POST IMPACT ASSESSMENT OF HYDROPOWER PROJECT ON FISHERIES: A CASE OF THE THUEN-HINBOUN HYDROPOWER PROJECT, LAO PEOPLE'S DEMOCRATIC REPUBLIC

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ABSTRACT

The study aimed to assess the impact of the Thuen-Hinboun Hydropower Project (THHP) on fishery since the project operation over the last 12 years from 1998 to 2010. One village in head-pond at Nam Thuen River and two villages in the Recipient River areas alongside upper and lower Nam Hai River were selected for this comparative study through review of reports and household interview conducted with 78 households in these three study villages.

The result of field research shows that before the project, selling of the fish catch was the supplementary income for all study villages. Currently the amount of fish catch is much less when compared to the past. Post-THHP amount of fish catch per household in the study villages has substantially declined in the range of 49-85%. There are several causes for such reductions in fish catch as indicated by the respondents interviewed. Namely, destructive fishing methods employed are believed by 25.6% of the households; followed by the hydrological change by 23.1%; and by

population growth by 21.8%. Apart from the quantity change, the composition of fish caught has also changed. In the head-pond area, only 42 species are found now by the villagers, as compared to 79 fish species available previously in the Nam Thuen River. In recipient river areas, only 68 species are found now, reduced from 118 fish species found earlier in the Nam Hai River. These changes can be affected by the project in many ways, such as loss of fish habitat due to increased water level and rapids being submerged in the head-pond area. In the recipient river areas, the project has changed the hydrologic regime and submerged fish habitat areas from erosion of the embankments, sediment deposits along the river bottom covering food sources, and filling of bottom pools along the Nam Hai River as possible reason for loss of some fish species. However, in order to assess all the relevant factors of reduction in fish species, future research is recommended to identify project impacts from both construction and operation phases of dams.

To mitigate the impact and improve fisheries for affected villages, fishery management such as stocking and introduction of aquaculture and cage culture has been reviewed and recommended. Designs of appropriate fish passage type in the dam site need more research to select a suitable type of fish pass for the Thuen River fish species.

Keywords: Thuen-Hinboun Hydropower Project/Fisheries Decline/Loss of Fish Species/ Mitigation Measures

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ABBREVIATIONS AND SYMBOLS

DO	Dissolve Oxygen
EdL	Electricité du Laos
EIA	Environmental Impact Assessment
GMS	Greater Mekong Subregion
HH	Household
LARReC	Living Aquatic Resources Research Center
LMB	Lower Mekong Basin
masl	meters above sea level
MDX	MDX Lao Public Company Ltd.
NTFP	non-timber forest products
OAA	Other Aquatic Animal
SED	Social and Environment Division
THHP	Theun-Hinboun Hydropower Project
THPC	Theun-Hinboun Power Company
TSS	Total Suspended Solid

Glossary of Lao term

Nam	River
Ban	Village
Kang	Rapid

CHAPTER 1

INTRODUCTION

1.1 Background

The Lao People's Democratic Republic (Lao PDR) is classified as a developing country. It is a poor, mountainous and highly forested landlocked country with few options to secure a sustainable and environmentally sound economic and social development. With a population of about 6.2 million (Ministry of Planning and Investment [MPI], 2010) most of the population lives in the rural area, 66.0% of population below 1 US$ a day (Asian Development Bank [ADB], 2011), per capita GDP is US$1087 (MPI, 2010).

The hydropower sector has the potential to play important role in achieving the social and economic development objectives of the Lao Government by expanding the availability of low cost, reliable electricity within the country and earning revenue from export sales to the region. The Government's power sector policy facilitates these objectives by encouraging optimal use of the country's natural resources; one key is hydropower development for the electricity generation. Hydropower development in Laos is moving ahead rapidly because large potential for generation of electricity from hydropower projects throughout the Mekong basin and its tributaries. It is considered a preferred form of energy because the power source is renewable and water is a clean fuel no air pollution is generated from the production of electricity (ADB, 2008).

The Theun Hinboun Hydropower Project (THHP) The project what so called river basin transfer project located about 100 km upstream of the confluence with the Mekong on the border between Bolikhamxay and Khammouane Provinces. The intake is located in Bolikhamxay Province and the powerhouse and the tailrace

canal are located in Khammouance Province. The water diverted from the Nam Theun River flows through a 6.2 km tunnel and penstock and a 3.4 km tailrace into the Nam Hai, a tributary of the Nam Hinboun, which joins the Mekong about 30 km upstream of Thakhek on the Thai border (see Figure 1.1 and Figure 1.2). Capacity of the THHP to generate electricity is 210 MW, it is the biggest hydropower project before The Nam Thuen 2 Hydropower Project come on stream.

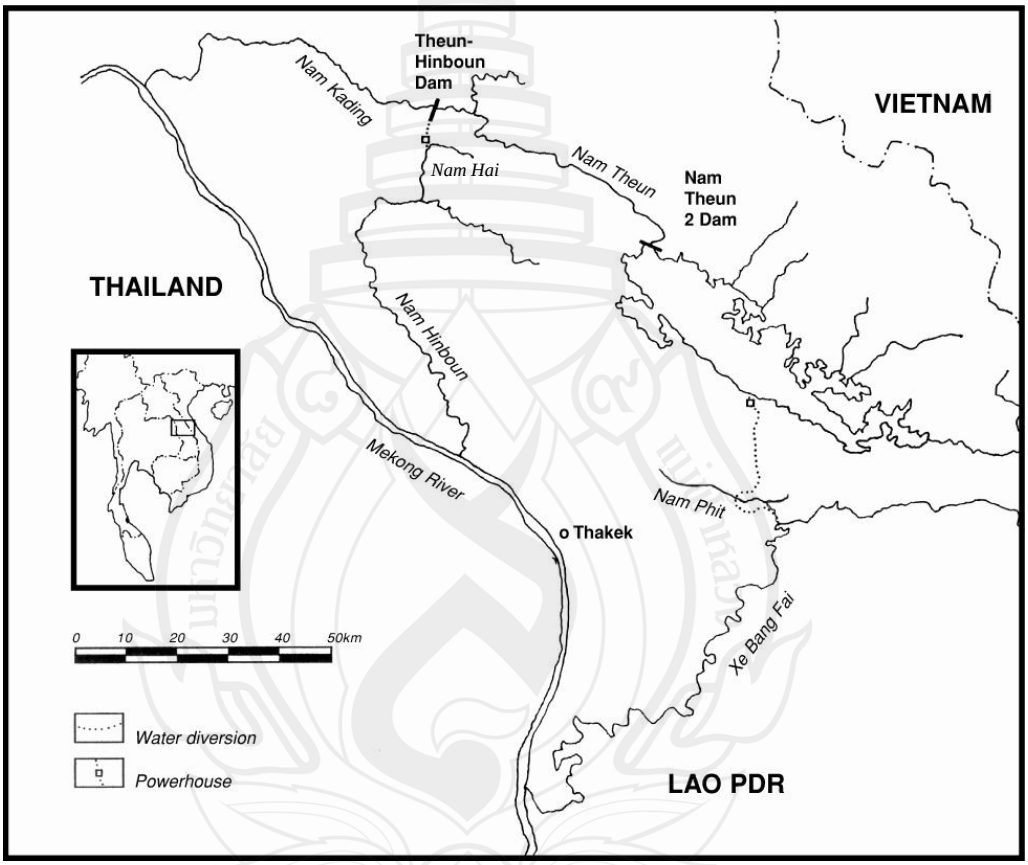

Figure 1.1 Location of the Thuen-Hinboun Hydropower Project and Main Rivers

It is the first time that the Government of Lao PDR formed a joint venture with the private sector for financing, construction and operation of a power plant (Build Own-Operate-Transfer Project). The Executing Agency for the Project is Theun Hinboun Power Co., Ltd. (THPC). The THPC is a joint venture between Electricité du

Laos (EdL) (60%), MDX/GMS-Thailand (20%) and Nordic Hydropower (20%). Nordic Hydropower's ownership consists equally of Vattenfall of Sweden and Statkraft of Norway, both state-owned utility companies. THPC was formally established in November 1994, and simultaneously granted a license by the Lao Government to develop, own and operate the project for a period of 30 years from the date of project commercial operation. Unless extended by mutual agreement, the facilities will be transferred to the Lao government at the expiry of the license term, (ADB, 2002; NORPLAN, 1996)

1.2 Problem Statement

Hydropower projects are known to cause both positive and negative impacts on the natural and socioeconomic environment (United Nations Environmental Programme [UNEP], 2007). It has been demonstrated that the positive impacts include people's access to electricity, opportunities for local and national employment, and through employment on such project better living conditions, improved housing, access to schools, health clinics, markets, and improved roads (World Commission on Dams [WCD], 2000a). Stated by WCD (2000a) negative impacts from hydropower projects include both impacts to people and to the environment. Impacts affecting people include involuntary resettlement of villagers from their ancestral lands, loss of access to forests and their traditional non-timber forest products. Impacts on the environment including loss of forests due to clearance of lands for project construction and from flooding of the reservoir, loss of biodiversity both in the lost forest and in the river system changes, and a significant reduction of fish species and aquatic life that in turn causes social-economic impacts with the changing of fisheries practices and changes in household fish catch. Reductions in harvests and catches by affected households resulted in reduction of consumption and cash income. In the case of the Thuen-Hinboun Hydropower Project, the prediction of environmental and socioeconomic impacts according to NORPLAN (1996) the likely impact in the project areas can be summarized as follows:

1.2.1 The livelihood system of the Thuen-Hinboun areas would be changes;

1.2.2 In the head-pond area, the creation of the reservoir will affect on important supplementary components of the system such as: vegetable gardens will be flooded and the nature of the present fishery will change both in terms of species composition and method of catch;

1.2.3 Fish catches may require more investment and could become more concentrated than pre-project;

1.2.4 Number of households in the affected areas will reallocate because of inundation or bank slumping and some loss of grazing land;

1.2.5 Several positive impacts of the project including access to water for gardening and river transportation along the Nam Thuen River will become easier after the mall rapids are drowned and still water condition prevails.

Since the project operation in 1998 there are increased complaints from the public and international NGOs regarding the adverse impact of the project on the livelihood of the population in the project areas particularly fishery declined, because the change of flow regimes. Dramatic and sudden reductions in catches reported by The Association for International Water Studies (FIVAS) the report mentioned that fish and aquatic resource stocks have continued to decline since the start of THHP, causing hardship and loss of livelihood options to local people (FIVAS, 2007).

1.3 Research Questions

To recognize the actual impacts of the THHP on fisheries throughout 12 years since project completed and operational, this research aims to find the answers the following research questions:

1.3.1 What are the environmental conditions of environmental in the post THHP period?

1.3.2 What are livelihood activities of peoples in the project areas before and after THHP?

1.3.3 What are mitigation measures to improve local fishery?

1.4 Research Objectives

1.4.1 To assess the impacts of fisheries on the livelihood of communities in the THHP project areas**;**

1.4.2 To compare the field research results with the impacts projection by THHP's Environmental Impact Study;

1.4.3 To explore mitigation options to improve the fishery in study areas.

Note. (1)&(2) THHP dam and diversion tunnel, (3) penstock, (4)&(5) powerhouse and tailrace, (6) discharge to Nam Hai River, (7) Nam Hai River.

Figure 1.2 Overview of the Project

1.5 Scope

This research focuses on change of environmental and socioeconomic condition of the affected areas in the period of THHP covered both in the headpond and recipient rivers area of the THHP namely: Ban Kangbit village located alongside of Nam Theun River upstream of dam site; and two villages in recipient river at upper and lower Nam Hai River downstream of powerhouse namely Ban Namsanam village (upper Nam Hai River) and BanVangthakhong village (lower Nam Hai River).

1.6 Conceptual Framework

The framework of PSR (Pressure-State-Response) has been applied for the research to analyse the current state of the fishery in the project areas and to identify various different pressures that are being placed as well as making a fishery management plan for coping with the situation. The conceptual framework of this study is illustrated in Figure 3 with three main steps towards all research objectives. The first step is to obtain background information about fishery and socioeconomic to understand the current situation of the study areas and how fisheries are vital to the livelihood of people living in the project areas. The second step is to identify the driver of the decline of fish catch by considering the pressure on the fishery by human and natural. Finally, recommendations for a feasible fishery management plan to cope with and reduce impacts from fishery decline through expert consultation and lesson learned from elsewhere applied to study areas.

