Doctoral Dissertation

Analysis of the Relationship between Rubber Tree Plantation and Forest Resource Dependency: A Case Study of Smallholder Rubber Plantation in Northern Laos

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SUMMARY

Transformation of the shifting cultivation to other permanent agricultures is a key development policy in upland of Northern Laos to contribute to the main goal of the Lao government to graduate from the least developed country by 2020. In practical, number of strategic and action plans have been produced by different government leading agencies in order to facilitate the poverty reduction. Among those, the main goals of the Strategic Framework for National Sustainable Development Strategy for Laos and the National Biodiversity Strategy to 2020 and Action Plan 2010 are to maintain diverse of biodiversity and to ensure that valuable environmental resources are conserved in order to permit social economic development, the improvement of livelihoods, and poverty reduction in a sustainable manner.

In line with the main goal, LuangNamTha Province is facing great challenge on poverty reduction and sustainable use of forest resources. Increasing market demand for NTFPs on the one hand creates favorable conditions for forest resource-based poverty alleviation. On the other hands, also continue increasing pressure on forest resources at the same time. Leading by strong demand for natural rubber from China, rubber tree plantation has given new economic opportunity to agricultural households and the former shifting cultivators. In addition, it is perceived that rubber tree plantation would also contribute to diminish the pressure on forest resources by reducing forest resource dependency among smallholder rubber households with supportive income from rubber. This research attempts to observe the relationship between rubber tree plantation and forest resource dependency through labor allocation decision for NTFP collection, and the values of collected NTFP and NTFP income shares. Although this research may not address the forest resource conservation or sustainable management of forest resource directly, however, this research might illustrate the direction of forest resource

dependency among smallholder rubber production in a long-term perspective and also contribute to fill the information gap of the government strategic plans.

Besides rubber tree plantation, smallholder also allocated labor for upland rice shifting cultivation, livestock production, NTFP collection, and off-farm employment. We firstly developed a system labor share equation from theoretical framework for labor allocation of agricultural household in developing countries. This model permit us to observe the interaction on labor allocation decisions among five livelihood activities mentioned above, in respond to changes in the labor productivity of each activity, with respect to different stages of rubber tree cultivation. We found that labor share for NTFP collection was not influenced by changes of its labor productivity regardless of stages of rubber tree cultivation. However, at unproductive stage, labor share for NTFP collection decreased with increasing area of plantation per adult labor and with increasing the productivity of labor for off-farm; while labor share for off-farm increased with higher level of education. At the productive stage, labor share for NTFP collection decreased with increasing the productivities of labor for livestock and off-farm. However, labor share for NTFP collection did not respond to changes in the productivity of labor of rubber tree cultivation.

The latter finding was unlikely to elucidate the current situation occurring in the study areas. This is because working hours allocated for NTFP collection captured the efforts households devoted for NTFP collection. It was however, unlikely to capture the real-term of forest resource dependency. By the real-term we meant forest resource dependency implied the absolute term of NTFPs that have been collected, utilized, or marketed by the households. This is because, by definition, working hours for NTFP collection was including hours required for travelling to the collection sites, and hours for searching and collecting. Since sample households are residing in the villages with different length of the distance to the forests. Therefore, those far from the forests required more number of hours to travel to the collection sites and thereby, reduced the number collecting hours and resulted in smaller amount of collected NTFPs. As consequences, the greater amount of working hours for NTFP collection was unlikely to imply the greater amount that can be collected. In addition, sample villages were also facing different size of forest which may affect the availability of the forest resources.

Therefore, to improve the definition of the forest resource dependency, we employed the ratio of the values of the collected NTFP and NTFP income to total household income as other two indicators to capture the real-term of forest resource dependency. At the same time, the technical constrain was not allowed a system equation to work with these two indicators. As consequences, the results were estimated by using a conventional approach that widely used to investigate factors influencing on forest resource dependency in developing countries. Results showed that, at unproductive stage, area of plantation per adult labor displayed insignificant results with NTFP income share and NTFP collection value share at unproductive stage. At productive stage, age and education displayed negative and significant results with NTFP income and NTFP collected value shares. The productivity of land of rubber tree cultivation revealed insignificant result with NTFP income share; however, it showed strong negative and significant result with NTFP collected value share. In addition, age and education also displayed negative and significant results with NTFP income and NTFP collected value share.

The strong correlation between the productivity of rubber tree cultivation and NTFP collected value share led us to analyze technical efficiency of rubber tree cultivation at the productive stage in order to observe the current efficiency level and the potential efficiency of smallholder rubber tree cultivation across the sample villages. Results showed that the current level of efficiency of rubber tree cultivation among smallholder in the study sites remained being low on average. This result implied the large potential efficiency that could be further improved in the near future. Also, we found that efficiency in rubber tree cultivation was not so largely different across the sample villages, however, the large gap of efficiency was observed among the sample households within each village. The smallholders in the Hadyao village where it was well-known as the first rubber cultivation village in Northern Laos was significantly gained the highest efficiency among other sample villages. Finally we found that technical efficiency in rubber tree cultivation was negatively influenced by female and positively influenced by age below 50 years old.

In conclusion, time competition between rubber tree plantation and forest resource extraction has emerged since at the unproductive stage especially among those are holding large area of plantation per adult labor. In addition, forest resource dependency at this stage was likely to decrease with increasing economic opportunity of off-farm employment especially among the group leading by better educated household head. Create incentives and favorable conditions for households to access to off-farm jobs would provide ad hoc livelihood alternatives, and, thereby, decreased their efforts on forest resource extraction. In practical, the government should introduce ad hoc supportive programs to improve education level of the household head in order to facilitate off-farm jobs accessibility and decrease households' livelihood pressure during waiting for rubber income.

At productive stage, rubber tree plantation allowed households to have steady income source to support their life in several ways for a long-term; this including substitute some subsistence NTFPs by commercial products at the market. Hence, additional increasing the productivity of rubber tree cultivation was likely to further decrease forest resource dependency

among smallholder rubber households. This result tends to imply that economic benefit of rubber tree cultivation and a reduction of forest resource dependency could be maintained in the same direction. Result showed the large potential efficiency of rubber tree cultivation implied a high possibility to sustain a reduction in forest resource decency in a long-term. This stage called for a better-planned long-term policy. This is because productive stage not only displayed the current situation of the productive stage, but also mirrored the future situation of the current unproductive stage. Since collection and store up rubber latex also combined as important components of rubber tree cultivation along with tapping which could determine the ultimate amount of rubber income obtained at the final stage. And female have taken as key actors for the collection and store up activities. Therefore, improving the capacity of young female would not only perceive to maintain the income from latex sales but would also reduce burden for male and enhance their capacity which is perceive to ultimately contribute to improving the efficiency of rubber tree cultivation as a whole. Since Hadyao village was perceived as the best performer for rubber tree cultivation among other sample villages. Therefore, further improve the capacity of young female would further enrich knowledge and experience that could be shared by this village.

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CHAPTER 1: INTRODUCTION

1.1. Roles of Non-timber forest products

Non-timber forest products (NTFPs) contribute largely to livelihoods and economy of rural households in developing countries. For instance, a total value of approximately $90 billion of NTFPs is harvested each year by more than 300 million people in developing countries (Pimentel et al., 1997). Different species of NTFPs have been utilized by households in different ecological zones (Gakou et al., 1994; and Bista and Webb, 2006) and by different ethnic groups (Yamada et al., 2004; and Yokoyama, 2004). The contributions of NTFP income on total household income vary across countries. For instance, NTFP income contributed from 60 percent of the average annual income per capita for households in Southern India (Narendran et al., 2001) to more than 90 percent of the total household income in the hill Nepal (Gakou et al., 1994). There are extensive observations noted that poorer villages and household groups relied heavier on NTFPs than other groups (Adhikari et al., 2004; Viet Quang and Anh, 2006; Shackleton and Shackleton, 2006; and Paumgarten and Shackleton, 2009).

The extraction of NTFPs is an integral part of the livelihood of many rural households in Laos. Wild plants and animals provide important foods to meet the daily nutritional needs of rural households, especially when there is a shortage of rice; diverse NTFPs are usually eaten in greater amount to prevent hunger (Krahn, 2005). Johnson et al., (2005), for example, observed that during the peak hunting season, wildlife and natural fish provided more than 60% of all meat consumed and wildlife was reported as being consumed twice a week. In addition, several types of NTFPs provide an important source of cash for purchasing staples when rice is short (Yamada et al., 2004). The contribution of NTFP accounted for approximately 45% of household cash income, and reached to 75-84% of non-cash income; cash generated from bitter bamboo shoot sales only accounted for 40% of total household income in the uplands of Northern Laos (Morris and Ketphanh, 2002; Foppes and Ketphanh, 2004 and 2005). Annually, approximately 800 to 1,000 tons of palm fruits have been exported from Oudomxay, Northern Province of Laos (IFAD and GTZ, 2005). Numbers of NTFP also appeared in the list of the national economy. Those are including of 8.1 million lines of rattan, 5.1 million lumps of bamboo, 38 thousands bars of fences, and other NTFPs such as wood oil, barn, flowers, roots, and tuber are collectively approximately 64,667 tones. Although major parts of the NTFPs have been domesticated but natural forest remained playing substantial role as a home of diverse NTFPs (GoL, 2011).

1.2. Non-timber forest products collection and forest resource degradation

Although NTFP collection compared to logging could help to preserve a tree cover, however, forest structure and the performance of environmental function are not the same level as a primary forest does (Arnold and Perez, 2001). There are several factors that could lead to forest degradation as consequences of NTFP collection. There is also evidence from some areas where population growth and/or technological progress is high that various household activities other than logging may also deplete forest goods, regardless of the distance to the forests (Godoy and Bawa, 1993). Singh (1999) has found that rising market demand, increasing population pressure and changes in socio-cultural and socio-economic values not only resulted in overharvesting of most of useful herbs in the regions but some species have become locally extinct. Belcher et al., (2005) have emphasized that economic incentive has been found as a key factor that accelerate forest resource degradation. For instance, improved infrastructure that enables market access raised demand or price of NTFP that resulted in increased harvesting and overexploitation of NTFP. As the economic benefits people seek to obtain from the forests change over time, pursuit of this objective is likely entail changes to the resource base. In addition, regeneration rates of NTFP are also found to be significantly affected by people's attempt ions to domesticate several types of NTFPs as a result of wild fruits and seeds are taken from the forests (Murali et al., 1996). Arjunan et al (2005) have suggested that resource extraction within the protected areas not only led to loss of biodiversity but also led to degradation of forest resources.

In LuangNamTha, Northern province of Laos, NTFPs serve as sources for food products, construction materials and tools, primary health care, income, and safety nets (Yamada et al., 2004; and Johnson et al., 2005). In LuangNamTha, NTFPs are traded domestically within the province, across the provinces, and cross-border. Bokeo neighbor province is the main domestic NTFP trade partner, while China and Thailand are other two main cross-border NTFP trade partners. Although trading of NTFPs between LuangNamTha and Yunnan province of China in 1990s was constrained by poor physical infrastructure services, the destruction of natural resources and biodiversity through over exploitation has been emerged since that time. This is because Chinese traders were purchasing maximum quantities of all NTFP species and pay according to weights regardless of quality (Ketphanh and Soydara, 1998). Recently, trade of NTFP was accelerated by improvement of road and infrastructure that facilitating access to outside markets. As consequences, local people are likely to increase efforts on searching for NTFP for marketing. As a result sustainable use of the natural resources becomes great challenge for the government and local communities (Phounvisouk et al., 2013). A long with the provincial government policy to promote rubber tree plantation to eliminating the shifting cultivation; it is expected that pressure on forest resources in LuangNamTha province would be reduced if rubber tree plantation could provide alternative income source and decrease forest resource dependency among smallholder rubber households.

1.3. Agricultural production and non-timber forest products collection

NTFP serves as sources for foods, construction materials and tools for housing and agricultural production, and primary source for health care that allow households to live with lower level of expenses for commercial products at the market (Delang, 2006). In additions, NTFP also provides source for cash income which enable households to purchase rice and the consumption food during the time of shortage (Yamada et al., 2004; and Jakobsen, 2006). Therefore, NTFP collection used to be a fit combination in the subsistence-based agricultural production system. Transforming from subsistence-based agricultural production to market-oriented agricultural production has been found to change the roles of NTFP for household's livelihoods and economy. Apparently, the spread of small-scale commercial agricultural production among rural households has changes the roles of NTFP serving for households' livelihoods and economy. Experience of agricultural households in Sri Lanka revealed the spread of small-scale commercial tea cultivation in Sri Lanka led to times competitions between tea cultivation and NTFP collection and thereby reduced role of NTFP on household economy (Senaratne et al., 2003; and Gopalakrishnan et al., 2005). The transforming process was based on economic rationale where households decided upon their actions based on the opportunity cost of time involved in NTFP collection and commercial agricultural production. Although several subsistence-based forest products such as food products, medicinal herbs and related products would be maintained by gathering from the forests; however, income from agricultures enabled households to substitute some subsistence uses NTFP by commercial products at the market. Following the similar pattern, with the spread of commercial smallholder rubber tree cultivation in this region made NTFP become less importance for households' livelihoods (Fu et al., 2009a). NTFP collection has been found as a decreasing function with agricultural efficiency among households which primarily depend on agricultural production and secondarily rely on NTFP collection. Improving efficiency of farming would increase agricultural income to compensate cash income from NTFP; thereby further decreased importance of NTFP for household's economy (Illukpitiya and Yanagida, 2010).

1.4. Agricultural transformation in uplands of Northern Laos

Laos is known as the least developed and land locked country where approximately 80% of total areas of the country is classified as mountains and concentrated in the uplands of northern regions (ICEM, 2003). Upland landscape creates the homogenous conditions in upland of Northern Laos and also limit irrigated agricultural development. As a consequence, rural households in this region are forced to rely on the shifting cultivation combined with non-timber forest products (NTFP) collection and animal husbandry for subsistence livelihoods. Shifting cultivation used to be the best land use system which allows rural households in the upland regions to maintain their livelihoods in the past. As consequences of population growth, rising market opportunities, increasing forest resource depreciation, and increasing international awareness on environmental impacts has transformed the shifting cultivation into a harmful system. Therefore, the government of Laos has given high priority to transform this perceived harmful system into other permanent agricultural production (Roder, 2001).

Rubber tree plantation has been identified rubber as a key poverty alleviation strategy and an instrument to stabilizing shifting cultivation of LuangNamTha province (Shi, 2008). The pilot project has been initiated in the mid 1990s when a group of six ethnic minorities were encouraged by the government to grow rubber trees. The first harvesting in 2002 serving by a high price of natural rubber from China made the early adopters gained high financially profitable from rubber tree cultivation. That successful story in rubber tree cultivation has attracted other villagers to transform their shifting cultivation plots into rubber tree plantation which led to a rapid expansion of rubber tree in upland of northern in general and in LuangNamTha in particular (Manivong 2007; and Shi, 2008).

A piece of the previous study to compared the livelihoods between shifting cultivation and rubber tree planting village confirmed that an average household income of the rubber tree planting village was relatively larger than that of the shifting cultivation village. It has been observed that the major livelihoods in the shifting cultivation village remained adopting by the households after adopted rubber tree plantation. For instance upland rice shifting cultivation and crops have been adopted by proportionate households in the rubber tree planting village (Figure 1.1). However, the percentage of households participated in NTF collection was much far below in the rubber tree planting village. Results in Figure 1.2 showed that percentage of household participated in NTFP collection decreased with the transitional stage. Furthermore, the relatively small amount of cash income from NTFP in Table 1.1 would imply that NTFP has become less importance for household economy after they obtained income from rubber to support live (D. Luangmany and S. Kaneko). The previous studies in the context of northern Laos gave us insufficient empirical ground to clearly discuss the relationship between rubber tree plantation and forest resource dependency. However, that small and interesting point motivates us to further investigate that relationship empirically in the context of northern Laos.

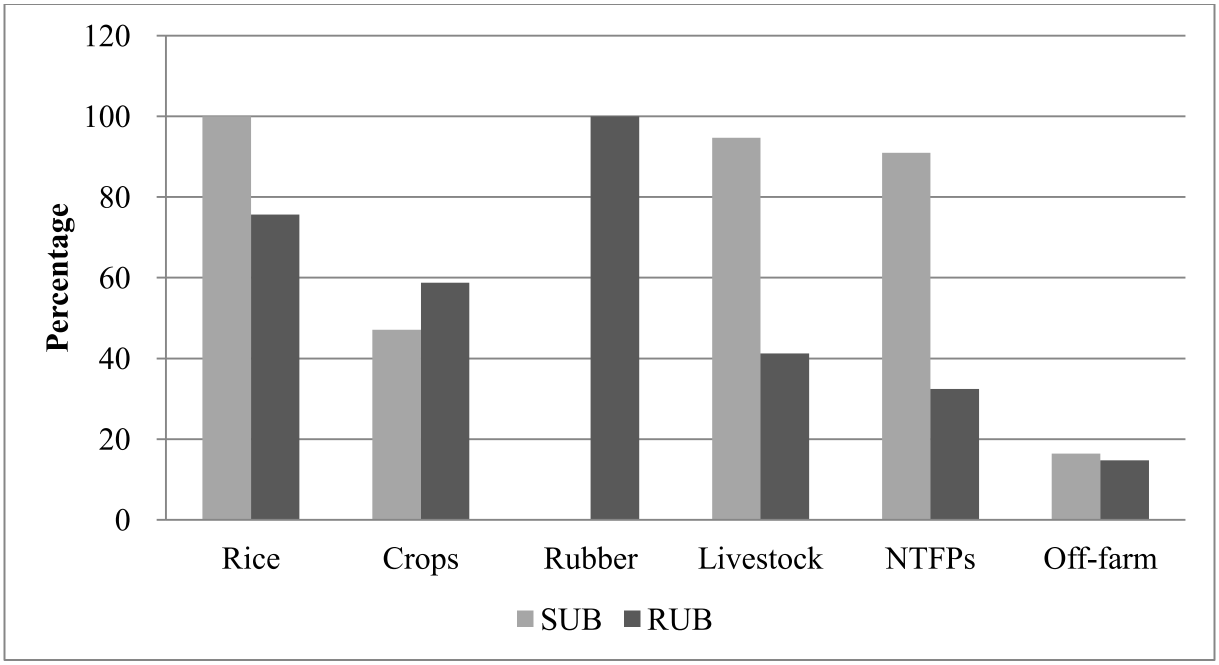

Figure 1.1: Labor participation rates across activities, source: Field Survey 2010

Source: D. Luangmany and S. Kaneko

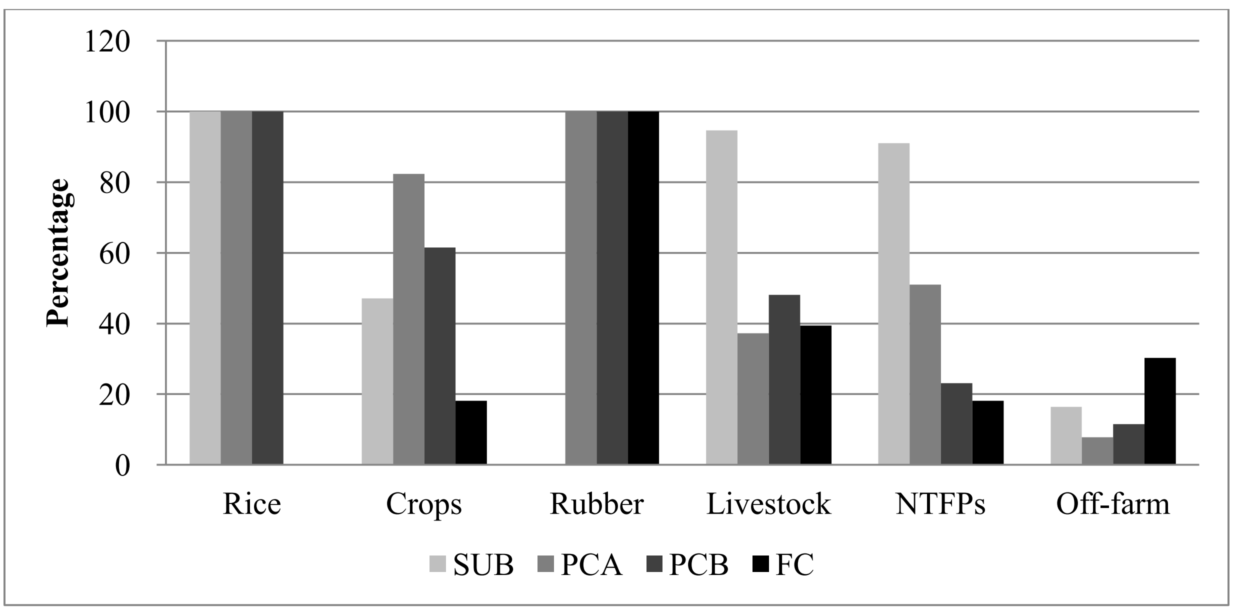

Figure 1.2: Break down labor participation rates across activities with respect to stages of transition

Source: D. Luangmany and S. Kaneko

Table 1.1: Structure of household income in the rubber tree planting and the shifting cultivation villages

Activity	SUB	Rubber tree plantation			
		PCA	PCB	FC	RUB
Rice	271 (17.3)	33 (2.6)	51 (0.8)	0	19 (0.9)
Crops	64 (4.1)	990 (78.2)	487 (8.0)	65 (1.0)	293 (13.2)
Livestock	858 (54.7)	33 (2.6)	70 (1.2)	53 (0.9)	24 (1.1)
NTFPs	73 (4.7)	25 (2.0)	17 (0.3)	6 (0.1)	11 (0.5)
Rubber	0	0	5,096 (84.1)	4,825 (77.7)	1,602 (72.4)
Off-farm	303 (19.3)	185 (14.6)	340 (5.6)	1,263 (20.3)	263 (11.9)
Total	1,569 (100)	1,266 (100)	6,061 (100)	6,212 (100)	2,212 (100)

Note: Number outside the parentheses refers amount of cash income measured in 1,000 kip, and number inside the parentheses indicates percentage share of each income source on total income

1 US$ = 8,000 kip (2010)

Note: SUB = household in the subsistence village; PCA = a partly commercialized (A) refers to household at unproductive stage of rubber plantation and continue shifting cultivation; PCB = a partly commercialized (B) mentions to household at productive stage of rubber plantation but continue shifting cultivation; and FC = a fully commercialized refers to households at productive stage of rubber plantation and quit shifting cultivation. The last three groups are in the rubber tree planting village.

Source: D. Luangmany and S. Kaneko

1.5. Research questions and objectives

This research seeks to answers the following questions: Do increasing productivity of rubber with respect to labor and land would have impacts on forest resource dependency among smallholder rubber production? How do households response with respect to the unproductive and productive stage of rubber tree plantation? If they do reduce their dependency on forest resource in response to increasing productivity of rubber tree cultivation, how large can efficiency in rubber tree cultivation could have been potentially increased?

To respond to the number of above questions, the overall objective of this study is to investigate the relationship between rubber tree plantation and forest resource dependency and analyzes the possibility to maintain that relationship. Forest dependency measured by working hours that household devoted for NTFP collection and the absolute monetary values of NTFP relative to household income. A system labor share equation based on the theoretical framework of agricultural households in developing country was developed to examine working hour's allocation decisions among five livelihood activities in respond to changes in their productivity of labor. Due to the indicator for forest resource dependency in the chapter four could not capture the net effect of working hours allocated for NTFP collection or could not represent the real-term of forest resource dependency. Chapter five examined the returns of rubber tree cultivation and other factors on forest resource dependency. Finally, this study analyzes the technical efficiency of rubber tree plantation in order to observe the current and potential efficiency to further improve the capacity and income of the smallholders and discuss the possibility to sustain the forest resource dependency for a long-term.

1.6. Significance of study

Unlike previous studies, this research discussed households' forest resource dependency in a regime of economic transition from subsistence-based shifting cultivation to early stage of market-oriented agricultural production-mainly rubber tree plantation. This study applies data of smallholder rubber households to test results of a system labor share equation and a stochastic production frontier in the context of Northern Laos. In addition, this study presents labor share for upland rice cultivation, rubber tree plantation, and animal husbandry separately due to they involve different activities, different management systems, and different number of required working hours. In general, this study present the first case to empirically observe the influenced of small-scale commercial agricultural production on forest resource dependency.

The results from this study would provide useful information to policy makers to discuss the conservation objective of rubber tree plantation. In addition, the results of the chapter six would enable makers to observe the efficiency of smallholder rubber production and provide practical information for further improving of their efficiency.

1.7. Scope of the study

Numbers of concerns have been discussed the consequences of rapid expansion of rubber tree plantation in Northern Laos such as food security, economic profitability, soil quality, and forest resources (detail discussion of those issues are given in chapter 2). This study focused on the latter issue. The potential role of existing rubber tree plantation was investigated through the households' forest resource dependency.

Rubber tree plantation divided into two major stages, namely unproductive and productive. Unproductive refers to first eight years after rubber trees have been planted. At this stage, rubber trees remained immature and rubber latex could not been collected. Households at this stage, thus, have not obtained cash income from rubber latex sales yet. Productive stage measured the plantation after eight years onward. At this stage, rubber trees have matured, and households, thus, continue generating cash income from rubber latex sales until the end of year 35 of the plantation. The analyzing in chapter four and five focused on sample households at both stages of the plantation, while an analysis in chapter six only focused on the productive group due to quantity of rubber latex yield was required as a key variable.

There are three types of rubber plantation arrangement in Laos such as (1) smallholder rubber plantation; (2) contract farming; and (3) land concession. Smallholder rubber plantation refers to the type of a hundred percent self-investment. Contract farming mentions to join-investment between the villagers and domestic or foreign investors. This study focused only smallholder rubber type of arrangement due to this type of arrangement accounted for 80% of LuangNamTha total rubber establishments, provides villagers more secure access to their land and a stronger sense of ownership in the plantation (Shi, 2008).

1.8. Structure of the dissertation

The dissertation consists of seven chapters (Figure 1.3). Chapter one is introduction. This chapter briefly introduces role of forest resource on households' livelihoods and economy. Then, this study discussed effects of forest resource utilization on forest resource degradation, and the roles of commercial agricultural production on a reduction of forest resource utilization. After that research questions and objectives are formed. Finally, the significance, scope of study and structure of dissertation are set. Chapter two reviews were divided into two parts. First part reviews situation of rubber tree cultivation in Northern Laos including its driving forces, management systems, economic important, food security, and environment issues. Second parts discuss the theoretical background and empirical models in order to make assumption on the key variables. Chapter three briefly introduced the study areas, described methods of data collection, and summary key information obtained from field survey. Chapters four through chapter six are analytical chapters. Chapter four examines economic rationale of smallholder rubber households on labor allocation for NTFP collection and observe the influenced of productivity of labor of rubber on labor allocation for NTFP. Chapter five examines the determinants (including productivity of rubber and household characteristics) of NTFP income share and NTFP collected value share. Chapter six analyzes the technical efficiency of rubber tree plantation and identifies its determinants. Chapter seven conclude main findings from the study and attempts to extracts some policy recommendation based on the main findings

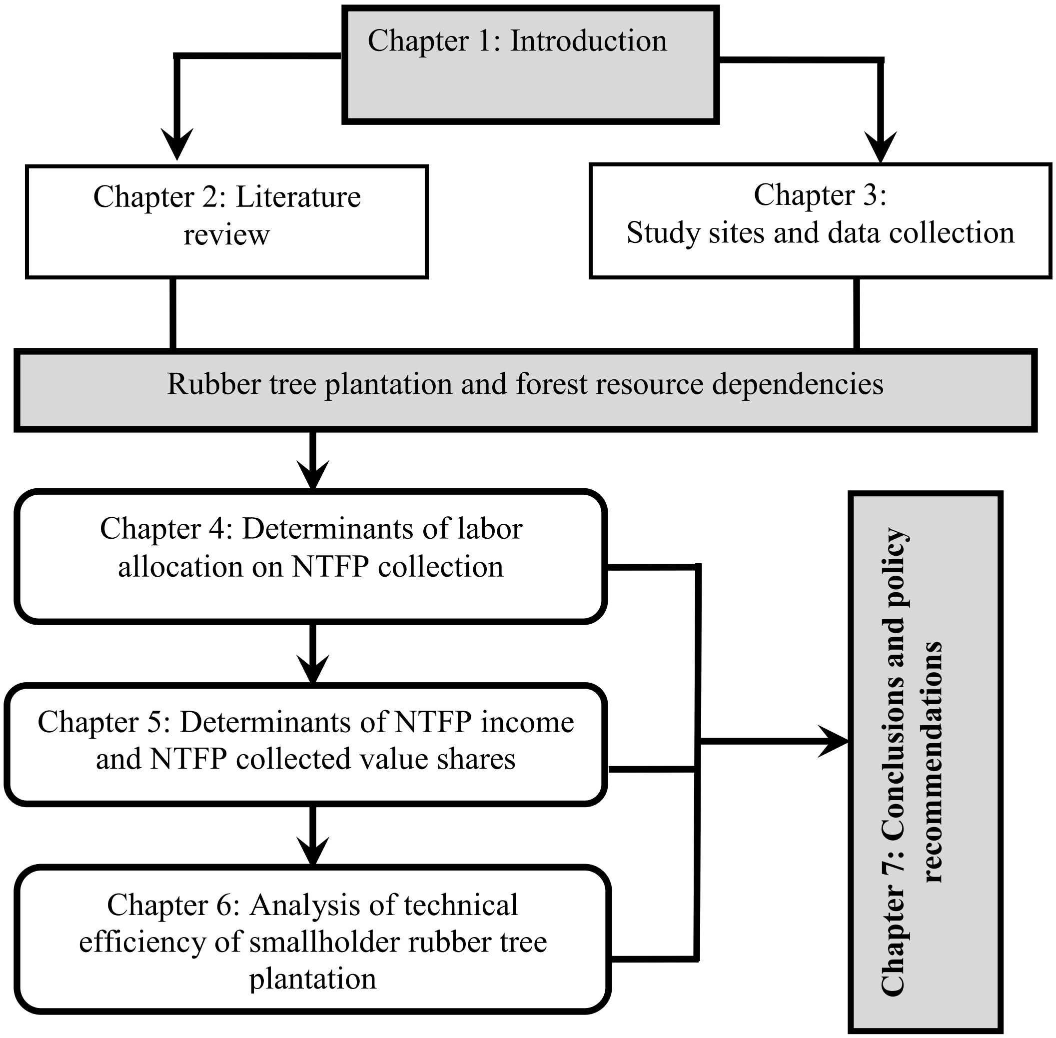

Figure 1.3: Structure of dissertation

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter reviews situation of rubber tree plantation in LuangNamTha Province, Northern Laos (study sites). Illustrates the supportive policies or driven factors for the expansion of rubber plantation in that province, discuss its roles for households and provincial economies, and touches on key environmental issues. This chapter divided in to ten sections. Section two discusses an expansion of rubber tree plantation in the study sites. Its driven forces discussed in section three. Section four presented technical of rubber management and productivity of rubber plantation in the study sites. Economic perspective of rubber plantation presented in section five. Section six criticizes on rubber plantation and food crops production. Environmental perspective of rubber plantation presented in section seven. Section eight described theoretical and empirical models for labor allocation of agricultural households in developing countries. Section nine discussed key factors influencing forest resource dependency. And final section described theoretical and empirical models for analyzing technical efficiency of rubber tree cultivation.

2.2. Expansion of rubber tree plantations in Northern Laos

The expansion of rubber tree plantation in Laos varies across the regions. The first rubber plantation had been established in Champasack, a Southern Province of Laos since 1930. At that time, rubber trees have been planted in a small area of 2 hectares, and the purpose of plantation was not for cash income generation. People around that plantation just tapped the latex for fun and used latex to trapped small animals, insects, and birds. Rubber plantation has been adopted in Central part in 1990, when there was a private company (Patthana Ketpudoi Company) established an 80 hectare of rubber plantation in Khammouane Province. And rubber tree was introduced into uplands of Northern region in 1994 (Ketphanh et al., 2003; Alton et al., 2005; and Manivong, 2007).

In fact, Northern region was not the first place that adopted rubber tree plantation, but this region contained the largest areas under rubber tree plantation among others (Figure 2.1). End of 2008, areas of rubber tree plantation in Northern region was reported more than 70,000 hectares, while in Central and Southern were less than 40,000 and 30,000 hectares, respectively. The distribution of the areas under rubber tree plantation also varies across provinces. Southern was predominated by Champasack province, Central region was occupied by Vientiane province, while a Northern region was dominated by LuangNamTha province (Figure 2.2). In general, LuangNamTha province had the largest areas of rubber tree plantation of the country. End of 2008, areas of rubber tree plantation in LuangNamTha province was more than 20,000 hectares, while Champasack province contained approximately 20,000 hectares, and Vientiane province less than 10,000 hectares.

