species and ecosystems which provide a range of goods and services essential to sustainable use of natural resources" (online at http://www.unep-wcmc.org/about-protected-areas_163.html, retrieved on March 1, 2014).

In the Sesan resettlement area, the surrounding forest type is also Deciduous dipterocarp forest. The proposed resettlement site located between the Sekong River and the Sesan River, just a few kilometers north of the Sesan riverbank. Previously, the forest area of this resettlement site was under a logging concession. This area extends to the north and northeast towards the Virachey National Park in Ratanakiri Province. To the far north is the Xe Pian protected area in Laos. The forest habitat of this Sesan resettlement site is home to large populations of threatened species of large mammals and endangered species. However, there is not much monitoring or control on hunting activity in this area. Wildlife is hunted mainly for local consumption, except for tigers and bears. There are trails/tracks that provide easy access to the resettlement site, which at the same time can disturb the forest and wildlife in this area. Types of forest in the proposed resettlement sites are shown in Table 5.3.

Table 5.3 Forest types in the proposed resettlement sites

Forest Types:	Area (ha)
Deciduous Forest	4,618.68
Semi-Evergreen Forest	1,556.92
Deciduous Woodland	226.65
Evergreen Forest	102.65
Evergreen Woodland	1.50
Total	*6,506.40*

Source: KCC (2008)

[40]The protected forest is the Seima Biodiversity Conservation Area (SBCA) in Mondulkiri Province, which is managed by Cambodia's Forest Administration.

A Sre Kor Pi villager mentioned during my field visit that the new resettlement area should have at least the same amount of area of community forest for the villagers to use to 'replace' the forest that would be lost by the dam. As of now, there is still no clear solution on community forest in the resettlement area. Sre Kor Pi and Sre Kor Muoy villages are scheduled to be in the same resettlement area in the Sesan resettlement site. The villagers are also concerned that the quality of the land in the resettlement site is not suitable for growing rice.

Baird (2009) documents that in Kbal Romeas village, the villagers understand that they were proposed two options as to their resettlement site. The first option is to move to the north side of the Srepok River, and the second option is to move to the south side of the Srepok River. For the first option, villagers expressed concerns about the quality of land is not suitable for agriculture and there will be not much land for villagers to cultivate rice. Also, there is already a land concession granted for a rubber plantation north of the Srepok River, hence it would be hard for villagers to claim the land to conduct agriculture. Moreover, there are already some conflicts and tensions between the villagers and the company over the concession land. For the second resettlement site option, there are some areas that suitable for growing rice, but the quality of land in general is worse than the current location of the village. Also, the whole village cannot be moved into one location, because the lands in this resettlement site are scattered in different locations. This will make the management of the village become more difficult when they are separated into small groups, and villagers also afraid that the separation will cause damages to their language and culture. Moreover, there is also a rumor about another land concession already granted to a private company for growing rubber south of Srepok River, so the villagers feel that it will be difficult for them to move to this proposed location.

5.4 Data

5.4.1 Questionnaire: Forestry activities

The questionnaire used to collect primary data under the 'Water Valuation Project' contains one module dedicated to forestry activities. Information collected under this forestry module involves types and quantities of products collected from forests, locations and types of forest from which each product is collected, value of each product in the past 12 months, total money earned from selling each forest product, amount of each forest product consumed in the household, and amount of each forest product given away. Types of forest products listed in the questionnaire can be categorized into three groups: Timber forest products[41] (TFPs), Non-timber forest products[42] (NTFPs), and Wildlife products[43].

Forest products harvested by households are sold to generate cash income or consumed within households, and several forest products serve households in both ways. Table 5.4 presents numbers of households that engage in selling and/or consuming each type of forest products. The information in Table 5.4 provides a

[41]Timber forest products listed in the questionnaire are (1) Timber/Wood; (2) Firewood; (3) Wood for charcoal; (4) Rattan; (5) Bamboo; (6) Palm leaves; (7) Resin; (8) Wood oils; and (9) Other.

[42]Non-timber forest products listed in the questionnaire are (1) Mushrooms; (2) Fruits; (3) Root crops; (4) Vegetables; (5) Honey; and (6) other.

[43]Wildlife products listed in the questionnaire are (1) Wild animals; (2) Wild birds; and (3) Other.

glimpse on how much each forest product is involved in rural livelihoods, in both income and consumption aspects.

Table 5.4 Number of households reporting sale and consumption of each forest product

Forest products:	Number of households reporting consumption	Number of households reporting sale	Number of households reporting both consumption and sale	Number of households reporting either consumption or sale
1. Firewood	251	1	0	252
2. Bamboo	64	3	1	66
3. Mushroom	45	23	11	57
4. Timber/Wood	1	47	0	48
5. Honey	15	26	5	36
6. Rattan	29	1	0	30
7. Wild Animals	8	17	3	22
8. Resin	2	22	2	22
9. Wild Birds	3	17	2	18
10. Woods for Charcoal	14	1	1	14
11. Wood Oils	1	11	0	12
12. Fruits	2	4	0	6
13. Vegetables	4	0	0	4
14. Other NTFPs	3	0	0	3
15. Root Crops	2	0	0	2
16. Palm Leaves	1	1	0	2
17. Other TFPs	2	3	2	3

On the income aspect of forest products, revenues that households generate from selling each forest products in the past 12 months are reported. Table 5.5 presents numbers of households reporting sale in each forest product, also average values of revenues generated from selling each forest product. For each household, the result from adding up revenues generated from selling each forest product together is reported here as ‘Forestry Income’ (YForest). The descriptive statistics on 'Forestry Income' variable were already shown in the Fish Dependence chapter (Table 4.10).

Table 5.5 Average revenues from selling forest products

Forest products:	Number of households reporting sale	Average revenues (Observation = 298 HHs)
1. Timber/Wood	47	$137.22
2. Honey	26	$8.59
3. Mushroom	23	$2.49
4. Resin	22	$24.06
5. Wild Birds	17	$30.94
6. Wild Animals	17	$6.69
7. Wood Oils	11	$21.12
8. Fruits	4	$1.79
9. Other TFPs	3	$5.97
10. Bamboo	3	$2.79
11. Rattan	1	$0.04
12. Palm Leaves	1	$0.03
13. Woods for Charcoal	1	$0.01
14. Firewood	1	$0.01
15. Vegetables	0	$0.00
16. Root Crops	0	$0.00
17. Other NTFPs	0	$0.00
Unit: US$/household/year		

5.4.2 Consumption values of forest products

Consumption values of each forest product are not reported directly. However, there is information about amounts of each forest products that are consumed within households, which can be used in the process of calculating household's consumption value of forest products.

The calculation of consumption values will be done only for the first nine forest products listed in Table 5.4. These nine forest products not only are most important in household livelihoods but also have enough information for the calculation of consumption values. Details about how consumption values of each forest product are calculated are as follows:

1. Firewood

Among all 252 households that participate in harvesting firewood, only one household reports selling, with the price of $2.49/ox-cart. This price will be used as a reference price for firewood in the calculation of consumption values.

Among 251 households that report harvesting firewood for self-consumption, there are 247 households that provide information on the quantity of firewood that they harvested. However, several units of quantity are used by these households, and their conversion into a common unit of quantity is required in order to proceed to the calculation of consumption values. The assumptions about units of quantity for firewood are as follows:

- 1 ox-cart of firewood equals 500 pieces of firewood
- 1 boat of firewood equals 500 pieces of firewood
- 1 bag of firewood equals 50 pieces of firewood
- 1 bundle of firewood equals 50 pieces of firewood
- 1 bucket of firewood equals 50 pieces of firewood
- 1 truck of firewood equals 2 ox-carts of firewood
- 1 tractor of firewood equals 2 ox-carts of firewood
- 1 kilogram of firewood equals 20 pieces of firewood

Value of ox-cart equivalent for each unit of quantity is calculated based on the assumptions stated above. Table 5.6 presents details about number of households that report each unit of quantity, and the values of ox-cart equivalent.

Table 5.6 Consumption of firewood: Units of quantity and ox-cart equivalent

Units of Quantity:	Number of households consuming firewood	Ox-cart equivalent
Ox-cart	112	1
Bundles	89	0.1
Truck	17	2
Tractor	16	2
Boat	7	1
Bag	2	0.1
Piece	2	0.002
Bucket	1	0.1
Kilogram	1	0.04
Households with unit of quantity	*247*	
Households with missing unit of quantity	*4*	
Number of households consuming firewood	***251***	
Number of households with no consumption of firewood	**47**	
Total	**298**	

For each household, by multiplying the reference price of firewood ($2.49/ox-cart) to quantity of firewood that is adjusted by ox-cart equivalent, we obtain the consumption values of firewood. Table 5.7 presents average values of firewood consumed by households in each community.

Table 5.7 Values of firewood consumed by households

Community:	Observations	Number of household consuming firewood	Mean	Max	Min	SD
Downstream	149	123	13.89	149.25	0.00	22.38
Relocated	72	59	12.75	149.25	0.00	24.24
Upstream	73	65	21.24	447.76	0.00	57.43
All	294	247	15.43	447.76	0.00	34.89
Unit: US$/household/year						

2. Bamboo

Of three households that report selling bamboo, two provide information about the income from selling bamboo and the quantity sold[44]. The average value of selling price calculated from these two households is $1.24/bundle. This price will be used as a reference price for bamboo.

