Land **2014**, *3*, 1059-1074; doi:10.3390/land3031059

OPEN ACCESS

land

ISSN 2073-445X

www.mdpi.com/journal/land/

Article

Economic Valuation of Land Uses in Oudomxay Province, Lao PDR: Can REDD+ be Effective in Maintaining Forests?

Grace Y. Wong [1,*], Souphith Darachanthara [2] and Thanongsai Soukkhamthat [2]

[1] Center for International Forestry Research, Jalan CIFOR, Situ Gede, Bogor Barat 16115, Indonesia

[2] National Economic Research Institute, Ministry of Planning and Investment, Vientiane, Laos; E-Mails: souphith@yahoo.com (S.D.); thanongsais@yahoo.com (T.S.)

* Author to whom correspondence should be addressed; E-Mail: g.wong@cgiar.org; Tel.: +62-251-8622-622; Fax: +62-251-8622-100.

Received: 31 March 2014; in revised form: 8 August 2014 / Accepted: 18 August 2014 / Published: 1 September 2014

Abstract: The rapid economic growth in Lao PDR over the last two decades has been driven by the natural resource sectors and commercialization in the agriculture sector. Rural landscapes are being transformed over the past decade from land use mosaics of subsistence and smallholder farms to large-scale plantations dominated by a few commercial crops. The capacity of these commercial agriculture plantations to alleviate rural poverty, part of the Government of Lao PDR's national development policy, is increasingly weighed against its long-term impacts on ecosystem services and sustainability of land and forest resources. We used an extended cost-benefit approach (CBA) to integrate certain environmental elements to traditional financial analysis for a comparative look at four land use systems in the northern part of the country. The CBA results demonstrate that commercial agriculture (maize and rubber plantations) does have the potential to support poverty alleviation in the short-run. It, however, exposes the land to serious environmental risks. By comparison, the traditional land uses studied (upland rice farming and non-timber forest products collecting) are largely subsistence activities that are still considered as sustainable, though this is increasingly affected by changing market and population dynamics. The results suggest that longer-term environmental costs can potentially cancel out short-term gains from the commercialization to mono-crop agriculture. Incentives for conserving ecosystem services (such as the Reducing Emissions from Deforestation and forest Degradation (REDD+) mechanism) may have a potential role in supporting diversification of traditional livelihoods and increasing the competitiveness of maintaining forests.

Keywords: cost-benefit analysis; ecosystem services; land use change; REDD+; Lao PDR

1. Introduction

Poverty alleviation is the overarching goal in the Lao People's Democratic Republic (PDR) five-year National Socio Economic Development Plan (NSEDP) for 2011–2015, the country's development blueprint. The country's approach to achieving this goal is to sustain continued high rates of economic growth through use of natural resources financed by domestic and foreign investments. Lao PDR's Gross Domestic Product (GDP) growth is one of the highest in Southeast Asia at 7% between 2001 and 2010 [1], and the target is set at 8% for 2011–2015 under the NSEDP. This level of economic growth is impressive for the landlocked, least-developed nation. Over the last decade, availability of forests and natural resources has attracted large flows of foreign direct investments into Lao PDR, particularly to the mining, hydropower, and agricultural sectors.

Agriculture and plantation forestry is one of the Government of Lao PDR's (GoL) four priority sectors for investment and industrialization (the others being energy, mining, and tourism). In the agriculture sector, maize and rubber are two of the more important commercial crops in terms of land area, and biofuel crops are also expanding rapidly, largely at the expense of forests and smallholder swidden systems.

