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ENVIRONMENTAL AND SOCIO - ECONOMIC IMPACT ASSESSMENT (ESIA) OF XESET 2 DAM, SALAVAN, LAO PEOPLE'S DEMOCRATIC REPUBLIC

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วิทยานิพนธ์ฉบับนี้ศึกษาผลกระทบสิ่งแวดล้อมและเศรษฐกิจ-สังคม (ESIA) ของเขื่อนเซเซ็ต 2 จังหวัดสาละวัน สาธารณรัฐประชาธิปไตยประชาชนลาวในปี 2011 งานนี้มีวัตถุประสงค์เพื่อเปรียบเทียบคุณภาพน้ำในปัจจุบันกับช่วงระยะเวลาก่อนการก่อสร้างเขื่อน (ในระหว่างการศึกษา EIA) ตั้งแต่ปี 1999 โดยมีขอบเขตการศึกษา 2 ส่วน คือ การประเมินผลกระทบสิ่งแวดล้อม โดยเน้นการศึกษาคุณภาพน้ำและการประเมินผลกระทบด้านเศรษฐกิจ-สังคม ของเขื่อนเซเซ็ต 2 ในปี 2011 ได้ทำการเก็บตัวอย่างคุณภาพน้ำใน 3 จุดเก็บ โดยจุดที่ 1 คือสะพานบนถนนแห่งชาติเลขที่ 20 หมู่บ้านเล่างาม (แม่น้ำตาปุง) จุดที่ 2 บริเวณหมู่บ้านโพธ์ตอก 100 เมตร เหนือเขื่อนเซเซ็ต 1 และท้ายเขื่อนเซเซ็ต 2 (แม่น้ำเซเซ็ต) และจุดที่ 3 บริเวณถนนสะพานเลขที่ 20 บริเวณท้ายเขื่อนเซเซ็ต 1 และ 2 โดยทำการเก็บตัวอย่างเพียง 2ฤดู ในฤดูฝนและฤดูหนาวเท่านั้น ยกเว้นฤดูร้อน เนื่องจากปริมาณน้ำในแม่น้ำที่เหลือน้อยมากจนไม่สามารถเก็บตัวอย่างในฤดูร้อนได้

การศึกษาผลกระทบสิ่งแวดล้อมจากการสร้างเขื่อน เน้นศึกษาด้านคุณภาพน้ำในแม่น้ำจากเขื่อนเซเซ็ต 2 โดยศึกษาคุณภาพน้ำทางด้านกายภาพ เคมีและชีวภาพ (APHA, 2005) ผลการทดลองพบว่า การสร้างเขื่อนส่งผลให้คุณภาพน้ำทางด้านเคมี มีค่าสูงกว่าในช่วงปี 1999 โดยเฉพาะในฤดูฝน เช่น ความกระด้าง ในจุดที่หนึ่งเท่ากับ 65.3 มิลลิกรัมต่อลิตรในฤดูฝนมากกว่าจุดที่ 2 และ3 ความเป็นด่างในฤดูหนาวจุดที่ 1 มีเท่ากับ 76.3 มิลลิกรัมต่อลิตร ความต้องการออกซิเจนทางเคมี (COD) ในฤดูฝน จุดที่ 1 เท่ากับ 129.3 มิลลิกรัมต่อลิตร ไนเตรต - ไนโตรเจน 8.9 มิลลิกรัมต่อลิตร จุดที่1 ในฤดูฝนและฟอสเฟตฟอสฟอรัส 0.1 มิลลิกรัมต่อลิตร คุณภาพน้ำเหล่านี้ พบว่าค่า COD สูงกว่า และมีการปนเปื้อนอุจจาระจากสัตว์เลี้ยงลูกด้วยน้ำนมและปนเปื้อนน้ำทิ้งจากอาคารบ้านเรือน

(APHA, 2005) มาตรฐานคุณภาพน้ำผิวดินของสาธารณรัฐประชาธิปไตยประชาชนลาว ทั้งสามจุดและสองฤดู ยกเว้นจุดที่สองและที่สามในฤดูหนาว ทั้งนี้เนื่องจากการปนเปื้อนสารอินทรีย์และอนินทรีย์ลงในแหล่งน้ำจากกิจกรรมของมนุษย์ เช่น การทำการเกษตรกรรม การซักล้าง และการปล่อยน้ำเสียจากครัวเรือนโดยตรงลงสู่แหล่งน้ำ อย่างไรก็ตามส่วนใหญ่คุณภาพน้ำของแม่น้ำเซเซ็ต (Xeset) และตาปุ้ง (Tapoung) ยังมีคุณภาพน้ำอยู่ภายใต้มาตรฐานคุณภาพน้ำผิวดินของสาธารณรัฐประชาธิปไตยประชาชนลาว และ USEPA ดังนั้น ผลการวิเคราะห์คุณภาพน้ำใน แม่น้ำเซเซ็ด และตาปุ้ง ส่วนใหญ่อยู่ภายใต้มาตรฐานคุณภาพน้ำผิวดินประเภท 2 คือการอุปโภคและบริโภค โดยต้องผ่านการฆ่าเชื้อโรคตามปกติก่อนและผ่านกระบวนการปรับปรุงคุณภาพน้ำทั่วไปก่อน การอนุรักษ์สัตว์น้ำ การประมง ว่ายน้ำและกีฬาทางน้ำ

สำหรับการประเมินผลทางเศรษฐกิจ-สังคม วิเคราะห์โดยแบบสอบถามและทำการเก็บตัวอย่างใน 3 หมู่บ้าน จังหวัดสาละวัน สาธารณรัฐประชาธิปไตยประชาชนลาว จุดที่ 1 คือ หมู่บ้านโพธิ์ตอก บริเวณเหนือเขื่อนเซเซ็ต 1 และท้ายเขื่อนเซเซ็ต 2 (แม่น้ำเซเซ็ต) จุดที่ 2 บ้านท่งสุ่ย ท้ายเขื่อนเซเซ็ต 2 (แม่น้ำเซเซ็ต) และจุดที่ 3 บ้านเล่างาม บริเวณ (แม่น้ำตาปุ้ง) แบ่งการวิเคราะห์เป็น 4 ส่วน ส่วนที่ 1 คือข้อมูลภูมิหลังทั่วไป ส่วนที่ 2 เป็นการวิเคราะห์ความคิดเห็นของประชาชนเกี่ยวกับ เศรษฐกิจ-สังคมก่อนและหลังสร้างเขื่อนในเรื่อง อาชีพ รายได้ โครงสร้างพื้นฐาน เป็นต้น ส่วนที่ 3 เป็นความคิดเห็นเกี่ยวกับการสร้างเขื่อนที่มีผลต่อคุณภาพชีวิตของประชาชนและส่วนสุดท้ายส่วนที่ 4 เป็นความคิดเห็นและความต้องการของประชาชนที่มีต่อโครงการเขื่อนเซเซ็ตและรัฐบาลแห่งสาธารณรัฐประชาธิปไตยประชาชนลาว

ผลการวิเคราะห์ข้อมูลพบว่าเขื่อนเซเซ็ต 2 จังหวัดสาละวัน ส่งผลให้คุณภาพชีวิตของคนพื้นเมืองในปี 2011 ดีกว่าในช่วงก่อนมีการสร้างเขื่อนคือในปี 1999 เขื่อนถือว่าเป็นปัจจัยสำคัญที่ส่งผลให้มีการพัฒนาโครงสร้างพื้นฐาน เช่น ถนน สะพาน การขนส่งพัฒนาดีขึ้น คนพื้นเมืองมีคุณภาพชีวิตดีขึ้นจากก่อนที่ยังไม่มีการสร้างเขื่อน ภายในหมู่บ้านตัวอย่างมีรายได้เพิ่มขึ้นเช่นเดียวกับด้านการศึกษาพบมากกว่าในปี 1999 ผลที่ได้ พบว่าสุขาภิบาลและสุขภาพภายในหมู่บ้านได้รับการปรับปรุงให้ดีขึ้น มีจำนวนของห้องสุขา ร้อยละ 94.61 แทนขับถ่ายภายนอก ตามพุ่มไม้ร้อยละ 61 นอกจากนั้นยังพบการลดลงของโรคมาลาเรีย และจะหายไปในปัจจุบัน อีกทั้งส่งผลให้ปริมาณน้ำใช้ไม่เพียงพอ อย่างไรก็ตามผลกระทบจากเขื่อนอาจส่งผลให้เกิดการเพิ่มขึ้นของประชากรร้อยละ 3.65 ± 0.80

ดังนั้นการวิเคราะห์ผลกระทบสิ่งแวดล้อมและเศรษฐกิจ-สังคมนี้น่าจะทำให้เกิดการจัดการสิ่งแวดล้อม การคำนึงถึงการเปลี่ยนแปลงคุณภาพน้ำจากกิจกรรมของประชาชนที่นำไปสู่ผลกระทบ ทั้งด้านบวกและด้านลบทางเศรษฐกิจ-สังคมติดตามมา ข้อมูลเหล่านี้จะเป็นการนำเสนอ

แนวความคิด การจัดการ นำไปสู่นโยบายเพื่อเป็นแนวทางในการจัดการสิ่งแวดล้อมในการพัฒนาประเทศของสาธารณรัฐประชาธิปไตยประชาชนลาวในอนาคต

ABSTRACT

TITLE : ENVIRONMENTAL AND SOCIO - ECONOMIC IMPACT ASSESSMENT (ESIA) OF XESET 2 DAM, SALAVAN, LAO PEOPLE'S DEMOCRATIC REPUBLIC

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KEYWORDS : EIA / SIA / ESIA / XESET 2 DAM / WATER QUALITY

This thesis studied the environmental and socio-economic impact assessment (ESIA) of Xeset 2 dam, salavan, Lao people's democratic republic (Lao PDR) in 2011. This work aimed to compare the water quality nowadays with the periods before dam construction (during EIA study) since 1999. The study comprised of 2 parts of environmental impact assessment (EIA) that focused on water quality and socio-economic impact assessment (SIA) of Xeset 2 dam. The sampling sites selected at three sites. The first site was collected at the bridge at national road No.20, Lao-ngam village (Tapoung river). The second location was Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river). Lastly, the third site was at the bridge at national road No. 20, downstream of the Xeset 1 and Xeset 2 dam. The entirely of water samples were collected only in 2 seasons of rainy season and winter, 2011 according to the shortage of water supply in summer.

EIA after dam in this study focused on the water quality in the river flow from Xeset 2 dam. The water quality studied physical, chemical and biological characteristics (APHA, 2005). The results confirmed that since dam started, the chemical characteristics of water samples mostly were higher than in 1999, especially in rainy season such as hardness at site 1 was 65.3 milligram per liter in rainy season higher than site 2 and 3, alkalinity in winter at site 1 was 76.3 milligram per liter, chemical oxygen demand (COD) in rainy at site 1 was 129.3 milligram per liter, nitrate-nitrogen was 8.9 milligram per liter at site 1 in rainy season, phosphate - phosphorus was

0.1 milligram per liter. Those water qualities found COD higher than surface water quality standard of Lao PDR all three sites and 2 seasons, except at site 2 and site 3 in winters because the organic and inorganic matter contamination from human activity such as from agricultural and domestic sewage release and manure along the river. However, most parameters of Xeset and Tapoung remain lies within the surface water quality standard of Lao PDR and USEPA. Thus, the result of mainly water quality analysis at Xeset and Tapoung rivers were within the surface water quality standard type 2, use for: consumption which requires ordinary water treatment process before use, aquatic organism of conservation, fisheries and recreation.

The socio-economic impact assessment (SIA) was analyzed by questionnaire and investigated at three villages in Salavan province, Lao PDR. The sample sites were 1) Photok village, upstream Xeset 1 dam and downstream Xeset 2 dam (Xeset river), 2) Thong soui village downstream Xeset 2 dam (Xeset river). Lastly, 3) Tapoung river at Ban Lao-ngam village. The questionnaires include 4 parts; the first part was general information. The part 2 focused on socio-economic before and after dam construction (occupation, income, infrastructure and etc.), the part 3 about dam construction has effect on human value aspect of local people. The final part was the recommendation to the dam project from native people to Xeset dam project and demand to the government of Lao PDR.

It was found that, Xeset 2 dam, Salavan province provides a quality of life for native people (2011) than the start-up periods (1999). Dam was the crucial factors that affected the infrastructure development for example roads, bridges and transportation improvement. Indigenous people altered to have the better quality of life than the start-up periods of Xeset 2 dam. The three villages gained more income as well as number of education system rose than on 1999. The result found that sanitary and health in the villages were also improved to 94.61 percentage of restrooms of instead excreta wasted left outdoor at bushes (61 percentage) in 1999. The Malaria patients was decreased and altered to disappear, recently. However, the effect from hydroelectric power dam possibly resulted in population increase was 3.65 ± 0.80 and 100 percentage was inadequate water and etc.

Water quality study for supply consumption from Xeset 2 dam, these kinds of activities had huge effects on water quality change from the start-up hydroelectric power Xeset 2 dam as well as the effect from socio-economic development of people around those areas. These activities directly affected in the contamination by the water activity from the villagers and socio-economic changes.

Thus, this environmental and social impact assessment (ESIA) will stimulate the people concern on their carefulness and the unavoidable behaviors in order to reduce the impact on the water quality and gain the sustainable natural resources that meet the better quality of life. This could lead in the dam project and national of Lad PDR consideration, strategy and policy in the future.

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CHAPTER 1

INTRODUCTION

1.1 Rationale

Lao People's Democratic Republic (Lao PDR) is bordered by 5 countries, Burma, People's Republic of China, Vietnam, Cambodia, and Thailand. Luang Prabang plateau is located in the North West and the area is characterized by steep terrain, elevations of above 500 meters, narrow river valleys and low agricultural potential. This mountainous landscape extends across the north of the country except in the plain of Vientiane and the plain of Jars in the Xiangkhoang plateau. The Southern 'panhandle' of the country contains the large level areas in Savannakhet and Champasak provinces that are well suited for extensive paddy rice cultivation and livestock. Most of Khammouan province and the eastern part of the Southern provinces are mountainous. The alluvial plains and terraces of the Mekong as well as its tributaries cover about 20% of the land area (Ministry of Public Work, 2011). However, Lao PDR is riched in natural capital for example forests, agricultural land, water and hydropower potential and mineral resources comprise more than half the country's total wealth. While electricity production and mineral extraction projects may not be large by international standards, they are significant relative to the size of the Lao economy and the government's fiscal revenues (World Bank, 2010). Lao PDR began a shift towards a market economy with the introduction of economic liberalization (the New Economic Mechanism) (IUCN and NERI, 2011). Hydropower has been recognized as an important factor in the promotion of economic and social advancement through the provision of a reliable and affordable domestic power supply and a source from which to earn foreign exchange from electricity exports (Xaypaseuth, 2010).

Hydropower dam has been recognized as an important factor in the promotion of economic and social advancement through the provision of a reliable and affordable domestic power supply and a source from which to earn foreign exchange from electricity exports (Xaypaseuth, 2010).

The natural resources of Lao PDR have been declined because of increasing pressure from activities such as logging, mining, and building of dams (Sengkham, 2007). Lao PDR has a national image of many wide rivers and has the potential to become a major source of electricity production in Southeast Asia. In 2020, the government electricity production plans to complete 29 development projects with a capacity of 8,657 MW (Visounnarath, 2010).

Dams are sources of water supply that serve as the main blood for agriculture, electricity production, irrigation and socio-economies of Vietnam, Cambodia, China, and Thailand. It normally brings about a better quality of life to local people (Sengkham, 2007). However, there have been several decades of debates about the pros and cons of large dams. Dams and reservoirs affect the ecological environment in such areas as variations in water quality (Yao, 2005) and reduced wildlife habitats and changes in surface water temperatures (Yao, 2006). Water supply from dams is strongly related to agriculture activities and the daily lives of rural people by a number of other activities, such as fishing and the gathering of various forest products including birds and eggs, fruits, honey, medicinal plants, resins, latexes, dyes, and wood for fuel and charcoal. Construction of the dam has improved the quality of the lives of indigenous people in terms of income, transport, and education, but there are questions about the quality of the water. The Xeset 2 dam draws water from the Xeset and Tapoung rivers. The former is an important source of water irrigation for the local villages' coffee plantations and the latter serves as the main source of water supply for the plantations of corn, chili, tobacco, pumpkins, and cabbages to 25 villages, 2,666 families, and 12,540 people nearby. The people of the area routinely survive by the Xeset and Tapoung rivers for their water supply, agricultural irrigation, fishery and domestic water supply such as washing, cleaning, and bathing in the river (Sayboualaven, 2005).

Water resources are regarded as a crucial factor in human life in terms of water supply, irrigation, and agriculture, and the key to national development (Moonha, 2011). Thus, this thesis focused on the environmental and social impact assessment (ESIA) after the start-up of the Xeset 2 dam through the investigation of water quality and the effects on the socio-economy of the villagers.

1.2 Objectives

1.2.1 Investigate the environmental impact assessment especially the water quality in terms of physical, chemical, and biological parameters as a result of the start-up of the Xeset 2 dam, since 1999 with the recent year, 2011.

1.2.2 Study the socio-economic impact that related to general backgrounds, occupations, income, infrastructure, human value and quality of life of local people (2011) which dam had operated in 1999.

1.3 Scope of the research

This ESIA thesis was based on two forms of assessment, an environmental impact assessment (EIA) and a social impact assessment (SIA).

1.3.1 Environmental Impact Assessment (EIA) of water quality

This study focused on the water quality that effected by people's way of life (especially irrigation) of the water flow from dam. Water samples were taken at three locations, upstream and downstream river around Xeset dam. This work investigated the physical, chemical, and biological parameters along the river. The locations were 1) the bridge on the national road No. 20, Lao-ngam village (Tapoung river). 2) Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river) and 3) the bridge on national road No. 20, downstream of the Xeset 1 and Xeset 2 dam (Xeset river). It was proposed that water quality would help to explain the effects of dam on human health and the quality of life of native residents along these rivers.

1.3.2 Social Impact Assessment (SIA)

This part studied the effects of water quality via consideration of the socio-economic point of views of general background, occupations, income, infrastructure, human value aspect and quality of life of people in the Xeset 2 dam area. These samples were surveyed by the questionnaires at Photok, Thong soui, and Lao-ngam village, Salavan province, Lao PDR. In addition, this part focused on the improvements in people's quality of life since the start-up of the Xeset 2 dam in 1999 compared with the year 2011.

1.4 Hypothesis

The monitoring on the water quality of the rivers from Xeset dam (Xeset and Tapoung rivers) (as shown by the EIA) will results in the proper environmental management for the quality of life for the people (as shown by the SIA).

1.5 Expected outcomes

It is anticipated that the EIA analysis may reveal changes in the water quality of the Xeset and Tapoung rivers and socio-economic conditions by the SIA analysis. These changes will associate with the activities by people since the operation of this hydroelectric dam (1999) until now (2011).

CHAPTER 2

LITERATURE REVIEW

This thesis investigated the effects of the construction of the Xeset 2 dam at Salavan, Lao PDR by the study of an environmental socio-economic impact assessment (ESIA). ESIA is consisting of an Environmental Impact Assessment (EIA) and a Social Impact Assessment (SIA). EIA in this thesis was particularly focused on the quality of the water as dam acts as the source of water for the local people along the flow river nearby. The increases in water for irrigation and agricultural improved the locals' quality of life but at the same time the increases in people's activities could lead into the contamination of water supplies, consequently. This was as a resulting in health problems and a decline in living standards. The SIA of this work was studies several parameters including general information, infrastructure, human value and quality of life of local people in 1999 before Xeset dam construction and in 2011 after the completion of this dam.

2.1 Environmental and Social Impact Assessment (ESIA)

ESIA assessed the environmental, economic, and social impacts of the project on local communities, identify positive and negative impacts, suggested a monitoring framework, outline development prospects, and recommended options. It also set a number of development activities focusing on eco-system sustainability and poverty alleviation (Dutta and Bandyopadhyayy, 2010) and (UNDP, 2006).

ESIA processes has following structure as shown in Fig. 2.1

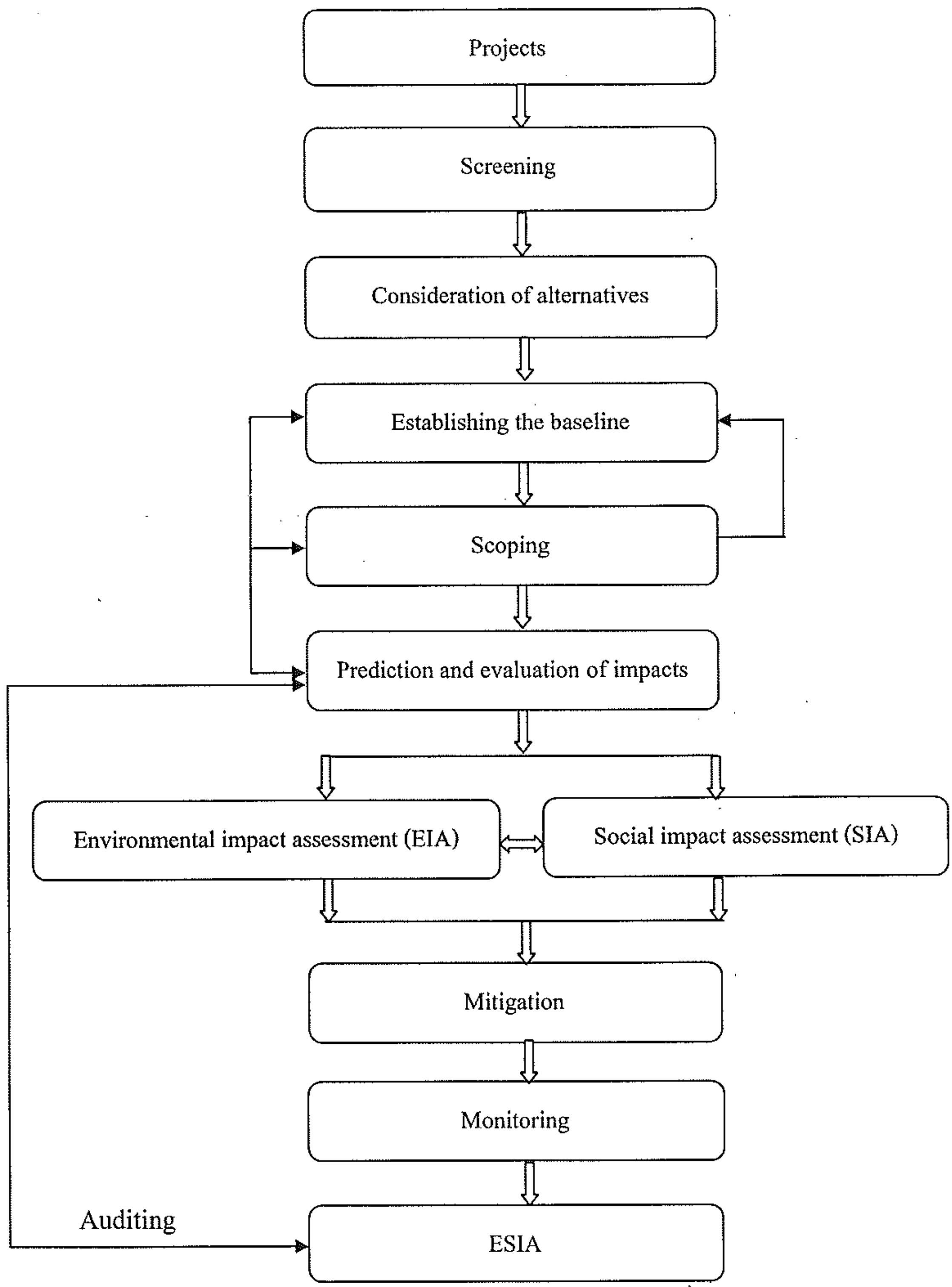


Figure 2.1 Environment and Social Impact Assessment (ESIA) process framework (World Business Council for Sustainable Development, 2012)

This process included mitigation or offset measures and monitoring plans for Environmental and Social Management (World Business Council for Sustainable Development, 2012) and consists of these following.