Among 64 households that report harvesting bamboo for self-consumption, there are only 45 households that provide information on amounts of bamboo harvested with proper units of quantity. Again, several units of quantity are used by these households. The assumptions used to convert these into a common unit are as follows:

- 1 bundle of bamboo equals 10 pieces of bamboo
- 1 boat of bamboo equals 10 bundles of bamboo
- 1 ox-cart of bamboo equals 10 bundles of bamboo

Values of bundle equivalent are calculated for all units of quantity. Table 5.8 presents details about number of households that report each unit of quantity, and the values of bundle equivalent.

For each household, by multiplying reference price of bamboo ($1.24/bundle) to quantity of bamboo that is adjusted by ox-cart equivalent, we get the consumption values of bamboo. Table 5.9 presents average values of bamboo consumed by households in each community.

[44]Another household reports only total revenue generated from selling bamboo, but no information about price and quantity.

Table 5.8 Consumption of bamboo: Units of quantity and bundle equivalent

Unit of quantity:	Number of households consuming bamboo	Bundle equivalent
Bundle	42	1
Boat	1	10
Ox-cart	1	10
Piece	1	0.1
Households with unit of quantity	*45*	
Households with missing unit of quantity	*19*	
Number of households consuming bamboo	***64***	
Number of households with no consumption of bamboo	**234**	
Total	**298**	

Table 5.9 Values of bamboo consumed by households

Community:	Observations	Number of household consuming bamboo	Mean	SD	Min	Max
Downstream	142	15	8.63	54.30	0.00	621.89
Relocated	67	9	1.08	3.34	0.00	18.66
Upstream	70	21	7.64	24.26	0.00	124.38
All	279	45	6.57	40.67	0.00	621.89
Unit: US$/household/year						

3. Mushroom

There are 23 households that report selling mushroom, of which 22 provide information about selling price. The average value of selling price calculated from these 22 households is $1.06/kilogram. This is used as a reference price for mushroom.

Table 5.10 Revenues from selling mushroom

Community:	Observations	Number of household selling mushroom	Mean	SD	Min	Max
Downstream	150	12	1.55	6.91	0.00	62.19
Relocated	73	6	6.34	25.74	0.00	124.38
Upstream	75	5	0.62	2.86	0.00	19.90
All	298	23	2.49	13.84	0.00	124.38
Unit US$/household/year						

There are 45 households that report harvesting mushrooms for consumption, and all of them provide the unit of quantity in kilograms. Hence, by multiplying the reference price and the quantity harvested for consumption, we get the consumption value of mushroom for these 45 households. Table 5.11 presents the average values of mushroom consumed by households in each community.

Table 5.11 Values of mushroom consumed by households

Community:	Observations	Number of household consuming mushroom	Mean	SD	Min	Max
Downstream	150	19	1.14	6.44	0.00	74.63
Relocated	73	11	0.80	2.67	0.00	15.94
Upstream	75	15	0.64	1.78	0.00	10.63
All	298	45	0.93	4.83	0.00	74.63
Unit: US$/household/year						

4. Timber

There are 47 households that report harvesting timber for sale. The details of average revenues generated from selling timber for households in each community are presented in Table 5.12.

Table 5.12: Revenues from selling timber

Community:	Observations	Number of household selling Timber	Mean	SD	Min	Max
Downstream	150	11	53.77	339.50	0.00	3,781.09
Relocated	73	8	157.41	504.42	0.00	2,100.00
Upstream	75	28	284.48	573.42	0.00	2,985.07
All	298	47	137.22	458.83	0.00	3,781.09
Unit: US$/household/year						

Only one household reports harvesting timber for self-consumption, though without a proper unit of quantity. Hence, it is not possible to calculate consumption value of timber for this household.

5. Honey

There are 26 households that report selling honey. Table 5.13 presents average revenues generated from sale for households in each community. The average values of selling price are calculated using information from these 26 households, resulting in two reference prices for honey which are $4.98/kilogram and $6.20/liter. Both reference prices are used for the calculation of household consumption values of honey, depending on which unit of quantity is reported by each household.

There are 15 households report harvesting honey for self-consumption. By multiplying quantity of consumption with respective reference price, we get the consumption value of honey for each household. Table 5.14 presents the average values of honey consumed by households in each community.

Table 5.13 Revenues from selling honey

Community:	Observations	Number of household selling honey	Mean	SD	Min	Max
Downstream	150	8	3.93	27.71	0.00	298.51
Relocated	73	10	20.60	97.09	0.00	736.32
Upstream	75	8	6.22	24.01	0.00	149.25
All	298	26	8.59	53.50	0.00	736.32

Unit: US$/household/year

Table 5.14 Values of honey consumed by households

Community:	Observations	Number of household consuming honey	Mean	SD	Min	Max
Downstream	150	2	0.08	0.71	0.00	6.20
Relocated	73	6	2.53	11.90	0.00	92.93
Upstream	75	7	0.95	3.18	0.00	12.39
All	298	15	0.90	6.17	0.00	92.93

Unit: US$/household/year

6. Rattan

There is only one household report selling rattan, with the selling price at $6.21/bundle. This is used as the reference price for rattan in the calculation of consumption values.

Among 29 households that report harvesting rattan for consumption, only 18 households provide amounts harvested with units of quantity. To convert the differences in unit of quantity into one unit, assumptions are set as follows:

- 1 bundle of rattan equals 10 pieces of rattan
- 1 truck of rattan equals 20 bundles of rattan

Values of bundle equivalent for every unit of quantity are calculated in order to convert amounts of rattan harvested by every household into the same unit. Table

5.15 presents details about number of households that report each unit of quantity, and the values of bundle equivalent.

Table 5.15 Consumption of rattan: Units of quantity and bundle equivalent

Unit of quantity:	Number of households	Bundle equivalent
Bundle	16	1
Piece	1	0.1
Truck	1	20
Households with unit of quantity	*18*	
Households with missing unit of quantity	*11*	
Number of households consuming rattan	***29***	
Number of households with no consumption of rattan	**269**	
Total observation	**298**	

For each household, by multiplying reference price of rattan ($6.21/bundle) by the amount of rattan harvested for consumption, we obtain the household consumption value of rattan. Table 5.16 presents average value of rattan consumed by households in each community.

Table 5.16 Values of rattan consumed by households

Community:	Observations	Number of household consuming rattan	Mean	SD	Min	Max
Downstream	149	0	0.00	0.00	0.00	0.00
Relocated	69	6	7.39	40.24	0.00	310.95
Upstream	69	12	13.16	54.44	0.00	373.13
All	287	18	4.94	33.47	0.00	373.13
Unit: US$/household/year						

7. Wild Animals

There are 17 households that report revenues from selling wild animals. Tables 5.17 presents average values that households in each community generate from selling wild animals. Among these 17 households, there are 15 households that provide information about selling price, and the average selling price of wild animals is calculated using this information. The average selling price of wild animals is $7.23/kilogram, which will be used as the reference price when calculating consumption values.

Table 5.17 Revenues from selling wild animals

Community:	Observations	Number of household selling wild animals	Mean	SD	Min	Max
Downstream	150	2	1.23	11.67	0.00	134.33
Relocated	73	13	24.23	72.25	0.00	348.26
Upstream	75	2	0.53	3.62	0.00	29.85
All	298	17	6.69	37.91	0.00	348.26

Unit: US$/household/year

Eight households report harvesting wild animals for self-consumption, and all of them provide unit of quantity in kilogram. By multiplying the reference price of wild animal by the amounts of wild animal harvested for consumption, we get the household consumption value of wild animals. Table 5.18 presents average values of wild animals consumed by households in each community.

Table 5.18 Values of wild animals consumed by households

Community:	Observations	Number of household consuming wild animals	Mean	SD	Min	Max
Downstream	150	3	3.55	32.61	0.00	373.13
Relocated	73	3	3.64	29.12	0.00	248.76
Upstream	75	2	0.96	5.87	0.00	36.17
All	298	8	2.92	27.37	0.00	373.13
Unit: US$/household/year						

8. Resin

There are 22 households that report revenue from selling resin. Table 5.19 presents average values of revenues that households in each community generated from selling resin. Among these 22 households, information about selling price from 5 households that report unit of quantity in liter are used to calculate the reference price for resin, which is $0.25/liter.

Table 5.19 Revenues from selling resin

Community:	Observations	Number of household selling resin	Mean	SD	Min	Max
Downstream	150	1	0.02	0.20	0.00	2.49
Relocated	73	10	65.22	412.08	0.00	3,483.59
Upstream	75	11	32.07	106.25	0.00	639.30
All	298	22	24.06	211.43	0.00	3,482.59
Unit: US$/household/year						

Only two households report harvesting resin for self-consumption, both of which provide amounts of resin harvested using liter as unit of quantity. By multiplying their amount of resin harvest with the reference price of resin, we get the consumption values of resin. Table 5.20 presents average values of resin consumed by households in each community.