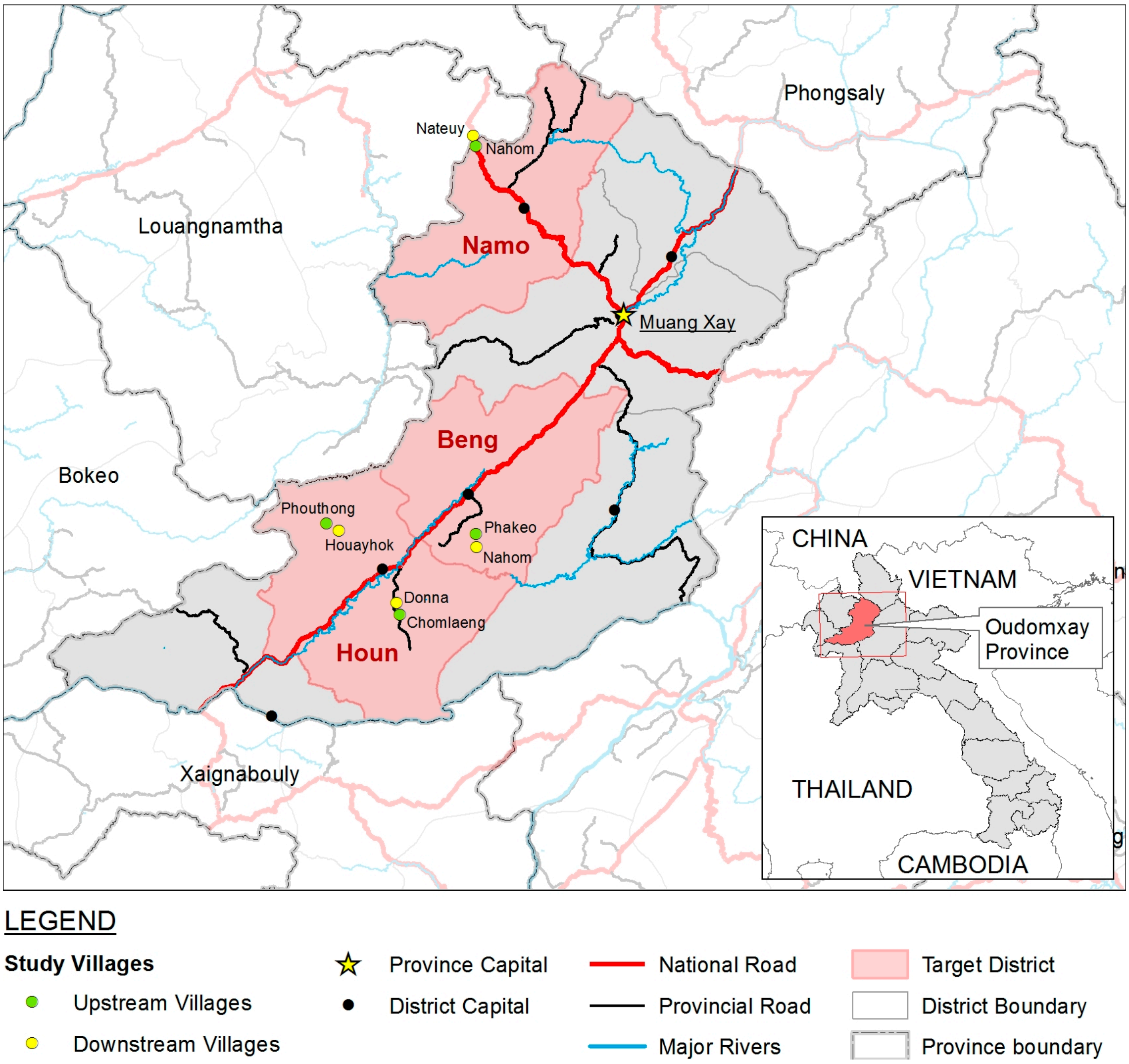
In addition to poverty alleviation and sustained high economic growth, the NSEDP also sets the target for "sustainable development by integrating economic development with socio-cultural development and environment protection to the nation's advantage" [2]. If Lao PDR is indeed to achieve both poverty alleviation and sustainable development goals of the NSEDP, then a more systematic analysis of the multiple consequences of land use decisions is needed, particularly in the context of rural farming landscapes in vulnerable upland areas of the country where poverty levels are highest. The objective of this paper, thus, is to examine how the development policies that lean towards commercialization of agriculture affect the land and forest resources, farmer livelihoods, and ecosystem services and to ask if such policies are sustainable.

This study looks at the potential role that emerging incentives such as the Reducing Emissions from Deforestation and forest Degradation (REDD+) mechanism can contribute towards poverty alleviation and sustainable development goals within the Lao context. REDD+ involves payments to forest-rich developing nations for achieving long-term reductions in carbon emissions by reducing the extent of deforestation and forest degradation, thereby protecting and enhancing carbon stocks [3]. The REDD+ framework could also produce co-benefits including maintenance of ecosystem services (e.g., preservation of biodiversity, soil, and water quality) and indigenous livelihoods and cultures [4,5]. There are two main approaches to investments in plantations in Lao PDR: large-scale concessions to companies, and smallholder plantations, including those organized through contract farming. We focus on the latter smallholder plantations in this study as it will also examine the household's decision-making relative to availability of REDD+.