2.1.1 Screening : This established whether an ESIA is needed or not for a particular project.

2.1.2 Consideration of alternatives : **Consideration of alternatives:** It considered alternatives and relevance of project to the local people.

2.1.3 Establishing the baseline : This described information related to the project's past, present, and future contexts. This part should provide a picture of existing trends resulting from natural events or human activities and the current state of the environment and socio-economic conditions in the region. It included any potential future changes which may occur as a result of planned developments. The first major assessment of the environmental and social impacts was processed to be during and after the scoping.

2.1.4 Scoping : It covered the objectives and scope of the project and an overview of the project and location. It should focus on a detailed description and layout, the site preparation, and construction. Scoping may also address baseline studies required to characterize the existing environment, types of alternatives to be considered, and consultations with relevant stakeholders. The significance of both positive and negative impacts will need to be assessed by weighing them against local conditions. Standards of comparison need to be defined for every issue to be analyzed as well as any pre-established limits to acceptable change.

2.1.5 Prediction and evaluation of impacts : This part emphasized the most important impacts, who or what these will affect, and how significant the effects will be (World Business Council for Sustainable Development, 2005).

2.1.6 EIA and SIA : EIA predicted the project construction that affects the quality of life of indigenous people and each process should improve as a result (Enderlin, 2012). SIA was a processed of analyzing, monitoring, and managing positive and negative social impacts (Vanclay, 2012).

2.1.7 Mitigation/offset measures : This provided an assessment of the hierarchy of impacts and whether mitigation is possible. It estimated successes of the mitigation measures proposed to alleviate the impacts and the residual and/or cumulative effects. Any offset schemes proposed to reduce negative impacts should also be included.

2.1.8 Monitoring plans : This needed to provide a framework for managing and monitoring impacts for the life of the project and to decide on the necessity or otherwise of introducing corrective measures. This should ensure commitments made in the ESIA and any subsequent assessment reports. It concluded with any license approval or similar conditions that are implemented (World Business Council for Sustainable Development, 2012).

2.2 Environmental impact assessment (EIA)

EIA EIA was evaluated of the potential impacts of a proposed project, plans, programs, or legislative actions relating to the physical-chemical, biological, cultural, and socio-economic components of the environment (Larry, 1996). EIA included processes of identifying, predicting, evaluating, and managing the adverse and beneficial impacts of the project on the quality of life of the indigenous people and evaluates the risk of significant deterioration in local people's health and livelihoods (Enderline, 2012).

EIA includes 4 aspects as follows. (Rattanachai, 2008)

2.2.1 Physical part

Physical resources were landscape, topography, water supply (water use and quality), air quality, and noise.

2.2.2 Biological part

Biological resources involved bio-diversity of animals, plants, terrestrial habitats, and forests.

2.2.3 Human use value

Human use value included agricultural irrigation, water for industrial and domestic use, transport, and infrastructure such as electricity, roads, and bridges.

2.2.4 Quality of life

The quality of life aspect consisted of socio-economic parameters such as population, occupations, employment, income, religion, settlement, economy, and literacy. Public health is included here in terms of sickness rates, fear, health impact assessment, and occupational health (Rattanachai, 2008).

Dams are the sources for electricity production and kinds of projects that need EIAs. Normally, the objectives of an EIA for such projects are required to 1) predict the positive and negative environmental impacts, 2) determine the environmental management to mitigate the project's impact, and 3) ensure the environmental implications are addressed and incorporated into the project's decision - making and implementation. EIA should guarantee a better quality of life for people along the river (Ministry of Industry and Handicrafts, Department of Electricity, 2001).

2.3 Social Impact Assessment (SIA)

SIA involved policies, programs, plans, and projects, and analyzes, monitors, and manages positive and negative social concerns focusing on human values and quality of life (Vanclay, 2003). Major projects usually caused socio-economic changes in social activities, tradition, health, and quality of life, involving irrigation, employment, agricultural products, fishing, transport, and communication. These changes may result in migration of residential populations, illness risks, and accidents. Indirect effects also arise from infrastructure requirements. Problems increased in scale from town to city leading to social disharmony and pollution (Rattanchai, 2008).

SIA involved 6 steps as the following: 1) Determination of the study area and identification of the social impacts, 2) Description of the social environment, 3) Remarks about social impacts and issues, 4) Prediction of the impact on various aspects of society, 5) Discussion of communities' problems and 6) Prediction of the social impact, include alternatives to the projects (Rattanachai, 2008).

Then, SIA was used to systematically analyze and predict the effects of the project development that may have impacts on the quality of life of the local people (Rattanchai, 2008).

2.4 Xeset 2 hydroelectric power Dam

Xeset 2 Dam is located on the Xeset river in Salavan province, 100 km East of Pakse in Southern Lao, PDR (15^0 10' N and 15^0 45'N latitude, 106^0 10'E and 106^0 20'E longitude). The dam construction started in November 2005 and operated in July, 2009.

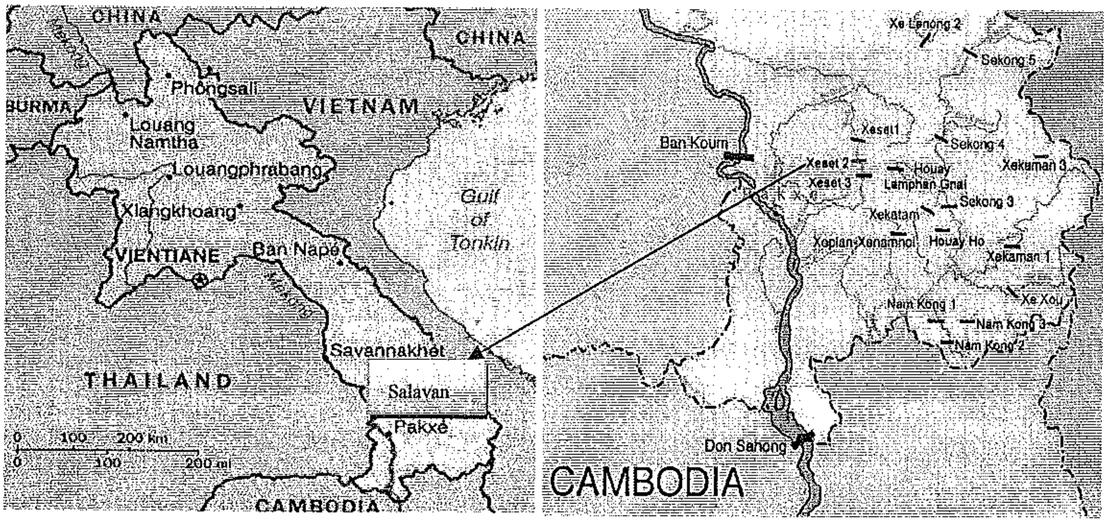


Figure 2.2 Map of the location of Xeset 2 dam, Salavan province, Lao PDR. (Central Intelligence Agency, 2013)

The total storage capacity of the dam is 800,000 m^3 and the electricity production capacity is 76 MW. These data included the diversion of the Tapoung river through a 1.6 km-long canal and flow through a 6.8 km-long tunnel to the Xeset 2 reservoir (Fig. 2.3)

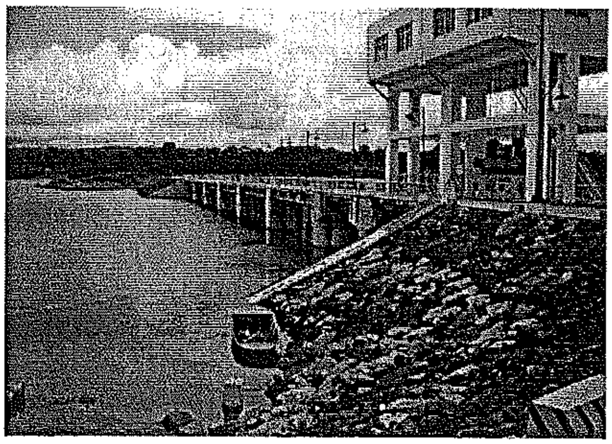


Figure 2.3 The overall view Xeset 2 dam, Salavan, Lao PDR, 2011

Figure 2.4 The hydropower plant of Xeset 2 Dam, Salavan province, Lao PDR, 2011

Xeset 2 Dam was constructed on the Xeset river approximately one kilometer upstream of this river's confluence with the Xedon River and is fed by water from the Xeset and Tapoung rivers that flow parallel from the Boloven plateau in a northerly direction (Paksong districts).

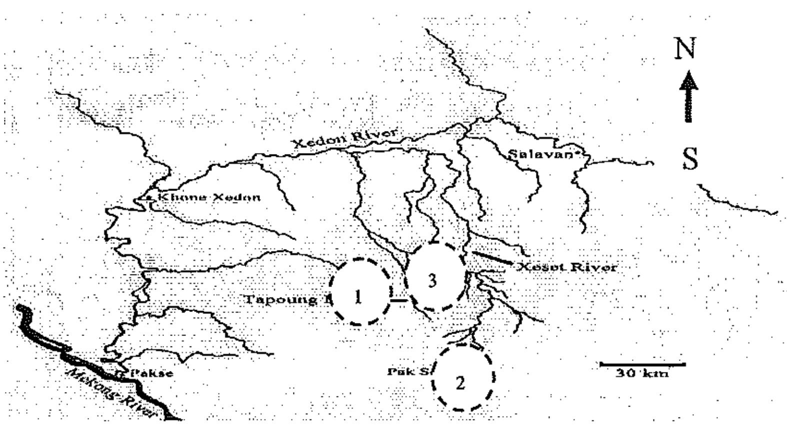


Figure 2.5 Xeset and Tapoung rivers topography, Salavan province, Lao PDR

(Central Intelligence Agency, 2013)

Remark: (1) = Bridge on the national road No. 20, Lao - ngam village (Tapoung river).

(2) = Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

(3) = Bridge on national road No. 20 downstream of the Xeset 1 and Xeset 2 dam (Xeset river)

These rivers are important tributaries of the Mekong River and all are characterized by large seasonal differences in flow volume (Fig.2.5). The larger and deeper Xeset generally maintains a minimal flow from December to May, while the smaller Tapoung occasionally ceases to flow during March and April (Sayboualaven, 2005).

Several human activities gained the advantage of downstream water supply. These activities are agriculture irrigation (edible plant and coffee crop), domestic irrigation (bathing and washing clothes), routinely (Sayboualaven, 2005). Dam serves an important source of water supply on local village infrastructure, nearby. This hydropower dam is not only export electricity to Thailand, but it is certainly the main source of water supply downstream around that area. The output from dam is the quantity and quality of water flow into the Xeset and Tapoung rivers and the Xeset resouvior. Dam definitely caused on ecosystems changes to indigenous people, mainly on water quality (Physical Chemical and Biological parameters). These changes also effected to the socio-economic influence (human health and environment) to the people, as the result (IUCN, 2001). The water quality from the Xeset and Tapoung rivers and Xeset reservoir from dam are the source on water supply (people irrigation). As a part on EIA, water quality is focused in this study.

2.5 Environmental Impact Assessment (Water quality)

The quality of the water is an important aspect of EIA. Water supply is an essential characteristic of the way of life of the people who settle along the rivers and its quality in terms of physical, chemical, and biological features accounts for the balance of the area's bio-diversity and eco-system. The quality of the water directly affects human value as well as the quality of life of the local people. As population in these areas increases, the demand for water increases (Jackson et al., 2000). Several activities that gain advantage of downstream water supply are agricultural irrigation,

bathing, animals, and households (Sayboualaven, 2005). Any changes in the water quality which affect human health and the environment are of a serious nature (IUCN, 2001). The dam also serves as an important source of infrastructure to the local villages nearby in terms of electricity supply and roads.

A study conducted by the Fisheries Office (2012) in a nearby location revealed the impact on the Se San river as a result of the Yali Fall Dam in Ratanakiri Province in North-East Cambodia. The study showed human health problems caused by water contamination. Several people have died as a direct or indirect results of changes of water quality, locals reported that 952 people were sick after these changes. Local people suffered eye irritation after bathing in the water, stomach problems, respiratory problems, throat and nostril irritation, dizziness, and vomiting after ingesting the water.

The consultants, 1999 found that the population who lived at Xeset 2 dam were reported drinking water contamination and appeared as the main source of illnesses such as diarrhea and malaria. The downstream of the diversion from the Tapoung river to the reservoir of the dam, a reduction in water flow resulting in a decrease in water quality and caused the increases in sickness. The following table 2.1 shows the water quality in terms of pH, conductivity, total suspended solids (TSS), hardness, alkalinity, chemical oxygen demand (COD), nitrate-nitrogen, phosphate-phosphorus and fecal coliform bacteria (FCB) of Xeset and Tapoung rivers during rainy and winter seasons since 1999.

Table 2.1 Water parameters of Xeset and Tapoung rivers in rainy season and winter (Consultants, 1999)

Parameters	Sampling sites					
	(1)		(2)		(3)	
	Rainy	Winter	Rainy	Winter	Rainy	Winter
pH	7.8	8.3	7.9	8.8	8.1	7.6
Conductivity (μS/cm)	6.8	9.8	4.1	7	6.0	7.3
TSS (mg/l)	132	9	35	3	16	2
Hardness (mg/l)	27.7	41.8	26.4	32.6	26.4	16.5
Alkalinity (mg/l)	30.4	48.9	24.3	35	27.3	36.5
COD (mg/l)	2.4	1.4	2.2	0.6	1.9	0.9
Nitrate –N (mg/l)	0.1	0.1	0.02	0.01	0.03	0.01
Phosphate – P (mg/l)	0.03	0.02	0.01	0.01	0.01	0.01
Fecal Coliform bacteria (cfu/100 ml)	15	30	10	ND	14	220

Remark: (1) = Bridge on the national road No. 20, Lao-ngam village (Tapoung river).

(2) = Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

(3) = Bridge on national road No. 20 downstream of the Xeset 1 and Xeset 2 dam (Xeset river)

2.5.1 Physical characteristics

The water quality is studied in terms of physical, chemical and biological characteristics. In this study, physical characteristics consist of temperature, conductivity, total suspended solids (TSS) and dissolved oxygen (DO) (Sirianuntapiboon, 2006).

2.5.1.1 Temperature

Temperature had an effect on chemical and biological characteristics of surface water, directly affecting aquatic life and levels of dissolved oxygen. Cooler water could hold more oxygen than warmer water and low dissolved oxygen levels cause oxygen-sensitive species to die (Department of Environment Quality, 2012). Temperature has an indirect effect on osmo-regulation and respiration of animals (Shinde et al., 2011). In addition, temperature directly influenced plankton mobility and indirectly influences flotation of plankton (Makhlough, 2008). The Environmental Protection Agency (USEPA) recommended limit value for surface water is $25^{\circ}C$ (USEPA, 2001).

2.5.1.2 Conductivity

Conductivity is the ability of a solution to carry an electric current. Sewage treatment plants, agriculture, and runoff increased electrical conductivity ions in water (Makhlough, 2008). Sewerage from industries caused high conductivity which is an indicator of serious water pollution. The USEPA recommended limit value for surface water is 1,000 $\mu S/cm$ (USEPA, 2001).

2.5.1.3 Total Suspended Solids (TSS)

High TSS in water affected the diversity of aquatic life. As a result of suspended solids sinking to the bottom and finally blanketing the river bed, fish habitats are destroyed, fish eggs and aquatic insects were smothered, fish gills become clogged, and growth rates are reduced (Department of Environment Quality, 2012). In addition, TSS prevents the penetration of sunlight into the water result in a reduction of the primary production of phytoplankton (Makhlough, 2008).

2.5.1.4 Dissolved Oxygen (DO)

DO concentrations of less than standard affect anaerobic decomposition of organic matter, resulting in odors and formation of hydrogen sulphide and ammonium (Zuma, 2010). These factors reduce the health prospects of animals (Makhlough, 2008). The water quality standard for DO in Lao PDR was 6 mg/l (Water Resources and Environmental Organization, 2009).

2.5.2 Chemical characteristics

The chemical characteristics of water, for example pH, hardness, alkalinity, COD, nitrate-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P), and trace heavy metals such as cadmium (Cd) and lead (Pb) were investigated. These heavy metals are crucial parameters that affect water quality and cause human sickness by Itai-Itai disease (as a result of Cd) and lead disease (as a result of Pb) (Sirianuntapiboon, 2006).

2.5.2.1 pH

The pH of water affected the quality of the water and the growth of organisms. Highly acidic water may include metals which are normally bound to organic matter and sediment and then released into the water. Mostly of these metals are toxic to fish and humans. Water with a pH reading below 4.5 is fatal to all fish (Department of Environment Quality, 2012). pH may increase to more than 8.5, result in high organic content and eutrophication of the surface water (Makhlough, 2008). Low pH causes a bitter taste in water, affects the mucous membrane, causes corrosion, and affects aquatic life. The water quality standard for pH in Lao PDR ranges from 5 to 9 (Water Resources and Environmental Organization, 2009). USEPA recommended a limit values for surface water is A_1 (5.5 – 8.5), A_2 and A_3 (5.5 -9) (USEPA, 2001) (A_1, A_2 and A_3 are the water categories of the 1975 Surface Water Directive/1989 Regulations).

2.5.2.2 Hardness

Hardness in water stops soap from creating foam or suds and this results in people using more soap in bathing, washing, and cleaning. Water hardness influences osmo-regulation and affects fish health. In the case of humans' health, hardness may cause heart disease and kidney stone formation (USEPA, 2001). The water quality standard for hardness in Lao PDR is 50-300 mg/l (Water Resources and Environmental Organization, 2009).

2.5.2.3 Alkalinity

Alkalinity was Low or very low and will be susceptible to pH reduction for example acid rain, if high alkalinity effects algal bloom in water (USEPA, 2001).

2.5.2.4 Chemical oxygen demand (COD)

High COD indicates inadequate oxygen available in water (USEPA, 2001). This leads to water pollution by anaerobic digestion. The water quality standard for COD in Lao PDR is 5 mg/l (Water Resources and Environmental Organization, 2009).

2.5.2.5 Nitrate-nitrogen (NO_3-N)

Nitrate is a crucial factor in the creation of algal blooms (eutrophication) which adversely affect aquatic organisms and the oxygen content of water. High nitrate levels in drinking water made it hazardous to infants leading to "blue baby" syndrome (USEPA, 2001). The water quality standard for nitrate-nitrogen in Lao PDR is <50 mg/l (Water Resources and Environmental Organization, 2009) and the USEPA recommended limit values for surface water (A_1, A_2 and A_3) are 50 mg/l (USEPA, 2001).

2.5.2.6 Phosphate-phosphorus (PO_4 - P)

Phosphate causes algae blooms (USEPA, 2001) and high phosphate in water results in the growth of aquatic plants and algae blooms. The water quality standard for nitrate-nitrogen in Lao PDR is <50 mg/l (Water Resources and Environmental Organization, 2009). USEPA also recommended limit values for surface water (A_1, A_2 and A_3) are 50 mg/l (USEPA, 2001).

2.5.2.7 Cadmium (Cd)

High Cd concentration is highly toxic to fish and is adsorbed in the food chain by fish and aquatic life and accumulates in the fat tissue. It is also toxic to humans' health via *itai - itai* disease which results in bone damage. Cd also causes chronic kidney disease, cancer, and hypertension (USEPA, 2001). The water quality standard for Cd in Lao PDR is 0.005 mg/l (Water Resources and Environmental Organization, 2009) and the USEPA recommended limit values for surface water for A_1, A_2 and A_3 are 0.005 mg/l (USEPA, 2001).

2.5.2.8 Lead (Pb)

Drinking water with a Pb contamination of more than 0.05 mg/l is a health risk. The mental development of infants and children suffers an adverse impact from lead disease. In adults, Pb contaminated water results in high blood pressure and kidney problems (USEPA, 2001). The water quality standard for Pb in Lao PDR is 0.05 mg/l (Water Resources and Environmental Organization, 2009) and the USEPA recommended limit values for surface water are 0.05 mg/l (USEPA, 2001).

2.5.3 Biological characteristic

Usually, a coliform bacteria is the index of pathogens in the water. In this study, we had focused on fecal coliform bacteria (FCB) bacteria by it's indicate of mammal and human fecal contamination. Besides, FCB also keys as the potential presence of pathogens associated with wastewater or sewage sludge. Eventually, FCB is interesting due to its contamination from villager and animal along the river. FCB rely in the intestine of warm-blooded animals FCB that excreted with human and animal waste into the river. A human activity along the river, indigenous people activities has impacted on water quality from their routine way of life, consequently. The water supply on domestic irrigation that contaminated with FCB bacteria, it leads to affect humans such as ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, hepatitis A and digestive system (Sirianuntapiboon, 2006). The high amount of FCB in surface water is not allow more than 1,000 MPN/100 ml (Water resources and environmental organization, 2009) with A_1=1,000, A_2 = 5,000 and A_3 = 40,000 MPN/100 ml (EPA, 2001). A1 represented simple physical treatment and disinfection, e.g. rapid filtration and disinfection. A2 was normal physical treatment, chemical treatment and disinfection, e.g. pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination) and A3 was intensive physical and chemical treatment, extended treatment and disinfection, e.g. chlorination to break-point, coagulation, flocculation, decantation, filtration and adsorption (activated carbon).

