Master's Thesis of Forest Science

Land Use and Household Income in Northern Lao PDR

– Case Study of Two Villages in Phuhiphi National Biodiversity Conservation Area, Oudomxay Province –

라오스 북부 지역의 토지이용과 가계 소득에 관한 연구

– 우돔싸이 푸히피 국가 생물다양성 보전 지역 인근 두 마을의사례 –

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Beun DONSAVANH

Land Use and Household Income in Northern Lao PDR.

– Case Study of Two Villages in Phuhiphi National Biodiversity Conservation Area, Oudomxay Province –

UNDER THE SUPERVISION OF ADVISOR
PROFESSOR YOUN YEO-CHANG

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Beun DONSAVANH

Graduate School, Seoul National University
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Chair Hong-Sok(Brian)Kim (Seal)
Vice Chair YOUN Yeo-Chang (Seal)
Examiner LEE Yo-Han (Seal)

Abstract

About 75-80% of people in the rural community in the Phuhiphi-National Biodiversity Conservation Area (NBCA) of Oudomxay Province in Northern Laos depend on the conversion of forests to agriculture lands for crop productions to support their livelihoods. This study aims to identify the factors influencing the household income and land use change in the mountain areas of Northern Laos, and its goal is to estimate the opportunity cost for avoiding deforestation from shifting cultivation. The randomized collection method and the Poverty Environment Network (PEN) guideline was utilized for surveys. 74 households (85% of the population) in two villages were interviewed, and land use changes were interpreted using satellite imageries by ArcGIS application. Additionally, the multiple linear regression method was used for investigating the factors influencing household income and land use change, and the opportunity cost of forest conservation was estimated.

This research showed that the household income was mainly obtained from forest products (NTFPs, timber and fuelwood), crop production (rice, corn and cardamom) and livestock husbandry. The income of households is influenced by the size of family, marketing by middlemen, as well as number of livestock animals. In Huaysang village, the family size negatively affected household income, while market access, years of education and number of medium-size animals contributed positively to household income. In Naxaythong village, only number of big-size animals positively affected household income.

The higher household income obtained from forest products and agricultural practices, including crop productions and livestock, the higher opportunity cost of avoiding shifting cultivation. Thus, forgone income from shifting cultivation for rice and other crop cultivations is the main source of opportunity cost for greenhouse gas mitigation from land use change in the mountain villages of Northern Laos. Finally, this study suggests that government policies related shifting cultivation should promote economic activities based on biodiversity conservation, rather than promoting household income from agriculture and trade of commercial crops.

Keyword: *Household income, Land use, Land use change, Opportunity cost, National Protected Area (NPA), Lao PDR.*

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Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

1.1. Background and problem statement

Forests play an important role in the livelihoods and welfare to the indigenous people in developing countries (Achard, 2009). Approximately 1.6 million of the people who depend on forest resources around the world (World Bank, 2004). According to Katia, et al., (2012), they explored the basically income for 7 categories, including agricultural wages, non-agricultural wages, crop activities, livestock activities, self-employment (household non-farm enterprises), transfers and other non-labor sources. Particularly, the role of forest resources supported households' income between 20-25% from environmental resources in developing countries (Langat, et al., 2016).

The factors influencing households' income may cause conversion of forest land to agriculture, pasture and mining sites, and some of them are related to biophysical characteristics of the land. Moreover, the infrastructure has influenced the cost of delivering goods to the market as well as demand for agricultural and forest products commodities, which can increase returns from land conversion. In addition, the governmental regime such as protected public land, open access commons, lease concession, and private ownership rights of differential tenure security matter (Ferretti-Gallon & Busch, 2014).

Concerning the Law on Land of Government of Laos (GoL) in 2007, land areas are under national and communal ownership including all of eight categories, namely: agricultural land, forest land, water area land, industrial land, communication land, cultural land, land for national defense and security and construction land. Forest accessible by people of Laos is classified four into categories, namely public benefit forest, forests for household' s utilization, customary utilization, and concession business operations (NA, 2007). However, the program of Land and Forest Allocation (LFA) had allocated land and forest land into two sections. Firstly, the allocation of potential agricultural land and degraded land to households is temporary under three years' land use with a certificate for crop cultivation and tree planting or grazing, and land title is granted for the land use satisfied certification. Secondly, the allocation of forest lands was within the village boundary to village community for sustainable management of the villages (NA, 2005).

In Laos, the people are around 75–80% of total population are living inside and close to forest area. Those inhabiting surrounding National Biodiversity Conservation Area (NBCA) or National Protected Area (NPA) practicing agriculture, clear and expand the land for paddy rice field, gardens, and commercial crops farming, and shifting cultivation, livestock husbandry, wildlife hunting, for subsistence and commercial timber harvesting. Their agricultural and forest products are marketed in the village. The households' activities such as shifting cultivation and over–exploitation forest resources caused deforestation and forest degradation (MoNRE and IUCN, 2016).

The traditional practices of upland farming and forest products collection are the main income sources of people living in rural area. These practices are to subsistence and commercial production by mono–culture crops such as rice, maize and rubber gathering timber, fuelwood and NTFPs. Moreover, the trade in the border of districts or provinces in the country is promoted for local economic development. In the year 2001, GoL promoted a border trade facilitation policy for supporting a small–scale commercial production and exports in addition to create jobs and income–generating the activities for people living on the country's borders (Intal, et al., 2011).

On the case study of Oudomxay province, it is located in the Northern Laos and share a border with China, which consists of seven districts, namely: Xay, La, Namo, Beng, Houn, Pak Beng and Nga with 471 villages (LSB, 2015). According to Wong, et al, (2014), who analyzed the economic valuation of land use in Oudomxay province that its a large landscape was transformed from forest to cropland by the swidden farming system for commercial mono–crop cultivation. They found almost half of 58% of forest land of the province in the year 2011 converted to commercial agricultural production with rubber and corn. Therefore, around 50% of the land expansion in commercial production was from forest conversion.

1.2. Objectives

The aim of this study is to identify what are the factors influencing household income of villagers in Northern Laos where are near to or inside the NPA. For this households' income activities from different income sources including forest harvesting and agricultural practices, investigated to understand how the factors influence household income and affect land use change. In addition, the opportunity cost of avoiding deforestation from agricultural practices for climate change mitigation policy program such as REDD+ projects will be estimated.

Chapter 2 Literature review

2.1. Key definition

Forest is a land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees being able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010).

Land is an area of the Earth's surface, comprising the physical environment, including climate, relief, soils, hydrology, and vegetation to the extent that these influence potential for land use. It includes the results of past and present human activities (FAO, 1976).

Land use is characterized by the arrangements, activities, and inputs people undertake in a certain land-cover type to produce, change or maintain it (FAO, 2016).

Land use change can be defined as clearing forests for agricultural utilization or settlements which are associated with clear changes in land cover and carbon stock. The different factors and mechanism drive land use and land cover transformation. In many cases, climate, technology, and economics appear to be determinants of land-use change at different spatial and temporal scales (IPCC, 2003).

Deforestation is the long-term or permanent conversion of land from forest use to other non-forest uses. Under Decision 11/CP.7, the UNFCCC defined deforestation as the direct and human-induced conversion of forested land to non-forested land (GOFC-GOLD, 2009). Additionally, FAO implies that the definition of deforestation is the permanent reduction of the tree canopy cover below the minimum 10 percent threshold (FAO, 2016).

Forest degradation: A secondary forest that has been destroyed by human activities, structures, functions and species composition and productivity are normally associated with a natural forest type expected on that site. Hence, a degraded forest delivers a reduced supply of goods and services from limited biodiversity (UNEP/CBD/SBSTTA, 2001).

Indigenous people and natural resources: The United Nation defined as the indigenous people who live in the society dependently on territories and surrounding natural resources. Their lives are based on distinct social, economic or political systems, distinct language, culture, and beliefs. They form non-dominant groups of society and resolve them to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities. The same as indigenous people, they may be referred to different countries such as indigenous ethnic minorities, aboriginals, hill tribes, minority nationalities, scheduled tribes, or tribal groups (UNFPII; Hall & Patrinos, 2012).

Forest-dependent people: Most of the people have some dependence on the forest for their livelihood. A fundamental review of the use of the term forest dependency, argues that it is more useful to present a typology of different types of users. They make a crucial distinction between people who rely on forest use and have no alternative. Those who use forest products or engage in economic activities involving forests do so as a matter of choice (Fisher, et al., 1997).

Additionally, FAO created the Asia-Pacific Forestry Sector Outlook Study in 1997 and it reported the number of forest dependent people and types of people-forest relationship. The people are more or less directly or indirectly reliant on forests for livelihood purposes. It shows in three broad types of people-forest relationship:

(1) People live inside forests and often live as hunter-gatherers or shifting cultivators and they are heavily dependent on forests for their livelihood and primarily on a subsistence basis.

(2) People live near forests and are usually involved in agriculture outside the forest and people regularly use forest products (timbers, fuel wood, bush foods, medicinal plants and etc.) partly for their own subsistence purposes and partly for income generation.

(3) People engage in commercial activities such as utilizing natural resources, collecting minerals or working in

forest industries such as logging. Such people may be part of a mixed subsistence and cash economy. These people depend on income from forest-dependent labor rather than from direct subsistence use of forest products.

The concept of opportunity cost (OC): Adam Smith invented the idea of the opportunity cost of economic theory around the eighteen centuries of the Wealth of Nations (1776) meanwhile his book is popular in the economic class.

In 1982, Oscar W. Jensen explained the economic theory on decision making on opportunity cost in production and the full costs of economic theory which may clarify the alternatives of a management decision problem. The opportunity cost is important for economic theory and for decision makers on forgoing the cost of the action given up by choosing the action rather than the alternative or the cost of any productive services.

According to a critical review of the opportunity cost concept, Yip (1999) stated that the conceptual opportunity cost is essentially related to the process of choice, and the most useful result of opportunity cost is a crucial decision, is the future-oriented and is related to the expectation of the decision maker about the future. Thus, the decision is always affected by an expectation rather than the fact although the decision maker may wish that the expected outcomes of his selected course of choice will subsequently turn into fact (Thirlby, 1946; Yip, 1999). Eventually, the choice of comparisons can play a crucial part in cost-effectiveness analysis. It affects the measurement of opportunity cost (Palmer and Raftery, 1999).

In 2011, World Bank developed a training manual of estimating the opportunity cost of REDD+. The cost of REDD+ resulted in the opportunity cost of the foregone benefits that deforestation would have generated for the livelihoods and the national economy including the foregone economic benefits of the alternative land use.

2.2. Opportunity cost of REDD+ for avoiding deforestation

Estimating the cost of REDD+ is important for the cost of generating emission reduction from REDD as well as it is the cost of the action needed to truly avoid deforestation (Pagiola & Bosquet, 2009). The cost of avoiding deforestation was claimed by Palmer, et al., (2009) that this contributes to the mitigation of climate change. Its viewpoint of the cost is necessary to estimate the drivers of deforestation into the economy of drivers of deforestation and forest environmental services (Angelsen, 1995; Chomitz, et al., 2006; Palmer, et al., 2009). Even though landholders clear forest because of given skills, finance, and technology available to them, they get a higher return from converting the forest to agriculture or ranching than they can get from sustainable forest management or forest conservation.

Additionally, the cost of REDD+ is crucial knowledge for governments, donors, and buyers of carbon credits. World Bank thus developed the manual for REDD+ opportunity cost which mentioned about the difference in net earnings from conserving or enhancing forest versus converting them into others, typically more valuable land uses. Hence, the opportunity cost becomes a financial compensation for forgone revenue and limited economic development of a reduction of deforestation (Pirard, 2008).

2.3. Livelihoods of indigenous communities

A livelihood is basically the means that a household uses to achieve well-being, which means just having enough to eat, a shelter for the family and a basic level of security (Messer and Townsley, 2003). The livelihood comprises assets (natural, physical, human, financial and social capital), activities and the access to those (mediated by institutions and social relations) that together determine the living grown by the individual or households. Specifically, the household livelihoods base on rural activities and income, which are complicated composition and level of the individual or households' income. The income of them includes the cash and materials for the welfare of the person or household obtaining from the set of livelihood activities in which household members are engaged. The cash income includes the items like crops or livestock sale, wages, rents, and remittances.

As the activities for total household income are usually disaggregated into different categories and sub-categories of income sources or activities. On the whole, the total household income comes from non-farm; unskilled labor, wage employment, and operating business profits. Agricultural productions represent the net income from crop sales, own-consumption, and labor including transfers income (national and international remittances, pensions, and payment to the poor), livestock and rental income are other types of their income (asset ownership, including land, machinery, and water) (Ellis, 2000). The concept of livelihood shows a diversified rural livelihood (Figure 1):

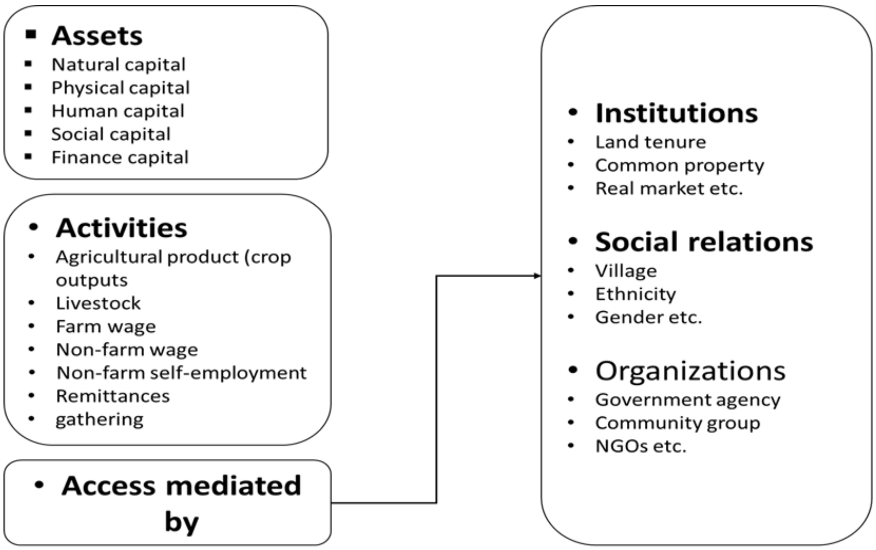

Figure 1: A diversified rural livelihood, source: (Ellis, 2000)

2.4. Factors influencing land use change and deforestation

Various factors influence land use change and deforestation through household activities implementing for their livelihoods (Geist and Lambin, 2001). The conceptual framework of deforestation is the complex set of action, in tropical zone including three major sources from proximate causes (agricultural expansion, wood extraction, and expansion of infrastructure), underlying driving forces (demographic, economic, technology, policy or institutional, and cultural or socio-political factors) and land characteristics or features of biophysical environment. Parts of proximate causes represent human activities (land use change) that directly affect the environment. Another part is an underlying cause of social process on human-environmental relations which are structural in nature (Geist and Lambin, 2001; PHAM, et al., 2015). Thus, the conceptual framework of land use change and deforestation is shown below (Figure 2).