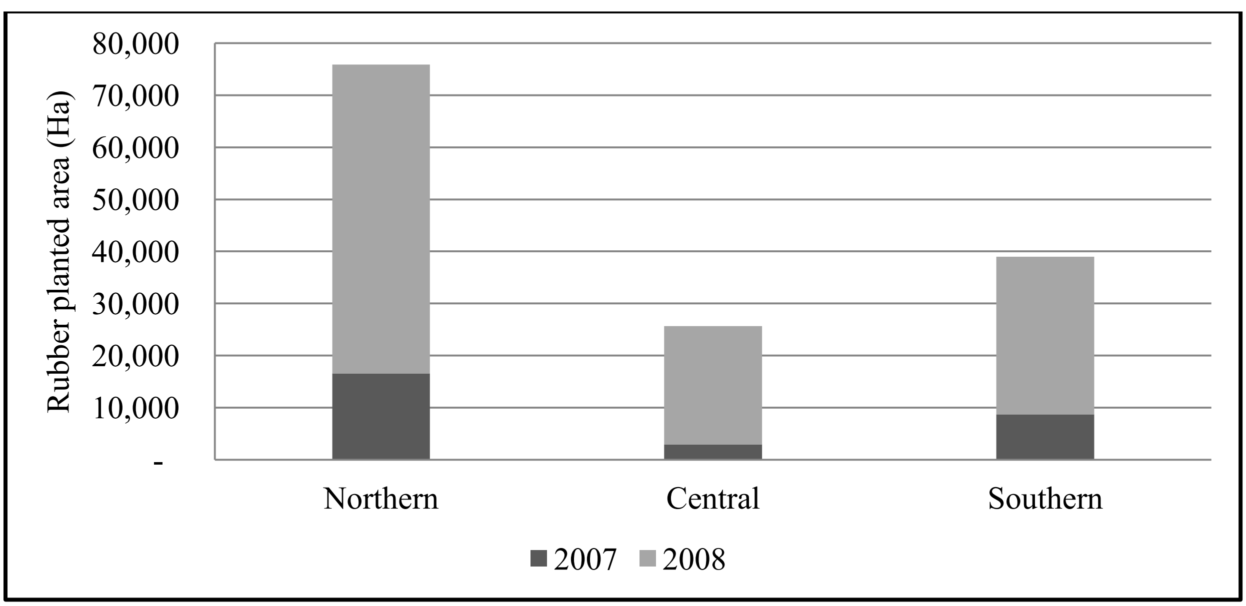

Figure 2.1: Aggregate areas of rubber tree plantation in Laos from 2007 to 2008 separated by regions

Source: GoL, 2009

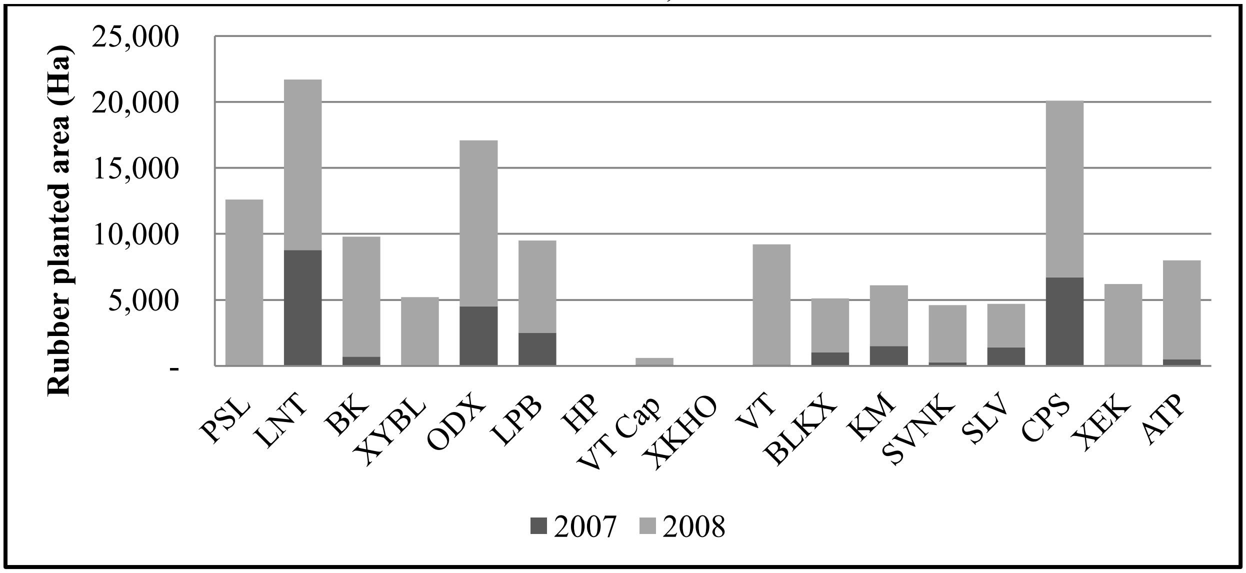

Figure 2.2: Aggregate areas of rubber tree plantation in Laos from 2007 to 2008 separated by provinces

Source: GoL, 2009

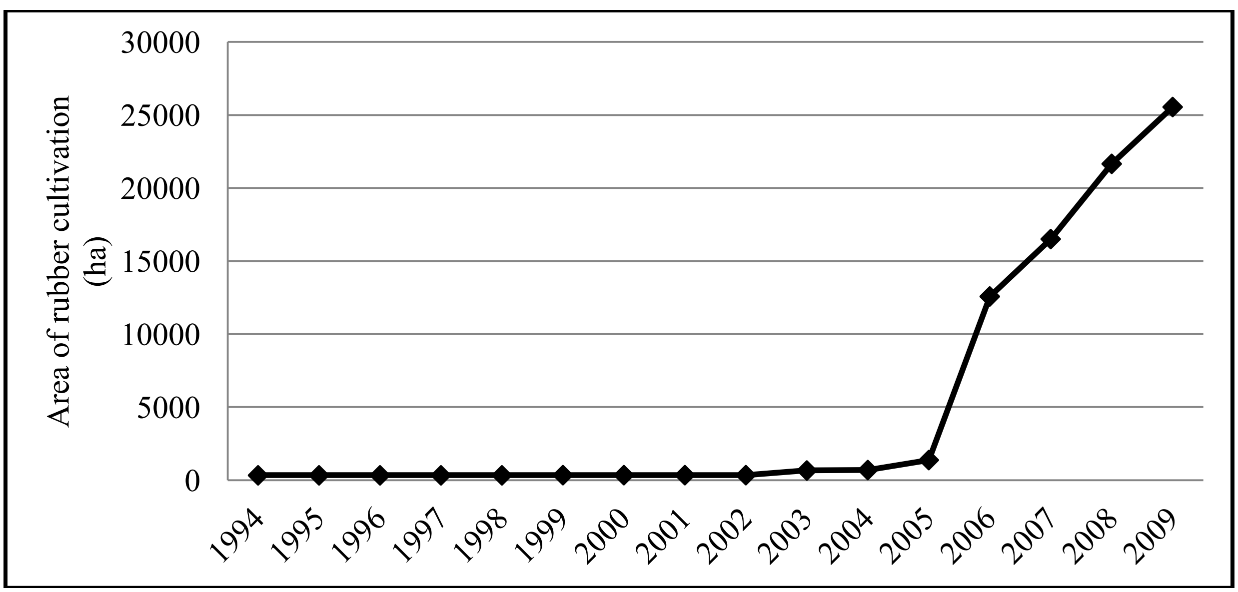

Figure 2.3 total areas (hectare) of rubber cultivation in LuangNamTha Province

Source: Manivong, 2007; Shi, 2008; Department of Planning and Investment of LuangNamTha Province (DOPI), 2008; and Department of Agriculture and Forestry of LuangNamTha Province (PAFO), 2010

Table 2.1: Areas of rubber tree plantation in LuangNamTha Province in 2009 by districts and by modes

ID	District	Planted areas(ha)	Company (ha)	Smallholder (ha)	No. of Household.	Tapped area (ha) smallholder
1	LuangNamTha	8,644	5,616	3,028	1,778	900
2	Sing	7,200	1,290	5,910	4,572	100
3	Long	4,823	3,631	1,192	720	0
4	Viengphoukha	2,536	929	1,607	978	0
5	Nalea	2,330	2,077	253	275	0
Total		25,533	13,543	11,990	8,323	1,000

Source: the Provincial Agriculture and Forest Office of LuangNamTha Province in 2010

Figure 2.3 showed an expansion of areas of rubber tree plantation in LuangNamTha province from 1994 to 2009. Rubber tree was first planted in LuangNamTha province in 1994. Approximately 342 hectares of land have been converted in to rubber plantation. The first tapping was begun from 2002 to 2003. From the first planting (1994) until the first tapping (2002-2003), an expansion of rubber tree plantation was almost stable. After that the areas of rubber tree plantation has been double increased to approximately 671 hectares in 2004. And then areas of rubber tree plantation in LuangNamTha province has been drastically increased after 2004. End of 2005, total areas of rubber tree plantation in this province reached 1,386 hectares, and then keep increasing to more than 10,000 hectares in 2006, and reached approximately 25,553 hectares by the end of 2009.

Table 2.1 showed total areas of rubber tree plantation in LuangNamTha province by the end of 2009 disaggregated by districts. LuangNamTha province consists of five administrative districts, LuangNamTha district is the municipal district. This district is also a location of Hadyao village where it is well-known as the first rubber village in LuangNamTha province and in the Northern Laos (Alton et al., 2005). LuangNamTha district contained the largest areas of rubber tree plantation. Though investments was dominated by the companies, this district also contained the largest areas of productive trees (mature trees) which in the form of smallholder rubber plantation. On the other hands, investments in Sing and Viengphoukha districts were occupied by the smallholder rubber plantations. The overall situation of rubber tree plantation in LuangNamTha province indicated that, rubber plantations were occupied by the companies, and approximately 97% of plantation remained at the unproductive stage (immature).

2.3. Driving factors behind rapid expansion of rubber tree plantation in Northern Laos

There were numbers of factor driven behind rapid expansion of rubber tree plantation in LuangNamTha province which can be classified into internal and external factor. Internal factors were direct and indirect supports from the Lao government, while a main external factor was increased demand for natural rubber from China that accompanied with the limitation of its domestic supply to meet their own demand.

2.3.1. External factor

Rubber is one of China's four main industrial materials, along with coal, iron, and petroleum. China's domestic supply for natural rubber has stagnated and has even shown signs of decline after 2005 when a severe typhoon hit Hainan, one of China's three main rubber producing provinces, and destroyed a substantial area of rubber forests (Shi, 2008). At the same time, China's total consumption of natural rubber continued increasing; averaging 11.5 percent growth per year from 862 thousand tons in 1999 to 1,504 thousand tons in 2005 at an average rate of 11.5% (Figure 2.4). Therefore, increasing rubber imports is one of China's main efforts to meet domestic demand of natural rubber (NR). In fact, China's NR imports exceeded the United States' making it the world's largest importer from 2003 to 2005 (Figure 2.5). In addition to increasing imports, China also made other efforts to stabilize the domestic supply of natural rubber; however, high land prices in China made this strategy prohibitive. Thus the Chinese government actively encouraged domestic investors to invest in foreign rubber producers. Hainan and Guangdong state-owned farms expanded their investment as far as to Malaysia, while Yunnan state farms have been seeking investment outlets in northern Laos since 2004. Narcotics control efforts have been officially integrated into the Chinese economic agenda in order to create a favorable environment for Chinese investors to invest in rubber tree plantations. Under this narcotics control strategy, the China subsidized the development of opium replacement plantations in northern Laos and aggressively promoted commercialization of trees and cash crops to eradicate opium cultivation. Officials in Xishuangbanna (Chinese Southwest province bordering Laos) reported that over 40 Chinese companies, among them rubber companies, are currently operating in northern Laos under the provision of opium replacement program (Shi, 2008). World market prices for natural rubber increased from approximately US$542.27 in 2001 to its highest price of approximately US$1,907.31 in 2006. Changes in the world market price of natural rubber from 1990 to 2006 are presented in Figure 2.5. As the world's largest consumer of natural rubber since early 2000, China's increasing demand for natural rubber along with the stagnation of the domestic supply may be one factor driving up natural rubber prices (Figure 2.6) in that time.

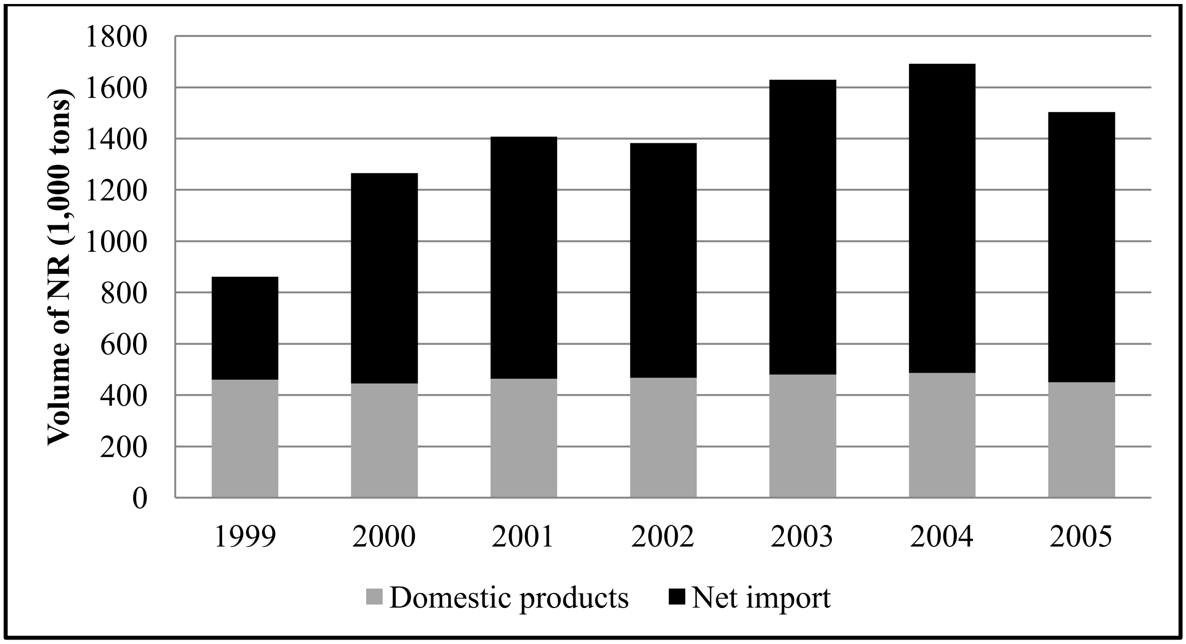

Figure 2.4 Total consumption of natural rubber for China from 1999-2005

Source: Tavarolit, 2006

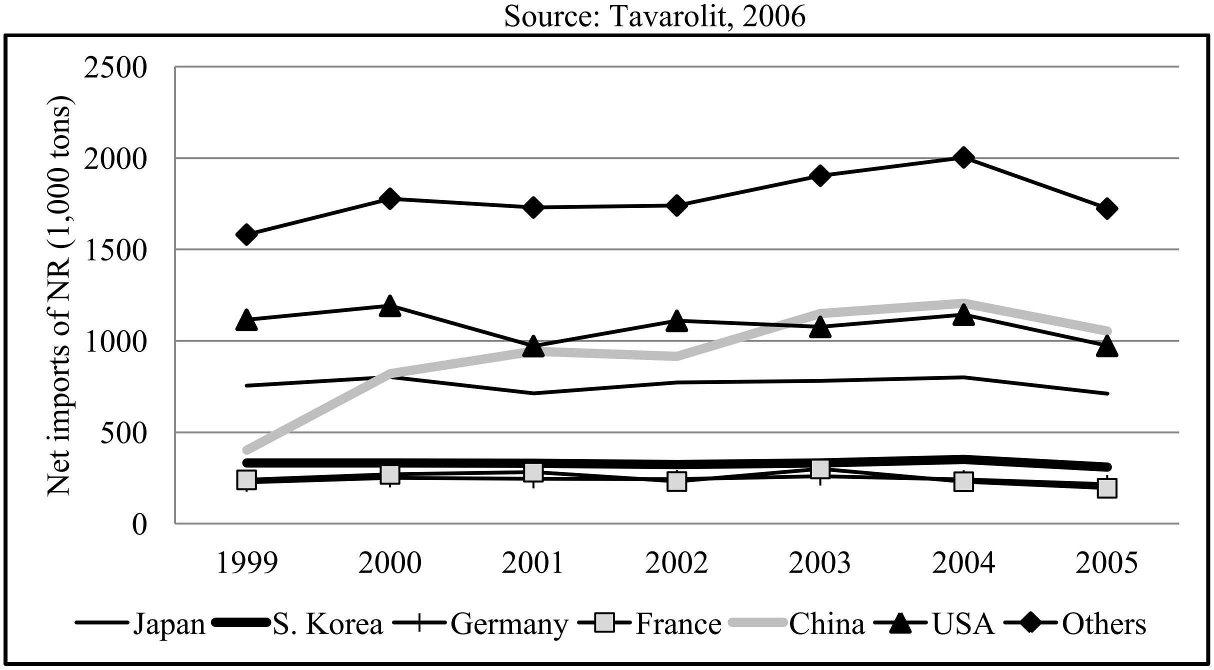

Figure 2.5: Net import of natural rubber (NR) by major countries from 1999-2005

Source: Tavarolit, 2006

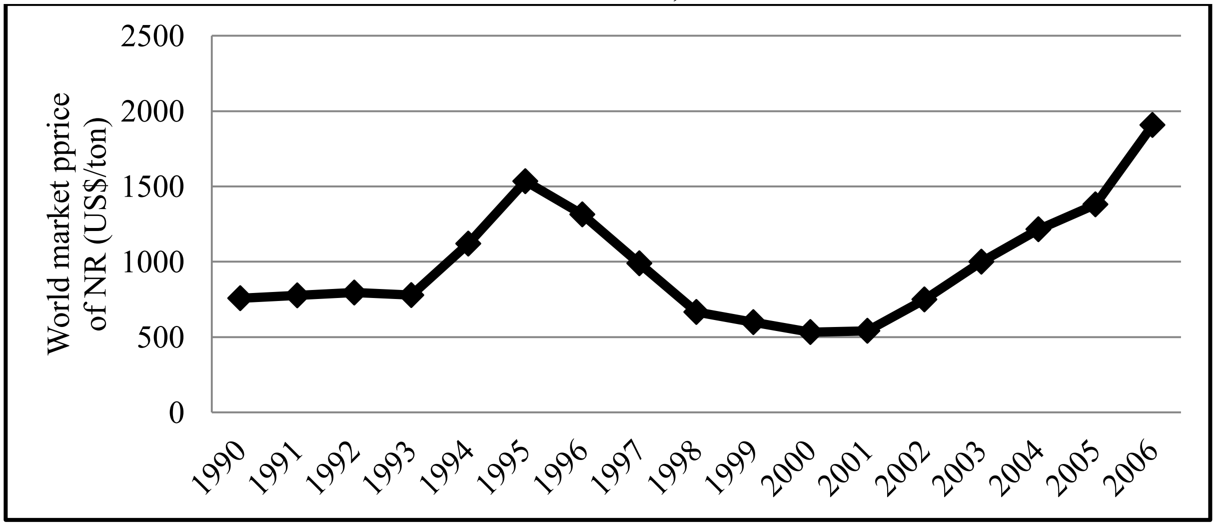

Figure 2.6: World market price of natural rubber from 1990 to 2006 ($/ton)

Source: Khin et al., 2008

2.3.2. Internal factors

LuangNamTha Province shares a 140-km-long border with China to the north and is a center for commerce between Laos, China, and Myanmar. China is its main trade partner. Trade between Laos and China is mainly conducted through the Borten international check point (DOPI, 2009). GDP growth of LuangNamTha province was 7.87 percent in 2008, and approximately 70 percent of GDP came from the agricultural sector. Total products of natural rubber latex produced within the LuangNamTha Province are exported to China in the form of tub-lump. During rubber tapping season, usually from April to November, Chinese traders come to LuangNamTha once a month to buy tub-lump rubber at the villages. Villagers would be given the price of tub-lump rubber by the Chinese trader at the time of purchase. This was the only source of price information. Over time, the price increased in line with world rubber prices

(Manivong, 2007).

Sharing border with China facilitate trade between China and LuangNamTha province in particular. The combination between government support and villagers' desires in response to strong demand for natural rubber from China are the two major internal factors for the rapid expansion of rubber tree plantation LuangNamTha Province. The government program began since 1994 when a group of six ethnic minority villages has been encouraged by the provincial government to grow rubber trees. However, Hadyao village became well-known as the first village to produce rubber in the Northern Region of Laos. This is because most of the trees in other villages were killed by the heavy frost in 1999, whereas Hadyao village was not affected to the same degree (Alton et al., 2005; Manivong, 2007; and Shi, 2008). At the same period (1994 and 1995) approximately 70 million kip as a combination loan from the Provincial funds, the Provincial Agriculture and Forestry Office (PAFO), and the Agricultural Promotion Bank (APB) was lent to the villagers with a very low interest rate (2%), and a 7-year of payback period.

In 2003, after rubber trees have been tapping and showed financially profitable, approximately 281 million kip loan from the APB was issued at the higher interest rate (7%) and a longer payback period of 10 years (Manivong, 2007). Within this year, rubber tree cultivation is now promoted in a larger scale. The provincial government is encouraging more villages to grow rubber trees while providing incentives and programs to attract domestic and foreign investors. The first broad-scale regulations on rubber plantation investment came in 2003. These regulations prescribed the general modes of rubber investments, provided specific procedures associated each mode, and delineated the investment scenarios for both domestic and foreign companies through either concession or contract farming.

In 2006, the government set an ambitious goal to cultivate 20,000 hectares of rubber. To realize that target, at a micro level, the provincial government gave a hectare of land and seedlings to families without paddy rice crops in 12 targeted villages in the LuangNamTha district. Funds for the project were borrowed from the Mengla County government in Xishuangbanna and distributed to the villagers through the Agricultural Promotion Bank as a subsidized loan. Foreign investment law also contributed for an expansion of rubber tree plantation in LuangNamTha Province. LuangNamTha province is located in zone 1(poor infrastructure and other services) as classified in the foreign investment law. The investors who invested in this zone will benefits from the profit tax exemption for 7 to 8 years after the business has became operative, since rubber tree plantation usually take 7 to 8 years to become productive, the investors, thus, will automatically gained profit tax exemptions for 14 to 15 years. As Chinese investors are seeking for investment opportunity in rubber tree plantation combined with attractive tax incentives and favorable location made investment in rubber tree plantation in LuangNamTha Province was dominated by Chinese.

At the national level, the government also offered land concession granted property rights to people who planted trees and distributed free seedlings to farmers and organizations (Shi, 2008). The LFA program introduced by the government also played an indirect part in shaping the rubber landscape in LuangNamTha Province because the villagers faced pressure to adopt permanent crops or return their allocated land to the State if the allocated plots were abandoned or undeveloped for three years. Thus rubber tree cultivation became a way for villagers to gain exclusive land rights on land, regardless of the ambiguous legal status of land ownership (Thongmanivong et al., 2009).

2.4. Rubber tree plantation management and productivity in LuangNamTha province

There are two rubber clone were planted in the study areas, namely GT1 and RRIM600. GT1 clone was a common clone used by smallholder in Indonesia, while RRIM600 was originated from Malaysia (Manivong, 2007). Rubber farmers in the study areas normally planted their rubber trees with an intra-row spacing of 3 m and an inter-row spacing of 7 m. This scale of tree spacing was reported to be appropriate for gently sloping land, which resulted in approximately 500 stems per hectare. Rubber management in the study areas was employed the conventional method for the agricultural production on the sloping land, fertilizer was not applied. Despite of the fact that the applications of herbicides were appeared in the study areas, however, hand weeding methods are still being widely adopted by the rubber growers in the study sites. Normally performance of hand weeding were divided into two periods, at unproductive stage (1-7 years after planted) and productive stage (after 7 years of planted). During unproductive stage, the rubber tree still being young, therefore, there would be speed competition between the growth of the planted trees and weeds, therefore, relatively higher frequencies of weeding were required at this stage. Normally, hand weeding usually performed 3 times annually. When the planted trees getting grown and matured. The sheds that produced by the trees will naturally limit the growth of weeds therefore; hand weeding would be less required at this stage. Normally, hand weeding usually performed once or twice a year. Manivong (2007) noted that labor required for hand weeding at the first stage of rubber tree plantation was 120 psd per hectare per year, while labor required for tapping, collecting, and hand weeding at the second stage was 259 psd per hectare per year.

The planted trees would mature at the 8^{th} years after planting. At this time a mature tree would have diameter of 30 cm with Diameter at Breast Height (DBH) at 150 cm. This size indicates that the mature trees are ready to be tapped. The tapping periods at the study sites normally began from early March till end of November. It was reported that the best tapping hours started from 1 am to 6 am in early morning. The applied tapping strategy at the study sites was 2 days holiday after tapping. The rubber latex will stopped to release within 3 hours after the tree was tapped, and the row latex will begin to be collected. Alton et al., (2005) noted that the tapping capacity varied from 250 to 300 matured trees per person per day. The most taugh taks for rubber tree cultivation at the productive stage is tapping. Since tapping has to conduct since early morning when is identified as the sleeping time. Therefore, Male and female are acting different roles in rubber tree cultivation. Male usually acted as the main labor; and rubber tapping usually performed by male. Therefore, after finished tapping male usually need times for break or other activitiee. On the other hands, female acted as the supportive labor and usually participate for collecting and store latex in the safe place.

Figure 2.7 illustrated predicted latex yield in Hadyao village over 35 years using BRASS. Results of this Figure were predicted by Manivong (2007). The general shape of the rubber latex yields expected to obtain from one rotation of rubber tree plantation was inverted U-shaped. The rubber latex yields entered into three periods of yield dropped. First dropped occurs in year 10. The second dropped occurs in year 21. The yields reached the maximum volume of 1,368 kg in year 22 before entered into the third dropped in year 32. The average rubber latex yield in one rotation of rubber tree plantation was 1,167 kg per hectare. The average level of rubber latex yield per hectare in a Northern Province of Laos was the lowest compared to the average level of 2,666 kg/ha in Northeast Thailand; of 1,536 -2,310 kg/ha Malaysia; and of 2,000 -3,000 kg/ha in Nigeria (Alton et al., 2005; Manivong, 2007; Giroh and Adebayo, 2007; NAFRI and NAFES, 2008; and Mustapha, 2011). Manivong and Cramb (2008) noted that the dropped periods occurred with the periods of the low rainfall, indicating that rubber latex yield would be affected by the amount of rainfall. In general, it can be observed that amount of rubber latex yields depending on the ages of trees.

The data of amount of collected rubber latex yield in 2011 by 168 households in Figure 2.8 also showed that amount of latex yields increased with the ages of the trees. However, the productivity also varied across households, this may be due to different management strategies.

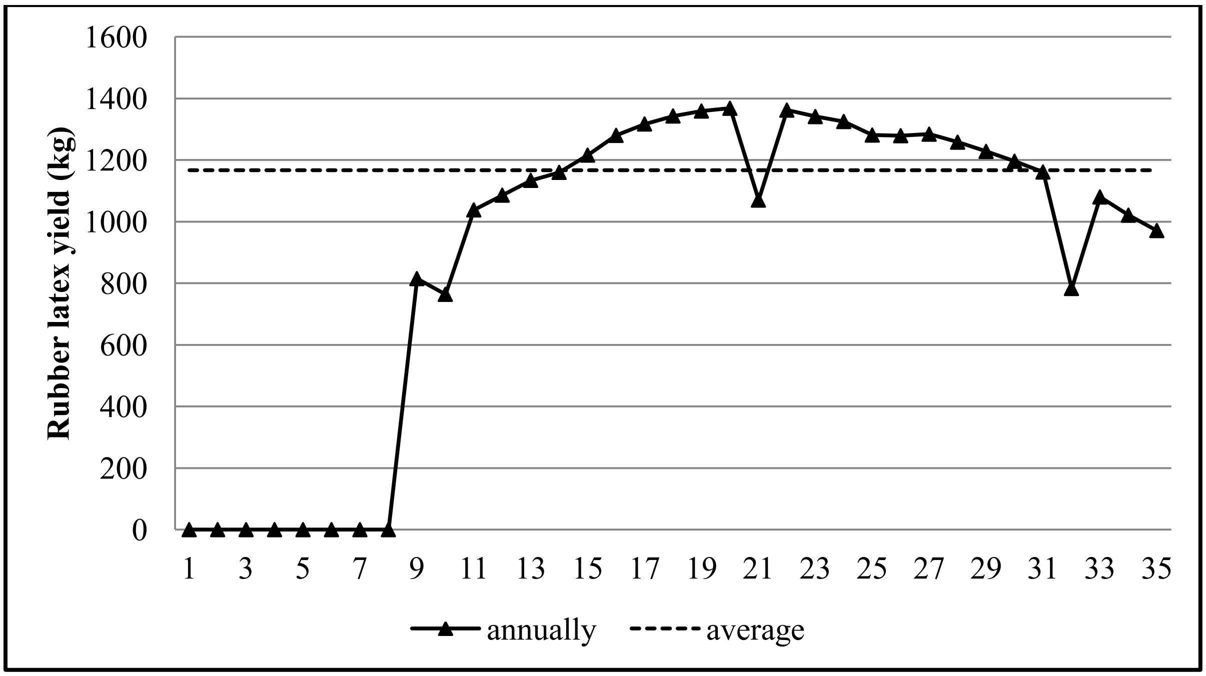

Figure 2.7: Predicted latex yield in Hadyao village over 35 years using BRASS

Source: Manivong and Cramb, 2008

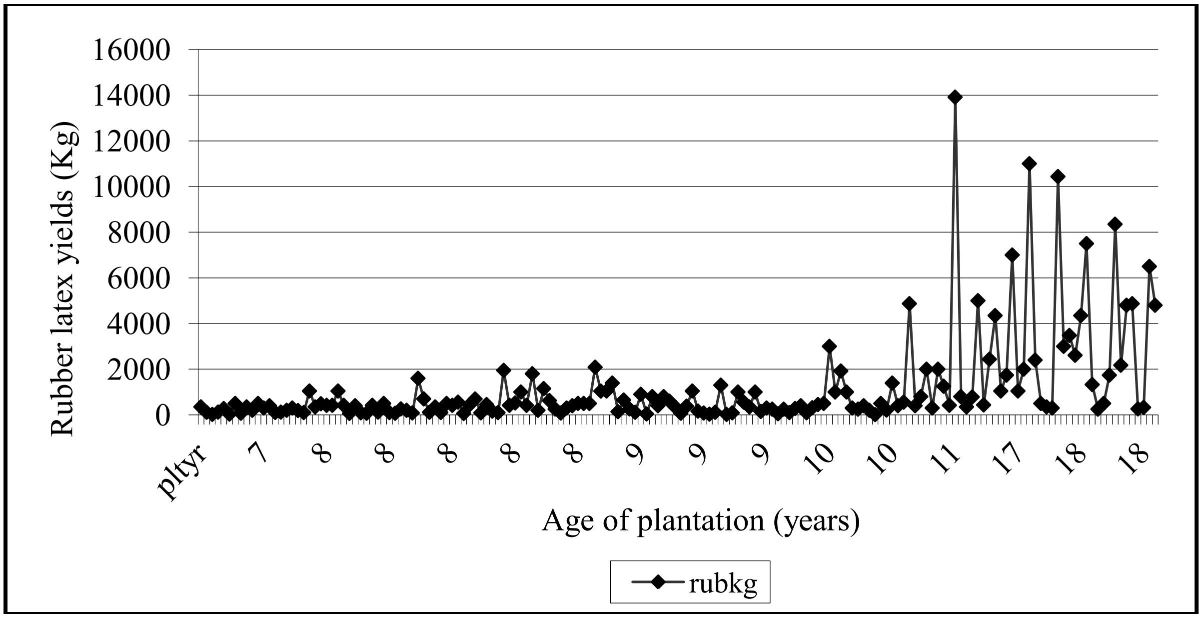

Figure 2.8: Amount of collected rubber latex yields (kg) per household in 2011

Source: Field survey 2012

2.5. Economic Perspective of Rubber Tree Plantation

2.5.1. Economic Significance of Rubber Tree Plantation at the Provincial Level

Agriculture was the main component in the LuangNamTha GDP. In 2008, agriculture sector shared approximately 70 percent of GDP. LuangNamTha Province has become known as the first place for rubber cultivation in the Northern Laos. Harvesting (tapping) rubber trees have been conducting since 2002. However, due to poor data recording system, the contribution of rubber revenue on the provincial economy has not emerged until 2006 (PDIT, LuangNamTha Province 2013).

Figure 2.9 showed the share of rubber revenue on the provincial aggregate revenue from agriculture. Rubber revenue has been recorded from 2006 to 2012. The gray line showed the share of rubber revenue in these periods on total aggregate revenue of agriculture in 2002 (when rubber trees were first harvesting). Black line illustrated the share of rubber revenue in the same periods on total aggregate revenue of agriculture in 2012 (when the field survey has been conducting). The relatively smaller shares of rubber revenue on aggregate revenue of agriculture in 2002 and 2012 have been observed from 2006 to 2010 (Figure 2.9). Total areas of mature rubber trees throughout LuangNamTha Province have been increased to 1,000 hectare in 2010; the share of rubber revenue on aggregate revenue of agriculture has been increasing by then. Rubber revenue shares have been increased since 2011. The revenue from rubber in 2012 shared approximately 10% of total aggregate revenue from agriculture value of the same year, while this share reached more than 30% of total aggregate revenue from agriculture value in 2002. In the near future, it is expected that the share of aggregate agricultural revenue would be dominated by rubber revenue as the revenue from rubber sales are expected to increase annually as a result of large areas of plantation will become productive.

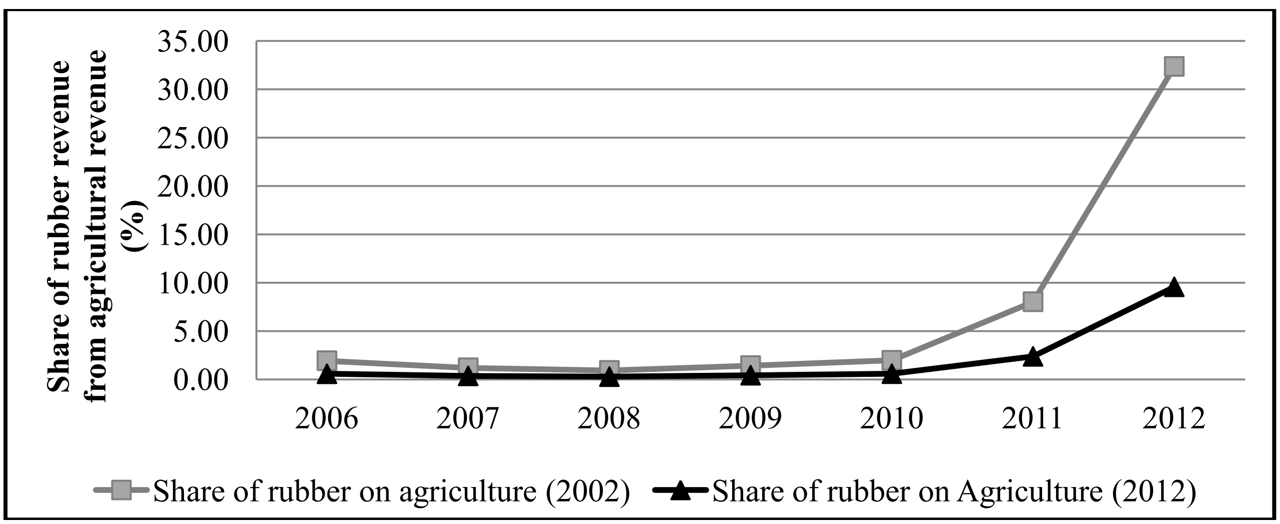

Figure 2.9: Percentage share of rubber revenue from 2006 -2012 on the aggregate revenue of agriculture in 2002 and 2012 in LuangNamTha province

Source: Department of Industry and Trade of LuangNamTha Province, Laos (2013)

2.5.2. Economic Significance of Rubber Tree Plantation at the Household Level

Investments in rubber tree cultivation by smallholders have been found to be financially profitable. In case of Xisuangbanna, Southwest China where smallholder had experienced in rubber tree cultivation, Fu et al., (2009b) have found that returns from rubber tree cultivation have significantly increased per capita income of smallholders from US$128.30 in 1998 to US$561.70 in 2004, of which income from rubber alone increased from US$75.80 in 1998 to US$451.40 in 2004.

Similarly, investment in smallholder rubber production in Northern Laos in general also found to be financially profitable; in particular, Hadyao village was the most successful case in LuangNamTha Province. Manivong and Cramb (2008) have conducted financial analysis of rubber tree cultivation in Hadyao village. The combinations of different price scenarios and discount rates have been discussed in their study. The results showed that under the based line of a combination of 8% discount rate and 7,800 kip/kg of tub-lump price, investment in smallholder rubber production was found to be financially profitable. In case the price decreased by 30% compared to the baseline scenario, new investment in smallholder rubber production was no longer worthwhile. However, if the rubber price increased by 30% relative to the baseline, this investment would generate a NPV of over 23 million Kip/ha (US$2,235/ha) and a rate of return of approximately 15%.

Furthermore, greater benefits could obtain from different stages of rubber tree plantation by combination with other crops or animal husbandry. Back to 1986 and 1988, the studies by Tajuddin; and Jusoff have suggested that rearing animals under rubber tree plantation not only increased economic value but also reduced costs of weeding and fertilizing. In Malaysia, sheep rearing under rubber plantations also appeared to be very attractive and practical, as apart from selling meats, it also served as a biological weed control measure. The cost of controlling weeds could be reduced by approximately 21% over the usual method by using sheep grazing or weed control. In addition, the Internal Rate of Return (IRR) from sheep rearing could be as high as 44% (Tajuddin, 1986). Sheep grazing was also found to improved soil fertility, which resulted in increased nutrient uptake and growth by rubber trees (Jusoff, 1988). In considering the topographical conditions of northern Laos, instead of sheep, goat and/or cattle grazing under mature plantation would enhance growth of trees through manure uptake and increase income through selling meats.

Intercropping during the unproductive immature stage of rubber provided a method to reduce the gap in income suffered by smallholders after replanting or new planting of rubber. A financial appraisal revealed that there was a potential to raise profits by more than 350% if the planting density of banana was increased threefold over the current practice of the Sri Lankan smallholders. The density of banana cultivation was increased from a single row of 500 banana clumps per 500 rubber plants per hectare to three rows of 500 banana clumps per 500 rubber plants per hectare. However, the authors emphasized that the yields expected in the third year, fertilizer costs, labor costs, and market value of banana were four major factors that governed the profitability of the intercropping (Rodrigo et al., 2001). Rubber-tea intercropping generated a higher Land Expectation Value (LEV) than rubber and tea monocultures. In Hainan province, China, rubber-tea intercropping generated the highest LEV, while tea monoculture had the lowest under current market conditions. The rubber-tea intercropping had an optimal rotation age of 26 years with LEV of 50,717 CNY/ha, and the optimal rotation year of rubber monoculture was 29 years with 39,286 CNY/ha. Tea monoculture had no optimal rotation age with maximum NPV (Guo et al., 2006).

