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Economics of smallholder rubber expansion in Northern Laos

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Abstract In Northern Laos, as elsewhere in the Southeast Asian uplands, there is an agricultural transition underway from subsistence production based on shifting cultivation to commercial production based on tree crops. In response to demand from China, rubber smallholdings are being established by shifting cultivators in Northern Laos, encouraged by government land-use policy. We examine the bio-economics of smallholder rubber production in an established rubber-growing village and model the likely expansion of smallholder rubber in Northern Laos. Data were obtained from key informants, group interviews, direct observation, and a farm-household survey. Latex yields were estimated using the Bio-economic Rubber Agroforestry Support System (BRASS). A financial model was developed to estimate the net present value for a representative rubber smallholding. This model was then combined with spatial data in a Geographical Information System (GIS) to predict the likely expansion of rubber based on resource quality and accessibility. Implications are drawn for upland development in the region.

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Introduction

In recent decades the uplands of Southeast Asia have experienced major changes due to economic growth in the region. In Northern Laos there is a transition underway from subsistence production based on shifting cultivation to commercial production. This change is a result both of increasing integration with the regional economies of Southeast Asia, particularly southern China, and of government policies directed towards upland development (Thongmanivong and Fujita 2006; Ducourtieux et al. 2005). Most of the change in agriculture has been driven by market forces and foreign investors, particularly from China. The government policy of stabilising shifting cultivation and improving road access has helped drive the change.

The most extensive and rapid change in the uplands of Northern Laos is the expansion of smallholder rubber. This has been made possible due to robust global demand for rubber, especially from China, and the interest of foreign investors from China, Vietnam, and Thailand. While rubber provides an attractive investment opportunity for foreign investors, the Government of Laos envisages it as a way of stabilising shifting cultivation and generating income for upland farmers. However, with a relatively small area having been planted with rubber and an even smaller area in production, there is little information currently available on the potential economic returns to smallholder producers that can be used as a basis for the promotion of the crop by the government (Manivong et al. 2003). If in fact smallholder rubber provides good returns to upland farmers, supporting its uptake by smallholders is likely to be a better rural development policy than granting large-scale concessions to foreign investors.

In this paper we examine the economics of smallholder rubber production in Luangnamtha Province. The paper draws on more detailed research on the economic potential of smallholder rubber production in Northern Laos (Manivong 2007; Manivong and Cramb 2007). The specific objectives of the research are to appraise the economics of smallholder rubber production in the established rubber-growing village of Hadyao in Namtha District of Luangnamtha Province, and to use this as a basis for modelling the economic potential of smallholder rubber production in a variety of settings to indicate the likely expansion of rubber in other areas within Luangnamtha Province.

The role of tree crops in upland agricultural transitions

Shifting cultivation has been the dominant land use in regions such as the sloping uplands of Southeast Asia for many centuries. Integral, rotational, long-fallow systems such as widely practised in the region are considered to be sustainable, provided population pressure is low (Raintree and Warner 1986; Fox 2000; Roder 2001). As Boserup (1965) has posited, steadily increasing population pressure in subsistence economies can induce the gradual intensification of such systems from forest-fallow to bush-fallow to short-fallow to annual or even multi-cropping, with necessary changes in crop technology along the way. However, the full intensification sequence proposed by Boserup, with progressively longer cropping periods and shorter fallow periods, is not feasible in much of the steeply sloping Southeast Asian uplands without causing serious land degradation and increasing poverty (Cramb 2005). Raintree and Warner (1986) have elaborated Boserup's theory of intensification, outlining a variety of agroforestry pathways that open up at different stages, such as enriched fallows in the forest- and bush-fallow stages and alley cropping in the short-fallow and annual cropping stages. They highlight that tree crops provide an alternative end-point to the intensification sequence, even at relatively low population densities and labour intensities. Mercer (2004) reviews evidence of such adoption pathways for a variety of agroforestry practices and settings.

Thus with population growth and the improvement of rural infrastructure, shifting cultivators in Southeast Asia have frequently been motivated to incorporate tree crops such as rubber, coffee, and cocoa in their farming systems rather than push shifting cultivation to its ecological limits, thus necessarily moving beyond subsistence production to at least partial engagement with global markets (Cramb 2007). This transition typically occurs in a step-wise fashion as an economy develops. Myint's (1973) 'vent-for-surplus' theory identifies two stages in the transition from subsistence production to production for the market. The first occurs when farmers use the larger proportion of their resources to produce for their own consumption, but use their spare land and labour to produce for the market, thereby minimising the risk involved. The second stage occurs when farmers allocate most of their resources to supplying the market and rely on purchasing commodities and services, with subsistence farming a spare-time activity. The shift is accelerated by the improvement of transportation and market infrastructure and the activities of market intermediaries, encouraging farmers to change from being 'part-time' to 'full-time' producers for the market. However, smallholders can remain at the semi-commercial stage for many decades, allowing temporary retreat to a subsistence economy when markets experience a downturn (Cramb 1993; Wadley and Mertz 2005). For example, Dove (1993) has highlighted how smallholder rubber in particular has provided shifting cultivators in remote areas of Indonesia with both ecological and economic adaptability for nearly a century.