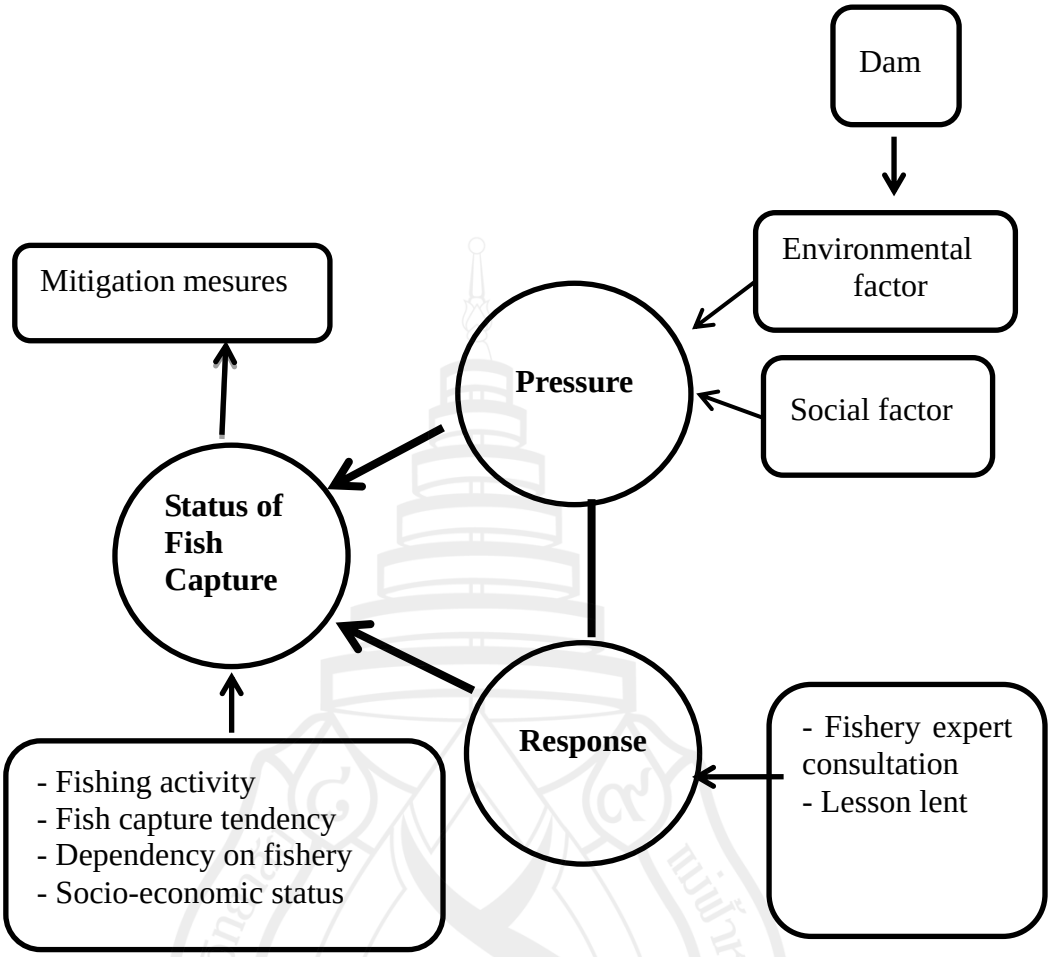

Figure 1.3 Conceptual Research Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Importance of Fish and Fisheries in the Lower Mekong Basin (LMB)

Fisheries have both direct and indirect values. Indirect values include biodiversity values and cultural values (Baran, Jantunen & Kieok, 2007; Hortle, 2009). The inland fisheries of the Mekong Basin are among the world's largest, with total production of about 3.9 million tonnes in 2008, comprising 1.9 million tonnes from capture and 2 million tonnes from aquaculture. The total economic value of the Mekong fisheries is estimated at 3.9-7 billion USD per year. In Lao PDR, more than half the population fishes, and fishing provides 20% of household income. In the south of the country fishing is even more important and 80% of households fish (Mekong River Commission [MRC], 2010).

Fish is the main source of animal protein and a vital source of micronutrients. According to Hortle (2007) consumption of fish and other aquatic animals (OAAs) in the Lower Mekong Basin (LMB) is estimated to be about 2.6 million tonnes by a population of 56 million in the year 2000 as fresh whole animal equivalents. About one-fifth of this total comprises of OAAs. About one-third of the fish is eaten preserved. Thailand and Vietnam consume the most, about one-third of the total each. Cambodia consumes about one-quarter, and Lao PDR less than one-tenth. Per capita consumption of inland fish and OAAs averages 34 kg/year as actual consumption. Cambodia and Vietnam have above-average per capita consumption, while in Lao PDR and Thailand per capita consumption is below-average. Inland fish and OAAs provide 47-80% (country range) of animal protein with an average intake of 18.3 g/capita/day of a total animal protein intake of 32.5 g/capita/day, a high intake compared with the recommended daily allowance.

2.1.1 Fisheries in Lao PDR

Fishing rank as the second or third most important activity after rice farming and animal husbandry and contributes on average about 20% of rural household income (Lorenzen, Choulamany & Parvin-Sultana, 2003). Full time fishers account for only a few per cent of the Lao population, but fishing is central to livelihoods in the southern provinces of the country (e.g. Roberts & Baird, 1995; Baird, 1996; Marine Resources Assessment Group [MRAG], 2002) and reliance on fishing is a common characteristic of all wealth groups within villages (Garaway, 2005; Guttman & Funge-Smith, 2000) detailed the time spent by Lao people in rural occupations. Fishing takes up around 10% of the time spent on income generating activities in rural areas that are dominated by rice cultivation followed by fishing and tending animals. Garaway (2005) showed that the poor spend more time fishing than the other categories of the population. Fishing as an activity is not gender specific (Lorenzen et al. 2003).

The role of fish and other aquatic resources in the diet of the Lao rural population was detailed in the Guttman and Funge-Smith (2000) and in Attapeu province; Meusch, Yhoung-Aree, Friend and Funge-Smith (2003) also highlighted the deplorable nutritional status of the population and the importance of aquatic resources in supplementing a nutrient-poor diet.

For the market value of fisheries in Laos, The gross value of fisheries output is estimated at around USD 48 million, commercial capture fisheries contributing approximately 4% of GDP and subsistence fisheries another 2% (Lorenzen et al., 2003). Souvannaphanh, Chanphendxay and Choulamany (2003) consider that fisheries account for about 8% of national GDP. According to Emerton and Bos (2004) fish and other aquatic animals are worth USD 100 million a year. The Living Aquatic Resources Research Center (LARReC) Medium Term Plan 2000-2005 estimates the value of total annual aquatic production to be in the range of USD 66 million, excluding aquatic plants. This estimate is based on the average market value of fish/frog/turtle (wet weight) at USD 0.66 per kg. According to Lorenzen et al. (2000) fish in local market costs between 0.5 USD/kg for small "trash" fish and 1.5 to 2.5 USD/kg for larger fish. As household catches consist of about one third "small" and two thirds "large" fish, the average value reaches 1.5 USD/kg. More

recently, Bush (2003) gave a value for the overall average price of capture species in three lowland districts (USD 1.14 kg per kg) that are superior to the average value of aquaculture species (USD 0.98/kg).

2.2 Fish Diversity and Migrations in the Mekong River Basin

2.2.1 Main Groups of Fishes

According to Welcomme (1985) broadly classification of fishes in the Mekong fisheries context is the classification of fishes into black-fishes and white-fishes.

Black-fishes are species that spend most of their life in lakes and swamps on the floodplains adjacent to river channels and venture into flooded areas during the flood season. They are physiologically adapted to withstand adverse environmental conditions, such as low oxygen levels, which enable them to stay in swamps and small floodplain lakes during the dry season. They are normally referred to as non-migratory, although they perform short seasonal movements between permanent and seasonal water bodies. Examples of black-fish species in the Mekong are the climbing perch (*Anabas testudineus*), the clarias catfishes (e.g. *Clarias batrachus*) and the striped snakehead (*Channa striata*).

White-fishes, on the contrary, are fishes that depend on habitats within river channels for the main part of the year. In the Mekong, most white-fish species venture into flooded areas during the monsoon season, returning to their river habitats at the end of the flood season. Important representatives of this group are some of the cyprinids, such as *Cyclocheilichthys enoplos* and *Cirrhinus microlepis*, as well as the river catfishes of the family Pangasiidae.

Recently, an additional group within this classification has been identified. It is considered an intermediate between black-fishes and white-fishes and therefore has been referred to as grey-fishes. Species of this group undertake only short migrations between floodplains and adjacent rivers and/or between permanent and seasonal water bodies within the floodplain (Van Zalinge et al., 2003).

2.2.2 Fish Migrations

Much of what is known about the fish migrations in the Mekong river basin has been gained by tapping the local knowledge that is held by the fisher communities along the rivers (Bao *et al*. 2001; Poulsen, Poeu, Viravong, Suntornratana & Tung, 2002) and through monitoring of selected landing sites in Cambodia (Srun & Ngor 2000; Kong, Ngor & Deap, 2001)

Typically, most of the migration activities in the Mekong River take place during the rising flood and the drawdown period. Based on different migration patterns Poulsen et al. (2002) distinguish three major systems in the lower Mekong River in which white-fish species participate. The systems are interconnected to some extent and have many species in common.

The Lower Mekong Migration System (altitudinal range 0-150m): This system covers the migrations taking place in Cambodia and Viet Nam. The upstream limit is the Khone falls, although Baird, Flaherty and Bounpheng (2000) reported that many species are able to cross this barrier, but possibly in small numbers only. The migrations are basically movements out of the floodplains and tributaries, including the Tonle Sap, to and up the Mekong at drawdown, where a number of species spawn around their dry season refuges usually at the onset of the monsoon. Then with the rising flood a return is made to the floodplains. Fish larvae are already exploited on their downstream drift during the rising flood, as Pangasiid larvae are acquired for culture purposes (Van Zalinge et al., 2003). However, the large seasonal fisheries target only the drawdown migrations. During the dry season the Sekong, Srepok and Sesan tributaries act as an extension of the Mekong for some species, such as *Henicorhynchus* spp. and *Probarbus jullieni*, a large Cyprinid (Poulsen et al., 2002), while other species, such as *Mekongina erythrospila* and *Bangana behri*, visit these tributaries mainly during the wet season.

The Middle Mekong Migration System (altitudinal range 150-200m): The system covers migrations from the Khone falls upstream to approximately Vientiane. Contrary to the Lower System in the Middle System the fish move upstream in the Mekong during the wet season and enter the tributaries (e.g. the Mun River, Songkhram River, Xe Bang Fai River, Hinboun River, and other tributaries) and their associated flooded areas for feeding. Some species spawn in the floodplains,

while others spawn around the dry season refuges. During the drawdown they leave the tributaries and return to dry season refuges downstream in the Mekong. These migrations tend to be shorter than in the Lower System. Both systems have many of the species in common that may or may not form genetically distinct populations. Interestingly Poulsen et al. (2002) report that some species, such as *Cyclocheilichthys enoplos* and *Cirrhinus microlepis* are mainly caught as juveniles and sub-adults in the Lower System and as adults in the Middle System. They speculate that this may be also true for other species, such as Giant Mekong Catfish (*Pangasianodon gigas*).

The Upper Mekong Migration System (altitudinal range 200-500m): This system is relatively isolated from the Middle System possibly by a lack of dry season refuges in the section between the two systems. It stretches from the mouth of the Loei river in northern Thailand (CA. 150km upstream of Vientiane) to Chiang Rai and probably beyond into China. This section of the river has relatively few floodplains and major tributaries. In the wet season fish migrate upstream to spawning habitats in the Mekong to return later to their dry season habitats also in the main river. Spawning habitats are to be found in river stretches with alternating rapids and deeper channels. Again also this system has some species in common with the downstream systems, such as the Giant Mekong Catfish (*Pangasianodon gigas*). In addition, there is also a *Henicorhynchus* species, which is also important for the fisheries here. It may be genetically distinct from the stock downstream.

2.3 Effects of Dams on Fish Population

2.3.1 Fish Migration Affected by Dam Construction

The dam prevents migration between feeding and breeding zones. The effect can become severe, leading to the extinction of species, where no spawning grounds are present in the river or its tributary downstream of the dam. Zhong and Power (1996) reported that the number of fish species decreased from 107 to 83 because the migration was interrupted by the Xinanjiang dam (China). The reduction of biodiversity occurred not only in the flooded section but also in the river below the dam. In Australia, obstructed fish passage has led to many instances of declining

populations or extinctions of species in the affected basin (Barry, 1990; Mallen-Cooper & Harris, 1990). The concept of obstruction of migration is often associated with the height of the dam. However, even low weirs can constitute a major obstruction to upstream migration. Whether an obstacle can be passed or not depends on the hydraulic conditions over and at the foot of the obstacle (velocity, depth of the water, aeration, turbulence, etc.) in relation to the swimming and leaping capacities of the species concerned. The swimming and leaping capacities depend on the species, the size of the individuals, their physiological condition and water quality factors as water temperature and dissolved oxygen (Mitchell, 1995).

2.3.2 Fish Habitat Loss

Dam construction can dramatically affect migratory fish habitat. The consequence of river impoundment is the transformation of the lotic environment to lentic habitats. Independently of free passage problems, species which spawn in relatively fast flowing reaches can be eliminated. About 40% of the spawning grounds in the Qiantang river above the Fuchunjiang dam were lost by flooding (Zhong & Power, 1996). On the Indus river, the construction of the Gulam Mahommed Dam has deprived the migratory *Hillsa ilisha* of 60% of their previous spawning areas (Welcomme, 1985). On the Columbia river and its main tributary the Snake river, most spawning habitat was flooded, due to the construction of dams creating an uninterrupted series of impoundments (Raymond, 1979).

The suppression of the flood regime downstream from an impoundment by means of flow regulation can deprive many fish species of spawning grounds and valuable food supply (Petts, 1988). This can lead to changes in species composition with loss of obligate floodplain spawners. Dam construction for industrial uses within the Rio Mogi Guassu Brazil has resulted in the progressive loss of flood plain wetlands (Food and Agriculture Organisation [FAO], 2001). The cumulative effect of diminished peak discharges, stabilized water levels, reduced current velocities and water temperature eliminated spawning grounds below the dams on the Qiantang and Han rivers: six migratory fish and five species favouring torrential habitats declined severely (Zhong & Power, 1996). The reaction of the fish communities of the Chari,

Niger and Senegal rivers to flood failures provoked by natural climatic variations illustrates the highly detrimental effect of suppressing the flood (Welcomme, 1985).