2.6. Rubber tree plantation and food crop cultivation

Expansion of rubber tree plantation was a trade-off of upland rice and other food crops cultivation. Investment in rubber tree plantation on the one hand, have been found to generate economic profits to the smallholder, it was on the other hands, also affected areas of rice cultivation negatively. In spite of the fact that rice (sticky and ordinary) is remained consuming nationwide by the Lao people as a staple, areas of upland rice cultivation under shifting cultivation system in the country as well as in LuangNamTha in particular has been declined annually (Figure 2.10). As the shifting cultivation has been perceived as a major cause of the forest cover changes in Laos (Vongsiharath, 2009); the government has put efforts to eliminate this type of forests harmful agricultural production system. A reduction in areas of shifting cultivation was directly influenced by the central governmental policy to liberalize trade and markets to promote private-sector activities. The normalization of trade relationships with Thailand and China boosted economic growth in Laos during the early 1990s; cash crop production increased in particular (Fujita, 2006; and Thongmanivong and Fujita, 2006). Then, from the mid-1990s to the mid-2000s, the expansion rubber tree cultivation was considered a major cause for further reduction in shifting cultivation. This decrease was especially noticeable after the rapid expansion of rubber tree cultivation (the rubber boom) began in 2006 when target areas for rubber cultivation had been chosen and several policies had been implemented to realize the goal (as described in the previous section).

The long-term decline of upland rice cultivated areas as a result of the rapid expansion of rubber tree cultivation was not surprising because evidence both in Laos and Yunnan province, China, has demonstrated that an expansion of rubber tree plantation occurred at the expense of forestlands and upland agricultural production, mainly shifting cultivation (Thongmanivong and

Fujita, 2006; and Liu et al., 2006). Thongmanivong and Fujita (2006) assessed land use changes from 1993 to 2000 in four northern provinces of the Lao PDR, including LuangNamTha Province. They found that the agro-ecological landscape of the upland areas in those four northern provinces is undergoing a rapid transformation from subsistence and swidden-based landscapes towards a more commercial and multifunctional use of uplands. In particular, upland agricultural land decreased significantly from 1993 to 2000, from more than 1.5 million hectares to 625,429 hectares. In Xishuangbanna, China, swidden fields decreased from 20.4 ha in 1998 to 12.7 ha in 2004, while the number of cultivated upland rice varieties decreased from 7 varieties in 2001 to 1 variety in 2004 because of a sharp increase in the price of rubber after 2002 (Fu et al., 2009b).

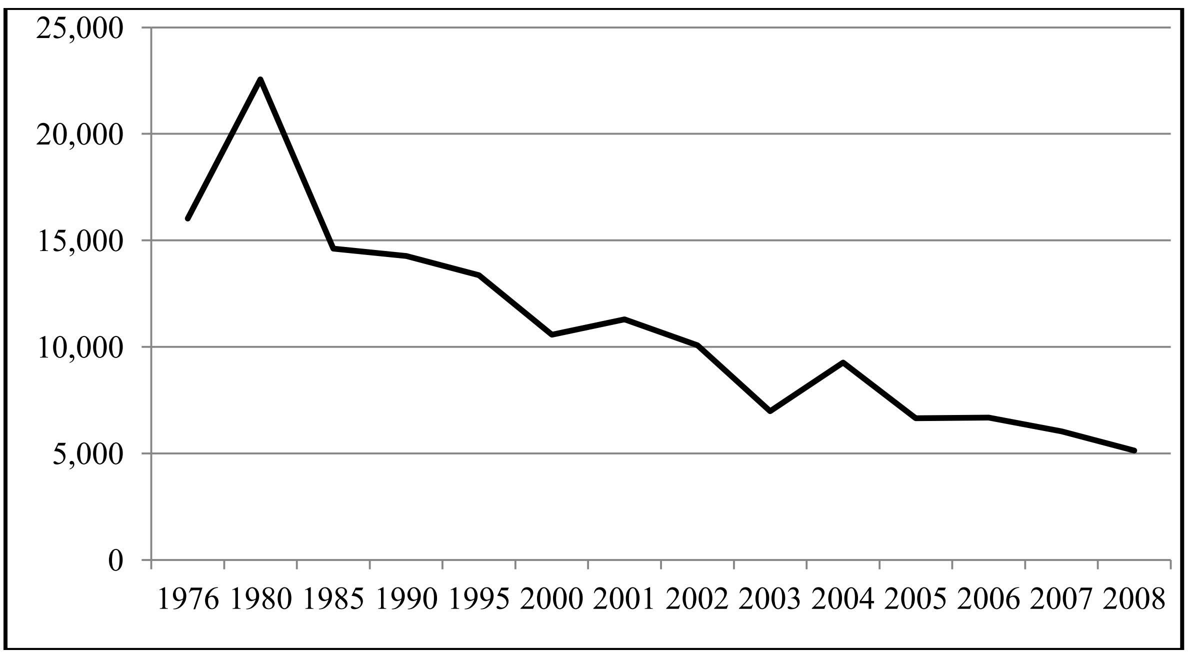

Figure 2.10: Upland rice cultivated areas in LuangNamTha Province (hectare)

Source: Agriculture Statistics 30 Years of Laos (1976-2006)

2.7. Environmental perspective of rubber tree plantation

2.7.1. Rubber tree plantation and forest cover changes

Forest cover in Laos has been declined continuously within three decades (Figure 2.11). The more rapid rate was observed in the second decade. The forest coverage as well as its changes varied across regions. Southern part had the largest areas of forest coverage, while the Northern had the smallest forest coverage areas (Figure 2.12). The most severe case has been observed in the Northern region. The forest cover in this region has declined continuously for three decades despite of the fact that it contains the smallest areas forest cover (Figure 2.12). The forest area covered approximately 38.1% of total areas in 1982 has decreased to 36.3% after one decade and continue to decreased to 27.9% in 2002. The decrease rate in the latter decade was 8.4% more rapid than the first decade (Vongsiharath, 2009). The more rapid change in the forest coverage in the latter decade was driven by several factors that can be classified into external and internal factors. High demand of wood and non-wood products in wood deficiency markets and an imposing logging ban in neighboring countries are the major external factors. Shifting cultivation and forest fires are the two major internal factors driven for rapid change in forest coverage in Laos. In addition, unsustainable and unmanageable extraction of forest and non-forest products further accelerate the change in forest cover in the later decade. Land conversion to permanent agriculture and infrastructure development are another two factor cased forest cover change. Finally, ineffective and not strict implementation of law and regulations remained contributing for the forest cover change in Laos (Vongsiharath, 2009). Although there is no clear evidence that supports the claim that the rapid expansion of rubber tree plantation was the main cause of forest cover changes in northern Laos, but upland cultivated plots for shifting cultivation and fallow forests have been converted to rubber tree plantation for either the benefits from foreign exchange as a result of a continued increasing demand for natural rubber from China or for acquisition of exclusive land use rights, regardless of ambiguous legal status of land ownership (Thongmanivong et al., 2009).

The experience from Xishuangbanna, southwest China has illustrated that from 1988 to 2003, rubber tree plantation increased by 324%, while forest cover decreased by 60%. Fallow lands for upland rice and other crops cultivations decreased by 95% (Liu et al., 2006). The most obvious change was the decrease in forest cover and increase in rubber tree plantations. A total area of 139,576 hectares of tropical seasonal rain forest was lost because of increased rubber tree plantation below 800 m and shifted agricultural activities to the higher elevations. The tropical rain forest of southwest China has the richest flora and fauna of China, and losing substantial parts of this forest type has increased the loss of biodiversity (Li et al., 2007)

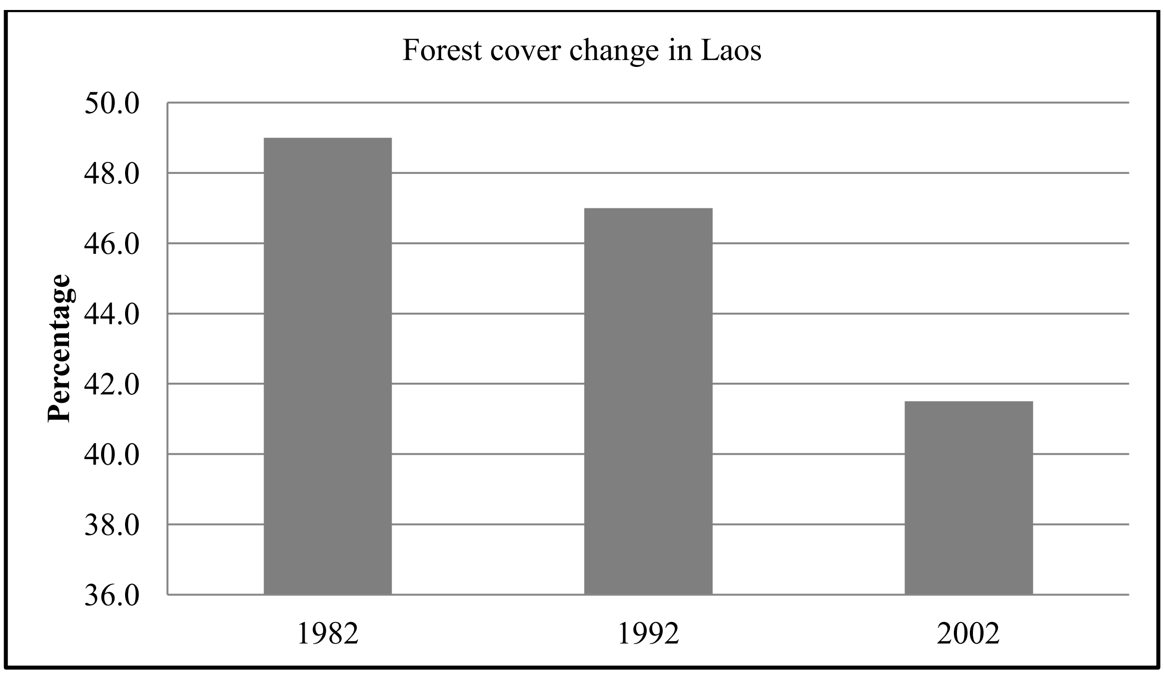

Figure 2.11: Forest cover change in Laos in three decades

Source: Vongsiharath, 2009

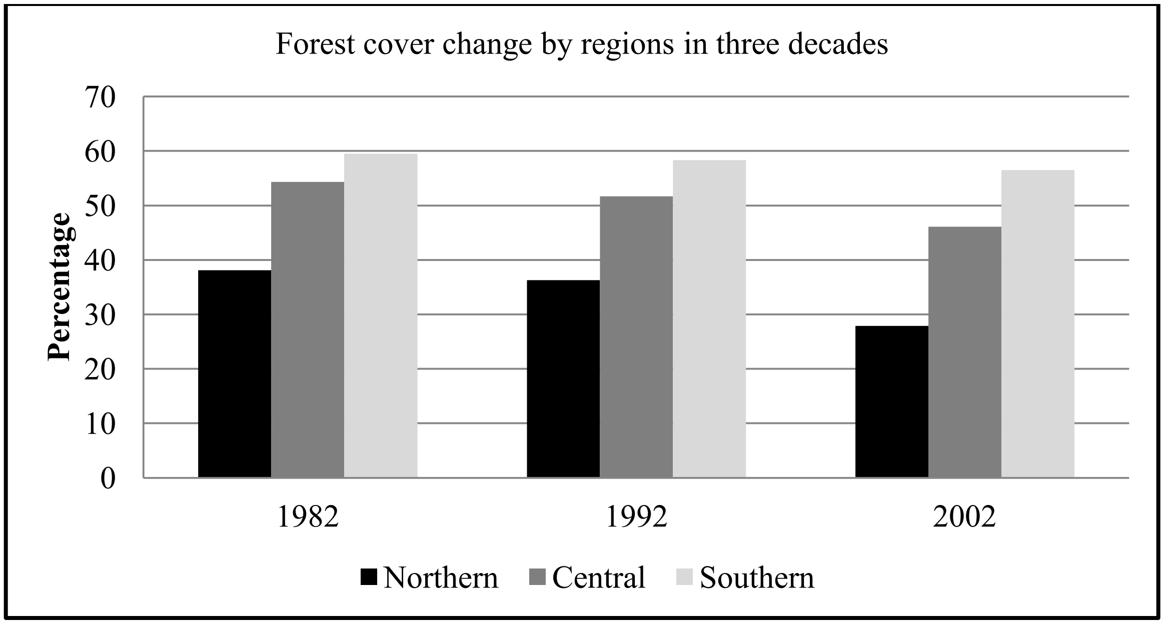

Figure 2.12: Forest cover change Laos in three decades, by regions

Source: Vongsiharath, 2009

2.7.2. Rubber tree plantation and soil quality

The impacts of planting rubber trees on soil quality have been widely recognized (Aweto, 1987; Zhang and Zhang 2005; Zhang et al., 2007a; and Zhang et al., 2007b). Aweto (1987) observed that in southwestern Nigeria, changes in soil bulk density and total porosity during the first 18 years of rubber plantation establishment were slight. However, most of the observed decline in soil mineral-nutrients occurred during the first 11 years following rubber tree plantation. The work of Aweto has been supported by a number of current studies conducted in Yunnan and Hainan Provinces of China. In Hainan, there was strong evidence that long-term rubber farming caused soil acidification, soil compaction, and depletion of organic matter and nutrients (Zhang and Zhang, 2005). Two years later, the authors found that rubber cultivation had resulted in a significant decline in soil organic Carbon (C) and microbial biomass carbon (C) and that adopting rubber-intercropping could not decelerate soil degradation (Zhang et al., 2007a). In addition, they found that total organic carbon (TOC) increased significantly in the tea-row soils of tea-rubber intercropping, but remained low in the rubber-row soils of rubber plantations and tea-rubber intercropping in the age 40 year stand (Zhang et al., 2007b). Other scholars suggested that adopting animal husbandry under rubber tree plantation would improve soil quality. For instance, sheep grazing under rubber tree plantation in Malaysia was found to improve soil fertility through the additional nutrients, which resulted in increased nutrient uptake and growth by rubber trees (Jusoff, 1988). In line with a number of advantages of rubber intercropping and combining animal husbandry, Guo et al. (2006) stated that there were some barriers that must be taken into consideration. (1) Rubber intercropping was more labor intensive than a monoculture system, so the labor sources and wages were two factors affecting its adoption. And (2) Intercropping could not be adopted by all smallholders because intercropping was more technically demanding. Intercropping may generate lower LEV than a monoculture if management was not applied properly.

2.8. Determinants of time allocation

2.8.1. Theoretical model

In concerns with the facts that the markets for the key factors and products are typical weak or absence in developing countries, rural households are therefore acting as both producers and consumers of agricultural products, forest goods, and non-forest goods. As a result production and consumption decisions are made jointly in response to changes in input and our prices

This chapter assumes that smallholder rubber households allocate family labor across five activities: upland rice shifting cultivation (Ls), rubber tree cultivation (Lr), livestock production (Ln), NTFP collection (Lf), and off-farm employment (Lo). The household solve

$$max_{L_i, C_{i,}} U = U(C_i, N; H), i = s, r, n, f, 0 \ldots \ldots \ldots (2.1)$$

Where utility (U) is derived from consumptions of representative staple crop rice (Cs), a composite good purchasing by rubber income (Cr), meat from livestock production (Cn), forest goods (Cf), a composite good purchasing by off-farm income (Co), and leisure (N). Household characteristics (H) influence preference. We assume U is strictly convex.

Utility is maximized subject to production functions for rice, rubber, livestock, forest, and off-farm, a full income constraint, a time constraint, and non-negativity constraint:

$$Q_s = g_s(L_s, A_0) \ldots \ldots \ldots (2.2)$$

$$Q_r = g_r(L_r, A_0), Q_r = 0 \; for \; unproductive \; stage, and \; Q_r > 0 \; for \; productive \; stage \ldots \ldots \ldots (2.3)$$

$$Q_n = g_n(L_n) \ldots \ldots \ldots (2.4)$$

$$Q_f = g_f\left(L_f, D\right) \ldots \ldots \ldots (2.5)$$

$$Q_o = g_o(L_o) \ldots \ldots \ldots (2.6)$$

$$Y = \sum_i P_i Q_i - \sum_i P_i C_i \ldots \ldots \ldots (2.7)$$

$$T - N = \sum_i L_i \ldots \ldots \ldots (2.8)$$

$$C_i, N, Q_i, L_i \geq 0 \ldots \ldots .. (2.9)$$

Equation (2.2) describes households' upland rice shifting cultivation. Quantity of rice yield (Qs) is a function of household labor allocates for rice (Ls) and households land endowments (A_0). Household allocate labor to clear forest and converted into rice field, after that labors are used to grow rice, weeding, and harvesting rice after rice became matured.

Equation (2.3) describes households' rubber tree cultivation. There was no reported of fertilizer application for rubber tree cultivation the uplands of Northern Laos. The quantity of rubber latex yield (Qs) is a function of household's labor for rubber (Lr) and land endowments (A_0). This study focused on smallholder rubber allocation to the existing rubber plantation. Rubber tree cultivation was divided into two stages of the cultivations: unproductive and productive. At unproductive stage, labor required for mainly weeding, and there is no output from rubber tree cultivation at this stage, (Qr) at unproductive stage is subject to zero. At productive stage, household labor allocated to weeding, tapping, and collecting the rubber latex. Households obtained outputs in the form of raw rubber latex, and generated income from latex sales.

Equation (2.4) describes the production function of livestock. This chapter assumes that the young livestock is given. Therefore, household labor is the only input to obtained quantity of livestock output (Qn). Households spent working hours to collect grass, fodder, preparing feed, and fed livestock. In case of large livestock such as cattle and buffalo, the working hours for grazing are needed.

Equation (2.5) describes production of NTFP (Qf). Households spent working hours for travelling to the collection sites, searching, and collecting the products from the forests. Distance to the forest (D) also enters into the production function to reflect potentially lower net benefits of product of labor in forest product collection due to times required for travelling to the collection sites increased. Equation (2.6) is a production function of off-farm good (Qo) which is required only labor (Lo).

Equation (2.7) defines the household full income. We assume all market prices are exogenous. There would be transaction cost incurred in order to access commercial goods at the market, however, due to lack that information, this study assumed that the transaction cost is zero. Due to imperfect market in rural areas of Lao in general, livelihoods of rural households in the upland of Northern Laos in particular is tightly stuck with upland rice shifting cultivation. Thought they are embracing to rubber tree cultivation as a new economic opportunity, where forestlands are accessible, upland rice shifting cultivation is remained adopting by the households mainly to secure staple supply for household needs. Equation (2.8) describes households'' time constraint. And non-negativity constraint in equation (2.9) completes the model.

The Lagrangian of the households' utility maximization problem can be express as:

$$\mathcal{L} = U\left(C_i, T - \sum_i L_i\,; H\right) - \lambda \begin{bmatrix} Y - P_s g_s(L_s, A_0) \\ -P_r g_r(L_r, A_0) \\ -P_n g_s(L_n) - P_f g_f(L_f, D) \\ -P_o g_o(L_o) + \sum_i P_i C_i \end{bmatrix} \dots\dots\dots (2.10)$$

After rearranging term, the first order condition can be expressed as the following:

$$\frac{\partial U}{\partial N} = \lambda P_s \frac{\partial Q_s}{\partial L_s} \dots\dots\dots (2.11a) \qquad \frac{\partial U}{\partial C_s} = \lambda P_s \dots\dots\dots (2.11f)$$

$$\frac{\partial U}{\partial N} = \lambda P_r \frac{\partial Q_r}{\partial L_r} \dots\dots\dots (2.11b) \qquad \frac{\partial U}{\partial C_r} = \lambda P_r \dots\dots\dots (2.11g)$$

$$\frac{\partial U}{\partial N} = \lambda P_n \frac{\partial Q_n}{\partial L_n} \dots\dots\dots (2.11c) \qquad \frac{\partial U}{\partial C_n} = \lambda P_n \dots\dots\dots (2.11h)$$

$$\frac{\partial U}{\partial N} = \lambda P_f \frac{\partial Q_f}{\partial L_f} \dots\dots\dots (2.11d) \qquad \frac{\partial U}{\partial C_f} = \lambda P_f \dots\dots\dots (2.11i)$$

$$\frac{\partial U}{\partial N} = \lambda P_o \dots\dots\dots (2.11e) \qquad \frac{\partial U}{\partial C_o} = \lambda P_o \dots\dots\dots (2.11j)$$

$$Y = \sum_i P_i Q_i - \sum_i P_i C_i \ldots \ldots \ldots (2.11k)$$

Equation (2.11a) through (2.11e) indicate that, at the optimum, households allocate working times across activities to the point where marginal value of household leisure equal the marginal product of labor or marginal returns to hourly wage. In other words, first order condition for this problem state that households equate their marginal rate of substitution between consumption and leisure, or shadow wage, either to their market wage or to their marginal products of labor. Equation (2.11f) through (2.11j) allocate labor to the point where marginal value of utility to the prices. Equation (2.11k) recovers the full income constraint. Theoretically, expression for labor supply, input demand, and commodity demand can be derived as a function of all exogenous variables

$$L_i = h(P_i, TC, H, A_o, D, T) \ldots \ldots \ldots (2.12)$$

2.8.2. Properties of labor supply

This section summarizes the properties of labor supply in the context of smallholder rubber cultivation in Northern Laos. The assumptions on the effects on NTFP labor share of the changes in its return, and in returns of other activities such as rice, rubber, livestock, and off-farm. The properties of labor supply were adopted from Fisher at al., (2005) but describes based on the situation of forest products collection of smallholder rubber households in Northern Laos. To better understand the implication of the model of labor supply of smallholder rubber households, the Slutsky equation is employed to hypothesize the effects on the forest labor share of the changes in its return, and in returns of other activities.

The Slutsky equation given the effect on NTFP labor share of a change in its return is expressed in equation (2.13)

$$\frac{\partial L_f}{\partial P_f} = \frac{\partial L_f}{\partial P_f}|_{U=\bar{U}} + \frac{\partial L_f}{\partial Y}\left(Q_f - C_f\right) \ldots (2.13)$$

The first term on the right hand-side is a substitution effect and the second term is an income effect. The substitution effect is positive since higher price of NTFP implies increased net benefits of NTFP collection, and thus increase its labor share. The income effect is indeterminate. First let assume that when income increases, the demand for leisure time (N) should increase if the leisure is a normal good; but for the same reason, will lead to increases in demand for NTFP products. However, due to imperfect markets for NTFP products in Northern Laos, higher NTFP consumption might require additional collection time rather than purchase, and would be attended by a rise in household NTFP labor share. Second, smallholder rubber households would continue collecting NTFP regardless of changes in cash income. The sign of income effect depends on the relative demand for leisure and NTFP products, and whether the household is the buyer of NTFP. Since the sigh of $\frac{\partial L_f}{\partial Y}$ is non-negative, the income effect is positive if $\left(Q_f - C_f\right) < 0$ or the household is a net buyer of NTFP. With the net seller of NTFP, the income effect is positive if the demand for NTFP is outweighs that for leisure time, and negative if the household choose to consume more leisure with its income rises. The effect on the NTFP labor share of a change in the return of NTFP is thus ambiguous and depends on household utility and endowments.

Equation (2.14) displayed the Slutsky equation given the effect on NTFP labor share of a change in the return of rice cultivation

$$\frac{\partial L_f}{\partial P_s} = \frac{\partial L_f}{\partial P_s}|_{U=\bar{U}} + \frac{\partial L_f}{\partial Y}(Q_s - C_s) \ldots (2.14)$$

As above, the first and second terms on the right hand side of equation (2.14) displayed substitution and income effects, respectively. The substitution effect can be positive or negative.

First assume that households response to the rising in return of rice by allocate more labor in rice cultivation and less labor for other activities including NTFP collection, either to gain higher profit from rice or to avoid purchasing rice for their own consumption. In this case, the substitution effect is negative. The substitution effect is positive if the household choose to allocate more labor on both rice to ensure staple supply and/or to gain higher benefit from rice and collecting NTFP to consume along with rice. The income effect may be positive or negative depends on the relative demand for leisure and demand for forest products and whether the household is a net seller of NTFP. With the net seller of NTFP, the income effect is positive if the demand for NTFP is outweighs that for leisure time, and negative if the household choose to consume more leisure with its income rises. In sum, the net effect on the change in NTFP labor share of a change in the price of rice also ambiguous.

The Slutsky equation given the effect on NTFP labor share of a change in the return of rubber tree cultivation is given in equation (2.15)

$$\frac{\partial L_f}{\partial P_r} = \frac{\partial L_f}{\partial P_r}|_{U=\bar{U}} + \frac{\partial L_f}{\partial Y}(Q_r - C_r) \ldots (2.15)$$

As above, the first and second terms on the right hand side represent substitution and income effect, respectively. The substitution effect is negative, and increase in return of rubber will increase household’s profits in rubber tree cultivation. Therefore, households allocate more labor share on rubber tree cultivation and less labor share on other activities including NTFP labor share. Income effect would be positive or negative depending on the relative demand for leisure and NTFP, and if the household is a net seller of forest goods. With the net seller of forest goods, the income effect is positive if the demand for NTFP is outweighs of that leisure time, and negative if the household choose to consume more leisure with its income rises. In sum, the net effect on a change in the NTFP labor share of the change in the return of rubber is ambiguous.

The Slutsky equation given the effect on NTFP labor share of a change in the price of livestock production is expressed in equation (2.16)

$$\frac{\partial L_f}{\partial P_n} = \frac{\partial L_f}{\partial P_n}|_{U=\bar{U}} + \frac{\partial L_f}{\partial Y}(Q_n - C_n) \dots (2.16)$$

As above, the first and second terms on the right hand side are substitution and income effects, respectively. The substitution effect is positive. Assume that household response to the rising in livestock price by increasing labor share for livestock production and less labor for other activities, including NTFP collection. The income effect would be positive or negative depending on the relative demand for leisure and NTFP, and whether the household is a net seller of NTFP. With the net seller of NTFP, the income effect is positive if the demand for forest products is outweighs of that leisure time, and negative if the household choose to consume more leisure with its income rises. In sum, the net effect on a change in NTFP labor share of the change in the returns to livestock production is ambiguous.

The Slutsky equation given the effect on NTFP labor share of a change in the returns of off-farm is expressed in equation (2.17)

$$\frac{\partial L_f}{\partial P_o} = \frac{\partial L_f}{\partial P_o}|_{U=\bar{U}} + \frac{\partial L_f}{\partial Y}(Q_o - C_o) \dots (2.17)$$

As above, the first and second terms on the right hand side displayed substitution and income effects, respectively. The substitution effect is ambiguously negative, but income effect is indeterminate. The income effect may be positive or negative depending on the relative demand for leisure and NTFP, and whether the household is a net seller of NTFP. With the net seller of NTFP, the income effect is positive if the demand for NTFP is outweighs of that leisure time, and negative if the household choose to consume more leisure with its income rises. In sum, the net effect on the forest labor share of a change in returns to off-farm employment is ambiguous.

2.8.3. Empirical analysis

Previous studies have found that agricultural households in Philippines, Malawi, and Kenya response positively on changes in the return of forest products, reflect the fact that households labor allocation for forest products collection in those countries based on economic rationale (Shively and Fisher, 2004; Fisher et al., 2005; and Sikei et al., 2009). However, this may not be the case of smallholder rubber households in Northern Laos where their decision on labor allocation for NTFP collection would base on the smallholder's taste or preferences rather than economic ground. There were inconclusive results on the effect of forest labor share of the change in the return of agricultural production. In most cases, previous studies have found that changes in the return of agricultural products had no effect on the forest (NTFP) labor share (Fisher et al., 2005; and Sikei et al., 2009). However, Shively and Fisher (2004) found that rising in return of agricultural products increase labor share among agricultural households in the Philippines.

In terms of effect on NTFP labor share of change in returns of off-farm employments, previous studies have shown different results based on the context of each study. For instance, Fisher et al., (2005); and Sikei et al., (2009) have found increasing in returns of off-farm employment had no effect on forest labor share in the case of low income household in Malawi and agricultural household living in forest margins in Kenya. However, Shively and Fisher (2004) have found that rising in returns of off-farm employment decreased forest labor share in the case of agricultural households in the Philippines. Based on the discussion above, empirical analyzes are needed to identifies the effects on forest labor share of the changes in the returns of NTFP, of rice cultivation, of rubber cultivation, of livestock production, and of off-farm employment of smallholder rubber households in Northern Laos.

Level of education found to have negative correlation with forest labor share; however, its effect on off-farm labor share was in conclusive. Among low-income households in Malawi, secondary education of household's heads showed positive correlation with off-farm labor share (Fisher et al., 2005), while education level among agricultural households in Kenya illustrated negative correlation to off-farm labor share (Sikei et al., 2009). Households with greater number of labor dependency ratio tended to allocate greater labor share on agricultural and forest collection activities than off-farm due to participation in agricultural production and forest collection activities are considered to be less restrictions compared to off-farm activities. Similarly, households with larger areas of cultivated land holding size concentrated major share of household labor on agricultural production. Forest collection activity was affected by the distance from the village to the community forest measured in kilometers. Households in the village where its location is relatively closer to the community forest allocated greater labor share on forest activities, and the degree of engaging in forest products collection decrease with increasing the length of the distance (Sikei et al., 2009) otherwise household had to reallocate labor from other activities if they chose to maintain the forest collection activities (Cooke, 1998).

2.9. Factor influencing household forest resource dependency

Non-timber forest products (NTFPs) contribute largely to livelihoods and economy of rural households in developing countries. Cash income generating from this source contributed from 60 percent of the average annual income per capita for households in Southern India

(Narendran et al., 2001), and shared more than 90 percent of the total household income in the hill Nepal (Gakou et al., 1994). There are extensive observations noted that poorer villages and household groups relied heavier on NTFPs than other groups (Adhikari et al., 2004; Viet Quang and Anh 2006; Shackleton and Shackleton 2006; and Paumgarten and Shackleton, 2009).

Several factors influence a dependence of a household on NTFPs. However, the NTFPs dependency may vary across household characteristics, income and wealth classifications, distance to markets and forests. Larger household size had greater demand for natural resources due to they had more mouth to feed and more labor to fulfill this demand (Adhikari et al., 2004). Mamo et al. (2007) noted that larger households faced increasing constraints in terms of alternative income and then had to dependence more on forest resources. Greater availability of adult labor was found to reduce both extraction and dependence, whereas households who had higher dependency ratio enjoy less benefit of collected NTFPs due to insufficient labor to participate in this activity (Viet Quang and Anh, 2006). The age of household may be positively associated with forest resource utilization due to older people may possess superior knowledge about various forest resources, and then may utilize more medicinal plants and wild foods (Piland 1991, cited in Godoy et al., 1997), while Cavendish (1999) noted that older people had difficulty carrying out arduous agricultural tasks and may turn to experience-based resource collection activities that require less physical labor and that are free of entry barriers. Higher level of education could create opportunities for off-farm employment, self-employment, and facilitate out-migration for better job that reduced dependence on forest resources (Godoy et al., 1998). Higher level of education would raise opportunity cost of labor for forest collection activities. Adhikari et al. (2004) illustrated that higher level of education made fuel wood collection increasingly unprofitable due to higher opportunity cost of labor. There was a strong gender division of labor for collecting NTFPs. Women played the most important role in NTFPs extraction and value, however, subsistence collecting was almost exclusive the task of women, whereas commercial gathering was often operated by men (Wickramasinghe et al., 1996; Misra and Dash, 2000). Adhikari et al. (2004) noted that in male-dominated rural settings, forest-based low-return cash activities were often taken up by female-headed households who could not make a significant living from agricultural due to lack of male labor for plowing.

The level of household income or wealth were negatively correlated with the income generated from NTFPs or the dependence of a household on NTFPs. Angelsen and Kaimowitz (1999) argued that higher income were likely to increase the pressure on forest. Cavendish (200) and Escobal and Aldana (2003) reasserted that the demand for natural resources grew with absolute income and the richer households used greater quantities of environmental resources in absolute terms while the poorer households were more dependence on the resources. Increasing distance to the forest edge also reduced overall extraction of forest resources. Both per capita forest income as well as the dependence of the household on NTFPs collection decreased with increasing distance to forest edge. Thus, only the villagers living near national nature reservation may become more dependent on NTFPs (Fu et al., 2009a). Household’s forest extraction has been found to decrease with increasing technical efficiency in agricultural production (Illukpitiya and Yanagida, 2010).

2.10. Technical efficiency studies

2.10.1. Technical efficiency

Figure 2.13 illustrate the simple concept to understand the definition of the technical efficiency measured by input-oriented (Farrell, 1957 and Coelli et al., 2005). Assumed a firm used two inputs (x_1 and x_2) to produce a single output (q) under the assumption of constant return to scale. This assumption allows technology to be represented unsing the unit isoquant. Knowledge of the unit isoquant of fully effieicny firm. In practical, the production frontier of fully efficienc firms is unknown and thus, must be estimated from observation on a samlple of firms in the industry concerned. The frontiers could be achieved by suing the Data Envelop Analysis (DEA) in case of multiple inputs and multiple outputs, and by Stochastic Frontier Analysis (SFA) in case of multiple inputs and single output. The latter analaysis was employed in to the analysis in this study.

The fully efficiency isoquant of the firm represented by SS' and permit the measurement of the technical efficiency. If a firm uses quantities of outputs at the point P, to produce a unit og output, the technical inefficiency of that firm coult be represented by the distance QP. That distance was perceived as the amount of by which all inputs could be proportionally reduced without a reduction in out put. This inefficiency usually expressed in percentage terms by the ratio QP/OP, which represents the presentage by which all inputs need to be reduced to achieve technically efficienct production. The technical efficiency (TE) of a firm is most commonly measured by the ratio OQ/OP, which is equal to one minus QP/OP. it takes a value between zero and one. This value, thus, provides an indicator of the degree of technical efficiency of the firm.

A value of one implies that the firm is fully technically efficienct. For example, the point Q is technically efficienct because it lies on the efficienct isoquant.

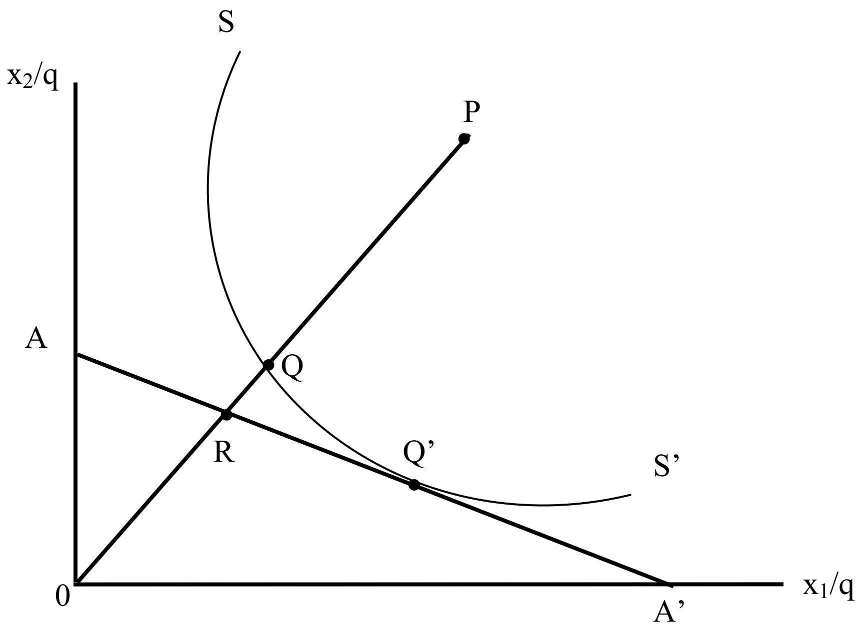

Figure 2.13: Technical and allocative efficiencies

If the input price ratio, represted by the slope of the isocost line, AA' is also known, allocative efficiency (AE) at P can be calculated and identified by the ratio OR/OQ. The decrease in production costs with distance from Q to R would happen if production is performed at the allocatively and technically efficienct poin Q' instead of at the technically efficient, but alocative inefficient point Q.

Finally, the total economic efficiency (EE) is defined as the ratio of OR/OP. the distance from P to R al represent the cost which could be reduced in the production if a firm produces at the point R with the technical efficiency and allocative efficiency. Economic efficiciency is the sum of the technical and allocative efficiency.