Table 5.20 Values of resin consumed by households

Community:	Observations	Number of household consuming resin	Mean	SD	Min	Max
Downstream	150	0	0.00	0.00	0.00	0.00
Relocated	73	0	0.00	0.00	0.00	0.00
Upstream	75	2	4.58	32.08	0.00	268.66
All	298	2	1.15	16.14	0.00	268.66
Unit: US$/household/year						

9. Wild Birds

There are 17 households that report revenues from selling wild birds. Tables 5.21 presents average values of revenues that households in each community generated from selling wild birds. Among these 17 households, there are only three households that provide information about selling price, in which the average selling price calculated from these households' information is $55.97/bird.

Table 5.21 Revenues from selling wild birds

Community:	Observations	Number of household selling wild birds	Mean	SD	Min	Max
Downstream	150	2	22.39	193.23	0.00	1,679.10
Relocated	73	12	56.29	195.28	0.00	1,194.03
Upstream	75	3	23.38	193.88	0.00	1,679.10
All	298	17	30.94	193.78	0.00	1,679.10
Unit: US$/household/year						

Three households report consumption of wild birds, and their consumption values are already estimated by each household. The self-report consumption values are used here. Table 5.22 presents average values of wild birds consumed by households in each community.

Table 5.22 Values of wild birds consumed by households

Community:	Observations	Number of household consuming wild birds	Mean	SD	Min	Max
Downstream	150	0	0.00	0.00	0.00	0.00
Relocated	73	2	4.23	34.94	0.00	298.51
Upstream	75	1	0.66	5.74	0.00	49.75
All	298	3	1.20	17.53	0.00	298.51
Unit: US$/household/year						

10. Consumption of forest products

The consumption values of the nine forest products, when added together, result in a new variable I call 'Consumption of Forest Products' (CForest), which will be used as the proxy for the value of forest products consumed by households. Table 5.23 presents the average values of forest products consumed by households in each community.

Table 5.23 Consumption of forest products (CForest)

Community:	Observations	Number of household consuming 9 forest products	Mean	SD	Min	Max
Downstream	139	118	27.52	67.68	0.00	625.26
Relocated	63	52	35.14	69.34	0.00	313.43
Upstream	66	60	49.83	86.00	0.00	460.15
All	268	230	34.80	73.26	0.00	625.26
Unit: US$/household/year						

5.4.3 The variables

Four 'Forest Dependence Variables' are created for this analysis:

1. Total Forest Product Value (TFPV)

Total Forest Product Value is calculated by adding 'Forestry Income' (YForest) to 'Consumption of Forest Products' (CForest). This variable reflects total value of forest products harvested by each household. Descriptive statistics of Total Forest Product Value is presented in Table 5.24. Households in the downstream community have the lowest average value of harvested forest products, while households in the relocated community have the highest average value of harvested forest products.

Table 5.24 Total Forest Product Value (TFPV)

Community:	Observations	Mean	SD	Min	Max
Downstream	139	108.3	406.6	0.00	4,051.5
Relocated	63	430.1	865.1	0.00	4,218.9
Upstream	66	389.3	588.8	0.00	2,986.3
All	268	253.2	605.4	0.00	4,218.9
Unit: US$/household/year					

2. Forest Revenue Dependence (FoRD)

Forest Revenue Dependence is a ratio between two variables: 'Forestry Income' (YForest) and 'Total Cash Income' (YTotal). This ratio ranges from 0 to 1. Table 5.25 presents the descriptive statistics of Forest Revenue Dependence for households in each community. The average value of Forest Revenue Dependence is highest for households situated in the upstream community with the average value of 0.37, which means that value of forest income equals 37% of household's total cash income on average. Households in the downstream community have the lowest average value of Forest Revenue Dependence at 0.05, which means that value of forestry income equals 5% of their total cash income in average.

Table 5.25 Forest Revenue Dependence (FoRD)

Community:	Observations	Mean	SD	Min	Max
Downstream	136	0.05	0.17	0.00	0.97
Relocated	63	0.18	0.29	0.00	1.00
Upstream	66	0.37	0.41	0.00	1.00
All	265	0.16	0.30	0.00	1.00

3. Forest Consumption Dependence (FoCD)

Forest Consumption Dependence is a ratio between two variables: 'Consumption of Forest Products' (CForest) and 'Total Cash Income' (YTotal). Unlike the value of FoRD, the values of FoCD can be greater than 1. Table 5.26 presents average values of Forest Consumption Dependence for households located in each community. Households in the upstream community have the highest average value of Forest Consumption Dependence, and the value is higher than that of the other two communities by substantial margin.

Table 5.26 Forest Consumption Dependence (FoCD)

Community:	Observations	Mean	SD	Min	Max
Downstream	125	0.03	0.07	0.00	0.39
Relocated	54	0.04	0.14	0.00	0.87
Upstream	59	0.15	0.40	0.00	2.59
All	238	0.06	0.22	0.00	2.59

4. Total Forest Product Dependence (TFPD)

Total Forest Product Dependence is a ratio between two variables: 'Total Forest Product Value' (TFPV) and 'Total Cash Income' (YTotal). The value of TFPD can be greater than 1. Households in the upstream community have the highest average value of Total Forest Product Dependence, which equals 50% of their total cash income.

Table 5.27 Total Forest Product Dependence (TFPD)

Community:	Observations	Mean	SD	Min	Max
Downstream	125	0.07	0.17	0.00	1.02
Relocated	54	0.21	0.31	0.00	1.01
Upstream	59	0.50	0.59	0.00	2.59
All	238	0.21	0.39	0.00	2.59

5.5 Who depends most on forest products?

5.5.1 Forest dependence variables and stratifications

In this section, similar to the Fish Dependence analysis in the preceding chapter, four Forest Dependence variables are used to construct four separate stratifications to shed light on the characteristics and the differences among households that depend differently on forest products.

The first variable to be considered is the 'Total Forest Product Value' variable (TFPV). The surveyed households are grouped according to value of 'Total Forest Product Value' as follows:

(i) *Low Total Forest Product Value Group*: Households with value of 'Total Forest Product Value' less than US$100.

(ii) *Moderate Total Forest Product Value Group*: Households with value of 'Total Forest Product Value' equal to or higher than US$100, but less than US$ 500.

(iii) *High Total Forest Product Group*: Households with value of 'Total Forest Product Value' equal to or higher than US$500.

The numbers of households belonging to each group, categorized by community, are shown in Table 5.28.

Table 5.28 Number of households categorized by community and Total Forest Product Value (TFPV)

Community:	High TFPV Group	Moderate TFPV Group	Low TFPV Group	All
Downstream	8	10	121	139
Relocated	15	10	38	63
Upstream	20	14	32	66
All	43	34	191	268

The second forest dependence stratification is created using 'Forest Revenue Dependence' variable (FoRD), which is a ratio between 'Forestry Income' and 'Total

Cash income'. This variable reflects the significance of forest products as sources of household's monetary income. The higher the value of 'Forest Revenue Dependence', the more dependent household is on forest products. After sorting all households according to their values of 'Forest Revenue Dependence', from the lowest to the highest value, the surveyed households are grouped such that the percentage of households in each group is the same percentage as that of the corresponding groups in the 'Fish Income Dependence' stratification[45]. The details on three groups of 'Forest Revenue Dependence' are as follows:

(i) *Low Forest Revenue Dependence Group*: There are 218 households in this group, in which the value of the 'Forest Revenue Dependence' variable less than 0.40.

(ii) *Moderate Forest Revenue Dependence Group*: There are 27 households in this group, their value of 'Forest Revenue Dependence' variable equal to or greater than 0.40, but less than 0.84.

(iii) *High Forest Revenue Dependence Group*: There are 20 households in this group, their value of 'Forest Revenue Dependence' variable equal to or greater than 0.84.

The numbers of households belonging to each group, categorized by community, are shown in Table 5.29.

[45] Percentage of households in the Low, Moderate, and High Fish Income Dependence Groups are 82.3%, 10.2%, and 7.5% of total households respectively.

Table 5.29 Number of households categorized by community and Forest Revenue Dependence (FoRD)

Community:	High FoRD Group	Moderate FoRD Group	Low FoRD Group	All
Downstream	1	6	129	136
Relocated	2	12	49	63
Upstream	17	9	40	66
All	20	27	218	265

Forest products are used within households as well, hence looking at household dependence on forest product for consumption is also important. The third forest dependence stratification is created using the 'Forest Consumption Dependence' variable (FoCD), which is a ratio between 'Consumption of Forest Products' (CForest) and 'Total Cash Income' (YTotal). The method used in the 'Forest Revenue Dependence' stratification is also applied here, in which households are ranked according to their value of 'Forest Consumption Dependence', from lowest to highest value. The percentages of households that belong to each group is the same as in the 'Fish Consumption Dependence' stratification[46].

The details of the Forest Consumption Dependence stratification can be summarized as follows:

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[46]These are 56.0%, 30.2% and 13.8% of total households for Low, Moderate, and High Fish Consumption Dependence groups respectively. There are 238 households that have 'Forest Consumption Dependence' values. Hence, numbers of households in the Low, Moderate, and High Forest Consumption Dependence Groups would be 133 households, 72 households, and 33 households respectively. After separating households into the Low and the Moderate Forest Consumption Dependence groups, there are 15 households in the Moderate Dependence group that have the same values of FoCD as the households in Low group (FoCD = 0.02). Hence, these 15 households are moved into the Low Dependence group. Also, after separating households into the Moderate and High Forest Consumption Dependence groups, there is one household in the Moderate Dependence group that has the same value of FoCD as the households in High group (FoCD = 0.08). This household is thus moved to the High Dependence group.