In 1999, Consultants started to investigate the water in the rainy and winter seasons upstream of the existing Xeset hydropower plant at 3 sites, the bridge on the national road No. 20, at Lao-ngam village (site 1), Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (site 2) and the bridge on national road No. 20, downstream of the Xeset 1 and Xeset 2 dam (site 3). The water samplings were analyzed for example pH, conductivity, TSS, hardness, alkalinity, COD, nitrate-nitrogen, phosphate-phosphorus and FCB. The samples were collected in rainy season and winter. The water quality was lies within the water quality standard of Lao PDR and USEPA.

Khongrack (2006) investigated the water quality of the Wang river, Lampang Province in Thailand, 2002 - 2006. The study collected water samples at three different times, winter, summer, and rainy seasons. The water characteristics were conductivity, total dissolved solids (TDS), pH, hardness, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO_3), sulphate (SO_4), chloride, and turbidity. The water quality reported the best quality in the summer and the worst in the rainy season. The study also found that the surface water quality was within the standards for agricultural purpose.

Mountongnoi et al. (2008) analyzed water quality and the contamination of heavy metals in the surface water of Huai Mae Tao, Tak Province, Thailand. The results found that the surface water quality was within the type 3 (The Surface Water Standard for Agriculture and Water Quality for Protection of Aquatic Resources, Thailand). However, the turbidity and suspended solid (SS) levels varied according to the season. The levels of these water quality indexes were higher than the allowed standard during the rainy season. Heavy metal contamination was also found in the surface water of Huai Mae Tao. The contamination levels were higher in the rainy season than in the summer, and the levels of cadmium were higher than the maximum allowed concentration in natural water resources for the protection of aquatic resources.

Bhatt et al. (2011) studied the impact of hydro-power project operations on water quality in Bhotekoshi River basin district, Nepal. The water quality parameters analyzed were temperature, pH, turbidity, conductivity, TSS, alkalinity, hardness, total nitrogen, lead, DO, COD, BOD, total coliform, and FC. In 1995, high levels of total coliform, suspended load, and turbidity were found, but BOD was lower. In 1998, the turbidity and suspended solids decrease as well as temperature and hardness upstream to downstream. It was found that the water was more acidic pH dissolved oxygen ranged between 7.50 and 8.50 mg/l and there were very poor microbial qualities. In 2010 (after the construction of the dam), the water had a mean range of 5-72 mg/l CaCO3, was salty and neutral with a mean pH of 7.98. Conductivity and TDS varied with elevated levels in the rainy season. The water quality indicated that most of the physical-chemical quality parameters of the Bhotekoshi river were within the World Health Organization (WHO) limits for drinking water and suitable for domestic purposes.

Chantree (2011) examined the impact on water quality of closing and opening the gates of the Pakmoon Dam, Moon River, Ubon Ratchathani, Thailand. Water samples were collected at four sites for a year. Temperatures ranged from 22°C to 32°C, pH from 6.2 to 8.5, conductivity from 20 to 280 μs/cm, turbidity from 1.4 to 137 NTU, and total solids from 92.6 to 292.6 mg/l. Chemical parameters found chloride (Cl^-) ranged from 10.6 to 64.6 mg/l, hardness from 20.6 to 93.3 mg/l, respectively. Ammonia-nitrogen was from 0 to 1.7 mg/l, nitrate-nitrogen was from 0.08 to 5.7 mg/l and phosphate ranged sfrom 0 to 7.9 mg/l. In case of heavy metal, Fe^{2+} varied from 0.1 to 13.7 ppm, Mn^{2+} from 0.03 to 0.1 ppm, Zn^{2+} from 0.004 to 0.5 ppm. Pb^{2+} was not be detected by FAAS. In addition, biological parameters, it found DO ranged from 4.07 to 8.9 mg/l, BOD from 0 to 7 mg/l, and FC varied from <20 to ≥ 16,000 MPN/100 ml. BOD was higher than the standard for site 1 and 3 (5-7 mg/l) during the closed-gate period. However, most of water parameters were within the standards of Lao PDR.

2.6 Socio-economic Impact Assessment

Hydroelectricity producing from dams is not only responsible for the provision of power to local villages but also serve as water sources to the ecosystem as well. The dam construction causes positive and negative economic and social changes for local people as a result. In terms of socio-economic advantages derived such as irrigation and occupations, infrastructure, and literacy increased. At the same time, it negatively affects human health by bringing about devastating disease and loss of livelihoods (Mudzengi, 2012).

2.6.1 Irrigation

The start-up of dams operation increased irrigation to agricultural, domestic, and industrial. It freshen the bio-diversity and the eco-system, and results in an influx of population. Dam irrigation improved community forests, agricultural products, fishing and tourism in the country (McKenney, 2001). More agricultural products such as coffee were also planted.

2.6.2 Occupations

Dam operation also of dams increased occupational opportunities in particular in agriculture and fishing downstream areas. In upstream regions, the establishment of dams changed flow regimes and causes sudden flooding, affecting rice fields, vegetable crops, and fishing, and changing the eco-system into a lake or reservoir (McKenney, 2001). The local people needed to survive by changing their careers to agriculture, fishing, and/or involving themselves in activities to meet the needs of tourism. Agricultural business from coffee were traded (Mudzengi, 2012).

2.6.3 Infrastructures

The construction of the Xeset 2 Dam had results in a better quality of life for the local people. Several electricity supplies were established. Roads and bridges in area were built and/or improved, transportation between villages. (Ovesen, 1999).

2.6.4 Education system

The general development of the area had resulted in a realization by the local people of the need to be able to read and write, schools, and training courses whenever the irrigation is fulfilled.

2.6.5 Sanitary and health

In the former times (1999), malaria was a common disease in this area but presently its incidence is decreasing. Davie (1999) believed that this was the results of the lower water level in the Tapoung River. The current local problems focused more on infant mortality and gastro-intestinal conditions.

As the Xeset 2 dam has affected the ecosystem by creating reservoirs upstream and increased irrigation downstream. This study considered EIA as an integral part of the research. According to SIA provides an assessment of socio-economic changes and alterations to locals' human value and quality of life in terms of irrigation, infrastructure, literacy, and human health. Then, the combination of EIA and SIA provides a strong assessment of the sustainable yield of water supply from the dam and gives sound guidelines for decision-makers considering future national development strategies.

Ovesen (1999) reported about the developments in education due to the effect of hydro-power development upstream of the existing Xeset Dam. The adult population above the age of fifteen became more literate, particularly the women. The largest number of literate adult males was found in the group older than 40 years. In 1999, there were about 40 government schools and temples in the 67 villages in the area. Average teacher ratio was 38 pupils per teacher, the same as in rural villages and urban areas in Lao PDR, generally.

The changes occurred in infrastructure as a result of the hydro-power development upstream of the existing Xeset Dam (Ovesen, 1999). It stated that the two province capitals, Pakse and Salavan, were connected by road No. 20 which became a paved road in good condition. Other roads in the area remained un-surfaced. Road No.20 became part of a well-developed road network, reflecting the importance of the agricultural trade (coffee and other crops) in the area. Electricity was supplied by the Electricite du Laos (EdL) to Lao-ngam town and to the villages along road No.20. Electrical appliances such as televisions, refrigerators, rice mills, and rice cookers became common. Local people became consumers of electricity that turn their life more convenient.

Monkolcharoenmitr (2001) studied the impact of Pak Moon dam project on natural resources and socio-economic status in Changwat Ubon Ratchathani. The results found that the implementation of the project cause the effect on the forest resources and fishery. The large number of fishes was decreased at Moon river. These additionally affected in the change on the occupations as well as the reduction on the income of native people.

Pongstornpluek (2007) examined the policy impacts of the Bhumibol Dam project on the way of life of Ban Na community in Sam Ngao district, Tak province, Thailand. Ban Na community were relocated to a new village and social problems arose, for example an increasing rate of divorce as a result of migration. People were prejudiced against the government due to the low amount of money provided for relocation and the lack of budget to solve other problems.

Tilt et al. (2009) studied the social impacts of large dam projects and found that, in the case of large dams constructed on trans-boundary rivers, problems became even more complex due to the limited data available and geo-political considerations. The study stated that it is important that SIA serves only as a starting point which must be followed up with equitable mitigation and compensation measures appropriate to the project.

Ogaboh el al. (2010) studied the socio-economic and cultural impacts of resettlement on the Bakassi people of Cross River state, Nigeria. The study involved 516 respondents who were purposively selected from the Bakassi resettlement site at Ekpiri Ikang in

Cross River state. It was found that the resettlement of the Bakassi people significantly influenced their occupations and culture.

Abdullateef (2012) reported the socio-economic analysis of the operational impacts of Shiroro hydropower Generation in the lowland areas of Middle river, Niger. The study showed that the economic engagements of the riparian communities have been distorted. This is noticeably fish bio-diversity and the eco-system were loss especially on fish species. There was a fall in the productivity of small-holder farmers and fishing personnel occasioned by avoidable flooding. Thus, it slowed down the socio-economic development in the area.

Mudzengi (2012) assessed the socio-economic impacts of the construction of Siya Dam in the Mazungunye area, Bikita, Zimbabwe. The study showed that the dam had both positive and negative socio-economic impacts, being used for irrigation for agriculture and fish habitats and the generation of electricity.

These thesis showed that dams are the sources of water supply in several sustainable development projects and impact on human development. Dams affected the quality of the water by contamination by local people's activities. However, at the same time, they also bring about socio-economic growth for the local community, unexpectedly.

CHAPTER 3

MATERIALS AND METHODS

This thesis studied 2 parts of Environmental Impact Assessment (EIA) and Socio-economic Impact Assessment (SIA). The study will combine EIA analysis on water supply and the socio-economic study (ESIA) of dam, Xeset 2 projects, Salavan, Lao PDR. EIA had particularly focused on the water quality of the dam according to the large amount of water flow and water surface are served on the local people and biota on irrigation, water supply, agricultural, crop and fishery. However, several human activities had contaminated the water surface by their use in particular agricultural irrigation (chemical fertilizer and pesticides). In addition, domestic irrigation (water usage, sewage and household wastewater had also discharged into the reservoir, directly. These caused the change on water quality at these areas. The socio-economic study (SIA) was consequently impacted from the human activities to water supply from the dam. Then, this work considered the impacts by comparing the current period (2011) with the start-up period of this Xeset dam (1999) as ESIA study.

3.1 Environment impact assessment (EIA) study of water quality

According to the dam brings enormous beneficial effect on irrigation water (domestic and agriculture purpose) from upstream and downstream water of Xeset dam. Then, this part focused on water quality on 3 parameters, physical, chemical and biological parameters of water samplings. The objective was designed to determine the impact of water quality of water supply from dam that changed from dam construction by people who living in these areas.

3.1.1 Location sites

The location sites in this thesis are Xeset 2 dam, Salavan province, Lao PDR (Fig.3.1)

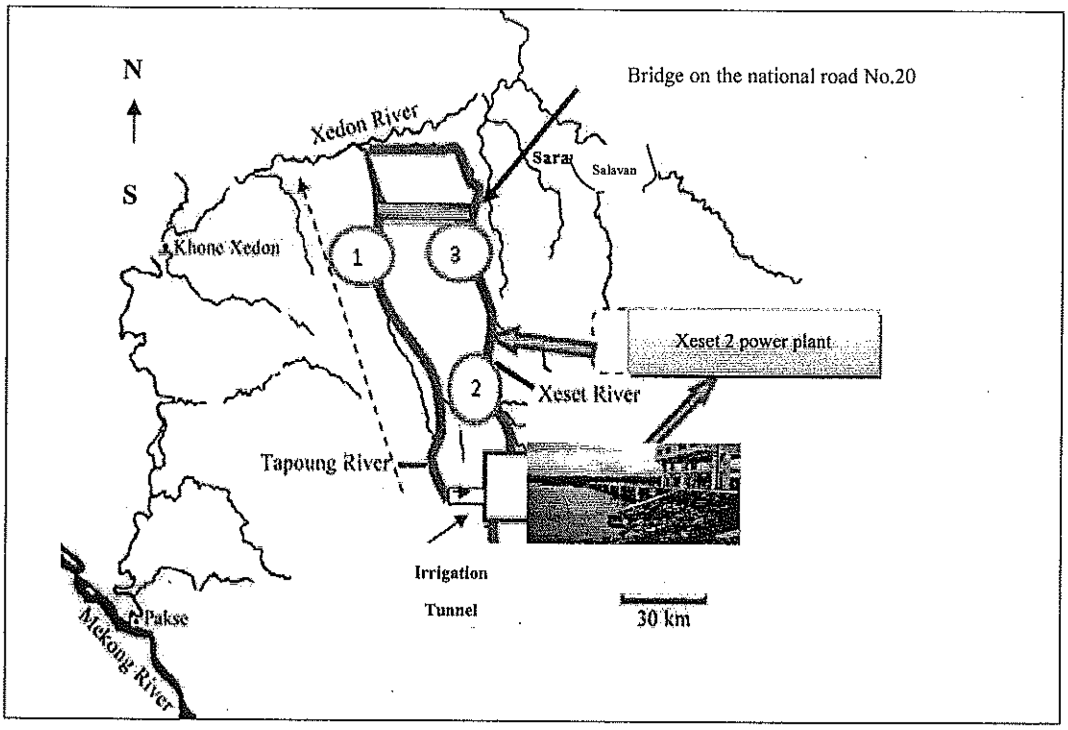


Figure 3.1 Location sites of water sampling

Remark: (1) = Bridge on the national road No. 20, Lao - ngam village (Tapoung river)

(2) = Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

(3) = Bridge on national road No. 20 downstream of the Xeset 1 and Xeset 2dam (Xeset river)

The water samples were collected from 3 sites. The first was collected at the bridge on the national road No.20, Lao-ngam village (Houay Tapoung) as shown in Fig. 3.2. The second was at Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river) (Fig. 3.3). Finally, the third site was at the (3) the bridge on national road No.20 downstream of the Xeset 1 and Xeset 2 dam (Xeset river) (Fig. 3.4).

The sites mostly surrounded by agricultural area which pesticides and fertilize, normally applied for more than 10 years.

Figure 3.2 Site No.1, the bridge on the national road No.20, Lao-ngam village (Tapoung river)

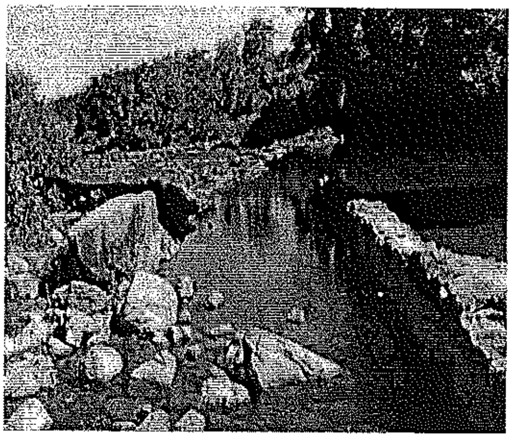


Figure 3.3 Site No. 2, Photok village, 100 meters, upstream Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

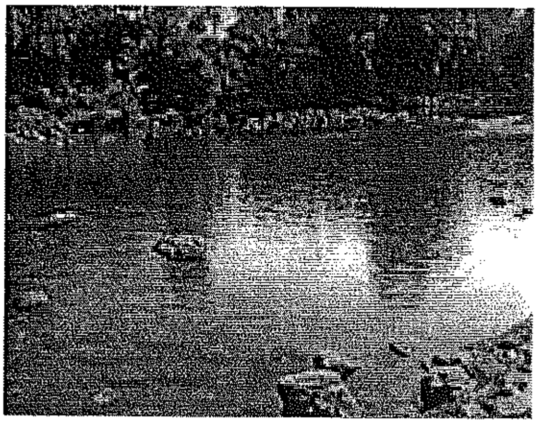


Figure 3.4 Site No. 3, the bridge on national road No. 20, downstream of the Xeset 1 and Xeset 2 dam (Xeset river)

3.1.2 Water samples collection

Water samples designed to collect in rainy season and winter except summer because in the summer time the water level appeared at a very low level of surface water in the river. Then, the samples were collected at 2 seasons, in rainy season, October, 2011 and in winter, December, 2011 at 3 sites. The samplings were taken by grab samplings. After that, it was brought to analyze the entire parameters such as physical, chemical and biological parameters at Analysis and Testing Laboratory Unit (ATL), Faculty of Science, Ubon Ratchathani University, Thailand. The physical parameters comprised of temperature, conductivity, total suspended solids (TSS) and dissolve oxygen (DO). The chemical study was designed to investigate pH, hardness, alkalinity, chemical oxygen demand (COD), nitrate-nitrogen, and phosphate-phosphorus.

In addition, heavy metal in this study was Lead (Pb) and cadmium (Cd) by its ecotoxicity to ecosystem. Pb and Cd contamination had severe effects to water quality and human health. Lead leads into lead poisoning syndrome that induces tiredness, vomiting, sleep problems, dizziness, headaches, joint and muscle pain and stomach aches. Cadmium contamination causes into Itai - Itai disease or Cd sickness. It appears a bone hurt and breakable joint all the part of the body. In case of the biological study, this part focused on the fecal coliform bacteria (FCB) in order to measure the mammals' fecal contamination (including human) as well as domestic wastewater which was discharged onto water supply in the river downstream.

The entirely collected samples were placed in sterilized bottle, stored in ice box, keep at 4°C, transported back to investigate at the laboratory (Zuma, 2010). Chemical reagents (H_2SO_4 and NHO_3) were added to sample preservation. In terms of temperature, conductivity and DO were immediately measured on sites. The entire samples brought back to determine at Analysis and Testing Laboratory Unit, Ubon Ratchathani University, Ubon Ratchathani province, Thailand.

3.1.3 Analytical procedures

The water sample was investigated by the standard methods for the examination of water and wastewater as shown in the following Table 3.1 (APHA et al., 2005)

Table 3.1 Water quality analytical methods (APHA et al., 2005)

No.	Parameters	Analytical methods	References
1	Physical characteristics		
	Temperature	Thermal and Conductivity measurement	APHA,2005
	Conductivity	Conductivity measurement	APHA,2005
	Total Dissolved Solid (TSS)	TSS analytical method (Dried at 103^0C-105^0C)	APHA,2005
	Dissolved oxygen (DO)	Azide modification method	APHA,2005
2	Chemical characteristics		
	pH	pH meter	(Bhatt et al.,2011)
	Hardness	EDTA Titration method	(Watt, 2003)
	Alkalinity	Indicator method	(Sirianuntapiboon, 2006)
	COD	Dichromate close reflux method	(Sirianuntapiboon, 2006)
	Nitrate-nitrogen	Brucine method	(Sirianuntapiboon, 2006)
	Phosphate-phosphorus	Ascorbic method	(Chantree, 2011)
	Lead	Flame AAS method	(Bhatt et al., 2011)
	Cadmium	Flame AAS method	(Bhatt et al., 2011)
3	Biological characteristics		
	Fecal coliform bacteria (FCB)	Membrane Filter Technique	(APHA,2005)

The water sample was investigated by the standard methods for the examination of water and wastewater as shown in the following Table 3.1 (APHA, 2005)

3.1.3.1 Physical parameters

Physical parameters in this part were temperature, conductivity, total suspended solids (TSS) and dissolved oxygen (DO). Temperature and conductivity were measured by Thermal conductivity meter (APHA, 2005; Suma, 2010). TSS were followed the TSS analytical method (dried at 103^0C-105^0C). DO was investigated by Azide modification method (APHA, 2005) (Table 3.1).

3.1.3.2 Chemical parameters

Chemical parameters were pH, hardness, alkalinity, COD, nitrate-nitrogen, phosphate -phosphorus and heavy metal (Pb and Cd). The pH measured by pH meter.

Hardness was analyzed by EDTA Titration method. Alkalinity tested by using the indicator method. Chemical Oxygen Demand (COD) analyzed by dichromate close reflux method (APHA, 2005). In case of Nitrate-nitrogen concentrations, it determined by Brucine methods with spectrophotometer wavelength at 410 nm (Sirianuntapiboon, 2006). Phosphate-phosphorus investigated by Ascorbic method (Chantree, 2011) with spectrophotometer at 880 nm. Lead and cadmium were analysed by Atomic Absorption Spectrometry (AAS) (APHA, 2005).

3.1.3.3 Biological parameter

Fecal coliform bacteria (FCB) were interested in this part. FCB were focused instead of coliform bacteria. The reason of why investigate particularly FCB because it indicated the mammal and human waste (fecal) excreta and then, contamination in the river as well as it was easily direct discharged together with household sewage. Therefore, the activity of indigenous people could effect the water quality and subsequently caused the gradually changes in the water quality in the river. FCB was measured by membrane filter method, using a sterile 0.45 μm membrane filter with M-FC agar. Then, it was incubated at 44.5°C for 24 hours.

3.2 Socio-economic Impact Assessment (SIA) study

This part focused on socio-economic impact assessment resulted from water supply downstream of Xeset 2 dam. This has effect on quality of life of indigenous people. The sampling areas focused on 3 sample villages' surveys. The data was considered and analyzed the socio-economic effects from dam by comparing the current surveys (2011) with the start-up period of this Xeset dam (1999).

3.2.1 Study areas

The study area designed to survey at 3 sites with follow the water quality location sites. The study areas were Photok village, Thong soui and Lao-ngam village, Salavan province, Lao PDR. The majority occupations of people are farmer. The survey details included general information. The latter focused on socio-economic before and after dam construction, quality of life aspect and the final part was the recommendation of local people all three villages to the Xeset 2 project and government of Lao PDR.

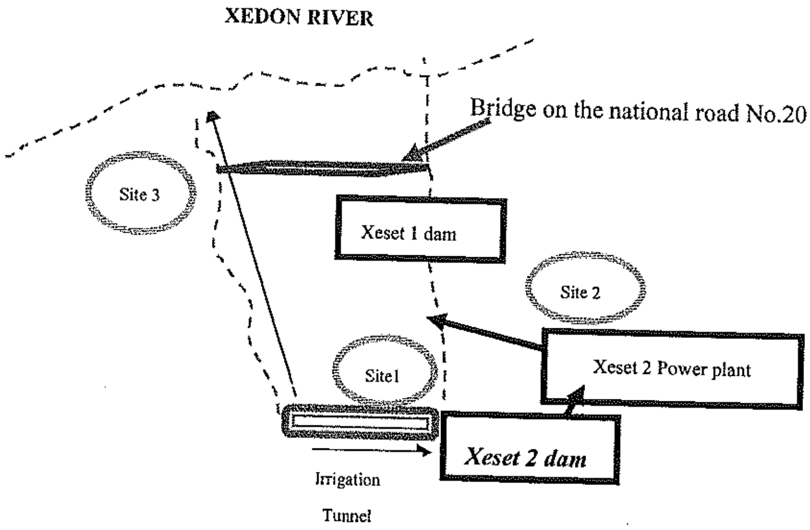


Figure 3.5 Locations sites on socio-economic study

Remark: Site 1 = Photok village upstream Xeset 1 dam and downstream Xeset 2 (Xeset river)

Site 2 = Thong soui village downstream Xeset 2 dam (Xeset river)

Site 3 = Lao-ngam village (Tapoung river)

3.2.2 Research methodology

The number of households selected in this thesis was determined by using Taro Yamane method as the following formula.