2.10.2. Analytical framework

This and the next sections described the theoretical and empirical model of technical efficiency of rubber tree plantation. Based on Coelli et al., (2005), technical efficiency measures the ability of the firm to obtain the maximum output from given in puts. Technical efficiency can be decomposed into three components, namely scale efficiency (the potential productivity gain from achieving optimal size of a firm), congestion (increase in some inputs could decrease output), and pure technical efficiency (Farrell, 1957).

There are two methods widely used in the literature review to estimate technical efficiency. The first is a non-parametric approach or mathematical programming method called Data Envelopment Analysis (DEA). This method is useful for multiple-inputs and multiple-outputs production technologies (Fare et al., 1985). The second one is an econometric approach that aims to develop stochastic frontier models based on the deterministic parameter frontier. The second approach is considered to be more efficient than the first since it has ability to separate effects of noise from the effects of inefficiency and confound effects of misspecification of a functional form with inefficiency, but generate good results only for a single output and multiple-inputs (Coelli et al., 2005).

The stochastic frontier production function have been proposed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) in the form

$$Y_i = f(X_i; \beta) exp\ (v_i - u_i) \ldots\ldots (2.18)$$

Where Y_i is the quantity of products of i^{th} farm with i ranging from 1, 2,…, n. X_i is the vector of input factors, β is the vector of unknown parameters to be estimated, v_i represents the two-sided ($-\infty < v_i < \infty$) or asymmetric random error accounting for the stochastic effects outside farmer's control such as weather, natural disaster, and luck; measurement errors; and approximation errors associated with the choice of functional form. The term u_i is a one-sided efficiency component or a non-negative random variable ($u_i \geq 0$) associated technical inefficiency (Coelli et al., 2005). This technical inefficiency might occur due to variation in farmer's socio-economic characteristics, government extension program, and so on. The v_i is assumed to be normally distribution, followed zero conditional mean and constant variance($v \sim N\ [0, \sigma_v^2]$). The error term u_i is assumed to have zero mean with constant variance and half-normal distribution($u \sim N\ [0, \sigma_u^2]$). The two components v_i and u_i are assumed to be independent of each other, and both errors are also assumed to be uncorrelated with the explanatory variables (X_i).

Equation (2.19) will be estimated by Maximum likelihood approach. Based on Aigner, Lovell and Schmidt (1977), the log likelihood function can be defined as

$$Ln\ L(Y_i|\beta, \sigma, \lambda,) = -\frac{1}{2} Ln\left(\frac{\pi\sigma^2}{2}\right) + \sum_{i=1}^{n} Ln\, \emptyset\left(-\frac{\varepsilon_i \lambda}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{n} \varepsilon_i^2 \ldots \ldots (2.19)$$

This is called half-normal model in terms of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u/\sigma_v \geq 0$. If $\lambda = 0$ there are no technical efficiency effects and all deviations from the frontier are due to noise and higher the value λ reflects more inefficiency effect explained by the model (2.19). Where Y is a vector of log-outputs; $\varepsilon_i \equiv v_i - u_i = Ln\, Y_i - X_i\beta$ is a composite error terms; and $\emptyset(X_i)$ is the cumulative distribution function (cdf) of the standard normal random evaluated at X_i.

Technical efficiency in the context of stochastic frontier production function cab be defined as

$$TE_i = Y_i/Y_i^* = f(X_i, \beta)\exp(v_i - u_i)/f(X_i, \beta)\exp(v_i) = \exp\ (-u_i) \ldots \ldots (2.20)$$

Where Y_i, X_i, β, v_i and u_i are as explained above. Y_i^* is maximum possible output. TE_i represents the technical efficiency. TE_i Measure the output of farm relative to the maximum output that can be produced in the same level of input vectors. The value of TE_i ranges from 0 to 1. If $TE_i = 1$, Y_i achieve the maximum value of f (X_i, β) exp (v_i) and $TE_i < 1$ represents the shortfall of production from the maximum possible production level in the environment characterized by stochastic elements which vary across farmers. Finally technical efficiency will be defined as the ratio of the observed output to the maximum possible out (equation 2.20).

2.10.3. Empirical analysis

Stochastic production frontier was extensively employed to analyze technical efficiency in agricultural production. These can be found in Yao and Liu 1998 for technical efficiency analysis of grain production in China. Iraizoz et al (2)003 employed this method to assess technical efficiency of horticulture in Spain. Lindara et al (2006) used this method to estimate technical efficiency in spice based agroforestry sector in Sri Lanka. Balcombe et al (2007); Shehu et al., (2007); and Khai and Yabe (2011) applied this method to examine technical efficiency in rice production in Bangladesh, Nigeria, and Vietnam, respectively. Recently, Idris et al (2013) employed this method to identify the determinants of technical efficiency in pineapple farming in Malaysia. However, the literatures on technical efficiency studies of rubber tree plantation were quite limited. These can be found in Son et al. (1993); Giroh and Adebayo (2007); and Mustapha (2011). Those studies employed different functional forms to estimate the stochastic frontier production to analyze technical efficiency of rubber tree plantation. For instance, Son et al., (1993) employed Cobb-Douglas stochastic production frontier to analyze the technical efficiency of 34 state rubber farms in Vietnam using panel data from 1986 to 1990. Similarly, Giroh and Adebayo (2007) used Cob-Douglas stochastic frontier to analyze technical efficiency of rubber tapping of 129 tappers in Nigeria using cross-sectional data. Recently, Mustapha (2011) employed Cob-Douglas and Tran-slog stochastic frontier models to examine technical efficiency of 35 smallholder rubber production in Malaysia using cross-sectional data. The author found that compared to Trans-log frontier, the Cob-Douglas could have explained better the relationship between the Y-output and X-inputs.

In the context of smallholder rubber cultivaton in Nigeria, the previous empirical work has found that female labor tend to constrained by social-cultural factors. In particular, female labor devoted most of times for household chores and taking care of children. This made male labor become more efficient compared to female (Giroh and Adebayo, 2007). This study also test the influenced of education and experiences on rubber cultivation, however, the results were not statistically significant. Similarly, experiences of Malaysia also found insignificant of the experience on technical efficiency of smallholder rubber tree cultivation. On the other hands, it has found that the variation in technical efficiency among smallholder rubber in Malaysia mainly due to some factors. Increasing density of planted tree per hectare reduced latex products per hectare. Whereas improving the productivity per a major tree tend to improve the productivity of rubber tree cultivation.

CHAPTER 3: STUDY SITES AND DATA COLLECTION

3.1. Introduction

This chapter divided into six sections. Description of the study sites was briefly described in section two. Section three described the data collection process. Data analysis illustrated in section four. Section five summarizes the results of the field survey. And final section was discussion and conclusion.

3.2. Study sites

Map of study sites presented in Figure 3.1. LuangNamTha Province is located in the Northern Region of Laos lying between 20°30' and 21°30' north and 100°30' and 102°00' east. It shares a border of 140 km with China in the north, 130 km with Myanmar in the west (PPCO 2005, cited in Manivong 2007). This Province is a centre for commerce between China, Laos, and Thailand.

The climate in the study site is humid tropical with an average temperature of 25°C. The annual precipitation is around 1,500 mm. The areas of LuangNamTha Province consist of 9,325 km^2, of which 85% is mountainous and 15% is lowland. The province is rich in forest resources. Its forest coverage was 59% of the total areas, of which 12.5%, 7.3%, and 5.6% were classified as National, Provincial, and District Biodiversity Conservation Areas, respectively. The remaining forests include upland mixed forest (26.6%) and young forest after slash and burn cultivation (48%). LuangNamTha province is the location of the third largest protected areas in Laos called Nam Ha National Biodiversity Conservation Area of LuangNamTha or in short Nam Ha protected area. Nam Ha protected area cover 2,224 square kilometers. Nam Ha protected area contains high rate of the primary forests, of which approximately 2% of the forest is either undisturbed or primary forest that regenerates itself.

In addition, Nam Ha protected areas contains richness of biodiversity. This protected area is a home of approximately 37 species of large mammals including Asian Tiger, Malaysian Sub Bear, Clouded Leopard, Asian Elephants and Black-Cheeked Crested Gibbon have been confirmed to exist, in addition, approximately 228 species of birds and over 200 species of NTFPs are found in Nam Ha Protected areas (Gujadhur et al., 2008).

Population in the province as well as in Laos as a whole are mainly classified into three groups, namely Lao Loum (Lowland Lao), Lao Theung (Midland Lao), and Lao Soung (Highland Lao). The main agricultural production system in lowland zone was irrigated lowland paddy cultivation, whereas combination systems between upland shifting cultivation and lowland paddy cultivated was found in the midland or hillside village, while the main agricultural production in the highland or mountain villages was the upland shifting cultivation (Yamada et al., 2004). Approximately 90% of the population involved in agricultural production, mainly rice cultivation, which including both lowland paddy fields and upland rice shifting cultivation.

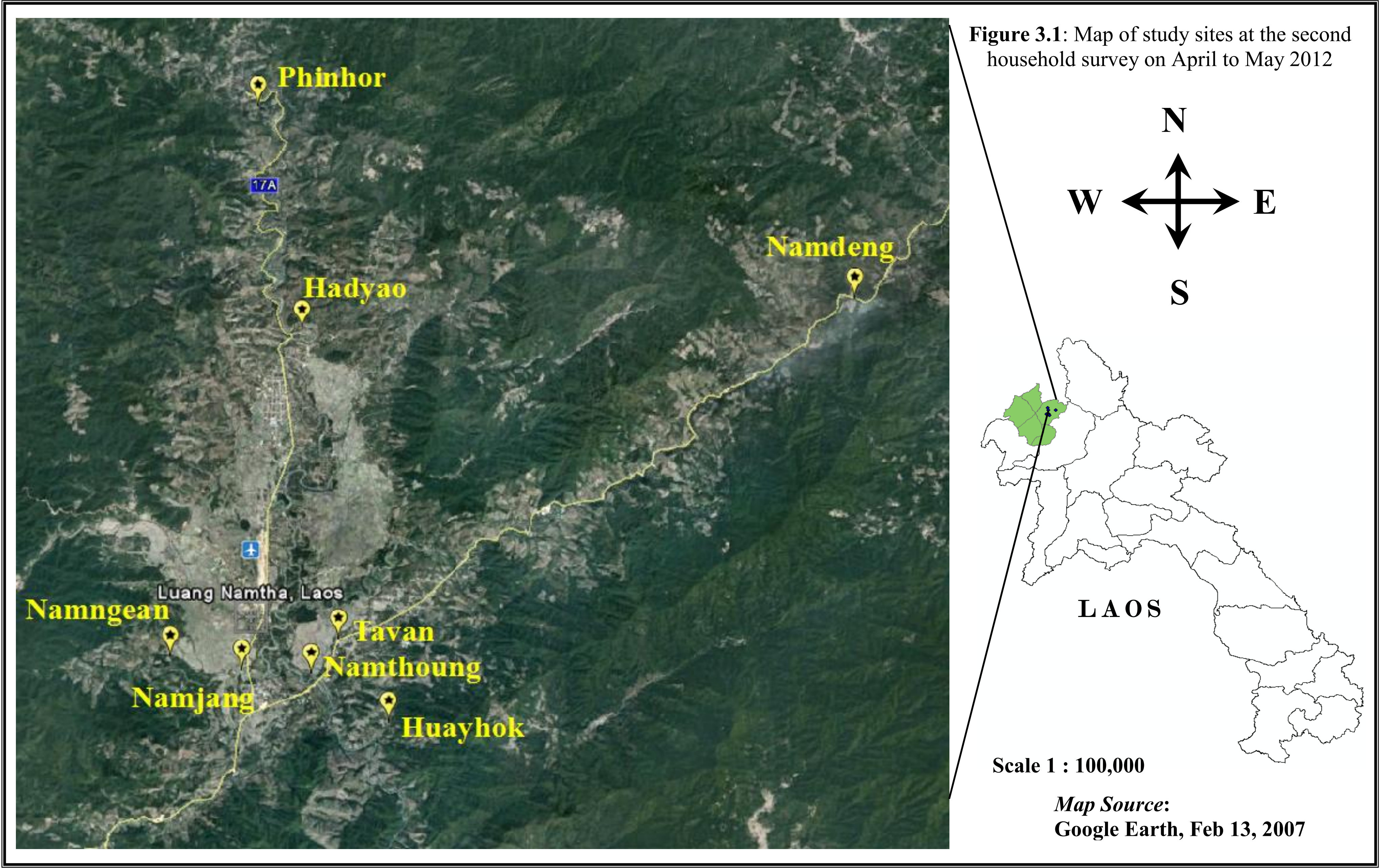

Figure 3.1: Map of study sites at the second household survey on April to May 2012

3.3. Sampling techniques and data collection

This study employed cross-sectional data derived from household survey. Data and required information obtained from face-to-face interview the villages by using questionnaire form. The sampling method and data collection are implemented through three steps. First step we met the staffs of the District Planning and Investment Office to investigated about the list of the villages that meet our requirements. After the list of the villages were given, second step the list was brought to confirm with the head or key persons of each villages, and then informed them about our purpose of the household survey, and sample households were selected randomly. During the meeting with the head or key persons of the villages, the information on the profiles of the villages was investigated by using semi-structured questionnaire form. Last step, the household survey was conducted with the assistance from the well-trained local staffs.

Household survey was conducting from April to May 2012. The data obtained from this time survey supplied for the empirical analysis from chapter four through chapter six. Approximately 405 households were randomly interviewed in eight villages in LuangNamTha District of LuangNamTha Province. After cleaning process, only 396 households were applicable. Those sample villages are including Hadyao, Namdeng, Namthoung, Phinhor, Namjang, Huayhok, Tavan, and Namngean villages. Majority of Highland Lao (Lao Soung) ethnic group located in the village Hadyao, Namdeng, Phinhor, and Tavan villages. Majority residents in Namjang and Huayhok villages are classified as Midland Lao (Lao Theung) ethnic group. The majority residents in the remaining two villages, Namthoung and Namngean are classified as Lowland Lao (Lao Loum). The main contents of the questionnaire form consists of information on (1) household's characteristics; (2) household resources (land holding size, labor, livestock holding); (3) livelihood activities adopted by the smallholder: rubber, upland rice shifting cultivation, animal husbandry, NTFP collection, and off-farm participation. The main data required from each of activity are including annually labor required for the production, annually quantity of yields (outputs) harvested from agricultural production and forest collection activity; and annually amount of cash income generated from each of activity.

3.4. Data analysis

3.4.1. Definition of terminology

3.4.1.1. Activity choices and labor inputs

Besides rubber tree plantation, sample households at the study sites also practiced upland rice shifting cultivation (rice); adopted livestock production or animal husbandry (these two phrases will be used interchangeably throughout this study); collected non-timber forest product (NTFP) collection; and participated in off-farm works.

Upland rice shifting cultivation was an annual rotation agricultural production system. This agricultural production involves cutting natural vegetation, burning slashed vegetation after they get dried, sowing rice, weeding, and harvesting. Labor required for upland rice shifting cultivation was estimated to be 340 psd per hectare per year (Field survey 2012). Therefore, total amount of labor required for upland rice shifting cultivation (hours) was calculated by multiplied number of total cultivated areas by number of labor inputs (340 psd) and times number of working hours per day.

Rubber trees are perceived as long-term crop. As mentioned above, rubber tree plantation was divided into two stages called unproductive and productive. Hand weeding and maintenance were the major activities which consumed labors at unproductive stage. At unproductive stage, there was high growth competition between young rubber and weeds. Therefore, hands weeding were normally performed three times annually. Manivong (2007) noted that total amount of labor required for hand weeding at unproductive stage was 120 person-days (psd) per hectare per year. On the other hands, rubber tapping and latex collecting activities were the major activities that required substantial amount of labors at productive stage, while weeding was less required. Labor required for weeding, tapping, and collecting at productive stage was estimated to be 259 psd per hectare per year (Manivong, 2007). The total working hours required for rubber tree plantation was separately calculated between unproductive and productive stage. Total working hours required at unproductive stage were defined as total areas of planted rubber under unproductive stage multiplied by 120 psd and times number of working hours per day, while total working hours required at unproductive stage were calculated by multiplied total planted areas under productive stage by 259 psd and times number of working hours per day. However, for those households who have been holding plantations under both unproductive and productive stage, their total working hours were calculated by the sum of total working hours of each stage.

Livestock production in this study referred to small scale of animal husbandry adopted at the household level. Activities required for livestock production were including cutting grass, collecting fodder, grazing livestock at a designated grazing zone, and feeding. The households were interviewed the total number of days preformed each activity per year, and then the number of hours per day performed each activity. And then the total working hours required for each activity were defined as the number of days multiplied by number of hours per day. Finally, total working hours required for livestock production per household per year was defined as the sum of total working hours for cutting grass, collecting fodder, grazing, and feeding.

Unlike agricultural production activities (rice and rubber), collection of NTFP normally conducted when the households were freed from agricultural production or on the day-off of off-farm works. Therefore, collection of NTFP was assumed to be a part time job, and assumed to consume half of hours putting for full time jobs or 4 hours per trips excluding travel times. In the questionnaire form, households were interviewed number of months that households participated in the collection activities per year, and number of days the household engaged in the collection per month. And then the total hours required for NTFP collection per year was defined as number of collected months multiplied by number of collected days per month and times number of hours per trip. However, since each village experienced different distance from the village to the community forests, therefore the travelling times were very critical in NTFP collection activities. From the field survey it was estimated that 35 minutes were required per km of the distance on foot. Therefore, the travelling hours per trip were defined as total distance (km) divided by 0.58 hours (35 minutes). Then the total travelling hours per year were calculated as total hours required per trip multiplied by total trips per year. Finally, total working hours required for NTFP collection per household per year equal to the total travelling hours plus total working hours for NTFP.

Total working hours for off-farm works were obtained from interviewed households. The questionnaire were as the number of laborers participated in off-farm works, the types of works, the number of hours worked per day, the number of days participated per week, the number of week worked per month, and the number of month participated per year. And then the total working hours required for each off-farm activity was calculated based on the obtained information. The sum of each type of work equal to the total working hours required for off-farm per household

Total household working hours was the sum of working hours from for rice, rubber, livestock, forest, and off-farm. Labor share for each activity was defined as the ratio of the total working hours of each corresponding activity to total working hours.

The community forest in this study defined as the place where some non-prohibited species of timbers, NTFPs, and wildlife are allowed to be hunted in a specific amount (Sirivath, 2005).

The distance from the village to the community forest presented in the fourth column measured the distance from the center of the village to the community forest. The center of the village in this study measured by the location of the village office or location primary school in case the village has no office. This is because the primary school usually is the place where the villagers are gathered for meeting and discussion regarding village issues.

3.4.1.2. Measurement and monetization

The income is measure on an annually average basis. Despite of the main purpose of upland rice shifting cultivation was to supply staple for household needs, number of households also had rice surplus and sold at the market for cash income. Therefore, the total values of upland rice defined as the total amount of harvested rice multiplied by its market prices, while total income obtained from upland rice sales defined as total amount of sold rice times its market price.

Total NTFP collected values defined as the total collected amount times market prices. NTFP income defined as total sold amount times market prices. NTFP collected value share defined as total collected value divided by total household income. This share was employed as a proxy of households' total forest resource dependency indicator. NTFP income share defined as

NTFP income divided by total household income. This share was employed as a proxy of households' forest resource income dependency.

Rubber income defined as the amount of cash earned from latex sale which is reported by the household. That amount of cash income from rubber latex was again cross checked with the volume of latex yields and multiplied by its price.

Income from livestock production or animal husbandry activity defined as the total amount of cash income earning from different types of small, medium, and large livestock sales which reported by the households.

The off-farm income was calculated based on wage or salary income. Different households consisted of different number of persons participated in off-farm jobs. Therefore, total household off-farm income is the sum of off-farm income obtained from all households member that participated in off-farm works.

Therefore, total monetary value was defined as the sum of total values of rice, total value of collected NTFP, rubber income, income from livestock sales, and total household off-farm income. Whereas, total household income defined as total cash income from rice sales, total cash income from NTFP sales, rubber income, livestock income, and total household off-farm income.

Households that participated in one activity and did not obtain cash income from that activity did not subject to zero labor returns of that activity. Due to total amount of working hours vary across sample households, it is plausible to assume that labor returns (hourly wage) also different across households. The hourly wage obtained from each activity thus defined as total monetary value obtained from one activity divided by total working hours corresponding to that activity.

3.5. Summary results of household survey

3.5.1. Profile of the sample villages

Brief descriptions of sample villages are displayed in Table 3.1. The list of the sample villages are presented in the first column. The villages are arranged based on the periods when each village has been officially report their first adopted rubber tree plantation (fifth column). However, each village also contained mixture period of times when households first adopted rubber tree plantation. Hadyao village adopted rubber tree plantation in 1994 and the first tapping began between 2002 and 2003. The profitable gained from rubber tree cultivation made this village became well-known as the first village for rubber tree cultivation in Northern Laos (Alton et al., 2005; and Manivong, 2007). This village has the second smallest areas of community forest with the furthest distance. In general, Highland Lao is the first group adopted rubber tree plantation, followed by Lowland Lao, while Midland Lao is the latest group adopted rubber tree plantation. Therefore, two Highland Lao villages (Hadyao and Phinhor) contained the largest proportion of households classified as productive, a village of Lowland Lao (Namthoung) had the largest proportion of households classified as productive group, while major residents in the two Midland Lao villages (Namjang and Huayhok) are classified as unproductive.

Community forest in this study defined as the place where some non-prohibited species of timbers, NTFPs, and wildlife are allowed to be hunted in a specific amount (Sirivath, 2005). The distance from the village to the community forest presented in the sixth column measured the distance from the center of the village to the community forest. The center of the village in this study measured by the location of the village office or location primary school in case the village has no office. This is because primary school usually is the place where villagers are gathered for meeting and discussion regarding village issues.

Table 3.1: Profiles of the sample villages in LuangNamTha District of LuangNamTha Province, Northern Laos

Village	Unproductive	Productive	All	Planted year	Distance to community forest (km)	Ethnic group
Hadyao	18 (32.1)	38 (67.9)	56 (14.1)	1994	15	Highland
Namthoung	12 (18.2)	54 (81.8)	66 (16.7)	1997	1.5	Lowland
Namdeng	20 (58.8)	14 (41.2)	34 (8.6)	2001	1	Highland
Phinhor	1 (6.7)	14 (93.3)	15 (8.6)	2002	5	Highland
Namjang	40 (58.8)	28 (41.2)	68 (17.2)	2003	3	Midland
Huayhok	41 (95.3)	2 (4.7)	43 (10.9)	2004	0	Midland
Tavan	33 (70.2	14 (29.8)	47 (11.9)	2004	8	Highland
Namngean	65 (97.0)	2 (3.0)	67 (16.9)	2005	0	Lowland
Number of households	230 (58.1)	166 (41.9)	396 (100)			

Note: *Numbers outside the parentheses indicate the sample size, number inside the parentheses in the second and third column show the percentage of household in each group from total sample of household of its corresponding group. The numbers in the parentheses in the fourth column indicate the percentage of sample household of each village from total sample size.

Source: field survey 2012

3.5.2. Characteristics of households

3.5.2.1. Sizes of household, labor, and dependency ratio

Household size measured by the number of residents living within the same household. There is not largely different in size of households between two stages of rubber tree plantation. A household at unproductive and productive stages had an average household size of 6 and 7 persons, respectively. Those numbers are equivalent to the average size of LuangNamTha Province as a whole (GoL, 2004). The size of unproductive group is ranging from 2 to 14, while the size of productive group is ranging from 4 to 16. The major proportion of the sample households with respect to the two stages of rubber tree cultivation distributed with the ranges of 4 up to 9 persons per households (Table 3.2)

Table 3.2: Comparison the distribution of sample households with different ranges of households sizes between unproductive and productive stages

Household size	Unproductive	Productive
Below 4	15 (6.5)	6 (3.6)
4 to 6	133 (57.8)	72 (43.4)
7 to 9	68 (29.6)	66 (39.8)
Above 9	14 (6.1)	22 (13.3)
No. of households	230(100)	166 (100)
Average size (person)	6	7
Minimum size (person)	2	3
Maximum size (person)	14	16

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within each household size range from total sample households.

Source: Field survey 2012

Table 3.3: Comparison the distribution of sample households with different ranges of labor sizes between unproductive and productive stages

Labor size	Unproductive	Productive
Below 3	101 (43.9)	53 (31.9)
3 to 5	95 (41.3)	78 (47.0)
Above 5	34 (14.8)	35 (21.1)
No. of households	230 (100)	166 (100)
Average size (person)	4	5
Minimum size (person)	1	1
Maximum size (person)	8	9

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within each labor size range from total sample households.

Source: Field survey 2012

An average labor sizes are 4 for unproductive group, and 5 for the productive groups, ranging from 1 to 8 for the unproductive, and ranging from 1 to 9 for the productive. However, major residents regardless of the stages of rubber tree cultivation distributed with the ranges of labor up to 5 (Table 3.3). Similarly, the major proportion of sample households regardless of the stages of rubber tree plantation distributed in the ranges up to 5 labor dependency ratio with an equivalent of an average number of 2 labor dependency ratio, indicating that each labor was responsible for two dependents (Table 3.4).

Table 3.4: Comparison the distribution of sample households with different ranges of labor dependency ratio sizes between unproductive and productive stages

Labor dependency ratio	Unproductive	Productive
Below 3	177 (77.0)	134 (80.7)
3 to 5	43 (18.7)	21 (12.7)
Above 5	10 (4.3)	11 (6.6)
No. of households	230 (100)	166 (1000
Average size (person)	2	2
Minimum size (person)	0	0
Maximum size (person)	10	10

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within each labor dependency ratio size range from total sample households.

Source: Field survey 2012

3.5.2.2. Gender, age, education level, and ethnic group of household head

Regardless of the stages of rubber tree cultivation major proportion of the sample households (60.9% for unproductive and 61.4% for productive) led by male household head (Figure 3.2). Household head with average ages of 42 years for unproductive and 41 years for productive.

Ages of household head at unproductive group ranges from 15 to 78 and from 17 to 72 for productive group. The youngest household heads are classified as the labor, while the oldest household head are classified as dependents. Regardless stage of rubber tree cultivation, the major proportion of household head is ranging from 25 years to 65 years, which classified as the labor (Table 3.5).

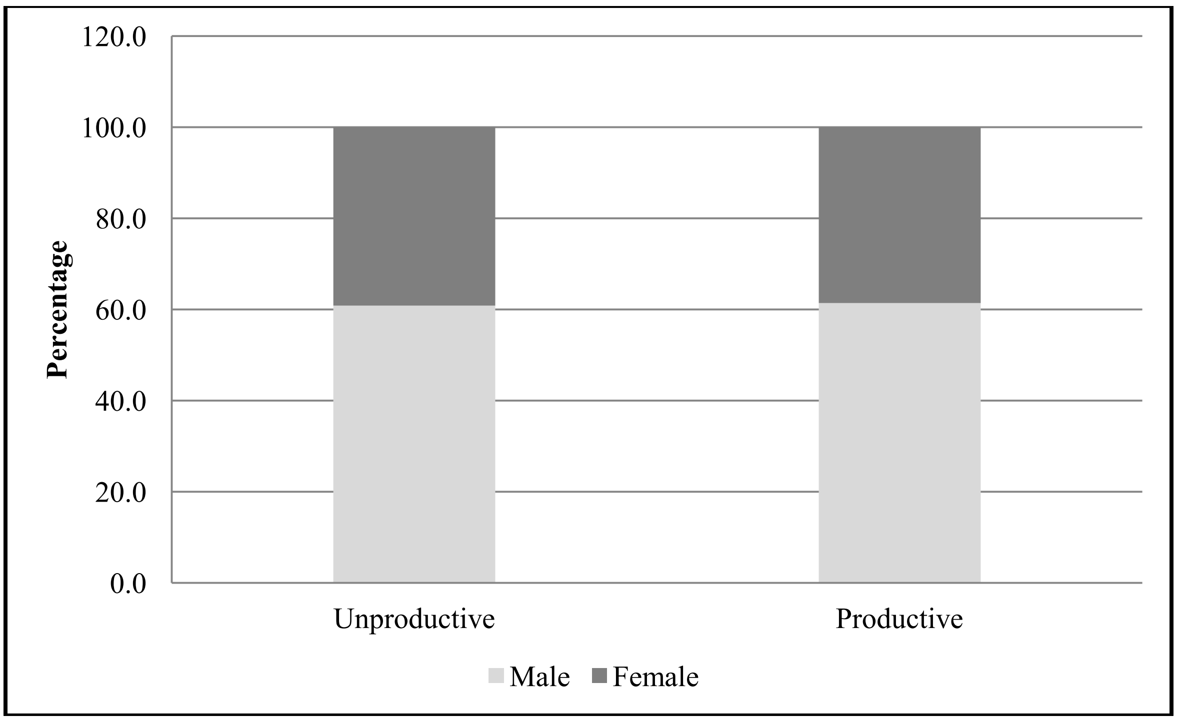

Figure 3.2: Comparison gender component of household head between unproductive and productive stages

Table 3.5: Comparison the distribution of household head with different age ranges between unproductive and productive stages

Age of household head	Unproductive	Productive
Below 25	18 (7.8)	10 (6.0)
25 to 35	62 (27.0)	47 (28.3)
36 to 45	65 (28.3)	44 (26.5)
46 to 55	51 (22.2)	47(28.3)
56 to 65	28 (12.2)	13 (7.8)
Above 65	6 (2.6)	5 (3.0)
No. of households	230 (1000	166 (100)
Average age (year)	42	41
Minimum age (year)	15	17
Maximum age (year)	78	72

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within each age range from total sample households.

Source: Field survey 2012

As a common issues of rural areas of several developing countries. Several constraints prevented household head in those areas to access to education. An average level of education of the household head within the sample households was 4 years, indicating that on average the household head have not completed primary education. Furthermore, approximately 24% of each group reported not attended school. With major household heads are educated at primary level, and relatively very small proportion was educated above high school level (Table 3.6).

Table 3.6: Comparison the distribution of education level of household head between unproductive and productive stages

Education level of household head	Unproductive	Productive
Not attend school	55 (23.9)	40 (24.1)
Primary	108 (47.0)	88 (53.0)
Secondary	45 (19.6)	20 (12.0)
High school	17 (7.4)	14 (8.4)
Above high school	5 (2.2)	4(2.4)
No. of households	230 (100)	166 (100)
Average schooling year (year)	4	4
Minimum schooling year (year)	0	0
Maximum schooling year (year)	16	14

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within each education level range from total sample households.

Source: Field survey 2012

The sample households represent the three major ethnic groups classified in Laos. Highland Lao is also known as Lao Soung, while Midland Lao and Lowland Lao are also known as Lao Theung and Lao Loum, respectively. The name of each ethnic group is basically given based on the place where they located and type of agricultural production they practiced. For instance, Lowland Lao usually resides at the flat land or along the river of which the main agricultural production is paddy field or lowland rice cultivation. Midland Lao on the other hands usually settle at the higher level of attitude and practice shifting cultivation integrated with small scale of animal husbandry, and NTFP collection. Finally, Highland Lao normally reside on the highest attitude compared to two groups and also practice shifting cultivation, opium cultivation, animal husbandry, and NTFP collection. Highland Lao is the first group that adopted rubber tree plantation since 1994, followed by Lowland Lao, and Midland Lao, respectively. Therefore, Highland ethnic group shared the largest percentage (51.8%) of sample households in the productive stage, followed by Lowland Lao (32.5%) and Midland Lao (15.7%), respectively. On the other hands, Lowland Lao shared the largest percentage (54.8%) of sample households in unproductive stage (Figure 3.3).

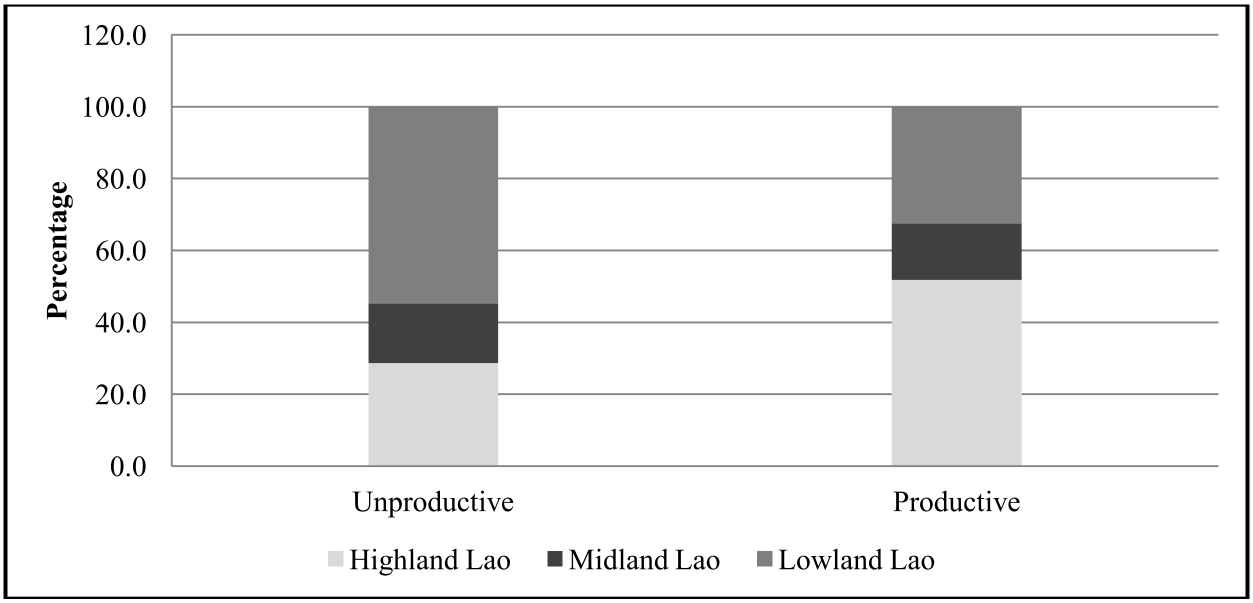

Figure 3.3: Comparison the distribution of ethnic groups between unproductive and productive stages

3.5.3. Rubber plantation

3.5.3.1. Age of plantation

Average ages of plantation are 4 years for unproductive groups and 11 years for productive groups. Households within each groups adopted rubber tree plantation in different years and thus varied in ages of plantation. Ages of plantation within unproductive groups are ranging from 1 to 7, while ages of plantation of the productive varied from 8 to 18. Major sample residents in unproductive groups have adopted rubber tree plantation below 5 years, while major sample residents of productive groups have adopted rubber tree plantation between 8 to 10 years.

Table 3.7: Comparison the distribution of sample households with different age ranges of plantation between unproductive and productive stages

Age of plantation	Unproductive	Productive
Below 5	137 (59.6)	0
5 to 7	93 (40.4)	0
8 to 10	0	120 (72.3)
11 to 13	0	14 (8.4)
Above 13	0	32 (19.3)
No. of households	230 (100)	166 (100)
Average age of plantation (year)	4.4	11
Minimum age of plantation (year)	1	8
Maximum age of plantation (year)	7	18

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within age of plantation range from total sample households.

Source: Field survey 2012

3.5.3.2. Size of area of plantation

There are considerable different in average size of plantation between unproductive and productive groups. Average sizes of plantation are 1.58 ha for unproductive group, and 2.46 for productive group. To some extent the possibility in access to forestlands for rubber plantation varied across households with respect to stages of rubber tree plantation. Households with smallest areas of plantation had only 0.2 ha. This is much far below than 1 hectare per household. While the households at unproductive with largest areas of plantation had up to 20 ha and 17.5 ha for productive group. Though major sample residents within the two groups (unproductive and productive) are holding plantation sizes in the ranges from 0.5 to 3.5 ha, but relatively larger proportion of household at productive stage is holding plantation size above 3.5 ha (Table 3.8).