Meanwhile, socioeconomic factors that affect land use change and deforestation include households' age, education, occupation, income, the number of family member, etc. The impact and influence of households have been studied attitudes, perception and behavior on land use change, for example, the usage of energy source for cooking and heating which consist of gas, electricity, wood, charcoal biogas, gel fuel and solar energy (Al-Subaiee and Sultan, 2016).

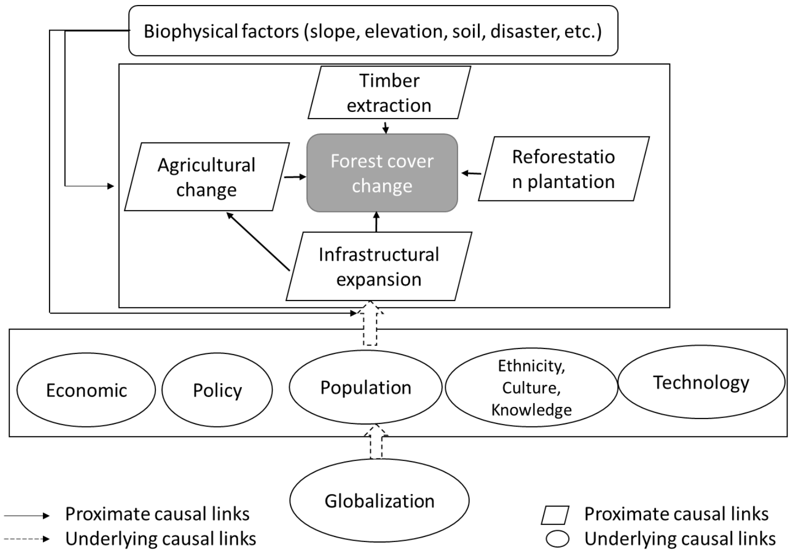

Figure 2: Causes of land use and land use change (LULC), adopted (Geist & Lambin's framework of the causes of tropical deforestation).

Moreover, the expansion of agricultural cultivation in many parts of the world has caused changing of land use and land cover change. Thus, there are several factors that affect land use change such as socio-economic factors including educational level, livestock husbandry, population growth, forestry products, shifting cultivation, cash crop price, farm size, and land tenure (Nzunda, et al., 2013), There are some factors such as road access and market access which were revealed as drivers of land use or land cover changes in Munessa-Shashemene landscape of south-central highlands of Ethiopia by Kindu, et al., (2015).

2.5. Household activities and shifting cultivation in Lao PDR

Shifting cultivation is often responsible for deforestation in a tropical forest as well as crop cultivations in upland (Seidenberg, et al., 2003). An approximately 75%-80% of the people live in the rural area growing rice and practicing mono crop production through shifting cultivation, particularly in the northern part of Laos. The rural people have been practicing Swedish agricultural system since decades ago (Yusran, 2016).

Upland rural people who have rough livelihood practice traditional shifting cultivation opium production since long ago (DOF, 2014) for their subsistence and cash income. Indeed, they try to improve their livelihoods by exploiting forest products (NTFPs, fuelwood, timber, etc.) and clearing forest land to be agricultural area to produce rice, maize, banana, etc.(Rigg, 2006).

Shifting cultivation is the dominant land use system of upland in Laos and around 300,000 families or 40% of the population engaged in shifting cultivation. Mostly, they change the forest land to agricultural land for planting mono culture crops in the Northern of Laos (Seidenberg, et al., 2003).

Farmers' income and farmers' decision making from understanding the governmental motivation for generating cash income, which bases on household activities relating livelihood. While the GoL is currently encouraging farmers who have a small scale of farm to change from subsistence-based shifting cultivating system to permanent commercial crops (Robert, 2015).

2.6. Land use and deforestation and forest degradation in Lao PDR.

The trend of forest area and land utilization in Lao PDR has been considered because forest resources in past two decades have been decreased for natural forestry. The capitalization on natural forest during recent decades has given benefit to the rural poor and this causes the degradation of the natural resource because the majority of the population needs to depend on the forest for their livelihood (World Bank, 2011; Costenbader, et al., 2015). The statistics of forest cover changes in the Greater Mekong Sub-region countries from 1990 to 2015 showed that Laos has the forest area hectare increased to 18,761,000 hectares in 2005 compared with last decades. It was found that forest cover in 2015 was 81%, and the annual rate of change of forest area from 1990 to 2015 was divided into four phases from 1990-2000, 2000-2010, 2010-2015, and 1990-2015 which increased from -0.7% to 0.8%, 1% but decreased by 0.2% of forest area changes.

However, the national statistic of forest cover change increases the percentage to 1% in 2015 (FAO, 2015). The agricultural land has been expanded by forest conversion to crops land. Due to causes of deforestation and forest degradation which are the result of illegal logging, agricultural expansion, tree plantations, hydropower, mining and other infrastructure development, unsustainable commercial timber extraction, and shifting cultivation which are direct drivers from human activities. On the other hand, indirect drivers include the socioeconomic, political, cultural, and technological process such as changing markets, community prices, population growth, national policy and governance, and dynamics of substance and poverty that affect direct drivers (Costenbader, et al., 2015).

Chapter 3 Materials and methods

3.1. Study area

Oudomxay province is located in the northern part of Laos in an area of moderately high mountains. The province has an area of 15,370-kilometer squares and shares border with China (15 km). It is also bordered by five other provinces, namely: Bokeo, Luang Namtha, Phongsaly, Luang Phabang and Sayaboury (figure 3). This northern mountainous province has a moist to dry sub-tropical climate, and northern Laos slopes are steep and elevation is generally greater than 1,000 meters (Bouahom et al. 2003; Michael, et al., 2007).

Figure 3: Location map of Oudomxay province.
Source: United Nation (2004).

There are seven districts in the Oudomxay: Beng, Houn, La, Namo, Nga, Pakbeng and Xay (the capital city of Oudomxay province). They consist of 471 villages and 56,000 households in the year 2015. It has a total population of 307,600 people or 20 people per square kilometer, and the average household size was 5.5 people per household. In 2005. There 14 ethnic groups in the province, 85% of Khmu (who are generally included in Lao Theung ethnic group), 25% of Lao, 15% of Hmong (Hmong Khao, Hmong Dam und Hmong lai), including Akha, Phouthai (Thai Dam & Thai Khao), Phou Noy (Phou Xang, Phou Kongsat, Phou Nhor), Lao Houy (also Lenten), Phouan, Ly, Yang, Ikho and Ho (RESIREA, no date).

The climate of the study area is a cooler dry season and higher temperature variations during the year than other parts of the country (Michael, et al., 2007). Being a tropical country, Laos has a tropical monsoon climate which is influenced by Vietnam. Especially, the weather in the mountains of the north and in the high range of the Annamite chain bordering Vietnam in the east is semi-tropical. Rainy season is from May to October and dry season is from November to April. According to the Oudomxay province meteorology and hydrology station, the average climate condition from 2006 to 2016 is shown in figure 4.

The total forest area of Oudomxay province is 1,531,700 ha or around 51% of all province areas. According to the interview with the government officers of Forest Resources Sector in Oudomxay province (2017), the forest is generally divided by the government into three types of forest area, which are 220,695 ha of production forest consisted three locations (Say Nam Pak, Say Khong, and Say Nam Nga), 442,550 ha of protection forest, and 118,000 ha of protected area (Phuhiphi national protected area 87,530 ha), respectively.

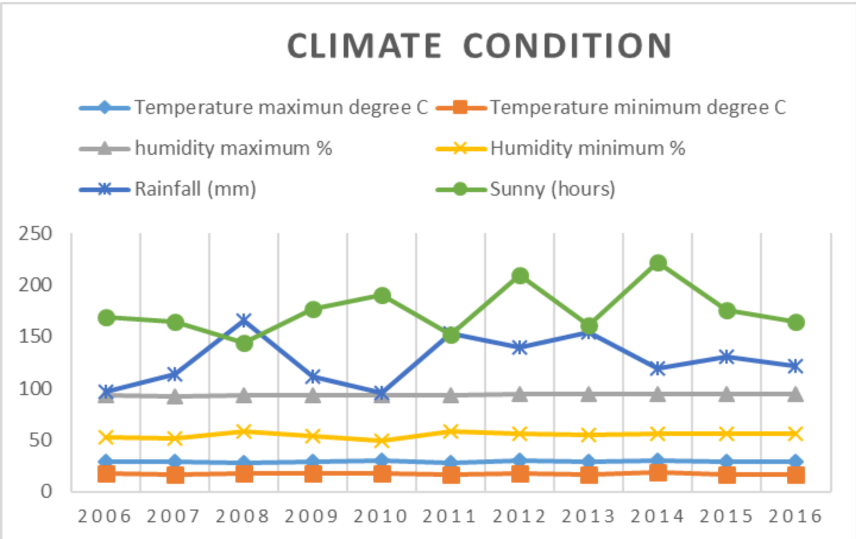

Figure 4: Oudomxay climate condition from 2010 to 2016. *Source: Oudomxay Provincial meteorology and hydrology station (2017)*

3.1.1 Surveyed village: Huaysang Village description

According to a report of the Huaysang village history and economy (2016). In 1998, 28 households of 150 people moved to this village, and built houses and cleared the forest area for shifting cultivation. After that, more families moved in from other villages nearby. There are 42 households and 214 people in 2016. Since decades ago, all households have expanded their rice fields into the forest area and they exploited the forest resources.

In 2016, the CCL (Comité de Coopération avec le Laos) set a project of land allocation and the allocated total 1,112 hectares of land into different uses in Huaysang village boundary. They include the protected area (23.5 ha), protection forest (48.5 ha), production forest (9.5 ha), reforestation (44 ha), agricultural land stock (50 ha), paddy rice field (736 ha), pasture land (63 ha), bamboo forest land (65.5 ha), rice field (9.5 ha), garden (26.5 ha), urban land (5 ha), community land or government land (18 ha), custom forest land (2 ha), and other lands (11 ha).

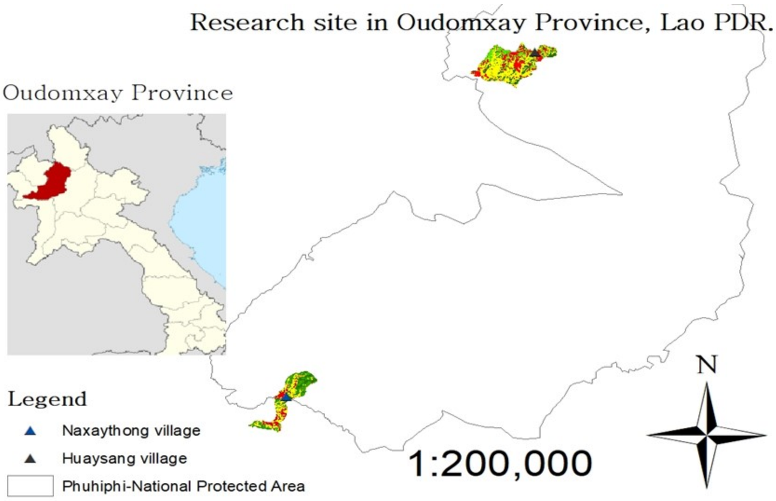

Figure 5: Study sites.

Huaysang village is locate in the north of Phuhiphi-NPA and also is inside NPA (figure 5) at the degree of Latitude 20.86N, and longitude 102.20E with the elevation of 781.1 meters. The population is 214 with 42 households. There is only one ethnic group (Khmu) living in the village which came from upland. There is the agricultural center for supporting technical services to local communities and one small primary school has around 25 students. There is no good gravel road access, and transport condition is not good in that area to the village. Most of the villagers use motorbike and transport their agricultural products in the dry season. Villagers get water for drinking and home use in the streams nearby. All of the households depend on agriculture, livestock husbandry, and harvesting NTFPs on upland for subsistence and cash (Report of village, 2016).

3.1.2 Surveyed village: Naxaythong Village description

This village was first settled in 1987 by 28 families with around 80 people. They moved from Nayarng village in Nam Bak District, Luang Prabang province because living in Naxaythong village was considered to provide more job opportunities to the immigrants. After that, they did not move to other places for searching land (lowland) for rice cultivation. In 2015, the land and forest allocation program by the government finalized land allocation and boundary but has not finished the map of land-use. The total village area includes forestland of 546.02 ha and rice field or agricultural land of 24.97 ha. All villagers have received land titles from the government in 2017. In 2016, there are 45 households including Lue and Hor (2 families) ethnic groups. The population is totally 201 of which are 106 women.

Naxaythong village is located close to the southern part of Phuhiphi-NPA at degree Latitude 20.61N, longitude 102.03E, and elevation 978.8 meters at the village. The national north road No. 13 is across to the Oudomxay city about 18 km. A half of the village land shares border land with Phuhiphi-NPA. Many households have own car for transportation and transfer their products to the city. All villagers do subsistence agriculture and their income is mainly from the selling of livestock, NTFPs, crops. Moreover, most of the villagers make handicraft at home, some villagers work as a teacher for a school in the village, and some have their own business such as small stores (Report of Village, 2016).

3.2. Materials for study

3.2.1 Instruments used for land use classification

The instruments used in this study include Global Position System (GPS) and Garmin GPS. These instruments are used to find out the coordinates of the study area.

Moreover, the software such as: ArcGIS 10.3.1, GIS software with the Spatial Analyst extension, Excel and SPSS were used.

3.2.2 Satellite imageries of Landsat4 TM and Landsat 8 OLI

Satellite imageries to know the location and land utilization were applied for this study. The study area, Oudomxay province or NPA, is located in a position of Path 126/Row 49 from Landsat Worldwide Reference System (WRS). Landsat time-series dataset from 1988 to 2016 with differencing year intervals are selected for extracting information on land use and land use changes in NPA. The images were downloaded from the US Geological Survey (USGS) National Center for Earth Resources Observation and Science through the GLOVIS data portal (http://glovis.usgs.gov). The image files are downloadable in Landsat data Level 1 of standard radiometric and geometric correction. Each Landsat information shows in table 1 and 2.