(i) *Low Forest Consumption Dependence Group*: There are 148 households in this group, for which the value of 'Forest Consumption Dependence' variable less than 0.02.

(ii) *Moderate Forest Consumption Dependence Group*: There are 56 households in this group. Their value of 'Forest Consumption Dependence' variable is equal or greater than 0.02, but less than 0.08.

(iii) *High Forest Consumption Dependence Group*: There are 34 households in this group, all of their value of 'Forest Consumption Dependence' variable is equal or greater than 0.08.

The numbers of households belonging to each group of Forest Consumption Dependence stratification, categorized by community, are shown in Table 5.30.

Table 5.30 Number of households categorized by community and Forest Consumption Dependence (FoCD)

Community:	High FoCD Group	Moderate FoCD Group	Low FoCD Group	All
Downstream	13	29	83	125
Relocated	5	12	37	54
Upstream	16	15	28	59
All	34	56	148	238

The last forest dependence stratification combines the income generation and consumption aspects together by using the 'Total Forest Product Dependence' variable (TFPD), which is a ratio between 'Total Forest Product Value' and 'Total Cash Income', as the measure. The percentage of households in each group in the

'Total Fish Dependence' stratification is again used as the reference in separating households under the 'Total Forest Product Dependence' stratification[47].

The details of Total Forest Product Dependence stratification can be summarized as follows:

(i) *Low Total Forest Product Dependence Group*: There are 144 households in this group, all of them have the value of 'Total Forest Product Dependence' variable less than 0.05.

(ii) *Moderate Total Forest Product Dependence Group*: There are 73 households in this group. Their value of 'Total Forest Product Dependence' variable is equal or greater than 0.05, but less than 0.88.

(iii) *High Total Forest Product Dependence Group*: There are 21 households in this group, all of them have the value of 'Total Forest Product Dependence' variable equal or greater than 0.85.

The numbers of households belonging to each group of Total Forest Product Dependence stratification, categorized by community, are shown in Table 5.31.

[47]The number of households in the Low, Moderate, and High Total Fish Dependence Groups is 58.7%, 32.4%, and 8.9% of total number of households, respectively. There are 238 households that have 'Total Forest Product Dependence' value. Hence, numbers of households in the Low, Moderate, and High Forest Consumption Dependence Groups would be 140 households, 77 households, and 21 households, respectively. After separating households into the Low and Moderate Dependence groups, there are 4 households in the Moderate Dependence group that have the same values of TFPD as households in the Low Dependence group (TFPD = 0.04). Hence, these 4 households are moved to the Low Dependence group.

Table 5.31 Number of households categorized by community and Total Forest Product Dependence (TFPD)

Community:	High TFPD Group	Moderate TFPD Group	Low TFPD Group	All
Downstream	1	29	95	125
Relocated	3	20	31	54
Upstream	17	24	18	59
All	21	73	144	238

5.5.2 Descriptive statistics for the four forest dependence stratifications

For each of the four forest dependence stratifications, the descriptive statistics of fifteen variables are calculated. Tables 5.32, Table 5.33, Table 5.34 and Table 5.35 report the mean values (or percentage in the case of dummy variables) for each variable.

In the 'Total Forest Product Value Stratification', Table 5.32, the High Dependence Group has the highest 'Forest Revenue Dependence' and highest 'Total Forest Product Dependence', but its 'Forest Consumption Dependence' is relatively low. These statistics imply that this group heavily relies on forest products as source of income rather than for self-consumption. This High Dependence group also has the highest average value of 'Total Cash Income'. When examine the mean values of income components, the stratification shows that the High TFPV group has highest mean values of both Fishery Income and Forestry Income, both generated from CPRs.

Table 5.32 Total Forest Product Value Stratification: Descriptive statistics

Variables:	High TFPV Group	Moderate TFPV Group	Low TFPV Group
Total Forest Product Value	$1,297.42 *(43)*	$242.00 *(34)*	$20.03 *(191)*
Forest Revenue Dependence	0.62 *(39)*	0.27 *(28)*	0.01 *(171)*
Forest Consumption Dependence	0.08 *(39)*	0.22 *(28)*	0.03 *(171)*
Total Forest Product Dependence	0.70 *(39)*	0.50 *(28)*	0.05 *(171)*
Fishery Income	$258.66 *(39)*	$183.38 *(29)*	$90.08 *(176)*
Farm Income	$104.93 *(43)*	$155.20 *(34)*	$221.53 *(191)*
Forestry Income	$1,213.45 *(43)*	$161.95 *(34)*	$4.35 *(191)*
Livestock Income	$379.76 *(43)*	$612.75 *(34)*	$423.98 *(191)*
Other Income	$464.55 *(43)*	$574.94 *(34)*	$1,019.78 *(191)*
Total Cash Income	$2,401.03 *(39)*	$1,783.83 *(29)*	$1,917.96 *(125)*
Latrine	18.6% *(43)*	14.7% *(34)*	33.7% *(190)*
Farm Size	3.23 ha *(43)*	3.72 ha *(34)*	2.95 ha *(190)*
HQI	1.26 *(42)*	1.53 *(34)*	1.42 *(186)*
Female Headed Household	11.6% *(43)*	3.0% *(33)*	9.5% *(189)*
Adult Equivalent	5.35 *(42)*	5.30 *(32)*	4.89 *(189)*

Note: number of observations in parentheses.

The 'Forest Revenue Dependence Stratification', in Table 5.33, classifies households based on the share of 'Forestry Income' in 'Total Cash Income'. The descriptive statistics show that the High Dependence Group has highest average values in all four Forest Dependence Variables. When consider all income components, the High Dependence Group also has highest average value of 'Forestry Income', as one might expect. However, its average values of other income components are the lowest among three groups, and this High Dependence Group is also the poorest group based on its average 'Total Cash Income'. Moreover, this High Forest Revenue Dependence Group also has the worst position in terms of all assets: the lowest percentage of households with latrines, smallest size of farm land, and lowest House Quality Index. These findings suggest that the group which depends the most on forest products for income generation is the poorest group judging by both cash income and assets.

Table 5.33 Forest Revenue Dependence Stratification: Descriptive statistics

Variables:	High FoRD Group	Moderate FoRD Group	Low FoRD Group
Total Forest Product Value	$1,113.49 *(18)*	$1,160.11 *(18)*	$96.22 *(202)*
Forest Revenue Dependence	0.96 *(20)*	0.63 *(27)*	0.03 *(218)*
Forest Consumption Dependence	0.16 *(18)*	0.12 *(18)*	0.05 *(202)*
Total Forest Product Dependence	1.12 *(18)*	0.76 *(18)*	0.08 *(202)*
Fishery Income	$19.90 *(20)*	$107.22 *(27)*	$145.30 *(218)*
Farm Income	$17.20 *(20)*	$29.67 *(27)*	$238.28 *(218)*
Forestry Income	$1,028.16 *(20)*	$1,116.04 *(27)*	$58.68 *(218)*
Livestock Income	$4.60 *(20)*	$243.96 *(27)*	$540.65 *(218)*
Other Income	$13.93 *(20)*	$261.58 *(27)*	$1,013.89 *(218)*
Total Cash Income	$1,083.79 *(20)*	$1,758.47 *(27)*	$1,996.81 *(218)*
Latrine	10.0% *(20)*	14.8% *(27)*	35.0% *(217)*
Farm Size	2.34 ha *(20)*	3.09 ha *(27)*	3.13 ha *(217)*
HQI	1.29 *(19)*	1.61 *(27)*	1.42 *(213)*
Female Headed Household	10.0% *(20)*	11.5% *(26)*	9.3% *(215)*
Adult Equivalent	6.0 *(20)*	4.58 *(26)*	4.91 *(214)*

Note: number of observations in parentheses.

On the other hand, the group with the highest 'Total Cash Income' is the Low Forest Revenue Dependence Group. Its average values of all four Forest Dependence Variables are the lowest among three groups. This group has substantially higher 'Farm Income', 'Livestock Income', and 'Non-agricultural Income' compared to the other two groups.

The 'Forest Consumption Dependence Stratification', in Table 5.34, classifies households according to the share of consumption value of forest products in total cash income. The average value of 'Forest Consumption Dependence' variable for the High Dependence Group is much higher than that of the other two groups; in which average consumption value of forest products for this group is approximately equal to 36% of its total cash income, while it is 3% and 0.3% of total cash income respectively for the Moderate and Low Dependence Groups. Based on the Income Variables, the High Forest Consumption Dependence Group is clearly the poorest one among all three groups. Its 'Total Cash Income' is much lower than that of the other two groups, and this pattern holds for other income components as well. The descriptive statistics show a similar story on the asset variables: the High Dependence Group has smallest average size of farm land, lowest percentage of households with latrines, and lowest value of the House Quality Index. These findings thus suggest that the group that depends the most on forest products for self-consumption is the poorest one.