Table 3.8: Comparison the distribution of sample households in different ranges of rubber tree planted area between unproductive and productive stages

Area of plantation	Unproductive	Productive
Below 0.50	25 (10.9)	13 (7.8)
0.50 to 1.50	146 (63.5)	74 (44.6)
1.51 to 2.50	36 (15.7)	36 (21.7)
2.51 to 3.50	4 (1.7)	12 (7.2)
Above 3.50	19 (8.3)	31 (18.7)
No. of households	230 (100)	166 (100)
Average area of plantation (ha)	1.58	2.46
Minimum area of plantation (ha)	0.20	0.20
Maximum area of plantation (ha)	20.00	17.50

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within area of plantation range from total sample households.

Source: Field survey 2012

Area of plantation per adult labor in Table 3.9 illustrates burden of adult labor in rubber tree cultivation. There are not so different between two stages, with average areas of less than a hectare per adult labor (of 0.62 ha per adult labor at unproductive stage, and of 0.89 ha per adult labor at productive). Major sample residents is holding up to 1 ha per adult labor, however, households at productive stage is currently holding above 1.5 hectare per adult labor is twice as unproductive group is (Table 3.9).

Table 3.9: Comparison the distribution of sample households in different ranges of area of plantation per adult labor between unproductive and productive

Area of plantation per adult labor	Unproductive	Productive
Below 0.50	139 (60.4)	87 (52.4)
0.51 to 1.00	60 (26.1)	45 (27.1)
1.01 to 1.50	12 (5.2)	7 (4.2)
Above 1.50	19 (8.3)	27 (16.3)
No. of households	230 (100)	166 (100)
Average area of plantation (ha)	0.62	0.89
Minimum area of plantation (ha)	0.07	0.05
Maximum area of plantation (ha)	6.54	11.60

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within area of plantation per adult labor range from total sample households.

Source: Field survey 2012

High competition on land for rubbers has been emerged in the mid 2000s after returns from rubber tree plantation have shown financially profitable. The late comers tried to seek land for adopting rubber tree planting as they expected higher returns from rubber latex sales after they have become mature, whereas early adopters also tried to expand their areas of rubber tree plantation to accumulate more wealth. Since rubber trees were perceived as a long-term crop, amidst high demand for land, planting rubber trees was often a direct way of acquiring exclusive rights to the land regardless of the ambiguous legal status of land ownership (Thongmanivong et al., 2009).

Number of adult labor per area of plantation in Table 3.10 is on the other hand illustrates degree of labor that households applied to cultivate rubber trees or in short measure the level of labor intensive. The ratio of adult labor to area of plantation is defined as number of labor equivalent. The larger number of labor equivalent not only indicates relatively larger size of labor, it is on the other hands also illustrates the relatively smaller size of plantation. On average, per hectare of rubber tree plantation was applied 3.6 and 3.2 number of labor equivalent at unproductive and productive stage, respectively. Labor-land ratio is ranging from 0.2 to 15.4 at unproductive stage, and ranging from 0.1 to 20 at productive stage. The maximum labor land ratio of 15.4 and 20 did not indicated that households had relatively larger size of labor, but it is on the other hand indicated that household had relatively much smaller in size of plantation compare to labor. This indicates that although at the productive stage, income obtained from rubber plantation would not sufficient to support households' consumption needs due to relatively smaller size of plantation.

Table 3.10: Comparison the distribution of sample households in different ranges of labor-land ratio between unproductive and productive

Number of adult labor per area of plantation	Unproductive	Productive
Below 1.0	31 (13.5)	32 (19.3)
1.1 to 2.0	60 (26.1)	48 (28.9)
2.1 to 3.0	34 (14.8)	29 (17.5)
3.1 to 4.0	36 (15.7)	12 (7.2)
4.1 to 5.0	25 (10.9)	14 (8.4)
Above 5	44 (19.1)	31 (18.7)
No. of households	230 (100)	166 (100)
Average labor-land ratio (number of labor equivalent)	3.6	3.2
Minimum labor-land ratio (number of labor equivalent)	0.2	0.1
Maximum labor land ratio (number of labor equivalent)	15.4	20.0

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within adult labor per area of plantation range from total sample households.

Source: Field survey 2012

3.5.3.3. Rubber productivity

This section illustrated the situation of rubber tree cultivation of sample households at productive group. Table 3.11 illustrates amount of productivity of rubber latex per household per year. On average, each household obtained approximately 1,116.1 kg of rubber latex per year, ranging from 10.4 kg to 13.913 kg. The varied in the productivity across households is due to differences in years of plantation among productive group. Major proportion of households obtained products of latex up to 600 kg per year.

Productivity per a mature tree in Table 3.12 on the other hand implied the soil quality where rubber trees have been planted. On average, household obtained 3.07 kg per a mature tree per year, ranging from 0.17 kg to 18 kg. These findings indicated that soil quality is varied across the plantations. However, soil quality not only one factor affected the productivity per a mature tree, but it was also affected by the ages of plantation as have been discussed in the section 2.4 of chapter 2 as well as observed through Table 3.8.

Table 3.11: The distribution of sample households in different ranges productivity per household with respect to stages of rubber tree plantation

Rubber productivity per household	Productive
Below 100	21 (12.7)
100 to 300	40 (24.1)
Above 300 to 600	47 (28.3)
Above 600 to 1,000	15 (9.0)
Above 1,000 to 3,000	29 (17.5)
Above 3,000	14 (8.4)
No. of households	166 (100)
Average productivity level (kg)	1,116.1
Minimum productivity level (kg)	10.4
Maximum productivity level (kg)	13,913.0

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within productivity range from total sample households.

Table 3.12: The distribution of sample households in different ranges of productivity per a mature tree with respect to stages of rubber tree plantation

Productivity per a mature tree	Productive
Below 1	40 (24.1)
1 to 3	78 (47.0)
Above 3 to 5	22 (13.3)
Above 5	26 (15.7)
No. of households	166 (100)
Average productivity per a mature tree (kg)	3.07
Minimum productivity per a mature tree (kg)	0.17
Maximum productivity per a major tree (kg)	18

Note: Number inside of the parentheses in the second and third column indicates the percentage of sample household within productivity per a mature tree range from total sample households.

Source: Field survey 2012

3.5.4. Household income

Figure 3.4 displayed average amount of income generated from five different sources, such as rice, livestock, forest (NTFP), off-farm, and rubber for household at productive only. Different structure of income could be observed with respect to each stage of rubber tree cultivation. Rubber income is the major income source for household at productive stage, while off-farm income is the major income source for household at unproductive stage. It is observed that average income of household at unproductive stage for rice, livestock, and forest are greater than that amount of average income of the household at productive stage. In off-farm, the average income of the households at productive stage is larger than that the average amount of household at unproductive stage. The sum of amount of income from five different sources, especially the contribution of rubber income made the total average income of the household at productive stage approximately three times larger than that the total average amount of income of household at unproductive stage.

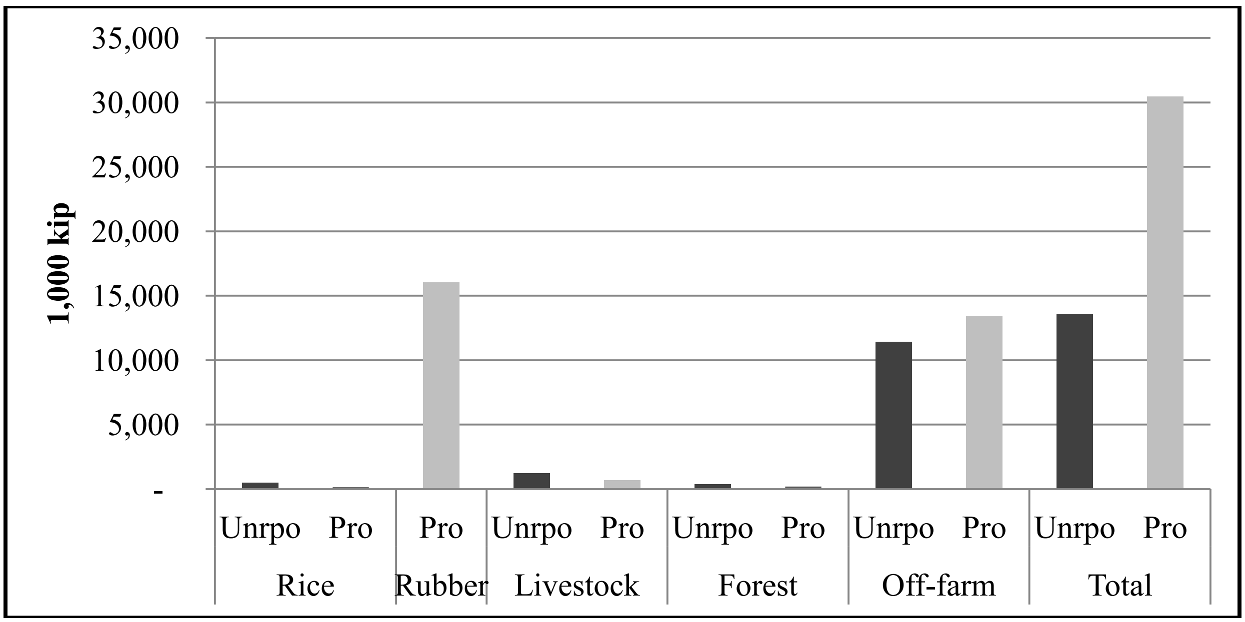

Figure 3.4: Comparison an average amount of income by different sources between unproductive and productive

Note: Unpro = unproductive; and Pro = productive

Exchange rate between Lao Kip and $US is 1$US = 8,000 kip (BOL, 2012)

Unit of income expressed in 1,000 kip

Source: Field survey 2012

Figure 3.5 illustrated the distribution of the sample households with different income ranges by different activities with respect to unproductive and productive stages of rubber tree cultivation. Different color bar illustrated different income ranges. Blue bar illustrate the smallest income range of less than one million kip. Red bar illustrate income range from one to five million kip. Green bar illustrates income above five to ten million kip. Purple bar indicates income above ten to fifteen million kip. Dark gray bar displays income range above fifth teen to twenty million kip. And finally, dark yellow bar illustrate the largest of income range above twenty million kip. Unpro is an abbreviation from of unproductive group, while Pro is the short form of productive. Results in Figure 3.5 showed that there are differences of households' distribution by different income ranges with different income sources. In cases of rice, livestock, and forest activities, largest proportion of sample households' regardless stages of rubber tree plantation distributed at the range of below one million kip. The distribution of households in off-farm activity is quite evenly with respect to unproductive and productive stages. Likewise, rubber, the major sample households at productive stage had income in the second and third range. For total household income, majority at the unproductive stage earned from five to ten million kip; majority at the productive stage of above twenty million kip.

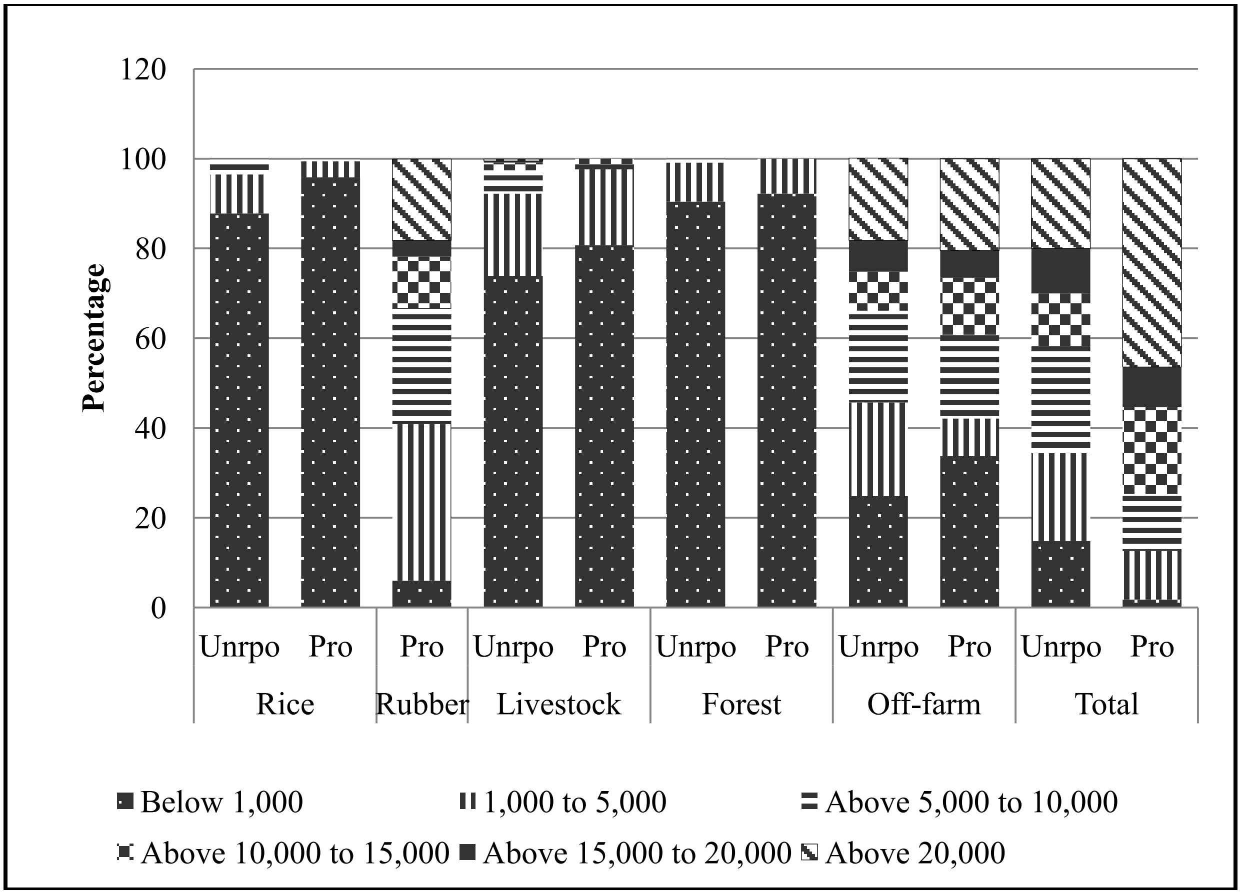

Figure 3.5: Comparison the distribution of households with different income ranges by different source between unproductive and productive stages

Note: Unpro = unproductive; and Pro = productive

3.5.5. Smallholder rubber household labor allocation

In addition to rubber tree plantation, forest activities in general, NTFP collection in particular remained participating by approximately 86.7% of productive households, and by more than 90% of households at unproductive stage. Similarly, off-farm employed is participated by 66.3% and 75.2% of households at productive and unproductive stage, respectively. Relatively smaller proportion of households at both stages remained participating in upland rice and livestock productions (Figure 3.6). Two major activities that remained adopting by smallholder rubber households along with rubber tree plantation played different roles on forest resource conservation. Collection of NTFP that conducted that exceeds the regeneration rates of forest resources could lead to forest resource degradation. Off-farm activities on the other hands can absorb the labors that will otherwise participate in forest activities or agriculture.

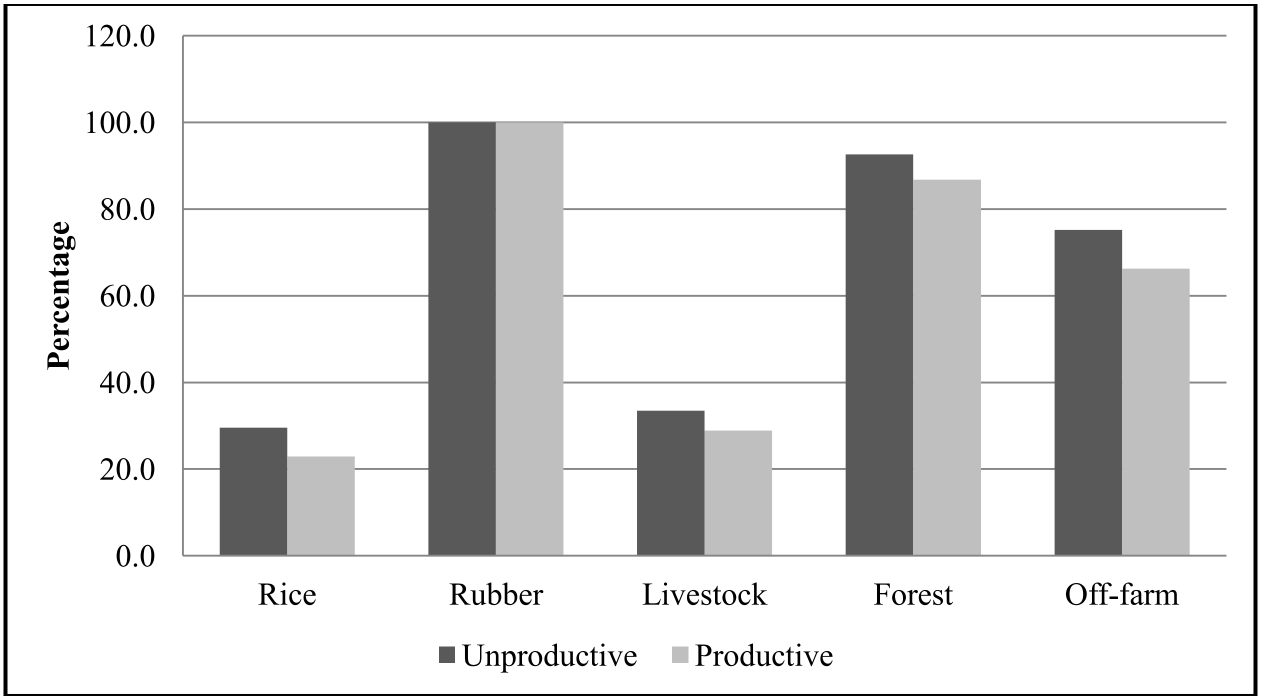

Figure 3.6: Comparison the labor participation rate by activities between unproductive and productive stages

Figure 3.8 illustrated average amount of working hours that smallholders at different stage of rubber tree cultivation allocated for different activities per household per year. It could observe that rubber tree plantation is the only activity that an average amount of working time of household at productive stage greater than that the amount of working time of household at unproductive stage. The working time of household at productive stage for rubber tree cultivation was more than twice greater than that the amount of working time of household at unproductive stage. Due to less hours of working for rubber is required for rubber tree cultivation, households at this stage had greater of working hours for other remain activities compared to household at productive stage. It could also observe that the total average amount of hours that households at unproductive stage allocated for working was greater than that the total average amount of household at productive stage. The greater amount of working time of households at unproductive stage would imply that in the absence of rubber income they had to actively working in other activities to generate cash income. In the presence of rubber income on the other hands, allow the smallholder to work less and enjoy more leisure hours.

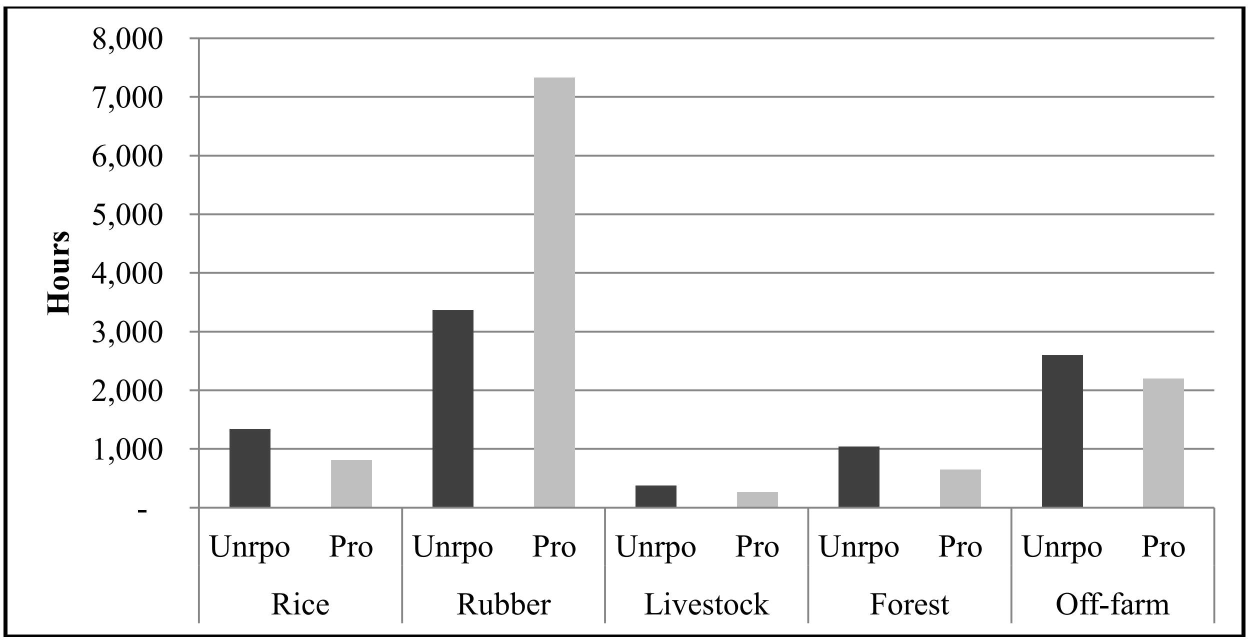

Figure 3.7: Comparison an average amount of working hours by different activity between unproductive and productive stages

Note: Unpro = unproductive; and Pro = productive

Figure 3.8 displayed the distribution of smallholder rubber households in different ranges of working hours with respect to unproductive and productive of rubber tree cultivation.

Regardless of the stages of rubber tree cultivation, the largest proportion of households allocated less than a thousand hours for upland rice shifting cultivation, livestock, and forest activities. Unlike rubber and off-farm activities, the largest proportion of household at unproductive stage distributed at a working hour range of 1,000 to 3,000 hours. While the distribution of households at productive stage was quite evenly, of which relatively larger proportion of household at this stage distributed at a working hour range of above 9,000 hours. The distribution of households for off-farm activity was evenly between the first, the second, and the third range regardless of the stage of rubber tree cultivation.

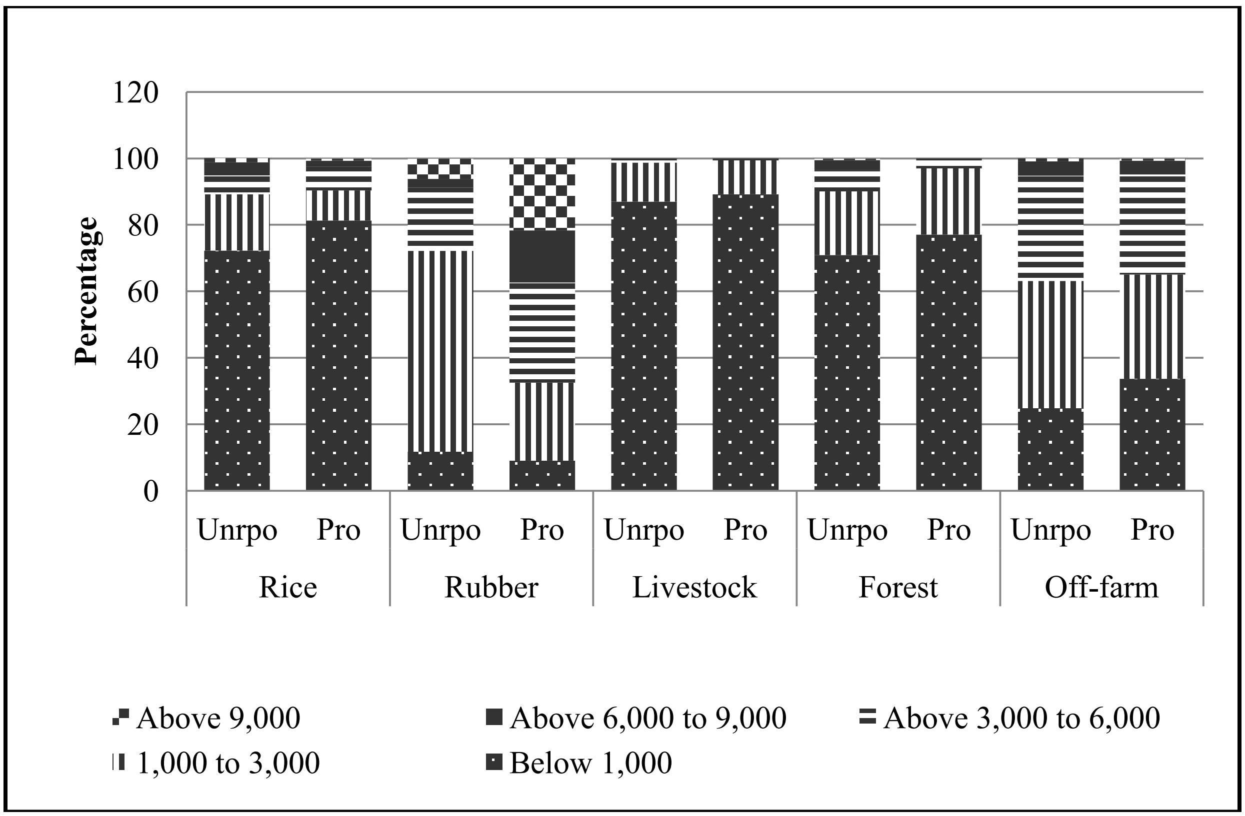

Figure 3.8: Comparison the distribution of households with different ranges of working hours by different activities between unproductive and productive stages

Note: Unpro = unproductive; and Pro = production

3.5.6. Non-timber forest product collection

The comparison of the purpose of NTFP collection as well as the values of collected NTFP between households at the unproductive and productive stages 3.9 and 3.10, respectively. Results in the Figure 3.9 showed that relatively larger percentage of household at unproductive stage remained participated on NTFP collection for both subsistence needs and cash income. However, majority households at the productive stage only participated on NTFP collection for mainly supply for subsistence needs. This finding implied that along with other activities households at unproductive also made efforts to earn cash income from NTFP during waiting for rubber income. However, with supportive income from rubber further reduced the dependency of household at the productive on NTFP for cash income. The interesting findings in Figure 3.10 showed although the average value of NTFP income of household at unproductive stage was slightly larger than that the average value of the household at the productive; however, the value of NTFP income was really small compared to the total collected value regardless the stages of rubber tree cultivation. This result implied that majority of collected NTFP are supply for the subsistence needs.

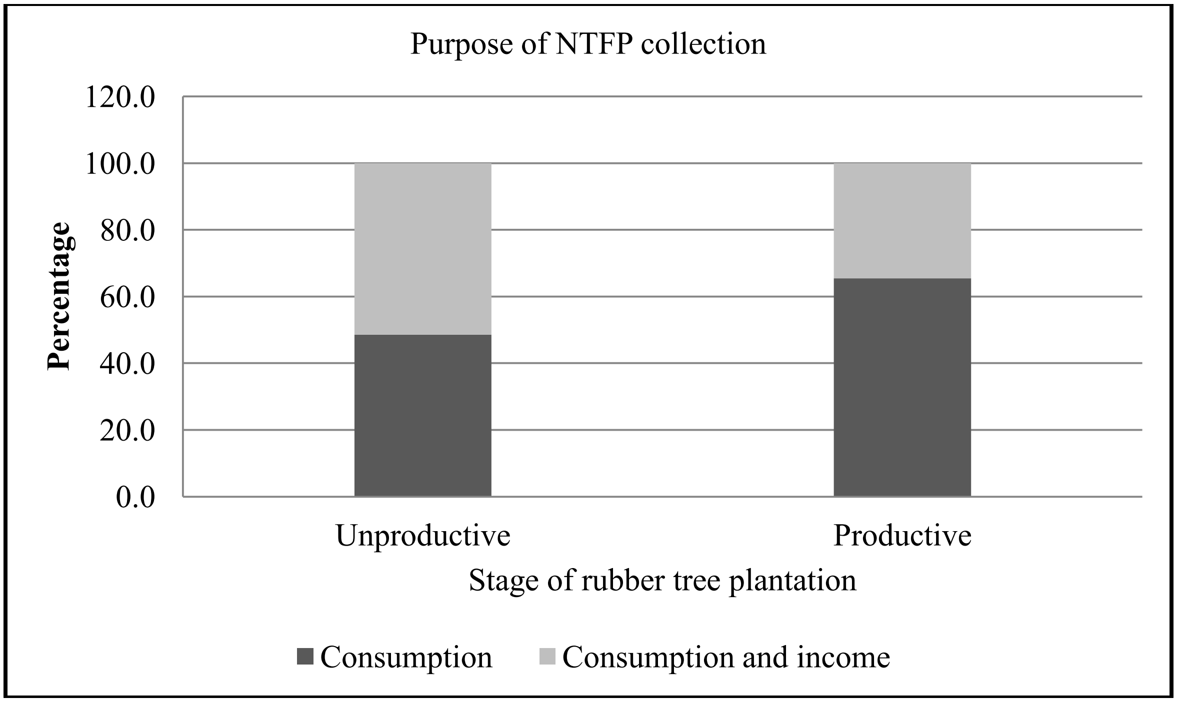

Figure 3.9: Comparison purpose of NTFP collection at unproductive and productive stage

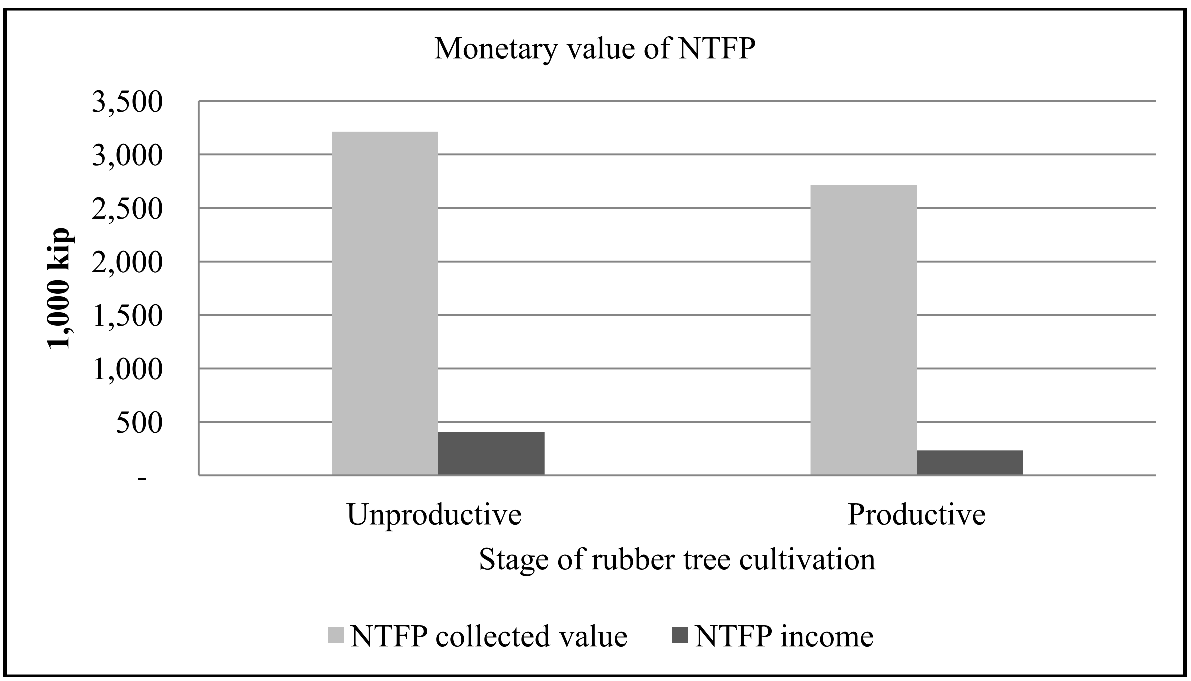

Figure 3.10: Comparison monetary values of the collected NTFP between unproductive and productive stage

3.6. Conclusion

This chapter summarizes the key information obtained from household survey. In general, characteristics of households were not largely different between household at unproductive and productive stage. In particular, the households had close size of household of 6 persons and 7 persons for unproductive and productive stages, respectively. With average of labor of 4 and 5 for unproductive and productive stage, respectively. With the same size of labor dependency ratio of two between the two stages. Major households are led by male, with average ages of 42 for unproductive and 41 for productive that were educated below primary level. Major group at unproductive stage was classified as Lowland Lao, while major group at productive stage was classified as Highland Lao.

Average ages of plantation varied from 4 for unproductive to 11 years at productive. The largest proportion of household at unproductive stage have adopted rubber tree plantation below 5 years, while major proportion of household at productive stage have adopted rubber plantation for 8 to 10 years. Household at productive stage is currently holding larger size of plantation than that the average size of the household at unproductive stage. The major sample households at both stages distributed in a range of plantation of 0.5 to 2.5 ha. Area of plantation per adult labor also not large different between the group of the two stage, of which average areas of 0.62 ha and 0.89 ha per adult labor at unproductive and productive stage, respectively. Major household distributed between the ranges up to one hectare per adult labor. With average labor-land ratio of 3.6 and 3.2 for unproductive and productive stage, respectively. Where major sample household distributed at the range above 1 to 2.

Household at productive stage obtained amount of rubber latex yield of 1,116.1 kg per year on average. Major sample households obtained up to 6,000 kg per year. Average productivity per a mature tree was 3.07 kg per year. Majority of sample household obtained up to 5 kg per a mature tree per year.

Total household income of the household at productive stage was approximately three times greater than that the total income of household at unproductive stage on average. Rubber tree is the major income source for household at productive stage, while major income source of household at unproductive stage was off-farm. In general, the average income of household at unproductive stage for rice, livestock, and forest (NTFP) are all individually greater than that the average income of household at productive stage. Regardless stages of rubber tree cultivation, the largest proportion of household earned income from rice, livestock, and forest below a million kip per year. While the distribution of household at different income ranges for rubber and off-farm are quite evenly. Largest proportion of household obtained total income in the range of above 5 to 10 million kip, while largest proportion of household at productive stage obtained income above 20 million kip per year.

Regardless of stages of rubber tree cultivation, large proportion of households remained participating in NTFP collection and off-farm activities along with rubber tree plantation, while relatively smaller proportion of households remained engaging in upland rice shifting cultivation and livestock production. Similar to the case of income, average amount of working hours that household at unproductive stage allocated for upland rice, livestock, and forest are individually greater than that the amount of working time of household at productive stage. Likewise, the total average working hours of household at unproductive stage was slightly bigger than the amount of household at productive stage. In contrast, average amount of working hours that household at productive stage allocated for rubber was more than three times greater than that the amount of working hours of household at unproductive stage.

Regardless of the stage of rubber tree cultivation, larger proportion of households allocated working hours for upland rice, livestock, and forest income are individually less than 1,000 hours per year. The distribution of households in each working hour ranges for off-farm are evenly distributed between the two stages. Largest proportion of household at unproductive stage distributed at working hours range between 1,000 to 3,000 for rubber, while largest proportion of household at productive stage distributed in the working hour range of above 3,00 to 6,000 for rubber tree plantation, and relatively larger proportion of this group distributed at the working hour range of above 9,000 for rubber.

Finally we found that NTFP has become less important for economy of smallholder rubber households. This statement was supported by the majority households only participated in NTFP collected for subsistence needs, and the value of NTFP income was very small compared to the total collected value.

CHAPTER 4: DETERMINANTS OF LABOR ALLOCATION FOR NTFP COLLECTION

4.1. Introduction

Although rubber tree plantation has been adopted as the main livelihood among smallholder rubber households; they remained participating in upland rice shifting cultivation, livestock production, forest products collection (NTFP), and off-farm employment along with rubber tree cultivation. In this case, the changes in productivity of labor of one activity is not only influence the amount of working hours allocate for that activity but also affect the amount of remaining working hours which have to be allocated to other remaining activities. This chapter developed a system labor share equation based on the theoretical framework of agricultural households in developing country to examine working hours allocation decisions among five livelihood activities in respond to changes in their productivity of labor. We specially to observe the changes in working time allocation for NTFP collection and the influence of the productivity of labor of rubber tree cultivation on this activity. Theoretically, proportion of working hours allocated to one activity increased in respond to higher rate of the productivity of labor households obtained from that activity and simultaneously decreased the proportion of working hours allocated to other remain activities due to total amount of working hours are constrained (Shively and Fisher, 2004; and Fisher et al., 2005). In other words, the result will show the positive cross-wage and negative own wage effects. Wage here refers to the productivity for labor. The existing of the positive own-wage effect implied that one activity remained important for household economy. However, the absence of the positive own-wage effect implied that one activity has become less important for the households for the economy. This is because for the positive own-wage effect could not be observed in the case of the subsistence activity (Senaratne et al., 2003).