2.3.3 Impact of Modification of Discharge on Fish Population

The modification of downstream river flow characteristics (regime) by an impoundment can have a variety of negative effects upon fish species: loss of stimuli for migration, loss of migration routes and spawning grounds, decreased survival of eggs and juveniles, diminished food production. Regulation of stream flow during the migratory period can alter the seasonal and daily dynamics of migration. Regulation of a river can lead to a sharp decrease in a migratory population, or even to its complete elimination. Any reduction in river discharge during the period of migratory activity can diminish the attractive potential of the river, hence the numbers of spawners entering the river are reduced. Because of this, regulation of a river can greatly influence the degree of migration to the non-regulated part of the river below the dam site. Zhong and Power (1996) noted that high discharge is important for inducing anadromous species to ascend rivers to spawn: after the construction of the Fuchunjiang dam on the Qiantang river, there was a significant correlation between the capture of an anadromous fish *Coilia ectenes* ascending the river to spawn and the amount of the discharge from the project. Variable flow regime resulting from operation of hydroelectric power-dams can have significant consequences for fish fauna: daily 2 m to 3 m fluctuation of Colorado river-levels below the Glen Canyon dam may have contributed to the decline in endemic fish (Petts, 1988). The native species have been replaced by the introduced species and spawning of the native species is restricted to tributaries. Walker, Hillman and Williams (1979) related the disappearance of *Tandanus tandanus* in the Murray River, Australia to short-term fluctuations in water level caused by reservoir releases in response to downstream water user requirements. The fluctuations of water-level and velocities due to power demand could have disastrous effects on fish: spawning behaviour could be inhibited, juveniles could be swept downstream by high flows, sudden reductions in flow could leave eggs or juveniles stranded (Petts, 1988).

2.3.4 Effect of Water Temperature and Water Quality Changes

Dams can modify thermal and chemical characteristics of river water: the quality of dam-releases is determined by the limnology of the impoundment, with surface-release reservoirs acting as nutrient traps and heat exporters and deep-release reservoirs exporting nutrient and cold-waters (Petts, 1988). This can affect fish species and populations downstream. Water temperature changes have often been identified as a cause of reduction in native species, particularly as a result of spawning success (Petts, 1988). Water-chemistry changes can also be significant for fishes, release of anoxic water from the hypolimnion can cause fish mortality below dams (Bradka & Rehackova, 1964). During high water periods, water which spills over the crest of the dam can become over-saturated with atmospheric gases (oxygen and nitrogen) to a level which can be lethal for fish.

2.3.5 Effect of Dam on Fisheries-Experience of Lao PDR and Elsewhere

The main issue regarding river changes and fisheries in Laos is hydropower development. The impact of Lao hydropower dams on the environment and poor communities has been addressed for a number of years by multiple NGOs, but few scientists have undertaken detailed impact studies. An overview of the issues inherent in each major dam is provided, with a pro-poor, pro-conservation perspective, in International Rivers Network (IRN, 1999). Below are some fisheries related issues in the case of Nam Ngum and Nam Theun 2 dams.

Example of Nam Ngum Dam: according to Mattson, Balavong, Nilsson, Phounsavath and Hartmann (2001) several studies have been conducted to estimate the fisheries production in the reservoir, but none has been done on the environmental impacts of the dam. A study done in 1982 by the MRC estimated the total fish production at 1,470 tonnes, while another study found it to be 6,833 tonnes. The increase could be due to reduced predation pressure, the initial high value predator species having been fished out. Other studies on reservoir fisheries in the dam indicated that the initial catch was low due to problems in water quality, but from the flooded trees in the reservoir were cut the water quality has improved. The fisheries landings are said to have increased by a factor of four between 1982 and 1998 (cited in Mattson, Hartmann & Augustinus, 2002) in correlation with an

increase in fishing effort, particularly using gillnets. The total estimated landings (6,833 tonnes) correspond to a 143 kg/ha/year yield. Annual registered yield amounted to USD 800,000 in 1997 (Ringler 2000). However, Roberts (2004) pointed out that in 1971 to 1979 the reservoir was largely anoxic with very little fish, and after a peak in fisheries production in 1985-1990 the fish catch declined. Careful management of the reservoir fishery is obviously essential. Lorenzen et al. (2000) found in their study that dam schemes in Laos are associated with declines of about 60% in fishing effort and catch for rural households. However, no literature was located on the impact of the dam on migratory species or the effect on downstream fisheries except that of Schouten (1998) who showed that the water released from the Nam Ngum reservoir has a much lower dissolved oxygen level than that in natural rivers and is unfavourable for aquatic life most of the year, especially during the wet season.

Example of Nam Thuen 2 Dam: Nam Theun 2 is the largest and most controversial hydropower project being planned in Lao PDR (IRN, 1999). The project is planned for Central Laos and consists of a 50 m high dam on the Theun River, the fourth largest tributary of the Mekong. The river provides habitat for 85 species of fish of which 16 are endemic (Roberts, 2004); of these species 33-55% are strongly migratory. Out of the 85 species only 27 are likely to become established in the reservoir and of these 14 are small species with little or no commercial value (Roberts, 2004). Several Environmental Impact Assessments have highlighted the fact that the dam would have a serious negative impact on fisheries by disturbing migration, creating a large body of still water to which most of the species could not adapt and degrading water quality downstream (IRN, 1999). Cumulative impacts have also been envisioned, and a significant negative impact on fisheries and aquatic biodiversity has been foreseen, although not detailed (NORPLAN, 2004). The reservoir fishery can be expected to increase during the first 5-10 years, but then it will decline (Roberts, 2004).

Apart from Laos, The negative impacts of dam construction on fishery examined in several research for instance Aleem (1972) examines the building of the Aswan dam to block the flowing of the Nile river, in Egypt, before the Mediterranean Sea in 1965, he found that this dam building threaten to the number of plankton which

it is the food for other aquatic animals. This also relates to Pandian (1980) study that the volume of sardine captured in 1964 is 15,000 tones, while a year after dam finished in 1966, it declines to 554 tones. While the study of Zhong and Power (1996) is about the impacts of Xinanjiang Dam that the species found has been declining from 107 to 83. This is the same the result of South East Asia Rivers Network (2002) study on the effect of opening the water gate of the Pak Mun dam, in Thailand which it shows that only 45 species was found while the gate closed. Conversely, the number of specifies found reaches to 156 when the gate was opened especially the giant catfish and other more than 148 species that normally resides in Mekong river migrate in the breeding season. This picture is the same with the study of Thailand's Marine and Coastal Resources Institute (2004) that conducted the number of species, during 1999-2003 after closing the water gate in Pakphanang dam was dropped from 218 to 76.

2.4 Term of Post Impact Assessment

Nowadays, Environmental Impact Assessment (EIA) is being used globally, either as a planning or management tool, in order to minimise the harmful consequences of development. Its emphasis is on prevention and it is hence an example of the precautionary principle. Ensuring environmental protection and management is the primary goal of EIA (Bailey, 1997; Morrison-Saunders & Bailey, 1999).

Post impact assessment (PIA) is a major component of environmental impact assessment (EIA) it is a systematic auditing or monitoring of the environmental impact of a project that has already been implemented (Osuji, Adesiyan & Obute, 2004). Similar to Zhao, Ma, Liang, Shi and Men (2012) what so call Post-project-analysis (PPA) it is referring to a method and system of tracing monitoring and confirmatory assessing the environmental impact of constructed projects and the efficiency of preventive measures, as well as proposing remedial plans or measures, aiming to achieve the coordination between project construction and environment.

The construction of dams and reservoir project plays important roles in many countries such as hydropower generation and the regulation of water resources.

However it also makes adverse effect on environmental and social. Owing to dam and reservoir projects have long construction period, big investment, broad social impact and complex social issues etc., the actual effects of the completed project prone to deviate from the predicted results of the EIA. After dam and reservoir projects are completed, the actual environmental impact can be investigated by PIA, and can be compared to the results of the EIA. The differences of environmental impact between actual and predicted results can be used to testify the predicted results of the EIA and reasonability of environment-protection design and evaluate the availability of environmental protection measures of the completed projects (Zhao et al., 2012; Wang, Du, Su & Chen, 2012). The main contents of PIA for dam and reservoir projects mainly focuses on water quality, aquatic livings, terrestrial livings, hydrological regime, environmental geology, landscape and heritage, and the resettlement of migrants from a reservoir (Wang et al., 2012).

2.5 THHP Related Studies

Impact study for THHP by NORPLAN (1996) indicated that the project probable impact fish catch due to obstruction of fish migration due to the dam and more difficult to fish in deep water with existing fishing gear, the reduction in fish catches upstream of the dam is roughly estimated to 50%. In the Nam Hai River, before the project it is almost dry up every year in the dry season. Diversion of water to the Nam Hai after the THHP operation would fulfil water to Nam Hai all year round, the “new” Nam Hai may become a productive river for fish.

One year after THPP operation, the team socioeconomic and environmental survey from National University of Laos has been study the socioeconomic dimensions of the communities in the Nam Hai and Nam Hinboun Rivers areas in 1999, the study found the main constraint of the village along Nam Hai river and Nam Hinboun river is the unclear water that cause by erosion affected, high spread water current drained by powerhouse, drinking water shortage, poor access road, far from health care centre and hospital, no electricity and irrigation system.

According to THPC engaged a consulting firm to investigate impacts of the project in 2000 to preparing Mitigation and Compensation Plan. The consultant identified the major impacts from the project for downstream recipient rivers one of the major impact is loss of access to traditional fishing and fish breeding areas, which are the most important protein source for villagers. The findings of the fishery expert studies reflect this collapse, but do not reach exactly the same conclusions. Warren's study (Warren, 1999) was focused more on the donor river, he conducted a quantitative monitoring program at two locations within the general Theun-Hinboun project area. One at Ban Kengbit Village just up from the Theun dam-site on the banks of the head-pond, and another at Ban Khongpat Village on the Nam Hinboun, just upstream from the confluence of the Nam Hai and Hinboun from December 1997 to November 1998. However he describes the collapse of the current fishery in the Nam Hai, the problems of erosion and sediment movements for the Hinboun, the crucial importance of future "capture" of migrants from the Mekong, and the need to focus mitigations on out of river aquaculture approaches.

The evaluation of environmental and social impacts of THHP on aquatic life and fisheries has been prepared by Schouten, Visounnarath, Souvannalath and Volakummane (2004) The results of this research, indicated that decline of average household fish catch per village are from 5% to 80% depending on the location of the village. His conclusions place more emphasis on the "background" changes in fish catches which he ascribes to over-fishing, without examining his own data too carefully. His own data show that the decline in the fishery in the lower Nam Hai and Hinboun is chiefly the result of the Project's impacts. The magnitude of the decline is large, and much larger than the "background" decline, and easily overwhelms any effects introduced to accommodate changes in the numbers of people fishing.

CHAPTER 3

RESEARCH METHODOLOGIES

Primary and secondary data have been collected to assess the post impact of the project. The structured questionnaires based household survey was used to collect the primary data as well as extensive review of previous studies and several reports done by consultants. The outcome of field research will provide valuable information about the situation of fisheries in the project areas, before the project commenced construction and after the project started operation.

3.1 Selection of Study Sites

The study has been carried out in three villages located in the head-pond and recipient rivers areas (Figure 3.1) as representative of different ecological zones namely: Ban Kengbit village in head-pond area; Ban Namsanam village and Ban Vangthakhong in recipient rivers areas. Selection has been considered by location and its environmental condition, detail are described below.

3.1.1 Head-Pond Area

The head-pond area is located in the western part of Khamkeut District, Bolikhamxay Province. Road No 8 is going through the area and crossing the Nam Theun River at Ban Thabak. The topography of the head-pond is diverse with the Pha Kouan Chan Mountain to the North that rises steeply from gently sloping or rolling land. Ban Kengbit village has been selected for the case study in the area; the villages are located in Nam Then/Nam Keding River basin alongside of the reservoir.

After the project the village has been relocated due to water level increased. There are consisted of 135 households, 155 families, population 715 (female 365).

3.1.2 Recipient Rivers Areas

The Recipient Rivers are the areas alongside the Nam Hai River downstream of the powerhouse until confluent Nam Hinboun River, and from the lower part of Nam Hinboun to confluent with Mekong River.

The Recipient Rivers affected areas are located in Khammouane and Bolikhamxay provinces. The Nam Hinboun/Nam Hai Basin is located at a much lower elevations than the head-pond area in Nam Theun/Kading River Basin. The headwaters of Nam Hinboun are located west of the Nam Theun catchment at about 400 masl. The topography of the areas is of similar nature with a generally flat alluvial flood plain of Nam Hai and Nam Hinboun with the elevation ranges from 180 to 150 masl (NOPLAN, 2008).

Two villages located alongside of the Nam Hai River downstream of powerhouse have been selected as a case study for the recipient rivers namely: Ban Namsanam located in the upper Nam Hai River which is 2 km downstream of THHP powerhouse. There are 188 households with a population of 1150 (female 582). Population of Namsanam village increased rapidly, especially in the years 2005 and 2006 by in-migration of people from Laksao district and upper Nam Hinboun area to find a site for rice cultivation and receive the benefits of good road, electricity and other opportunities. Ban Vangthakong is situated alongside of lower Nam Hai River bank and 6.4 km downstream of THHP powerhouse. There are 60 households and the population is 305 (female 151) people.

3.2 Data Collection Techniques

Data was collected in August 2011, preliminary collection and review of available secondary data related to the study was done in order to identify the required primary data to be further collected in the field survey. A tentative set of

questionnaires for the village and household levels was initially devised and pre tested during field visits.

3.2.1 Primary Data Collection

Primary data were collected from field survey using both methods of formal and informal interviews. The survey aimed to obtain detailed information on all aspects of household livelihood, and to quantify those aspects that related to fishery activities in terms of their degree of participation. This survey was carried out by household interview using questionnaires consisting of sets of questions to investigate the level of dependency and trend of fishery activities in the project areas as well as socioeconomic data (Appendix D).