Table 5.34 Forest Consumption Dependence Stratification: Descriptive statistics

Variables:	High FoCD Group	Moderate FoCD Group	Low FoCD Group
Total Forest Product Value	$326.97 *(34)*	$304.97 *(56)*	$217.33 *(148)*
Forest Revenue Dependence	0.31 *(34)*	0.17 *(56)*	0.10 *(148)*
Forest Consumption Dependence	0.36 *(34)*	0.03 *(56)*	0.003 *(148)*
Total Forest Product Dependence	0.67 *(34)*	0.21 *(56)*	0.10 *(148)*
Fishery Income	$9.31 *(34)*	$249.46 *(56)*	$114.69 *(148)*
Farm Income	$44.96 *(34)*	$194.31 *(56)*	$250.44 *(148)*
Forestry Income	$199.37 *(34)*	$246.90 *(56)*	$209.24 *(148)*
Livestock Income	$137.06 *(34)*	$581.16 *(56)*	$494.68 *(148)*
Other Income	$154.36 *(34)*	$598.80 *(56)*	$1,206.22 *(148)*
Total Cash Income	$545.06 *(34)*	$1,870.63 *(56)*	$2,275.27 *(148)*
Latrine	17.6% *(34)*	28.6% *(56)*	35.4% *(147)*
Farm Size	2.63 ha *(34)*	3.34 ha *(55)*	3.01 ha *(148)*
HQI	1.23 *(31)*	1.44 *(55)*	1.46 *(147)*
Female Headed Household	8.8% *(34)*	3.6% *(55)*	11.6% *(146)*
Adult Equivalent	5.04 *(34)*	5.66 *(54)*	4.77 *(146)*

Note: number of observations in parentheses.

Lastly, the 'Total Forest Product Dependence Stratification' is presented in Table 5.35. In this case, households are classified according to the share of 'Total Forest Product Value' in 'Total Cash Income'. The descriptive statistics show similar patterns as in the 'Forest Revenue Dependence Stratification' and 'Forest

Consumption Dependence Stratification', in which the High Dependence Group has highest average values of all four Forest Dependence Variables. This group is also the poorest group among all three groups, judging from both income aspect and asset aspect.

Table 5.35 Total Forest Product Dependence Stratification: Descriptive statistics

Variables:	High TFPD Group	Moderate TFPD Group	Low TFPD Group
Total Forest Product Value	$993.83 *(21)*	$504.58 *(73)*	$18.44 *(144)*
Forest Revenue Dependence	0.88 *(21)*	0.22 *(73)*	0.001 *(144)*
Forest Consumption Dependence	0.35 *(21)*	0.09 *(73)*	0.007 *(144)*
Total Forest Product Dependence	1.22 *(21)*	0.31 *(73)*	0.008 *(144)*
Fishery Income	$18.95 *(21)*	$147.45 *(73)*	$139.57 *(144)*
Farm Income	$14.84 *(21)*	$92.07 *(73)*	$294.74 *(144)*
Forestry Income	$910.27 *(21)*	$438.20 *(73)*	$3.25 *(144)*
Livestock Income	$6.28 *(21)*	$337.78 *(73)*	$594.64 *(144)*
Other Income	$28.67 *(21)*	$420.58 *(73)*	$1,291.65 *(144)*
Total Cash Income	$979.01 *(21)*	$1,436.07 *(73)*	$2,323.85 *(144)*
Latrine	9.5% *(21)*	23.3% *(73)*	38.5% *(143)*
Farm Size	2.39 ha *(21)*	2.97 ha *(73)*	3.16 ha *(143)*
HQI	1.15 *(20)*	1.37 *(70)*	1.49 *(143)*
Female Headed Household	9.5% *(21)*	8.2% *(73)*	9.9% *(141)*
Adult Equivalent	5.74 *(21)*	4.84 *(70)*	5.00 *(143)*

Note: number of observations in parentheses.

A consistent story emerges from this analysis of Forest Dependence Stratifications, in which households that depend highly on forest products for income, consumption, or both tend to be considerably poorer than the households in the Moderate or Low Dependence Groups.

5.6 A statistical analysis of forest dependence

In this section, correlation analysis and multiple regression analysis are used to investigate further the relationship between forest dependence and livelihoods of households located in each community around the Lower Sesan 2 hydropower project.

5.6.1 Correlation analysis

A correlation matrix is generated for each community in order to observe the correlation coefficients among 15 variables. Table 5.36, Table 5.37, and Table 5.38 present the matrixes for each of the three communities. Noteworthy correlation coefficients include the following:

(i) Correlation between 'Forest Revenue Dependence' (FoRD) and 'Forest Consumption Dependence' (FoCD)

This correlation coefficient equals -0.01 for downstream community, 0.05 for relocated community, and 0.002 for upstream community. The weak value of these coefficients suggests that, in all three communities, the group of households that highly depends on forest product for cash income is distinct from the group of households that highly depends on forest products for consumption. This finding is similar to the finding in Fish Dependence Correlation Analysis, in which the values of correlation coefficients between 'Fish Income Dependence' and 'Fish Consumption Dependence' are weakly negative. In the next section, the regression model will be estimated separately for Forest Revenue Dependence and for Forest Consumption Dependence.

(ii) Correlation between 'Total Cash Income' (Ytotal) and 'Forest Consumption Dependence' (FoCD)

This correlation coefficient equals -0.23 for downstream community, and -0.22 for both the relocated community and the upstream community. The negative value of the coefficients means that households that depend more on forest product for consumption tend to have lower cash incomes.

(iii) Correlation between 'Total Cash Income' (YTotal) and 'Forest Revenue Dependence' (FoRD)

The correlation coefficients for the downstream community and the relocated community are very weak, at the value of -0.01 and 0.03 respectively. On the other hand, the coefficient correlation is stronger, at the value of -0.20, for the upstream community, indicating that in this community low values of 'Total Cash Income' are associated with high values of 'Forest Revenue Dependence'.

(iv) Correlation between 'Total Cash Income' (YTotal) and 'Total Forest Product Dependence' (TFPD)

This correlation coefficient equals -0.11 for the downstream community, -0.07 for the relocated community, and -0.30 for the upstream community. Though all the correlation coefficients are negative, the strongest one is the correlation coefficient for upstream community. The negative value indicates that low values of 'Total Cash Income' are associated with high values of 'Total Forest Product Dependence'.

Table 5.36 Correlation matrix of the downstream community

Downstream (Observation = 118 HHs)		Forest Dependence				Income						Asset			Demographic	
		TFPV	*FoRD*	*FoCD*	*TFPD*	*YFish*	*YFarm*	*YForest*	*YLives*	*YOther*	*YTotal*	*Latrine*	*Farm*	*HQI*	*Fem*	*AdultE*
Forest Dependence	*TFPV*	1.00														
	FoRD	0.68	1.00													
	FoCD	0.09	-0.01	1.00												
	TFPD	0.65	0.90	0.42	1.00											
Income	*YFish*	-0.02	-0.04	-0.05	-0.06	1.00										
	YFarm	-0.03	-0.09	-0.13	-0.13	-0.05	1.00									
	YForest	0.98	0.69	-0.03	0.61	-0.02	-0.02	1.00								
	YLives	0.17	-0.02	-0.10	-0.06	-0.07	0.44	0.14	1.00							
	YOther	-0.10	-0.13	-0.17	-0.20	-0.16	-0.13	-0.10	0.01	1.00						
	YTotal	0.16	-0.01	-0.23	-0.11	-0.08	0.21	0.16	0.49	0.84	1.00					
Asset	*Latrine*	0.07	0.03	-0.003	0.02	-0.05	-0.03	0.07	0.19	0.15	0.22	1.00				
	Farm	0.07	-0.02	0.12	0.03	-0.08	0.25	0.04	0.19	0.03	0.14	0.16	1.00			
	HQI	0.14	0.14	-0.08	0.09	-0.04	0.11	0.14	0.38	0.02	0.21	0.29	0.09	1.00		
Demographic	*Fem*	-0.07	-0.08	-0.11	-0.12	0.03	-0.13	-0.06	-0.11	-0.04	-0.11	-0.02	-0.01	-0.08	1.00	
	AdultE	0.01	0.01	0.21	0.10	-0.05	0.18	-0.01	0.02	0.02	0.05	0.13	0.37	0.14	0.10	1.00

Table 5.37 Correlation matrix of the relocated community

Relocated (Observation = 52 HHs)		Forest Dependence				Income						Asset			Demographic	
		TFPV	*FoRD*	*FoCD*	*TFPD*	*YFish*	*YFarm*	*YForest*	*YLives*	*YOther*	*YTotal*	*Latrine*	*Farm*	*HQI*	*Fem*	*AdultE*
Forest Dependence	*TFPV*	1.00														
	FoRD	0.72	1.00													
	FoCD	0.004	0.05	1.00												
	TFPD	0.63	0.90	0.48	1.00											
Income	*YFish*	0.37	0.12	-0.08	0.07	1.00										
	YFarm	-0.12	-0.19	-0.08	-0.20	-0.05	1.00									
	YForest	0.997	0.71	-0.05	0.60	0.36	-0.11	1.00								
	YLives	-0.13	-0.25	-0.12	-0.27	0.08	0.14	-0.14	1.00							
	YOther	-0.09	-0.23	-0.15	-0.26	-0.19	-0.03	-0.08	-0.10	1.00						
	YTotal	0.40	0.03	-0.22	-0.07	0.34	0.42	0.40	0.42	0.58	1.00					
Asset	*Latrine*	0.17	-0.02	-0.07	-0.05	0.31	-0.15	0.18	-0.0003	0.01	0.11	1.00				
	Farm	-0.10	-0.17	-0.12	-0.20	-0.06	0.43	-0.09	0.20	0.16	0.31	-0.08	1.00			
	HQI	-0.11	-0.06	-0.21	-0.14	-0.003	-0.08	-0.10	0.12	-.17	0.07	0.11	-0.03	1.00		
Demographic	*Fem*	0.06	0.10	-0.10	0.05	0.16	-0.07	0.07	-0.06	-0.10	-0.04	0.22	0.07	-0.01	1.00	
	AdultE	0.03	0.06	-0.07	0.03	0.17	0.11	0.03	0.13	-0.003	0.15	0.09	0.23	-0.12	0.11	1.00