According to Barlow and Jayasuriya (1986), the development of smallholder tree crop cultivation can be classified into three stages. The first is 'emergence from subsistence' when subsistence production is supplemented by a plantation crop. Simple, labour-intensive tree crop technologies are rapidly adopted by smallholders, typically through diffusion from estates. This is followed by the stage of 'agricultural transformation' when smallholder farming becomes largely commercialised and new high-yielding tree crop technologies are progressively adopted. Finally, the stage of 'extended structural change' is characterised by the increasing significance of the industry and service sectors in the economy, rendering smallholder tree crops less profitable due to the rising cost of land and labour. In a later contribution that particularly focuses on the case of rubber, Barlow (1997) further elaborates on this transition, distinguishing between the 'early' and 'late' phases of the agricultural transformation stage.

Barlow and Jayasurija (1986) and Barlow (1997) show that the development of smallholder rubber in Malaysia and Thailand has experienced all three stages, whereas in countries such as Indonesia and Vietnam rubber is in the (late) agricultural transformation stage. In this framework, as indicated in subsequent sections, Laos is clearly at the (early) agricultural transformation stage, with rapid diffusion and adoption of simple labour-intensive rubber production technologies—though with the benefit of previous technology development in other countries such as Malaysia and Thailand, and the adaptation of this technology to higher latitudes and altitudes on estates (collective and state farms) in southern China. For Laos to move into the (late) agricultural transformation stage will require further economic growth, more extensive government support, and the development of improved and locally adapted rubber technologies.

This framework for understanding agricultural transitions in the Southeast Asian uplands highlights the responsiveness of farmers to changing economic incentives. Hence to explain and predict the expansion of rubber in Northern Laos it is necessary to examine the returns to rubber smallholders under various resource and market conditions.

Background

Laos is one of the poorest nations, with a GDP per capita in 2002 of US$330 and a ranking of 135 out of 175 countries in UNDP's Human Development Index (ICEM 2003; UNDP 2003). Laos is a predominantly rural country with approximately 83% of the population living in rural areas, of whom 66% rely on subsistence agriculture. The national economy is overwhelmingly dependent on agriculture, which accounts for around 47% of GDP and absorbs approximately 80% of the labour force (NSC 2005a). Based on the total area of 236,800 km^2 and the population of 5.6 million, Laos is the least densely populated country in Asia at only 24 persons per km^2 (NSC 2005b).

Rubber was first introduced into Laos in 1930, with the first rubber plantation established in Champasack Province by French planters during the colonial era. Then in 1995 rubber was again planted in Bachiangchalernsouk District of Champassack Province over an area of 50 ha by the Development of Agriculture, Forestry and Industry (DAFI) state company. Between 1994 and 1996, the Hmong village of Hadyao in Laungnamtha Province established rubber over 342 ha in the form of smallholdings. Since then, the rubber area in Laos has increased steadily, but at a more rapid pace since 2003 as many individuals, private sector entities (both domestic and foreign), and state sector entities have responded to high rubber prices and the growth in demand from China (Alton et al. 2005).

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, 230 km with Oudomxay Province in the east and 100 km with Bokeo Province in the southwest. The province is divided into five administrative districts, namely Namtha, Sing, Long, Viengphoukha, and Nalae. Luangnamtha Province is a centre for commerce between China, Laos, and Thailand.

In order to evaluate the economics of smallholder rubber production, the village of Hadyao in Namtha District of Luangnamtha Province was selected for in-depth study as Hadyao was the first village in Northern Laos to plant rubber. Hadyao is a Hmong village located around 2 km from the district centre and near the main road to the Chinese border via the Boten international checkpoint in Sing District. The village is located on acid upland soils in mountainous terrain at a latitude of 21°00′ N and an elevation of about 900 m. Rainfall averages 1,500 mm and is concentrated in May–October. Rubber was introduced in the 1990s by Hmong migrants from China and was planted on sloping land by individual smallholders. In the first phase (1994–1996) 341 ha were planted but trees on about 75 ha were killed by a heavy frost in 1999. In the second phase (2003–2005) a further 296 ha were planted. Tapping of 266 ha commenced in 2002, making Hadyao the first rubber-producing village in Laos.

Methods

Discounted cash flow analysis

Discounted cash flow (DCF) analysis was used as the framework for assessing the returns from the investment of household resources in smallholder rubber production, with the usual investment criteria of net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) (Campbell and Brown 2003). Within this framework, consideration was given to the appropriate valuation of unpaid household labour and of the appropriate discount rate to use in calculating present values, given that farmers are only partially engaged in both labour and capital markets.

Investment analysis of rubber production required data on costs and benefits of smallholder rubber production, which were collected through key informants interviews, group interviews, direct observation, and a questionnaire survey of 95 farm-households conducted in August 2005. Most of the interviews were carried out in the respondent's house as this also provided a chance to observe living conditions; however, farm visits were also undertaken.

In addition, since rubber is a long term investment, estimates of the yield of latex over the life of the investment were required. Annual latex yields were estimated using the Bioeconomic Rubber Agroforestry Support System (BRASS), which is the best available tool for modelling smallholder rubber production (Grist et al. 1998; Cacho 2001). BRASS has a biophysical and an economic component, of which only the former was used in this study (Fig. 1). The biophysical module incorporates many variables in order to estimate the intercrop yields during the intercropping period, the stream of latex yields over the life of the plantation, and the volume of harvestable timber at the end of the production period. These variables are grouped into climate, topography and soil, rubber management, and intercrop management. Climate variables were based on an 11-year data set (1994–2004) for Luangnamtha Province obtained from the Meteorology Station of Luangnamtha Province. Topography and soil variables were based on soil properties in Luangnamtha Province as recorded by the Soil Survey and Land Classification Centre (SSLCC) of the National Agriculture and Forestry Research Institute (NAFRI). Variables of rubber and intercrop management were based as far as possible on the actual practices of rubber farmers in the study village obtained during the fieldwork.