2. Land Use and Socio-Economic Context of the Study Region

Oudomxay province in northern Lao PDR has undergone rapid land use change in recent years as part of the national development boom, with large swaths of its landscapes transformed from forests and upland swidden farming systems into commercial mono-crop plantations. During the past five years, the economy of Oudomxay had expanded rapidly with an average growth of 13% per year. The gross domestic income increased from US$119.31 million in 2005 to US$192.87 million in 2010, and the average income per capital doubled during the same period to US$651. Despite this growth, the number of poor households remained high and accounted for 30% of all households in the province [6], suggesting a highly unequal distribution of income.

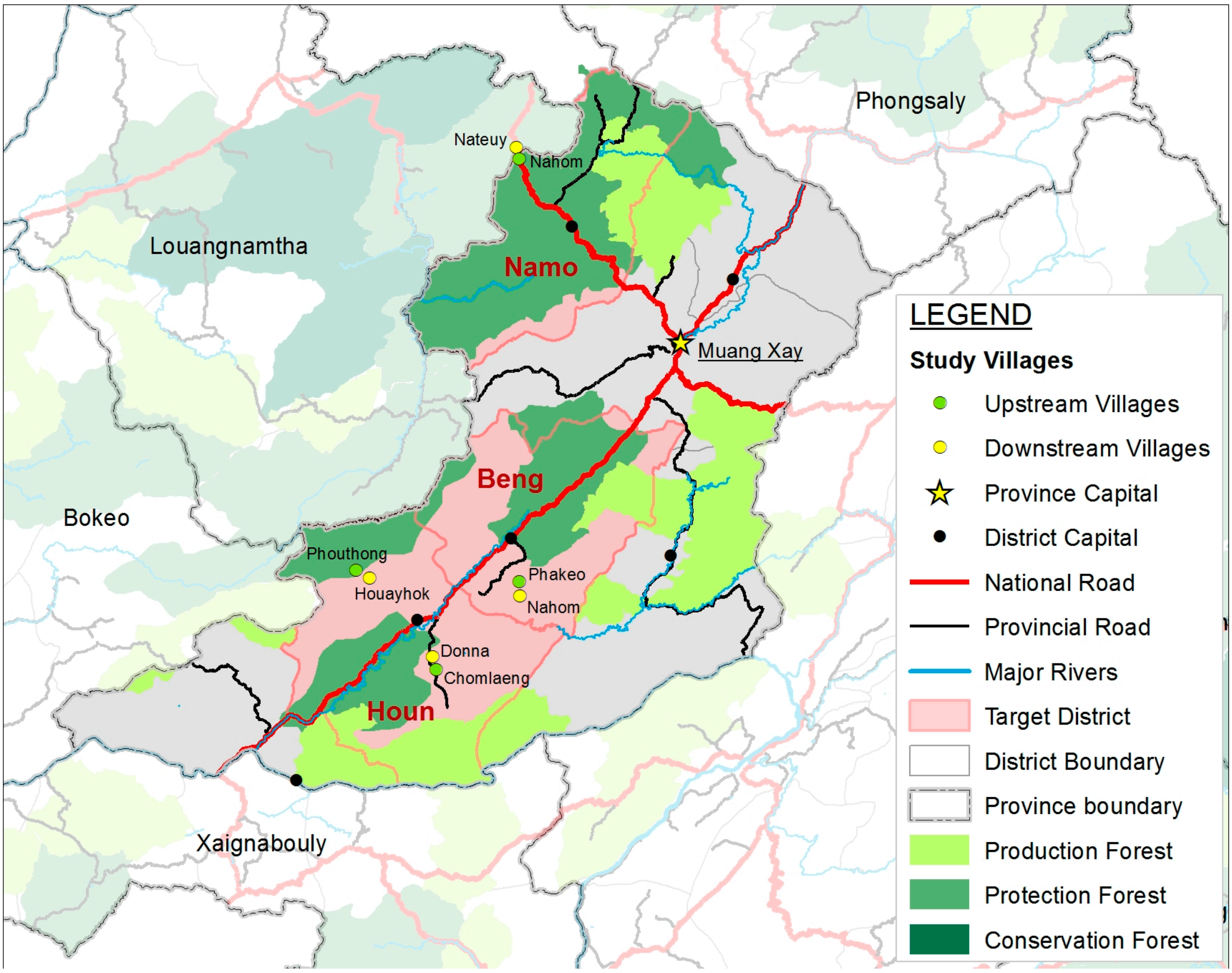
Figure 1. Location of Oudomxay province and research sites.