This chapter organized into four sections. Methodology including data, models, and variables described in section two. Section three discussed main results of the chapter with respect to each stage of rubber tree plantation. Discussion and conclusion withdraw from this chapter was presented in the final section.

4.2. Methodology

4.2.1. Data

The sample households of this chapter consist of consists of 396 households. Unproductive group comprises 230 households or approximately 58.1% of total sample households, while productive groups consist of 166 households or 41.9% of total sample households. The data collection procedures have been described in the chapter three.

4.2.2. Empirical models

The empirical model was a system labor share of smallholder rubber production in a Northern Province of Laos that was developed from Shively and Fisher (2004) for the agricultural households in the Philippines and Fisher at al., (2005) for low-income households in Malawi. A piece of pervious study has combined labor shares for maize cultivation and livestock production and presented under category of labor share for agricultural production (Fisher et al., 2005). However, the current study presents labor share for upland rice cultivation, rubber tree plantation, and animal husbandry separately due to they involve different activities, and different number of required working hours. The separation of labor for agricultural production into three categories became the new contribution of this study.

Although household livelihood in the study areas has been dominated by the rubber tree plantation, but the group of the households in different stages of rubber tree cultivation also participated in other activities such as upland rice cultivation, animal husbandry (livestock production), NTFP collection, and off-farm employment. This chapter attempts to estimate a system of five jointly major activities adopted by smallholder rubber production.

A system of labor share equation can be constructed as the following.

$$L_i^{unpro} = \ _i + \sum_j \beta_{(ij-1)} \text{Log}\ (w_{(j-1)}) + \ _{i1}dep + \ _{i2}age + \ _{i3}edu + \ _{i1}rubha + \ _{v1}disf + \ _i \ldots\ldots\ldots; \ w_j = 4 = w_s; w_n; w_f; \text{and } w_o \ (w_r = 0) \ldots 4.1$$

$$L_i^{pro} = \ _i + \sum_j \beta_{ij} \text{Ln}\ (w_j) + + \ _{i1}dep + \ _{i2}age + \ _{i3}edu + \ _{i1}rubha + \ _{v1}disf + \ _i \ldots\ldots\ldots; \ w_j = 5 = w_s; w_r; w_n; w_f; \text{and } w_o \ldots 4.2$$

Where, subscript (i^t) and (j^{th}) represented list of livelihood activities. There are five dependent variables: (1) labor share for upland rice shifting cultivation or labor share for rice in short (Ls); (2) labor share for rubber (Lr); (3) labor share for livestock (Ln); (4) labor share for NTFP (Lf); and (5) labor share for off-farm (Lo). The five labor shares are sum to 1 or 100%. Each dependent variable is estimated against the same set of independent variables. In the absence of labor market for agricultural households, the marginal product of labor is theoretically equivalent to the shadow wage. Based on the properties of labor supply discussed in the early section, shadow wages or marginal product of labor are employed as returns from those five activities. The marginal product of labor is defined by multiplied the realized wage to the coefficient of the labor input derived from the estimate of the Cobb-Douglas production functions of each activity that described earlier in the theoretical model.

The inclusion of labor dependency ratio to reflect the forest use across household size, while the inclusion of education level and age of household head are to reflect the forest use across household with different level of opportunity to access to non-forest sector jobs and life cycle of household head. Distance to forest is introduced as the independent variable to reflect the productivity of NTFP collection. The productivity of labor of rubber is a key variable associated with rubber tree plantation at the productive stage. However, in the absence of rubber income at unproductive stage, area of plantation per adult labor is alternatively employed as the variable associated with rubber tree cultivation. The list of variables and their expected signs with each of dependent variable are presented in Table 4.1.

Estimate procedure of a system labor share equation is similar to the procedure of Almost Ideal Demand System (AIDS). For detail information of estimation procedure please see (Deaton and Muellbauer, 1980). Since the observed labor share is sum to one. To ensure that estimated labor shares also sum to one, the following restrictions are imposed

$\sum_j \beta_{ij} = 0$ … … … (4.3a); $i = j = s, r, n, f$, and o

$\sum_i \beta_{ij} = 0; \sum_i \delta_{ik} = 0;$ and $\sum_i \gamma_{il} = 0$ … … … (4.3b); $k = 1; 2;$ and 3 and $l = 1; 2;$ and 3

$\sum_i \varepsilon_i = 0$ … … … (4.3c)

$\sum_i \alpha_i = 1$ … … … (4.3d)

Homogeneity degree zero restriction in equation (4.3a) implies that a given labor share be invariant to proportion changes in all wages. Constraints (4.3b) requires that the individual effects on labor allocation of changes in a given explanatory variable be offsetting, such that the net effect of a given change be zero. Constraint (4.3c) says that, for each observation, error terms across equation are linearly dependent. Constraint (4.3d), along with the adding up restrictions, ensures that the estimated labor share sum to one. The restrictions collectively imply that labor allocation decisions are related across activities. To impose the restrictions, the forest equation is dropped to avoid singularity of the disturbance covariance matrix (Sadoulet and Janvry, 1995). Data was estimated by using Seemingly Unrelated Regression (SUR) introduced by Zellner (1962) to provide more efficient estimate results of a system labor share equation.

Table 4.1: List of variables and expected sign

Variable	Expected signs				
	Rice Labor share	Rubber Labor share	Livestock Labor share	NTFP Labor share	Off-farm Labor share
Marginal product of labor of rice (kip/hour)	(+)	(-)	(-)	(-)	(-)
Marginal product of labor of rubber (kip/hour)	(-)	(+)	(-)	(-)	(-)
Marginal product of labor of livestock (kip/hour)	(-)	(-)	(+)	(-)	(-)
Marginal product of labor of NTFP (kip/hour)	(-)	(-)	(-)	(+)	(-)
Marginal product of labor of off-farm (kip/hour)	(-)	(-)	(-)	(-)	(+)
Dependency ratio (dependents divided by laborer)	(+)	(+)	(?)	(+)	(-)
Age of household head (year)	(+)	(-)	(?)	(+)	(-)
Education of household head (year)	(-)	(-)	(?)	(-)	(+)
Area of plantation (ha)	(+)	(+)	(-)	(-)	(-)
Distance to community forest (km)	(+)	(+)	(+)	(+)	DR

Note: (+) and (-) indicates that independent variables are expected to have positive and negative signs with dependent variable respectively; (?) means the relationships between independent and dependent variables need to be tested and DR= dropped out from equation.

4.3. Results

4.3.1. Summary statistic values

Figure 4.1 illustrates the comparison of percentage of households allocated to each activity between unproductive and productive stages of rubber. Besides rubber tree cultivation, major percentage of households allocated labor for NTFP collection and off-farm employment regardless of the stage of the rubber tree cultivation. On the other hands, upland rice shifting cultivation and livestock remained participating by relatively smaller percentage of the households between the two stages. In general, it can be observed that the major participants in every non-rubber activities are classified as the unproductive group. These findings implied that households at unproductive groups tried to diversify among four activities to support their livelihoods during living without rubber income. However, off-farm and rubber are the two main activities that absorbed the substantial proportion of working hours of households at unproductive stage; while working hours for rubber shared the largest proportion at the productive and followed by considerably decreased in working hours for off-farm (Figure 4.2). This finding implied that although larger proportion remained participating in NTFP collection, however, this sector only absorbed small proportion of working hours. The combination of labor participation rates and the values of labor shares by different activities displayed interesting discussion on the NTFP collection in particular. Though NTFP collection remained conducting by major smallholder rubber households regardless of the stages of rubber tree cultivation, but their labor shares on this activity ranked the second smallest after livestock. With relatively smaller amount of household's working times allocate for NTFP collection made this activity obtained the highest returns to labor among other activities, while upland rice shifting cultivation provided the smallest returns to labor (Table 4.2).

Since households obtained the highest productivity of labor on NTFP collection should mobilize household on NTFP collection activity and neglect other activities. However, unlike other four activities, there are some constrains in adopting NTFP collection as the major livelihood activities. First of all, NTFPs are seasonally available; therefore, it would not possible to maintain the income during the off season. Second, the availability of NTFPs is constrained by natural ecosystem or forest conditions. Finally, high valued products only available at a certain time and in a specific area. Another reason to make the productivity of NTFP collection very high compared to others was that this productivity was defined as the ratio of the total collected value and amount of working hours spent for NTFP collection which was the second smallest among the livelihood activities. Likewise, the second higher productivity of labor for off-farm employment also constrained by market labor and the skill of labor which also constrained by low level of education.

There are similar household characteristics between the households at the two stages of rubber tree cultivation. For instance, household was led by the head of ages of 41 years on average, with dependency ratio of 1.4 and 1.2 for households at unproductive and productive stage, respectively. Household head was educated at primary education on average. On the other hands, household at unproductive stage was holding smaller size of plantation than that the size of plantation of the productive stage. Household at unproductive stage on average also faced shorter distance to the community forests. The combination of smaller size of plantation and facing shorter distance to the community forest would be one plausible reason that increases participation rates of households at unproductive stage on NTFP collection.

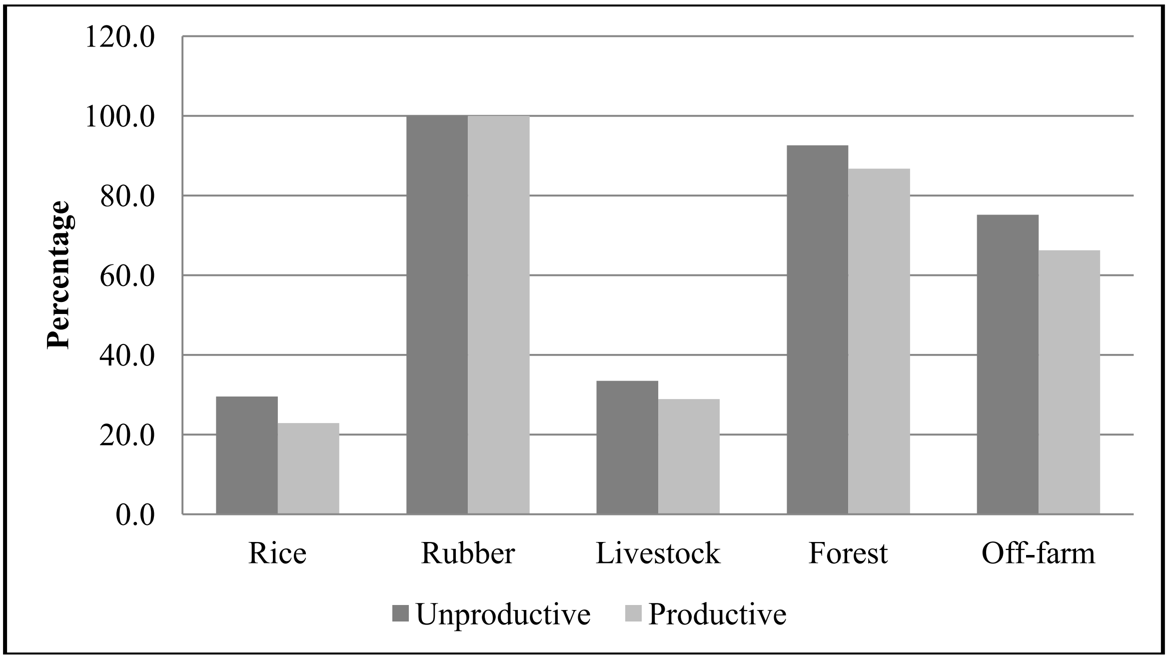

Figure 4.1: The distribution of households participated in different activity with respect to stages of rubber tree cultivation

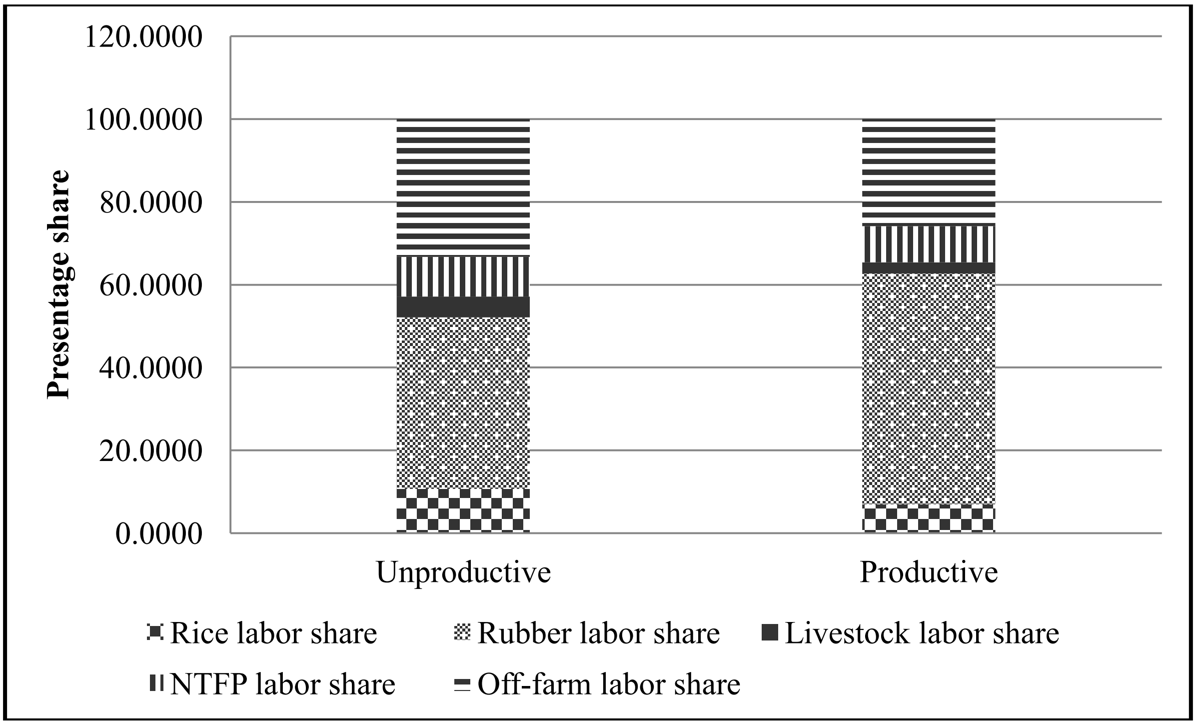

Figure 4.2: Proportion of labor share by activity with respect to unproductive and productive stages of rubber tree cultivation

Table 4.2: Summary statistic value of variables employed in the models

Dependent variables	Unproductive		Productive	
	Mean	SD	Mean	SD
Productivity of labor of rice (kip/hour)	885.0	2,099.6	956.1	2,966.2
Productivity of labor of rubber (kip/hour)	0.0	0.0	1,979.6	2,070.3
Productivity of labor of livestock (kip/hour)	2,845.4	5834.3	1,965.3	4,548.2
Productivity of labor of NTFP (kip/hour)	25,609.0	44,660.8	25,290.9	52,142.2
Productivity of labor of off-farm (kip/hour)	7,121.4	9,346.5	8,771.8	13,592.1
Dependency ratio (dependents divided by laborer)	1.4	1.6	1.2	1.5
Age of household head (year)	41.6	12.7	41.4	11.7
Education of household head (year)	4.3	3.5	4.0	3.6
Area of plantation (ha)	1.6	2.2	2.5	3.0
Distance to community forest (km)	3.0	4.4	5.5	5.4

4.3.2. Influencing factors on working hours allocation decision

4.3.2.1. Decision on working hours allocation for NTFP collection

We found that in the absence of rubber income (unproductive stage), productivity of labor of NTFP collection displayed positive sign with its labor share, however, that coefficient was not significant statistically (Table 4.3). Likewise, in the presence of rubber income (productive stage), productivity of labor of NTFP collection revealed negative sign and non-significant with its labor share (Table 4.4). Those results are collectively indicated NTFP collection has become less importance for household economy regardless of the stages of rubber tree cultivation. Therefore, economic incentive was not the main concern on making decision for working hours allocation for NTFP collection among smallholder rubber households. The experience from agricultural households in Sri Lanka revealed that positive own wage effect could not be observed of the majority of NTFP are collected for subsistence uses (Gopalakrishnan et al., 2005). Findings from this chapter tend to follow the similar trends of the agricultural household in Sri Lanka. This statement is supported by what we have found in chapter three. (1) The major percentage of smallholder rubber households engaged for NTFP collection mainly for consumption; (2) relatively smaller amount of working hours are allocated for NTFP collection; and (3) income from NTFP was very small compared to the value of total collected NTFP.

Disregard of the rubber production stages, productivity of labor for off-farm, age of household head, and area of plantation showed negative signs and significant with NTFP labor share; while distance to community forest displayed positive sign and significant with NTFP labor share. In addition, at productive stage we found that productivity of labor for livestock, and education of household head revealed negative signs and significant with NTFP labor share (Table 4.3 and 4.4).

The negative signs of productivity of labor for off-farm with NTFP labor share at the two stages are consistent with the cases of agricultural households in the Philippines (Shively and Fisher, 2004) and low-income households in Malawi (Fisher et al., 2005). Recalled from the Stutsky equation $\frac{\partial L_f}{\partial P_o} < 0$ and $\frac{\partial L_f}{\partial P_n} < 0$, there are two possible scenarios to be discussed in the case of smallholder rubber household in Northern Laos. First, a substitution effect is negative, and an income effect is positive in the case of net sellers of NTFP, and a negative substitution effect dominated a positive income effect. Second, although household was a net buyer of NTFP, and since NTFP is a normal good, they chose to collect from the forest rather than enjoy consuming leisure time and purchase NTFP at the market. Since each village has community forests where a certain species of NTFPs are allowed to be collected, therefore, there is unlikely that the smallholder rubber household will enjoy leisure time with income rises by purchasing what can be collected from the forest at the markets especially fuel wood.

The negative correlation between ages of household head and NTFP labor share indicated that working hours for NTFP collection decreased when the people become advanced in ages. Likewise, the negative sigh of household head education at productive stage suggested that household led by better educated household head reduced labor share for NTFP collection. In general, better educated increased opportunity to be employed in off-farm jobs (Fisher et al., 2005). However, in the context of Northern Laos, with average education of primary level made it difficult to be employed at the off-farm jobs or could be employed as good as unskilled labor if jobs are available. Therefore, household at unproductive stage choose to allocate household labor seeking for off-farm job opportunities, while after obtaining returns from rubber tree cultivation, households at productive stage choose to mobilize their working hours for rubber tree cultivation. The statements above are supported by the positive correlation between education and off-farm labor share at unproductive stage (Table 4.3), and positive sign of education with rubber labor share at productive stage (Table 4.4).

Stages of rubber tree cultivation are not matter when households are currently holding large size of plantation, they increase labor share for rubber tree cultivation and decrease labor share for upland rice, NTFP, and off-farm. Finally, the positive signs of distance to the forest with NTFP labor share at the two stages indicate that efforts on NTFP collection not decrease with increasing the distance to the community forests. There are plausible reasons behind these results. First, this variable measured the distance from the village edge to the distance of the community instead of the distance from each household to the community forest. Since the sample households were randomly selected, and some sample households are located far from the forests, while others may located close to the forest edge. Second, in addition to community forest, part of sample households would collect NTFP in other fallow forests as well. Due to information constraints, the distance may not fully reflect the real situation of the sample households.

Table 4.3: Constrained Seemingly Unrelated Regression (SUR) results for labor share equation at unproductive stage

	Dependent variable: Labor share (at unproductive stage)				
Independent variable	Rice	Rubber	Livestock	NTFP	Off-farm
Constant	0.1321***	0.4960***	0.0861***	0.0971	0.1888***
	(3.1856)	(7.7574)	(3.6191)	(0.1458)	(4.1511)
Productivity of	0.0332***	-0.0072**	-0.0036***	0.0010	-0.0235***
labor of rice	(16.4545)	(-2.2945)	(-3.0690)	(0.6139)	(-10.4291)
Productivity of	-0.0113***	0.0097***	0.0140***	0.0005	-0.0129***
labor of livestock	(-6.1217)	(3.3973)	(13.2522)	(0.3849)	(-6.2712)
Productivity of	-0.0092***	0.0188***	-0.0050***	0.0009	-0.0055***
labor of NTFP	(-4.3674)	(3.6767)	(-7.2355)	(0.3369)	(-2.0818)
Productivity of	-0.0127***	-0.0214***	-0.0055***	-0.0024**	0.0419***
labor of off-farm	(-6.6166)	(-7.1473)	(-4.9337)	(-1.7372)	(19.4618)
Dependency	0.0093*	-0.0070	-0.0013	0.0144	-0.0154**
ratio	(1.6993)	(-0.8259)	(0.3965)	(1.6398)	(-2.5032)

Age of household head	0.0022*** (3.0270)	-0.0033*** (-2.9823)	0.0002 (0.4291)	-0.0004*** (-2.6373)	0.0014* (1.6999)
Education of household head	0.0017 (0.6900)	-0.0069* (-1.7537)	0.0022 (1.5127)	-0.0017 (-0.8952)	0.0046* (1.6449)
Area of plantation	-0.0026 (-0.6588)	0.0418*** (6.8179)	-0.0003 (-0.1418)	-0.0082* (-1.7527)	-0.0306*** (-7.1156)
Distance to forests	-0.0038* (-1.8419)	-0.0013 (-0.4886)	-0.0014 (-1.2347)	0.0065*** (5.1640)	DR
R-squared	0.5727	0.3373	0.4767	0.3621	0.6852
No. of households	230				

Note: ***, **, * indicate statistically significant level of 1%, 5%, and 10% level, respectively. And DR= dropped out from equation.

Number inside the parentheses display the t-statistic value

4.3.2.2. Labor allocation decision for other non-forest activities

There is existence of positive own-wage and negative cross-wage effects among upland rice shifting cultivation, rubber tree cultivation, livestock production, and off-farm employment at the two stages of rubber tree cultivation. The positive own wage and negative cross-wage effects at unproductive stage suggest that, at unproductive stage, higher returns from upland rice shifting cultivation increases labor share for upland rice shifting and reduce labor share for livestock production and off-farm employment. Likewise, increases returns from livestock production increases labor share for livestock and reduce labor shares for upland rice shifting cultivation and off-farm employment. Similarly, rising returns in off-farm employment increases labor share for off-farm employment and reduce labor shares for upland rice shifting cultivation and livestock production. These results collectively imply the substitutability among these three activities at unproductive stage.

We found that households increases labor share for livestock in response to rising of its productivity by decreasing labor share for off-farm. It was surprising to see that labor share for rubber increases with increasing productivity of livestock and NTFP. This result can be possible at unproductive stage. There are reasons behind these labor allocation decisions. First of all, labor allocation for rubber tree cultivation at unproductive are more flexible compared to productive stage. Productive stage required exact period of times, for example 3 to 6 pm to conduct rubber tapping. However, those who have more number of productive trees even start tapping earlier in the morning. After that, 9 to 11 am is time for rubber collecting, and then stored tapped latex in a safe place. Then the rest of time may need for leisure or social cultural activities. Unlike productive stage, the main activities at unproductive stage are mainly weeding and other maintaining rubber garden that have to conduct once in every two or three months. During the holiday from rubber garden allow households to engage in other activities for example livestock, and NTFP. Second, among households who had small amount of capital but still want to invest in rubber plantation, they could perform by gradually accumulated the income from other source and re-invest in rubber tree plantation, while income could have been generated from livestock or NTFP. The existence of positive own wage effect among upland rice livestock and off-farm implied that these activities are importance for household economy during they were living without rubber income at the unproductive stage. Therefore, households made decision on labor allocation for those activities based on economic rationale.

At productive stage, higher returns of upland rice shifting cultivation increases its labor share and reduce labor shares for rubber tree cultivation, livestock production, and off-farm employment. Likewise, increases returns of rubber tree cultivation increases its labor share and reduce labor share for upland rice, livestock, and off-farm. Similarly, higher returns of livestock increase its labor share and reduce labor share for forest and off-farm. Finally, increases labor share for off-farm increases its labor share and reduce labor share for the four remaining activities.

Decisions on working hours allocation for non-NTFP activities vary across household characteristic with respect to the two stages of rubber tree cultivation. In the absence of rubber income, labor dependency ratio showed positive and significant result with upland rice labor share but negative with off-farm labor share. Age of household head displayed positive signs with upland rice and off-farm labor share but showed negative signs with rubber and forest labor share. Education of household head illustrated negative sign with rubber labor share but positive with off-farm labor share. In the presence of rubber income, labor dependency ratio revealed a positive sign with rubber labor share and negative sign with off-farm labor share. Education illustrated positive sign with rubber labor share.

The significant results of the household characteristics are collectively suggest that in the absence or presence of rubber income, household with larger number of labor dependency ratio had less labor for off-farm employment. However, due to lack of income from rubber households at this stage, they choose to mobilize household labor for upland rice shifting cultivation in order to increase efforts to provide staple for household needs, while households those obtained income from rubber choose to increase their labor share for rubber tree cultivation. In the absence of rubber income, household led by advanced ages head also put efforts to secure staple by either mobilizing households labor for upland rice shifting cultivation and/or seeking for off-farm jobs opportunity to earned cash to alternatively purchase staple at the market, and less labor for rubber tree cultivation.

Finally, area of plantation showed positive signs with rubber labor share at the two stages of rubber tree cultivation, while this variable showed negative signs with off-farm labor share at the two stages and with upland rice labor share at productive stage. The significant results of this variable are collectively indicate that household those are currently holding larger size of plantation mobilize their household labor for rubber tree cultivation regardless stages of the cultivation, and had less labor for other activities such as upland rice, and off-farm employment.

Table 4.4: Constrained Seemingly Unrelated Regression (SUR) results for labor share equation at productive stage

Dependent variable: Labor share (at productive stage)					
Independent variable	Rice	Rubber	Livestock	NTFP	Off-farm
Constant	0.2526***	0.2901***	0.0723***	0.1158	0.2693***
	(6.2989)	(3.7985)	(4.2584)	(0.0501)	(4.2995)
Productivity of	0.0309***	-0.0127***	-0.0024**	-0.0038	-0.0120***
labor of rice	(13.4730)	(-2.9153)	(-2.4570)	(-1.4747)	(-3.3759)
Productivity of	-0.0245***	0.0309***	-0.0054***	0.0153	-0.0163***
labor of rubber	(-6.6705)	(4.5643)	(-3.4645)	(0.6591)	(-3.0559)
Productivity of	0.0002	0.0016	0.0100***	-0.0049***	-0.0069**
labor of livestock	(0.0799)	(0.4353)	(12.1176)	(-2.6545)	(-2.2951)
Productivity of	-0.0013	0.0039	-0.0008***	-0.0021	0.0003
labor of NTFP	(-1.4679)	(1.1422)	(-4.9817)	(-0.8679)	(0.1548)
Productivity of	-0.0052***	-0.0237***	-0.0014*	-0.0046***	0.0349***
labor of off-farm	(-2.8688)	(-6.9376)	(-1.8004)	(-3.1137)	(12.5857)
Dependency	-0.0087	0.0210**	-0.0036	0.0089	-0.0175**
ratio	(-1.5815)	(2.0228)	(-1.5470)	(0.6441)	(-2.0889)

Age of household head	0.0000 (0.0119)	0.0008 (0.5429)	0.0000 (0.1013)	-0.0010*** (-4.1269)	0.0002 (0.01661)
Education of household head	-0.0026 (-1.1049)	0.0081* (1.8196)	-0.0006 (-0.5818)	-0.0076*** (-3.1956)	0.0026 (0.7238)
Area of plantation	-0.0085*** (-2.8730)	0.0497*** (9.2726)	-0.0018 (-1.4208)	-0.0117*** (-2.9425)	-0.0277*** (-6.7175)
Distance to forests	0.0032* (1.7834)	-0.0056** (-2.2593)	-0.0003 (-0.4141)	0.0027* (1.9651)	DR
R-squared	0.6022	0.4933	0.5094	0.4108	0.6341
No. of households	166				

Note: ***, **, * indicate statistically significant level of 1%, 5%, and 10% level, respectively. And DR= dropped out from equation.

Number inside the parentheses display the t-statistic value

4.4. Conclusion

This chapter developed a system labor share equation based on the theoretical framework of agricultural households in developing country to examine working hours allocation decisions among five livelihood activities in respond to changes in their productivity of labor. We specially to observe the changes in working time allocation for NTFP collection and the influence of the productivity of labor of rubber tree cultivation on this activity. Theoretically, proportion of working hours allocated to one activity increased in respond to higher rate of the productivity of labor households obtained from that activity and simultaneously decreased the proportion of working hours allocated to other remain activities due to total amount of working hours are constrained. In other words, the result will show the positive cross-wage and negative own wage effects. Wage here refers to the productivity for labor. The existing of the positive own-wage effect implied that one activity remained important for household economy. However, the absence of the positive own-wage effect implied that one activity has become less important for the households for the economy.

The positive own-wage effects exist in the case of rice, livestock, rubber, and off-farm except for NTFP collection. These result suggest that in the absence of rubber income at unproductive stage, households mobilize working hours to upland rice shifting cultivation, livestock, and off-farm so as to provided ad hoc livelihood activities during waiting for rubber income. Upland rice shifting cultivation allows households to ensure staple consumption in order to avoid spending cash income for rice products at the market or enable them to supplement cash income. Livestock on the other hand acted as the second main source of income. The largest proportion of cash income earned from off-farm jobs. At the productive stage, smaller proportion of the households allocated working hours for upland rice shifting cultivation. And the main purpose of this activity is to supply staple for household consumption in order to avoid spending cash for rice products at the market, and alternatively spent cash from rubber and other source for other purposes. Income from livestock and off-farm are the complement alternative to supplement income at the productive stage. We could observe that along with rubber income, where the favorable conditions are available households also tried to diverse income source in to other activates.

We could not observe the positive own wage or negative cross wage effects of working time allocation for NTFP collection. These results suggest that NTFP collection activity had become less important for household economy after they adopted rubber tree plantation. These findings are likely to illustrate the trend in forest resource utilization in the study areas. Households are likely to be well-embracing on the introducing of rubber tree plantation as a new livelihood alternative which gradually drawing away from the subsistence activities such as shifting cultivation, livestock production, and NTFP collection. Although majority of the households at unproductive and productive stage remained participating for NTFP collection, however, the main purpose of that collection was for household consumption. Thereby, they spent the second smallest share of working hours on NTFP collection (Figure 3.4 in section 3.5.4 chapter 3). On the other hands, working hours that used to allocated for NTFP collection were observed to be flexible to be reallocated in respond to livestock, and off-farm activities as an ad hoc economy activities during waiting for rubber income and as the activates supplement cash income at the productive stage.

Decisions on working time allocation for NTFP collection also varied across household characteristics. Households living without income which led by advance age and with greater number of dependents relative to labor chose to mobilize household labor for upland rice shifting cultivation in order to ensure staple supply for household needs. Whereas those led by advanced age with better educated head choose to seek for off-farm job opportunities for earning income to purchase rice by reducing labor shares for rubber and NTFP activities.

Working hours allocated for NTFP collection captured the efforts households devoted for NTFP collection. It is however, unlikely to imply the real-term of forest resource dependency. By this statement it means that, real-term forest resource dependency implied the absolute term of the collected NTFP that have been collected, utilized, or marketed by the households. One reason is that by definition in this chapter working hours for NTFP collection is including hours required for travelling to the collection sites, hours for searching and collecting. Since sample households are residing in the villages with different distance to the forests. Based on the assumption that collectors are travelling to the collection sites on foot; therefore, those far from the forests required more number of hours to travel to the collection sites and therefore decreased the collecting hours and resulted in smaller amount of collected NTFPs. Therefore, greater amount of working hours for NTFP collection may not implied the greater amount that can be collected. Second, sample villages were also facing different size of forest which may affect the availability of the forest resources. Therefore, to cope with this problem, in chapter five we employed the ratio of the values of the collected NTFP and NTFP income to total household income as other two indicators to capture the real-term of forest resource dependency.

CHAPTER 5: DETERMINANTS OF NTFP INCOME SHARE AND NTFP COLLECTED VALUE SHARE

5.1. Introduction

NTFP collected and NTFP income shared as indicators of NTFP dependency to capture the monetary values (real-term) of NTFP dependency which was classified into overall and income dependencies. The monetary values of NTFP also captured the returns of the net hours spent for NTFP collection after deducted the travelling hours, which could not be captured in the chapter four. And then examines the changes in NTFP dependency across households' characteristics and across stages of rubber tree cultivation. The variables in chapter four are determined based on the theoretical framework of agricultural households in developing countries. The labor allocation for working is well-explained by the productivity of labor or wage rates. Along with agricultural production, working hours are also allocated to other activities such as forest extraction, livestock, and off-farm in order to diversify their livelihoods. Therefore, changes in the productivity of labor of one activity was not only affected labor allocation for that activities but also related to other remaining activities. In this case a system labor share equation model was an appropriate approach to address the changes or adjusted in labor allocation in all activities in response to the changes in productivity of labor.

In this chapter the dependent variable was the share of total household income, which also sum to 1 or 100% as the case of labor share. However, there was lack of theoretical background to develop the determinants which well-explained the dependent variable systematically. And thereby, lack of theoretical background to well-support the interpretation of the results. Therefore, the single equation and a conventional approach to examine factors influencing forest resource dependency was employed to investigate the factors affecting households' forest resource dependency including productivity of land of rice, productivity of land of rubber, and household characteristics. This chapter divided into four sections. Methodology including data, model, and variables were presented in section two. Main results were discussed in section three. Final section presented the discussion and conclusion drawing from this chapter.

5.2. Methodologies

5.2.1. Data, model and dependent variables

Sample households employed for data analysis in this chapter including 349 households, of which 210 households are in the group of unproductive and the remaining 139 households are classified as productive. Sample households of this chapter only consider those engaged in NTFP collection along with rubber tree plantation.

NTFP collected value share which was defined as values of total collected NTFP divided by total household income was employed as a proxy of households' total forest resource dependency indicator (TD). NTFP income share which was defined as NTFP income divided by total household income was employed as a proxy of households' forest resource income dependency indicator (ID). NTFP collected value share and NTFP income share were employed as two dependent variables against the same set of independent variables (Fu et al., 2009; and Rayamjhi et al., 2012).

We address the study objectives using Tobit model. There are reasons why Tobit model was chosen. (1) Although all sample households of this chapter remained participated in NTFP collection but their main purpose of the collection is for consuming within households. Hence, not all sample households had cash income from NTFP sales. (2) Some households did not report their income. Therefore, the values of the dependent variables including zero values. This type of sample households is known as 'a censored sample'. And the Tobit model is also known as a censored regression model. Furthermore, during the process of estimation, Tobit model also takes the zero values into account. In addition, the interpretation of the coefficient in this model can be interpreted similar to the regression coefficients. For instance, the negative coefficient of (Z) independent variable on (Y) dependent variable means that the higher the (Z), the lower the (Y) (Guajaraty. 3rd edition). We estimate the results of unproductive and productive stages separately in order to observe the determinants of households' forest resource dependency by different stages of rubber tree plantation.

5.2.2. Determinants and expected signs

The factors that are expected to influence household dependency on NTFP in term of overall and for income among smallholder rubber households are classified as variable associated with rubber tree plantation, upland rice shifting cultivation, households' characteristics, and forest vicinity. The productivity of land of rubber tree is employed as a key variable associated with rubber tree plantation since households had obtained cash income from rubber. However, as a result of lack of rubber income at unproductive stage, area of plantation per adult was selected as a key variable associated with rubber tree plantation. The rubber plantation variables are assumed to show negative sign with NTFP dependency as a result of time competition and alternative income.

NTFP collection is an integral activity that firmly adopted by the shifting cultivators. The productivity of land of upland rice shifting cultivation was introduced to test whether this relationship has the possibility to be broken down or not after households transformed shifting cultivation to commercial production-mainly rubber tree plantation.

Variable associated with household characteristics are including labor dependency ration, dummy of female household head, ages, and education of household head. Labor dependency ratio was defined as number of dependents (households' residents less than 15 years old and over 65 years old) divided by number of laborers (households' residents 15 to 65 years old). Gender is a dummy variable that takes value of 1 for female, and 0 for male. Education level measured number of years that person attending school.