Spatial analysis

As well as considering economic returns over time, the study considered the spatial potential of rubber, drawing on the concept of land use-capacity in land resource economics. Land use-capacity has two major components—resource quality and accessibility

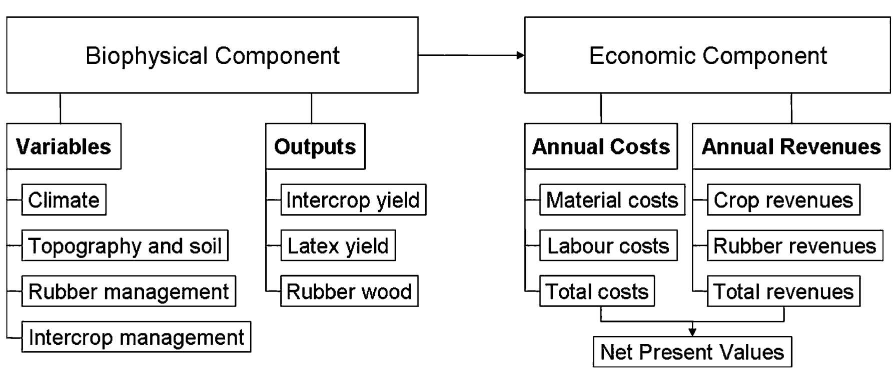

Fig. 1 Variables in the biophysical and economic components of BRASS

(Barlowe 1986). Resource quality involves the relative ability of the land resource to produce desired products, returns, or satisfactions. With agricultural lands, quality is usually viewed in terms of native fertility or fertility in combination with the ability to respond to fertilizer inputs. Quality may reflect climatic advantage—favourable temperature and precipitation, low wind velocity, or infrequency of storms. Accessibility involves the convenience, time, and transport cost saving associated with specific locations with respect to markets, transport facilities, and other resources. Areas near the road, city, or market have more advantage than those located at greater distance. The extent of this advantage corresponds with differences in transportation costs; fields located at greater distances from market naturally have higher transportation costs and thus receive a lower price for products and incur a higher price for inputs.

The areas with the highest land use-capacity ordinarily have the greatest production potential and yield the highest return. In this study, resource quality was based primarily on the soil properties affecting latex yield in the BRASS model and accessibility was based on the distance from the main road and the corresponding mode of transporting rubber to the point of sale. The data on soil properties for Luangnamtha Province were obtained from the Soil Survey and Land Classification Centre of NAFRI. Road data and village locations were obtained from the GIS Unit of NAFRI. These dimensions were mapped using ArcView GIS 3.2a, resulting in a map of the economic suitability of rubber in the study area.

Results

DCF analysis for Hadyao village

The costs and benefits associated with the production of smallholder rubber over the life of a typical 1-ha plantation in Hadyao village were identified and quantified using constant 2005 prices. The costs included material costs and labour costs. The benefits included the output from intercropping upland rice in the first three years, tub-lump rubber (the main form in which rubber was sold), and rubber wood harvested at the end of the plantation's productive life. Costs and benefits were expressed in Kip; in August 2005, the exchange rate was US$1 = Kip 10,500.

Survey data were used to obtain the cost of materials used in each phase of rubber production. The output of rice was estimated from the average rice yields reported in the survey, valued at the 2005 price of 3,500 Kip/kg. The output of rubber from Years 9–35 was estimated using BRASS (Fig. 2) and valued at the 2005 price of tub-lump rubber of 7,800 Kip/kg. The output of rubber wood was also estimated using BRASS. Since there is not yet a market for rubber wood in Laos (given the age of the plantations), the price of rubber wood in Yunnan Province was used, adjusted to reflect the actual price which is likely to be offered by Chinese traders when rubber wood comes to be sold in the future. The 2005 price of rubber wood in Yunnan was 360 Yuan/m^3 (Alton et al. 2005). The farm gate price in Laos was

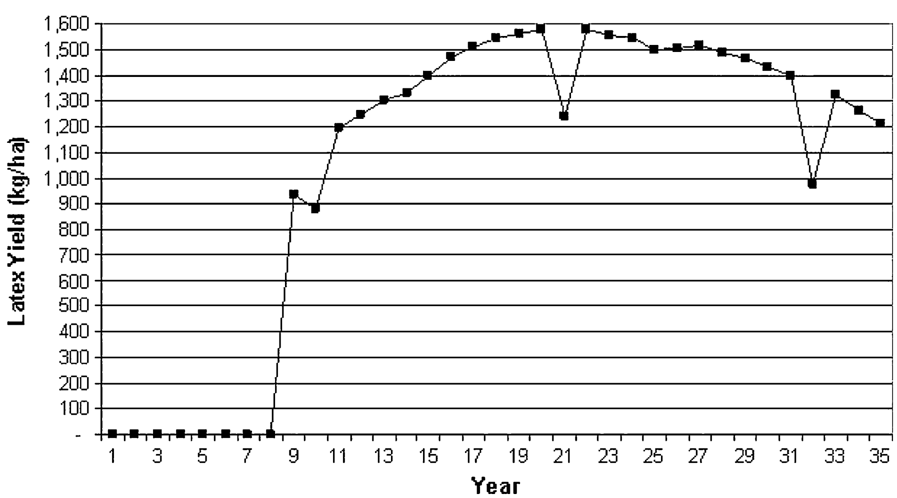

Fig. 2 Predicted latex yield in Hadyao over 35 years using BRASS

assumed to be about 280 Yuan/m^3 or 364,000 Kip/m^3 (Yuan 1 = Kip 1,300 in August 2005).