Oudomxay remains a highly forested area, official statistics claim that 58% of the province is under forests in 2011 [7] though this is fast changing. The area planted in maize has been growing at an average of 12 percent per year since 2006 to about 28,600 ha in 2010 [8]. Although only recently introduced to the region, rubber already covers over 30,000 ha in 2010 [8]. Together, maize and rubber covers over 50% of total arable agriculture land in the province. Upland rice swiddens has declined by almost half since 2006 and covers only around 9200 ha in 2010 [9], driven by the national policy to "eradicate" swidden farming [10]. Almost 50% of the expansion in commercial agriculture was from conversion of forests, particularly secondary and old fallow forests. This pattern clearly indicates that Oudomxay is transitioning rapidly along the agriculture development curve from forests and subsistence farms to semi-commercial and commercial plantations.

This study carried out household surveys in four research sites in three districts of Oudomxay, where each site represents dominant activity in one of the land use systems being assessed. The total land area in the four research sites is 9481 ha, of which approximately 3200 ha (or 34%) is classified as agriculture land. Figure 1 captures the location of the four research sites in Oudomxay province, and Figure 2 shows the areas under different categories of forest.

Figure 2. Areas of forests under different classifications in Oudomxay.



The surveyed households share many similar socio-economic characteristics (see Table 1). Households have large number of family members and a fairly even dependency ratio across the different land uses. Majorityth of household heads and family members have primary school education, and the level of illiteracy is high. Average income per capita range between USD 104 and 351, depending on the household's dominant land use practice. It should be noted that the rubber incomes are an under estimate as much of the rubber plantations were not yet at production age during the study period.

The majority of land converted for commercial plantations (rubber and maize) in the study sites were converted from old fallow forests and upland swidden fallows. This implies that promotion of maize and rubber plantation will cause a decline in staple crop farming and might put pressure on local food security in the future. There is anecdotal evidence that Houn District, which was previously a surplus rice producer exporting to other cities has now had to import rice from other regions for its domestic consumption [8].

Table 1. Characteristics of Surveyed Households in the Four Research Villages. Source: Field survey data [8].

Household Characteristic	Unit	Rubber	Maize	Upland Rice	NTFP
Number of households surveyed	number	37	35	30	36
Average family size	person	8	7.54	6.53	6.67
Dependency ratio	Ratio	0.77	0.82	0.97	0.9
Average income per capita	USD	157	351	104	205
Household head's education					
Illiterate	percent	35	29	17	33
Less than primary school	percent	32	48	30	17
Higher than primary school	percent	33	23	53	50
Average household crop land holding	ha	2.55	1.61	1.71	-
Agriculture land use in study villages are converted from:	ha	92.5	46.3	286.6	-
Secondary forest	ha	10.6	-	26.7	-
Fallow forest	ha	49.2	31.4	259.9	-
Old upland rice farming area	ha	32.7	14.9	-	-

All households practice diversified farming practices with incomes derived from various activities and crops, even for those who have commercial crops as their primary land use. Upland rice swidden farming continues to be practiced by all households, largely as a complementary practice for household food needs. Using the national standard, most household incomes fall below the poverty line and households that predominantly practice NTFP collection and upland rice swidden farming are more likely to be classified as very poor. The rural poverty rate is defined by law (Lao PDR Decree No. 285/PM of 13 October 2009) at 2,160,000 Lao kip (US$253) per person per year. The possible exception is households planting maize, whose average gross incomes are relatively higher than the national poverty line. The livelihoods of households practicing rubber plantations are also impacted over the short-term, as rubber replaces annual crops, declines in cash income can be quite serious for households with little savings or capital over the first six years until rubber trees are mature enough to be tapped. At the time of survey, most of the rubber plantations in the region are not yet mature enough for latex production.