Table 1: Satellite datasets used for this study

No.	Satellites	dated	Resolution (m)
1	Landsat 4 TM[1] 1988	27/02/1988	30
2	Landsat 4 TM 2005	09/02/2005	30
3	Landsat 8 OLI[2] 2016	08/02/2016	30

Source: USGS (1988, 2005, 2016)

[1] TM: Thematic Mapper
[2] OLI: Operational Land Imager

Table 2: Characteristics of Landsat 4 TM and 8 OLI

Landsat Sensors	Bands	Spectral Range (μm)	Resolutions (m)	Data (bit)	Swath width (km)
Landsat 4 Thematic Mapper (TM)	1 Blue	0.45−0.52	30	8	185
	2 Green	0.52−0.60	30		
	3 Red	0.63−0.90	30		
	4 NIR	0.76−0.90	30		
	5 SWIR 1	1.55−1.75	30		
	6 Thermal	10.40−12.50	120*30		
	7 SWIR2	2.08−2.35	30		
Landsat8 Operational Land Imager (OLI)	1 Ultra Blue	0.43−0.45	30	8	185
	2 Blue	0.45−0.51	30		
	3 Green	0.53−0.59	30		
	4 Red	0.64−0.97	30		
	5 NIR	0.85 − 0.88	30		
	6 SWIR1	1.57 − 1.65	30		
	7 SWIR2	2.11 − 2.29	30		
	8 Panchromatic	0.50 − 0.68	15		
	9 Cirrus	1.36 − 1.38	30		
	10 TIRS1	10.60 − 11.19	100*30		
	11 TIRS2	11.50 − 12.51	100*30		

Source: USGS (1998, 2005, 2016).

3.2.3 Processing of land classification

Land classification is to classify land use in order to estimate land use change in the study area. The ArcGIS was used to estimate the forest area, agricultural land, and other lands. The land uses of this study includes four categories: (1) uncover land or paddy or rice field, (2) pasture or fallow forest, (3) young forest and (4) secondary forest. The estimation was applied with the Spatial Analyst extension by the functioning of supervised image classification. Satellite images for the year 1988, 2005, 2016 were firstly combined band, then did supervise classification and change detection of agricultural land use in the forest area (Tillmann, et al., 2012) by generating a signature file from the area of interest from ground truth data complemented by manual interpretation of the image. Finally, the area of each land use category was calculated by ArcGIS geometry analyst with multiplying cell 30 meters of Landsat.

3.2.4 Determinants of land use classification

All land classes of interest must be selected and carefully defined to classify remotely sensed data successfully into land use in the survey area (Kim, 2016). The definition of four categories: Uncovered land or paddy or rice field, pasture or fallow forest, young forest and secondary forest.

Table 3: Determinants of land use classification

Land use classes	Definition	Authors
(1) Paddy field or rice field	Rice field covers a largely agricultural area with rice and lower profitability on upland or Lowland.	Kleinhenz, et al., 1996
(2) Fallow Forest	- All complexes of woody vegetation deriving from the clearing of natural forest for shifting agriculture. - Long fallow: Forest affecting by shifting	FAO, 2001

	cultivation - Short fallow: Agricultural areas with short fallow period of time shifting.	IPCC, 1996
(3) Young forest	Natural regeneration of forest lands or Young plants regrow on land use	FAO, 2001
(4) Secondary forest	Secondary forests have been clearance by human or without a period of conversion to another land use. Forest cover has regenerated naturally or artificially through planting	UNEP/CBD/ SBSTTA, 2001

3.3. Methodology

3.3.1 Household sampled selection

Two study sites were selected as the survey area: (1) Huaysang village of La district, and (2) Naxaythong village of Xay District in Oudomxay province and both are slightly different topography. La district has totally 45 villages (Statistic provincial office, 2016). Among of them, 17 villages are inside Phuhiphi-NPA, consisting of 1,319 households and a total population of 6,999 (Sector of Forest Resource in provincial office, 2016). However, Xay district has totally 97 villages (Statistic provincial office, 2016). where 22 villages are inside Phuhiphi-NPA, with 4,651 households and the total population is 22,147 (Sector of Forest Resource in provincial office, 2016). La district is 25 km far from the Oudomxay city, and Xay district is the capital city of Oudomxay province.

Focus group meetings in the village location with village leaders were organized as the preliminary survey according to the practice guideline from CIFOR (Liswanti, 2012). The households were randomly selected to be interviewed by the researcher and his assistants in February 2017. 74 households

(85.05%) of total households were randomly selected for data collection and analysis. The number of a sample size of each village can be seen in Table 4.

Table 4: Number of households sampled in each village

Village	Huaysang	Naxaythong	Total
Total households	42 (100%)	45 (100%)	87 (100%)
Households Sampled	33 (78.57%)	41 (91.77%)	74 (85.05%)

3.3.2 Data collection

The data collection was conducted by mixed research methodology including primary and secondary data. The quantitative and qualitative method (Plumb, et al, 2012) to collect the data on socioeconomic, land use, land tenure and right properties, forest product collection, agricultural activities, livestock raising, household income in diversity income sources were applied. The guideline of National Socioeconomic Surveys in Forestry: guidance and survey modules for measuring the multiple roles of forests in household welfare and livelihoods (FAO, CIFOR, IFRI, and World Bank, 2016) was applied to the survey. The forest areas and land use change were calculated by using Landsat4 TM and landsat8 OLI downloadable version and ArcGIS application for interpreting and analyzing land classification of research sites (Šimić, et al., 2015).

The sample households were selected randomly by using materials from the protocol designed by CIFOR (Liswanti, et al., 2012). 85.05% of total households were sampled and interviewed with the questionnaire. The primary data such as socioeconomic (age, gender, educational level, ethnicity, occupation), land use (types of land use, the year of practices and rotation), land tenure and right properties, forest product collection (NTFPs, firewood, and timber), agricultural activities (crop production–rice and other crops), livestock, and off–farm activities were questioned, and forest areas were using farm area by pointing with GPS. Secondary data calculated from the government database. The ArcGIS was used to analyze the satellite imageries of Landsat4 TM and 8 OLI for the years 1988, 2015 and 2016. In addition, the information such as maps, official government reports, statistic reports, from academic institutions and non-government organizations are used as the secondary data. Moreover, Lao's forestry related laws, national strategies, decrees, and regulation concerning forestry, land use, management, and conservation were examined.

3.3.3 Data analysis

(1) Household income estimation

The household income data collections were conducted by Poverty Environment Network (PEN) technical guideline (CIFOR, 2007). The household's income measurements are used as an indicator of the well-being of the indigenous villagers. In the case of Nigeria, according to Fadipe, et al. (2014), they investigated the income determinants among rural community of agricultural and off-farm income for consumption and cash income. This research collected data for households' income by interviewing the heads of households or a wife or others responsible were asked with questionnaires.

In this study, to calculate total household income the revenue of subsistence and cash income, including expenditure accounting of gross income were questioned to the respondents (Campbell and Luckert, 2002; Langat, et al., (2016). The households' income was calculated with those formulas below.

Household annual income = (forest income + agricultural income[1] + Wage income[2]).

$$Annual\ income = \sum_{i=1}^{n}[Si] \qquad (1)$$

Where Si is income source i

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[1] Agricultural income includes crop products, livestock for subsistence and commercial production, and excluded livestock income for OCA.
[2] Wage income was excluded for multiple linear regression models analysis and opportunity cost analysis.

Forest income = (fuelwood income + NTFPs income + logging income)

$$\text{Net revenue} = \sum_{i=1}^{n}[QiPi - (Ci)] \qquad (2)$$

Where Qi is the quantity of product collected i, Pi is the market price of forest product i, and Ci is production cost of forest product i.

Crop income is calculated by multiplying the market price of the crop with the yield from various crops grown by household deducting all cost of production. Total crop income was calculated as:

$$\text{Net revenue} = \sum_{i=1}^{n}[CjPj - (Kj)] \qquad (3)$$

Where Cj is a yield of crop j, Pj is the market price of the crop j, Kj is the production cost of the crop j.

Livestock income = (Pigs selling income + cattle income + buffalo income + goats income + duck and chicken income). Income from livestock products that is:

$$\text{Net revenue} = \sum_{k=1}^{n}[NkPk - (Kk)] + \sum_{k=1}^{n}[QkPk - (Kk)] \qquad (4)$$

Where Nk is an amount of livestock in categories k, Qk is the quantity of product from livestock k, Pk is the market price of livestock k, and Kk is cash cost of keeping livestock k, cost includes wage paid to herder, medicine, feeds.

Income from off-farm or employment is the total value of earnings from working out of labor on another household's agricultural or economic activities.

(2) Opportunity cost analysis (OCA)

According to World Bank (2011), the opportunity cost of REDD+ incorporated the approaches for estimating opportunity cost of avoiding forest land conversion to agricultural practices was estimated for OC of avoiding deforestation. This manual showed the outcome of the opportunity cost for REDD+, in terms of the Net Present Value (NPV) (US$ per ha). The opportunity cost analysis (OCA), therefore, was calculated based on the NPV of forest and agricultural annual profits (US$ per ha). The profits per area (ha) of land use was calculated as the OC for creating forest carbon credits (tons C per ha).

The results of OCA indicates that REDD+ can serve in a large - scale and cost effective funds of reducing emission over the next 20 years (Deveny, et al., 2009; Plumb et al., 2012), and these authors determined that the cost of REDD+ activities can vary widely across countries.

The NPV or some time called Present value (PV) is a calculation commonly used to estimate the profitability of a land use over many years. NPV takes into account the time−value of money. Since waiting for profits is less desirable than obtaining profits now, the "value" of future profits is discounted by a specific percentage rate (World Bank, 2011). The discount rate range from 6 to 10%. The formula of NPV is shown as below:

$$NPV = \sum_{1=t}^{T} \frac{\Pi_t}{(1+r)^t} \qquad (US\$\ ha^{-1}) \qquad (5)$$

Where t=year, T=length of time horizon, Π= Annual profits of the land use ($US\$ha^{-1}$), r=discount rate (6% and 10%) for 20 years of shifting cultivation.

Then, the Opportunity Cost Analysis (OCA) was calculated as below formula (World Bank, 2011).

$$\text{Opportunity Cost (OC)} = NPV/tCO2e \ (US\$\ tCo2e^{-1}) \qquad (6)$$

The carbon stock estimation for different land uses from previous researchers were used to calculate Co2 emission of the study area (Table 5). The OC estimation was calculated by NPV per ton of Co2 emission. The tonCo2 was converted by a conversion factor of 3.67 carbon atom to carbon dioxide equivalent (Co2e) (IPCC, 2003).

Table 5: Carbon stock of different land use

No.	Activities on land use	Climate zones	Type of stock	Carbon stock (t $C.ha^{-1}$)	Conversion factor of Biomass to Carbon	Locations	References
1	Secondary forest	South East Asia	AGB[2] C	140.7	0.5	Indonesia	Suzanne (2014)
2	Soil C[1] in Secondary forest (Forest before restoration 11 years)	South East Asia	Soil	127.41	0.58	North Thailand	Kavinchan, et al. (2015)
3	Total C stock of Crops field (Rice, corn, Job's tear)	South East Asia	AGB C + SOC[3]	86.78	(Soil 0.58, root & AGB 0.5)	Northern Laos	Takeuchi, et al. (2015)
4	Carbon stock from Rice fields	South East Asia	AGB C + SOC	28.11	(Soil 0.58, root & AGB 0.5)	Northern Laos	Takeuchi, et al. (2015)

[1] Carbon stock in land uses, [2] Above Ground Biomass, [3] Soil Organic Carbon

(3) Land use classification

According to World Bank (2011), they described the significance of land cover and land use for opportunity cost estimation and avoiding deforestation. Land use was identified by interpreting satellite images with actual land uses on the ground of land use mapping (Cihlar and Jansen, 2001; World Bank, 2011b). Generally, the methods are available to interpret remote-sensing imagery. After an image interpretation method is selected, an analysis can be conducted and digital maps can be produced to make the legend of land use.

The U.S. Geological Survey established the standard for land use identification and classification into agricultural land and forestry utilization (Anderson, 1976). European communities also created a manual of land cover concept and land use information system in 2001 for identification and classification (European, 2001) as shown in Table 6 below is:

Table 6: Land use classification by satellite image

Type of group and land use	Subjects classification	Description and color of each land use type	Satellite images
Forest land[1,2]	Tree, all plantation, river, lake, etc.	- As a tree-crown areal density into three categories: Deciduous, Evergreen, and Mixed -colors: Green (Munsell 10GY 8/5) and watercolor: Dark Blue (Munsell 10B 7/7)	Landsat
Agricultural Land[1, 2]	Farm activities: cropland, livestock land, etc.	- As Cropland and Pasture; Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas, animal farm with horse, etc. - Light Brown (Munsell 5YR 7/4)	Landsat
Urban area[1]	Housing building, storehouse, etc.	- As cities, towns, villages, transportation, power, and communications	Landsat

	facilities, etc. - Color: Unknown

Sources: [1] U.S. Geological Survey, and [2]European, 2001.

In this study, there are three steps for land use identification and classification. Firstly, a field survey was conducted in the sample villages, which are inside Phuhiphi-NPA. Each village was observed and checked for the forest, forest use and agricultural activities by research team then marked the referent point with GPS surrounding boundary of the village. Secondly, areas were applied by Google Earth and re-checked the research site with points of land use activities. Lastly, the process of Landsat imageries interpretation was conducted with ArcGIS application. This procedure required Landsat 4 TM of band 3, 2, 1 (RGB), and Lansat8 OLI of band RGB (4,3,2), the spatial resolutions are 30 meters of composite and ArcGIS was analyzed in order to have a land classification. Consequently, the land classification was identified into forest land and agricultural practices.

(4) Descriptive and statistical analysis

Kindu, et al. (2015) applied the descriptive analysis of simple frequency analysis to describe socio-economic characteristics of households and summarized their response factors of land use. In this study, frequency and descriptive statistics were used to analyze the surveyed data such as household per capita income from the forest, agriculture, livestock products and other incomes (labor and business). Then, the annual return and gross income analysis between the two villages were conducted.

(5) Multiple linear regression model analysis

A linear regression analysis is a conceptually simple method for investigating functional relationships among variables (Chatterjee and Hadi, 2015). Moreover, the multiple linear regression allows more factors to enter the analysis separately and estimate the effect of each. This model applied the Enter method for reasonable quantify of various influences on the single dependent variable. Thus, multiple linear regression is a very flexible method and may be suitable for quantitative dependent variables to estimate the relationship and more independent variables could be linear and factors may be qualitative or quantitative (Božić, et al., 2013). According to Chatterjee & Hadi, (2015) established the textbook of Regression analysis for exploring the multiple linear regression models equation is shown as below:

$$y_i = \beta_0 + \beta_1 \chi_{i1} + \beta_2 \chi_{i2} + \dots + \beta_p \chi_{ip} + \varepsilon_i \quad (7)$$

where y_i represents the ith value of the response variable Y, χ_{i1}, χ_{i2},....., χ_{ip} represent the values of the predictor variables for the i^{th} unit, β_0, β_1, β_2, ……β_p represent the coefficients, and ε_i represents the error in the approximation of y_i.