The labour costs were valued by calculating the labour requirements for rubber establishment and production over the life of the plantation and estimating the opportunity cost of labour or wage rate. The 2005 wage rate for agricultural work in Hadyao village was 20,000 to 25,000 Kip/person-day, depending on the type of work (light or heavy), while the wage rate in Luangnamtha town was 25,000 Kip/person-day. These rates apply to an adult male or female working for 8 h in a day. In the study village, rubber production was undertaken by male and female labour, but school-children also helped. In many cases school-children assisted by tapping before they went to school or collecting latex during the weekend. Also, it cannot be assumed that all adult household members had the option of off-farm employment, particularly in town. Hence it was assumed that the opportunity cost of labour was about two thirds of the maximum market wage rate of 25,000 Kip/person-day, that is, around 17,000 Kip/person-day. While not exact, this was considered a better estimate than the full market wage.

Figure 3 shows the estimated undiscounted annual net returns for a hectare of rubber over 35 years in Hadyao village, using the estimated value of family labour of 17,000 Kip/person-day and (for comparison) the non-farm market wage of 25,000 Kip/person-day. It can be seen that in the immature phase of the plantation net returns are only positive in Years 2 and 3, when development costs are minimal and a crop of upland rice is harvested. Net returns become positive from Year 10 when tapping begins and from that point follow the yield profile as shown in Fig. 2. At the end of the productive life of the rubber in Year 35 there is an additional return from rubber wood.

The selection of a discount rate was also crucial in determining the result of the DCF analysis. Following Perkins (1994), the market borrowing rate or interest rate was adopted as most Lao farmers lack the capital to invest in agricultural production without obtaining credit, particularly in the early stages of transition to commercial agriculture as in the case study area. Since the interest rate varies with different sources of funds, the important issue was which interest rate to use. In the case of borrowing from the Agricultural Promotion Bank (APB) the interest rate was 12%, from commercial banks, 15%, and from money lenders, 20%. Allowing for the 2005 inflation rate of 7% (BOL 2006), these three rates were used in the DCF analysis, i.e., 5%, 8% and 13%.

The DCF analysis for a typical hectare of rubber in Hadyao using a discount rate of 8%, an estimated wage rate of 17,000 Kip, and the 2005 market price of tub-lump rubber of 7,800 Kip/kg showed that the investment in rubber was clearly worthwhile, based on conventional investment criteria (Table 1). The result is plausible and helps confirm the farmers' assessment that smallholder rubber is a profitable investment, thus helping to explain the expansion of rubber planting in the study village.

However, the conventional investment criteria may not be entirely applicable in the case of semi-

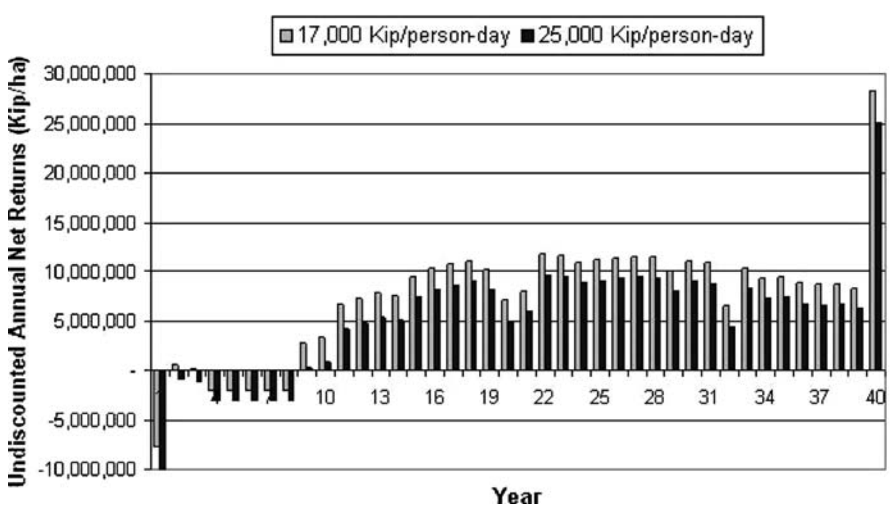

Fig. 3 Undiscounted annual net returns using opportunity and market wage rates

Table 1 Results of DCF analysis for smallholder rubber in Hadyao (2005 prices)

Rubber prices (Kip/kg)	NPV (Kip/ha) and BCR at selected discount rates			IRR (%)
	5%	8%	13%	
5,460	−4,958,000 (0.94:1)	−9,361,000 (0.84:1)	−10,847,000 (0.71:1)	3.4
7,800	23,038,000 (1.27:1)	7,048,000 (1.12:1)	−3,347,000 (0.91:1)	10.7
10,140	51,034,000 (1.61:1)	23,463,000 (1.40:1)	4,153,000 (1.11:1)	15.4

Note: US$1 = Kip 10,500, August 2005; family labour valued at 17,000 Kip/day

commercial smallholder agriculture, in which the markets for land and labour are incomplete. It can be argued that the relevant criterion is the net return to the family's own resources of labour and land, sometimes termed farm family income. Without costing family labour, and using a discount rate of 8%, the NPV per person-day is around 29,000 Kip. This is higher than the non-farm wage of 25,000 Kip/person-day, again reflecting the farmers' calculation that rubber is indeed a worthwhile use of family resources.