2.1. Research Question

The first objective of this study is to assess the costs and benefits of different land use systems, as incurred by local farmers who are actively practicing the land use system, including impacts on ecosystem services, to answer the question if the commercialization of agriculture can contribute towards national goals of rural poverty alleviation and sustainable development. A second objective is to assess whether incentives, such as REDD+, could have a viable role in influencing land use behavior within this increasingly market-driven rural economy. To determine how large REDD+ incentives would need to be in order to solicit a positive response from farming households to not convert forests, we first assess the value of the alternative agricultural activities, as opportunity costs to REDD+.

The study is set up to answer the following research questions:

- Is the development of commercial agriculture an effective strategy for reducing rural poverty?
- How are gains and losses of ecosystem services factored in rational decision-making on land use practices?
- Can incentives such as REDD+ be an effective mechanism for supporting sustainable livelihoods and maintaining forests?

Structured surveys were carried out with 136 households in three districts in Oudomxay province in northern Lao PDR to examine the costs and benefits related to four different land use practices: rubber and maize plantations, upland rice swidden farming, and non-timber forest product (NTFP) collection. The gains or losses on ecosystem services were also measured, through environmental health impacts on local farmers (measured as lost labor days and treatment costs) and extrapolated effects of soil degradation on farming productivity. These were assessed through a mix of quantitative and qualitative information gained through participatory assessments and ranking methods.

2.2. Analytical Framework

A simple cost-benefit framework is used to estimate the net revenues from one hectare of land use practice to the individual farming household (rubber and maize plantations, upland rice swidden farming and forest/NTFP collection).

Net present value (NPV) for each land use practice is derived by:

$$NPV_L = \sum_{t=1}^{30} \frac{(TR_{L,t} - TC_{L,t})}{(1+r)^t} \quad (1)$$

where NPV_L is the net present value for each land use practice L (US$·ha^{-1}), $TR_{L,t}$ is total revenue for each land use practice L (US$·ha^{-1}), $TC_{L,t}$ is total cost for each land use practice L (US$·ha^{-1}), t is the time frame for the analysis (30 years), and r is the discount rate (12 percent). For the analysis, market prices were assumed to be constant over the 30 year time period. Table 2 [7,8,10–15] provides detailed descriptions of the four land use practices.

An extended cost-benefit framework that incorporates potential revenues and costs of managing a forest for REDD incentive into total revenue $TR_{L,t}$ and total cost $TC_{L,t}$ functions for comparison with other land use systems (following [16,17]). We assume that only land maintained as forest qualify for REDD incentives. Total revenue from each land use L, $TR_{L,t}$ in Equation (1) is thus:

$$TR_{L,t} = R_L + R_{f,CO_2} \quad (2)$$

Table 2. Description of the land use practices considered in this study.

Land Use Practice, L	Production Cycle	Description
Maize	Annual crop	Maize plantations have dramatically expanded in northern Lao PDR, and Oudomxay province is the second largest producer in the country with much of the crops exported to China. The Provincial Agriculture and Forestry Department has promoted maize amongst local farmers, and expansion of maize farms is largely from conversion of production and fallow forests [7]. Maize is mostly grown in the mountainous regions and slopes, causing soil erosion in many areas. Maize is also a highly soil-depleting crop and farmers commonly reported that harvests begin to decline drastically after year 5. Local maize farming practice is heavily dependent on chemical herbicides and, typically used unchecked, has led to soil degradation, water contamination, farmer illnesses, and death of livestock and fisheries.
Rubber (self-financed and 2 + 3 contract farming models)	30 year cycle, with production of latex starting at year 7	The emergence of rubber is driven by both policy and investor interests. The main arrangement in rubber plantations is through a '2+3' contract model where farmers provide land and labour, and the plantation company provides capital (in the form of seedlings, fertilizer and other equipment), technology and access to markets. When the trees become productive in 7 years, revenues from sale of latex are shared according to conditions set in the initial contract—usually 60% to farmers and 40% to the company [8]. There are also instances where farmers with relevant knowledge (e.g., villagers located close to borders with China and Thailand and who have worked on rubber farms in these countries), capital and agency (e.g., farmers' groups) can negotiate better arrangements that limit the role of investors or even resist their offers if they have already secured market access (as documented in [11]). Both scenarios of a self-financed and 2 + 3 contract farming rubber land use systems are modeled here. Due to the region's geography, rubber plantations have expanded into uplands and hill slopes, increasing soil erosion risks, and use of chemical herbicides have also caused local health issues.
Upland rice swidden	Rotational annual crops, with fallow periods ranging from 3 to 7 years	Upland rice swiddens are normally practiced on a rotational basis moving from plot to plot within the same landscape after a certain fallow period. While generally considered to be environmentally sustainable, rotational swiddens do require extensive land area. This is the predominant traditional farming system in the northern uplands of Lao PDR. Pressures from national policies [8] and expanding maize and rubber plantations are shortening fallow cycles and impacting the productivity, biodiversity and ecosystem services from this land use system [12,13]. Communities in the northern uplands actively cultivate in the fallow lands and also depend on the fallow forests for wide variety of forest foods and non-timber products [4,10]. In the study region, expanding maize and rubber plantations have generally come at the expense of old fallow and secondary forests.