Practical method of Rapid Appraisal was used in relevant parts of the field survey. A combination of different formal and informal interviews was conducted using additional matrices, checklist and structure questionnaire. Matrices and checklist were used to collect data information during the interviews with the village heads. Informal interviews or group discussion was conducted with the key informants, namely, elders, experience fishers.

The sample size for this research is n ≈ 78 households, calculated by using Taro Yamane formula for ±10% precision levels where confidence level is 90% and uses the quota sampling method to calculate the number of samples in each village. The result of sample size for each study villages are shown in Table 3.1.

Formula: $$n = \frac{N}{1+N(e)^2}$$

Where: n = Sample size

N = Population size

e = confidence level (= 0.10)

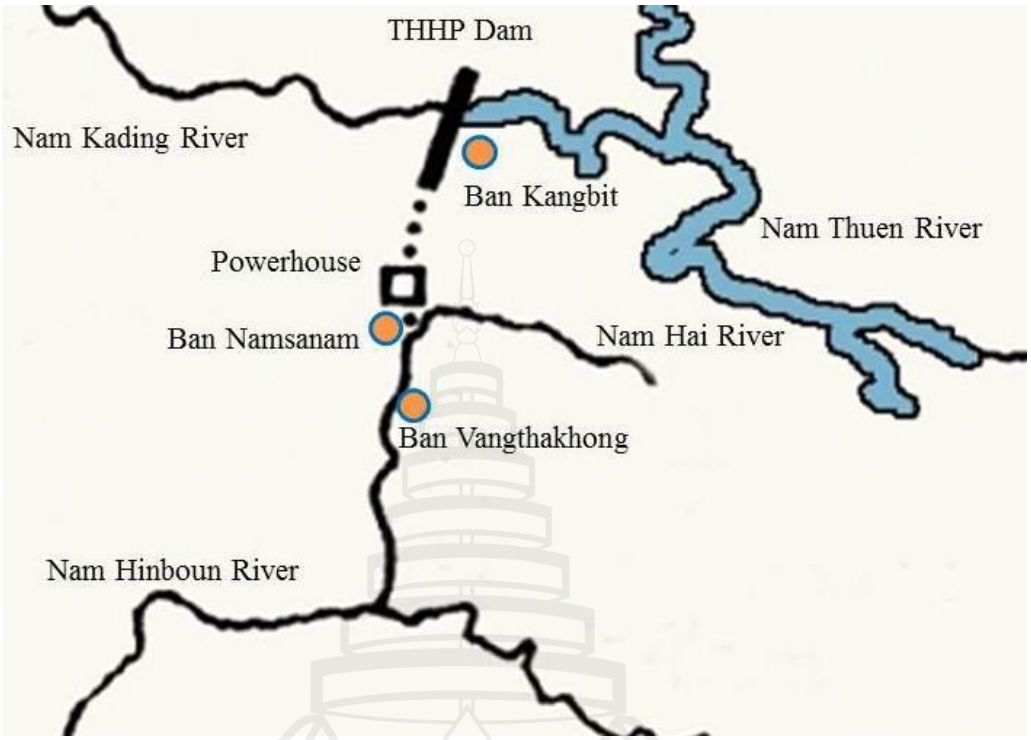

Figure 3.1 Location of Study Villages

Table 3.1 Number of Households in Study Villages and Sample Size

Locations	Villages	HH No.	Sample size	Sample method
Head-pond	Ban. Kengbit	135	28	Quota Sampling
Recipient rivers (Nam Hai)	Ban. Namsanam	188	39	
	Ban. Vangthakong	53	11	
Total		**376**	**78**	

3.2.2 Secondary Data Collection

Relevant secondary data and information from various official sources were collected to support the study such as project documents, annual reports, maps, journal articles, etc. The secondary data to be collected were divided into two main

categories such as environmental and socioeconomic. Most of reports and documents were gathered from the Social and Environment Division of Thuen-Hinboun Power Company (THPC).

Fisheries data especially current fish catch data are obtained from monthly monitoring by the Environmental Unit of THPC. This data is based on location in the impacted zone, which focused on the head-pond area and various parts of the recipient rivers which see the most profound changes in hydrology and aquatic ecology. As lack of fish catch data before the project, thus this research relied on the data from previous research such as Schouten et al. (2004) and several reports done by consultants.

3.2.3 Data Processing and Analysis

Raw field data were entered into a database using Microsoft Excel and analysed by the standard software package SPSS (Statistical Package for Social Sciences). Common statistical tools such as percentage, mean, frequencies and standard deviation were extensively used for the data analysis.

CHAPTER 4

RESULTS

The chapter presented results of research which included socioeconomic and environmental condition; characteristic of fisheries in the study villages during pre THHP and post-THHP to understand affected by the project on fisheries as well as identify possibility cause of the impacts and discussion of mitigation measures to improve the fishery in the study villages to reach the research objectives.

4.1 Environmental Condition Pre and Post-THHP

4.1.1 Hydrology

Compared hydrological condition of rivers in the project areas namely Nam Thuen River at the head-pond area and Nam Hai River in the recipient river areas during pre-THHP and post-THHP period, found that the condition of hydrological has changed.

In the Nam Theun River, closure of the THHP dam in December 1997 it has created an impounded stretch of water extending some 24 km up the mainstream Nam Theun River , 14 km up the Nam Ngouang River, and also some 3 km up the Nam Ao River a small stream entering the Theun at the dam site. Downstream of THHP dam before the project natural flow is 401 m^3/s currently changed to 317 m3/s which decreased 21% of flows after completion of THHP dam. Upstream of THHP condition of water flow pre-THHP and post-THHP it is noticeable that before impoundment of Nam Thuen 2 Hydropower water flow is same level.

In recipient river, The effects of the THHP operational have changed the flow regime of the Nam Hai River, natural conditions of Nam Hai which normally 9.0

cubic meters per second (m^3/s) current water flow was 110 m^3/s which increased 1122%. This I can explain that during the project is running at full capacity, discharged volume of 110 m^3/s of turbinated flow volume is discharged from the powerhouse into the Nam Hai plain. The extra 110 m^3/s then joins whatever seasonal flows are passing down the Nam Hai and together this volume move down the Nam Hai channel and eventually enters the Nam Hinboun just upstream from Vangdao village (see Figure 4.1). Some key figures describing the natural hydrological features of the Nam Thuen River in head-pond and Nam Hai River systems and shows the comparison of flows during natural conditions before the project and with the present THHP operation in Table 4.1**.**

Table 4.1 Comparison of Hydrological Characteristics of the Nam Thuen and Nam Hai Rivers During Pre-THHP and Post-THHP.

Features	Location	Pre-THHP	Post-THHP	Changes
Mean annual flows (m^3/s)	Upstream THHP dam	237	237	Same*
	Downstream THHP dam	401	317	Decreased 21%
	Downstream of powerhouse (Nam Hai)	9	110	Increased 1122%

Note. * Before impoundment of NT2 dam

From NORPLAN A.S. (2008). **Final EIA/EMMP for Theun-Hinboun Power Company**. Vientiane, Laos: Theun-Hinboun Hydropower Company. pp. 27-31.

Figure 4.1 Natural Conditions of Nam Hai River Downstream of Powerhouse Pre and Post-THHP.

4.1.2 Water Quality

Three water quality parameters which related to living conditions of fish and other aquatic animals such as dissolved oxygen (DO), pH, Total Suspended Solid (TSS), and temperature has been selected to compare. The older data series is found in NORPLAN (1996). The NORPLAN analysis covers December 1994 and March, April and July 1995. For construction period 1995 to February 1998 there is no historical water quality. The most consistent time series have, however, been collected by Theun Hinboun Environment Management Division (EMD), which since July 2002 has carried out water monitoring for key water quality parameters at 12 stations in the basin. The synthesis of available data was presented in Table 4.2 and Table 4.3. Further, since Lao does not have criteria for specifying fishes and other aquatic animals, Thailand's criterion (Ministry of Natural Resources and Environment [MONRE], 2011) which similarly to Laos in terms of environmental condition has been used for comparison. The result of comparison shows that three water quality parameters mentioned above during pre and post THHP has no change.

Table 4.2 Summaries of Water Quality Data of Head-Pond Pre and Post-THHP

Parameter	1996[1]	1998-2006[1]	2010[2]	WQ standard[3]
Temperature (°C)	24.4	25.0	26.2	23-32
DO (mg/l)	8.1	7.5	7.7	> 3
pH	8.0	7.9	7.4	5-9
TSS (mg/l)	8.0	35.9	22.2	≤ 38

Note. [1] Data from the "Final EIA/EMMP for Theun-Hinboun Power Company" prepared by NORPLAN A.S (2008) pages 32-42.

[2] Data provided by Theun-Hinboun Hydropower Company.

[3] Water quality standard for freshwater animal by Thailand's Ministry of Natural Resources and Environment.

Table 4.3 Summaries of Water Quality Data of Nam Hai Pre and Post-THHP

Parameter	1996[1]	1998-2006[1]	2010[2]	WQ standard[3]
Temperature (°C)	24.2	25.0	25.8	23-32
DO (mg/l)	7.8	7.7	7.6	> 3
pH	7.0	7.5	7.4	5-9
TSS (mg/l)	6.0	64.3	40.8	≤ 38

Note. [1] Data from the "Final EIA/EMMP for Theun-Hinboun Power Company" prepared by NORPLAN A.S (2008) pages 32-42

[2] Data provided by Theun-Hinboun Hydropower Company.

[3] Water quality standard for freshwater animal by Thailand's Ministry of Natural Resources and Environment.

Status of Dissolve Oxygen (DO) both in head-pond and Nam Hai are characterized as high (6-8 mg/l) or very high (> 8 mg/l). During the dry season hyper-saturation can be noticed as a result of increased phytoplankton and algae growth in the slow flowing rivers at the end of the dry season. Phytoplankton and algae produce oxygen during day time by photosynthesis. Over saturation of DO during day time gives an indication of the density of phytoplankton and algae blooms. Characteristic of year round DO were presented in Appendix B.

The Nam Hai water flow and water quality have undergone significant changes since 1998 when the THHP commenced operation. From being rivers with large seasonal variations in flow and quality (as seen in the upper reaches of the rivers today), there is a high year around flow but with very large daily fluctuation. The dramatic increase in dry season flow and the intermittent discharge, varying from 0 to 110 m3/s in one day during the dry season and an annual flood flow of 200-300 m^3/s during the wet season (NORPLAN, 2008) as a result of the extra discharge from the powerhouse have started extensive erosion processes along the Nam Hai (see detail in Appendix C. This process is still ongoing and river morphology does not yet seem to have been stabilised. Characteristic of of year round TSS were presented in Appendix B.

4.1.3 Aquatic Biodiversity and Fish Species

Relied on available data it shows that before the project according to the Environmental Impact Study (NORPLAN, 1996) reported that fish species in the Nam Theun River is 79 species, nowadays based on data from Environmental Unit of Theun Hinboun Hydropower Company (THPC) they reported that there are 42 of fish species found in the Nam Theun in head-pond section which disappeared 37 species. Recipient river in the Nam Hai according to NORPLAN (1996) reported that before the project there are 118 fish species, presently found 68 of fish species which disappeared 50 species. The comparison showed in Table 4.4.

These changes, it might be affected by the project in many ways, in the Nam Theun construction of THHP dam might be the main factor affected to disappeared of some fish species due to increase of water elevations, and decreased water flow in the head-pond, it also modified and altered aquatic habitats in the head-pond such as

rapids along the river as it is fish spawning ground has submerged, according to interviews there are 13 rapids along the Nam Then in section of head-pond but all it has disappeared. Increased of water elevation might also affect to reduce some water plants including periphyton which is food for many fish species has reduced as a result of reduced sunlight penetration through higher water levels. Creation of the head-pond has change of natural condition of the Nam Thuen River, this assumption confirms by appearance of common carp (*Cyprinus carpio*) because this species generally inhabits lakes, ponds, and the lower sections of rivers (usually with moderately flowing or standing water) and it is seeming to be capable of reproducing in cooler waters.

In the recipient river, increased of water volume, change hydrological regime, and disappeared of the deep pool along the Nam Hai might have potential to affect some fish species. However for the factors of reduced in fish species it may need more research to investigation to identify factors related to construction and operation of dams.

Table 4.4 Number of Fish Species in Each River Section

River section	No. of species		Change
	Pre-THHP[1]	Post-THHP[2]	
Nam Thuen (head-pond)	79	42	- 46%
Nam Hai/Nam Hinboun	118	68	- 42%

Note. [1] Data reported by NORPLAN A.S (1996) in the "Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 14.

[2] Data provided by Theun-Hinboun Hydropower Company

4.2 Livelihood Activities and Characteristic of Fishery Pre and Post-THHP

4.2.1 Ban Kengbit Village:

The head-pond section of Nam Thuen is predominantly hilly and mountainous with settlements along the river, little or no paddy is grown in this area, villagers have adapted their livelihood system to upland rice cultivation and vegetable growing along the riverbank, livestock raising such as poultry and cattle serve as main economic. Forest product is collected and wildlife hunted for household consumption and income.

Ban Kenbit villages have relocated from original location in 1996 before construction of THHP dam due to water level, number of household that time is 30 HHs. Current number of households were increased to 135 HHs (increased 350%) with a total population of 715 people, with 350 men (48.95%) and 365 women (51.04%). The village is composed of three main ethnic groups, namely, Tai Kha, Tai Man, and Tai Meuy.