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

n = the population size

N = the sampling size

e = the error

The number of sampling population calculated as in Table 3.2

Table 3.2 Number of populations sample calculated in this study (Sinecharu, 2010).

Sites	Villages	Number of households	Sample size
1	Photok village	45	40
2	Thong soui village	75	63
3	Lao-ngam village	210	138
	Total	330	241

Remark: Calculated from Yamane formula

The study was conducted on the basis of the survey of people from Salavan province at 3 sites. The calculated households from 330 household's were 241 households by Yamane formula (Table 3.2). This part was surveyed research with questionnaires. The questionnaires were both close-ended and open-ended questions (Mudzengi, 2012). It included 4 parts as follows.

3.2.2.1 General information

The details were general information (gender, age, marital status, education background and home settlement).

3.2.2.2 Socio-economic aspects

This part surveyed the opinion of the villagers in the topics of occupation, income, infrastructure (road, bridge and electricity sources, irrigation, water supply) and human value aspect. The survey included domestic water supply, drinking water processes, education system and sanitary and health of native people.

3.2.2.3 Quality of life aspect

Quality of life in this part focused on the opinion on quality of life view on dam before the start-up period. This part included agriculture area change, resettlement, cultural and mental deterioration, crime, divorce, employment and over-population.

3.2.2.4 The recommendation

The recommendation is the final part. This part was designed to observe the people's point of view from on their recommendations, advantages and disadvantages comments. The topics were occupations, income, infrastructure, human value and quality of life.

clearly led into advantage or disadvantage to native people. Theoretically, the development from dam construction and operation should bring about a better quality of life to the people.

3.3 Statistical analysis

This work used questionnaires to survey within three villages. The sites were Photok, Thong Soui and Lao-ngam village. Then, the samples analyzed the data of population and identified the sample groups by frequency, percentage, mean and standard deviation (Sinecharu, 2010).

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter comprised of EIA and SIA studies. EIA was studied on the water quality from Xeset 2 dam in 2011. The water flow (irrigations) keys as roles as a crucial main output hydropower dam. The water is freshens and feeds the surrounding of the local people in these areas. Then, EIA study in this thesis designed to focus on water quality and reflected the social impact assessment, consequently. The water characteristics investigated the physical, chemical, and biological parameters of the Xeset 2 dam on Xeset and Tapoung rivers. The water quality at Xeset and Tapoung rivers was compared with the startup year in 1999. In terms of SIA showed the difference of socio-economic impact that related to general backgrounds, socio-economic and quality of life aspect. The final part included the recommendation advantage and disadvantage to Xeset 2 dam projects and the government of Laos.

4.1 Environment impact assessment (EIA) study of water quality

Dam is the source on water supply that impact to human value and socio-economic sides of local people in these areas. This thesis was focused on water quality in the river flow from this dam. The sampling sites were collected at 3 sites (1) bridge on the national road No. 20, Lao-ngam village (Tapoung river). (2) Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river) and (3) bridge on national road No. 20, downstream of the Xeset 1 and Xeset 2 dam (Xeset river). The results were indicated in the following section.

4.1.1 Water quality of Xeset and Tapoung river from Xeset 2 dam

This topic studied the water quality of Xeset and Tapoung rivers after Xeset 2 dam in 2011. This part included the study on physical, chemical and biological characteristics as follows.

4.1.1.1 Physical characteristics

The physical characteristics of water quality in Xeset and Tapoung rives, Xeset 2 dam in 2011, mostly found at high amount in rainy season at three sites. The results were shown in the following table 4.1.

Table 4.1 Physical characteristics of water quality at Xeset and Tapoung rives after Xeset 2 dam startup in (2011)

Parameters	**Sampling sites**						**Standard**	
	(1)		(2)		(3)			
	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter	Lao PDR	EPA
Temperature (°C)	25.1	22	23.9	19	23.6	19	35	25
Conductivity(μS/cm)	0.1	0.1	0.006	0.01	0.04	0.07	-	1000
TSS (mg/l)	9.7	7.7	1.3	0.7	5.3	ND	-	-
DO (mg/l)	7.6	10.1	6.7	10.3	6.8	9.6	6	-

Remark: (1) = bridge on the national road No. 20, Lao - ngam village (Tapoung river).

(2) = Photok village, 100 meters, upstream of hydroelectric power Xeset 1 dam and downstream hydroelectric power Xeset 2 dam (Xeset river)

(3) = bridge on national road No. 20 downstream of the hydroelectric power Xeset 1 and Xeset 2 dam (Xeset river)

ND = not detect

Temperature at Xeset and Tapoung rivers appeared greater (23.9°C-25.1°C) in rainy season than winter (19°C-22°C) all three sites. According to this season is the period of the agricultural crops, then, in rainy season had the water volume, the depth of the water, suspended solids and turbidity higher than in winter (Trichaiyaporn and Chitmanat, 2008). Temperature at site 1 was similarly higher than site 2 and 3 in rainy season and winter (25.1°C and 22°C) as well. Site 2, the temperature were 23.9°C and 19°C and site 3 were 23.6°C and 19°C in rainy season and winter, respectively. However, temperature lies within the water quality standard of Lao PDR at 35°C (Water resources and environmental organization, 2009). The factor affected on the temperature change caused from the several reasons of season, water body, water depth, SS, turbidity as well as human activity (Chantree, 2011).

Conductivity at Xeset and Tapoung rivers found elevated in winter at all three sites. The conductivity at site 1 was higher than site 2 and site 3. At site 1, the conductivity in rainy and winter were 0.1 and 0.1μS/cm, that were higher than site 2 of 0.006 and 0.01μS/cm and site 3 were 0.04 and 0.07μS/cm, respectively. These results agreed with the research of Khongrack, 2006. According to in winter, the concentration of minerals in water was higher than rainy season. The rainwater dilutes the concentration of minerals or compounds in the surface water and less evaporation in the rainy season (Makhlough, 2008). Several factors that effect on conductivity were rainwater, mineral leaching, organic and inorganic matter by communities and agriculture areas (Chantree, 2011). The other factors for examples treatment plants, agricultural and urban runoff that increase ions and contaminated the surface water in the river (Makhlough, 2008).

In case of total suspended solids (TSS), appeared higher amount in rainy season than winter all three sites at Xeset and Tapoung rivers. This result is agreed with the research of Consultants, and precipitation is stored in snow, the total suspended 1999 by in winter, when the ground is frozen solids level drops to near zero. TSS at site 1 in rainy and winter were 9.7 and 7.7 mg/l, respectively showed the higher TSS amount than site 2 and 3. By TSS at site 2 found 1.3 mg/l and 0.7 mg/l and TSS site 3 were 5.3 mg/l and non detected (ND), respectively. TSS in surface water sourced from a wide variety of material such as soil particles (silt, sand and clay), organic and inorganic matter, plankton, small organisms, industrial wastes and sewage.

Xeset and Tapoung rivers found the less amount of dissolve oxygen (DO) in rainy season. Site 1 found DO higher than at site 2 and site 3. DO at site 1 in rainy season and winter was 7.6 mg/l and 10.1 mg/l, site 2 were 6.7 mg/l and 10.3 mg/l and site 3 found 6.7 mg/l and 9.6 mg/l, respectively. This result is agreed with the research of Chantree, 2011 that the sediment was washed into the water as an effect to dissolve oxygen reduced especially in rainy season (Chantree, 2011). The concentrations of dissolved oxygen were high during winter. This was probably caused by the low water temperature, no turbidity and increased photosynthetic activity of the green algae. During the winter low temperature, high aeration rate and high photosynthetic activity might have been increased the amount of dissolved oxygen (Joshi et al., 2009). However, DO lies within the water quality standard of Lao PDR at 6 mg/l (Water resources and environmental organization, 2009). The source of DO in the river was mainly come from human which were the factors on the contamination of organic wastes flows with sewage and nutrients.

4.1.1.2 Chemical characteristics

Chemical characteristics on water quality at Xeset and Tapoung rives in 2011 were pH, hardness, alkalinity, chemical oxygen demand (COD), nitrate-nitrogen, phosphate-phosphorus and heavy metal. Lead (Pb) and cadmium (Cd) were also interested by its toxicity. The result of chemical characteristics of water quality at Xeset and Tapoung rives in the 2001 were shown in Table 4.2.

Table 4.2 Chemical characteristics of water quality at Xeset and Tapoung rives after Xeset 2dam start-up in 2011.

Parameters	Sampling sites						Standard	
	(1)		(2)		(3)			
	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter	Lao PDR	EPA
pH	8.02	8.2	7.4	7.9	7.1	7.8	5-9	5.5-9
Hardness (mg/l)	65.3	59.2	42.5	42.8	29.6	42.2	50-300	-
Alkalinity (mg/l)	71.0	76.3	51.0	61.7	34.0	38.0	-	-
COD (mg/l)	129.3	7.9	72.7	4.8	67.9	ND	5	-
Nitrate-N (mg/l)	8.9	1.7	0.4	0.2	2.1	0.2	<50	50
Phosphate-P (mg/l)	0.1	ND	0.02	ND	0.09	ND	-	0.5, 0.7
Lead (mg/l)	ND	ND	ND	ND	ND	ND	0.005	0.005
Cadmium (mg/l)	ND	ND	ND	ND	ND	ND	0.05	0.05

Remark: (1) = bridge on the national road No. 20, Lao - ngam village (Tapoung river).

(2) = Photok village, 100 meters, upstream of hydroelectric power Xeset 1 dam and downstream hydroelectric power Xeset 2 dam (Xeset river)

(3) = bridge on national road No. 20 downstream of the hydroelectric power Xeset 1 and Xeset 2 dam (Xeset river)

ND = not detect

The pH at Xeset and Tapoung rivers found higher in winter than rainy season all three sites especially at site 1. The pH at site 1 in rainy and winter was 8.02 and 8.2 that higher than site 2 wih 7.4 and 7.9 and site 3 were 7.1 and 7.8, respectively. This result is agreed with the research of Khongrack, 2006 by in the winter, the water consumption in the river is quite low that is not enough by native people on their activity. Those activities were bathing, washing and agriculture in the river. The main sources for natural alkalinity are bedrocks, which contain carbonate, bicarbonate and hydroxide compounds such as limestone (Tang, 2009).

Hardness contamination at Xeset and Tapoung rivers, mostly found at winter more than rainy season. This result is agreed with the research of Jena et al., 2013 that in winter, water level is not enough for the native people on their domestic water supply domestic (bathing and washing). Hardness at site 1 (were 65.3 mg/l and 59.2 mg/l) that were higher than site 2 (42.5 mg/l and 42.8 mg/l) and site 3 (29.6 mg/l and 42.2 mg/l) in rainy season and winter, respectively. Hardness changes cause from several reasons of dissolved salts of calcium and magnesium rich minerals from rocks (Jackson et al., 2000) such as limestone gypsum, clay minerals and sewage that contaminated into domestic wastes (Singh et al., 2012).

Alkalinity at Xeset and Tapoung rivers found high in winter. The alkalinity at site 1 was higher than site 2 and 3. Alkalinity at site 1 at rainy season and winter were 71.0 mg/l and 76.3 mg/l, site 2 were 51.0 mg/l and 61.7 mg/l. Wheareas, at site 3 was 34.0 mg/l and 38.0 mg/l, respectively. This result is agreed with the research of Consultants, 1999 that the rainfalls during rainy season dilute the alkalinity of the water surface (Jena et al., 2013). Alkalinity in water causes from the dissolution of the bicarbonate, carbonate and hydroxide salts of calcium, magnesium, sodium and potassium (Jackson et al., 2000). In addition, the cattle soaking and washing of clothes by detergents, soaps resulted in the water softening agents and washing soda and sodium carbonate dissolved into the river (Agarwal and Saxena, 2011).

The chemical oxygen demand (COD) indicated the sewage and industrial plants discharged into natural water bodies (Makhlough, 2008). The results of COD at Xeset and Tapoung rivers found higher in rainy season than winter all three sites (Consultants, 1999). At site 1, COD found higher than site 2 and site 3. COD at site 1 in rainy season and winter were 129.3 mg/l and 7.9 mg/l, at site 2 were 72.7 mg/l and 4.8 mg/l and site 3 were 67.8 mg/l and 0 mg/l, respectively.

The Xeset and Tapoung rivers found nitrate-nitrogen higher in rainy season than winter. The factors of nitrate contamination in water possibly come from several reasons of inorganic fertilizer and animal manure (Tang, 2009). This caused from the rainy season is the period of the agriculture practice on their plantation. Then, they use lets of fertilizers during this time and allow the rain-water leached the fertilizer as dissolved nitrate contamination into the river. Nitrate-nitrogen found intensified high at site 1, site 3 and site 2. Nitrate-nitrogen in rainy season and winter were at site 1 were 8.9 mg/l and 1.7 mg/l, site 2 were 0.4 mg/l and 0.2 mg/l, while site 3 were 2.1 mg/l and 0.2 mg/l, respectively.

The phosphate-phosphorus (PO_4-P) found higher at Xeset and Tapoung rivers in rainy season than winter all three sites. The phosphate-phosphorus appeared at site 1 higher than site 2 and 3. The phosphate-phosphorus at site 1 were 0.1 mg/l and non-detected, at site 2 were 0.02 mg/l and non detected and site 3 were 0.09 mg/l and non detected, respectively in rainy season and winter. The primary sources of phosphate from anthropogenic activities are sewage, fertilizer, agricultural runoff, detergents and animal wastes (Tang, 2009). The other reason come from the rainy season that farmer use more fertilizers for plantation that allowed the rain-water to leach the fertilizer more into the river. Besides, the native people applied the large detergents into river from their activities on bathing, swimming and clothes washing. However, in winter time they use less detergents as well as water supply on their routine life in the river, in winter.

In case of lead (Pb) contamination in Xeset and Tapoung rivers, it was not found (ND) by all three sites in rainy season and winter. This result is agreed with the research of Chantree, 2011 that although lead contamination was not found, but it should monitor regularly. Generally, lead is rarely found in surface water. The existence of lead that found in a water supply over water standard, possibly come from industry, mine and discharges or the dissolution of old lead plumbing and leaching from ores, effluent discharges and flow onto reservoirs by water pipes (USEPA, 2001).

Cadmium (Cd) contamination at Xeset and Tapoung rivers found non detection at all three sites in rainy season and winter. This result is agreed with the research of Trichaiyaporn and Chitmanat, 2008. Cadmium concentration should monitor regularly as well as lead. Cd may enter waterway by a result of industrial discharges or the deterioration of galvanized pipe. Cadmium in water is exclusively come from industrial discharges (electroplating, paint-making and manufacture of plastics) and landfill leachates (USEPA, 2001).

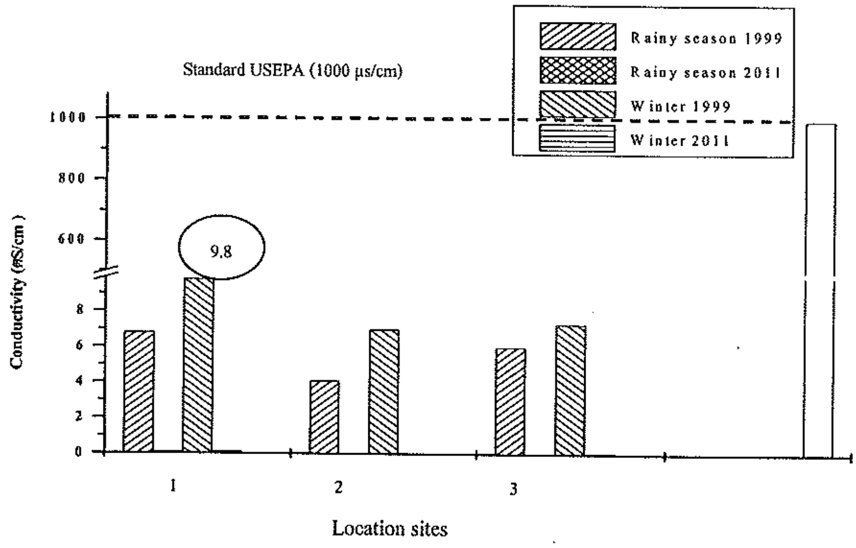
4.1.1.3 Biological characteristics

Biological characteristics of water quality in Xeset and Tapoung rivers after Xeset dam startup in 2011 was focused in especially fecal coliform bacteria (FCB) in this part. FCB is relying in the intestine of warm-blooded animals that reported of the contamination by mammal or human feces directly into the river whether by the excreta or household sewage. FCB at Xeset and Tapoung rivers found in the greater amount in rainy season than winter (non detection) at all three sites. FCB found top at site 3 than site 1 and site 2. In particular FCB at site 1 in rainy season, found 8cfu/ml and 4cfu/100 ml, at site 2 were 4cfu/ ml and 1cfu/ml which lesser amount than in 1999. Oppositely, in rainy season, at site 3 found upper than in the startup time (1999) that were 35 cfu/100 ml and only 4 cfu/100 ml. In rainy season, FCB contaminated in water resulted from the leaching by rainwater sewage into water. Besides, FCB contamination in surface water also caused from several reasons of agricultural runoff, wastewater treatment plants, domestic, human waste and animal waste (Graves, 2003).

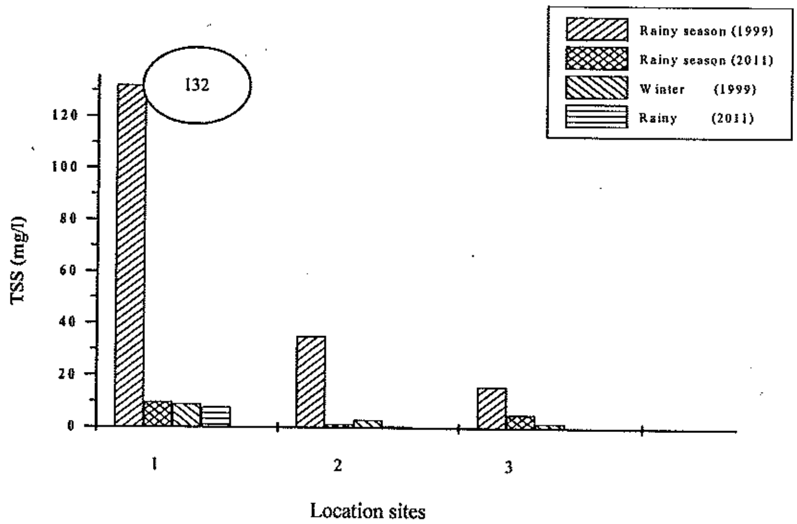
4.1.2 The difference of water quality of Xeset and Tapoung rives (1999 and 2011), Xeset 2 dam

4.1.2.1 Physical characteristics

The physical characteristic studied the conductivity and suspended solids TSS at Xeset and Tapoung rivers in 1999 and startup 2011 of the Xeset 2 dam shown as in the following Fig. 4.1



a) Conductivity



b) Total Suspended Solid (TSS)

Figure. 4.1 Physical parameters (a) Conductivity and b) TSS) of Xeset and Tapoung river in rainy season and winter of hydroelectric power Xeset 2 dam (1999 and 2011)

Remark: (1) = Bridge on the national road No. 20, Lao - ngam village (Tapoung river)

(2) = Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

(3) = Bridge on national road No. 20 downstream of the Xeset 1 and Xeset 2 dam (Xeset river)

The conductivity at Xeset and Tapoung rivers in rainy season and winter at 1999 and after dam startup (2011) appeared higher than the start-up period of Xeset dam in 1999. The low amount of conductivity had found in 2011. According to in 2011, the water level in both rivers is low level and it is not enough to use by native people on their farm. While in 1999, the conductivity found upper amount at site 1 than site 2 and 3 in rainy season and winter than in 2011. The conductivity at site 1 in rainy season were 6.8 μS/cm (1999) and 0.10 μS/cm (2011). Sites 2 were 4.1 μS/cm (1999) and 0.006 μS/cm (2011) and site3 were 6 μS/cm (1999) and 0.04 μS/cm), respectively. In winter, at site 1 conductivity found higher at 9.8 μS/cm (1999) and 0.12 μS/cm (2011) than site 2 that found at 7 μS/cm (1999) and 0.01 μS/cm and site 3 were 7.3 μS/cm (1999) and 0.07 μS/cm in 2011, respectively.

However, these parameters were lied within the surface water quality standard of USEPA which at 1,000 μS/cm (USEPA, 2001). Mostly of the parameters at site 1, site 2 and site 3 were higher in 1999 than 2011. This might come from people that mostly were agriculture in 1999. They changed into another career in 2011. These farmers allowed agricultural and urban runoff discharge in to the Xeset river. This let the ions increase into the water body in the river (Makhlough, 2008).

TSS at Xeset and Tapoung rivers in rainy season and winter in 1999 and 2011 show the higher of TSS in 1999 than 2011. In 2011, the native people mostly used groundwater and tap water on their daily life. TSS in surface water in these rivers appeared with a water quality more than 1999. In 1999, at site 1, TSS found sharper at site 2 and 3 in rainy season and winter than in 2011. The amount were 132 mg/l (1999) and 9.7 mg/l (2011) at site 1. Site 2 found lesser amount of TSS of 35 mg/l (1999) and 1.3 mg/l (2011) and site 3 with 16 mg/l (1999) and 5.3 mg/l (2011), respectively. Whereas, in winter at site 1, TSS found at 9 mg/l (1999) and 7.7 mg/l (2011). At site 2, TSS were 3 mg/l (1999) and 0.7 mg/l (2011) while site 3 was 2 mg/l (1999) while in 2011 was non detected (ND). The reason why site 1 in rainy season and winter were higher than site 2 and site 3. At site 1, the people mostly use water source for activity such as agriculture and domestic irrigation (bathing and cleaning) more than at site 2 and site 3 that wastewater were indirectly discharged into the water resource.

4.1.2.2 Chemical characteristics

The difference on pH, Hardness, Alkalinity, COD, Nitrate–nitrogen, Phosphate-phosphorus and heavy metal (Pb and Cd) at Xeset and Tapoung rivers in 1999 and 2011 at Xeset 2 dam shown as in the following Fig. 4.2 and 4.3.