In order to analyze the factors influencing the household income and land use by forest-dependent people in the protected area, linear regression models were defined per capita annual household income only from agricultural practices, forest products collection and livestock husbandry (excluded other income of off-farm activities) was modeled as a function of household characteristics, land use practices and marketing method (model 1), area of land used for rotational cropping system (model 2) was modeled as a function of household characteristics, land use practices, and marketing method (Appendix 2).

Two models were analyzed by multiple linear regression in SPSS, the models explain that the unit increase in the value of the p^{th} predictor by 1 unit increases the value of dependent by β_p units. Note that β_0 is the intercept, the model predicted the value of the dependent variable once the value of every predictor is given.

Multiple linear regression model 1: (8)

$$Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon_i$$

Independent variables:

X_1: Family size

X_2: Market access (dummy: 1=Middlemen, 0=other market).

X_3: Educational years.

X_4: Rice field distance (kilometer)

X_5: Amount of medium size animals (pigs and goats)
X_6: Amount of big size animals (buffaloes and cows)

Where Y_1 (dependent variable) represents the household per capita income (income unit: million LAK (Lao Kip)) from total forest products collection, agricultural production, and livestock of two villages.

Multiple linear regression model 2: (9)

$$Y_3 = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 T_5 + \beta_6 T_6 + \beta_7 T_7 + \varepsilon_i$$

Where Y_2 (Dependent variable) represents the area of crop land used by the households in two villages.

T_1: Family size
T_2: Educational years
T_3: Market access (dummy variables: 1=Middleman, 0=others)
T_4: Income from forest products
T_5: Income from crops production
T_6: Income from livestock
T_7: Forest land in each village (testing for combining sample two villages)

3.4. Characteristics of the households

3.4.1 Population, ethnicity and household size

A survey was conducted to 85.05% of total households in two villages (Table 4). The ethnical groups of the household are namely: Khmu, Lue, Lao, and other (Ho) which accounted for 44.59%, 50%, 4.05%, and 1.35% individually. In the Huaysang village (100%) of respondents are Khmu ethnical groups. But Naxaythong village consists of Lue, Lao, and Hor (Aka) (Figure 8).

The respondents are normally distributed in the case of gender (Figure 6), which accounted of a male for 54.05% while the female is 45.59%. In Huaysang village, the respondents' ages (Figure 7) are a range of three groups of the ages ' range from 20 to 80 such as 20-39, 40-59, 60-80 years accounted for 20.27%, 21.62%, 2.70%. In the case of Naxaythong, the ages 'range was 21.62%, 21.62%, 12.62% respectively. Most of the households consist of 1 to 4 household members which are 48.65%, 5 to 8 members which are 41.89% and 9 to 14 members which are 9.46% (Appendix 1).

The average household size is 5. In Huaysang village, the household size from 1 to 4 persons is 14.86%, household member from 5-8 person is 21.62% and 9 to 14 persons is 8.11%. In the case of Naxaythong village, the household size 1-4 person is 33.78%, member from 5-8 persons is 20.27% and a member from 9-14 persons is 1.35% (Figure 9).

3.4.2 Education and occupation

For this study, the educational levels are divided as the illiterate (0 years), primary school (5 years), secondary school (6 years), and college or university (3 to 5 years) (Figure 7 and Appendix 1). About 5.41% achieved college or university level, while about 16.22% and 13.51% were unschooled education and finished by secondary school, respectively. About 64.86% of total population in two sample villages finished primary school (Figure 10).

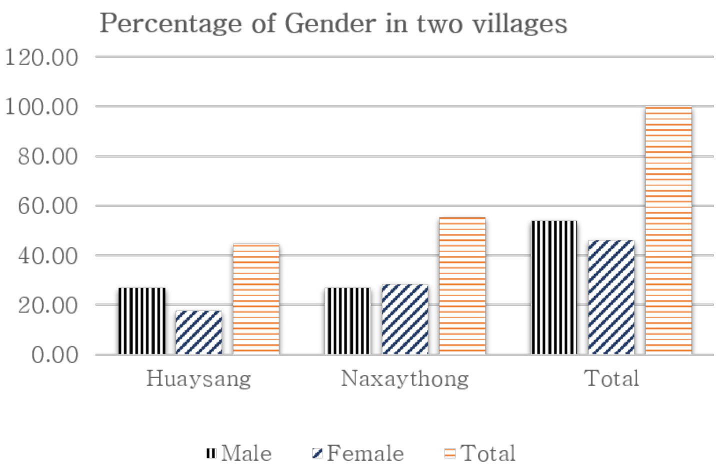


Figure 6: Percentage of gender of respondents in two villages

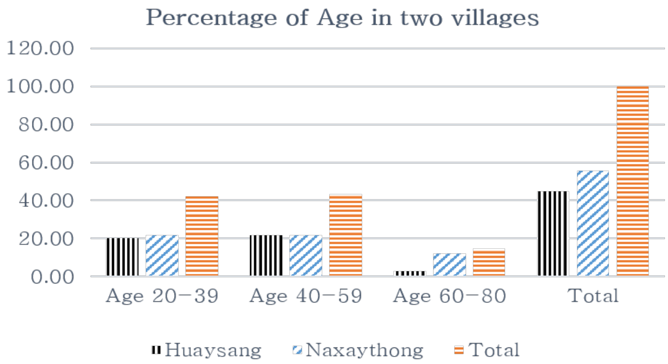


Figure 7: Percentage of age of respondents in two villages

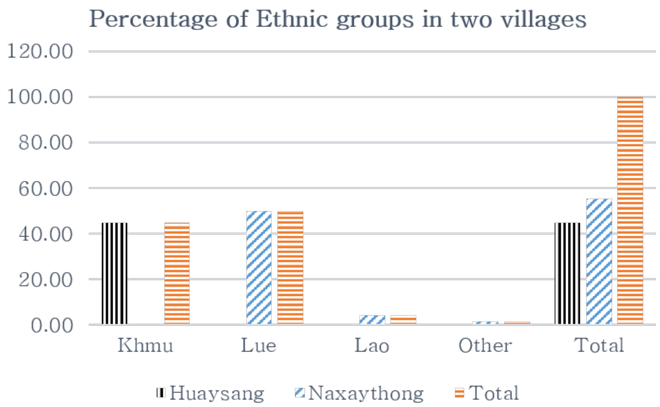


Figure 8: Percentage of Ethnic groups of respondents in two villages

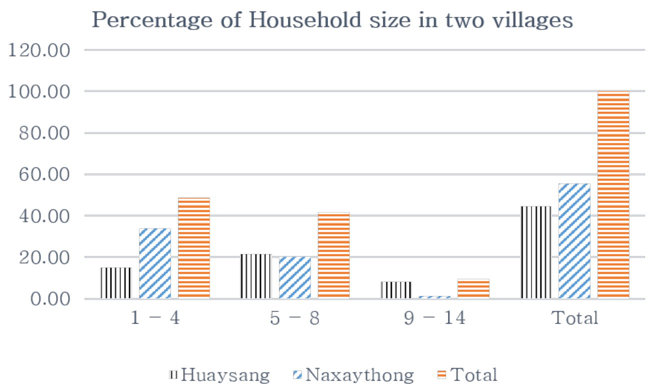


Figure 9: Percentage of Household size in two villages

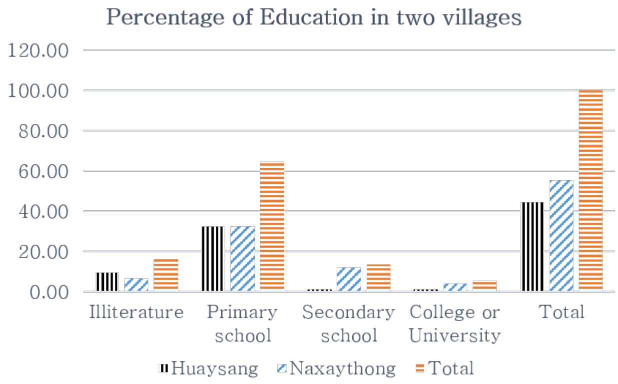


Figure 10: Percentage of Education of respondents in two villages

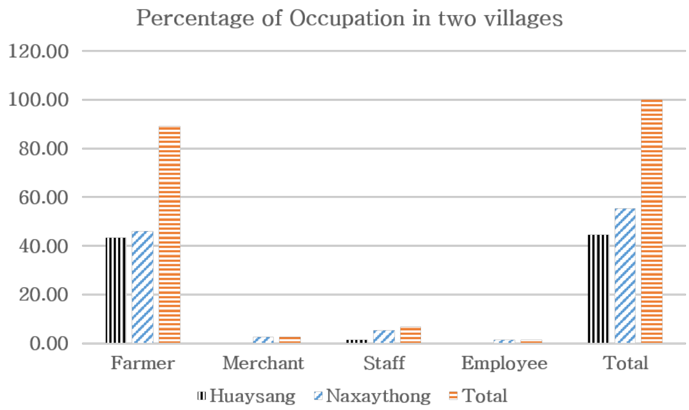


Figure 11: Percentage of Occupation of respondents in two villages

The respondents in Huaysang village more likely have a lower educational level. About 1.35% of the respondents finished secondary school and college or University while the illiterate was 9.46% and 32.43% for primary school. The educational level of respondents in Naxaythong village was 4.05% for college or university and 12.16% for secondary school, respectively. The higher educational level in this study found that some people have a work in school such as teachers, they actually practice rice and other crops cultivation, forest products collection and livestock after finishing their work.

About 89.19% of total respondents in two sample villages were farmers, and other were merchants, staff or teachers and employees with 2.70%, 6.76%, and 1.35% respectively. Specifically, in Huaysang village, the survey found that only the farmers and staffs were 43.24% and 1.35% of total respondents. In contrast, the survey found that the farmers, merchants, staff, and employees for 45.95%, 2.70%, 5.41% and 1.35%, respectively (Figure 11).

3.4.3 Household income sources of two villages

Almost all villagers of two villages always perceive income from forest resources, crop cultivation, livestock husbandry and off-farm activities (Laborer and operating a small business at home), which accounted about 54%, 27%, 5%, 1% and 13% respectively, in Hauysang village. The villagers obtained, in Naxaythong village, about 16% from forest resources, 18% of crop production, 7% from livestock keeping, 32% from operating a small business at home and 27% from working as labor respectively (Figure 12).

Additionally, the household income sources can be separated into the income from forest products collection and agricultural practices by percentage. The forest products provided the three main sources such as NTFPs, timber, and fuelwood; and agricultural products included rice, vegetables, corn and cardamom. In Huaysang village, the people acquired the income about 48%, 4%, 18, 23 and 7% from NTFPs, rice, corn, and vegetables respectively. About 6%, 7%, 52%, and 35% come from NTFPs, fuelwood, rice, and cardamom individually in Naxaythong village (Figure 13).

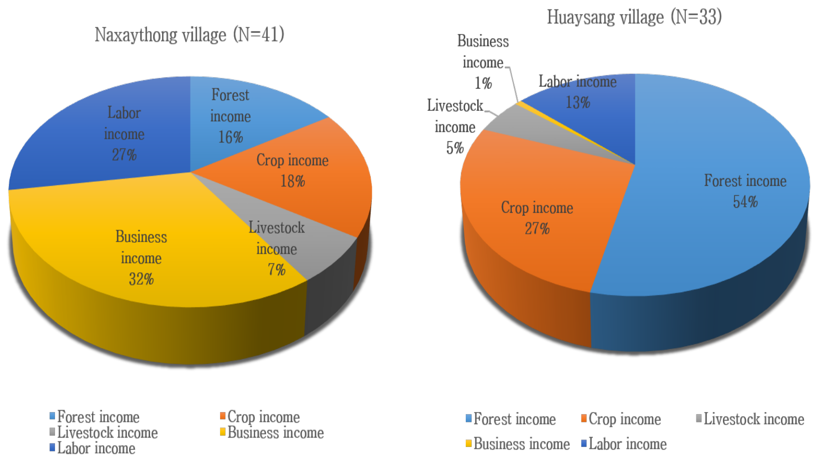


Figure 12: Household income sources by activities

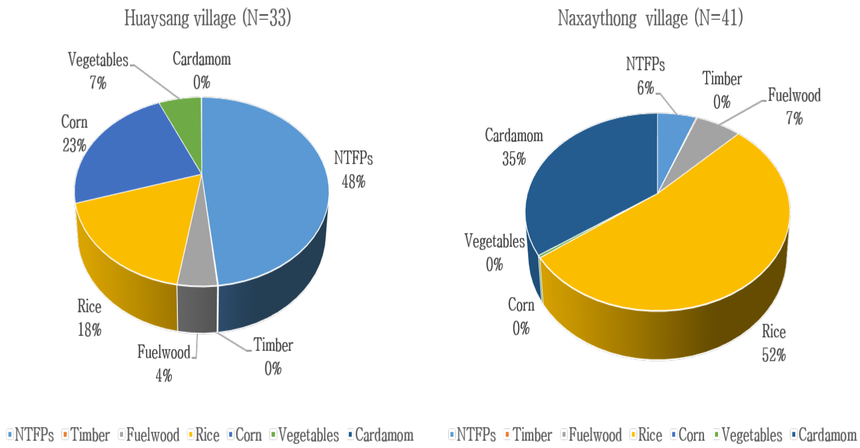


Figure 13: Household income sources by products.

Table 7: Land use activities of two villages

Villages	Income sources	N	Total land holding (ha)	Total land rotation/year (ha)	Cash/capita (%)	Subsistence /capita (%)	Average (%)
Huaysang	Forest products	33	464	–	11.23	18.81	15.02
	Crop products	33	745.5	63.22	2.61	16.06	9.33
	Livestock	33	–	–	5.18	1.03	3.10
	Off-farm	33	–	–	5.89	–	2.94
Total		33	1,209.50	63.22	24.91	35.90	30.39
Naxaythong	Forest products	41	321	–	1.54	28.84	15.19
	Crop products	41	24.97	35.05	-1.35	32.56	15.60
	Livestock	41	–	–	8.88	2.7	5.79
	Off-farm	41	–	–	66.03	–	33.01
Total		41	345.97	35.05	75.10	64.10	69.59

3.5. Household livelihoods of two villages

Almost all people depend on forest resources and agricultural practices in the study area. In Haysang village, the people apply the swidden agricultural system or shifting cultivation about 63.22 hectares per year from total 745.5 ha for mono-crops cultivation, livestock husbandry about 9.33% and 3.10% respectively. The other activities are the forest products collection about 15.02%, which covered both subsistence and cash income, and another was the off-farm activities over 2.94% for cash income (Table 7).