Independent variables associated household characteristics are including labor dependency ratio, age of household head, gender of household head, and education of household head. Labor dependency ratio represents the burden for adult workers in each household. We expect the estimated coefficient to display a positive sign with TD and negative sign with ID as households with more number of dependents tend to depend more on forest resource, however, large proportion of the collected amount will serve for household consumption and a commensurately lower proportion remaining for cash income. For instance, Viet Quang and Nam Anh (2006) noted that households with a higher dependency ratio enjoyed fewer benefits from collected NTFPs because they lacked the available labor to participate in NTFP collection.

Wickramasinghe et al., (1996) have found that purposes of NTFP collection varied across gender. In other words, the subsistence gathering of NTFPs is generally almost exclusively the task of women, while men engaged in NTFP collection for cash income. This study also expected coefficient of female dummy to show positive sign with TD and negative sigh with ID due to the same pattern of NTFP collection was observed in the case of Northern Laos, high value of NTFP collection seemed to collect by men.

We expect the age and education of the household head to be also important in determining lower dependency on NTFPs across both indicators. This is because older household heads have less ability to fulfill collection activities, while household heads with a higher level of education would find it less profitable to engage in NTFP collection given their higher opportunity cost of labor. In terms of existing findings, Adhikari et al., (2004) noted that a higher level of education made fuel wood collection increasingly unprofitable because of the higher opportunity cost of labor. Further, Fisher et al., (2005) have found that education signals employers about the potential productivity of workers, thereby increasing the likelihood of being hired into attractive nonfarm, non-forest employment and thus reducing labor allocation to the forest sector.

We expect the distance from the village to the community forest to display a negative coefficient with both indicators as longer distances imply the lower net benefit of NTFP collection given the increase in the time required to travel to a collection site. In other work, Mamo et al., (2007) have found that increasing distance to the forest edge reduces the overall rate of NTFP extraction as well as the level of forest dependency.

Table 5.1 provides the description, definition, and expected sign for each independent variable where TD and ID denote households' total forest resource dependency indicator NTFP income dependency indicator, respectively.

Table 5.1: List of independent variables and expected signs

List of variables	Definition and measurement	Expected sign	
		TD	ID
Productivity of land of rubber	Rubber income over area of plantation	-	-
Productivity of land of upland rice shifting cultivation	Rubber income over labor inputs (kip)	+	+
Area of plantation per adult labor	Hectares(ha) per working adult (kip)	-	-
Labor dependency ratio	Number of dependents (persons aged 0 to 15 and over 65 years) over total number of household laborers	+	-

Female household head	1 if female, otherwise 0	+	-
Age of household head	Number of years	-	-
Education of household head	Number of years	-	-
Distance to community forest	Number of kilometers (km)	-	-

Note + and – indicate the sign of the estimated coefficient for the independent variable in each row in a regression with the dependent variable headed in each column.

5.3. Results

Key statistic variables that employed to estimate the results are presented in Table 5.2. The level of NTFP dependency in term of income was not different between households at both stage, however, in term of overall dependency, households at unproductive stage was twice more depend on NTFP compared to productive stage. The share of NTFP income from total household income implied that while NTFPs tend to become less importance for household economy, however, some of NTFPs seem to remained importance for subsistence needs, especially among those lacks of rubber income.

Households' characteristics are observed not so largely different in terms of labor dependency ration, age and education of household head. However, there were slightly different in area of plantation holding among households between the two stages of rubber tree cultivation where an adult labor within households at productive stage is holding relatively large areas of plantation compared to the one within households at unproductive stage. Furthermore, on average, households at the productive stage have been engaging in rubber tree plantation for approximately 10 years

Table 5.2: Summary statistic values of dependent and independent variables employed in the analysis

Variable	Unproductive		Productive	
	Mean	SD	Mean	SD
NTFP collected value share	0.38	0.77	0.15	0.13
NTFP income share	0.07	0.19	0.07	0.21
Productivity of land of rubber			21,500	26,400
Productivity of land of rice	1,714	3,319	1,723	4,431
Area of plantation per adult labor	0.59	0.73	0.8	1.47
Age of plantation	4.34	1.5	10.23	3.25
Labor dependency ratio	2.4	1.53	2.24	1.58
Female household head	0.39	0.49	0.42	0.49
Age of household head	41.28	12.56	41.58	11.23
Education of household head	4.28	3.56	3.63	3.45
Distance to forest	2.97	4.33	4.95	4.94

Note: The exchange rate between Lao kip and US$ is 1US$ = 8,000 kip (BOL, 2012)

Households obtained the same productivity rate per hectare of upland rice shifting cultivation. This result implied the homogenous soil quality for upland rice shifting cultivation among households between the two groups as fertilizer was normally not applied for agricultural production on the sloping land. Household obtained considerably greater value productivity of rubber per hectare compared to the value of upland rice shifting cultivation. Therefore, it was surprising that rubber tree plantation has been widely adopted by the former upland shifting cultivators in Northern Laos.

The independent variables productivity of land of rubber tree and rice cultivation are included as determinants of forest dependency indicators among households at the productive stage only due to households at unproductive stage had no rubber income to define these variables. As can be observed in the Table 5.2 above, the values of the land productivity of rubber and rice are expressed in monetary term (Lao currency: 1,000 kip). Estimate results by using that absolute terms led to significant results but the coefficients are extremely small. Therefore, the coefficient could be scaled up by transforming the absolute values into logarithm form and used to estimate the results.

5.3.1. Determinant of NTFP collected value share

NTFP collected value share is employed as a proxy of overall NTFP dependency including both cash income and subsistence uses. Table 5.3 displays estimate results of factors influencing overall NTFP dependency. The influenced factors are classified into household characteristics associated factors which including dummy of female household head, age of household head, and education of household head. Rubber tree planted associated factors, namely productivity of land of rubber is employed as a key factor associated with rubber tree plantation at the productive stage, while as a result of lacking rubber income at unproductive stage, area of plantation per adult labor is alternatively employed as a key variable to observed the influenced of rubber tree plantation on the overall NTFP dependency.

We could not observed an influenced of rubber tree plantation on overall NTFP dependency at unproductive stage since rubber plantation per adult labor displayed negative coefficient by not significant with the overall dependency. Similar to the variables associated with household characteristics, which we found none of them displayed either negative or positive significant coefficients. However, we found that the coefficient of productivity of land of upland rice shifting cultivation displayed a positive and significant result with the overall NTFP dependency (p-value = 0.0660). Whereas distance to forests revealed negative and significant coefficient (p-value = 0.0070). The positive coefficient of the productivity of rice with respect to the cultivated areas (land) implied that an improving the productivity of upland rice shifting cultivation tend to result in increasing forest resource dependency among smallholder rubber who had not obtained cash income from their rubber plantation yet. This is not surprising results since NTFP collection have been tightly embraced as an integral part of the shifting cultivation among upland households in Northern Laos (Roder, 2001). In addition, this result also implied that shifting cultivation usually adopted in the areas with fertile soil which enable households to benefit from NTFP collection. On the other hands, the negative coefficient of the distance to the forest implied that NTFP dependency tend to decrease with increasing distance to the forests which reflects the fact that the farther distance decrease the labor productivity of NTFP collection. This finding is consistent with the cases of agricultural households in developing countries (Adhikari et al., 2004; Mamo et al., 2007; and Rayamajhi et al., 2012).

At productive stage we found that productivity of land of rubber tree cultivation displayed negative and significant with NTFP collected value share (p-value = 0.0000). Productivity of land of upland rice shifting cultivation revealed stronger positive results compared to the unproductive stage (p-value 0.0160). In addition to the productivity of land, the positive and significant coefficient of labor dependency ratio (p-value = 0.0120) allowed us to observed the influenced of household characteristics on overall NTFP dependency. The coefficient of the productivity of land of upland rice shifting cultivation disclosed similar trend to the unproductive stage which indicates that although with supportive rubber income, overall NTFP dependency tend to increases with improving the productivity of upland rice shifting cultivation, especially among households with greater number of residents which are classified as children and elder people. This type of households had insufficient labor to fulfill other times consuming activities such as rubber, livestock, and off-farm activities, and thereby they are enforced to firmly depend on NTFP. However, we found that overall NTFP dependency tend to decreases with improving the productivity of land of rubber tree cultivation. This result tends to follow the same trend in the case of commercial tea cultivation and smallholder rubber tree cultivation in southwest China (Senaratne et a., 2003; and Fu et al., 2009a). Since income generated from tea and rubber tree cultivation enabled households to substitute some subsistence NTFP with commercial products at the market and thereby decrease their dependency on forest resources. At the productive stage, income generated from rubber allowed households to substitutes for construction materials for housing and some wild plants by market products.

Table 5.3: Tobit results of factors influencing NTFP collected value share

Dependent variable: NTFP collected value share				
Independent variables	Unproductive		Productive	
	Coef.	p-value	Coef.	p-value
Area of plantation per adult labor	-0.0023	0.9580		
Productivity of land of rubber			-0.0733***	0.0000
Productivity of land of rice	0.0078*	0.0660	0.0073**	0.0160
Labor dependency ratio	0.0103	0.6320	0.0369***	0.0120
Female household head	-0.0148	0.8200	0.0398	0.3610
Age of household head	-0.0024	0.3670	0.0023	0.2760
Education of household head	-0.0033	0.7070	-0.0089	0.1490
Distance to the forest	-0.0189***	0.0070	-0.0051	0.2250
Constant	0.4634	0.0060	1.2518***	0.0000

No. of household	210	139

Note: ***, **, * indicate 1%, 5%, and 10% level of significance.

Log likelihood ratio chi-square of 16.97 (df=7) with p-value of 0.0176 at unproductive stage; and chi-square of 37.57 (df=7) with p-value of 0.0000 at productive stage; tell us that our model as a whole fits significantly better than an empty model (i.e., a model with no predictors).

5.3.2. Determinants of NTFP income share

We separate the NTFP dependency in term of income from overall NTFP dependency and employed NTFP income share as the NTFP income dependency. Table 5.4 presents the results of factor influencing NTFP collected value share. At unproductive stage we found the similar results as the case of the overall NTFP dependency. Area of plantation per adult labor as well as variable associated household characteristics displayed insignificant result with NTFP collected value share. The productivity of land of upland rice shifting cultivation and distance to the forest disclosed significant positive and negative (p-value = 0.0460 for productivity of upland rice, and p-value = 0.0100 for distance, respectively). Similarly, at the productive stage, productivity of land of rubber tree cultivation also presented insignificant results with NTFP income share and the productivity of land of upland rice shifting cultivation showed positive and significant result (p-value = 0.0030). However, the negative and significant coefficients of age and education of household head (p-value = 0.0020 for age 0.0650 for education, respectively) allow us to discuss the influenced of households characteristics on NTFP dependency for income.

The positive coefficient of productivity of rice with respect to land implied that NTFP collection which usually acted as a bundle of the shifting cultivation system is not only for subsistence use but also to earn cash income at unproductive stage and to supplement cash income. However, NTFP dependency for cash income also found to decreases with increasing the distance to the forest. In general, we found that productivity of rubber tree cultivation with respect to land did not affect the NTFP income dependency, however, among female household head and household head with better education tend to depend less on NTFP for cash income after they obtained income from rubber to support their live. Female is found to be influenced negatively on NTFP income; this finding emphasize that the subsistence collection is the main task of women (Wickramasinghe et al., (1996); and Foppes and ketphanh, 1997). On the other hands, people with better educated found NTFP collection for income become less profitable activity especially when compared with off-farm job employment. This finding is also consistent with findings elsewhere of developing countries (Adhikari et al., 2004; and Rayamajhi et al., 2012).

Table 5.4: Tobit results of factors influencing NTFP income share

Dependent variable: NTFP income share				
Independent variables	Unproductive		Productive	
	Coef.	p-value	Coef.	p-value
Area of plantation per adult labor	-0.0392	0.3090		
Productivity of land of rubber			0.0228	0.5530
Productivity of land of rice	0.0067**	0.0460	0.0195***	0.0030
Labor dependency ratio	0.0190	0.2730	0.0039	0.8970
Female household head	-0.0231	0.6520	-0.1147	0.2420
Age of household head	-0.0023	0.2730	-0.0148***	0.0020
Education of household head	0.0036	0.6070	-0.0269*	0.0650
Distance to the forest	-0.0155***	0.0100	-0.0012	0.9040
Constant	0.0218	0.8650	0.0636	0.9280

No. of household	210	139

Note: ***, **, * indicate 1%, 5%, and 10% level of significance.

Log likelihood ratio chi-square of 13.72 (df=7) with p-value of 0.0565; and chi-square of 31.19 (df=7) with p-value of 0.0001; tell us that our model as a whole fits significantly better than an empty model (i.e., a model with no predictors).

5.4. Conclusion

This chapter examines factors influencing NTFP dependency that we separate the dependency in term of cash income from the overall dependency. The influenced factors are classified as variables associated with rubber tree cultivation, household characteristics, upland rice shifting cultivation, and forest vicinity. Area of plantation per adult labor and the productivity of land of rubber are the two key factors associated with rubber tree cultivation at unproductive and productive stages, respectively. Households' characteristics are including labor dependency ratio, female household head dummy, age and education of household head. Other variables including productivity of land of upland rice shifting cultivation and the distance to the forest.

We found the similar results at unproductive stage in term of factors influencing overall NTFP dependency and the dependency for cash income. Lack of the significant results of variable associated with rubber tree plantation and household characteristics gave us lack of supportive results to discuss the influenced of rubber tree plantation and household characteristic on NTFP dependency. However, we found that it seem not straightforward to breakdown the NTFP dependency from the system of the shifting cultivation at unproductive stage, while the further distance from the forest encourage household to depend less on NTFP for both cash income and subsistence needs.

At the productive stage, although with supportive rubber income, those who obtained higher productivity of upland rice shifting cultivation and households with greater number of dependents tend to firmly depend on NTFP; however, at the same size of cultivated area, the value of the productivity of land of rubber tree cultivation was considerably greater than that the productivity of land of upland rice shifting cultivation. Therefore, improving the productivity of land of rubber tree cultivation tend to result in a reduction of overall NTFP dependency after household had obtained cash income from rubber at the productive stage.

Finding from this study emphasized that though returns of rubber tree cultivation is unlikely to decreased efforts that smallholder devoted for NTFP collection. However, the returns to rubber did decrease the forest resource dependency in the absolute term. The more productivity or income they obtained from rubber tree cultivation the less value of forest resource they pursuit. Among the collected NTFP, firewood was the most necessary NTFP using as the main source of fuel. This type of NTFP was reported obtaining by self-collected. However, in the near future, increasing of productive trees would enable them to substitutes greater proportion of subsistence NTFP for commercial products and the market including firewood. This is because the market for firewood was emerged in the study areas. This is expected to encourage a reduction of forest resource dependency among smallholder rubber in the study areas.

CHAPTER 6: ANALYSIS OF TECHNICAL EFFICIENCY OF SMALLHOLDER RUBBER TREE PLANTATION

6.1. Introduction

Rubber tree cultivation had recently become the main livelihood activity of agricultural households in LuangNamTha Province. Cash income from rubber latex sales is holding the largest proportion in the households income structure (Section 3.5.4 of Chapter 3), while the contribution of rubber revenue on the aggregate agricultural revenue of LuangNamTha province has been increasing annually (Section 2.5 in Chapter 2). A key finding in chapter five showed that increasing productivity of rubber tree cultivation tend to decrease forest resource dependency. Therefore, this chapter analyzes technical efficiency of rubber tree cultivation among smallholder rubber households across the sample villages. Results of this chapter would provide information on current technical efficiency of rubber tree cultivation on average, and how the efficiency varies across the sample villages. This chapter divided into four sections. Methodology including, data, empirical models, and variables were presented in section two. The main results including of level of technical efficiency of rubber tree cultivation, its determinants, and its effect on households' forest resource dependency were discussed in the third section. Conclusion extract from this chapter was presented in the final section.

6.2. Methodology

6.2.1. Data

This chapter employed the same data set as the previous analytical chapters four and five. However, as rubber latex yields measure in kilogram was a key variable required for analyzing technical efficiency in this chapter. Therefore, only sample households at the productive stage employed to obtain the results of this chapter. Total sample household of this chapter consists of 166 households. Those households began rubber taping in different period. The earliest households began rubber tapping from 2003, while the latest households just began rubber tapping in 2011, one year before field survey was conducted.

6.2.2. Empirical model

Stochastic production frontier was extensively employed to analyze technical efficiency in agricultural production. These can be found in Yao and Liu 1998 for technical efficiency analysis of grain production in China. Iraizoz et al., 2003 for the case of horticulture in Spain. Lindara et al., (2006) for spice based agroforestry sector in Sri Lanka. Balcombe et al,. (2007); Shehu et al., (2007); and Khai and Yabe (2011) for rice production in Bangladesh, Nigeria, and Vietnam, respectively. Recently, Idris et al (2013) employed this method to identify the determinants of technical efficiency in pineapple farming in Malaysia.

Amidst an extensive literature on technical efficiency in agricultural production, studies on analyzing technical efficiency in rubber tree cultivation are quite limited. These could be found in the works done by Son et al., (1993); Giroh and Adebayo (2007); and Mustapha (2011). Those studies employed Cobb-Douglas stochastic frontier production function to analyzed technical efficiency of rubber tree cultivation by state farm and smallholders using cross sectional household survey and panel data. In particular, Son et al., (1993) employed Cobb-Douglas stochastic production frontier to analyze the technical efficiency of 34 state rubber farms in Vietnam using panel data from 1986 to 1990. Similarly, Giroh and Adebayo (2007) used Cob-Douglas stochastic frontier to analyze technical efficiency of rubber tapping of 129 tappers in Nigeria using cross-sectional data. Recently, Mustapha (2011) employed Cob-Douglas and Tran-slog stochastic frontier models to examine technical efficiency of 35 smallholder rubber production in Malaysia using cross-sectional data. The author found that compared to Trans-log frontier, the Cob-Douglas could have explained better the relationship between the Y-output and X-inputs.

In considering its better explanatory power, this chapter employed Cob-Douglas stochastic frontier model to analyze technical efficiency of smallholder rubber production in a Northern Province of Laos using cross-sectional data survey of 168 rubber households. The Cobb-Douglas stochastic frontier model is written as

$$LnY_i = \beta_0 + \beta_1 Ln\text{Ha}_i + \beta_2 LnLabor_i + \beta_3 female + \beta_4 age30 + \beta_5 age3050 + \beta_6 sec + \beta_7 Hig + \beta_8 abHig + v_i - u_i \ldots\ldots\ldots (6.1)$$

Where Y_i represent the quantity of rubber latex yield measured in kg. In the study areas, rubber trees have been planted on the sloping land by using conventional plantation method. There was no reported on fertilizer application. Therefore, land and labor inputs are the two main inputs that defined the productivity of rubber latex yields. Ha represent areas of productive rubber measured in hectare. Labor represents labor inputs measured in person-days per households per year. v_i is the two side random error, and u_i is the one-sided half-normal error that has been explained earlier. Stochastic frontier model (equation 6.1) was estimated by using maximum likelihood approach in order to see the effects of each input on the outputs as well as to predict the technical efficiency of rubber production of each household.

6.2.3. Variables and expected sign with technical efficiency

There are two key dependent variables. Each of them involved in different estimation steps. (1) Input of rubber tree measured by the total amount of latex obtained per household in 2011. And (2) Technical efficiency score obtained from the maximum likelihood approach. Output of rubber is a key input of the stochastic production frontier. This production function is assumed to be a function of the land and labor inputs, and will also affected by the quality of human capital or labor. Land input represented by cultivated areas measured by number of hectares that contains productive tree, on the basis of 500 trees per hectare. And labor input measured by a person-days per households.

In addition, female dummy, education dummy, and age dummy are also introduced into the production function to capture the effect of quality of human capital. Female is assumed to have lower quality or lower efficiency compared to male. This is because, male usually acted as the main labor for rubber tree cultivation, including, planting, maintaining, and tapping. Female is on the other hands acted as a sub-labor participating for maintaining, collecting and rear case for tapping. This is because female has been constrained by social cultural, such as give birth, taking care children, household chores, and so forth (Giroh and Adebayo, 2007). Young people are assumed to have higher ability to supervised information and new technology compared to elder people (Khai and Yabe, 2011). Therefore, the people age up to 50 are classified as the young labor age and assumed to have better performance compared to the older. Education secondary and above are also assumed to facilitate people in accessing to information and extension program, and thereby assumed to have positive influencing on technical efficiency of rubber tree cultivation.

Table 6.1: List of independent variables and their expected signs

Independent variables	Definitions and measurement unit	Expected sign
Tapped area (ha)	Area of productive plantation (ha)	+
Labor inputs (psd)	labor inputs person days per household	+
Female dummy	1 for male, 0 for female	-
Age dummy 30	1 for ages below 30 years old and 0 otherwise	+

Age dummy 3050	1 for ages 30 to 50 years old and 0 otherwise	+
Secondary school dummy	1 for secondary and 0 otherwise	+
High school dummy	1 for high school and 0 otherwise	+
Above high school dummy	1 for above high school and 0 otherwise	+

Note: (+) indicates positive relationship between dependent and independent variables; (-) indicates negative relationship between dependent and independent variables.

6.3. Results

6.3.1. Summary statistic value of variables

Summary statistic values of dependent and independent variables are expressed in Table 6.2. Household at the productive stage is currently holding approximately 0.71 hectare of productive plantation on average. Each household obtained quantity of rubber latex of 1,152.07 kg per year or equivalent to 1,622.63 kg per ha. This number was greater than that an average amount (1,167 kg per ha per year) estimated by Manivong and Cramb (2008) for the case of Hadyao village alone.

Labor inputs were measured by number of person days (psd) per household per year. On average each household put 627.13 psd for their rubber tree plantation. Rubber tree plantations have been adopted in Northern Laos (LuangNamTha Province) in 1994. However, different ethnic groups in different villages adopted rubber tree plantation in different periods. On average, sample household adopted rubber tree plantation for approximately 10.43 years. The sample households have been engaging in rubber tapping for 3.38 years on average. An average education level of household head was 4 years indicating that on average household head has not completed primary level of education.

Table 6.2: Summary statistic value of variables

Variable	Mean	SD
Rubber latex yields (kg)	1,152.07	2,051.47
Tapped area (ha)	0.71	0.67
Labor inputs (psd)	627.13	701.14
Age of plantation (years)	10.43	3.75
Age of household head (years)	41.19	11.71
Education level of household head (years)	4	3.55
Female household head dummy	0.61	0.49

6.3.2. Estimation of stochastic frontier production function

Table 6.3 displayed estimate results of Cobb-Douglas stochastic frontier production function by Maximum likelihood approach. There are five variables among eight displayed significant results. And the signs of coefficients were fulfilled our expectation. The important parameter of log-likelihood in the half-normal model was $\lambda = \sigma_u/\sigma_v$. If $\lambda = 0$ there were no effects of technical in efficiency and all deviations from the frontier were due to noise (Aigner at., 1977; and Khai and Yabe 2011). The estimated value of $\lambda = 1.7914$ significantly different from zero, indicating that all deviations from the frontier were due to the effects of technical inefficiency.

Typical of Cobb-Douglass production function, the estimated coefficients for a specified function can be explained as elasticities of the independent variables, the quality of human capital. The estimate parameters of stochastic frontier production function indicated that elasticity of rubber latex yield with respect to tapped areas was positive and approximately 1.2872 (p-value = 0.0020). Whereas the elasticity with respect to labor inputs was 0.6420 (p-value = 0.0000). These results suggested that tapped area is a profound factor that influences productivity of rubber trees in the study sites. In particular, an increase of 1% in tapped areas will increase rubber latex yields by 1.2346% on average. In the mean time, 1% increase in labor input will increase rubber latex yield by 0.7193% on average.

The sum of elasticity was 1.9292 greater than 1, showing that rubber tree cultivation in a Northern Province of Laos is producing in areas of increasing return to scales. This result suggested that any additional increases in input will lead to more than proportionate increases in rubber latex yields.

In addition to this we found that three among six variables associated the quality of human capital revealed significant results and satisfied our expectation. These results are partly support that efficiency in rubber tree cultivation was affected by the quality of human capital. In particular, the negative and significant of female dummy (p-value = 0.0010) indicate a strong result to support that female on average has performed less efficiency compared to male in rubber tree cultivation.

The dummy of age below 30 years old and ages between 30 to 50 years old also displayed significant results (p-value = 0.0790 and p-value = 0.0570 for age below 30 years old, and age between 30 to 50 years old, respectively) indicate weak results to support that young people tend to gain for efficiency in rubber tree cultivation on average compared to elder people.

Table 6.3: Maximum likelihood and marginal effects from stochastic frontier model

Stochastic frontier: Dependent variable: rubber latex yield (kg)			
Independent variable	Coef.	Z-value	P-value
Tapped area (ha)	1.2872	3.0800	0.0020***
Labor inputs (psd)	0.6420	4.2600	0.0000***
Female dummy	-0.5318	-3.3100	0.0010***

Age dummy 30	0.4315	1.7500	0.0790*
Age dummy3050	0.3732	1.9000	0.0570*
Secondary education dummy	-0.0593	-0.2800	0.7800
High school education dummy	0.0317	0.1700	0.8640
Above high school education dummy	0.1413	0.3500	0.7260
Constant	2.4282	3.1800	0.0010***
Sum of elasticity	1.9292		
Log likelihood	-226.3912		
Sigma V	0.6517		
Sigma U	1.1675		
Sigma square	1.7879		
Lamda (Sigma U/Sigma V)	1.7914		
Number of households	166		

Note: The symbol *, **, and *** denote the level of significance of 0.1, 0.05, and 0.01 respectively

6.3.3. Technical efficiency scores of smallholder rubber cultivation

The technical efficiency of smallholder rubber cultivation varied from 3.18% to 79.8%. This result indicates a large gap of technical efficiency in rubber tree cultivation among the sample villages at the productive stage. The average efficiency score of the sample villages was approximately 48%. This number suggests that the current level of efficiency in rubber tree cultivation among the sample households at productive stage remained low; and ranged the lowest among the former rubber countries such as Vietnam, Malaysia, and Nigeria (Son et al., 1993; Giroh and Adebayo, 2007; and Mustapha, 2011). In addition, approximately 46.4% gained the technical efficiency score below the average efficiency level. On the other hands, the lower level of technical efficiency also implied the large potential efficiency. From this result we could observe that on average approximately 52% of technical efficiency could be potentially increased in the future.

The distribution of technical efficiency scores of smallholder rubber tree cultivation in the sample villages in Figure 6.1. The distribution of the sample households with respect to the same rage of efficiency score could be perceived as the U-shaped. The smallest percentage, accounting for 7.2% achieved below 20% of efficiency. The larger percentage of the sample households achieved the higher range of technical efficiency. The largest percentage of the sample households, accounting for approximately 20% achieved above 50% to 60% level of technical efficiency. After that the percentage of the sample households achieved the higher range of technical efficiency level was diminished. Approximately 17% and 12% of the sample households achieved above 60% to 70%, and more than 70% of technical efficiency, respectively. The households achieved the second largest range of the efficiency score was greater than the households in each of the first; second, third, fourth smallest ranges of efficiency score. Finally, the households achieved the highest range of the technical efficiency score was almost two times larger than that the households achieved the lowest range of technical efficiency score.

Topography conditions constrain rubber tree cultivation in upland of Northern Laos. There was not reported on fertilizer application due to rubber trees have been planted on sloping land. Land and labor inputs are only the two main productive input factors. The combination of conventional production system and relatively smaller number of years participating in rubber tree cultivation made smallholder rubber tree cultivation in upland of Northern Laos gained the smallest level of technical efficiency among others.

The comparison of the direction of the technical efficiency score and age of plantation between group of the sample households achieved efficiency score below 20% and the group achieved efficiency score above 70% is give in Figure 6.2. Results showed that efficiency score and age of plantation followed the same direction. Similarly, Figure 6.3 illustrated that the efficiency score followed the same trend with the productivity of a mature tree. Whereas, the Figure 6.4 revealed that the productivity of a mature tree followed the same direction with the age of plantation. The Figure 6.2, 6.3, and 6.4 are collectively implied that. The efficiency score followed the same direction with the age of plantation and the direction of the productivity per a mature tree. However, we observed that the productivity per mature tree followed the same direction with the age of plantation. Therefore, the efficiency score is likely to depend on the age of plantation, suggesting that the mature tree in a range of appropriate years enhanced the amount of rubber latex per a mature tree; which then ultimately enhances the efficiency level of rubber tree cultivation.

Therefore, as relatively longer times engaging in rubber tree plantation made the former rubber cultivating countries gained better experiences in rubber tree plantation management systems and had obtained higher productivity per a mature tree. Further more in case of Nigeria, selective clone which suitable to the conditions of that region has been introduced to the smallholder rubber households.

In case of smallholder rubber households in Malaysia, in addition to advanced skills in rubber tree cultivation, the government also provided special extension program. Under this program, smallholders were closely supervised by the Rubber Industrial Smallholder Development Authority (RISDA), of which agricultural assistants have been assigned to smallholders at a rate of 1:3. This means each supervisor acted as overseer responsible to three rubber smallholders. The supervision program has been implemented with the combination of better husbandry practice and selective clone (Mustapha, 2011). Those special extension programs made smallholder rubber production in Malaysia gained the highest level of average TE among others.

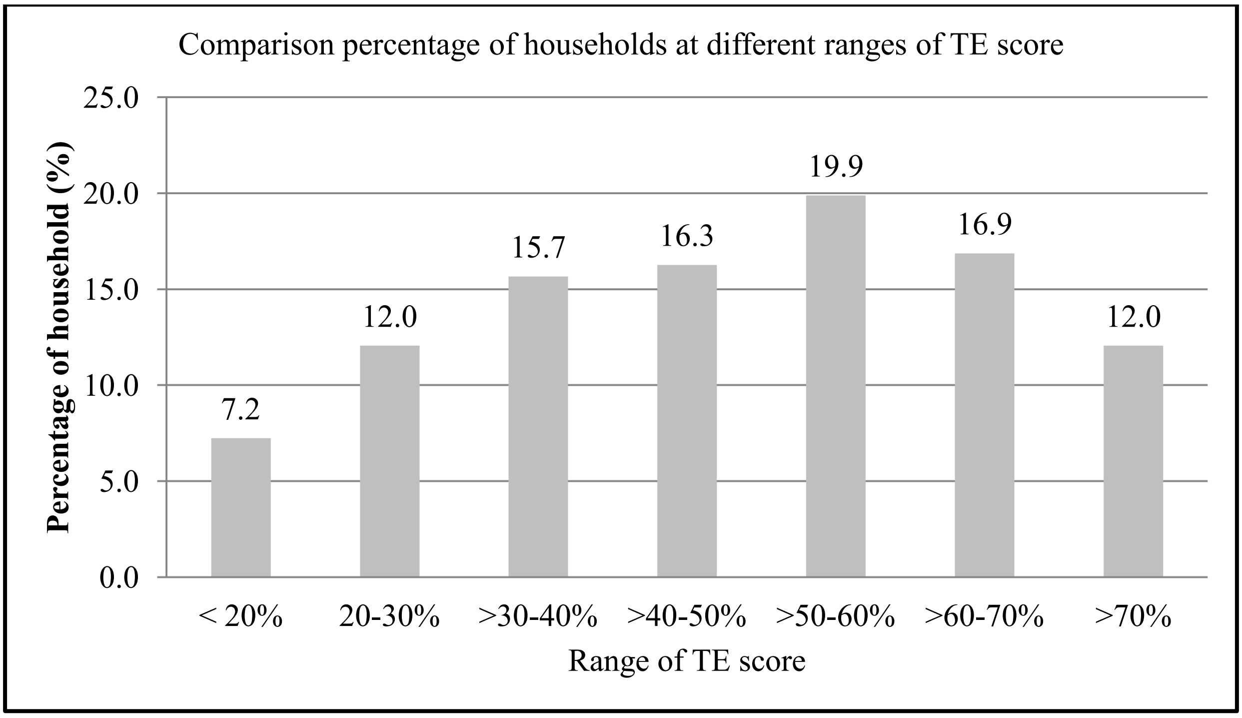

Figure 6.1: Comparison the distribution of sample households at different ranges of technical efficiency score

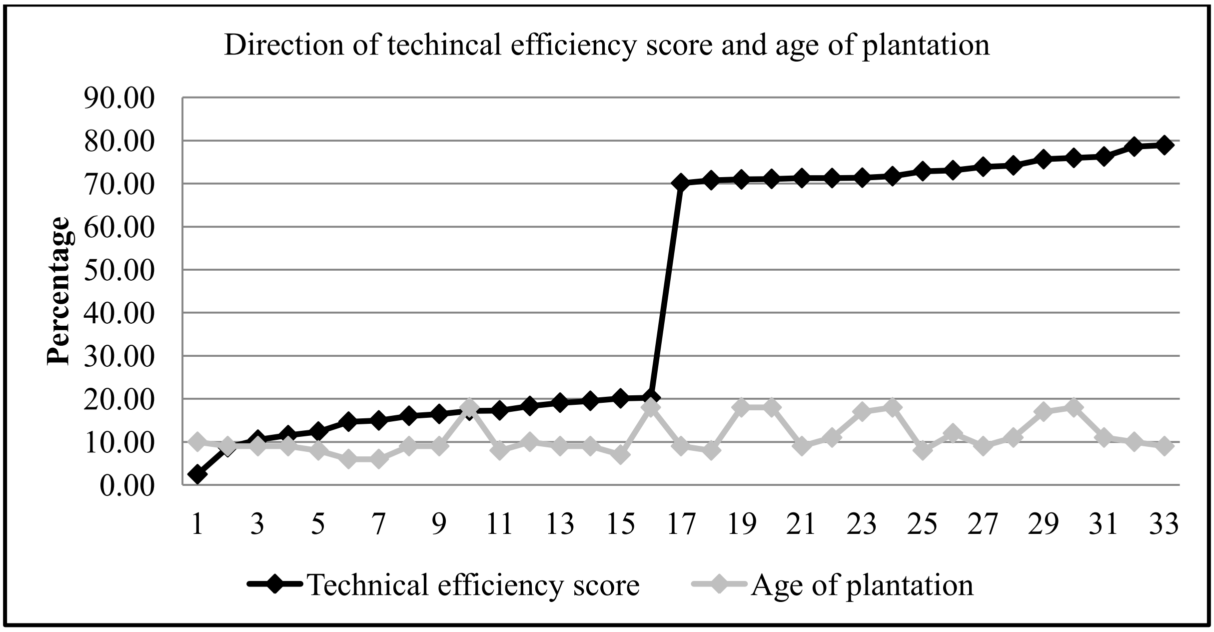

Figure 6.2: Comparison the distribution of sample households at different ranges of technical efficiency score

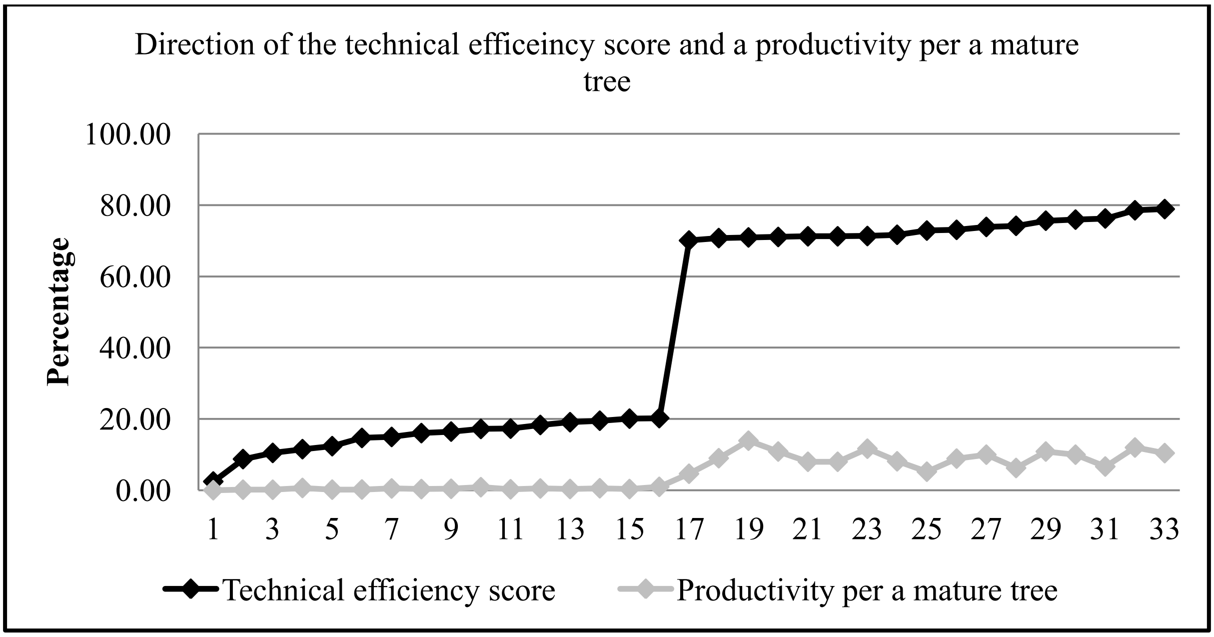

Figure 6.3: Comparison the distribution of sample households at different ranges of technical efficiency score

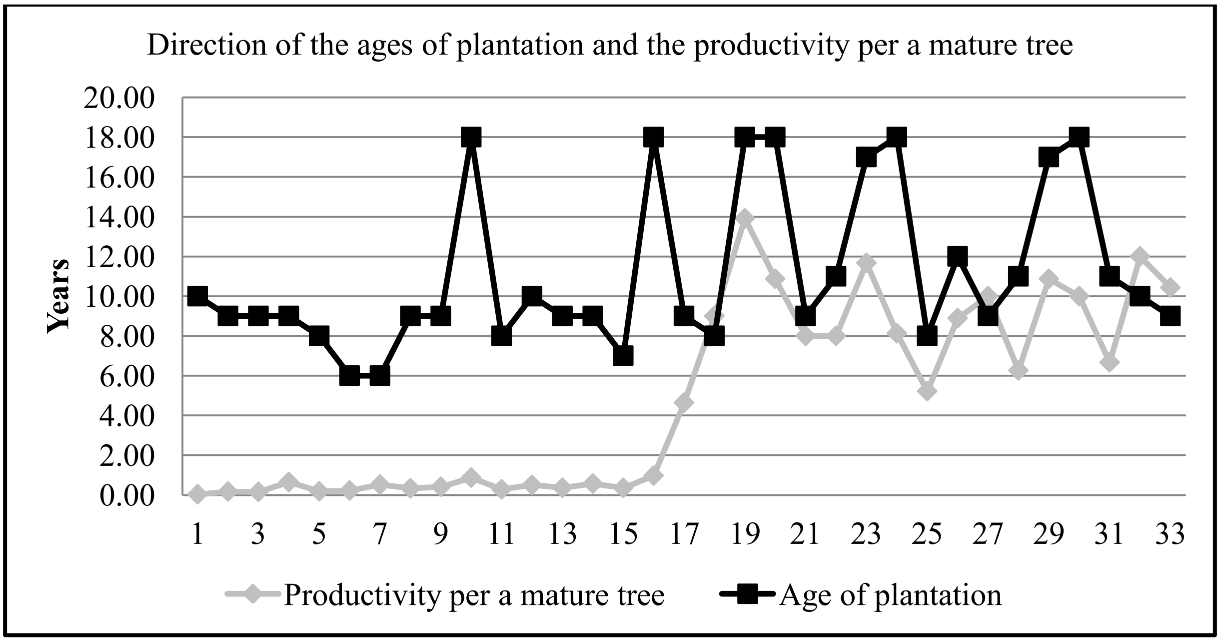

Figure 6.4: Comparison the distribution of sample households at different ranges of technical efficiency score

6.3.4. The efficiency in rubber tree cultivation across sample villages

Comparison of an average efficiency score across the sample villages was given in the Figure 6.5. An average technical efficiency score among the sample villages varied from the lowest of approximately 40 % to the highest of approximately 55%. Hadyao village gained the highest efficiency score among others followed by Phinhor village with an average efficiency score of slightly lower than that of the Hadyao. Namdeng gained the smallest technical efficiency score among other sample villages.