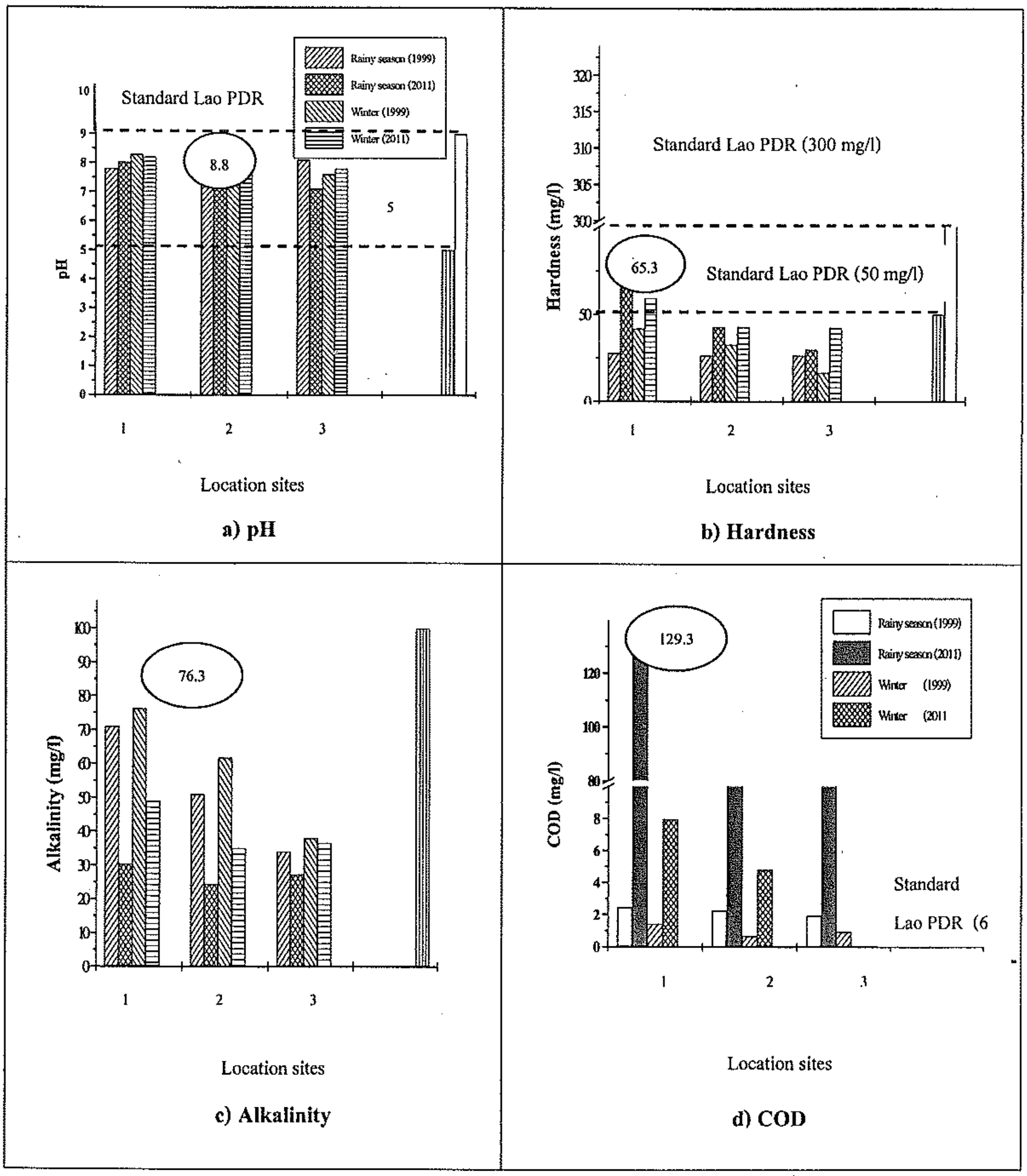


Figure. 4.2 Chemical parameters a) pH, b) Hardness, c) Alkalinity and d) COD of Xeset and Tapoung rivers in rainy season and winter, Xeset 2 dam (1999 and 2011)

Remark: (1) = Bridge on the national road No. 20 (2) = Photok village (3) = Bridge on national road No. 20

The pH at Xeset and Tapoung rivers in rainy season and winter in 1999 and 2011 all three sites (Fig 4.2, a) were mostly sharp in 1999. In 1999, pH was higher amount than 2011 at site 2 and 3 in rainy season while site 1 appeared as high amount in 2011. Great pH effected from alkaline minerals to raise the alkalinity of the water. The extent of the high pH from alkalinity depends on the source water. The pH value was similarly found in 1999 and 2011 by in rainy season in 1999 and 2011, site 1 were 7.8 and 8.02, at site 2 was 7.9 and 7.4 while at site 3 were 8.1 and 7.1, respectively. In winter, ph at site 1 were higher with 8.3 and 8.2, site 2 were 8.8 and 7.9 and sites 3 were 7.6 and 7.8 in 1999 and 2011, respectively. These indicated that at site 1, have phosphate and nitrate contaminated higher than site 2 and 3 from human activity. However, pH was lies within the surface water quality standard of Lao PDR (Water resources and environmental organization, 2009) and USEPA (pH at 5-9) (USEPA, 2001)

The hardness was high at dam startup in 2011 and found low in 1999 (EIA) at all three sites (Fig 4.2, b). The hardness in 2011 possibly found from human activity and several reasons of clay minerals, sewage and domestic wastes, which mostly caused from human activity. This activity appeared to increase in 2011. This confirmed that dam startup has affected on hardness contamination. In 2011, hardness at site 1 found higher site 2 and 3 in rainy season and winter than in 1999. In rainy season in 2011 and 1999, at site 1 found 65.3 mg/l and 27.7 mg/l than sites 2 were 42.5 mg/l and 26.4 mg/l, respectively. Whereas, at site 3 were 29.6 mg/l and 26.4 mg/l, respectively. Besides, hardness in winter at site 1 found 59.2 mg/l and 41.8 mg/l than site 2 were 42.8 mg/l and 32.6 mg/l and site 3 were 42.2 mg/l and 16.5 mg/l, respectively. However, this hardness quality was under the surface water quality standard of Lao PDR (Water resources and environmental organization, 2009) and USEPA (USEPA, 2001) by mostly of samples were soft hardness (up to 50 mg/l) except at site 1 was moderately (50-100 mg/l). The intensified value of hardness at site 1, come from the discharge of sewage from the restaurant, hotel and tourist sites. Besides, there are crowded living areas of native people settled along the river. They regularly used of soaps and detergents by laundries, washing and bathing by people directly discharge into river.

Alkalinity showed the high amount in 2011 at all three sites (Fig 4.2, (c)). The alkalinity of water (2011) found high at site 1, site 2 and site 3 more than 1999. The high value of alkalinity at site 1 mostly caused by the native people routinely consumed water on their activity for example cattle bathing and clothes washing in the high amount at site 2 and 3. In rainy season, at site 1 found 71 mg/l (1999) and 30.4 mg/l (2011) than sites 2 were 51 mg/l (1999) and 24.3 mg/l (2011). At site 3, were 34 mg/l (1999) and 27.3 mg/l (2011) as well as in winter found 76.3 mg/l (1999) and 48.9 mg/l (2011) at site 1 than site 2 that were 61.7 mg/l (1999) and 35 mg/l (2011). At site 3 appeared less amount of alkalinity of 38 mg/l (1999) and 36.5 mg/l (2011), respectively.

Alkalinity (Figure 4.2, c) showed the maximum amount in 2011 at all three sites. The alkalinity of water found high at site 1, site 2 and site 3 great more than in 1999. The alkalinity at site 1 mostly caused by the native people routinely consumed water on their activity for example cattle bathing and clothes washing in the great amount at site 2 and 3 in the year 2011. In rainy season, the alkalinity at site 1 found 71 mg/l (1999) and 30.4 mg/l (2011) than sites 2 were 51 mg/l (1999) and 24.3 mg/l (2011). At site 3, it were 34 mg/l (1999) and 27.3 mg/l (2011). In winter, alkalinity were 76.3 mg/l (1999) and 48.9 mg/l (2011) at site 1 with higher than site 2 with the amount of 61.7 mg/l (1999) and 35 mg/l (2011). Furthermore, at site 3 appeared minimum amount of alkalinity of 38 mg/l (1999) and 36.5 mg/l (2011), respectively.

COD at Xeset and Tapoung rivers in rainy season and winter in 1999 and 2011 indicated as in the following Fig. (4.2,d). COD showed mostly greater amount in 2011. Particularly, in rainy season and winter, COD found in the higher amount in 2011 than 1999. Oppositely, COD at site 3 in winter found higher in 1999 than 2011. COD in rainy at site 1 found more COD were 129.3 mg/l and 2.4 mg/l than sites 2 were 72.7 mg/l and 2.2 mg/l. At site 3 were 67.8 mg/l and 1.9 mg/l, respectively. In winter, COD were lower than in rainy season, it were 7.9 mg/l and 1.4 mg/l at site 1. Site 2 was 4.78 mg/l and 0.6 mg/l. Whereas, at site 3 was 0 mg/l and 0.9 mg/l, respectively. The result found that COD in 2011 was sharper than the standard of Lao PDR (5 mg/l) all three sites at rainy season and winter except site 3 in winter season. This arise COD in 2011 caused from the infrastructure development, house settlement, people and human activities and economic growth that allowed the nutrient, detergent, fertilizer and pesticides from their agricultural and domestic activities discharged into the river.

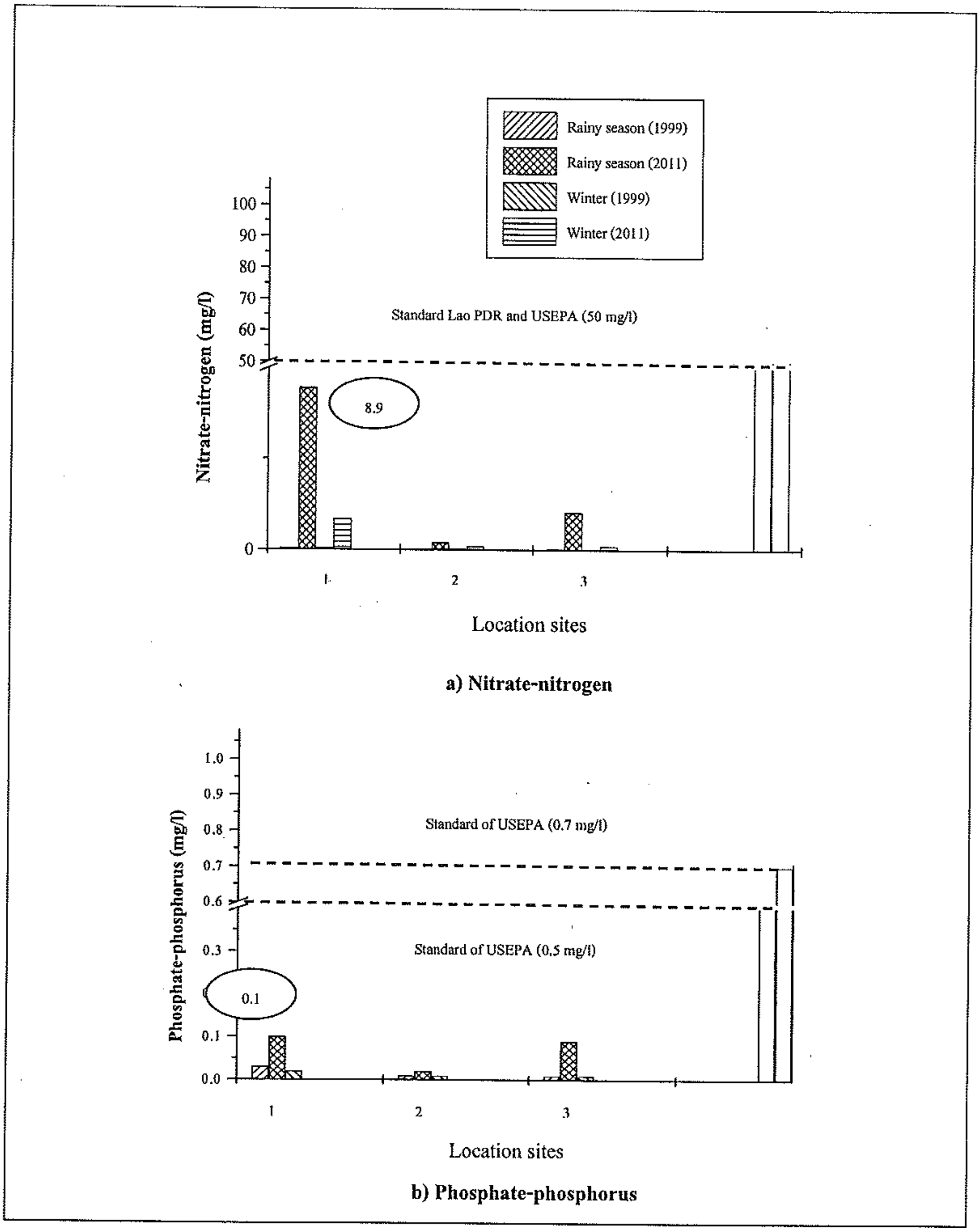


Figure 4.3 Chemical parameters a) Nitrate-nitrogen, b) Phosphate-phosphorus of Xeset and Tapoung rivers in rainy season and winter

Remark: (1) = Bridge on the national road No. 20, Lao - ngam village (Tapoung river)

(2) = Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

(3) = Bridge on national road No. 20 downstream of the Xeset 1 and Xeset 2 dam (Xeset river)

Figure (4.3, a) indicated that nitrate-nitrogen shown the high amount in 2011 and low amount in 1999 (EIA) at all three sites. This indicated that in 2011, with the better infrastructure, more house settlement, more people and human activities, this caused into the enormous contamination in particular on nitrate into the river. The higher amount of nitrate contamination in rainy and winter were elevated in 2011 more than 1999 at all three sites. In rainy season at site 1 found more nitrate-nitrogen were 8.9 mg/l and 0.1mg/l than sites 2 were 0.4 mg/l and 0.02 mg/l and site3 were 2.08 mg/l and 0.03 mg/l, respectively. In winter, nitrate was lesser amount than rainy season by at site 1 found 1.7 mg/l and 0.1 mg/l than site 2 were 0.2 mg/l and 0.01 mg/l while site 3 were 0.2 mg/l and 0.01 mg/l, respectively. However, nitrate lies within the water quality standard of Lao PDR and USEPA (50 mg/l). The reason of high value of nitrate-nitrogen at site 1 because at site 1, mostly indigenous people was farmer who applied fertilizer than site 2 and site 3.

Figure (4.3, b) showed the high phosphate-phosphorus of Xeset and Tapoung rivers in 2011. In rainy season, the phosphate-phosphorus found high amount in 2011. At site 1, it found more phosphate-phosphorus in 1999 and 2011 (0.03 mg/l and 0.1 mg/l) mg/l than sites 2 (0.01 mg/l and 0.02 mg/l) and site 3 (0.01 mg/l and 0.09 mg/l), respectively. In winter, it found greater amount of phosphate in 1999 than in 2011 which the phosphate was non detected at three sites. At site 1, site 2 and 3, in winter were 0.02 mg/l, 0.01 mg/l and 0.01 mg/l of phosphate in 1999, respectively. However, phosphate lied within the water quality standard of USEPA (0.5 and 0.7 mg/l). The high value of phosphate at site 1, caused from the rainy season that is the period of the agriculture for native people in this area. They used more chemical fertilizer during this time and allowed the phosphate contamination with the rainwater by leaching the fertilizer to the river.

4.1.2.3 Biological characteristics

This part studied the contamination of fecal coliform bacteria (FCB) that indicated the mammal and human fecal contamination. FCB of Xeset and Tapoung rivers, in 1999 and after Xeset 2 hydroelectric dam start up (2011) shown in Table 4.3

Table 4.3 Fecal coliform bacteria (FCB) of Xeset and Tapoung rivers in 1999 and in 2011

Years	**FCB at sampling sites (cfu/ 100 ml)**					
	(1)		(2)		(3)	
	Rainy season	Winter	Rainy season	Winter	Rainy season	Winter
1999	15	30	10	ND	14	220
2011	8	ND	4	ND	35	ND

Remark: (1) = Bridge on the national road No. 20, Lao - ngam village (Tapoung river)

(2) = Photok village, 100 meters, upstream of Xeset 1 dam and downstream Xeset 2 dam (Xeset river)

(3) = Bridge on national road No. 20 downstream of the Xeset 1 and Xeset 2 dam (Xeset river)

FCB in the Xeset and Tapoung rivers was mostly low in 1990 (Table 4.3). In 1999, FCB in rainy season at site 1, 2 and 3 were (15 cfu/ml, 10 cfu/ml) and 14 cfu/ml). In winter differently found 30 cfu/ml, ND and 220 cfu/ml, respectively. Whereas, in 2011, FCB appeared shape at site 1, FCB in rainy season that was 8 cfu/ml, at site 2 was 4 cfu/ml, respectively. Noticeably, at site 3 was higher than 1999 with 35 cfu/ml. While in winter were non detected at all three sites. At site 3 in rainy season FCB found higher than site 1 and 2. The reason of the high FCB at site 3 because this area is a reservoir downstream that collected water flow over of the Xeset 1 dam. In addition, there are crowded living areas of people along the river between site 2 and 3. They released waste domestic wastewater and soil and leaching by rainwater into the river. Then, this resulted of FCB in 1999 were greater than 2011 in these areas. In addition, local people have their household toilet rather than fecal discharged outdoor (in the bush) except site 3 in rainy season, in 2011. The rainwater discharged, waste, sewage including outdoor fecal and contaminated these rivers.

4.2 Socio-economic Impact Assessment (SIA) study

This part studied the effect of water supply by local people and impact into socio-economic effects. This part surveyed in term of general information, socio-economic aspect, human value and quality of life.

4.2.1 General information

This part focused on general information of people on the topic of sex, age, marital status, literacy and home settlement. The location sites designed to study at 3 sites as showed in the following figure 4.4 – 4.5.

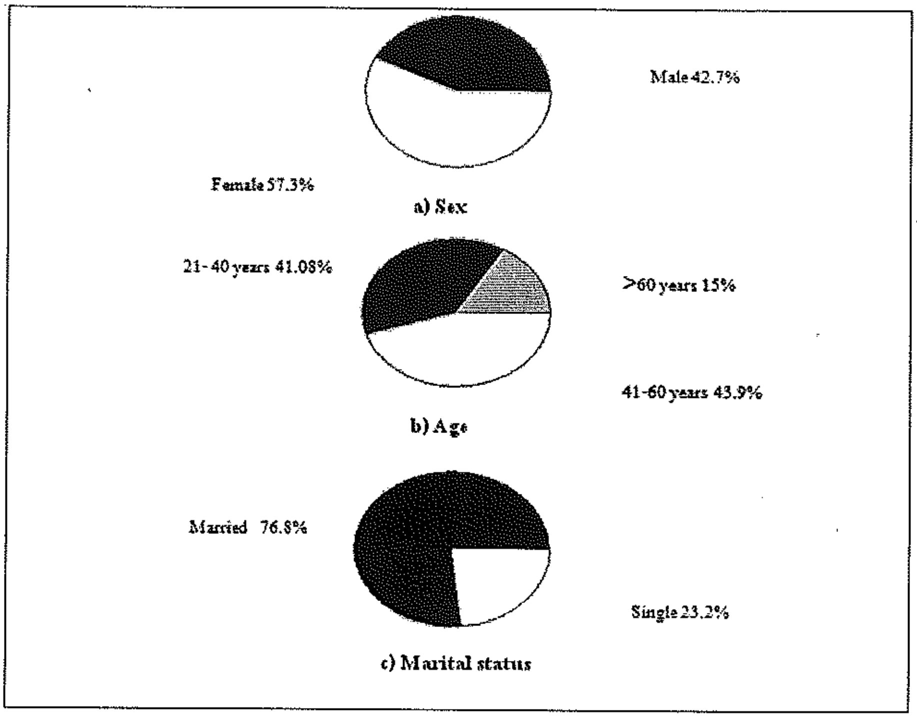


Figure 4.4 The general information a) sex, b) age and c) marital status of people at Photok, Thoung soui and Lao-ngam villages, Salavan province, Lao PDR.

Fig 4.4 stated that people were female (57.3%) and male (42.7%). Female found mostly at site 3 (31.1%), site 2 (15.4%) and site 1 (10.8%) respectively. In case of male, at site 3 similarly found greatest in terms of 26.1%, site 2 (10.8%) and site 1 (5.8%), respectively. Almost 43.98% of the population were in the middle-age (41-60) years old. The older (than 60 years) found 2.9%, 4.2% and 7.8% at site 1, 2 and 3. However, this study stated that native people at three villages get married mostly at site 3 (44.8%), site 2 (19.1%) and site 1 (12.8%), respectively.

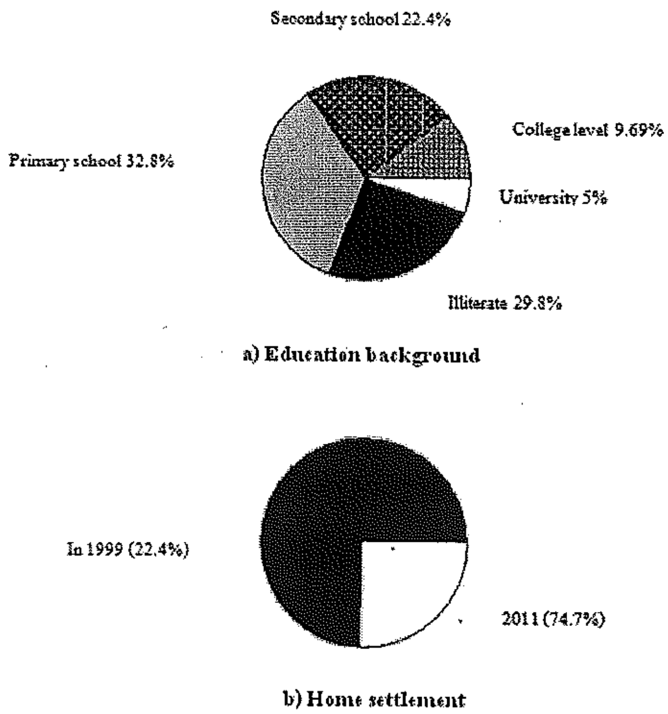


Figure 4.5 The general information a) education background and b) home settlement of people at Photok, Thoung soui and Lao-ngam villages, Salavan province, Lao PDR.