Most of the villagers in Naxaythong village likely depends on agricultural practices, forest products harvesting, livestock and off-farm activities. They obtained the benefits from forest resources about 15.19%. Others were the crops production, livestock over 15.60% and 5.79% respectively. The big income of them were the off-farm activities including laborers and operating a small business at home of 33.01% (Table 7).

3.6. Marketing method in two villages

Figure 10 showed the market types or market access by middlemen, which enters the villages for collecting their products in Huaysang and Naxaythong villages (figure 10). In Huaysang village, there is only one market access by middlemen about 100% selling their products through middlemen, while 81% of respondents in Naxaythong village sell their products to middlemen, 12% of respondents sell their products at the local market and 7% sell to the friends or give to visitors at home (Figure 14).

3.7 Land use characteristics of two villages

Huaysang village has a total area of 1,112 hectares, including community forested utilization area (utilization zone, urban, road, etc.), and land use of householders (agricultural area, housing area). All households use the land for crop productions which is total 745.5 ha, but they have rotated area (Upland with shifting cultivation) around 63.22 ha per year (Table 7). Additionally, they use forest land for the harvesting of forest products which is around 464 ha. This forest area is under village community and governmental regulation.

On the other hand, Naxaythong village is located closely to Phuhiphi-NPA as well as is close to the national road and share a border with production forest. This village has a total area of 546.02 hectares, including community forested utilization area and land use of landholders. All households have a permanent land for agricultural production (flat land) around 35.05 ha, and they also exploit the forest resources for collecting forest products in over 321 ha (Table 7).

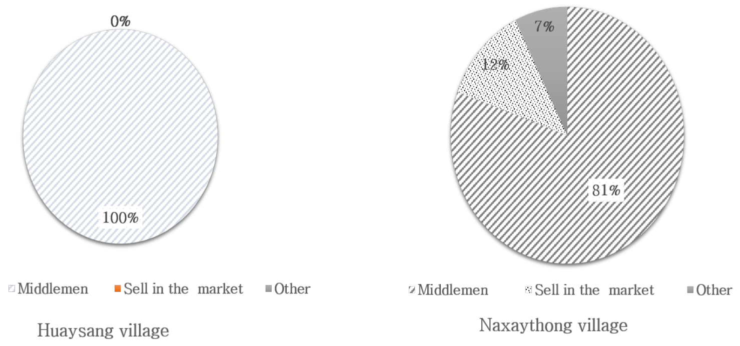


Figure 14: Commodity marketing method of villagers

Chapter 4 Results and discussion

4.1. Household income

The total household income includes subsistence and cash income. These consist of forest products collection (NTFPs, timber, and fuelwood), crop productions and livestock husbandry. The cash incomes are the off-farm activities as a laborer and operating a small business. Table 8 shows the income per person for forests, crops, livestock, business, and labor in two villages surveyed.

Table 8: Summary of household income per person per year of two sample villages

Income sources	Huaysang (N=33)	Naxaythong (N=41)
Forest	2.16 (53.46%)	1.74 (15.99%)
Crops	1.10 (27.22%)	1.95 (17.91%)
Livestock	0.21 (5.23%)	0.72 (6.66%)
Business	0.03 (0.74%)	3.48 (31.97%)
Labor	0.54 (13.35%)	2.99 (27.47%)
Total	4.04 (100%)	10.88 (100%)

Note: Unit of income (million LAK (Lao Kip) per capita/year)

In Huaysang villages, almost people collect the forest products and cultivate crops for generating household income over 2.16 and 1.10 million LAK per capita contributing 53.5% and 27.2% respectively. The income from forests was higher than other income sources in Huaysang village (Table 8). In contrast, in Naxaythong village, the off-farm activities (operating small business and laborer) were more important sources of income about 3.48 and 2.99 million LAK per capita, contributing 32% and 27.5% respectively.

Table 9: Calculation of NPV of Land use in Northern Laos

Village	Income activities	Est. total Land used per HH (ha)[1]	Total HH income (US$/ yr.)	Total HH production cost (US$/ yr.)	HH Net revenue (US$/ yr.)	Land use net revenue per ha (US$/ ha/yr.)[2]	Average land use cost per ha (US$/ha /yr.)[3]	Profits of land use per ha (US$/ha/ yr.)	NPV for land use (US$/ha) for next 20 years	
									Discount rate 6%	Discount rate 10%
Huay-sang (N=33)	Forest collection	235.62	44,244.29	75.83	44,168.45	187.77	0.32	187.45	2,337.56	1,783.37
	Rice cultivation	258.39	19,580.24	76.53	19,503.70	75.77	0.29	75.48	941.25	718.09
	Total crop production	258.39	25,148.29	230.16	24,918.12	97.32	0.89	96.43	1202.55	917.45
Naxay-thong (N=41)	Forest collection	120.51	6,247.01	27.75	6,219.25	51.83	0.23	51.60	643.54	490.97
	Rice cultivation	146.43[4]	19,580.24	158.01	19,422.22	133.71	1.07	132.63	1,653.98	815
	Total crop production	146.43[4]	44,028.09	475.20	43,552.89	300.67	3.24	297.43	3,708.94	1827.58

Note: 1US$=8,224 LAK (online on 2017/06/04); HH: Household, Yr.: Year, [1]Area estimated by ArcGIS. [2]Land use net benefit was calculated by dividing household net revenue excluding the cost for labor and operation business by total area of land used. [3]Average land use cost was obtained by dividing total production cost excluding the cost for labor and operation business by estimated total area of land used. [4] Rice and other crops were cultivated in the same area.

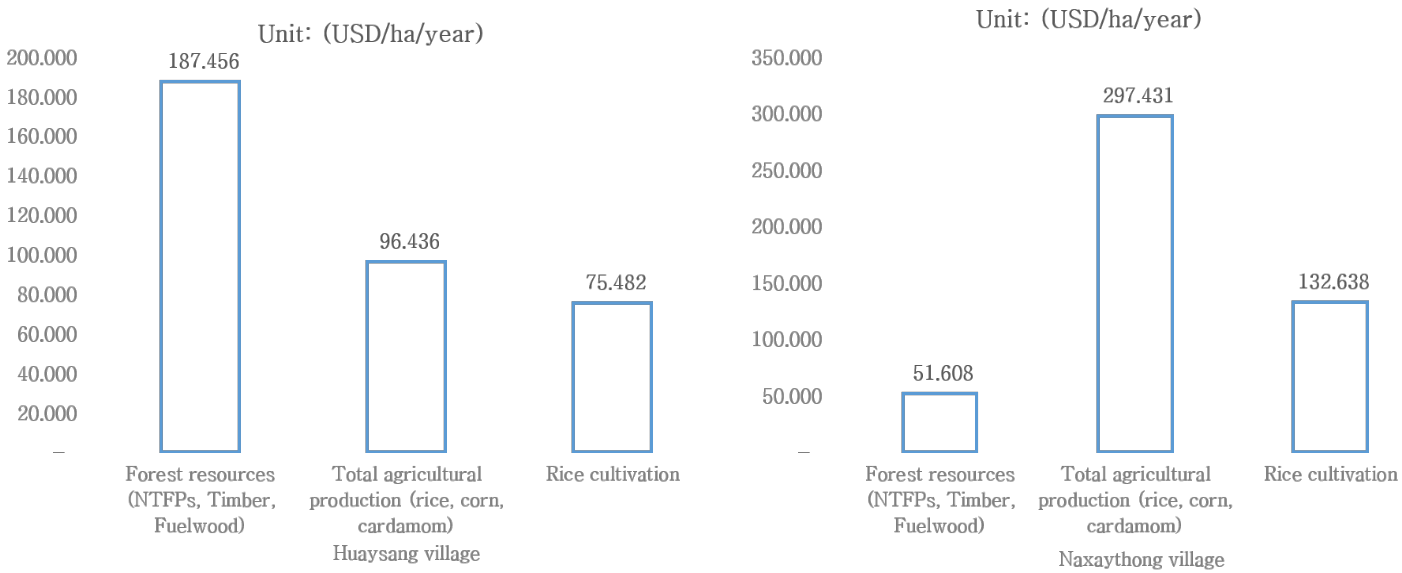


Figure 15: Villager's annual net income from land uses per person

Table 10: Average income per household of two villages

Village	Income activities	Total HH income (US$/ yr.)	Total income per HH (US$/ yr.)
Huaysang (N=33)	Forest collection	44,244.29	1,340.74
	Rice cultivation	19,580.24	593.34
	Total crop production	25,148.29	762.07
Total		88,972.82	2,696.15
Naxaythong (N=41)	Forest collection	6,247.01	152.37
	Rice cultivation	19,580.24	477.57
	Total crop production	44,028.09	1,073.86
Total		69,855.34	1,703.79

4.2. Household revenue of two villages

The main sources of household revenues are forest resources and agricultural productions in two villages. In Huaysang village, the income sources such as forest products and rice provided the net revenue about US$ 44,168.45 and 19,503.70 per year, respectively. Average income from forest products collection per household was US$ 1,340.74 per year, while that of rice cultivation was US$ 593.34 per year (Table 10). In the case of Naxaythong village, the net revenues from forest products and rice were about US$ 6,219.25 and 19,422.22 per year, respectively (Table 9), and that of average income from forest products collection per household was US$ 152.37 per year, and average income from rice cultivation was US$ 477.57 per year (Table 10).

In Huaysang village, the annual profits from forest resources including NTFPs, timber, and fuelwood was US$ 187.45 per ha higher than from rice cultivation while the total profits of agricultural products including rice, corn and cardamom were US$ 96.43 per ha. In Naxaythong village, the annual profits from forest resources were US$ 51.60 per ha, which is lower than profits from rice and agricultural production (Figure 15).

In Huaysang village, forest resources contributed a large amount to annual profits because people depend on forest products for their livelihood. In addition, the rice cultivation contributes not much because shifting cultivation provided low revenues from rice and corn growing, and the crop yield relies on one-time cultivation a year. On the other hand, in Naxaythong village, almost people perceived the more revenues from rice cultivation on (flat farming) and cardamom than forest products (Figure 15).

4.3. Factors related to household incomes and land use change of two villages

The factors influencing household income include family size, market access by middlemen, years of education, rice field distance, the number of medium and big size animals. The model 1 was based on household income from agricultural products, forest products, and livestock husbandry. This model emphasized the relationship among those factors relating the total household income of two samples villages combined. Thus, the model found that the number of the family was a negative factor, meaning that as the household size increases per capita income decreases. The market access and a number of big sized animals were positively related to per capita income of households, meaning that the household income can increase when the re-exists market access and more big animals are raised (Table 11).

Table 12 shows the multiple linear regression model 1 focused on each factor influencing household income for each village, the model was separated household income for a sample each village. This model also found the size of family member negatively influences household income per capita, while the positively significant the market access, years of education and number of medium sized animals positively influence. This means that when there exists more market access to the village, if people have high educational opportunities, they can raise more money from livestock husbandry, crop cultivation and harvesting forest products they can generate more income in Huaysang village.

In Naxaythong village, On the other hand, the number of big sized animals was positively affecting household income because they raise buffaloes and cows on their farm.

Table 11: Multiple linear regression results of model (1)−factors to land use determining household income[1] with samples of two villages combined

Factors	N	Mean and S.E	Std. Deviation	Standardized coefficients (Beta)	t	P−value
Family member	74	5.067 (±0.285)	2.45	−0.23	−2.01	0.049*
Market access (dummy)	74	0.878 (±0.038)	0.33	0.24	2.20	0.031*
Years of Education	74	3.445 (±0.038)	2.63	0.07	0.60	0.547
Rice field distance	74	1.702 (±0.118)	1.02	0.22	1.87	0.066
Amount of medium size animals	74	5.135 (±1.169)	10.05	0.09	0.78	0.437
Amount of big size animals	74	3.337 (±0.796)	6.85	0.38	3.53	0.001**
Constant					−0.26	0.792

Enter method is significant at *p−value <0.05, 0.001**. R=0.495; R square 0.254 or 25.40%; Adjusted square 0.177; F−value=3.625; Sig. 0.04.

[1] Total household income per capita (definition on below Table 11).

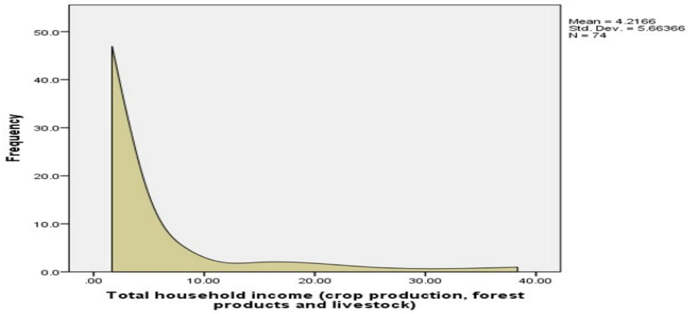


Figure 16: Characteristics of total household income (million LAK per capita) of two villages for model 1.

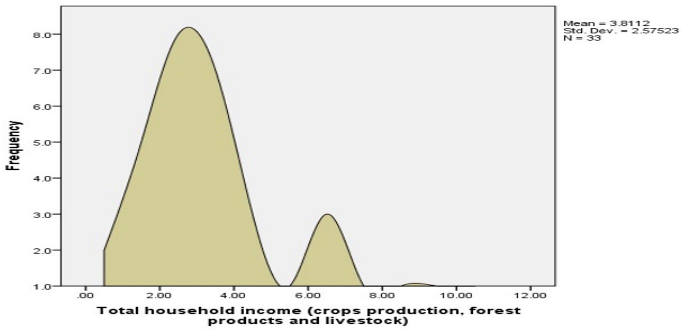


Figure 17: Characteristics of total household income (million LAK per capita) of Huaysang village for model 1.

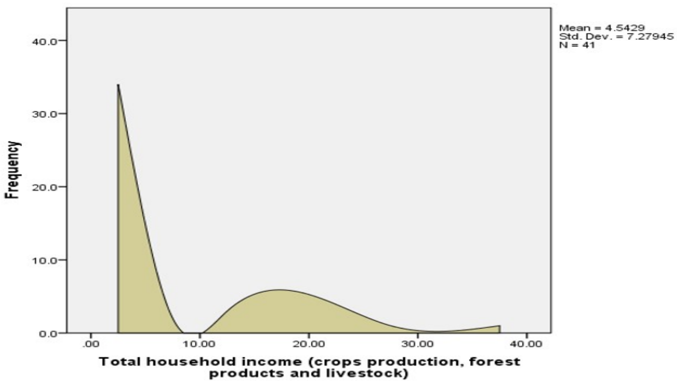


Figure 18: Characteristics of total household income (million LAK per capita) of Naxaythong village for model 1.