Table 5.38 Correlation matrix of the upstream community

Upstream (Observation = 55 HHs)		Forest Dependence				Income						Asset			Demographic	
		TFPV	*FoRD*	*FoCD*	*TFPD*	*YFish*	*YFarm*	*YForest*	*YLives*	*YOther*	*YTotal*	*Latrine*	*Farm*	*HQI*	*Fem*	*AdultE*
Forest Dependence	*TFPV*	1.00														
	FoRD	0.63	1.00													
	FoCD	-0.10	0.002	1.00												
	TFPD	0.38	0.72	0.70	1.00											
Income	*YFish*	-0.11	-0.25	-0.08	-0.23	1.00										
	YFarm	-0.12	-0.25	-0.11	-0.25	0.37	1.00									
	YForest	0.99	0.65	-0.14	0.36	-0.15	-0.14	1.00								
	YLives	-0.11	-0.36	-0.11	-0.33	0.32	0.56	-0.18	1.00							
	YOther	-0.08	-0.27	-0.13	-0.28	-0.02	-0.06	-0.09	0.21	1.00						
	YTotal	0.22	-0.20	-0.22	-0.30	0.51	0.53	0.17	0.77	0.55	1.00					
Asset	*Latrine*	-0.06	-0.11	-0.11	-0.15	0.32	0.30	-0.05	0.16	0.17	0.31	1.00				
	Farm	0.09	0.01	-0.10	-0.07	0.09	0.44	0.08	0.45	0.01	0.39	0.18	1.00			
	HQI	-0.22	-0.12	-0.15	-0.19	-0.07	0.17	-0.23	0.17	-0.15	-0.06	0.11	0.32	1.00		
Demographic	*Fem*	0.10	0.05	0.13	0.12	-0.09	-0.09	0.08	-0.05	-0.03	-0.07	-0.11	-0.15	-0.05	1.00	
	AdultE	0.13	0.32	-0.11	0.15	0.02	0.27	0.11	0.19	-0.09	0.16	0.30	0.16	0.25	0.12	1.00

5.6.2 Regression analysis

Similar to the Fish Dependence Regression Analysis, regression models for Forest Dependence analysis are constructed and tested for each community. The dependent variables for the regression models are the four Forest Dependence Variables, while the independent variables are the same as in the regression analysis for Fish Dependence.

Four regression models are estimated as follows:

(i) *TFPV* = f (*Fem*, *AdultE*, *Latrine*, *Farm*, *HQI*, *YTotal*)

(ii) *FoRD* = f (*Fem*, *AdultE*, *Latrine*, *Farm*, *HQI*, *YTotal*)

(iii) *FoCD* = f (*Fem*, *AdultE*, *Latrine*, *Farm*, *HQI*, *YTotal*)

(iv) *TFPD* = f (*Fem*, *AdultE*, *Latrine*, *Farm*, *HQI*, *YTotal*)

Ordinary Least Square (OLS) method is used to test each regression model for each community separately. Tables 5.39, Table 5.40, and Table 5.41 report the estimated coefficients of independent variables from the initial models and from the best-fit models.

For the downstream community, none of the independent variables are statistically significant in the 'Total Forest Product Value' regression. This result may not be a surprise because downstream community has lowest values of the contribution of forest products on household's livelihoods, as presented earlier by the descriptive statistics in Table 5.24. A similar result is found in the second regression model, with 'Forest Revenue Dependence' as the dependent variable. Again, when we look back at the descriptive statistics in Table 5.25, households in the downstream community have a low value of 'Forest Revenue Dependence' on average. In the third regression model, both the initial model and the best-fit model show a strongly significant effect of 'Total Cash Income', with a negative value on the coefficient. This result is consistent with the negative correlation coefficient between 'Total Cash Income' and 'Forest Consumption Dependence' in the correlation analysis, and gives us another confirmation that it is the poorer households with less cash income that depend more on forest products for self-consumption. Apart from that, the regression result also suggests that households with higher 'Number of Adult Equivalent' harvest more forest products for consumption while 'Female Headed Households' tend to harvest less forest product for consumption, which suggests a gender division of labor in this community. In the last regression model with 'Total Forest Product Dependence' as dependent variable, none of the independent variables are statistically significant.

For the relocated community, the result in the first regression model suggests that households that have more 'Total Cash Income' harvest higher values of forest products; at the same time, it also shows that households with smaller 'Size of Farm Land' tend to harvest higher values of forest product as well. In the second regression model, of 'Forest Revenue Dependence', none of the independent variables are statistically significant. This is consistent with the correlation coefficient between 'Total Cash Income' and 'Forest Revenue Dependent' for this community. The third and fourth regression models that have 'Forest Consumption Dependence' and 'Total Forest Product Dependence' as dependent variables, respectively, also have no statistically significant coefficients for any of the independent variables.

For the upstream community, both the initial model and the best-fit model for the 'Total Forest Product Value' regression suggest that poorer households, judging from lower value of 'House Quality Index', harvest higher values of forest products. In the second regression, of 'Forest Revenue Dependence', the coefficient for 'Total Cash Income' is statistically significant with negative value suggesting that poorer households with less cash income depend more on forest products as source of income. Also, the coefficient for 'Adult Equivalent' is statistically significant with positive value, which means that larger families tend to depend more on forest products as source of income. In the third regression, of 'Forest Consumption Dependence', the result also suggests that poorer households, with less 'Total Cash Income', depend more on forest products for self-consumption. Finally, in the 'Total Forest Product Dependence' regression, the results show statistically stronger effects of 'Total Cash Income' and 'House Quality Index', with negative coefficients, consistent with the hypothesis that poorer households depend more on forest products than richer households. Also, the 'Adult Equivalent' is statistically significant with positive value of coefficient, suggests that larger households depend more on forest products.

Because some households have extremely high values of 'Forestry Income' variable, which might affect the results of the regression, the process of data censoring was applied to Forestry Income variable to test the robustness of these results. The censored value of Forestry Income is set to be equal to the mean value plus three times of value of standard deviation[48]. This censored value is used to substitute any values of Forestry Income that exceed it. For households whose Forestry Income variable is censored, new calculations are also done for their 'Total Cash Income' variable, 'Total Forest Product Value' variable, 'Forest Revenue Dependence' variable, 'Forest Consumption Dependence' variable, and 'Total Forest Product Dependence' variable.

The four regression models were re-estimated for each community using the censored data. What is found from this set of regression is not much different from the original regression results. For the downstream community, only in the 'Total Forest Product Dependence' regression is the result different, in that 'Total Cash Income' is now statistically significant, with a negative value of the coefficient. For the relocated community, the coefficient on 'Total Cash Income' in the 'Total Forest Product Value' regression is still positive and statistically significant, but with lower confidence level, while the results in the other three regression models are much the same. For the upstream community, the results are also little changed, except that the 'Adult Equivalent' variable in the first regression model is now statistically significant with a positive value of the coefficient.

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[48]Mean value of Forestry Income variable is $241.77. Value of Standard Deviation of Forestry Income variable is $609.47. Hence, the censored value equals to $2,070.18.

Table 5.39 Regression results for downstream community

Downstream Community								
Dependent Variables:	**TFPV**		**FoRD**		**FoCD**		**TFPD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	-68.180 (0.588)		-0.045 (0.367)	-0.044 (0.362)	-0.043* (0.064)	-0.043* (0.057)	-0.083 (0.136)	-0.082 (0.132)
- Adult Equivalent	-5.073 (0.800)		0.005 (0.549)		0.008** (0.028)	0.009*** (0.006)	0.009 (0.315)	0.009 (0.253)
Economic Variables								
- Latrine	2.191 (0.978)		-0.002 (0.941)		0.005 (0.728)		0.004 (0.909)	
- Farm Size	9.987 (0.608)		-0.003 (0.616)		0.003 (0.419)		0.0005 (0.954)	
- HQI	65.004 (0.255)	61.953 (0.238)	0.033 (0.152)	0.029 (0.156)	-0.009 (0.356)	-0.008 (0.389)	0.024 (0.338)	0.024 (0.305)
- Total Cash Income	0.024 (0.191)	0.027 (0.122)	$-2.45E^{-6}$ (0.734)		$-9.00E^{-6}$*** (0.007)	$-8.46E^{-6}$*** (0.009)	$-1.25E^{-5}$ (0.115)	$-1.22E^{-5}$ (0.112)
Constant	-35.731 (0.761)	-42.395 (0.614)	-0.007 (0.887)	0.006 (0.862)	0.017 (0.429)	0.019 (0.373)	0.023 (0.664)	0.022 (0.666)
Observations	122	126	128	131	118	119	118	119
R-squared	0.0440	0.0376	0.0309	0.0231	0.1371	0.1305	0.0534	0.0529
Adjusted R-squared	-0.0059	0.0219	-0.0171	0.0079	0.0904	0.1000	0.0022	0.0197
Prob > F	0.5107	0.0949	0.6952	0.2235	0.0106	0.0029	0.4011	0.1812
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