Another criterion which a semi-commercial smallholding farmer would consider is the short-term cash flow, taking borrowings and repayments into account. Farmers could not afford to have a negative cash flow and would want to ensure they had the capability to service their loans. Hadyao rubber farmers received loans with a 2% interest rate and a 7-year repayment period in 1994–1995 and then in 2003 they received loans with a 7% interest rate and a 10 year repayment period. In both cases interest charges were accumulated and paid at the end of the loan period. To check the capacity of farmers to pay back their loans and not suffer a cash flow problem, cash flow budgets were developed for the first eleven years of a 1-ha rubber enterprise (thus including 3 years of tapping), using both current prices and constant 2005 prices. In both cases, as would be expected, farmers had little problem with cash flow and could comfortably pay back the loans, due to the favourable terms provided. It is likely that farmers could afford to pay somewhat higher interest rates but would still need the grace period during the establishment phase if they were planting for the first time. Similar support has been given to rubber smallholders in the past in the major producing countries, such as Thailand and Malaysia (Barlow 1997).

Though the DCF analysis shows that the investment in rubber in this case was clearly profitable, risk and uncertainty are always involved in predictions about the future and should be taken into account in DCF analysis. In particular, given the overwhelming importance of market demand in driving the expansion of rubber, it is essential to examine the sensitivity of the results to alternative assumptions about the price of rubber. For this study, the price of tub-lump rubber was varied from a low of 5,460 Kip/kg to a high of 10,140 Kip/kg, that is, 30% below and above the 2005 market price respectively (Table 1).

With a 30% decrease in prices, new investment in smallholder rubber in Hadyao is no longer worthwhile, indicating that farmers may have to re-evaluate their investment plans if market conditions deteriorate in the future. However, for those with established gardens, for whom the investment is a 'sunk cost', the price would have to fall up to 60% from 2005 levels before it would no longer be worthwhile to tap. Even in that case, the rubber plots could be left untended and 'opened up' again for tapping when prices rose sufficiently, which is the practice of smallholders in other countries (assuming of course that farmers had retained land for subsistence or other pursuits). The threat of price falls can also be countered to some degree by adopting practices to improve yields in the future, as well as improving the quality of the rubber to obtain a marketing premium. These would translate directly into improved returns to family labour, hence higher household incomes.

Nevertheless, and notwithstanding expansion elsewhere in the region, rubber prices have been forecast to continue rising for the next decade, driven by growing demand from China (Burger and Smit 2004; Jumpasut 2004), and this has been borne out by price trends since 2005. Table 1 shows that a 30% higher price than in 2005 would generate a NPV of over 23 million Kip/ha (US$2,235/ha) and a rate of return of around 15%, spurring even greater interest in smallholder rubber planting.

There are other risks associated with the investment in smallholder rubber in the uplands of Northern Laos, in particular climate and market uncertainty. The occurrence of heavy frost in 1999, killing many rubber trees in Luangnamtha Province, indicates the foremost climatic risk that farmers face. There is a justifiable concern that this could happen again as most rubber trees in the province are planted at an elevation of almost 700 m above sea level. Another concern is market uncertainty. The sudden but temporary close of border trade with China in late 2006 is one example of market uncertainty that seriously affected Lao rubber farmers, as their only market is China. An improved road network will help to reduce marketing costs and maintain the farm-gate price of rubber, but the pace and extent of this investment in infrastructure is itself uncertain.

Spatial analysis for Luangnamtha Province

The previous section presented a DCF analysis for smallholder rubber production in the study village, showing that, on various criteria and under current market conditions and levels of support, investment in rubber is worthwhile. That is the reason for the expansion of rubber planting in Hadyao and other villages in the study area. The purpose of this section is to assess the scope for further expansion of smallholder rubber within Luangnamtha Province. The approach was first to define representative scenarios in spatial terms, then to estimate the economic suitability of those scenarios for rubber planting.

Different scenarios can be defined in many ways, depending on the criteria used. For this study, the scenarios were based on the concept of use-capacity, which is a function of two major attributes—resource quality and accessibility. In general the potential yield is the best summary measure of resource quality because it reflects all the different biophysical dimensions in a given location. Hence resource quality categories were based on the aggregate yields over the life of a rubber plantation for various locations within Luangnamtha Province. Data on soils, topography and climate for these locations, represented by 116 5 km by 5 km mapping units, were fed into the biophysical component of the BRASS model to generate latex yields for each mapping unit.

This measure of resource quality was classified into three levels—high (yields greater than 1,300 kg/ha), moderate (yields between 1,000 and 1,300 kg/ha), and low (yields less than 1,000 kg/ha). By integrating these three levels in a GIS, a resource quality map for smallholder rubber in Luangnamtha Province was produced (Fig. 4).