Table 12: Multiple linear regression results of model (1) – factors to land use determining household income[7] of each village

Village	Factors	N	Mean and S.E	Std. Deviation	Standardized coefficients (Beta)	t	P–value
Huaysang[1]	Family member	33	5.939 (±0.479)	2.749	−0.511	−2.888	0.008*
	Market access (dummy)[4]	33	0.969 (±0.030)	0.174	0.566	2.661	0.013*
	Years of Education [3]	33	2.742 (±0.390)	2.240	0.460	2.371	0.025*
	Rice field distance	33	1.939 (±0.122)	0.704	0.057	0.321	0.751
	Number of medium animals	33	8.00 (±1.807)	10.380	0.364	1.934	0.064*
	Number of big animals	33	1.515 (±0.450)	2.587	0.149	0.807	0.427
	Constant					−1.284	0.210
Naxaythong[2]	Family member	41	4.365 (±0.304)	1.946	−0.190	−1.187	0.243
	Market access (dummy)	41	0.804 (±0.063)	0.401	0.217	1.413	0.167
	Years of Education [3]	41	4.012 (±0.438)	2.807	0.019	0.105	0.917
	Rice field distance	41	1.512 (±0.185)	1.186	0.218	1.304	0.201
	Number of medium size animals[5]	41	2.829 (±1.449)	9.276	0.063	0.361	0.720
	Number of big size animals[6]	41	4.804 (±1.354)	8.672	0.384	2.526	0.016*

Constant	0.129	0.898

[1] Enter method for significant at *P−value<0.005; R 0.626, R Square 0.392 or 39.20%, Adjusted R Square 0.252; F−value 2.799; ANOVA 0.03.

[2] Enter method for significant at *P>0.005; R 0.495, R Square 0.245 or 24.50%, Adjusted R Square 0.112; F−value 1.842; ANOVA 0.121.

[3] Educational years of villagers finished school by mean of during total years in school level as illiterate 0, primary school 2.5, secondary school 5.5 and College or University 9.5 of two villages.

[4] dummy variable (1=middlemen, 0=other market access);

[5] Number of medium−size animal included pigs and goats;

[6] Number of big size animal included buffaloes and cows.

[7] Total households' income per capita (dependent variable) includes income sources from forest products collection, agricultural production and livestock husbandry.

Table 13: Multiple linear regression results of model (2)−factors determining land use change[1] with samples with two villages combined

Factors	N	Mean and S.E	Std. Deviation	Standardized coefficients (Beta)	t	P−value
Family members	74	4.365 (±0.304)	1.946	0.039	0.332	0.741
Years of education	74	4.012 (±0.438)	2.807	0.170	1.467	0.147
Market access (dummy)	74	0.804 (±0.063)	0.401	0.183	1.564	0.123
Income from forests	74	1.718 (±0.733)	4.694	−0.020	−0.181	0.857
Income from agricultures	74	1.635 (±0.317)	2.031	0.162	1.394	0.168
Income from livestock	74	1.340 (±0.622)	3.986	0.037	0.312	0.756
Forest land	74	384.770 (±8.319)	71.566	0.358	2.859	0.006*
Constant	74				−2.227	0.029

Enter method for significant at *P−value<0.005, R 0.454; R square 0.206 or 20.06%, Adjusted R Square 0.122, F−value 2.444, ANOVA 0.027.

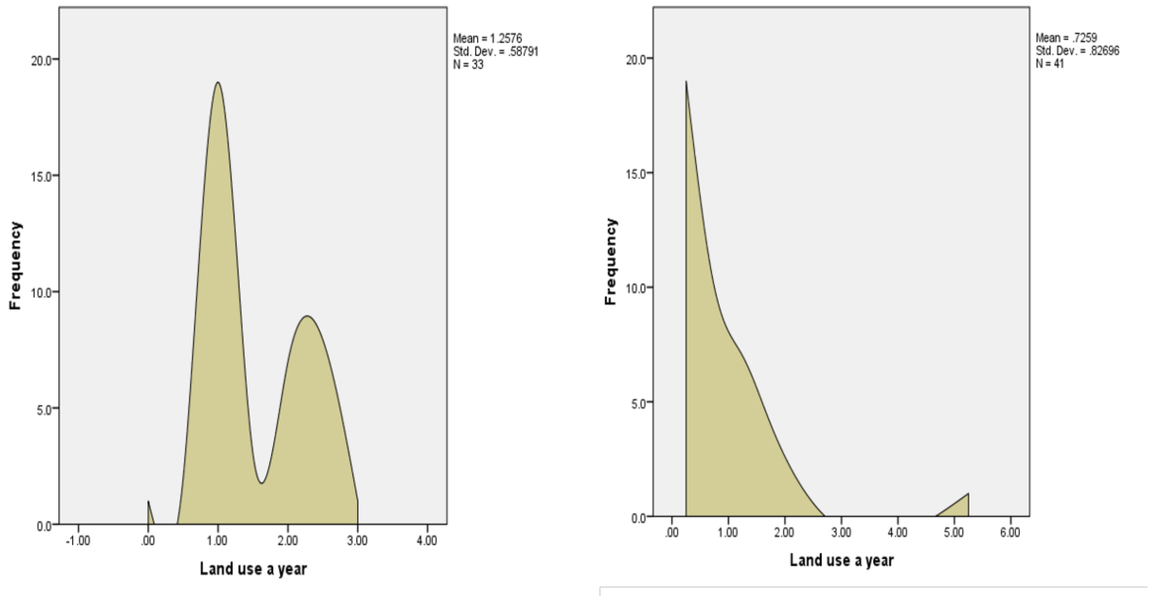
[1] Total land areas use per year of villagers were cleared for crop cultivation (unit of land use size: hectare). Huaysang villagers used their land (upland) by rotating every year for crop production. Naxaythong villagers used their land for permanent crop cultivation (flat land).

Table 14: Multiple linear regression results of model (2)−factors determining land use change with sample of each village

Village	Factors	N	Mean	Std. Deviation	Standardized coefficients (Beta)	t	P−value
Huaysang[1]	Family members	33	5.939 (±0.479)	2.749	−0.062	−0.401	0.692
	Years of education	33	2.742 (±0.390)	2.240	0.155	0.853	0.401
	Market access (dummy)	33	0.969 (±0.030)	0.174	0.391	2.210	0.036*
	Income from forests	33	2.1209 (±0.301)	1.846	−0.185	−1.186	0.246
	Income from agriculture	33	1.131 (±0.136)	0.784	0.346	2.153	0.041*
	Income from animals	33	0.589 (±0.191)	1.099	0.363	2.286	0.031*
	Constant					−0.557	0.582
Naxaythong[2]	Family members	41	4.365 ±(0.304)	1.946	0.082	0.474	0.639
	Years of education	41	4.012 (±0.438)	2.807	0.242	1.442	0.158
	Market access (dummy)	41	0.804 (±0.063)	0.401	0.148	0.886	0.382
	Income from forests	41	1.718 (±0.733)	4.694	−0.002	−0.009	0.993
	Income from agriculture	41	1.635 (±0.317)	2.031	0.117	0.674	0.505

	Income from animals	41	1.340 (±0.622)	3.986	0.005	0.025	0.980
	Constant					−0.071	0.944

[1] Enter method for significant at *P−value <0.005; R 0.735; R Square 0.540 or 54%; Adjusted R Square 0.434; F−value 5.086; ANOVA 0.001. [2] Enter method for significant at P−value >0.005. R 0.301; R Square 0.090; Adjusted R Square −0.070. F−value 0.563; ANOVA 0.757.



Huaysang village Naxaythong village

Figure 19: Characteristics of land use per year (hectare) for model 2 of each village.

The model 2 is based on household activities on their land use for shifting cultivation and farming. The model tested the samples of two villages combined. This model included family members, years of education, market access by middlemen, income from forest resources, agriculture, livestock and forest land independent variables with samples combined from two villages. We found that only forest land was positively significant to increase land use area for cultivation. This implied that if these are abundant forest land not cleared, there will be changed for land use conversion to shifting cultivation and farming (Table 13).

When the model 2 applied to each village (Huaysang and Naxaythong village) separately, the results are different (Table 14). In Huaysang village, family members, years of education, market access, income from forest, agriculture, and livestock were found to be statistically significant. The result of regression shows that the market access through middlemen, income from agriculture and income from animals were positively related to land use for shifting cultivation. This means that when middlemen (market access) enter the village for collecting products, the people who practice shifting cultivation clear more forests for crops cultivation and raise more livestock husbandry in order to generate the households' income.

Table 15: Land use area and land use change of two villages for the period 1988-2005, 2005-2016, 1988-2016.

Villages	Land uses class	Area (ha)			Changes (%)		
		1988	2005	2016	1988-2005	2005-2016	1988-2016
Huaysang	Uncover Land/Paddy rice Field	191.88	112.95	258.39	-7.11	13.09	5.99
	Fallow area	293.22	292.68	254.7	-0.05	-3.42	-3.47
	Young Forest area	294.39	364.23	362.07	6.29	-0.19	6.09
	Secondary Forest	331.29	340.92	235.62	0.87	-9.48	-8.61
	Total[1]	1110.78	1110.78	1110.78	0	0	0
Naxaythong	Uncover Land/Paddy rice Field	98.91	140.22	146.43	7.57	1.14	8.70
	Fallow area	110.16	136.71	157.86	4.86	3.87	8.74
	Young Forest area	162.63	144	121.14	-3.41	-4.19	-7.60
	Secondary Forest	174.24	125.01	120.51	-9.02	-0.82	-9.84
	Total[2]	545.94	545.94	545.94	0	0	0

Data of land use areas were collected by the field survey of village boundary and estimating area by functioning of ArcGIS.

[1] Missing 1.22 ha, and [2] Missing 0.08 Hectare for total area of village was interpreted from Landsat TM and OLI with Spatial Analyst extension in ArcGIS.

4.4. Land uses and Land use change during 1988–2016

The result from spatial analysis of ArcGIS indicates the considerable limitation from applying Landsat database on among three years of 1988, 2005, and 2016. The interpretation of land use change from satellite images in this study focused on four categories of land use, including paddy rice or rice field both of upland and flat land, pasture or fallow area, young forest and secondary forest (Appendix 1).

Table 14 shows the area and percentage of land use change in two villages. The field observation focused on the area of crop cultivation, fallow land, young forests and secondary forests in the period years of 1988–2016, 2005–2016 and 2005–2016. In Huaysang village, the land areas of the crop (rice and other crops) cultivation increased by 13.09% for the period of 2005–2016, and secondary forest areas decreased by 9.48% (Table 15). This is because they rotate the land for shifting cultivation. Agricultural crops such as rice and other are cultivated more than one year after clearing forests.

In Naxaythong village, the area of crops and fallow land increased by 8.70% and 8.74% for the period 1988 - 2016. But young forests and secondary forests areas decreased by 7.60 and 9.84%, respectively. Because of farming for agricultural production, they cleared only their land holdings within the village, they are unable to clear forests in other areas beyond their village. Especially, GoL restricts the land use for expanding of agricultural land to other areas beyond the village boundary.

4.5. Co2 emission from land use changes

The greenhouse gases (GHG) carbon dioxide (Co2) emissions from shifting cultivation depend on the type of land use change. There are three main types of land uses observed in the village studied. This research applied the carbon stock level on above ground biomass and soil organic carbon based on literature which is considered to be relevant to land uses including shifting cultivation in Northern Laos (Table 5). Table 15 shows the Co2 emission from deforestation and forest degradation by land use including secondary forest, shifting cultivation for rice and crop cultivation with rice, corn and cardamom of the two villages. The GHG emission due to land use changes from changing the secondary forest areas to shifting cultivation for rice cultivation (LUC1) which emits Co2 about 880.80 ton per ha, changing secondary forest to other crops cultivation (LUC2) emits Co2 about 665.481 ton per ha, and changing the crop cultivation to shifting cultivation for rice (LUC3) emits the Co2 about 215.318 ton per ha (Table 16) (Suzanne, 2014; Kavinchan, et al., 2015; Takeuchi, et al., 2015).

The GHG emission due to land use change from secondary forest to rice and other mono-crop cultivation b shifting cultivation was found to be largest, while land use change from other crop cultivation to rice mono-culture shifting cultivation is least. The GHG emission for land use change from secondary forest area to shifting cultivation for rice was about 880.80 ton per ha calculated by Co2 stock in secondary forest area minus the Co2 stock in the areas of shifting cultivation for rice. The case of land use change from secondary forest area to crop cultivation including rice, corn and cardamom area was about 665.48 ton per ha calculated by Co2 stock in secondary forest area minus Co2 stock in the area of crop cultivations. The case of land use change from crop production areas to shifting cultivation for rice cultivation, it was about 215.318 ton per ha calculated by Co2 stock in crop cultivation area minus Co2 stock in areas of shifting cultivation for rice (Table 16).

According to the result, if we clear the secondary forest for shifting rice cultivation, it will emit a larger amount of Co2 to the atmosphere than the case of changing the secondary forest area to crop cultivation including rice, corn and cardamom, and that of changing crop production land to shifting rice cultivation. This means that in order to reduce GHG emissions forest areas should be compensated to avoid household activities for generating income by practicing agriculture.

4.6. Opportunity cost of avoiding deforestation and forest degradation

The estimation of opportunity cost (OC) generally is necessary for compensating the shifting cultivation for their cost of avoiding deforestation. The OC is the economic benefits forgone in terms of the value of products gained from land use otherwise (US dollar per hectare). Thus, the opportunity cost analysis (OCA) indicates the potential the cost associated with avoiding deforestation from land use practices for the successful REDD+ payment scheme (Plumb, et al., 2012).

Table 17 shows the opportunity cost of avoiding deforestation and forest degradation for forest conservation. The OC differs for land use changes in the two villages. In Huaysang village, the net benefits from conversion of forest land (secondary forest areas) to shifting cultivation land for rice (LUC1) was US$ 0.942 per tonCo2, net benefits from secondary forest to other crop cultivations (LUC2) US$ 1.593 per tonCo2, and in the case of changing crop cultivations to shifting cultivation for rice (LUC3) US$ 3.853 per tonCo2, respectively.