The maximum values of technical efficiency score varied from approximately 63% to 80%. Hadyao hold the highest maximum efficiency score among other sample villages, while Tavan hold the smallest maximum efficiency score. Phinhor, Namthoung, and Namjang hold the second, third, and fourth highest maximum efficiency score, respectively. In addition, there was only small gap of the maximum efficiency scores among those villages; while there was quite large gap of maximum efficiency score between the first and second lowest maximum scores.

The minimum values of the efficiency score varied from approximately 10.5% to 20.4%. Phinhor achieved the highest minimum efficiency score. Tavan achieved the smallest minimum score, while Hadyao achieved moderate minimum score. The value of the highest minimum score was approximately two times larger than that the smallest minimum score suggesting for the large gap of between the lowest and highest minimum efficiency score compared to the value of an average and maximum score.

The comparison of the values of the efficiency score across the sample villages showed unsurprising results that Hadyao was perceived as the best performance, since this village has been longest engaged in rubber tree among others (Figure 6.6). This results emphasize that Hadyao deserved the villages that most famous for rubber tree cultivation in Northern Laos. On the other hand, it was quite surprised in the case of Phinhor village. This village has been shorter engaged in rubber tree cultivation compared to Hadyao (Figure 6.6), however, Phinhor was evaluated to hold the second best performance after Hadyao. Namdeng was only slightly shorter years of engaging in rubber tree cultivation compared to Phinhor (Figure 6.6). Furthermore, Hadyao and Namdeng are classified as the Hmong village. The head of Namdeng was the younger brother of the Hadyao's head. These two villages usually shared knowledge, experience and information regarding rubber tree cultivation. Therefore, it was quiet surprised to found that Namdeng village holds the second worst performance among the sample villages after Tavan.

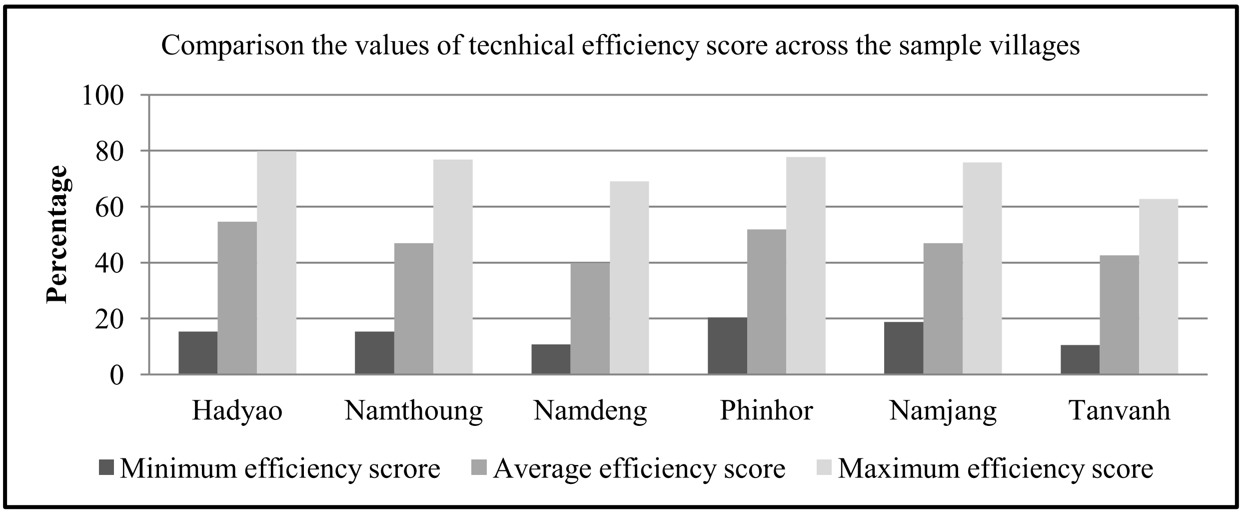

Figure 6.5: Comparison values of the efficiency score across the sample villages

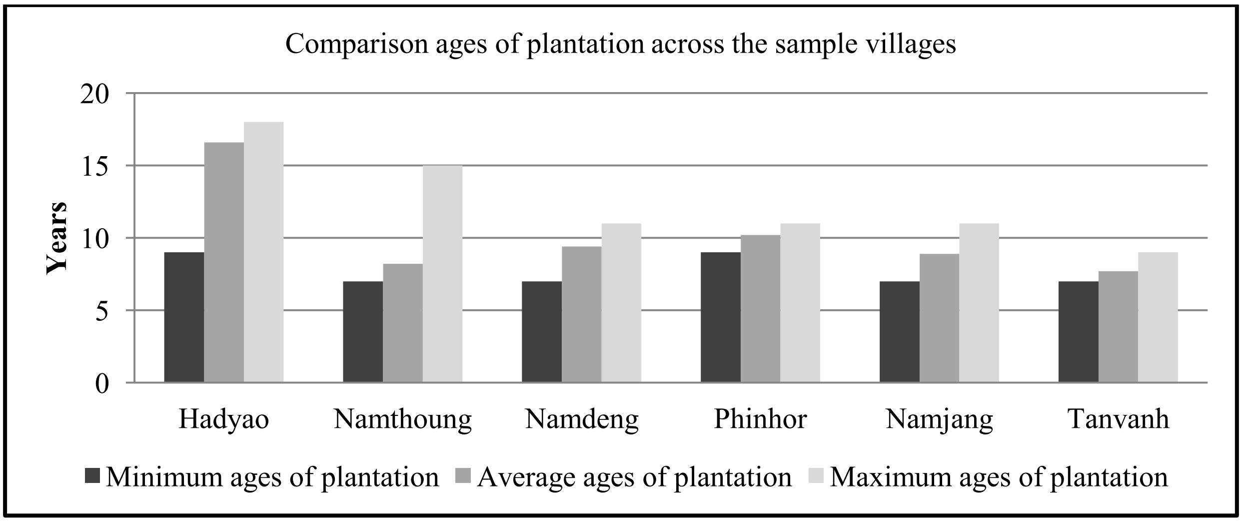

Figure 6.6: Comparison values of the age's plantation across the sample villages

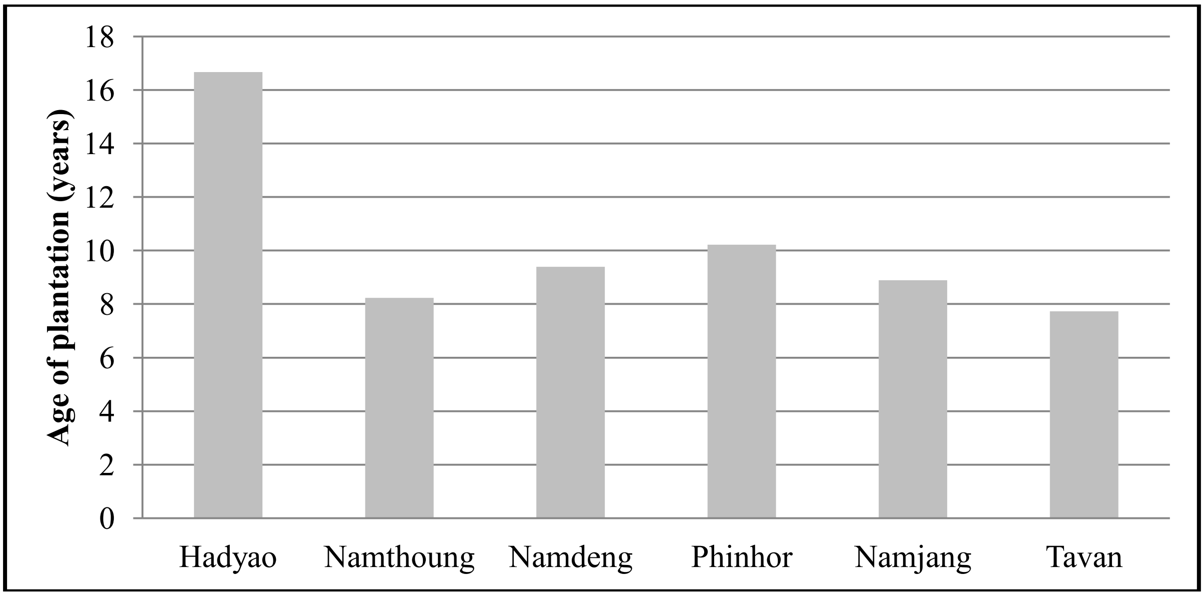

Figure 6.7: Comparison an average age of plantation across the sample villages

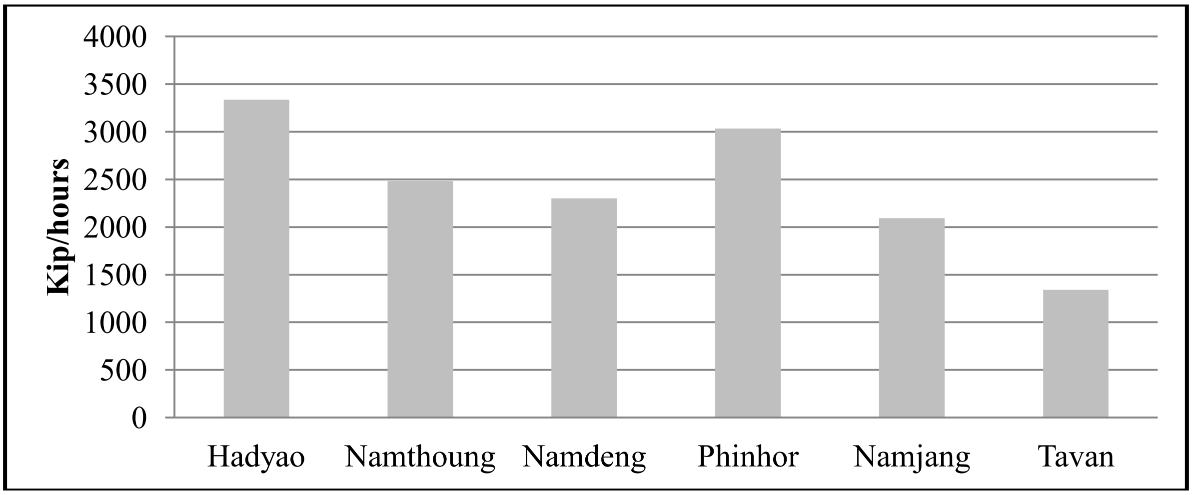

Figure 6.8: Comparison the productivity of rubber tree cultivation across the sample villages

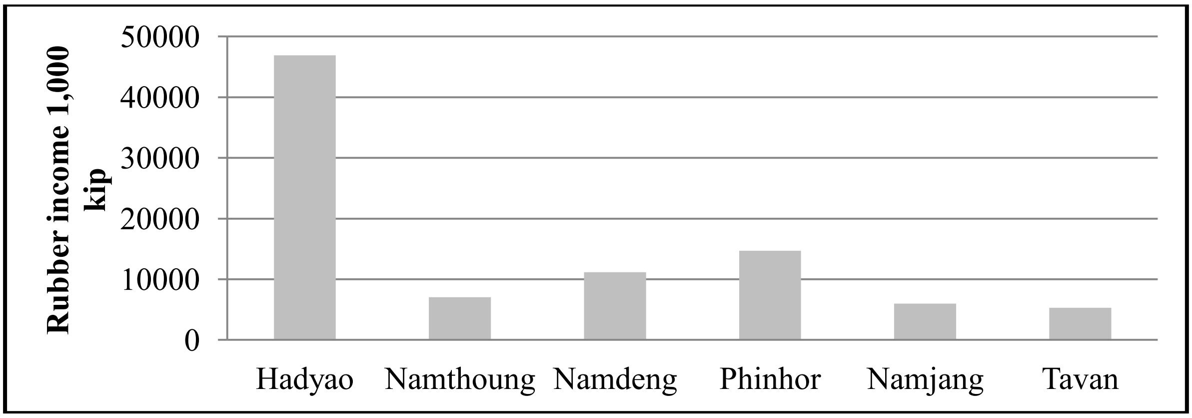

Figure 6.9: Comparison an average rubber income across the sample villages

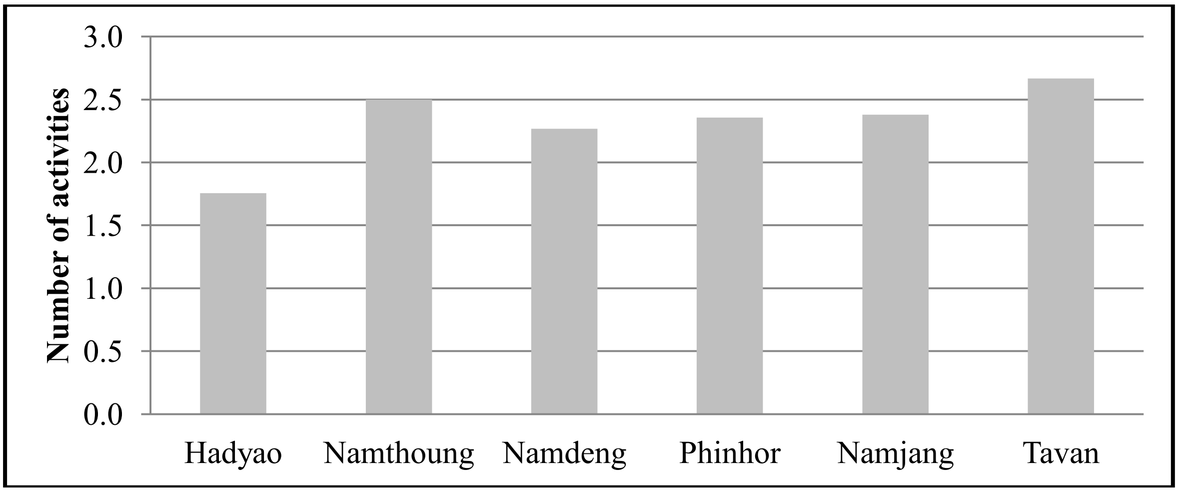

Figure 6.10: Comparison an average number of activities adopted per household across the sample villages

There are some reasons why Hadyao village was perceived as the best performer among others. First of all, Hadyao village contained number of resource persons since the first time of adoption rubber tree plantation. These resource persons are Hmong refugees migrated from China. At that time they brought with them the experiences of rubber tree cultivation in China for more than fourteen years (Alton et al., 2005). Second, this village already obtained the largest average income generated from rubber which made their productivity of labor also highest among other sample villages. This made them specialize in rubber tree cultivation and gained the highest efficiency among others (Figure 6.8 and 6.9).

Similarly, Phinhor village was perceived as the second best performer. This is because, although Phinhor village announced the year of rubber tree plantation after Namthoung and Namdeng village, the sample households in this village have adopted rubber tree plantation early than that. Their plantation was the second oldest after Hadyao village. This made this village obtained the second largest average income from rubber after Hadyao (Figure 6.7). This made this village obtained the second largest productivity of rubber tree cultivation. On the other hands, other villages are holding realitive younger productive trees. Therefore, they obtained relatively smaller amoung of average income from rubber and lower productivity of labor of rubber tree cultivation. As a result they participated in other activities to diversify their livelihoods (Figure 6.10). Finally, there was time competition between rubber tree cultivation and other activities which ultimately lower the efficiency of rubber tree cultivation in other sample villages.

6.4. Conclusion

Key findings from the chapter five showed that increasing the productivity of rubber is likely to decrease the forest resource dependency among smallholder rubber tree cultivation at the productive stage. However, rubber tree plantation has been adopted in Northern of Laos in 1994, and the rapid expansion has emerged in the mid 2000s. Therefore, the technical knowledge and experiences for rubber tree cultivation gained by smallholder rubber households in Lao in general and in northern in particular are subject to immature. As a result of immature experiences in rubber tree cultivation is expected that efficiency in rubber tree cultivation would be low which is subject to high potential efficiency. Thus, this study conduct to analyzes the technical efficiency in rubber tree cultivation across the sample villages in order to find the current and the potential level of technical efficiency in rubber tree cultivation. Results from this study enable us to discuss the possibility to sustain a reduction of forest resource dependency.

Findings from this chapter showed that technical efficiency among smallholder rubber tree cultivation on average remained being low and become the lowest among the former rubber tree planting countries such as Vietnam, Malaysia, and Nigeria; which is generally suggesting for the high possibility to sustain a reduction of forest resource dependency through enhancing the capacity and income for the smallholder.

In addition, there are large gap between the perceived best achievement and the worst achievement. There was not so large gap of efficiency score among the sample villages on average, however, the large gap of technical efficiency was exist among the households within the same village. It was not quite surprised to find that Hadyao village perceived to be the best performer among the sample villages since.

The low average level of technical efficiency on the other hands implied the large potential efficiency that could be further improved to enhance the potential capacity and income of the smallholder rubber households. The increasing returns to scale among smallholders further emphasize the possibility to realize the potential efficiency score with less quantity of inputs requirements. Improving the quality of human capital by supportive program for female and young labor would contribute to improve the capacity of the smallholders and ultimately improve the efficiency of rubber tree cultivation as a whole. As described in the section 2.4 in chapter two. Although male is acted as supportive labor; however, collecting and storing the latex are also perceived as the impotant components which could affect the technical efficiency of rubber tree cultivation in general. First reason, if the collection activtity did not perform well, part of latex will be lost which ultimately affect the overall quantity obtained from rubber trees. Secondly, if the storing was not perform appropriately; latex would contain sand or dirt which is further lower the price of the latex during the time of selling.

CHAPTER 7 CONCLUSION AND POLICY RECOMMENDATION

7.1. Conclusion

On the one hand market demand for NTFPs in LuangNamTha is driven by domestic and cross-border markets and facilitating by improvement of road conditions and other infrastructure services. Accordingly, sustainable uses of forest resources become great challenges for the government of the government and local community. On the other hands, leading by strong demand for natural rubber from China, LuangNamTha province has identified rubber tree plantation as a key strategy to alleviate poverty and instrument to stabilizing shifting cultivation. Although this research would not address forest resource conservation and sustainable forest resource management directly; however, the pressure on forest resource would be diminished if alternative income could decrease forest resource dependency among smallholder rubber households. The overall objective of this study is to investigate the relationship between rubber tree plantation and forest resource dependency and analyzes the possibility to maintain that relationship.

In order to achieve the research goal, a system labor share equation based on the theoretical framework of agricultural households in developing country was developed to examine working hour's allocation decisions among five livelihood activities in respond to changes in their productivity of labor. Due to the indicator for forest resource dependency in the chapter four could not capture the net effect of working hours allocated for NTFP collection or could not represent the real-term of forest resource dependency. Chapter five examined the returns of rubber tree cultivation and other factors on forest resource dependency. Finally, this study analyzes the technical efficiency of rubber tree plantation in order to observe the current and potential efficiency to further improve the capacity and income of the smallholders and discuss the possibility to sustain the forest resource dependency for a long-term.

Households are more likely to embrace rubber tree plantation as an alternative livelihoods and gradually discard the activities they used to adopt in the subsistence economy, such as upland rice shifting cultivation, livestock production, and NTFP collection. NTFP collection in particular has become less important for household economy. Although majority of the households at unproductive and productive stage remained participating for NTFP collection, however, the main purpose of that collection was for household consumption.

Findings described above are the key explanations why forest NTFP dependency in term of income could not be explained by the changes in the productivity of rubber tree cultivation. On the other hands, some subsistence NTFP remained important for household livelihoods for a certain degree especially to maintain the consumption of forest products that could not be possible to perfectly substitute by commercial products or the current condition is not allow the substitutability among them. For instance, fire wood for main source of fuel consumption. On the other hands, commercial products have been replaced where the substitutability conditions are allowed especially for the housing construction materials. Therefore, additional increase in the productivity of rubber tree cultivation tends to decrease the overall forest resource dependency among smallholder rubber households. This is because the large proportion of the NTFP collect values was for subsistence use.

Although increasing the productivity of rubber tree cultivation would lead to overall reduction of forest resource dependency at the productive stage. We observed different decisions on forest resource dependency among households between unproductive and productive stage of rubber tree cultivation. Working hours that used to allocate for NTFP collection were observed to be flexible to be reallocated in respond to livestock, and off-farm activities as ad hoc economy activities during waiting for rubber income and as the activates supplement cash income at the productive stage. Continue relying on NTFP along with supportive rubber income was observed among smallholder rubber households where the majority household's residents are classified as children and elder people (non-labor). However, seeking for off-farm job as a complement activity along with supportive rubber income and decrease dependency on forest resource was observed among the households leading by perceived better educated head. Finally, the high potential average efficiency in rubber tree cultivation creates favorable conditions to improving capacity and income of the smallholder rubber three plantations. These results suggest for the high possibility to sustain a reduction in forest resource dependency in a long-term perspective. The possibility to sustain a reduction in forest resource dependency was observed not largely different across the villages. However, it was observed to be largely different among the households within each village.

Although the problem of data constrains led this study to find quite weak policy to realize the potential possibility to sustain a reduction in forest resource dependency; however, across the sample villages, the highest possibility to sustain a reduction in forest resource dependency was observed in the case of Hadyao village. This result seemed not surprised because this village was the most successful case for rubber tree cultivation in LuangNamTha province. For human capital perspective, the lower possibility to sustain a reduction in forest resource was observed among households are leading by female head or among female labor, while the high possibility was observed across young household head or young labor below 50 years old.

7.2. Policy recommendation

Based on the major conclusion above, what we can propose to the policy makers are listing below:

An influenced of rubber tree cultivation on a reduction of forest resource dependency has not been observed at unproductive stage as households are living without rubber income. However, since working hours for NTFP collection decreased in response to increasing the productivity of labor of livestock production and off-farm jobs, especially among households are leading by better educated head. Therefore, creates economic incentives in livestock or off-farm employment would reduced number of working hours that households allocated for NTFP collection.

Adoption of livestock production as ad hoc livelihood alternative at this stage is likely to be constrained by the capital investment, since household lack of rubber income. On the other hands, off-farm employments seemed to be more appropriate ad hoc livelihood activity at this stage. Therefore, the government should introduced supportive program that will enable households which majority of them was educated at the primary education to access to short-term off-farm jobs. In practical, the policy should target to households with greater number of dependents relative to number of household labor and households led by advanced age household head. This is because these two groups remain seeking forestlands to continue practicing upland rice shifting cultivation in order to provide staple for their own consumption during the time living without rubber income to alternatively purchase staple at the markets.

Productive stage called for a better-planned policy. This is because productive stage not only displayed the current situation of the productive stage, but also mirrored the future situation of the current unproductive stage. Therefore, this required a long-term perspective policy. The key findings of this study suggest that materialize the potential technical efficiency of rubber tree cultivation would increase capacity and income among smallholder rubber tree cultivation. This will further enlarge scale of a reduction in forest resource dependency.

The collection and store up rubber latex also combine as important components along with tapping which could determine the ultimate amount of income obtained at the final stage of rubber tree cultivation. And the female has taken as the key actor for those two activities. Therefore, improving the capacity of young male would not only perceive to maintain the income from latex sales but would also reduce burden for male and enhance the capacity of male as well which is perceive to ultimately contribute to the improving of the efficiency of rubber tree cultivation as a whole.

Since Hadyao village was perceived as the best performer for rubber tree cultivation. Lessons and experiences in rubber tree cultivation within these villages have been widely spread to other smallholder rubber household in LuangNamTha already. However, large gap of technical efficiency among households was observed in this village. Therefore, further improve the capacity of young female would further enrich knowledge and experience that could be shared from this sample village.

7.3. Limitation and suggestion for further study

In spite of the fact that there was no a piece of perfect study in the real world, this study was conducting under some limitations. First of all, this study employed primary data that obtained from household survey using questionnaire form. The main method employed for data collection called one year recalled information. This may affect the accuracy of data obtained. The accuracy would be enhanced if the future studies could observe the data by quarter or seasonal.

Second, the amount of working hours for upland rice shifting cultivation and rubber tree plantation are calculated based on the area basis rather than direct interviewed sample households, this may not fully reflect the amount of working hours for these two activities across households.

Third, the list of the potential variables such as extension program, training program, rubber clone, and fertilizer application are missing from the technical efficiency analysis. Experience from this study suggests that technical analysis of rubber tree cultivation in particular was perceived as one of the most appropriate study at the study site. Therefore, in the future if more policy variable can be observed, and this approach could be employed to compared the technical efficiency of rubber tree cultivation at the experimental sites, or among different types of rubber arrangements. Those studies would provide very useful pieces of information for policy makers and for smallholder rubber households as well.

Finally, key findings from this study revealed that increasing the productivity of rubber tree cultivation was likely to decrease forest resource dependency. Whether or not a reduction in forest resource dependency among smallholder would enhance forest resource conservation or not also suggest for future study to search for an appropriate approach to address this issue.

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APPENDICES

Questionnaire form for survey smallholder rubber production in LuangNamTha province, Northern Laos. April to May 2012

My name is Duangmany Luangmany; I am working on my PhD dissertation under the theme "Impacts of rubber tree plantation on livelihoods of smallholder rubber production in LuangNamTha province." The purpose of this survey is to collect the data and information to complete my PhD dissertation. Therefore, please be certain that all information answered in the questionnaire form will be used for the academic purpose only and will never present to the tax department or using for other purposes.

Name of enumerator: ____________ Date of interview: ____/____/2012
Start to interview at: _______ (times)   Finish an interview at: ___________ (times)

1. Background Information

1.1. Name of the village __________1.2. HH. Number ________ 1.3. HH. Unit ______

1.4. What is respondent's name? _____________________

1.5. What is the gender of the respondent?   1. Male   2. Female

1.6. What is the age of the respondent in his last birthday? ______________ years

1.7. What is the respondent's ethnic group?   1. Hmong   2. Khmu

3. LaoLoum   4. Other (specify ________________________)

1.8. What was the highest level of education of the respondent?

1. Not attending school   2. Primary   3. Secondary
4. High school   5. Higher education   6. Bachelor
7. Others (Specify ---------------------------)

1.9. What was the total number of respondent's schooling year? ---------------------- Years

1.10. How many people are currently living together within your household? _____ People

1.11. Please fill information of each household member in to the table below

ID	Sex	Age	Relationship	Job	ID	Sex	Age	Relationship	Job
1					10				
2					11				
3					12				
4					13				
5					14				

6					15				
7					16				
8					17				
9					18				

1.12. How many people are specified as the full time labourers in your household? _____ People

2. Information on livestock production

2.1. What were total numbers of each type of livestock holding by your household?

Type of livestock	Buffalo	Cattle	Goat	Horses	Pig	Duck
Number of livestock holding						
Type of livestock	Chicken	Goose	Turkey	Fish	Other 1__	Other 2___
Number of livestock holding						

2.2. What were the total numbers of each type of livestock sold in last year?

Type of livestock	Buffalo	Cattle	Goat	Horses	Pig	Duck
Number of livestock sale						
Type of livestock	Chicken	Goose	Turkey	Fish	Other 1____	Other 2___
Number of livestock sale						

2.3. What was total amount of income earned from each type of livestock sale in last year?

Type	Buffalo	cattle	Goat	Horse	Pig	Duck
Income(kip)						
Type	Chicken	Goose	Turkey	Fish	Others 1___	Other 2___
Income(kip)						

2.4. What are the following people that take care livestock in your family? (Put this symbol ✓ in to the table with the corresponding person)

Tasks	Yourself	Spouse	Daughter	Sons	Others

Cutting grass					
Take livestock to the grazing zone					
Collect fodder					

2.5. In last year, how many days did you spent for livestock activities?

Tasks	Cutting grass	Take livestock to the grazing zone	Collect fodder	Prepare feed
No. of days/year				
No. of hours/day				

3. Information on agricultural production

3.1. Rubber tree plantation and time allocation

3.1.1. Does your household own rubber tree plantation?

1. Yes(Proceed # 3.1.2)   2. No (Proceed # 3.2)

3.1.2. How many plots of rubber tree plantation own by your household? __________ plot(s)

3.1.3. How many trees were planted in each year?

Planted year	1994	1995	1996	1997	1998	1999	2000	2001	2002
Planted trees									
Planted year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Planted trees									

3.1.4. Does your household begin to tap your mature trees?

1. Yes (# proceed 3.1.8)   2. No (# proceed 3.1.11)

3.1.5. When did your household begin your first tapping? In ___________(year)

3.1.6. What was the number of your accumulated mature trees for each year?

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
No. of mature trees										

3.1.7. What was the amount of total rubber yield collected by your household annually?

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Latex yield (kg)										

3.2. Information on upland rice cultivation

3.2.1. In last year, what was the total upland area under upland rice cultivation? ________Ha

3.2.2. In last year, what was the total amount of rice seed grown in the upland field? _____Kg

3.2.3. In last year, what was the total amount of harvested upland rice yields? __________Kg

3.2.4. Did part of your upland rice yields was sold?

1. Yes (Proceed # 3.2.5 and 3.2.6) 2. No (Proceed # 4)

3.2.5. If yes, what was total amount of rice sale? _________________ Kg

3.2.6. What was total amount of income earned from upland rice sale? ______________Kip

4. Information on non-timber forest products collection and time allocation

4.1. In last year, what types of NTFPs were collected by your household? (Fill number into the table: 1 for "Yes" and 2 for "No")

NTFPs	Palm fruit	firewood	Broom grass	Barks	Rattan fruit	Rattan cane	Rattan shoot
Collect							
NTFPs	Galangal	Carda mom	Bamboo shoots	Mush room	Paper mulberry	Vegetables	Wildlife
Collect							
NTFPs	Honey	Insects	Roots/ tuber	Flowers	Other1___	Other 2___	
Collect							

4.2. In last year, how many kg of each type of NTFP have been collected by your household?

NTFPs	Palm fruit	firewood	Broom grass	Barks	Rattan fruit	Rattan cane	Rattan shoot
Kg							
NTFPs	Galangal	Carda mom	Bamboo shoots	Mush room	Paper mulberry	Vegetables	Wildlife
Kg							
NTFPs	Honey	Insects	Roots/ tuber	Flowers	Other1___	Other 2___	
Kg							

4.3. From which month to which month can each type of specified NTFP be collected in a year round?

NTFPs	Palm fruit	Fire wood	Broom grass	Barks	Rattan fruit	Rattan cane	Rattan shoot
From…to…							
NTFPs	Galangal	Carda mom	Bamboo shoots	Mush room	Paper mulberry	Vegetables	Wildlife
From…to…							
NTFPs	Honey	Insects	Roots/ tuber	Flowers	Other1___	Other 2___	
From…to…							

4.4. How many days per month did you spent to collect NTFPs? ____________ Days

4.5. In last year, what was the total amount of income earned from each type of NTFP?

NTFPs	Income (kip)	Price (kip/kg)	NTFPs	Income (kip)	Price (kip/kg)
Palm fruit			Paper mulberry		
Firewood			Vegetables		
Broom grass			Wildlife		
Barks			Honey		
Rattan fruit			Insects		
Rattan cane			Roots		
Rattan shoots			Flowers		
Galangal			Other 1____		
Cardamom			Other 2____		
Bamboo shoots			Other 3____		
Mushrooms					

5. Household Labor Allocation on Non-farm activities

5.1. Who are the following persons working for the activities specified below? (Put the number in to the Table. For example, 1 = Wife, 2 = husband, 3 = daughter, 4 = son, 5 others (Specify__))

Activity	Government official	Private company	Worker	Run small shop

Person				
Activity	Handicraft	Weaving	Pick up carry	Other _
Person				

5.2. How many days did they spend in working on each types of activity in last year?

Activity	Government official	Private company	Worker	Run small shop
Days				
Activity	Handicraft	Weaving	Pick up carry	Other _
Days				

5.3. How many hours per day did they spend in working on each type of activity in last year?

Activity	Government official	Private company	Worker	Run small shop
Hours				
Activity	Handicraft	Weaving	Pick up carry	Other _
Hours				

5.4. How many months per year did they spend time to work in each type of activity in last year?

Activity	Government official	Private company	Worker	Run small shop
Months				
Activity	Handicraft	Weaving	Pick up carry	Other _
Months				

5.5. How much did they earn from each type of activity per month in last year?

Activity	Government official	Private company	Worker	Run small shop
Monthly income (kip)				
Activity	Handicraft	Weaving	Pick up carry	Other _
Monthly income (kip)				

Thank you for your kind cooperation and tolerant answering questions