It can be seen that the majority of the area in Luangnamtha Province is at the moderate level of resource quality, with only a small proportion at the high level. The main differences between these three levels are that the areas of low resource quality are predominantly Eutric Cambisols that are shallow, rocky, of poor nutrient status, and steeply sloping topography, while the areas of moderate resource quality are predominantly Haplic Acrisols and Dystric Cambisols that are limited by moderate levels of soil nutrients, soil pH, drainage and steeply sloping topography. The areas of high resource quality are predominantly Haplic Acrisols that have good soil depth, texture, and drainage and relatively flat topography.

The accessibility attribute was also divided into three levels—good, moderate, and poor accessibility—based on the distance from a main road. Areas less than 0.5 km from a main road were defined as good accessibility, from 0.5 to 3.5 km as moderate accessibility, and more than 3.5 km as poor accessibility. Villages with good accessibility are located along or very close to the main road, hence agricultural produce such as rubber can be collected directly by traders or transported by truck to the market. Most villages with moderate accessibility are located in gently sloping areas and can access the main road by cart-tracks, though some may only have footpaths. Agricultural produce from this zone is normally transported by human-drawn carts to the side of the main road and then collected by traders or transported to the market. Most villages with poor accessibility are located in hilly areas reachable only by footpaths. Agricultural produce is normally back-loaded to the main road.

Obviously the time spent in transporting produce to the roadside increases as accessibility declines due to the greater distance, poorer condition of the road, and more difficult mode of transportation, resulting in higher unit cost of transportation. It should be noted that, according to provincial agricultural officials, some villages in the more accessible parts of the poor

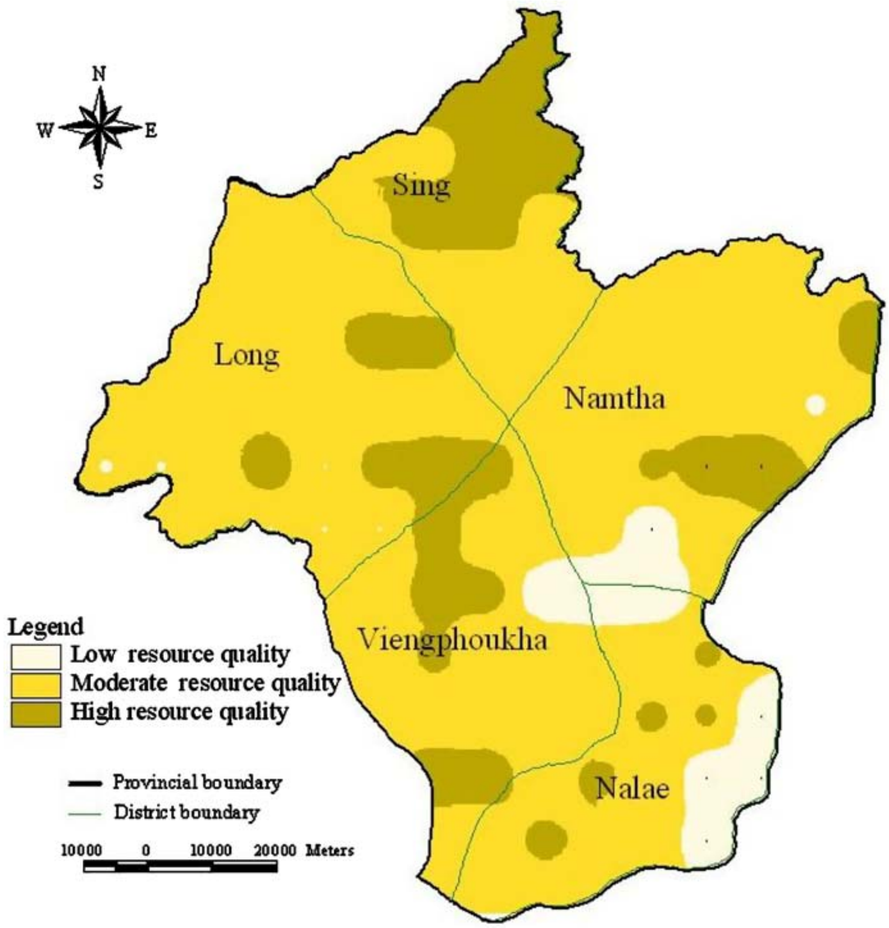

Fig. 4 Resource quality map for smallholder rubber in Luangnamtha Province

accessibility zone had already started planting rubber, with the intention to upgrade their footpaths to cart-tracks when they started tapping.

By integrating these three levels of accessibility in a GIS, an accessibility map for Luangnamtha Province was produced (Fig. 5).

After the levels of resource quality and accessibility had been defined, these dimensions were combined to form scenarios. Three levels of resource quality and three levels of accessibility gave nine scenarios (Table 2). For example, Scenario A combined a high level of resource quality and a high level of accessibility, while Scenario I combined a low level of resource quality and a low level of accessibility. Each of these scenarios were spatially referenced to the 116 mapping units referred to above.

In order to define the economic suitability of these scenarios, hence of the spatial units they described, a DCF analysis was undertaken for each scenario. The DCF model for Hadyao (using the lower value for farm labour) was modified by developing new yield profiles from the BRASS model for each level of resource quality and adjusting prices and costs based on the estimated unit transport costs for each level of accessibility. This entailed a 2% and 50% increase in material costs for the moderate and poor accessibility zones, respectively, and a 2% and 50% decrease in output prices and wage rates for the same zones, relative to the roadside zone.