Table 5.40 Regression results for relocated community

Relocated Community								
Dependent Variables:	**TFPV**		**FoRD**		**FoCD**		**TFPD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	222.388 (0.598)		0.064 (0.636)		-0.044 (0.522)		0.079 (0.617)	
- Adult Equivalent	-9.285 (0.877)		0.009 (0.657)		-0.003 (0.788)		0.009 (0.690)	
Economic Variables								
- Latrine	274.845 (0.433)		-0.081 (0.503)		-0.004 (0.944)		-0.068 (0.604)	
- Farm Size	-70.155* (0.091)	-72.229* (0.062)	-0.018 (0.202)	-0.012 (0.338)	-0.002 (0.711)		-0.023 (0.142)	-0.019 (0.155)
- HQI	-240.586 (0.216)	-214.624 (0.241)	0.034 (0.599)		-0.044 (0.166)	-0.042 (0.156)	-0.066 (0.369)	-0.068 (0.316)
- Total Cash Income	0.215*** (0.001)	0.220*** (0.000)	$1.62E^{-5}$ (0.455)		$-1.25E^{-5}$ (0.222)	$-1.39E^{-5}$ (0.124)	$1.97E^{-6}$ (0.933)	
Constant	562.948 (0.237)	531.228 (0.120)	0.119 (0.460)	0.228*** (0.000)	0.168** (0.033)	0.139*** (0.008)	0.347* (0.056)	0.383*** (0.003)
Observations	52	54	59	63	52	54	52	54
R-squared	0.2545	0.2350	0.0441	0.0151	0.1039	0.0879	0.0739	0.0565
Adjusted R-squared	0.1551	0.1891	-0.0662	-0.0011	-0.0156	0.0521	-0.0495	0.0195
Prob > F	0.0322	0.0036	0.8759	0.3377	0.5247	0.0959	0.7296	0.2268
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

Table 5.41 Regression results for upstream community

Upstream Community								
Dependent Variables:	**TFPV**		**FoRD**		**FoCD**		**TFPD**	
Independent Variables:	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*	*Initial Model*	*Best-Fit Model*
Demographic Variables								
- Female Headed HH	166.738 (0.565)		0.039 (0.821)		0.164 (0.402)		0.119 (0.643)	
- Adult Equivalent	50.774 (0.244)	45.278 (0.269)	0.088*** (0.003)	0.083*** (0.002)	-0.010 (0.733)		0.083** (0.037)	0.084** (0.025)
Economic Variables								
- Latrine	-295.088 (0.305)	-280.657 (0.265)	-0.130 (0.455)	-0.158 (0.306)	0.008 (0.966)		-0.191 (0.452)	-0.287 (0.202)
- Farm Size	24.578 (0.549)		0.015 (0.568)		0.012 (0.665)		-0.044 (0.234)	0.043 (0.232)
- HQI	-232.873* (0.086)	-210.648* (0.091)	-0.115 (0.175)	-0.095 (0.228)	-0.102 (0.268)	-0.095 (0.229)	-0.286** (0.020)	-0.279** (0.020)
- Total Cash Income	0.079 (0.177)	0.076 (0.129)	$-6.66E^{-5}$* (0.080)	$-6.35E^{-5}$* (0.051)	$-6.17E^{-5}$ (0.130)	$-5.39E^{-5}$* (0.011)	$-1.44E^{-4}$*** (0.009)	$-1.40E^{-4}$*** (0.005)
Constant	308.463 (0.216)	383.248 (0.104)	0.167 (0.283)	0.195 (0.187)	0.351** (0.041)	0.333*** (0.009)	0.557** (0.014)	0.550** (0.011)
Observations	56	58	62	64	55	57	55	57
R-squared	0.1462	0.1202	0.1988	0.1817	0.0935	0.0733	0.2426	0.2392
Adjusted R-squared	0.0416	0.0538	0.1114	0.1262	-0.0198	0.0390	0.1479	0.1646
Prob > F	0.2345	0.1405	0.0485	0.0172	0.5562	0.1279	0.0311	0.0136
Variable significance: *α=.10; **α=.05; ***α=.01; p-value in parentheses.								

5.7 The relationship between forest dependence and fish dependence

Our analysis of fish dependence and forest dependence stratifications, in this chapter and the preceding one, has shown that, across the study area, the households that highly depend most on these two threatened common pool resources are tend to be the poorest groups. This section investigates whether the households that highly depend on fish are the same as those who highly depend on the forest, and whether the relationship between the two is the same for within each community.

The results from the fish dependence and forest dependence stratifications indicate that the households that highly depend on one CPR tend to have the lowest income generated from the CPR. The High FID group, the High FCD group, and the High TFD group all have the lowest Forestry Income, while the High FoRD, group, the High FoCD group, and the High TFPD group all have the lowest Fishery Income, among their respective stratifications. Further investigation here will focus on the combined income and consumption from CPRs, analyzing Total Fish Dependence (TFD) and Total Forest Product Dependence (TFPD) in relation to Total Cash Income (YTotal). The mean values of all three variables are presented in Table 5.42.

Table 5.42 Average values of fish dependence, forest dependence, and income

Community:	TFD	TFPD	Total Cash Income (Unit: US$)
Downstream	0.44 *(120)*	0.07 *(125)*	1,954.94 *(140)*
Relocated	0.29 *(51)*	0.21 *(54)*	2,260.76 *(63)*
Upstream	1.06 *(54)*	0.50 *(59)*	1,299.10 *(68)*
All	0.55 *(225)*	0.21 *(238)*	1,861.47 *(271)*

Note: number of observations in parentheses.

In all three communities, the mean values of TFD are higher than those of the TFPD, indicate the higher dependence on fish in general for all community. The upstream community, which is the poorest community among all, has the highest average values of both TFD and TFPD. Another noteworthy finding is that the difference between the mean values of TFD and TFPD is largest for the upstream community, and this difference becomes smaller in the richer communities.

Correlation coefficients are used to investigate the association between households that depend highly on fish and households that depend highly on forest. The correlation between Total Cash Income (YTotal) and level of fish and forest dependences are revisited here as well. Table 5.43, Table 5.44, and Table 5.45 present correlation matrices for each of the three communities, and the correlation matrix for all households across the study area is presented in Table 5.46.

Table 5.43 Correlation matrix for downstream community

Downstream (n = 110 HHs)	TFD	TFPD	YTotal
TFD	1.000		
TFPD	0.051	1.000	
YTotal	-0.285	-0.117	1.000

Table 5.44 Correlation matrix for relocated community

Relocated (n = 45 HHs)	TFD	TFPD	YTotal
TFD	1.000		
TFPD	-0.044	1.000	
YTotal	-0.237	-0.099	1.000

Table 5.45 Correlation matrix for upstream community

Upstream (n = 48 HHs)	TFD	TFPD	YTotal
TFD	1.000		
TFPD	-0.083	1.000	
YTotal	-0.139	-0.346	1.000

Table 5.46 Correlation matrix for all households across the study area

All (n = 203 HHs)	TFD	TFPD	YTotal
TFD	1.000		
TFPD	-0.006	1.000	
YTotal	-0.127	-0.191	1.000

The correlation coefficients between Total Cash Income and TFD for each community and for households across the study area all have negative values, consistent with the hypothesis that poorer households tend to depend more on fish to support their livelihoods. Similar results are found for the correlation coefficients between Total Cash Income and TFPD.

The correlation coefficients between TFD and TFPD in all three communities, as in the study area as a whole, are very weak. This indicates that the groups of households that highly depend on fish are distinct from the groups of households that highly depend on forest products. Also, it implies that if one interested in the contribution of CPRs in the livelihoods of rural households, it is not enough to look at the role of fishery or forest products alone.

5.8 Discussion of the results

The descriptive statistics from the 'Forest Product Dependence Stratifications' provide insights on the attributes of households across the study area that rely differently on forest products. The results from 'Forest Revenue Dependence', 'Forest Consumption Dependence' and 'Total Forest Product Dependence' stratifications suggest that households that depend heavily on forest products for both income generation and consumption tend to be the poorest in the area, whether looking from the cash income aspect or the asset aspect. This finding is similar to the findings from 'Fish Dependence Stratifications' in the previous chapter.

Households in the relocated community, which have highest average forestry income and total cash income, also have highest average 'Total Forest Product Value'. When we look at the details on types and average values of forest products harvested and sold by this community, the data show that apart from timber, which has very high market value, wildlife (wild birds and wild animals) and non-timber forest products (honey and resin) are also important in terms of contributing to households' forestry income. At the same time, the numbers of households in this community that report selling wildlife are higher than the other two communities, suggesting that wildlife is more abundant in this community. It is also possible that these households are highly engaged in illegal hunting. The regression results indicate that households with high cash income, as well as households that own smaller size of farm land, tend to harvest greater values of forest products. Correlation coefficients show the association between high forest consumption dependence and low cash income, but there is no confirmation of that relationship in the regression analysis.