Literacy of the local people was mostly educated in particular at site 3 village. 32.8% of people studied from primary school (5.8%, 10.4% and 16.6%) from 1,2 and 3 sites, respectively. The graduate from university has found only 4.9%, especially at site 3. The literacy people was quite high up to 29.8% (8.3%, 8.3% and 13.3%) at 3 sites respectively.

In terms of resettlement, mostly of native people 74.6% was settlement since 1999, site (19.9%), site 2 (22.4%) and (42.3%) at 3 sites. The rest 25.31% were moved after dam startup (2011). Mostly of native people was living at these areas before dam startup. These indigenous people relied on water resource on their activities for example drinking water, fishery, bathing, cleaning and agricultural irrigation directly and indirectly. This caused the contamination in the river, consequently. Furthermore, it definitely altered these effects (water contamination from human activities) onto water quality change.

4.2.2 Socio-economic aspect

This part focuses on socio-economic study before and after dam startup. The criteria comprised of occupations, income, infrastructure, literacy, sanitary and health of native people.

4.2.2.1 Occupation

The occupations in 1999 and 2011 shown in the following figure 4.6

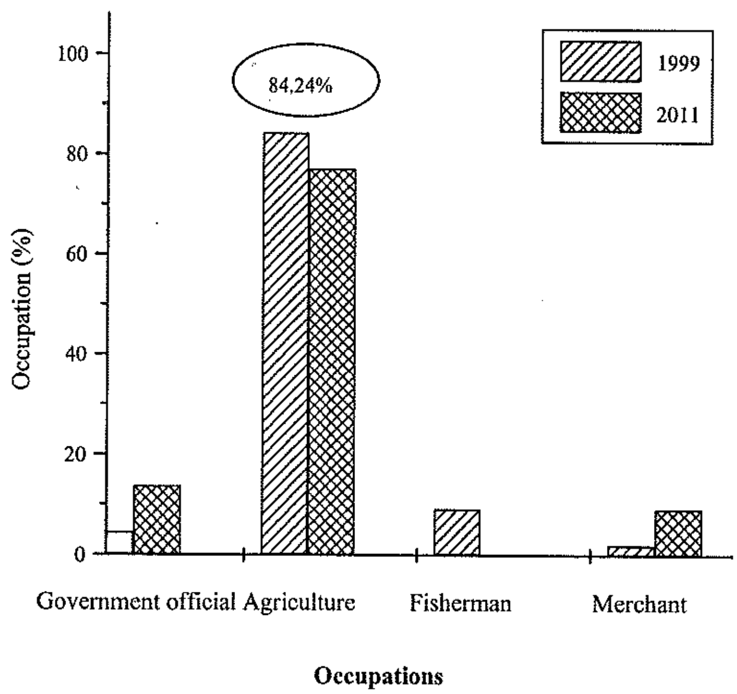


Figure 4.6 The occupations of people at 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011

In 1999, the occupation at 3 villages since 1999 mostly was farmmer (84.2 %), fisherman (9.1 %) while the government officer and businessmen found low (4.6 % and 2.1 %), respectively.

However, in 2011, farmer and fisherman were decreased from the previous time (1999) by 77.2 % and no fisherman was surveyed (0%) in 2011. The government officer and businessman increased into 13.7 % and 9.1%, respectively. This confirmed that dam have the effect on farmer careers from water quantity and the flow from the rivers (Monkolcharoenmitr, 2001). The main occupations at of three villages was agriculture.

4.2.2.2 Income

The average income in 1999 and after dam startup in 2011, shown in the following figure 4.7.

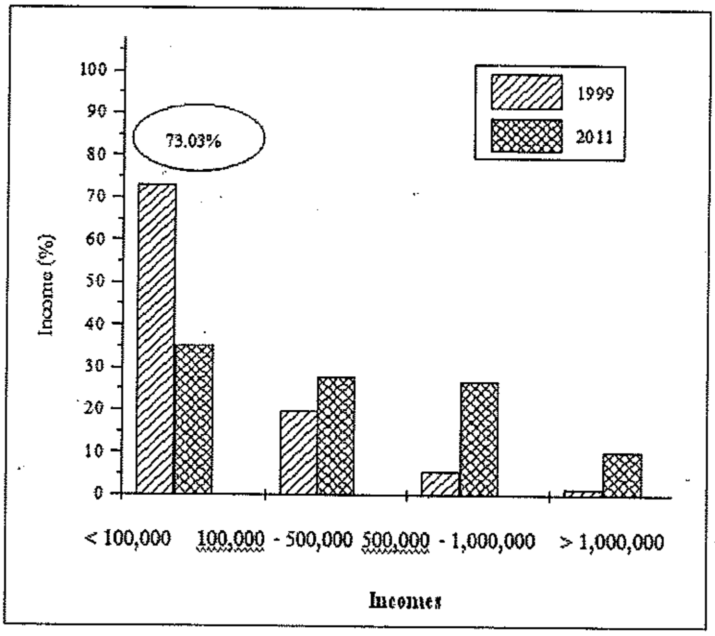


Figure 4.7 The income of people at 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011

The income of people in 3 villages showed the greater amount of income than before dam operation. Mostly (73.03%) of people received a few income less than 100,000 Kip and 19.92% earned more income (100,000 - 500,000 Kip). The rest (1.66 %) derived salary more than 1,000,000 Kip. In conclusion, the income of people received higher than in past from of dam.

The average income of three villages found sharper after dam startup. It appeared that income more than 1,000,000 Kip/month was 10.4% while only 35.3%, the average income altered to decrease less than 100,000 Kip. This result is agreed with the research of Sanunnaam et al., 2012 that by the reason for the increase of income come from the infrastructure development for example concrete bridges, paved roads, transportation and electricity in the village. Thus, dam startup by water resource has influenced on the increase of the average income alteration.

4.2.2.3 Infrastructure

The infrastructure that clearly developed at the survey area comprised of roads, bridge, electricity and irrigation. The result was shown in the following figure 4.8.

The roads conditions before (1999) and after (2011) of Xeset dam, the results were shown in the following (Fig 4.8, a). The road situation at location sites found the progress after dam startup. In 1999, at Xeset dam found 42.3% of the paved roads in the villages while the rough roads were 32.4%. However in 2011, it found the better condition (paved) more than year 1999 paved road increased 57.3%. The roads in these villages were improved, roads was mostly developed into concreted condition for example Photok village. In addition, mainly of the infrastructure of native people is improved by compared with the time of dam startup. This result is agreed with the research of Pongstornpluek, 2007 that dam startup bring to better quality of life.

The bridges conditions and numbers were developed and increased the numbers around Xeset dam as the results from dam (2011). The result was shown in the following (figure 4.8, b). The bridges at 3 villages around Xeset dam showed the number and development of bridges increasing. Currently, the bridges were mostly steel bridges for 57.3% and concreted bridges 42.7% within 5 km along Xeset 2 dam. Previously, dam condition found only wooden bring (32.4%). The results reported that the infrastructures of native people were developed more than dam startup (1999). This means that Xeset dam have enormous influenced into several people infrastructure from water supply such as occupations (agricultural, fishing, rice field, coffee crops), roads and bridges (Pongstornpluek, 2007).

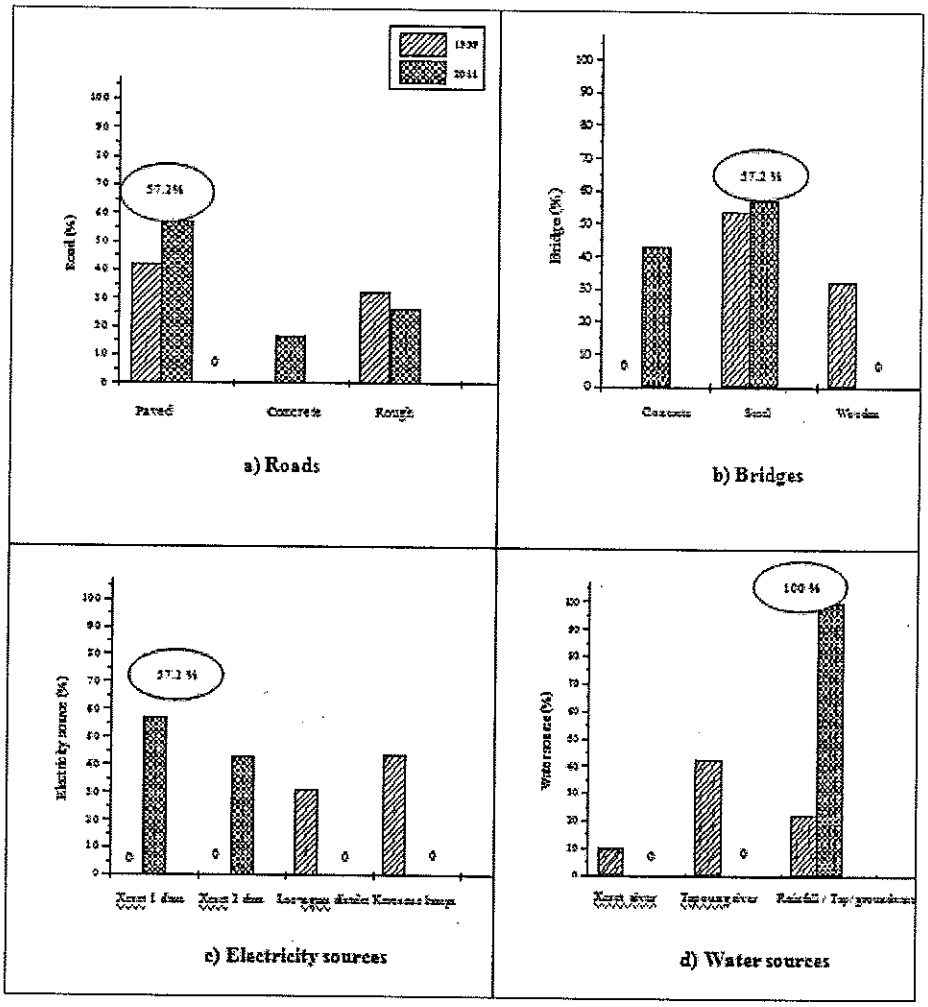


Figure 4.8 Infrastructure a) roads, b) bridge, c) electricity sources and d) irrigation (water sources) of people at 3 sites of Photok, Thong soui and Lao-ngam villages, Salavan, Lao PDR.

Remark: Lao-ngam district = Private power plant

The electricity had developed into several areas nearby this Xeset dam in 2011, the results shown in the following (figure 4.8, c). The main electricity of this Xeset dam business is exported by the demand to Ubon ratchathani, Thailand. The electricity source inside the country (Lao, PDR) of local people at 3 villages showed differently changed during before (1999) and after Xeset dam settlement. Previously, the electricity source come from kerosene lamps was 43.6 % and Lao-ngam district was 31.1 %. Since dam startup, native people turned to more electricity source usage from Xeset 1 dam that was 57.3 % and Xeset 2 dam was 42.7%

(Ovesen, 1999). The quality of life of indigenous people turned to be better than before dam startup from infrastructure development at these Xeset 1 and Xeset 2 dam.

The water from these dams was served on irrigations before (1999) and after dam startup in 2011. The results were shown in the following (figure 4.8, d). The water consumption mainly come from Xeset and Tapoung rivers and other sources was (9.9%, 42.3% and 22.4%), respectively. Currently, the dam project is trying to serve water supply to meet the need of the villagers at Xeset dam. According to the summer and winter time, the effect from low water level in the river was not for people's demand. The villagers gained the advantage of new source of the water consumption nowadays by using tap water (domestic irrigation) from dam.

The domestic irrigation, water supply at Xeset and Tapoung rivers before (1999) and after dam startup in 2011, the result was shown in the following figure 4.9.

1) Roads

The roads conditions before (1999) and after (2011) of hydroelectric power Xeset dam, the result was shown in the following Fig 4.6.

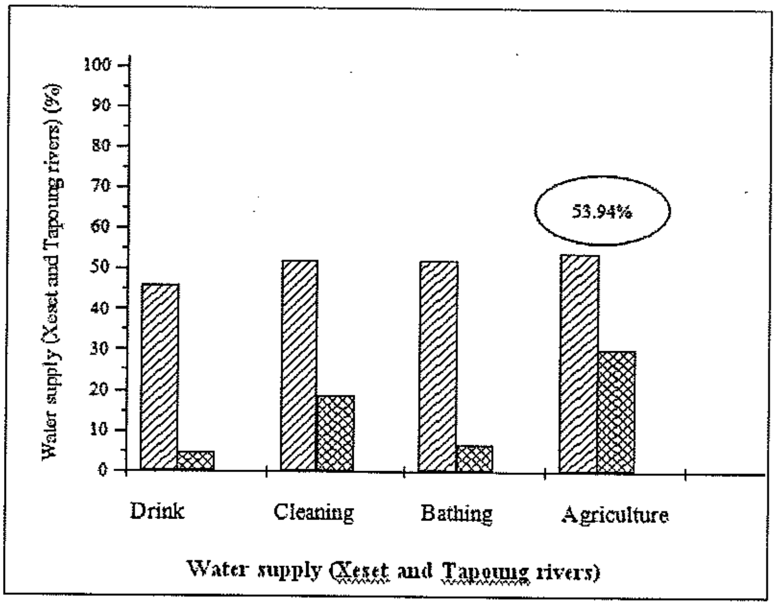


Figure 4.9 The water supply Xeset and Tapoung rivers of people at 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011

Water supply at Xeset and Tapoung rivers in 1999 and 2011 of Xeset dam found that the water supply (1999) previously served on irrigations for example agriculture, cleaning, bathing and water consumption (drinking water) were 53.9%, 52.3%, 52.3% and 46.1%, respectively. In 2011, irrigation at Xeset and Tapoung rivers was decreased from 1999 on agriculture (30.3%), cleaning (18.7%), and water consumption (6.6% and 4.6%). These indicated that dam served as the sources on ecosystem biodiversity. Native people have the advantage from water supply on various purpose of their irrigation usage. However, these activities also have both positive and negative sides on water contamination, consequently.

4.2.2.4 Human value aspect

Human value influenecd from water supply from Xeset dam in this work. It considered in terms of water comsumption as drinking water, education and sanitary and health system. The important one is water consumption by domestic water supply in 1999 and after dam startup (2011). The result was shown in the following figure 4.10.

1) Domestic water supply

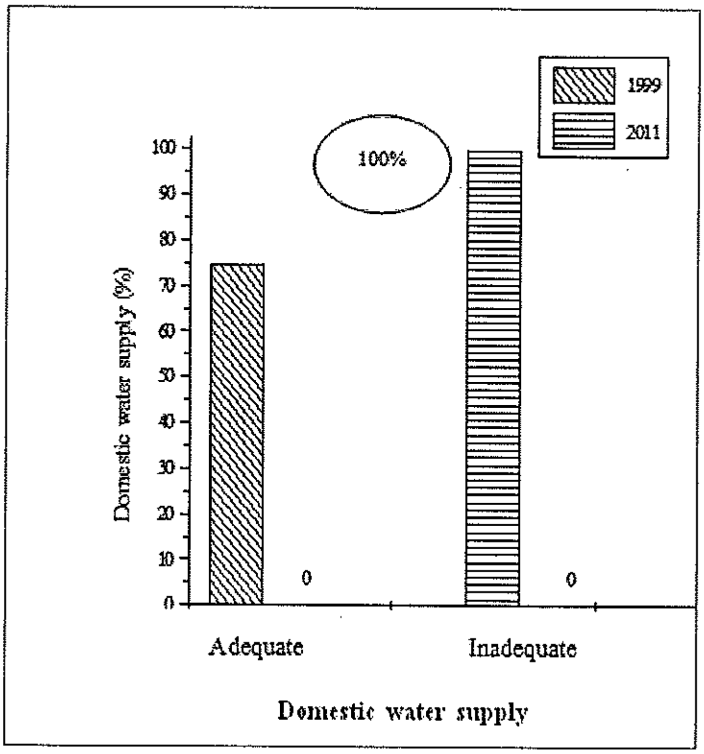


Figure 4.10 The domestic water supply from the rivers of villagers at 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011

The domestic water supplies demand before and after dam start-up were studied. In 1999, mostly people were adequate for domestic water supply from Xeset and Tapoung rivers (74.68%). Currently, it found that people (100%) inadequate water because of the low water level in the river, in winter and summer.

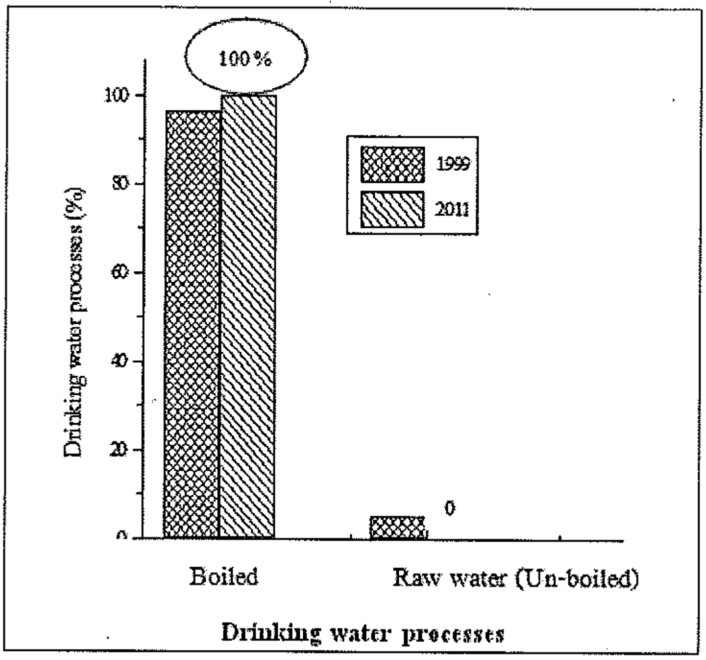


Figure 4.11 The drinking water processes of people 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011.

The drinking water quality of people at 3 villages were usually boiling. However, the raw water also served in the former time (1999) as the source on water consumption (4.9%). Nowadays, water purification processes by boiling become popularly done by the villagers, that counted for 69.7% (1999). Recently, people changed into boiling the drinking water (100%) instead.

2) Education system

The dam roles as the source on water supply to these area, it also directly impacted on their education system all three villages in 1999 and after dam startup (2011). The results was shown in the following figure 4.12.

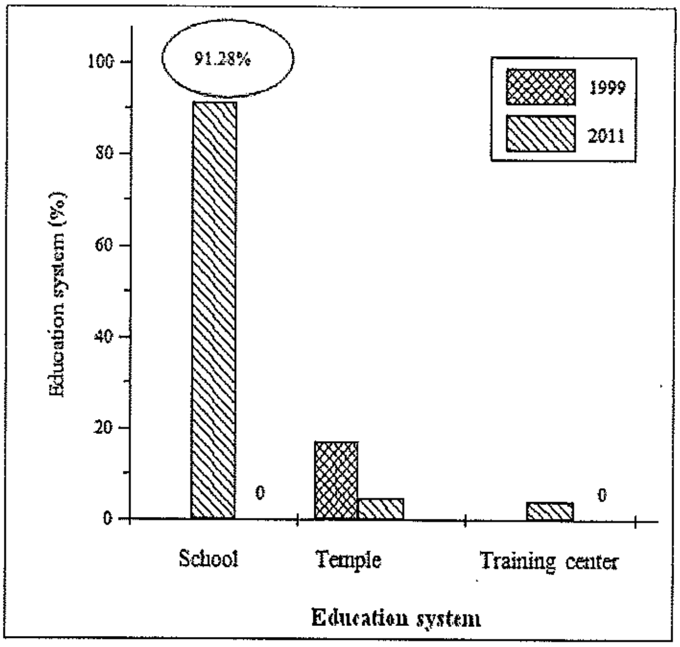


Figure 4.12 The education system (number) of local people 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011

The education system in 1999 and 2011, people mostly educated from temple (17.01%) in 1999. However, the education system from school counted for 91.3%, temple was 4.6% and the rest from training center 4.2% in 2011. The education system changed to allow the people to educate at higher education school than in the past. The potential supporting aids are supported from government of Lao PDR that willing to improve education system, nowadays.

3) Sanitary and Health system

The sanitary and health system had changed since 1999 from several infrastructure developments. Dam brings into irrigation on many purposes such as water supply, domestic, agricultural irrigation and personal sanitary of the villagers. Toilets are sources to prevent diseases and sickness. The number of household restroom can reduce the sickness people in the area. This definitely brings into the socio-economic progress, the sustainable life and the quality of life to these areas.

The personal sanitary and health aspect improved from household the increase restrooms/ toilets number at Xeset dam area. The poor sanitary and health could result in sickness of villagers in various ways. This part reported the number of toilets which were the first criteria that considered as the crucial part on the villagers' health all three villages by compare in 2011 with (1999). The result was shown in the following figure 4.13.

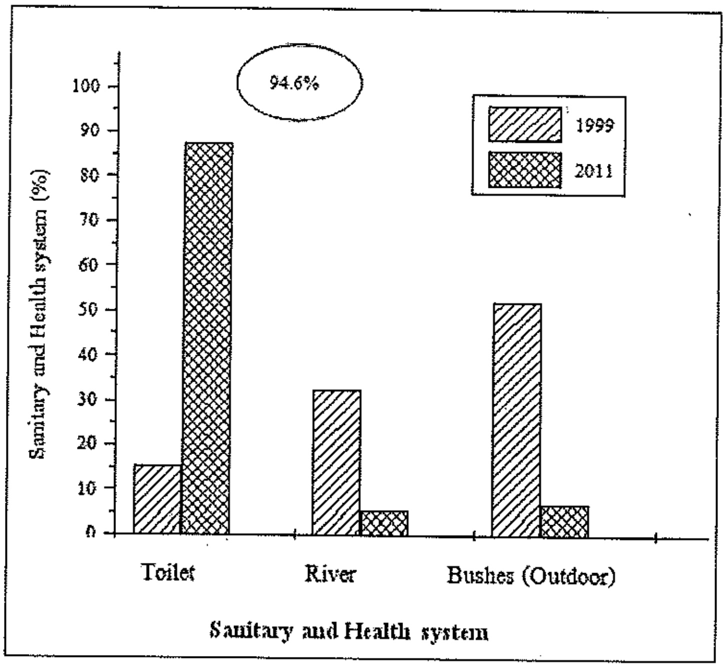


Figure 4.13 Sanitary and Health system of people at 3 sites of Photok, Thoung soui and Lao – ngam villages, Salavan, Lao PDR 1999 and 2011

The toilets of people at 3 villages changed to be more hygiene recently. In 1999, the people mostly have no their own personal restrooms. The places on their daily human excreta were bushes outdoor nearby (61%). Sometime they were wasted while bathing in the river (30.3%). Toilets were used in household only 14.5% in 1999. Oppositely, nowadays (2011), the villagers mostly had their own restroom. The toilets were increased 87.6%, bushes 12.9% and remain excreted directly into the river 9.5%. According to the sufficient on surface water, irrigation (water supply, agricultural and domestic) from dam, this bring into the infrastructure and sanitary development in these areas.