The DCF analysis for each scenario was performed using a real discount rate of 8%. The results in terms of NPV, IRR, and BCR are shown in Table 3. It can be seen that the investment in rubber is clearly worthwhile in Scenarios A and D, and marginally so in Scenarios B and E, but not in Scenarios C, F, G, H, and I. Hence low resource quality and poor accessibility combined to make rubber unattractive.

Fig. 5 Accessibility map in Luangnamtha Province

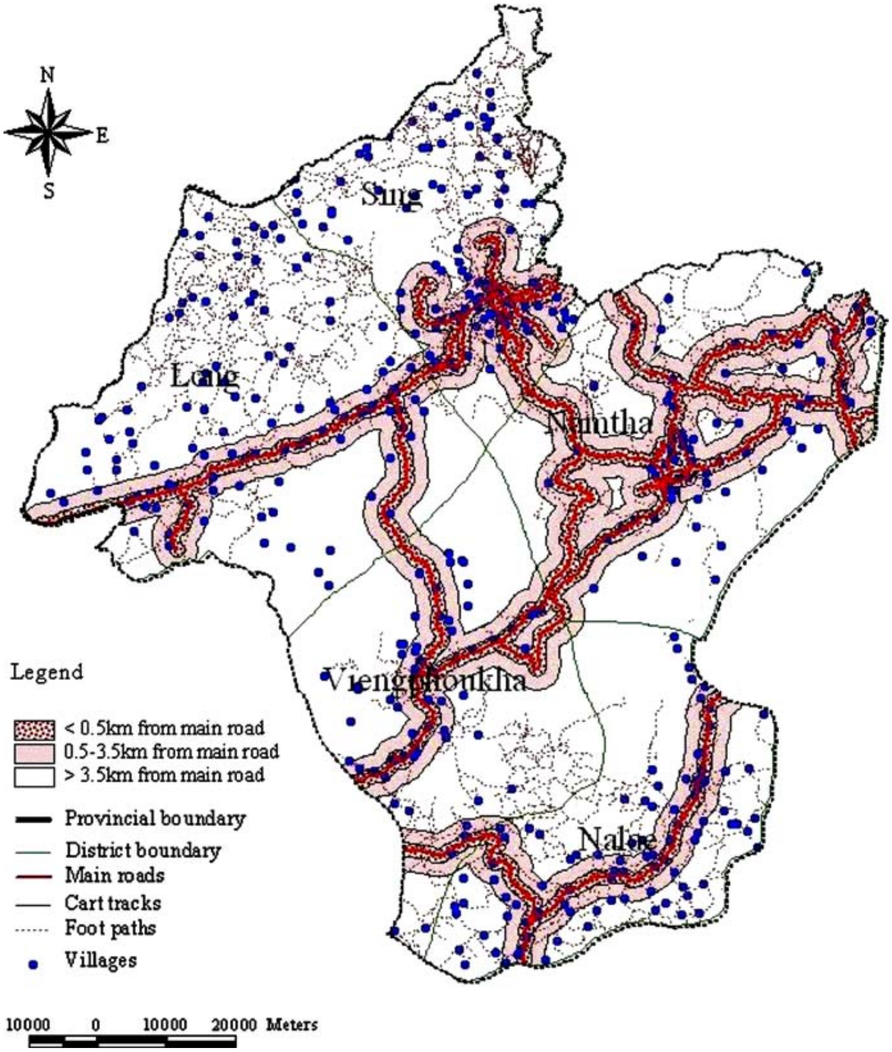

Table 2 The levels of accessibility and resource quality in each scenario

Resource quality	Accessibility		
	Good	Moderate	Poor
High	Scenario A	Scenario D	Scenario G
Moderate	Scenario B	Scenario E	Scenario H
Low	Scenario C	Scenario F	Scenario I

The nine scenarios were then ranked according to NPV per hectare to give a measure of economic suitability (or land-use capacity) for smallholder rubber in Luangnamtha Province (Table 3, last column). By integrating these nine categories of economic suitability in a GIS, an economic suitability map for rubber in Luangnamtha Province was produced (Fig. 6). Given that categories 1 to 4 were associated with a positive and large value for NPV per hectare, it can be seen that approximately 239,600 ha (or 26% of the total provincial area) were considered as economically suitable for smallholder rubber plantations. These areas were concentrated along the main road, indicating that road access is likely to be the key factor, but moderate to high resource quality was also important.

It should be noted that these areas designated as economically suitable for smallholder rubber are upper bound estimates, ignoring the requirements for other land uses such as rice cultivation, residential areas, and conservation areas. Ideally, it would be possible to overlay maps of these other uses to

Table 3 Results of DCF analysis for each scenario

Scenario	NPV (Kip/ha)	IRR (%)	BCR	Economic suitability ranking
A	13,935,000	13.8	1.24	1
B	2,730,000	9.5	1.05	3
C	−15,428,000	−23.9	0.74	6
D	12,662,000	13.4	1.22	2
E	1,712,000	9.0	1.03	4
F	−16,026,000	−26.5	0.73	7
G	−17,769,000	−12.0	0.73	5
H	−22,600,000	−37.2	0.66	8
I	−30,250,000	NC[a]	0.54	9