In the case of Naxaythong village, the net benefits from changing secondary forest areas to shifting cultivation for rice (LUC1) was US$ 1.402 tonCo2, the net benefits from secondary forest to other crop cultivation US$ 1.855 tonCo2, and net benefits from crop cultivation to shifting cultivation for rice US$ 5.733 tonCo2.

Finally, the OC for avoiding deforestation and forest degradation is based on people's benefits from land use changes. The high net benefits from changing secondary forest area to shifting cultivation are most important for forgone the forest areas conversion to rice and other crop productions because almost all people live in the mountainous area, they practice the agriculture for their livelihoods. In Naxaythong village, people can perceive higher benefits from rice and crops cultivation than Huaysang village, because the farming in the flat land can produce higher yields of rice and crop production than shifting cultivation (Table 17). Therefore, the high benefits from shifting cultivation for rice is the high opportunity cost which leads to deforestation and forest degradation. Hence, the governmental policies should promote these issues to the international funds for reducing GHG of Co2 emission such as REDD+ projects.

Table 16: Greenhouse gases emission from deforestation and forest degradation due to the agricultural expansion of two villages in Northern Laos.

Village	Land use	Carbon stock (AGB[1]+SOC[2]) (tone/ha)	Co2 [3] (tone/ha)	Co2 emission from land use change (tone/ha)	
				(Changing) from secondary forest	(Changing) from crop productions
Huaysang, Naxaytong	(to) Secondary forest	268.11	983.963	0	−665.4811
	(to) Shifting cultivation for rice	28.11	103.163	880.800	215.318
	(to) Crop cultivations (rice, corn and cardamom)	86.78	318.482	665.481	0

[1]AGB: Above ground biomass carbon; [2]SOC: Soil Organic Carbon; [3]Carbon dioxide store by default value conversion 3.67 from carbon stock.

Table 17: Opportunity cost of avoiding deforestation and forest degradation for forest conservation.

Village	LUC1[1] (US$/ tonCo2)	LUC2[2] (US$/ tonCo2)	LUC3[3] (US$/ tonCo2)
Huaysang	0.942	1.593	3.853
Naxaythong	1.402	1.855	5.733

LUC: Land Use Change; [1]LUC1: Changing from secondary forest areas to shifting cultivation for rice; [2]LUC2: Changing from secondary forest to crop cultivation include rice, corn, and cardamom; [3]LUC3: Changing from crop cultivation to shifting cultivation for rice.

4.7. Discussion

The main research objectives are to investigate the factors influencing households' income from land use change by indigenous people who are closely living to and inside NPA, and to estimate the opportunity cost of forest conservation from shifting cultivation for foregone activities which lead to deforestation.

The annual households' incomes per capita differ in two villages investigated. The household income per capita of Huaysang village is 4.04 (US$ 491) million LAK and that of Naxaythong village 10.88 (US$ 1,323) million LAK. The household per capita income is lower than national per capita income of Laos which is US$ 1,740 in 2015 (World Bank, 2017). Meanwhile, the households earn income as subsistence and cash income, which was around US$ 1.35 per day in Huaysang village and US$ 3.62 per day in Naxaythong village. The Huaysang's per capita income is close to the poverty line which is US$ 1.25 per day (ADB, 2016). According to these results, the indigenous practicing shifting cultivation in the protected area is in poverty line.

The income sources of two villages in Northern Laos depend on forest land uses from forest resources (NTFPs, timber, and fuelwood) collection, agricultural practices (rice and crops cultivation, livestock husbandry) by shifting cultivation.

The results of multiple linear regression analysis revealed that households' incomes and land use changes are a function of socioeconomic factors, type of land use change practices and access to markets.

The model 1 identified the factors relating households' income in two villages. The same regression model was applied to two cases. First, factors determining household income with two sample villages combined, and second, factors determining household income with each village. Firstly, the model estimated with samples of two villages found that family size, marketing by middlemen and number of big-size animals influence to household income. The family size is negatively significant to household income. When the number of family size in the household increases, the household income will decrease. But the market access by middlemen and number of big-size animals positively influence to household income. When the middlemen enter the villages, almost all people can raise the household income by converting forest land to agricultural lands for crop cultivation and livestock husbandry.

Secondly, the model applied of each village. In Huaysang village, the result of estimation found that the family size negatively influences household income, meaning that the household income will be decreased by the size of the family in rural areas. The market access by middlemen, years of education and number of medium-size animal positively influence household income, meaning that the middlemen enter the village or when the villagers have easy access to the market, the market will motivate the villagers to generate more income by clearing forest areas to crops land and livestock husbandry in the farm. Especially, they practice agriculture with big animals at farm land, they have more number of animals then they can raise household income. Specifically, the people with high educational level are teachers of the primary school located in Huaysang village. They can generate more money into households because they can earn money from working in a school and enter the forest area. In the case of Naxaythong village, number of big-size animals was also important for generating household income of villagers

This study suggests the market access by middlemen, a number of livestock animals and years of education in rural community influence the household income. According to some investigations from previous studies, the number of livestock influences household income, and it was important to economic activities by households (Langat et al., 2016) of the case study for the role of forest resources for local livelihood in Kenya. The higher educational level can generate more the household income more than lower educational level but it does not influence land use change (Nzunda, et al., 2013). The big family size cannot generate more income from the agricultural practices and forest harvesting (Fadipe, et al., 2014).

The second was designed to model explain the factors influencing land use change in the two villages. This model based on land use per year of each household including crops land and livestock husbandry field. There are two cases of applying this model: one for factors determining land use change with samples of two villages combined and another for the factors determining land use change with samples of each village. The first case found that the size of forest land influences positively land use change, meaning that when the people increase the clearing of forest areas for shifting cultivation for rice and other crops cultivation, the deforestation will be at a higher rate when there is abundant forest remaining. Secondly, the model has compared the result of regression to each village. In Huaysang village, the result of regression analysis discovered market access, income from crops cultivation and livestock husbandry positively influence the land use change. The market accessibility powerfully influences land use change, because as the middlemen enter the village, the villagers try to be increased household income by changing the forest areas to shifting and crop cultivations and livestock husbandry. But in Naxaythong village, any factor was not found be significant for land use change.

The market access by middlemen is important for increasing their household income because the marketing by middlemen collects their agricultural, forest products and livestock animals in rural villages. According to previous studies, the market access to the middlemen are the proxy drivers of land use and land cover changes of the south-central Highland in Ethiopia (Kindu et al., 2015). Other cases found some factors in the article of the land use changes in the upland of South East Asia, this research site was located in Northern

Laos, which expressed the market access by promoters in order to motivate generating household income. This issue was affected land use changes by the Governmental policy of Laos, they supported investors in provinces for their collecting and/or producing crop productions in rural area, meaning that when the traders have more demands of the forest and crops products in rural village, villagers will be exploiting the natural resources (Thongmanivong, et al., 2009).

This study suggests that the market access by middlemen are related the land use changes because market access can increase people converting forest areas to agricultural land with livestock husbandry. If there is the market access to the villages, it will cause to land use change. In this case, even though people can raise their income by selling their crops to the middlemen, it will be giving more incentive to the local people for practicing shifting cultivation with rice, corn and cardamom and timber harvesting.

Land use changes are under the household activities for generating income from agricultural practices and forest products harvesting. Two villages differ in the land areas, operating jobs, regional conditions and facilities for crop cultivation. In Huaysang village, people practice the shifting cultivation on the upland and over-exploitation of forest resources clearing new land areas each year over one hectare per household for crop production, which caused to decrease secondary and young forest areas.

In Naxaythong village, people use land as a permanent farm, because their land are a flat and limited area, meaning that they are unable to move to other places for crop productions. One reason is that the government organized land allocation for farming and forest areas such as villages' community forest utilization and individual land holdings. The household practice for rice, cardamom cultivation and harvesting the forest resources for NTFPs, timber, and fuelwood. Indeed, this effect of land use made to increase the secondary and young forest areas in the period the years 2005-2016.

In this study, the opportunity cost analysis provided the reduction of GHG emission from deforestation and forest degradation. Considering the current practices of changing forest areas to rice cultivation and forest area to other crop cultivations, these could be the high opportunity cost for foregoing the household activities from clearing forest areas to shifting cultivation if REDD+ program is enforced. As a result, there will be high opportunity cost evolved to implement REDD+ to reduce deforestation and forest degradation, almost all people in Laos perceive more benefits from changing forest areas to shifting cultivation for rice and other crop cultivations. Understanding of these land use changes are important for estimating opportunity cost for forest conservation from deforestation and forest degradation.

FAO (2016) reported the OC for forgoing the crop productions in forest land, which focused on integrating forests and wood products in climate change strategies. Therefore, the value carbon of maize, groundnut, cocoa bean, and sorghum were considered as high OC, but rice cultivation could not be considered in the case of Africa because the particular maize growth covered the value of carbon from US$5 to 20 per tonCo2. Thus, the result suggested that avoiding clearing forest for maize and others were the best opportunity for mitigation from land use change. The case study of Africa countries is higher opportunity cost than this study in Northern Laos about US$3.8 per tonCo2 and US$5.7 per tonCo2 from changing secondary forest area to shifting cultivation and other crops cultivation, respectively.

In conclusion, the most important factors influencing the household income are the market access by middlemen, years of education, and livestock number. Family size negatively influences household income per capita. Moreover, this study found that the forest areas affected land use change in the Naxaythong village, and the market access, income from agricultural products and livestock positively influence land use change in the Huaysang village.

Chapter 5 Conclusion and recommendation

5.1. Conclusion

Generally, the main sources of household income include forest resources, agricultural practices including rice and other crop cultivations, livestock husbandry, and off-farm activities (labor and business). In Huaysang village, household income from the forest, crops, livestock, business operation and working as labor were estimated to be about 54%, 27%, 5%, 1% and 13%, respectively. In Naxaythong village, household income from the forest, crops, livestock, operating a business and working as labor was estimated to be about 16%, 18%, 7%, 32% and 27%, respectively. Additionally, the percentage of household income per capita of Huaysang village from forest resources harvesting and crop production accounted for 53.5% and 27.2%, respectively. In Naxaythong village, household income from business operation and working as labor contributed to about 35% and 27.5%, respectively. According to the main household activities on farms, there were annual profits from forest products, rice, and other crop cultivations in the two villages. In Huaysang village, they accounted for US$ 187.45, 75.48 and 69.43 per ha respectively, while in Naxaythong village US$ 51.60, 132.63 and 297.43 per ha, individually.

Data collected was applied regression analysis for factors influencing household income per capita and land use change in two villages. According to the result of linear regression analysis, when all factors combined samples of two villages, the result shows that the market access and a number of big-size animals positively influence household income, this means that the middlemen enter the village, people can raise the household income from the animals, crop cultivation, and forest products. However, family size negatively influences household income. When the regression analysis separated the samples of each village, it found that the market access by middlemen, years of education and number of medium-size animals positively influence household income, but family size also negative influence household income, meaning that the family size increase members, their income will be decreased. Meanwhile, when the linear regression combined the samples of two villages for analyzing factors influence land use change, it found that the forest land positively influences land use change, if the government does not protect the forest areas, there will increase deforestation area. Moreover, when the regression analysis has separated the samples of each village. In Huaysang village, the market access by middlemen, income from agriculture and livestock positively influence land use change, meaning that when the middlemen enter the village, people can increase household income by clearing and expanding the forest areas to crop cultivations with livestock husbandry.

There are many land use changes due to household activities in two villages in 1988, 2005 and 2016 in Northern Laos. In Huaysang village, satellite imagery interpretation shows that land use change from converting forest land to paddy rice area, fallow area, young forest areas, and secondary forest area from 1988 – 2016 are about 5.99%, 3.47%, 6.47% and 8.61%, respectively, the land use change from forest areas to paddy rice field increased a larger area in 2005 to 2016 about 13%. In Naxaythong village, the land use changes from converting forest land to rice field, fallow area, young forest areas, and secondary forest in 1988 – 2016. The land use change from forest area to rice field was the larger area in 1988–2005 about 7.57%, this area decreased to 1.14% in 2005–2016. For the period (1988–2016), paddy, fallow area increased by 8.7%, while forest land decreased by the same amount.

Finally, land use change from forest areas to agricultural land for rice shifting and other crop cultivations, and harvesting forest products were generating benefits. These benefits cause deforestation and forest degradation. In Huaysang village, the OC of avoiding land use change from forest area to shifting cultivation for rice (LUC1) was US$ 0.942 per tonCo2, that of land use change from secondary forest area to other crop cultivation (LUC2) was about US$ 1.593 per tonCo2. The case of land use change from crop cultivations to shifting cultivation for rice (LUC3), which accounted US$ 3.853 per tonCo2. Another case, in Naxaythong village, the opportunity cost of avoiding LUC1 was US$ 1.402 per tonCo2, US$ 1.855 per tonCo2 for the LUC2, and US$ 5.733 per tonCo2 for the LUC3, respectively.

This research presented evidence of factors influencing household income from converting forest areas to crop land. Forest area conversion from shifting cultivation for upland rice, corn, and cardamom of two villages in Northern Laos generate high benefits. These activities of people clearing forest areas to rice and other crop cultivation gathering livestock husbandry can provide the basis for estimating opportunity costs of avoiding deforestation and forest degradation. Thus, the avoiding forest conversions can be an opportunity for forest conservation from shifting cultivation for rice and other crop cultivation, which is the most efficient for GHG Co2 emission mitigation from land use change.

5.2. Recommendation

This study site lacks land allocation for mapping and database about crop productions, sustainable forest management in term of forest utilization and conservation. Socioeconomic and culture influence household income and land use change. The factors influencing household activities are motivated by economic benefits from land uses. All of the villagers have access to the natural resources from the surrounding areas and activities include harvesting NTFPs, timber, fuelwood in NPA. Many households conduct shifting cultivation in the NPA region with mono-crop production. Their behaviors result in deforestation and forest degradation, which affect the forest cover and contribute to land use change.

Therefore, future studies should be focused on forest carbon sequestration and biodiversity in the national protected area in order to monitor the forest cover change, as well as ecosystem services for people living inside the national protected area.