In terms of sickness all three villages before (1999) and after dam startup in 2011 was shown in the following figure 4.14.

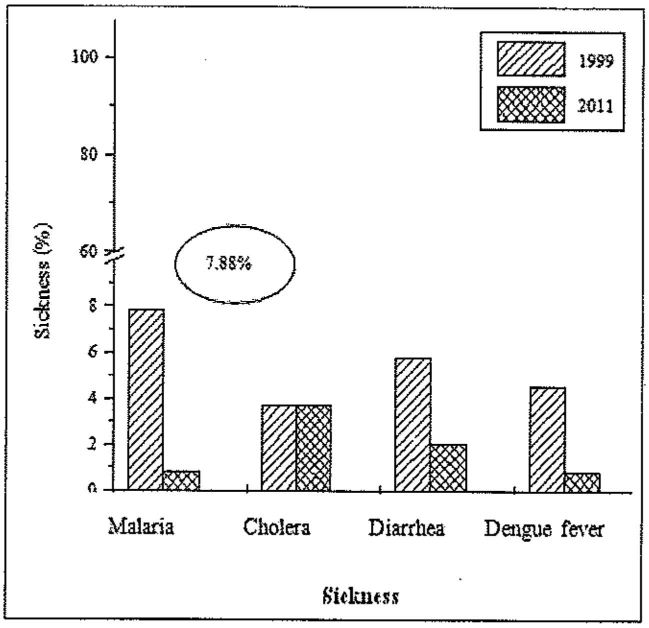


Figure 4.14 The sickness of people at 3 sites of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR in 1999 and 2011

The sickness in 3 villages since 1999 were malaria, cholera, diarrhea and dengue fever. In 1999, malaria found 7.8%, diarrhea 5.8%, dengue fever 4.6% and cholera 3.7%. After that, the trend of sickness found downward from 1999 by malaria increased to 0.8%, diarrhea downed to 2.1%, dengue fever 0.8% and cholera was remain stable 3.7%. The reason for sickness decrease caused by the developed sanitary health of indigenous people that gained more knowledge than before dam start-up. However, cholera reported of the contamination that raised from the people behavior on water consumption from dam. This could concern into the national environmental management strategy.

The results confirmed that dam settlement at this area have the effects on socio-economic parameters. Income, infrastructure, literacy and sanitary and health had changed in both positive and negative results (Pongstornpluek, 2007).

4.2.3 Quality of life aspect

This part focused on the quality of life (agriculture areas change, resettlement/ movement, cultural and mental deterioration, crime, divorce, employment and population size) as in the following Table 4.4

Table 4.4 Quality of life aspect from dam construction

Socio-economic parameters	Sampling sites			
	1) Photok	2) Thong soui	3) Lao-ngam	Total
Agriculture areas change	2.73 ±0.72	2.57±0.64	2.78±0.83	2.71±0.77
Resettlement	2.43±0.50	2.54±0.59	2.88±0.74	2.72±0.0.69
Cultural and mental deterioration	2.23±0.53	2.52±0.56	2.54±0.56	2.49±0.56
Crime	1.93±0.47	2.35±0.60	2.39±0.61	2.30±0.61
Divorce	1.63±0.49	1.76±0.43	1.74±0.44	1.73±0.45
Employment	2.55±0.68	2.60±0.58	2.76±0.67	2.68±0.65
Population increasing	3.48±0.78	3.68±0.82	3.69±0.80	3.65±0.80

Remark: mean ± SD

Table 4.4 showed the quality of life aspect from dam startup at three location sites. The result found that population increase (3.65 ± 0.8), resettlement (2.72 ± 0.07), agriculture areas it change at (2.71 ± 0.7), and employment (was 2.68 ± 0.7), respectively. Divorce it found at low level of 1.7 ± 0.5. Generally, dam startup was developed infrastructures especially roads, bridges and transportation. As a result, it consequently brought about the infrastructure as well as socio-economic problem raised (divorce, crime and birth control that increase the rate of over-population) (Pongstornpluek, 2007).

4.2.4 Recommendation, Advantage and Disadvantage

This final part was the suggestion from native people to Xeset dam project and the Lao, PDR government all three villages. However, people mainly agreed that dam bring into the better quality of life than before dam construction (Figure 4.14 and 4.15).

4.2.4.1 Recommendation to Xeset dam project

This part focused on the suggestion of native people to Xeset dam project all three villages of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR, (1999 and 2011). However, people mostly agreed that dam bring into the better quality of life than before in several socio-economic improvement (Figure 4.14).

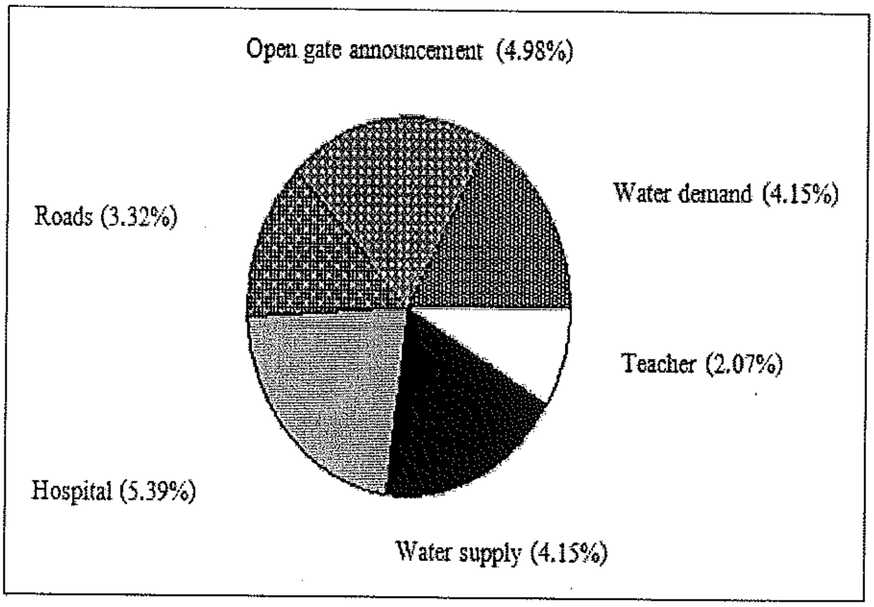


Figure 4.15 The recommendation of three villages of Photok, Thoung soui and Lao-ngam villages to Xeset dam project

Figure 4.15 indicated the recommendations from the people at all 3 villages to Xeset dam project. They mostly need more hospital 5.39% and irrigation on water supply 4.15%. Lao-ngam village, the native people need more irrigation project as river ways canal in summer. The villagers need to clarity the open gate time announcement by 4.98%.

4.2.4.2 The recommendation to the government of Lao PDR

The native people from sampling sites (Photok, Thong soui and Lao-ngam village) had the recommendation to the Lao PDR government as follows (Fig 4.16)

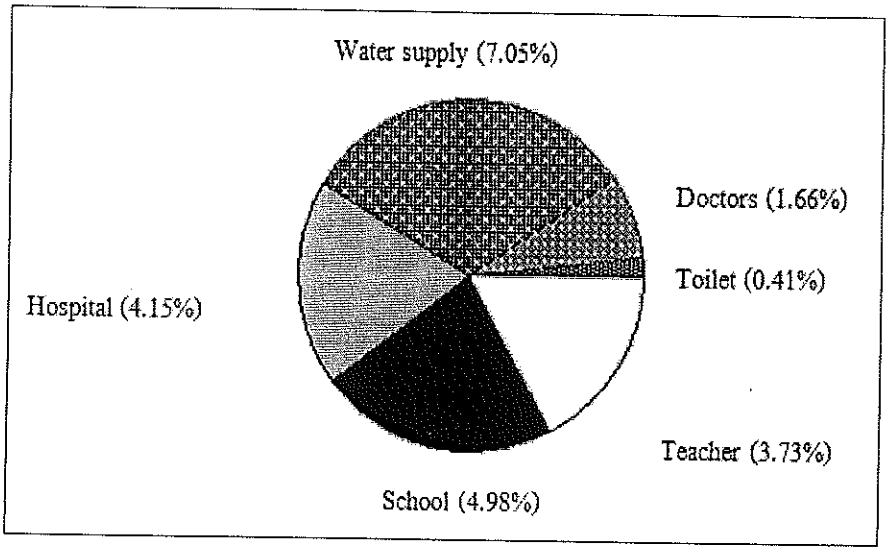


Figure 4.16 The demand recommen at Photok, Thoung soui and Lao-ngam villages to the government of Lao PDR.

The recommendation from native people at 3 villages of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao PDR. The basic factors on socio-economic and human value lead into a better quality of life after the Xeset hydropower project operated the areas.The villagers requested to the government at 3 villages of Photok, Thoung soui and Lao-ngam villages, Salavan, Lao, PDR. They need more water supply 7.05%, school 4.98%, hospital 4.15% and teacher 3.73%, respectively. Whereas, the toilets found very few amount 0.41% among 3 villages. The sanitary management was improved more than in the past (1999).

CHAPTER 5

CONCLUSIONS AND SUGGESTIONS

This work studied ESIA which concluded environmental impact assessment (EIA) and socio-economic impact assessment (SIA) studies together. EIA focused on water quality along the river from Xeset 2 dam in 2011 compared with 1999. Water quality was investigated in term of physical, chemical, and biological parameters, Xeset and Tapoung rivers, Xeset 2 dam. The water quality of Xeset 2 dam at Xeset and Tapoung rivers was compared with the past ten years on 1999 with 2011. SIA showed the difference of socio-economic impact that related to general backgrounds, occupations, income, infrastructure, human value aspect and quality of life as a result of the Xeset 2 dam which started up in 1999 and was completed in 2011.

5.1 Environmental Impact Assessment (EIA) of water quality

The EIA study focused on the potential products from Xeset 2 dam that is water supply in the river downstream. It was found that after dam start its operation in 2011, the chemical parameters in the river way that found higher than standard in 1999, dominantly was COD. Among several characteristics, this work investigated hardness, alkalinity, chemical oxygen demand (COD), nitrate-nitrogen and phosphate-phosphorus. In 2011 at site 1, hardness, especially was 65.3 mg/l in rainy season, alkalinity was 76.3 mg/l in winter, chemical oxygen demand (COD) in rainy season, was 129.3 mg/l, nitrate-nitrogen and phosphate-phosphorus were higher in rainy season (9.8 mg/l and 0.1 mg/l) respectively. COD found higher than the surface water quality standard of Lao PDR at all three sites especially in rainy season, except at site 2 and site 3 in winter.

However, the water parameters of Xeset and Tapoung rivers were under the surface water quality standard of Lao PDR and USEPA. The results of the water quality at Xeset and Tapoung rivers met the surface water quality standard of type 2. This type 2 is used for water consumption (the water supply that needs ordinary treatment process before consume) by the notification of the National Environment Board (PCD, 2012).

5.2 Socio-economic Impact Assessment (SIA)

This SIA part studied the socio-economic impact from Xeset 2 dam. The result showed that income, infrastructure especially (bridges, roads and electricity), literacy and sanitary health were mostly developed before dam start-up period. However, the community development enlarged since dam construction. It was found that the career such as agriculture and fishing had decreased, while the governmental official and merchant were increased, oppositely. In the winter and summer, the water volume of Xeset and Tapoung rivers were low level that was not sufficient for consumption and any irrigation.

Over-population was faced by 3.6 ± 0.80 and resettlement was 2.72 ± 0.69. The local people commented to the government and Xeset 2 dam project that they need more water supply and hospitals as well as they asked the project to release more water in summer. Moreover, the local people asked the dam to announce the open - gate period. Over - population in thses area caused several the changes on water quality. Finally, this section gathered the recommendation about the environmental management to the relevant authorities, Xeset project as well as the government of Lao PDR.

5.3 Suggestions

5.3.1 Environmental Impact Assessment (EIA) of water quality

The water quality from the Xeset 2 dam area has useful for local people way of life. They need to survey and monitor the water quality of Xeset and Tapoung rivers on the following categories.

5.3.1.1 Environmental sensitivity and awareness on the human activities

5.3.1.2 Water monitoring and audit by the relevant agencies, should take action frequently and regularly (rainy season, winter and summer), annually (at site 1 and site 3)

5.3.2 Socio-economic Impact Assessment (SIA)

The analytical data that responded from the native people around the Xeset 2 dam recommended as follows.

5.3.2.1 Socio-economic monitoring

The monitoring about the socio-economic aspects of the people in these areas, is regularly needed.

5.3.2.2 Training

The people should join the public participation on the media or environmental management training course in the topics of water supply consumption, solid and hazardous waste management and chemical usage for environmental conservation.

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APPENDICES

APPENDIX A

ANALYTICAL METHODS

Table A.1 Preservation and containers for water samples for each parameter

No.	Parameter	Container	Preservation
1	Temperature	-	-
2	Conductivity	-	-
3	Total Suspended Solids	Plastic bottle	Refrigerate
4	pH	Plastic bottle	Refrigerate
5	Dissolved oxygen	BOD bottle	$MnSO_4$, AIA
6	Hardness	Plastic bottle	Refrigerate
7	Alkalinity	Plastic bottle	Refrigerate
8	Chemical Oxygen Demand	Light brown glass bottle	Add H_2SO_4, pH <2
9	Nitrate – N	Plastic bottle	Add H_2SO_4, pH <2
10	Phosphate – P	Plastic bottle	Add H_2SO_4, pH <2
11	Lead	Plastic Bottles Nalgene	Add NHO_3, pH <2
12	Cadmium	Plastic Bottles Nalgene	Add NHO_3, pH <2
13	Fecal Coliform Bacteria	Light brown glass bottle sterilizer	Refrigerate

Table A.2 The methods of water quality (APHA et al, 2005)

No.	Parameter	Methods
Physical characteristics		
1	Temperature	Electrometric Method
2	Conductivity	Electrometric Method
3	Total Suspended Solids	Dried at 103-105 ^{0}C
Chemicals characteristics		
1	pH	Electrometric Method
2	Dissolved oxygen	Azide modification Method
3	Hardness	Titration Method
4	Alkalinity	Indicator Method
5	Chemical oxygen demand	Dichromate close reflux Method
6	Nitrate –N	Brucine Method
7	Phosphate –P	Ascorbic Method
8	Lead	Flame Atomic Absorption Spectrometry Method
9	Cadmium	Flame Atomic Absorption Spectrometry Method
Biological characteristics		
1	Fecal coliform bacteria	Membrane Filter Technique

APPENDIX B

WATER QUALITY STANDARDS

(LAO PDR and USEPA)

Table B.1 Surface water quality and drinking water standard of Lao PDR and USEPA

No.	Parameters	Lao PDR		USEPA
		Surface water	Drinking water	Surface water
1	Temperature	N'	25 – 35°C	A1,A2 and A3=25 35°C
2	pH	5 - 9	6.5 - 8.5	A1= 5.5 – 8.5, A2 and A3= 5.5 - 9.0
3	Conductivity		< 1,000 μs/cm	A1,A2,A3=1000
4	TSS			
5	DO	6 mg/L		
6	Hardness		50 – 300 mg/L	
7	Alkalinity			
8	COD	5 mg/L		
9	NO_3-N	<5.0 mg/L		A1,A2 and A3=50 mg/L
10	PO_4-P			A1=0.5, A2 and A3=0.7 mg/L
11	Pb	0.05 mg/L		A1,A2 and A3=0.05 mg/L
12	Cd	0.005 mg/L		0.005 mg/L
13	FC	1000 MPN/100 mL		A1=1,000, A2=5,000 and A3=40,000

Remark : A1 = was water properties that had simple physical treatment and disinfection, e.g. rapid filtration and disinfection

A2 = was water properties treated by normal physical treatment, chemical treatment and disinfection, e.g. pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination)

A3 = was the water properties treated by intensive physical and chemical treatment, extended treatment and disinfection, e.g. chlorination to break-point, coagulation, flocculation, decantation, filtration and adsorption (activated carbon)

Table B.2 Surface water quality standards are classified into 5 classes (Thailand) (Pollution control department; PCD, 1992)

Classification	Objectives/Condition and Beneficial Usage
Class 1	Extra clean fresh surface water resources used for : (1) conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction (2) ecosystem conservation where basic organisms can breed naturally
Class 2	Very clean fresh surface water resources used for : (1) consumption which requires ordinary water treatment process before use (2) aquatic organism of conservation (3) fisheries (4) recreation
Class 3	Medium clean fresh surface water resources used for : (1) consumption, but passing through an ordinary treatment process before using (2) agriculture
Class 4	Fairly clean fresh surface water resources used for : (1) consumption, but requires special water treatment process before using (2) industry
Class 5	The sources which are not classification in class 1-4 and used for navigation.

APPENDIX C

WATER QUALITY ANALYSIS

LABORATORY PROCEDURE

1. DO procedure

1.1 Collect the sample to be tested in a 300 ml BOD bottle taking special care to avoid adding air to the liquid being collected. Fill bottle completely and add stopper.

1.2 Remove bottle stopper and add 1 ml of the manganous sulfate solution at the surface of the liquid.

1.3 Add 1 ml of the alkaline-potassium iodide-sodium azide solution at the surface of the liquid.

1.4 Replace the stopper, avoid trapping air bubbles and shake well by inverting the bottle several times. Repeat shaking after floc has settled halfway. Allow floc to settle a second time.

1.5 Add 1 ml of concentrated sulfuric acid by allowing the acid to run down the neck of the bottle above the surface of the liquid.

1.6 Restopper, rinse the top of the bottle to remove any acid and shake well until the precipitate has dissolved.

1.7 Titrate a volume of treated sample which corresponds to 200 ml of the original sample. This corrects for the loss of some sample during the addition of reagents. This volume calculated using the formula : mL of sample to titrate = 200 x [300/(300-2)] = 201 ml

1.8 Pour 201 ml of sample from the BOD bottle into an Erlenmeyer flask.

NOTE: Since variations occur in the actual volume of each BOD bottle, do not pour 99 ml of sample out of the BOD bottle and assume that 201 ml will be left.

1.9 If the solution is reddish-brown in color, titrate with 0.0250 N sodium thiosulfate or 0.0250 N PAO until the solution is a pale yellow (straw) color. Record the amount of titrant used. Add a small quantity of starch indicator and proceed to step 11.

1.10 If the solution has no reddish-brown color, or is only slightly colored, add a small quantity (approximately 1 ml) of starch indicator. If no blue color develops, there is zero dissolved oxygen. If a blue color develops, proceed to step 11.

1.11 Titrate with 0.0250 N sodium thiosulfate or 0.0250 N PAO to the first disappearance of the blue color. Record the total number of ml of sodium thiosulfate or PAO used.

1.12 Calculation

DO, mg/L = mL $Na_2S_2O_3$ x 0.025N x 8000/ mL water sample used in titration

Or DO (mg/L) = Solution volume of 0.025N $Na_2S_2O_3$ used in the titration

2. TSS procedure

2.1 Preparation of the glass fiber filter disk: Insert the filter disk onto the base and clamp on funnel. While vacuum is applied, wash the disk with three successive 20 ml volumes of Milli-Q water. Remove all traces of water by continuing to apply vacuum after water has passed through. Dry in a oven at 103-105^0 C for one hour in aluminum dish. When needed, remove dish from the oven, desiccate, and weigh in dish.

2.2 Re-dry and re-weigh filter until weight change is less than 4% of previous weight or 0.5 mg.

2.3 Select a sample volume (max. of 200 ml) that will yield no more than 200 mg of total suspended solids.

2.4 Place the filter on the base and clamp on funnel and apply vacuum. Wet the filter with a small volume of Milli-Q water to seal the filter against the base.

2.5 Stir sample continuously while sub-sampling and quantitatively transfer the sample to the filter using a 100 ml graduated cylinder. Remove all traces of water by continuing to apply vacuum after sample has passed through.

2.6 Rinse the graduated cylinder onto the filter with 3, 20 ml portions of Milli-Q water. Remove all traces of water by continuing to apply vacuum after water has passed through.

2.7 Carefully remove the filter from the base. Dry at least one hour at 103-105^{0}C. Cool in a desiccator and weigh. Re-dry and re-weigh filter until weight change is less than 4% of previous weight or 0.5 mg.

2.8 Calculation

TSS, mg/L = (B-A) x10^6/mL water sample

A = Weight of filter paper before drying (g)

B = Weight of filter paper after drying (g)

3. Hardness procedure

3.1 25.0 ml of the hard water sample into a 250 ml flask. Add approximately 25 ml of deionized water to the flask.

3.2 Add 2.0 ml of the buffer solution. The remainder of the titration must be completed within 15 minutes of the time when the buffer is added.

3.3 Add 4 drops of Eriochrome Black T indicator solution.

3.4 Titrate using the EDTA titrate. At the end point the color should change from red to blue.

3.5 Repeat this procedure at least twice.

3.6 Use this data and the data from parts A and B to calculate the hardness of your water sample in mg $CaCO_3$/l.

3.7 Repeat the procedure for the Paper Plant water samples (you may have to adjust the procedure in order to see the color change)

3.8 Calculation

Hardness, mg/L = A x B x 1000 / mL water sample used in the titration

A = Volume of EDTA used in the titration

4. Alkalinity procedure

4.1 Measure 50 ml or 100 ml of your sample into a 250 mL beaker or erlenmyer flask. Place your sample onto a stir plate (make sure to put a bar magnet in the flask).

4.2 Measure initial pH of your sample. <u>If the sample pH is below 8.3</u> (if above 8.3, do step 3 first), add several drops of bromcresol green indicator. If the color of the solution turned blue, titrate your sample with 0.02 N H_2SO_4 or HCl (you may need to dilute the acid provided in the lab) until the color changes to yellow (pH 4.5). Record the total volume of acid used for the titration.

4.3 Measure initial pH of your sample. <u>If the sample pH is above 8.3</u>, add several drops of phenolphthalein indicator. If the color of the solution turned pink, titrate your sample with 0.02 N H_2SO_4 or HCl (you may need to dilute the acid provided in the lab) until color changes from pink to clear (pH 8.3). Record the volume of acid used for the titration. Then, proceed with step 2.