Households in the upstream community are the poorest among all three communities. The descriptive statistics show that they have highest average consumption value of forest products, Forest Revenue Dependence, Forest Consumption Dependence and Total Forest Product Dependence. Households in this community engage the most in harvesting and selling timber, which is the main contribution in their forestry revenue. This information raises a question about whether it is all legal timber harvest. High numbers of households that consume rattan and bamboo also suggest the importance of these two timber forest products in household livelihoods, as well as the abundance of these products.

The regression analysis for this community shows the strongest results, all of which consistent with each other. The poorest households in this community are the ones that harvest greater value of forest products, and also depend more on forest products for both income generation and consumption. The level of significance is even higher when Forest Revenue Dependence and Forest Consumption Dependence are combined. The case of upstream community thus provides strong evidence to support the argument that poorer households rely more on CPRs.

Households in the downstream community engage the least in harvesting forest products. They have the lowest average value of forestry income as well as the lowest consumption value of forest products, hence their average Total Forest Product Value is also the lowest and it is less than the other two communities by substantial margin. Descriptive statistics for the other three Forest Product

Dependence variables also show similar results. In terms of statistical analysis, the regression result from Forest Consumption Dependence model again shows that it is the poorer households, as well as larger households, that depend more on forest products for household consumption. The result also shows a gender division of labor, as female headed households tend to depend less on harvesting forest products for consumption.

Another noteworthy result is that, when comparing average values of Forest Revenue Dependence (FoRD) to average values of Forest Consumption Dependence (FoCD), the former is higher than the latter for every community. This is opposite to what was found in the Fish Dependence analysis, in which the average value of Fish Income Dependence (FID) is less than the average value of Fish Consumption Dependence (FCD) in every community. It suggests that, in general, forest products are more important to households' livelihoods on the income aspect, while the significance of fishery products is more important on the consumption aspect.

The results from both Fish Dependence and Forest Dependence Stratification indicate that, across the study area, the groups of households that highly depend on fish and forest are the poorest group in their respective stratification. Examination of the correlations between Fish Dependence and Forest Dependence reveals that the group of households that highly depends on fish is distinct from the group of households that highly depends on forest products. This held true for all households across the study area, as well as for households within each community. This finding justifies the separation of fish and forest in our analysis. A full picture of patterns of CPR dependence can be obtained only by studying both.

5.9 Conclusion

As another common pool resource in the Lower Sesan 2 project area, the forest supplies rural villagers with several products that serve as a safety net for their subsistence. The upland areas of Stung Treng province are known for the existence and practice of traditional community forest which gives villagers free access and use of forest products. After the new Land Law was adopted in 2001, some parts of community forest areas have been taken away and allocated into private hands under the Economic Land Concessions. The proposed Lower Sesan 2 hydropower project adds another threat to the livelihoods of population in the area, since it will inundate thousands hectares of forest land.

This study finds that the groups of households that depend the most on forest products for income, for household consumption, and for both combined, tend to be the poorest among all households in the project area. However, these forest dependence livelihoods are not recognized or being compensated by the project developer. Moreover, future plans on using community forest in the resettlement areas are uncertain, and may be threatened by the Economic Land Concession policy.

Overall, these findings on forest dependence are consistent with the findings of our analysis of fish dependence. The livelihoods of poorer households depend most heavily on CPRs, hence they are more vulnerable when losing access to CPRs. The analysis of forest dependence, together with the fish dependence analysis, provides a disturbing picture on the prospective losses in the CPR-based livelihoods due to the implementation of the Lower Sesan 2 hydropower project.

CHAPTER 6

CONCLUSION

This dissertation assesses the significance contribution of two threatened common pool resources, fish and forest, in the livelihoods of the rural poor in Stung Treng province of Cambodia. When the importance of common pool resources for rural livelihoods is not realized or considered by policy makers, natural resource-based economic development policies may end up exacerbating the problems of income inequality and poverty. Benefits from the Lower Sesan 2 hydropower project for economic development and poverty alleviation are often cited by the Cambodian government to justify the project, despite the fact that it would substantially reduce the amount of fish stock in the Mekong River Basin. Fish is a crucial common pool resource for the rural poor in this area, and this project would definitely impose changes on fishery benefits to the locals. Before this particular hydropower project was proposed, villagers in the area already faced the decline of community forests, another significant common pool resource, due to Economic Land Concessions under the national policy to promote agro-industrial business.

In Chapters 4 and 5, I start by using descriptive statistics to capture the overall characteristics, as well as to compare the differences among households situated in three communities that will be impacted by the project. I find that, on average, the contribution of fish in household livelihoods is higher than that of the forest products across the study area, as well within each community. A closer look at fish dependence variables and forest dependence variables reveals that the contribution of fish goes towards household consumption more than generating cash income, while it is the opposite in the case of forest products.

Examining descriptive statistics through different fish and forest dependence stratifications provides further insight on the characteristics and economic status of households across the study area whose livelihoods depend on fish and forest products in different respects and to different degrees. The main conclusion drawn from the analyses is that, across the study area, households that heavily extract and highly depend on these two common pool resources tend to be the poorest groups. Further investigation using correlation coefficients reveals that the group of households that highly depends on forest products is distinct from the group of households that highly depends on fish.

Households located in three different communities are facing different challenges from the construction of Lower Sesan 2 hydropower project, as well as from the decline of community forest areas due to Economic Land Concessions. In addition, within the same community, the magnitude of the impacts from these two policies that each household would bear is also different and closely linked to how much their livelihoods rely on fish and forest products. Generally, households that heavily depend on common pool resources, either for income generation or self-consumption, are more vulnerable to the changes in quality of common pool resources or the restriction in accessing and utilizing common pool resources.

Correlation analysis and regression analysis are used in order to identify more precisely which households in each community are more vulnerable towards the changes in these two common pool resources. Households in the relocated community would face the most extreme change in their livelihoods as they are forced to abandon their villages and move to the new resettled sites. This group of households tend to be relatively richer compared to households in the other two communities, and their average values of household cash income generated from fish and forest products are also higher compared to households in the other two communities. On average, income generated from fish and forest products account for 10% and 18% of their total cash income, respectively. As for the contributions of fish and forest products towards direct household consumption, on average, these were equivalent to 23% and 4% of their total cash income, respectively.

Regression results suggest that losing their current fisheries activities will affect the richer households greatly via the loss of income, while the poorer households are more likely to face a threat to their food security. As for forest dependence, it is found that richer households, as well as households that have relatively smaller size of farm land, tend to harvest greater values of forest products. How their living situation would be in the new resettlement site is still uncertain. The location of the resettlement site, which is farther away from the river, concerns the villagers on how they could maintain their fishery livelihoods. In addition, the existing Economic Land Concession policy will still be a threat on their opportunity to rely on community forest in the new resettlement site.

The upstream community is located farthest from the provincial capital, and has the longest distance to the market. This might be part of the explanation for their largely self-sufficient livelihoods. It is the poorest community, and the differences among households within this community in terms of cash income and farm size are relatively small compared to those in the other two communities. In general, households in this community are found to heavily rely on both fish and forest products for their livelihoods. On average, incomes generated from fish and forest products account for 6% and 37% of their total cash income, respectively. In terms of their dependence for self-consumption, on average, the values of fish and forest products are equivalent to 101% and 15% of their total cash income, respectively. Regression analysis shows that the poorer households in this community depend on forest products more than the richer households, while the richer households depend on fish more than the poorer households.

The location of the downstream community is closer to the provincial capital, and this opens up opportunities for households in this community to seek employment outside the agricultural sector. On average, the contribution of incomes generated from fish and forest products towards household total cash income are at 7% and 5%, respectively. The average valuations of fish and forest products consumed by household are found to be equivalent to 39% and 3% of their total cash income. Despite the fact that households in this community are less dependent on both fish and forest products compared to households in the other two communities, results from regression analyses reveal strong evidence that it is the poorer households in this community that depend on both fish and forest products for self-consumption more than the richer households. Hence, the poorer households in this community would be hardest hit from the decline of fish stock and community forest areas.

The contributions of community forest in household's livelihoods are not at all recognized by the developer of the Lower Sesan 2 hydropower project, as there is no mention of compensation on losses of forest products to be offered to villagers in the relocated community. As for the fishery losses, based on the latest available information, no compensation is to be offered to households located in the downstream community. The relocated households as well as households located in some areas upstream of the Lower Sesan 2 hydropower project are offered lump-sum money to compensate for one-year loss of fishery products, though the amount of it is not yet clear.

The losses of benefits from common pool resources, even when they contribute a modest percentage in household income, can be critical for poor households that live close to the survival line, particularly since rural households also rely on those resources for their food security, as documented in this dissertation. It is important that the households impacted by the Lower Sesan 2 hydropower project are provided with compensation and supporting income generation programs that can at least, if not more, sufficiently substitute for their losses of common pool resource-based income. In addition, due to the significant contribution of fish to households' direct consumption, especially for the poorer households, a supporting program must be created to ensure household food security in the post-dam period.

More importantly, if the target of development is to reduce poverty in local communities, these supporting programs on income generation and food security should not limit local access to common pool resources or degrade the environment, as this dissertation has shown the importance of common pool resources to the poor's livelihoods. To follow the goal and purpose of pro-poor development, the protection of common pool resources can be a key for an alternative development approach to secure livelihoods of the rural poor and alleviate local poverty.

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