Before the project population in the village mostly involved in agriculture such as upland rice cultivation, livestock raising, fishing, and collecting of non-timber forest product (NTFPs) and hunted wildlife both for sale and home consumption. During the construction period, serve the construction and maintenance activities of the dam are becoming sources of income for villagers. The project has constructed new road 12.6 kilometre length accessed to damsite. This road has beneficial on village livelihood as it created opportunities for villagers able to access to market centres opening up especially for commercial fish, agriculture and forest products.

Finding of the research according to households interviewed and comparison of previous study (i.e. EIA) shows in Table 4.5. It has shown that before the project sell of the crop product created high proportion of income (58%) follow by sell of fish (27%), and sale of livestock (15%) respectively. Nowadays, non-farm income sources are important for villager's cash income from trade, servicing, and wage labour was highest (75%) followed by selling of crop production (34%), fish catch (4%) and livestock (1%) respectively.

Important of fishery before and after the project are also illustrated in Table 4.5. According to interviewed before the project villagers sell fish to gain income when construction of Route 8 and Nam Thuen Bridge as well as construction of THHP was started, villagers sell their fish to these workers and to merchants outside especially from Laksao district. Fish is sold fresh, smoked or dried, although fresh fish are more popular. Ban Thabak located on Nam Thuen Bridge, 20 km upstream of the village is the main fish market. Presently fish catch in the village has reduced fish is caught mainly for household consumption and less for commercial.

Table 4.5 Proportions of Income Sources for Ban Kengbit Pre and Post-THHP

Income sources	**Pre-THHP (%)**[1]	**Post-THHP (%)**[2]
Fish catch	27	4
Crop production	58	20
Livestock	15	1
Cash income	0	75
Total	100	100

Note. [1] Data reported by NORPLAN A.S (1996) in the " Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 61.

[2] Data from field research

From past to present day fishers is fish in the same period during the year round especially in during the fish migration period June to October a period of low agricultural labour demand (e.g. upland rice). Before the project during dry season fishing in rapids it is most favourable for most fishers as the fish in the rapid is abundant. Fishers in the village usually fish in 13 rapids along Nam Thuen from village to Nam Thuen Bridge, since construction of THHP dam all 13 rapid has been submerge , nowadays fishers only able to catch in 3 fishing areas namely: Nam Aow River (small tributary of Nam Thuen near THHP dam), upstream and downstream of

THHP dam, however fish at upstream is difficult because water level is too high fishers only able to fish along riverbank comparison of catch among both areas amount of catch in downstream is higher (see Table 4.6). Data from Division of Environment of THPC shows that the total amount of catch per household in year 2010 is 287 kg/hh/yr, compare to amount of catch declined 78% (from 1275 kg/hh/yr to 287 kg/hh/yr). According to interview a group of fisher they mention that factors of change is mainly affected by destructive fishing method for instance use of dynamite and electric shock together with increased number fishers and commercial fishing. Characteristic of fishery in Ban Kenbit has shown in Table 4.7.

Table 4.6 Fishing Areas of Ban Kangbit Pre and Post-THHP Based on Interviews

Fishing areas pre-THHP	**Fishing areas post-THHP**
1. Keng Sob Aow;	1. Nam Aow River;
2. Keng Thitla;	2. Upstream THHP dam; and
3. Keng Saipan;	3. Downstream THHP dam.
4. Keng Thawai;	
5. Keng Bit;	
6. Keng Fan;	
7. Keng Lath;	
8. Keng Huea;	
9. Keng Phee huean;	
10. Keng Kapap;	
11. Keng Kwang;	
12. Keng Sob Nguang; and	
13. Keng Sune.	

Note. Term of *"Keng"* in Lao is means "rapid". Since construction of THHP dam, all 13 rapids along the Nam Theun River from upstream of the dam to the Nam Thuen Bridge are fishing areas for villagers has submerged.

Table 4.7 Characteristics of Fishery in Ban Kengbit Pre and Post-THHP

No.	Features	Pre-THHP[1]	Post-THHP[2]
1	Population of Kengbit	30 HHs (1995)	135 HHs (2010)
2	Fish species	79 fish species	42 fish species (loss 37 species)
3	Fishing areas	13	3
4	Seasonality	Fishing year round but frequently in fish migration periods Jun-Oct.	Same as before THHP
5	Amount of catch	Predicted in EIS (1996) fish catch would reduce 50%	Declined 78%.
6	Fishing gears	1. cast net (mesh size 2-3.5 cm) 2. hook (size 8-10 cm)	1. gillnet (mesh size 3-6 cm) 2. hook (size 8-10 cm)
7	Fishing effort	Less effort and investment	More effort into fishing and invested more for fishing gears and fuel cost for the boat's engine.

Note. [1] Data reported by NORPLAN A.S (1996) in the "Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 61.

[2] Data from field research

The predictions of environmental and socioeconomic impact report on the Environmental Impact Study (NORPLAN, 1996) impacts of the project are both positive and negative. Negative impacts include loss of land areas and village have to relocate due water level increased, the amount of fish catch would reduce. Positive impacts include improving of road transportation and communication as the project constructed and upgrade new roads accessed to the THHP dam site, river transportation would be better than before the project because the rapids which caused difficulty for river transportation has submerged. To confirm predictions of the Environmental Impact Study report mentioned above, the result of field research used to compare as Table 4.8.

Table 4.8 Impacts of the THHP on the Head-Pond Area at Ban Kengbit

No.	Impacts prediction for Head-pond[1]	Field research finding	Remarks from field research
1	Inundation	Yes	The village has relocated due to inundation
2	Loss of land	Yes	Vegetable gardens and grazing land has lost due to increased water level and inundation
3	Livelihood system change	Yes	Before the project most of habitant highly relied on nature and its resources. Presently there are more option for their livelihood **Pre-THHP:** 1. Upland rice cultivation; 2. Livestock raising; 3. Fishing; 4. Vegetable gardens; 5. Collecting NTFPs and wildlife hunting. **Post-THHP:** 1. Upland rice cultivation; 2. Livestock raising; 3. Fishing; 4. Collecting NTFPs; 5. Non-farm income (e.g. trade, servicing, wage labour, and salaries).
4	Reduce fish catch 50%	More than predicted	Study village has declined 78%
5	Better navigation	Yes	Navigation more convenience as several rapids has submerged
6	Better road	Yes	Construction of new road to dam site has improved transportation and communication
7	Better water supply	Yes	Better access to water for vegetable gardens due to the permanent higher water level

From [1] NORPLAN A.S. (1996). **Impact Studies for the Theun-Hinboun Hydropower Project Laos.** Vientiane, Laos: Ministry of Industry and Handicrafts Hydropower Office. p. 61.

4.2.2 Ban Namsanam Village

In recipient river area, before the THHP the Nam Hai River dries up in most years from February to May. The Nam Hai plain is a flat area suitable for agriculture, but lack of water in the dry season has made difficult for habitation to develop agricultural and potable water needs, also water transportation.

The village has established since 1915. In 1995 there are 76 households, presently (2010) the number of households has increased to 188 households which increased 147% with total population of the 1150, with 568 men (49%) and 582 women (51%). The village is composed of three main ethnic groups, namely, Tai Pao, Tai Man, and Tai Meuy.

Before the project population in the village mostly involved in agriculture such as upland rice cultivation, livestock raising, fishing, and collecting of non-timber forest product (NTFPs) and hunted wildlife both for sale and home consumption. Table 4.9 illustrated that income from selling of crop production is the main source of income (45%), during the construction period of Rout 8 and THHP villagers can gain more income from selling of their fish catch for worker, the proportion of income from fish catch is wealth 38% and sales of livestock 17.0% respectively. Compare to the past sources of income for villages has changed, presently cash income from trading and servicing and wage labour is the major income for villagers (76%) sell of fish is less import compare to the past.

Table 4.9 Proportions of Income Source for Ban Namsanam Pre and Post-THHP

Income sources	Pre-THHP (%)[1]	Post-THHP (%)[2]
Fish catches	38	1
Crop production	45	22
Livestock	17	1
Cash income	0	76
Total	**100**	**100**

Note. [1] Data report by NORPLAN. A.S (1996) in the "Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 61.

[2] Data from field research

Before the Project fishing activities depend on the natural conditions, before the project operation Nam Hai dries up during February to May (Figure 4.1), Most of fishing areas is number of pools situated upstream of the village all pools is far from the village and fishers can travel only by walk, some pool villagers have to spend time all day walks to reach destination. In present day all pools are remaining as its location is far from the confluent point where powerhouse released water, therefore all pools not affect by backwater effect. But there are few fishers travels to fish as it is far from the villages (see Table 4.10).

Since operational of THHP, Nam Hai has been full of water all year round villagers can fish at downstream of surgepond. Mentioned by fishers at the present day amount of the catch is less than before but it is easier to fish in term of accessing to fishing areas as Nam Hai full of water all year and the fishing areas closed to the village. Fishing is intensely during wet season as fish migration from the Mekong to upstream Nam Hai for breeding (May-August) and down migration back to Mekong (September-October), fisher also fish in flood areas during the season fishers can use various fishing gear to catch, and average catch during this time is high. The total amount of catch per household in year 2010 is 108 kg/hh/yr, compare to amount of

catch declined 85% (from 720 kg/hh/yr reduced to 108 kg/hh/yr). According to interviews a group of fisher they mention that factors of change is mainly affected by destructive fishing method for instance use of dynamite and electric shock together with population increased. Characteristic of fishery in Ban Namsanam has shown in table 4.11.

Table 4.10 Fishing Areas of Ban Namsanam Pre and Post-THHP Based on Interviews

Fishing areas pre-THHP	Fishing areas post-THHP
1. Vang Hu;	1. Vang Hu;
2. Vang Wer;	2. Vang Wer;
3. Vang Hai;	3. Vang Hai;
4. Vang Hatsompoy;	4. Vang Hatsompoy;
5. Vang Teentok;	5. Vang Teentok;
6. Vang Lathkai;	6. Vang Lathkai;
7. Vang Khoke;	7. Vang Khoke;
8. Vang Phasack; and	8. Vang Phasack;
9. Vang Namyat (head of Nam Hai).	9. Vang Namyat (head of Nam Hai); and
	10. Downstream of tailrace.

Note. Term of *"Vang"* in Lao is means "pool" important habitat for fishes especially in dry season where fish gathering and breeding. Since the operation of THHP, release of water from powerhouse has filled the Nam Hai River all year round and it has created a new fishing area for villagers of Namsanam

Table 4.11 Characteristic of Fishery in Ban Namsanam Pre and Post-THHP

No.	Features	Pre-THHP[1]	Post-THHP[2]
1	Population of Namsanam	76 HHs (1995)	188 HHs (2010)
2	Fish species	118 fish species (in Nam Hai section)	68 fish species (loss 50 species)
3	Fishing areas	9	10 (1 new area)
4	Seasonality	Intensities in wet season Aug-Sep	Fishing year round, frequently during fish migration period Aug-Sep; and Oct-Nov.
5	Amount of catch (kg/hh/yr)	720	Declined 108 (85%)
6	Fishing gears	1. Cast net (mesh size 2-3.5 cm) 2. Lift net 3. Hook (size 6-16)	1. Gillnet (mesh size 3-5 cm) 2. Cast net (mesh size 2-3.5 cm) 3. Lift net 4. Hook (size 6-16)
7	Fishing effort	Less effort and investment	More effort into fishing and invested more for fishing gears and fuel cost for the boat's engine.

Note. [1] Data reported by NORPLAN. A.S (1996) in the "Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 61.

[2] Data from field research

After the project diversion water, the Nam Hai has changed in its hydrology, and water ecology. Water flow increased from 9.0m^3 per second to 110m^3 (NORPLAN, 2008) per second, strong water flows caused serious riverbank erosion. Villagers have loss vegetable gardening along riverbank due to water level increased. Comparison of research result and the impacts predicted by environmental impact study (NORPLAN, 1996) are summarized in Table 4.12 below.

Table 4.12 Impacts of the THHP on the Recipient River Area at Ban Namsanam

No.	Impacts prediction[1]	Field research finding	Remarks from field research	
1	Hydrology change	Yes	Water flow 9.0m^3/s increased to 110m^3/s	
2	Riverbank erosion	Yes	Strong water flow accelerated riverbank erosion particularly in the wet season. Presently, riverbank erosion in a section of Ban Namsanam has stopped due to bank protection has been constructed	
3	Loss of vegetable gardens and grazing land	Yes	Dry season river bank gardens and grazing land loss due to water level increased	
4	Livelihood system change	Yes	**Pre-THHP** 1. Rice cultivation; 2. Livestock raising; 3. Fishing; 4. Vegetable gardens; 5. Collecting NTFPs and wildlife hunting.	**Post-THHP** 1. Rice cultivation; 2. Cash crop (e.g. tobacco, cassava) 3. Livestock raising; 4. Fishing; 5. Non-farm income (e.g. trade, servicing, wage labour and salaries).
5	More fish	No	Study village has declined 85%	
6	Better navigation	Yes	Water transportation more convenience especially dry season	
7	Better road access	Yes		
8	Better water supply for cultivation	Yes	Better water supply for rice and cash crop (e.g. tobacco) cultivation	

From [1] NORPLAN. (1996). **Impact Studies for the Theun-Hinboun Hydropower Project Laos.** Vientiane, Laos: Ministry of Industry & Handicrafts Hydropower Office. p. 61.

4.2.3 Ban Vangthakhong Village

Ban Vangthakhong village has a total population of 1150 people at the present time, with 200 men (65.57%) and 105 women (34.42%). The main ethnic group in the village is Kaleung.

Presently sources of income for Ban Vangthkhong highly incomes are from sell of livestock which constitute about 60% of the total income for households. In addition as the village has good road access it is suited to gaining income from non farm activities such as trading and services, and cash from wage labours. No income from selling of fish catch, it is different from the past fish is a second source of income for the household, sources of income for Ban Vangthakhong shows in Table 4.13.