Note: [a] Not Computable

US$1 = Kip 10,500, August 2005

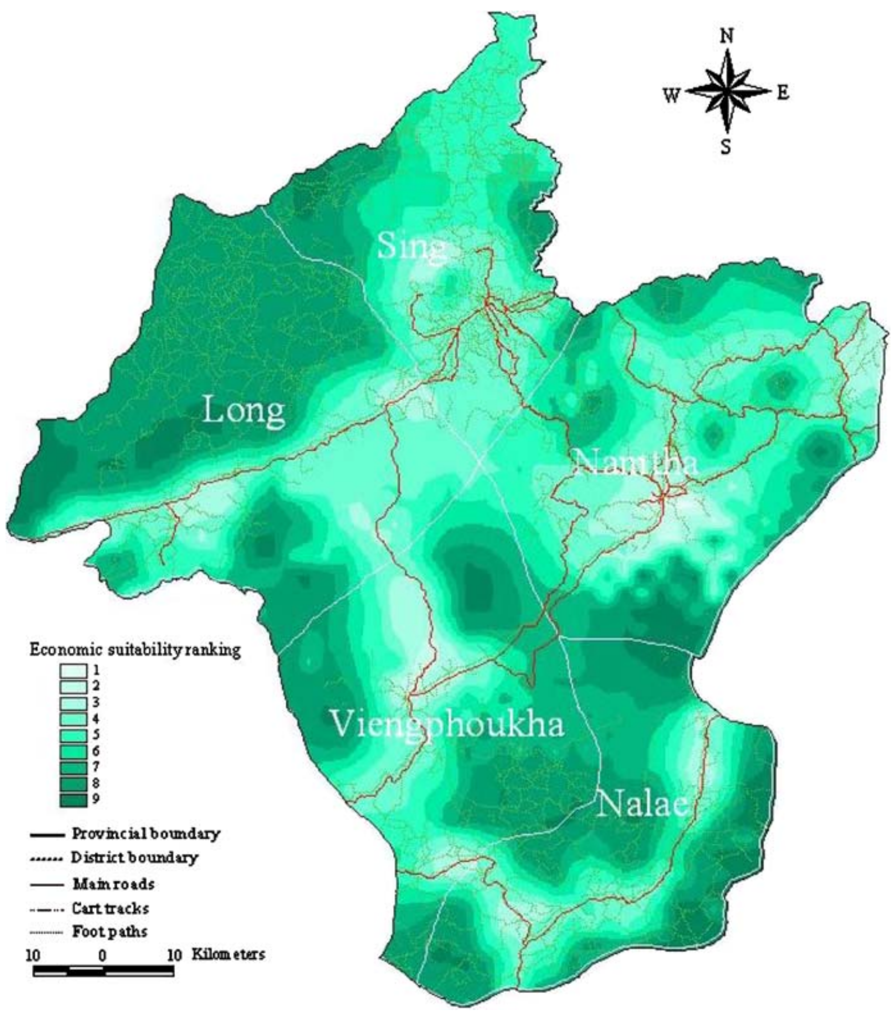

Fig. 6 Economic suitability ranking for smallholder rubber in Luangnamtha Province

indicate the area remaining for rubber. However, such data were not readily available. An indication can be given by using the example of Hadyao. The land allocation process in Hadyao resulted in 15.2% for conservation forest, 28.3% for protection forest, 36.9% for agricultural land, 15.2% for plantation forest, 4.3% for grazing area and 0.1% for residential area (Manivong and Cramb 2007). At the most, only agricultural and plantation land could be used for rubber, accounting for about half of the village lands (though including the latter category would require that rubber be classified as a forest plantation). If this proportion applied across the Province, then 120,000 ha or 13% of the total land area would be both suitable and available for smallholder rubber. This still leaves open the question of how much land could or should be retained in subsistence production for a balanced rural economy.

Conclusion

These results show that, given current and likely future market conditions, investment in smallholder rubber production in the uplands of Northern Laos can be highly profitable. The results from the discounted cash flow analysis for the study village help confirm that the expansion of rubber planting in that village is based on good economic returns. Therefore, rubber can be considered as having considerable potential for poor upland farmers, in line with the government policy of stabilising shifting cultivation and supporting new livelihood options for poverty reduction. This should be given prominence in current policy discussions about the desirability of granting large-scale foreign concessions for rubber planting.

The spatial analysis indicates that the potential for rubber in the study village is not an isolated case; there is a considerable area in Luangnamtha Province that appears to be economically suitable for smallholder rubber. It is important to note that the maps presented are very rough approximations and should not be used for the government's land-use planning and allocation process, especially where farmers are uncertain about reducing their dependence on shifting cultivation. The role for government, as in other countries where smallholder rubber has played a significant role in rural development, is to ensure the provision of good quality planting material, to assist financially during the long investment period when no income is generated, and to continue investing in roads and marketing infrastructure, especially feeder roads to enable those in less accessible areas to participate.

More generally, this study provides further insight into the long-term transition from subsistence to commercial agriculture in the Southeast Asian uplands and the important role of tree crops in this transition. There is no doubt of the responsiveness of upland farmers to the opportunities provided by global markets, even where this involves relatively long-term investment. Moreover, farmers in late-developing regions such as Northern Laos do not necessarily have to repeat the full sequence of development observed in earlier-developing regions, such as Southern Thailand or Peninsular Malaysia. The availability of more advanced technologies (such as improved rubber clones) can accelerate the transition, leading to rapid and widespread transformation of rural livelihoods. Likewise, policy lessons can be learned from the experience of earlier-developing regions, such as the long-term rise of smallholder tree crop production relative to estates and the effectiveness of supportive (rather than highly directive) policies, such as supervised planting grants for smallholders.

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