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Appendix

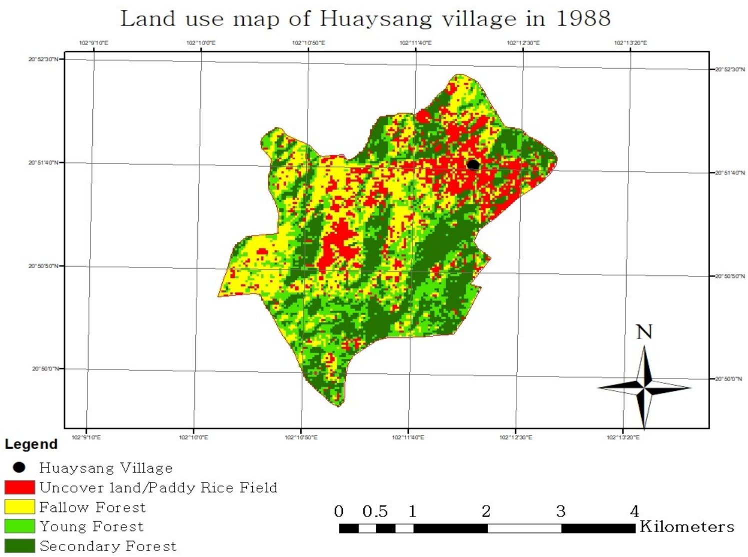
1. Household characteristic of two sample villages.

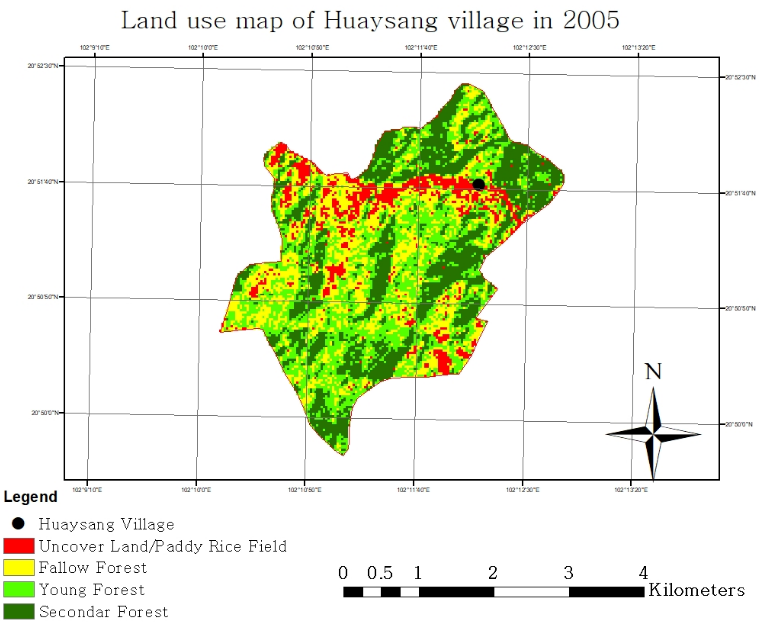
Household Characteristic of two sample village						
Variables	Villages				Total	
	Huaysang		Naxaythong			
	N	%	N	%	N	%
Gender						
Male	20	27.03	20	27.03	40	54.05
Female	13	17.57	21	28.38	34	45.95
Total	33	44.59	41	55.41	74	100.00
Age Range						
Age 20−39	15	20.27	16	21.62	31	41.89
Age 40−59	16	21.62	16	21.62	32	43.24
Age 60−80	2	2.70	9	12.16	11	14.86
Total	33	44.59	41	55.41	74	100.00
Ethnical groups						
Khmu	33	44.59	0	0.00	33	44.59
Lue	0	0.00	37	50.00	37	50.00
Lao	0	0.00	3	4.05	3	4.05
Other	0	0.00	1	1.35	1	1.35
Total	33	44.59	41	55.41	74	100.00

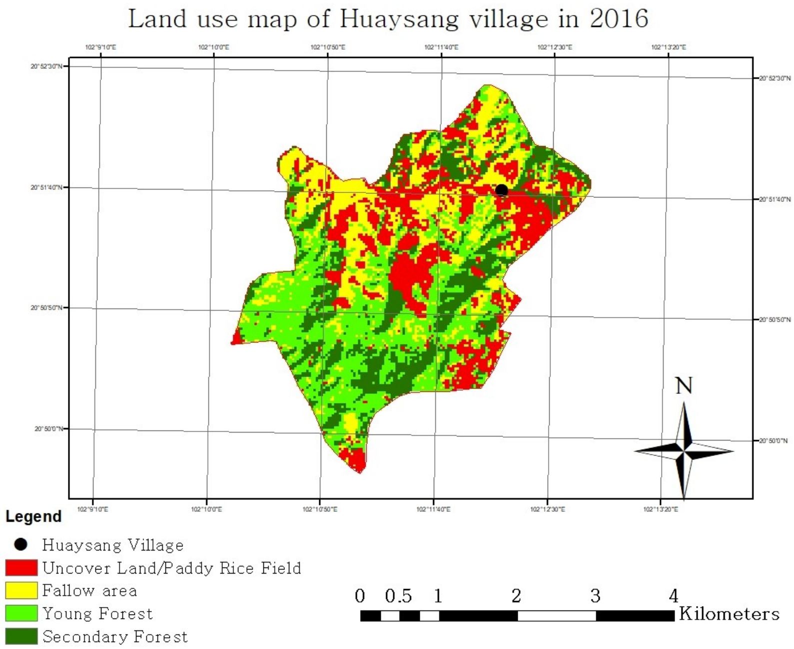
Household size						
1 – 4	11	14.86	25	33.78	36	48.65
5 – 8	16	21.62	15	20.27	31	41.89
9 – 14	6	8.11	1	1.35	7	9.46
Total	33	44.59	41	55.41	74	100.00
Educational levels						
Variables	Village				Total	
	Huaysang		Naxaythong			
	N	%	N	%	N	%
Illiterate	7	9.46	5	6.76	12	16.22
Primary school	24	32.43	24	32.43	48	64.86
Secondary school	1	1.35	9	12.16	10	13.51
College or University	1	1.35	3	4.05	4	5.41
Total	33	44.59	41	55.41	74	100.00
Occupation						
Farmer	32	43.24	34	45.95	66	89.19
Merchant	0	0.00	2	2.70	2	2.70
Staff	1	1.35	4	5.41	5	6.76
Employee	0	0.00	1	1.35	1	1.35
Total	33	44.59	41	55.41	74	100.00

2.Land use map

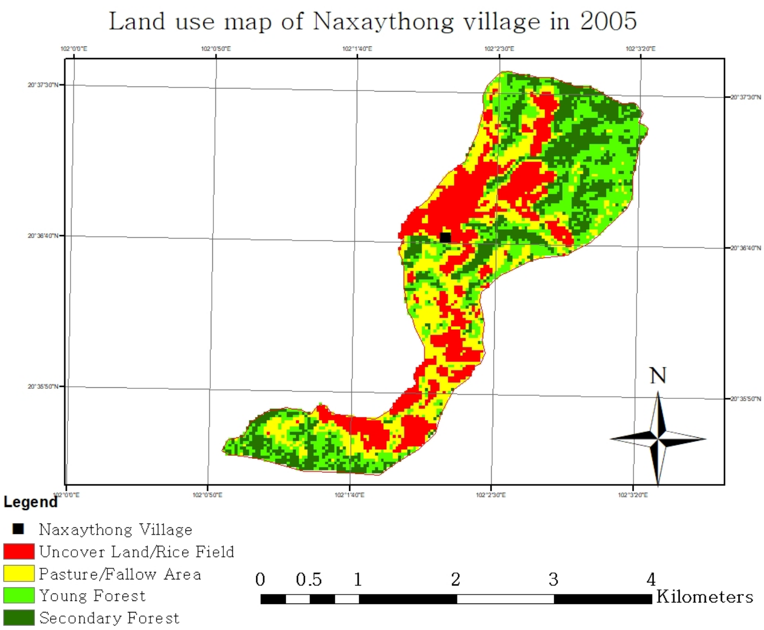
2.1 Land use map (unpublished) of Huaysang village in 1988 – 2016



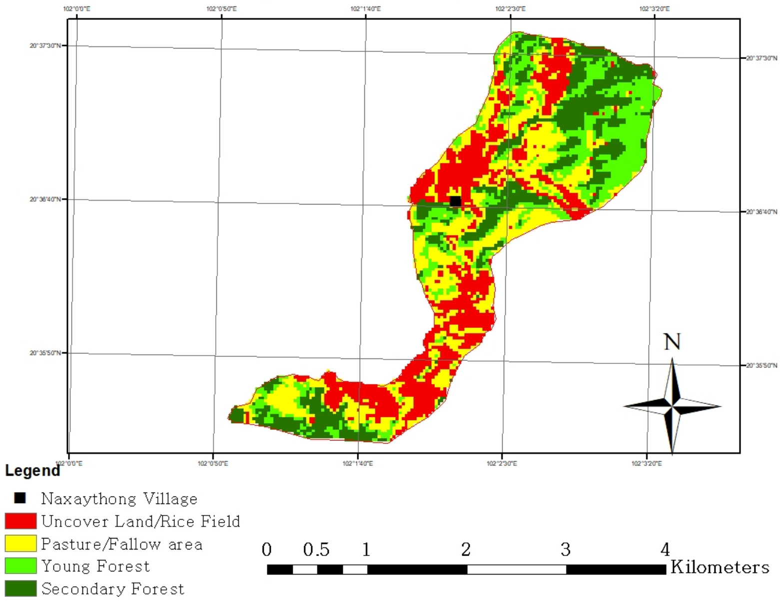




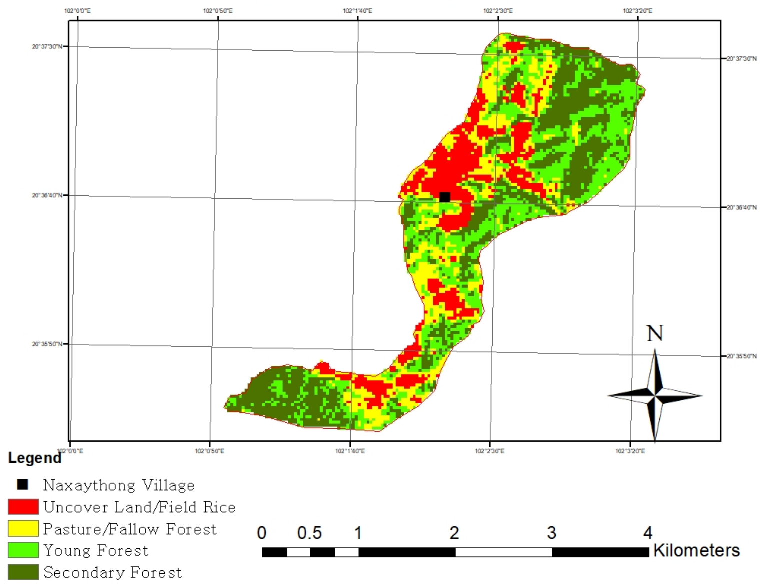
2.2 Land use map (unpublished) of Naxaythong village in 1988 – 2016



Land use map of Naxaythong village in 2016



Land use map of Naxaythong village in 1988



3. Factors identification and definition

No.	Model	Variables	Definition	indicators
1	1	Household income per capita	Household Incomes come from agricultural practices (crops cultivation), forest products collection (NTFPs, timber, and fuelwood), and livestock	Dependent variable
2	2	Total land use per year	Land use for crop cultivation per year (rotating land use per year)	Dependent variable
3	1	Number of medium-size animal	The number of medium- size animals.	Independent variable
4	1	number of big-size animals	The number of big-size animals.	Independent variable
5	1	Rice field distance	Distance (kilometer) of rice farm far from villages.	Independent variable
6	1-2	Market access	The middlemen collect all products in villages	Dummy (1; 0)
7	1-2	Years of Education	The years finished of respondent sampled household in education, including illiterate 0 year, primary school 2.5 years, secondary school 5.5 years, and college or University 9.5 years.	Independent variable
8	1	Household size or family size	Number of family in the households	Independent variable
9	1	Village	Huaysang village (1), Naxaythong village (0)	Dummy (1; 0)
10	2	Forest land	Each village has forest area for every one as	Independent variable

			the same area	
11	2	Income from forest harvesting	Income from forest harvesting of NTFPs, timber and fuelwood	Independent variable
12	2	Income from agricultural production	Income from agricultural production include rice, corn, vegetables and cardamom	Independent variable
13	2	Income from livestock husbandry	Income from livestock husbandry include big, medium and small animals	Independent variable

초 록

라오스 북부 우돔싸이주푸히피 국가 생물다양성 보전 지역(NBCA)에 거주하는 지역주민의 75~80%가량은 산림을 농지로 전용하여 농작물을 생산하는 일에 생계를 의존한다. 이 연구의 목적은 라오스 북부 산림 지역의 가구 소득과 토지이용 변화에 영향을 미치는 요인을 규명하고, 화전 경작으로 인한 라오스 산림 전용을 방지하기 위해 발생할 기회비용을 산정하는 것이다. 두 마을에서 74 개 가구를 랜덤 추출한 뒤 빈곤환경네트워크(PEN) 가이드라인을 이용하여 인터뷰하였고, 현장조사와 ArcGIS 프로그램에서 제공하는 위성영상을 이용하여 토지이용 변화를 분석하였다. 가구 소득과 토지이용 변화에 영향을 미치는 요인을 분석하기 위해 다중회귀분석을 실시하였고, 산림 전용 방지의 기회비용을 산정한 뒤 이를 순현재가치(NPV)로 변환하였다.

이 연구에서 우돔싸이 지역의 가구 소득은 주로 비목재임산물, 목재, 땔감 등의 임산물과 쌀, 옥수수, 카르다몸 등의 농작물, 그리고 가축 축산물로부터의 소득으로 구성되었다. 전체 응답을 분석한 결과, 가족 수, 중간 상인을 이용한 시장 접근, 가축의 수가 이들의 가구 소득에 영향을 미치는 요인으로 나타났다. 후아이상(Huaysang) 마을에서는 가족 수(−), 시장 접근성(+), 교육 년 수(+), 중형 가축의 수(+)가 가구 소득에 영향을 미쳤으며, 나사이통(Naxaythong) 마을에서는 대형 가축의 수(+)만 가구 소득에 영향을 미쳤다.

임산물과 농작물, 축산물로부터 얻은 가구 소득이 높을수록 화전 경작 방지를 통한 온신가스 감축의 기회비용이 크다. 쌀과 다른 농작물 경작으로부터 얻게 될 소득은 라오스 북부 산촌 마을의 토지이용 변화로부터 온실가스를 감축하기 위한 기회비용의 주요 원천이다. 따라서 이 연구에서는 화전 경작과 관련된 정부의 정책이 농업과 농작물 거래로부터 가구 소득을 증가시키는 것보다 생물다양성 보전에 기반한 경제 활동을 장려할 것을 제안한다.

Keyword: 가구 소득, 토지이용, 토지이용변화, 기회비용, 국가 보호지역, 라오스

Student ID: 2015-22342