Table 4.13 Proportions of Income Source for Ban Vangthakhong Pre and Post-THHP

Income sources	Pre-THHP (%)[1]	Post-THHP (%)[2]
Fish catches	38	0
Crop production	45	16
Livestock	17	60
Cash income	0	24
Total	**100**	**100**

Note. [1] Data reported by NORPLAN. A.S (1996) in the "Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 61.

[2] Data from field research

Fishing is intensely during wet season as fish migration from the Mekong to upstream Nam Hai for breeding (May-August) and down migration back to Mekong (September-October), fisher also fish in flood areas and small stream during the season fishers can use various fishing gear to catch, average catch during this time is high. Dry season dry season villagers mostly fish in the middle part of the Nam Hai

River. Shown in Table 4.14, before the project there are two pools in the middle part of Nam Hai situated near the village (i.e. Vang Khainoon and Vang Muangkhai) villagers fish intensely especially in dry season, but in present day are these pools has disappeared after operational of THHP because it has filled with sediment as a consequent of riverbank erosion, also increased of water level and strong current ($110m^3/s$) cause of water released from the powerhouse.

Table 4.14 Fishing Areas of Ban Vanthakhong Pre and Post-THHP Based on Interviews

Fishing areas pre-THHP	**Fishing areas post-THHP**
1. Along Nam Hai	1. Along Nam Hai
2. Flood areas during wet season	2. Flood areas during wet season
3. Small stream (tributaries of Nam Hai)	3. Small stream (tributaries of Nam Hai)
4. Vang Khainoon.	
5. Vang Muangkhai	

Note. Released water from powerhouse to the Nam Hai River since the project has started, two "pool" as fishing areas for Vangthakhong's filled by sediment as a consequence of riverbank erosion, and increasing of water level and strong current ($110m^3/s$) which unfavourable for fishes.

Amount of catch per household in year 2010 is 115 kg/hh/yr which reduced 49% compared to the amount of catch in pre-THHP period. Villagers mentioned that factors of change are mainly affected by destructive fishing method for instance use of dynamite and electric shock together with population increased. Characteristic of fishery in Ban Vangthakhong shown in Table 4.15.

Table 4.15 Characteristics of Fishery in Ban Vangthakhong Pre and Post-THHP

No.	Features	Pre-THHP[1]	Post-THHP[2]
1	Population	76 HHs (1995)	188 HHs (2010)
2	Fish species	118 fish species	68 fish species (loss 50 species)
3	Fishing areas	5	3
4	Seasonality	Fishing year round but frequently in fish migration periods Jun-Oct.	Same as before THHP
5	Amount of catch (kg/hh/yr)	225	115 (-49%)
6	Fishing gears	1. Gillnet (mesh size 3-5 cm), 2. Cast net (mesh size 1-2cm), 3. Hook (size 6-16)	same as pre-THHP
7	Fishing effort	Less effort and investment	More effort into fishing and invested more for fishing gears and fuel cost for the boat's engine.

Note. [1] Data reported by NORPLAN. A.S (1996) in the "Impact Studies for the Theun-Hinboun Hydropower Project Laos" page 61.

[2] Data from field research

The impact of the project to the village is similar to Ban Namsanam, but it is notable that riverbank of Nam Hai is highly eroded since operation of THHP since 1996, and collapses occurred every year and tend to continue. Affected with loss of agricultural and grazing land and. RMR (2006) reported that Nam Hai river from tailrace to a Nam Hinboun river junction, severe to catastrophic erosion along the whole reach, channel widening (almost 3 fold increase in 7 years, 25m to 70m) and straightening, the average rate of erosion over 1-2 million tons/year. 70 ha of riverbank have a loss. The factors contributing to erosion and increases in river suspended sediment and bed load levels, induced erosion due to: (1) Deforestation of the Nam Hai plain by forest concessionaires including removal of protective riparian forest vegetation. (2) Residents removing riparian vegetation and terracing banks for

the establishment of dry season river gardens. (3) Rapidly increasing numbers of grazing animals on the Nam Hai plain, especially goats, destroying riparian vegetation regrowth. Result of measurements shows that Total Suspended Solids of Nam Hai exceeded water quality standards in several months especially during the wet season, the impacts of the project to the village has shown in Table 4.16.

Table 4.16 Impacts of the THHP on Recipient River Area at Ban Vangthakhong

No.	Impacts prediction[1]	Field research finding	Remarks from field research	
1	Hydrology change	Yes	Water flow 9.0m^3/s increased to 110m^3/s	
2	Riverbank erosion	Yes	Strong water flow accelerated riverbank erosion particularly in the wet season and likely to continue	
3	Loss of vegetable gardens and grazing land	Yes	River bank gardens and grazing land loss due to bank erosion and water level increased	
4	Livelihood system change	Yes	**Pre-THHP** 1. Rice cultivation; 2. Livestock raising; 3. Fishing; 4. Vegetable gardens; 5. Collecting NTFPs and wildlife hunting.	**Post-THHP** 1. Rice cultivation; 2. Cash crop (e.g. tobacco, cassava) 3. Livestock raising; 4. Fishing; 5. Non-farm income (e.g. trade, servicing, wage labour, and salaries).
5	More fish	No	Study village has declined 49%	
6	Better navigation	Yes	Water transportation more convenience especially dry season	
7	Better road access	Yes		
8	Better water supply	Yes	Better water supply for vegetable garden and cash crop (e.g. tobacco) cultivation	

From [1] NORPLAN. (1996). **Impact Studies for the Theun-Hinboun Hydropower Project Laos.** Vientiane, Laos: Ministry of Industry & Handicrafts Hydropower Office. p.61

4.2.4 Observation on Fish Catches in Study Villages

This section was presented observation on fish catches based on the result of field research and comparison within the pre and post period of THHP, also presented attitude fish catch changes based on research result and report reviews. Summary of the impacts shown in Table 4.17.

With regard to amount of fish catches the data monitored by Social and Environment Division of THPC during the year 2010 from 36 active fishers in the study villages (12 fishers from each village). The data indicated that during the year the amount of fish caught is different among the head-pond area and recipient rivers areas. Head-pond area in Ban Kangbit the whole year total amount of catches is between 200 to 300 kg per month, dry season during the November amount of fish caught are the highest in the year. In fact, fishers can catch nearly 500 kg in certain month (e.g. November) the lowest amounts of fish caught are in February according to discussion with fishers. They mentioned that fewer catches are in February because of the condition of the water such as the cold water temperatures, which is not favourable for fishes. Recipient rivers area in Nam Hai River, Ban Namsanam in dry season fishers can catch plenty this time as low water level and river flow is weak, they can use various fishing gears such as gillnet, lift net, hooks, also spear gun etc.., amount of catches at Ban Namsanam are 250 kg in March. During the wet season from June until August, an amount of catches is less than half due to peak water level and water flow in Nam Hai, which lead to difficulties in catching fish. In Ban Vangthakhong, the amount of catches is quite similar within the year. An amount of catches is higher in April with total amount of 262 kg per month and lower only of 108 Kg per month in November. The amounts of catch of all areas are shown in Table 15 (see detail number on Appendix A).

Table 4.17 Total of Fish Catches by Villages in 2010

	Amount of fish catch in 2010 (kg)			
Villages	**Monthly Min**	**Monthly Max**	**Monthly Mean**	**Annual**
Kangbit	187	498	287	3,442
Namsanam	47	250	108	1,298
Vangthakhong	41	251	116	1,389
Total				**6,129**

Note. Data provided by Theun-Hinboun Hydropower Company.

To compare the amount of catch before and after the project, available fish catch data in the study villages prior to the project operation by Schouten (2004) has been used to compare. The data show that before the project, fishers report that they were able to catch more than after the project. Table 19 shows that in Kangbit fisher able to catch 1275 kg/hh/yr, Namsanam 720 kg/hh/yr and Vangthakhong 225 kg/hh/yr. Presently, the amount of catch in all villages has extremely declined, particularly in Namsanam which decline -85% of the catch before the Project, Kangbit -78%, and Vangthakhong -49% respectively. Table 4.18 shows a comparison of fish catch before and after the project.

Table 4.18 Estimates of Annual Household Fish Catch in Study Villages Pre and Post-THHP (kg/hh/yr)

	Amount of catch per household per year		
Villages	**Pre-THHP**[1]	**Post-THHP (2010)**[2]	**Catch change (%)**
Kangbit	1275	287	- 78
Namsanam	720	108	- 85
Vangthakhong	225	115	- 49

Note. [1] Annual household fish catch per household period of pre-THHP on an interview by Schouten et al.(2004)**;**

[2] Data provided by Thuen-Hinboun Hydropower Company.

The Table 4.19 shows the overall figure of the general observations on fish catches by the respondents of sample household in the study villages. The majority of all respondents (94%) claimed that their fish catches have considerably decreased when compared before the project, only an insignificant proportion of respondents (3%) mentioned that their fish catches to stay at the same level, and 4% of respondent mentioned that fish catches increase.

Table 4.19 Observation on Fish Catches According to Interviews

	No. of respondent by villages						**Respondent rate**	
Observation on fish catches	**Kangbit**		**Namsanam**		**Vangthakhong**		**Total**	
	f	%	f	%	f	%	f	%
Decrease of fish catches	28	100	34	87	11	100	73	94
Same level of fish catches	0	0	2	5	0	0	2	3
Increase of fish catches	0	0	3	8	0	0	3	4
Total	**28**	**100**	**39**	**100**	**11**	**100**	**78**	**100**

The different views of the respondents on the issue of fish catch change is shown in Table 4.20. Major causes of fish catch decrease by the respondents of each village, are ranked in the Table 18 in respective order of priority. Major causes of fish catch decrease were found that the fish catch changes majority cause by use of illegal fishing methods for instance the use of explosive and electric shock (26%) together with change in favourable natural condition for fish such as quality and quantity of water has changed (23%) follows by the increased commercialization of catches leading to higher competition (18%) and 17% of respondent mentioned that catch decreased because fish migrate to another area. Nevertheless, high proportions of respondent have no idea about the change of their catch.

Table 4.20 Attitude of Fish Catches Changes According to Interviews

Driver of change	The attitude of villager for fish catch change							
	Kangbit		Namsanam		Vangthakhong		Total	
	f	%	f	%	f	%	f	%
Water level / quality change	3	11	13	33	2	18	18	23
Increased number of fishers	6	21	8	21	3	27	17	22
Illegal fishing method	10	36	6	15	4	37	20	24
Use of the small mesh size net	0	0	0	0	0	0	0	0
Fish migrate to another area	5	18	6	15	2	18	13	17
Others / No ideas	4	14	6	16	0	0	10	13
Total	**28**	**100**	**39**	**100**	**11**	**100**	**78**	**100**

The project might affect to household fish catch declined in many ways particularly ecosystem has changed, but it is might also as a result of increased of population in the study villages, increase of fish trade opportunities, increase of fishing efforts, and destructive fishing methods. Table 4.21 shows percentage of population growth in the study villages in 15 years during 1995 to 2010, the highest is in Ban Kangbit which increased 350%, Ban Namsanam increased 147%, and Ban Vangthakhong increased 32%.

Construction of new roads and upgrading existing has increased access to market centres opening up for commercial exploitation of fish, agriculture and forest products. Accessibility and open opportunities for trade it is initially beneficial on village livelihood, other hand it may lead to over fishing and illegal fishing methods.

In a head-pond before the project villagers catch fish for subsistence purposes, but they have begun to catch for sale since the construction of Route 8, the Nam Thuen Bridge and hydropower project moved in. Villagers sell their fish to these workers and to merchants from Laksao district. Fish is sold fresh, smoked or dried, although fresh fish are more popular. Ban Thabak is the main market place along the Nam Thuen River. The head-pond villagers claim that the number of fish caught has been declining gradually in recent years. This is attributed to the increased use of effort and destructive fishing method to catch more fish to serve the market demand

The problem is illustrated by the fact that in the year 2009 the villagers upstream head-pond have been set up regulations preventing the use of dynamite. This is just one case, mentioned by villagers in Ban Kengbit that used by destructive fishing method is occurring but often cannot find a violator.

Similar to villages in recipient river areas, villagers from Ban Namsanam and Vangthakhong began selling fish about 3-4 year later when the construction of Route 8 stared. At first they sold fish at a flat rate of 400 kip/kg (value in 1996), but as their experience in trade grew, fish prices were set according to species, such as that of catfish is priced at 1,500 Kip/kg (value in 1996). Presently, fish can be sold at the market at Ban Nahin near THPC camp.

Table 4.21 Number of Households in Study Villages Before and After the Project

Village	Number of Households		Growth rate (%)[3]	
	Before (1995)[1]	After (2010)[2]	1995 - 2010	Annual
Kangbit	30	135	350	23.3
Namsanam	76	188	147	9.8
Vangthakong	40	53	32	2.1

Note. [1] Data provided by Theun-Hinboun Hydropower Company.

[2] Data from field survey

[3] Estimate by author

4.3 Mitigation Measures to Improve Fishery for the THHP

To improve fishery in the project areas, also respond to adverse impact of the project. Numerous of activities have been implemented by project proponent (Thuen-Hinboun Power Company-THPC) to mitigate impacts of the project on loss of fish catch according to recommendation from consultants, several mitigation measures consist of development of small-scale aquaculture in some affected villages (included study villages) and fish monitoring program to understand the situation of fishery in the affected villages. Apart from mitigation measures provided by the project proponent, all study villages have requested for additional support from the project proponent to construct a natural fish pond to maintain fish stock (Table 4.22).