4.4 Calculate both Phenolphthalein alkalinity and total alkalinity using the formula provided above

4.5 Calculation

Alkalinity, mg/L = A x N x 50, 000 / mL water sample

A = Volume of H_2SO_4 used in the titration

N = Normal of H_2SO_4

5. COD procedure

5.1 Take 15 ml COD digestion tubes (pre-washed with dilute H_2SO_4) and add the following in sequence.

5.2 Transfer 0.50 ml wastewater sample (Inlet) or 1.00 ml treated sample.

5.3 Add 2.5 ml standard potassium dichromate digestion reagent slowly and mix.

5.4 Add 3.5 ml sulfuric acid reagent through sides ofthe tubes and let it go to the bottom.

5.5 Cap and mix the contents (wear gloves as contents are very hot) and cool

5.6 Transfer tubes to the pre-heated COD digester at 150^0 C and digest for 2 hrs.

5.7 Run 3 blanks by substituting DW for sample and proceed exactly as sample.

5.8 Transfer the contents of the COD digestion tube in 100 ml beaker. Add distilled water to make the volume to 50 ml. Add 1-2 drops of Ferroin indicator and titrate against 0.05 M Ferrous Ammonium Sulfate solution.

5.9 Calculation

COD, mg/L = (A-B) x N x 8000 / ml sample

A = ml of Fe $(NH_4)_2(SO_4)_2$ used in the titration Blank

B = ml of Fe $(NH_4)_2(SO_4)_{22}$ used in the titration sample

N = Normality of Fe $(NH_4)_2(SO_4)_2$ used

6. Nitrate-nitrogen

6.1 Pipette water to a total volume of 10 ml

6.2 If samples are saline, add 2 ml sodium chloride solution

6.3 Add 10 ml sulfuric acid solution and mix well by shaking while cooling in flowing water.

6.4 Do not stopper the tube/flask.

6.5 Add 0.5 ml brucine in sulfanilic acid solution and mix by shaking

6.6 Heat 20 minutes at 95 °C in a water bath

6.7 Cool with flowing water, dilute to 25 ml with deionized water, stopper and invert several times to mix thoroughly

6.8 Using spectrophotometer 410 nm

6.9 Calculation

NO_3-N, mg/L = nitrate nitrogen from standard curve / water sample

7. Phosphate-phosphorus procedure

7.1 Pipette 50.0 ml or an appropriate amount diluted to 50 ml of digested sample into an acid cleaned, dry 125 mL Erlenmeyer flask.

7.2 Add 1 drop of phenolphthalein indicator. If a red color develops, add 5 N sulfuric acid until the color disappears.

7.3 Add 8.0 mL of combined reagent and mix thoroughly.

7.4 Allow at least 10 minutes (but not more than 30 minutes) for color development.

7.5 Measure absorbance at 880 nm using a reagent blank to zero the spectrophotometer.

7.6 Calculation

PO_4-P, mg/L = phosphate phosphorus from standard curve / water sample

8. Fecal coliform bacteria procedure

8.1 Selection of sample size: Use sample volumes that will yield counts between 20 and 60 fecal coliform colonies per membrane. When the bacterial density of the sample is unknown, filter several decimal volumes to establish fecal coliform density. Estimate volume expected to yield a countable membrane and select two additional quantities representing one-tenth and ten times this volume, respectively.

8.2 Filtration of sample: Follow the same procedure and precautions as described above.

8.3 Preparation of culture dish: Place a sterile absorbent pad in each culture dish and pipet approximately 2 mL M-FC medium, prepared as directed above, to saturate pad. Carefully remove any excess liquid from the culture dish. Place prepared filter on medium-impregnated pad. As a substrate substitution for the nutrient-saturated absorbent pad, add 1.5% agar to M-FC broth.

8.4 Incubation: Place prepared cultures in waterproof plastic bags or seal petri dishes, submerge in water bath, and incubate for 24 +/- 2h at 44.5 +/- 0.2°C. Anchor dishes below the water surface to maintain critical temperature requirements. Place all prepared cultures in the water bath within 30 min after filtration. Alternatively, use an appropriate, accurate solid heat sink or equivalent incubator.

8.5 Counting: Colonies produced by fecal coliform bacteria on M-FC medium are various shades of blue. Pale yellow colonies may be atypical E.coli; verify for gas production in mannitol at 44.5°C. Nonfecal coliform colonies are gray to cream-colored. Normally, few nonfecal coliform colonies will be observed on M-FC medium because of selective action of the elevated temperature and addition of rosolic acid salt reagent. Elevating the temperature to 45.0 +/- 0.2°C may be useful in eliminating environmental Klebsiella from the fecal coliform population. Count colonies with a low power (10-15 magnifications) binocular wide-field dissecting microscope or other optical device

8.6 Calculation

Sum of colonies in all samples x 100 / Sum of volumes water filter

APPENDIX D

QUESTIONNAIRE (SIA)

QUESTIONNAIRE

Environmental and Socio-economic Impact Assessment (ESIA) of Xeset 2 dam, Salavan, Lao people democratic republic

1. The objectives of this study is investigated the option of people on socio-economic impact towards the Xeset project after 10 years of dam project startup.
2. The questionnaire divided into four parts.

Part 1: General information

Part 2: Socioeconomic aspect

Part 3: Quality of life aspect

Part 4: Recommendation on the dam settlement, advantage and disadvantage

Thank you very much for your cooperation.

General Information

Part 1: General information

1. Sex: ☐ Female, ☐ Male
2. Age: ....years old.
3. Marital status: ☐ Married, ☐ Single
4. Education and background

   ☐ Illiteracy ☐ College

   ☐ Primary school ☐ University

   ☐ Secondary school

5. Home settlement

   ☐ Settlement (before dam construction)

   ☐ Settlement (after dam construction)

Part 2: Socio-economic aspects

Parameters	Before	After
1) **Occupations** - Government officer - Farmer - Fisherman - Businessman		
2) **Income** - <100,000 Kip - 100,000 - 500,000 Kip - 500,000 - 1,000,000 kip - > 1,000,000 kip		
3) **Infrastructure** **3.1 Road** - Paved - Concreted - Rough		

Part 2: Socio-economic aspects (Continued.)

Parameters	Before	After
3.2 Bridge - Concreted - Steel - Wooden		
3.3 Electricity sources - Xeset 1 dam - Xeset 2 dam - Lao-ngam district - Kerosene lamps		
3.4 Irrigation 3.4.1 Water source - Xeset river - Tapoung river - Other		
3.4.2 Water supply: Xeset and Tapoung - Drink - Cleaning - Bathing - Agriculture		
4) Human value aspect **4.1 Domestic water supply** - Adequate - Inadequate		
4.1.1 Drinking water processes - Boiled - Un-boiled		

Part 2: Socio-economic aspects (Continued.)

Parameters	Before	After
4.2 Education system - Schools - Temples - Training centers		
4.3 Sanitary and Health system 4.3.1 Sanitary and Health system - Toilet - River - Outdoor (bush)		
4.3.2 Sickness - Malaria - Cholera - Diarrhea - Dengue fever		

Part3: Quality of life aspect

5 = strongly agree, 4 = Agree, 3 = undecided, 2 = disagree, 1= strongly disagree

Parameters	Level of the comments				
	5	4	3	2	1
1. Agriculture areas change					
2. Resettlement					
3. Cultural and mental deterioration					
4. Crime					
5. Divorce					
6. Employment					
7. Population					

Part 4: Recommendation on the dam settlement, advantage and disadvantage

Recommendation action to Xeset dam project………………………………

Recommendation action to government of Lao PDR………………………

APPENDIX E

THESIS DATA

EIA: WATER QUALITY

Table E.1 Biological characteristic (FCB) of water quality of Xeset and Tapoung rives after Xeset dam startup in 2011

Sampling sites	**Water volume (ml)**							
	1 ml		**0.1 ml**		**0.01 ml**		**0.001 ml**	
	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter
(1)	8	0	4	0	0	0	0	0
(2)	4	0	1	0	0	0	0	0
(3)	35	0	4	0	0	0	0	0

Remark : (1) = Bridge on the national road No.20, Lao-ngam village (Houay Tapoung)

(2) = Photok village, 100 meters, upstream of hydroelectric power Xeset 1 dam and downstream hydropower Xeset 2 dam (Xeset river)

(3) = Bridge at national road No. 20, downstream of the hydroelectric power Xeset 1 and Xeset 2 dam (Xeset river)

1. Standard curve use for water quality analysis of Xeset and Tapoung rivers in 2011

Standard curve use for water quality analysis include nitrate – nitrogen and phosphate - phosphorus as show figure F.1 to F.4

1.1 Nitrate – nitrogen analysis

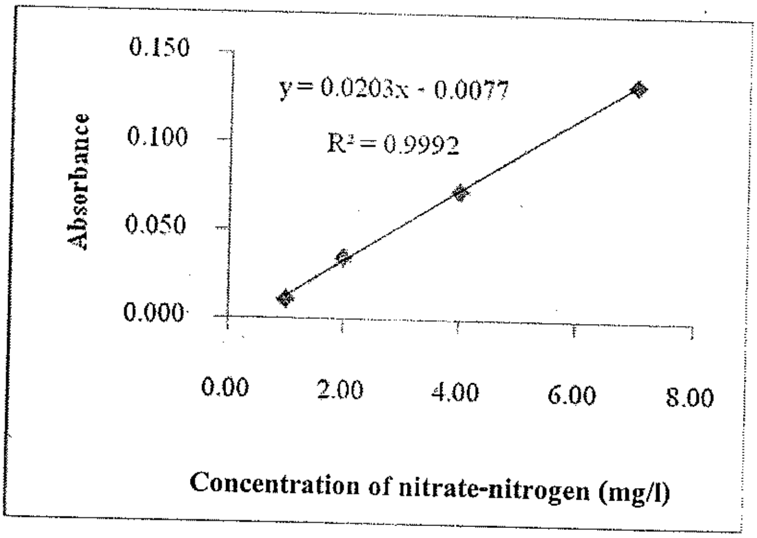

Figure. E.1 The relationship between the absorbance at wavelength 410 nm with concentration nitrate and nitrogen analysis of Xeset and Tapoung rivers in Rainy season

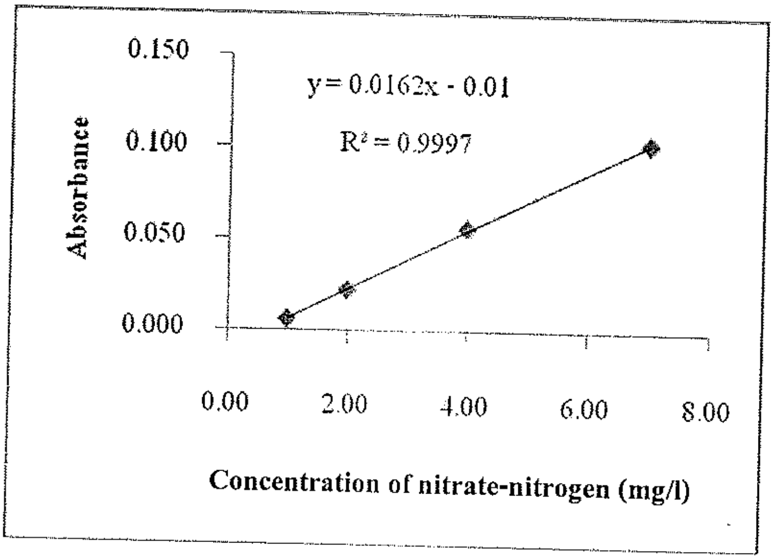

Figure. E.2 The relationship between the absorbance at wavelength 410 nm with concentration nitrate and nitrogen analysis of Xeset and Tapoung rivers in winter season

1.2 Phosphate – phosphorus

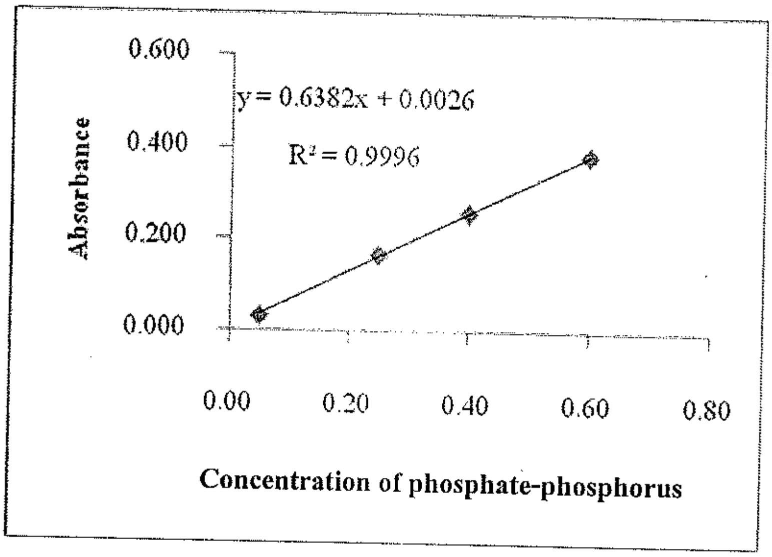

Figure. E.3 The relationship between the absorbance at wavelength 880 nm with concentration phosphate-phosphorus analysis of Xeset and Tapoung rivers in rainy season

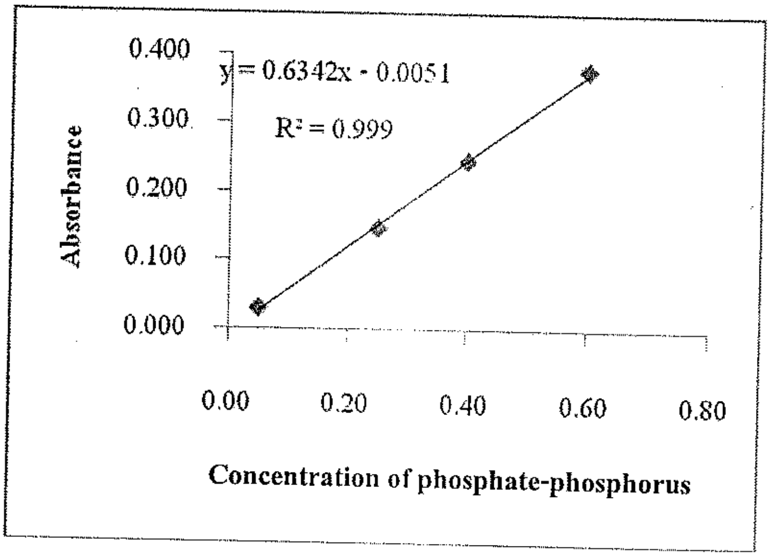

Figure. E.4 The relationship between the absorbance at wavelength 880 nm with concentration phosphate - phosphorus analysis of Xcset and Tapoung rivers in winter season

Table E.2 General information of respondents all three villages

Variables	Photok		Thong soui village		Lao-ngam village		Overall	
	No.	%	No.	%	No.	%	No.	%
Sex								
Female	26	10.79	37	15.35	75	31.12	138	57.26
Male	14	5.81	26	10.79	63	26.14	103	42.74
Total	40	16.60	63	26.14	138	57.26	241	100.00
Age								
21-40 years	12	4.98	25	10.37	62	25.73	99	41.08
41-60 years	21	8.71	28	11.62	57	23.65	106	43.98
>60	7	2.90	10	4.15	19	7.88	36	14.94
Total	40	16.60	63	26.14	138	57.26	241	100.00
Marital Status								
Single	9	3.73	17	7.05	30	12.45	56	23.24
Married	31	12.86	46	19.09	108	44.81	185	76.76
Total	40	16.60	63	26.14	138	57.26	241	100.00
Education and background								
Illiterate	20	8.30	20	8.30	32	13.28	72	29.88
Primary school	14	5.81	25	10.37	40	16.60	79	32.78
Secondary school	6	2.49	14	5.81	34	14.11	54	22.41
College level			4	1.66	20	8.30	24	9.96
University					12	4.98	12	4.98
Total	40	16.60	63	26.14	138	57.26	241	100.00
Home settlement								
Settle before dam	24	9.96	54	22.41	102	42.32	180	74.69
Movement after dam	16	6.64	9	3.73	36	14.94	61	25.31
Total	40	16.60	63	26.14	138	57.26	241	100.00

Remark : n=3

Table E.3 Socio-economic aspects

Parameters	Photok				Thongs				Lao-ngam				Overall			
	Before		After		Before		After		Before		After		Before		After	
Occupation	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Government officer	0	0	5	2.07	1	0.41	4	1.66	10	4.15	24	9.96	11	4.57	33	13.70
Farmer	37	15.35	34	14.11	57	23.65	54	22.41	109	45.23	98	40.66	203	84.24	186	77.18
Fisherman	3	1.24	0	0	5	2.07	0	0	14	5.81	0	0	22	9.12	0	0
Businessman	0	0	1	0.41	0	0	5	2.07	5	2.07	16	6.64	5	2.07	22	9.12
Income																
< 100,000 Kip	32	13.28	17	7.05	50	20.75	17	7.05	94	39	51	21.16	176	73.02	85	35.26
100,000 – 500,000	8	3.32	18	7.47	13	5.39	27	11.20	27	11.20	22	9.13	48	19.92	67	27.80
500,000 – 1,000,000	0	0	3	1.24	0	0	14	5.81	13	5.39	47	19.50	13	5.40	64	26.56
> 1,000,000	0	0	2	0.83	0	0	5	2.07	4	1.66	18	7.47	4	1.66	25	10.38
Roads																
Paved	0	0	0	0	0	0	0	0	102	42.32	138	57.26	102	42.32	138	57.26
Concrete	0	0	40	16.60	0	0	0	0	0	0	0	0	0	0	40	16.60
Rungh	24	9.96	0	0	54	22.41	63	26.14	0	0	0	0	78	32.37	63	26.14
Bridges																
Concrete	0	0	40	16.60	0	0	63	26.14	0	0	0	0	0	0	103	42.74
Steel	0	0	0	0	0	0	0	0	130	53.94	138	100	130	53.94	138	57.26
Wooden	24	9.96	0	0	54	22.41	0	0	0	0	00	0	78	32.37	0	0

Table E.3 Socio-economic aspects (Continued.)

Parameters	Photok				Thongs				Lao-ngam				Overall			
	Before		After		Before		After		Before		After		Before		After	
Electricity sources																
Xeset 1 dam	0	0	0	0	0	0	0	0	0	0	138	57.26	0	0	138	57.26
Xeset 2 dam	0	0	40	16.60	0	0	63	26.14	0	0	0	0	0	0	103	42.74
Lao-ngam district	0	0	0	0	0	0	0	0	75	31.12	0	0	75	31.12	0	0
Kerosene lamps	24	9.96	0	0	54	22.41	0	0	27	11.20	0	0	105	43.57	0	0
Water sources																
Xeset river	24	9.96	0	0	0	0	0	0	0	0	0	0	24	9.96	0	0
Tapoung river	0	0	0	0	0	0	0	0	102	42.32	0	0	102	42.32	0	0
Other	0	0	40	16.60	54	22.40	63	26.14	0	0	138	57.26	54	22.41	241	100
Water supply Xeset and Tapoung rivers																
Drink	13	5.39	2	0.82	0	0	0	0	98	40.66	9	3.73	111	46.06	11	4.56
Cleaning	24	9.95	10	4.14	0	0	0	0	102	42.32	35	14.52	126	52.28	45	18.67
Bathing	24	9.95	6	2.48	0	0	0	0	102	42.32	10	4.14	126	52.28	16	6.63
Agriculture	24	9.95	13	5.39	4	1.65	0	0	102	42.32	60	24.89	130	53.94	73	30.29
Domestic water supply																
Adequate	24	9.95	0	0	54	22.40	0	0	102	42.32	0	0	180	74.68	0	0
Inadequate	0	0	40	16.60	0	0	63	26.14	0	0	138	57.26	0	0	241	100

Table E.3 Socio-economic aspects (Continued.)

Parameters	Photok				Thongs				Lao-ngam				Overall			
	Before		After		Before		After		Before		After		Before		After	
Drinking water processes																
Boiled	22	9.12	40	16.60	49	20.33	63	26.14	97	40.25	138	57.26	168	69.71	241	100
Un-boiled	2	0.83	0	0	5	2.07	0	0	5	2.07	0	0	12	4.98	0	0
Education system																
School	0	0	40	16.60	0	0	60	24.89	0	0	120	49.79	0	0	220	91.28
Temple	0	0	0	0	6	2.48	3	1.24	35	14.52	8	3.31	41	17.01	11	4.57
Training center	0	0	0	0	0	0	0	0	0	0	10	4.15	0	0	10	4.15
Sanitary and Health system																
Toilet	8	3.31	33	13.69	10	4.15	50	20.74	19	7.88	128	53.11	37	15.35	211	87.56
River	12	4.98	4	1.66	25	10.37	5	2.07	41	17.01	4	1.65	78	32.37	13	5.39
Outdoor (bush)	20	8.30	3	1.24	28	11.61	8	3.31	78	32.37	6	2.48	126	52.28	17	7.05
Sickness																
Malaria	4	1.66	0	0	8	3.32	0	0	7	2.90	2	0.83	19	7.88	2	0.83
Cholera	4	1.66	0	0	3	1.24	2	0.83	2	0.83	7	2.90	9	3.73	9	3.73
Diarrhea	2	0.83	4	1.66	1	0.41	1	0.41	11	4.56	0	0	14	5.81	5	2.07
Dengue fever	2	2.07	2	0.83	0	0	0	0	6	2.49	0	0	11	4.56	2	0.83

Remark : N = number households of respondents, % = percentage households of respondents, ND = no data

Table E.4 show the result recommendation all three villages on the Xeset 2 project

Parameters	Location sites (villages)							
	Photok		Thong soui		Lao-ngam		Overall	
	No	%	No	%	No	%	No	%
Teachers	5	2.07	ND	ND	ND	ND	5	2.07
Water supply	3	1.24	ND	ND	8	3.32	11	4.56
Hospital	10	4.15	3	1.24	ND	ND	13	5.39
Roads	ND	ND	8	3.32	ND	ND	8	3.32
Open gate enouncement	ND	ND	ND	ND	12	4.98	12	4.98
Water demand	ND	ND	ND	ND	10	4.15	10	4.15

Remark : N = number households of respondents, % = percentage households of respondents

ND = no data

Table E.5 The recommendation all three villages to the government of Lao PDR

Parameters	Location sites (Villages)							
	Photok		Thong soui		Lao-ngam		Overall	
	No.	%	No.	%	No.	%	No.	%
Teachers	5	2.07	4	1.66	ND	ND	9	3.73
School	4	1.66	8	3.32	ND	ND	12	4.98
Hospital	5	2.07	5	2.07	ND	ND	10	4.15
Water supply	3	1.24	4	1.66	10	4.15	17	7.05
Doctors	ND	ND	ND	ND	4	1.66	4	1.66
Toilet	ND	ND	1	0.41	ND	ND	1	0.41

Remark : N = number households of respondents, % = percentage households of respondents

ND = no data