Table 4.22 Fishery Management by Project Proponent

Proposed by project proponent	Status	Remarks from field research	Additional requested by villages
Aquaculture development	Implemented	Fish and frog raising in small plot for selected household in all study villages	In addition to project proponent provided all study villages need support to construct a natural fish pond.
Fisheries monitoring program	Implemented	Long-term fish monitoring program by the project proponent conducted in 25 affected villages in various locations	

4.3.1 Mitigation Options Recommended from Research

Although several mitigation measures has been conducted by the project proponent but there have still limited success. There are numerous mitigation options which have been successfully used elsewhere as suggested by research according to reviews of good practices in other countries. These options are to maintain fish stocks and to promote employment opportunities for those dependent on the fishery for their livelihoods. The mitigation measures are most important to minimize conflicts between project proponent and affected peoples in the project areas. Combination of mitigation measures that may be appropriate for the head-pond and recipient river areas are outlined below:

4.3.1.1 Stocking enhancement

To mitigate the impact of fishery declined perhaps stocking and introductions are the most widespread fisheries management practice in reservoirs and it is perhaps one of the oldest management practices. There are several successful approaches for enhancing and intensifying reservoir fisheries production. However it has been controversial because in many instances it has disrupted fish communities, contributed to the loss of

wild strains, and reduced genetic diversity. Nevertheless, stocking has a significant role in reservoir management when used in the right manner and in the right location. Several stocking technics for head-pond and recipient river areas identified as follows:

1. Head-pond Area: In the head-pond which mountainous and lack of land mitigation options to improving fisheries is relatively limited, however inundate area in dam site are made opportunity for promotion of aquaculture in reservoir such as cage culture. As illustrated in several countries it is a very productive aquaculture practiced in the reservoirs of Vietnam and China, high yields of cage culture are often realized. In Laos cage culture is a very productive form of aquaculture practiced in the reservoirs of Nam Ngum and Nam Houm Reservoir in Vientiane Province (de Silva, 1992).

Nevertheless, ecological problems associate with cage culture has been concerned especially the introduction of exotic species. At present, the common carp (*Cyprinus carpio*) and tilapia (*Oreochromis* spp.) are two of the most commonly farmed fish species in countries in the Mekong Basin as well as Laos are not native to the Mekong River Basin, is suspected of causing serious ecological damage to native fish species and aquatic communities. History indicates that it is reasonable to expect that fish farmed over many years will eventually escape or be released into the wild (FAO, 1999). Therefore, introducing for cage culture should focus on identifying and promoting native fish species for cage culture.

However the disadvantage of cage culture is relatively cost time and money to build and they have limited lifespan and are subject to outsider theft.

In Nam Theun River, during the wet-season months, they are vulnerable to submerging by flash floods and physical damage from floating debris. Fish also require good-quality protein food in order to grow and provide returns on investments this might be a limitation for villagers in the head-pond.

2. Recipient River Areas: Promotion of stocking in small waterbodies might be appropriate for the villages in recipient river as its vastness of land areas consisted of small streams and flood areas differ from the head-pond which is mountainous. Small waterbodies have been defined as small reservoirs and lakes less than 10 km2, small ponds, canals, irrigation canals, swamps and small, seasonal,

inland floodplains (Marshall & Maes, 1994). In Laos, stocking of Nile tilapia *(Ore ochromis niloticus)* has been actively promoted by the government since 1994 and the practice is spreading rapidly particularly promoted for small waterbodies aquaculture (Phonvisay, 1994).

Appearance in research of Garaway, Lorenzen and Chamsingh (2001) stocking in small waterbodies have provided benefits both direct biological effects of stocking (increased recruitment of valuable species) and indirect effects due to institutional change resulting from the investment into common pool resources (e.g. incentives for sustainable use, reduced fishing pressure and higher returns to labour). However the success of the program has depended on effective of management by local.

According to field research found that most of the household is practiced paddy rice and vast area of paddy fields in recipient river areas is considerable to introducing of aquaculture in the rice field might be attractive approached. Rice-fish culture is culturing fish and growing rice together in the same fields, it is an old practice in many countries in the world particularly in Asia. It can provide supplemental income and food for farmers as well as help to control pest in the rice field. However, Rice-fish culture might not preferable for farmers because it need additional management and requires more labour than rice culture alone. Furthermore culturing fish in paddy field it is crucial to restrict use of pesticide and chemical fertilizer.

4.3.1.2 Construction of small-scale fish hatcheries

This program aims to adequate supplies of fry and fingerling for aquaculture development programs mentioned above. Small-scale hatcheries can be effective in producing low cost fry in the project areas because the present price of fry and fingerling relatively high due to the lack of hatcheries around the country and also due to the difficulties in communications between provinces. Furthermore, a small hatchery is low investment this would appropriate for lower income farmers. According to Samruay and Funge-Smith (2007) advantage of small scale fish hatcheries including:

1. Small size results in low construction cost;
2. Small size is easy to manage at family scale;
3. Do not always require sophisticated equipment (pumps, aerators, electricity);

4. The range of species that can be produced are not restricted by hatchery size; and

5. They can be located almost anywhere that has a suitable supply of water

However, the effectiveness of the program will be dependent on a numerous factor mainly from ability of support staffs and management procedures.

4.3.1.3 Management of the fish passage facility at the dam site

Dams usually block upstream fish migration and interfere with downstream fish migration. A variety of mitigation measures have been used to deal with these problems and research is continuing to improve them further. One of the measure is construction of fish passage also known as a fish ladder, it is a structure on or around artificial barriers (e.g. dams) to facilitate fishes natural migration. Most fish passage enable fish to pass around the barriers by swimming and leaping up a series of relatively low steps (hence the term ladder) into the waters on the other side. Therefore fish ladders have been presented as a mitigation measure to reduce the impact of dam project on fish in many countries (WCD, 2000a).

However, according to World Commission on Dam (WCD, 2000a) successful of fish passage is very few. For example in the USA only around 10% of almost 2,000 large dams have fish passage, in South Africa there are over 450 large dams but only 16 dams have available fish passage. In Norway there are 34 fish passage on the 40 dams, these only 26% work with 'good efficiency,' 41% work less well, and as many as 32% are not working at all. At Pak Mun Dam in Thailand, the case study documents the ineffectiveness of the fish pass, especially for the large migratory species in the Mekong that may be up to two metres long and cannot fit through the 15x20 cm of salmon sized slots.

In addition, typically fish passage should design and construct in the same period of dam construction, in case of THHP there might be a delay since the dam has completed and operation. Furthermore successful of fish passage are comprised of many factors so we cannot ensure that if fish passage has been built it will effectively or not. Therefore, design of fish passage facilities for the THHP must need more research to explore appropriate design for behaviour of fish species dominant in the project area.

4.3.1.4 Fish conservation plans and public awareness

Parallel with the program to increase fish population mainly with aquaculture development, it is significant that we should protect and conserve natural fish including

1. Establish a fishery conservation zone to protect the habitat of large numbers of migratory species during breeding season, in these areas all fishing methods were prohibited to fish in certain time for subsistence purposes or no fishing.

2. To deal with the serious problem of prohibiting destructive fishing practices should establish fishery group at commune level to collaborate and controlling within their areas parallel with training for patrolling and enforcement

3. For successful of conservation program involve and support of local communities is crucial, therefore implement of fish conservation education for villagers to make them realize the importance of fish and fishery should be conduct

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Results of field research compared to the prediction of impacts reported by EIS confirm that the project created both negative and positive impact to the livelihood of the villages in the affected areas. In the head-pond area, villagers have lost land areas and relocated due to an increase in water levels. In recipient river area, the impacts have been the loss of land due to increased water level and riverbank erosion. However, construction and upgrade of the road to the project sites has improved transportation, and more water, both in head-pond and recipient river villages has made river transportation more convenient than pre-THHP. The results of field research are concluded as follows:

Construction of THHP dam has changed hydrological condition of the study areas. However water quality of selected indicators such as DO, TSS, pH, and water temperature relatively unchanged

Before the project sells of the fish catch is supplementary income for all study villages. Presently income from sells of the fish catch is less compared to before the project as amount of fish catch is reduced, thus fish is catch mainly for subsistence purpose. Through twelve years of operation of THHP (1998-2010) fishery in the study village has changed. In the head-pond areas, fishing areas has loss as several rapids have submerged; amount of catch per household in the study village (Ban Kengbit) has declined by 78%. Similar to recipient river area the villages have experienced loss of fishing areas, accepted Ban Namsanam the village new fishing

area since the project diverted water to the Nam Hai River. Ban Namsanam fish catch per household declined by 85% and Ban Vangthakhong declined 49% respectively. Apart from a change of quantity, composition of fish caught has also changed. In head-pond there are 79 fish species found in Nam Thuen River nowadays fishers found only 42 species. In recipient river areas there are 118 fish species found in Nam Hai River, presently fishers found only 68 species.

The changes in the Nam Thuen River may be affected by the construction of THHP dam. The main factor affected appears to be the disappearance of some fish species due to increase of water elevations, and decreased water flow in the head pond. The higher level has also modified and altered aquatic habitats in the head-pond such as rapids along the river. The rapids have been submerged and these were the main spawning grounds, according to interviews there were 13 rapids along the Nam Thuen River in sections of the head-pond but have disappeared. The increase of water elevation might also affect and reduced some water plants including periphyton which is food for many fish species. The higher depth has reduced the sunlight penetration.

In the recipient river, increased water volume has changed the hydrological regime, and the disappearance of the pools along the Nam Hai River might have affected some fish species. However for the factors of why fish species are reduced, more research is needed to identify factors related to both the construction and operation phases of dam.

While fisheries shared small proportion of cash income, it is much more important for subsistence as fish provide the major source of protein and essential elements. Therefore the fish catch decline has affected directly to their livelihood. The purpose of fisheries management is aiming to maintain fish stock in the project areas and aim to increase benefits and employment opportunities for households who depend up on the fishery for their livelihoods. To achieve those objectives we need to find a combination of management measures that should appropriate for the areas. Development of aquaculture for stocking fish such as cage culture might be a reasonable approach to the village in head-pond area, however cages culture cost more input to build and it has limited life spans as limitation of resources in head

pond village it may need support from the project proponent and government authorities. Furthermore affected by the introduction of alien species is concerned, therefore fish species to stock in cage culture should be carefully selected. In the recipient river area, small water-bodies aquaculture might suitable because there is large of land consisted of small stream and flood areas these would be potential for the village to implement this approach, however this approach might not appropriate for the village at the head-pond area because it is mountainous lack of land. To conserve the number of indigenous fish species construction of a fish hatchery has been recommended, the purpose of the program aim to breeding and releasing certain indigenous fish species currently found in the project areas.

Numbers of fish pass types are available but effectiveness are still unclear especially in the countries of the Mekong Basin. However, the existing research does show that obstruction of the river has affected a reduction of fish species. Therefore it is strongly recommended that the dam project should manage fish passage in the dam site to facilitate their migration.

5.2 Recommendation for Further Research

According to limitation of time and resources there are several issues having oversight. To fulfill the gaps, further research should remain focused on the level of dependency of peoples in the project areas in various perspectives such as depend on fisheries of ethnic group, gender, age or fish consumption (e.g. per capita consumption, nutrition intake compares to other diet etc…) and analysis of the economic value of fish is also important. To examine fishery declined caused by the project, further in-depth research should focus closely on environmental condition changed by the project such as change in hydrological and ecological, various water quality indicators should apply, also patterns of fish migration have to be considered.

With regard to mitigation measures to reduce impact of the dam operation, more research is also needed. For instance, introduction of fish for aquaculture

should conduct more research to be precautionary of introducing exotic species for aquaculture. Additional research should identify and promote certain native fish species for aquaculture, there are probably more than 1000 indigenous fish species in the Mekong River Basin. This means some species might be suitable for aquaculture development for project areas. Construction of fish passage at the dam site is difficult issues to select the type appropriate for the project, which really requires more innovative research to explore best solutions to deal with these issues.

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APPENDICES

APPENDIX A

Data Table of Fish Catch in 2010

Table A1 Fishing Data in Year 2010 of 42 Active Fishing Households in Study Villages (12 household per each village)

Villages	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kangbit	Amount (kg)	293	187	235	290	298	261	332	261	244	232	498	311	3442
	Sell (kg)	44	16	17	18	37	13	66	48	52	28	176	72	587
	Consumption (kg)	249	171	218	272	261	248	266	213	192	204	322	239	2855
Namsanam	Amount (kg)	65	78	250	153	216	47	66	60	102	50	98	113	1298
	Sell (kg)	0	0	0	0	26	0	0	0	0	0	4	1	31
	Consumption (kg)	65	78	250	153	190	47	66	60	102	50	94	112	1267
Vangthakhong	Amount (kg)	65	96	120	251	201	137	110	133	106	76	41	53	1389
	Sell (kg)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Consumption (kg)	65	96	120	251	201	137	110	133	106	76	41	53	1389

Note. Data monitored by THPC, 2011.

APPENDIX B

Figure of Water Quality

1 Dissolve Oxygen

During the dry season hyper-saturation can be noticed as a result of increased phytoplankton and algae growth in the slow flowing rivers at the end of the dry season. Phytoplankton and algae produce oxygen during day time by photosynthesis. Over saturation of DO during day time gives an indication of the density of phytoplankton and algae blooms.

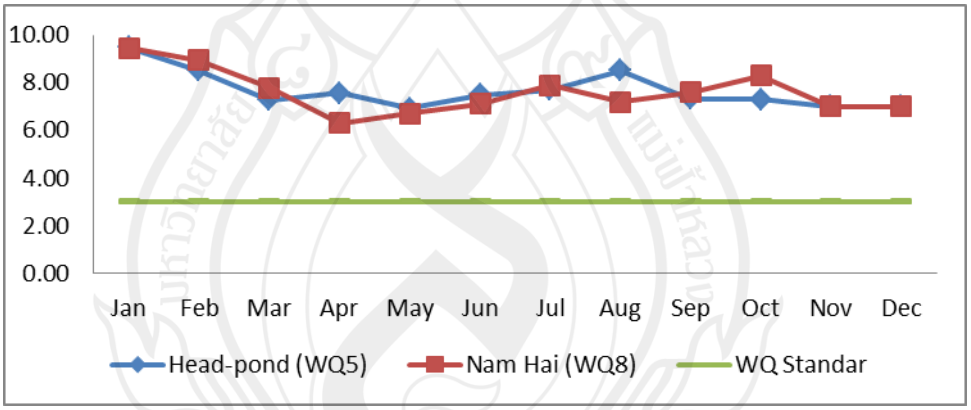

Figure B1 DO Values for One Year in Head-Pond (Nam Theun River) and Nam Hai River.

Note. Data provided by Theun-Hinboun Hydropower Company.

2 Total Suspended Solid (TSS)

The dramatic increase in dry season flow and the intermittent discharge, varying from 0 to 110 m3/s in one day during the dry season and an annual flood flow of 200-300 m^3/s during the wet season (NORPLAN, 2008) as a result of the extra discharge from the powerhouse have started extensive erosion processes along the Nam Hai.

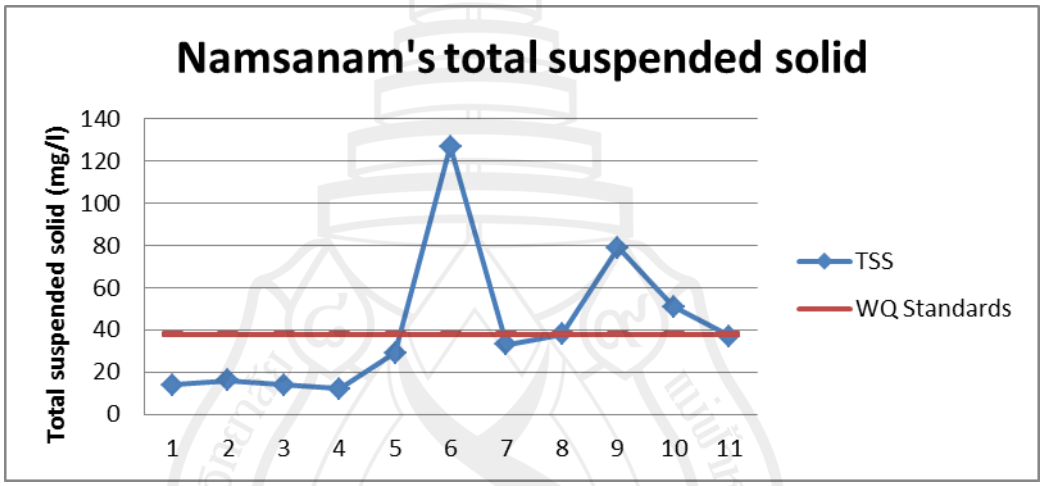

Figure B2 Average Total Suspended Solid in Lower Nam Hai (WQ8) in 2010**.**

Note. Data provided by Theun-Hinboun Hydropower Company.

Monitoring of TSS in the head-pond there is only conduct during the wet season (August to October) and transition of wet to dry season (October to December). The result indicated that during flood events very high turbidity levels caused by sedimentation have been measured, caused by bank erosion, sediment flushing of the riverbed and soil slips.

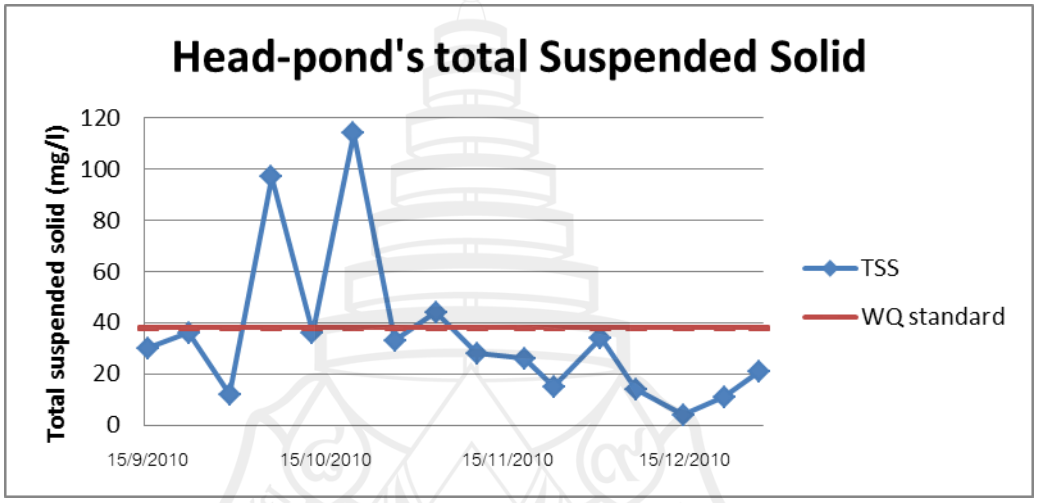

Figure B3 Average Total Suspended Solid of Head-pond (WQ5) in 2010.

Note. Data provided by Theun-Hinboun Hydropower Company.

APPENDIX C

Riverbank Erosion

From tailrace to a Nam Hinboun junction, severe to catastrophic erosion along the whole reach, channel widening (3 fold increase in 7 years, 25m to 70m) and straightening. Rapid migration of river bends. Some bed degradation in the upper reaches but armouring and limestone reefs control this process. Some sediment deposition on banks and as midstream channel bars in the middle and lower reaches reducing channel competence despite widening. Average rate of erosion over 1-2 million tons/year. 70 ha of river bank land lost (RMR, 2006).

The main factors contributing to erosion and increases in river suspended sediment and bed load levels, induced erosion due to: (1) Deforestation of the Nam Hai plain by forest concessionaires including removal of protective riparian forest vegetation. (2) Residents removing riparian vegetation and terracing banks for the establishment of dry season river gardens. (3) Rapidly increasing numbers of grazing animals on the Nam Hai plain, especially goats, destroying riparian vegetation regrowth. Result of measurements shows that Total Suspended Solids of Nam Hai exceeded water quality standards in several months especially during wet season.

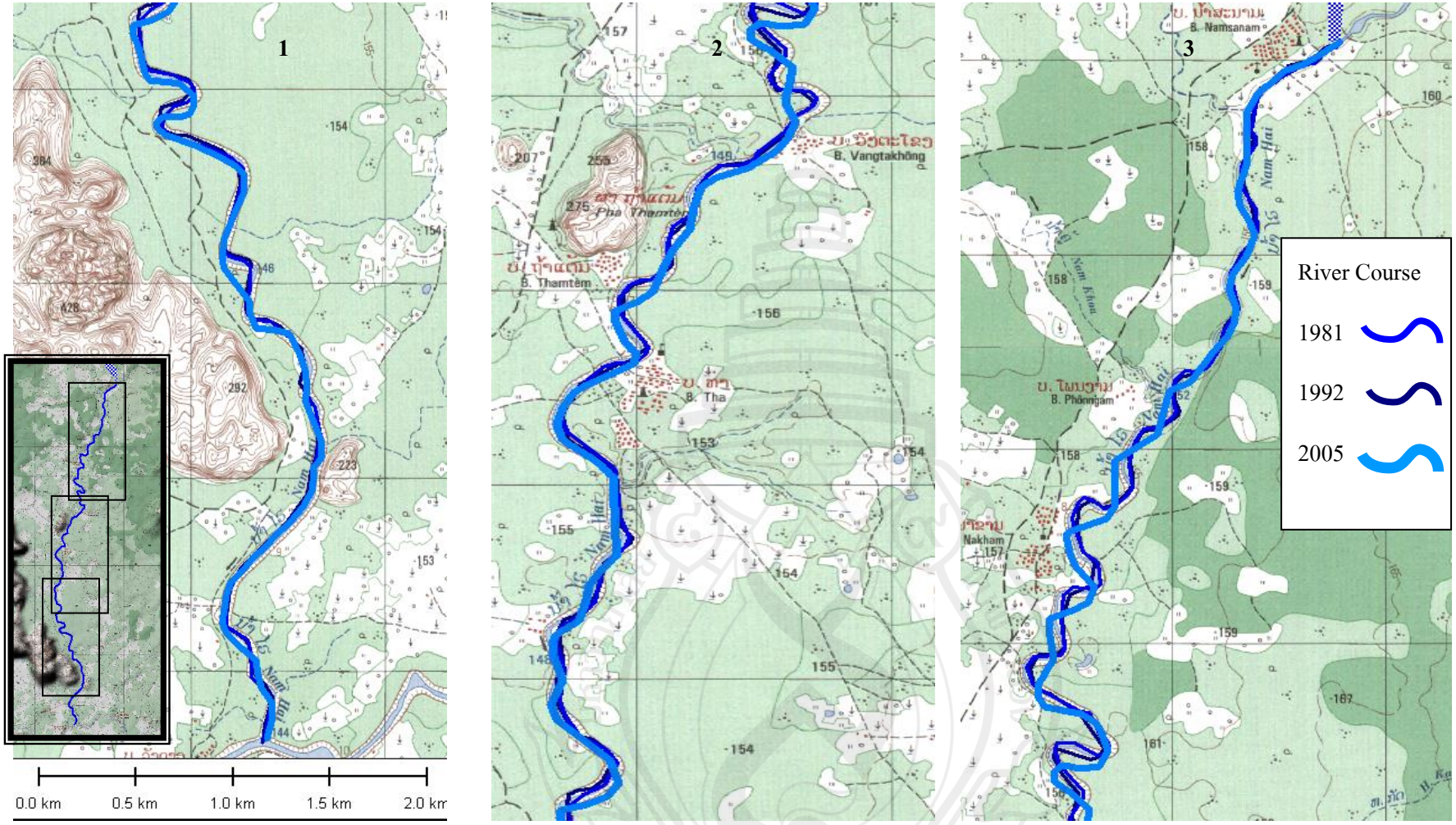

Figure C1 Erosion in the Nam Hai (Superimposition of River Courses and Widths for Nam Hai) 1981, 1992, 2005

APPENDIX D

Questionnaire Form

There are three different questionnaire forms which have been applied for different purposes, form number (1) I have used for collecting village background information such as number of household, population and other relevant information by asking head of each study village. Apart from village information this form included key questions for guiding discussion with a group of 5 to 10 active fishers in each study village; form number (2) I have used for collecting socioeconomic and fishing activities information about individual household which focus on active fishers; form number (3) used by Social and Environment Division of Theun-Hinboun Power Company to monitor monthly fisheries data in the affected village in the different location of project areas. This form was filled by fisherman after they were trained.

(1). Village Questionnaire and key question for focus group discussion

Date: ……...

Village name: …….

Number of households: ……

Number of families: …….

Number of population: …… (Female)……..

Fishing areas: …….

Where do you or your household members go fishing more often?

Dry season: ……

Wet season: ……...

Fishing effort

Time spent	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average number of days *Per week*												

I would like to compare your current fishing activity with the time before THHP project. Following items what has been changed:

- Seasonal fishing areas change

Dry season ( ) Yes ( ) No

Wet season ( ) Yes ( ) No

- Fishing gears change ( ) Yes ( ) No

If "yes", please indicate what have been changed?

( ) Move from one dominate gear type to another ( ) New fishing gear used ( ) Mesh size change ( ) more gear used

What are common species you have found?

……

……

Was your catch changed compared to 10 years ago in term of quantity?

( ) Same ( ) More ( ) Less

What do you think has caused the change?

For less catch: …….

For more catch: …….

Does your village have any fisheries management plan? ( ) Yes ( ) No

If "yes" what kind of plan did you have:

……

……

…….

(2). Household questionnaire:

Date: ……...

Name: …….

Ethnic:…….

Village: ……...

Background information:

Number of household members: ……

Livelihood activities (X)

Activities	Subsistence	Main income	Support income
Rice farming			
Wage labour			
Livestock raising			
Capture fish			
Service			
Cash remittent			

Fishing:

Important of fisheries ( ) not important ( ) slightly important ( ) important

Fishing areas: …….

Where do you or your household members go fishing more often?

Dry season: ……

Wet season: ……...

What fishing gear you are using (what size)

……

……

How much you invested for your fishing gear per year?

……...

How much you caught per day?

Dry season ……

Wet season ……

Compare amount of catch with last 10 year ( ) same ( ) less ( ) more

What do you think has caused the change?

For less catch: …….

For more catch: …….

How much you earn per year from selling fish? ……

Aquaculture:
Apart from wild fish capture, do you raise fish or OAAs? ( ) Yes ( ) No
If "yes" what is size of area / cage number: ……

Total income last 12 months, and percentage of income source

Total (kip)	**Fish (%)**	**Crop production (%)**	**Livestock (%)**	**Cash income (%)**

CURRICULUM VITAE

CURRICULUM VITAE

NAME	Mr. Thanongkham Venethongkham
DATE OF BIRTH	1 July 1979
ADDRESS	Ban. Chansavang, Sikhottabong District Vientiane Capital, Laos

EDUCATIONAL BACKGROUND

2003	Bachelor of Science in Plant Science National University of Laos

WORK EXPERIENCE

2011-Present	Technical Officer Ministry of Natural Resources and Environment, Laos
2008-2011	Technical Officer Water Resources and Environment Administration, Laos
2007-2008	Environmentalist Thuen-Hinboun Hydropower Company, Laos
2004-2005	Research Assistant L'Institut de recherche pour le développement (French Research Institute for Development (IRD**)**