Table 2. *Cont.*

Land Use Practice, L	Production Cycle	Description
Forest/NTFP (with and without REDD+ incentives)	Daily and seasonal activity	Collection of NTFPs is a traditional practice throughout rural Lao PDR for cash incomes and subsistence needs. Forest use includes harvesting wild products for food and sale at local markets, medicines, fodder, house construction and handicrafts production. Forest food contributes substantively to rural household diets, both in terms of diversity and weight, up to 80% of non-rice food consumption and between 30% to 50% of protein consumption. NTFPs are estimated to have an annual direct use value of between US$313–525 per household in Lao PDR [14,15]. REDD+ incentives could also target swidden systems in addition to forests, towards lengthening fallow periods and increasing carbon stocks in fallow forests, and also co-benefits of biodiversity and other ecosystem services [4,12]. For simplification and due to lack of detailed information on the economics of rotational swidden patterns across the entire landscape, the study assumes that REDD+ incentives are applicable only to forest land use. In this way, we compare the profitability to households in converting forest to the other land uses (upland rice swidden, maize and rubber) *versus* maintaining the forest for REDD+ and NTFPs.

where R_L is revenues from land use type L (US$·ha^{-1}). The yield and price information is in Table 3. For the NTFP/Forest land use, a total of 29 NTFP products are assessed and detailed information is available [8]. We model the impact of soil depletion on crop productivity, and consequently on revenues R_L as a way of capturing the costs of soil degradation and overuse. This is particularly relevant to the case of maize. $R_{f,CO2}$ is carbon revenue to REDD project beneficiaries from land maintained in forest, f (US$·ha^{-1})and is defined by:

$$R_{f,CO_2} = P_{CO_2} \times CS_f \quad (3)$$

where R_{CO_2} is the price of carbon dioxide, CO_2 (US$·ton·$CO_2^{-1}$) P_{CO2} vary widely in the literature and practice, ranging from US$2 per ton·$CO_2$ [17] to US$4.80 (average price from 11 cases of avoided deforestation projects, [18]) to US$10.30 (€ 8.03 trading price for European Union Allowances [19]). A sensitivity analysis is applied using the three different price points. CS_f is the total volume of aboveground and belowground CO_2 stored in each ha of forest. The average stocks of aboveground carbon in the old fallow and secondary forests of northern Lao PDR is estimated at 52 tons of carbon per ha [20] and belowground carbon is typically 20% of the aboveground content [21]. Thus, total above- and below-ground carbon stock is 62.4 tons carbon per ha. Using the Clark conversion factor [22], CS_f equals 228.63 ton·CO_2·ha^{-1}. This is well within the range in literature of carbon stocks in similar fallow farming systems in the region [4,23]. We assume that $R_{f,CO2}$ will be distributed in equal annual payments from year 2 through 30 year, and that $R_{f,CO2}$ will be distributed to the households who are currently involved in the forest/NTFP land use and who will have to incur the opportunity cost of not being able to use the land for another purpose.

Total costs from each land use type L, $TC_{L,t}$ in Equation (1) is:

$$T_{CL,t} = C_{L,Labor} + C_{L,equip} + C_{L,Env} + C_{f,CO_2} \quad (4)$$

where $C_{L,Labor}$ is the cost of labor (or in cases where no wages are paid to household labor, the opportunity cost of labor) in the land use L (US\$·ha^{-1}), $C_{L,\ equip}$ is the cost of equipment or tools needed (US\$·ha^{-1}) and $C_{L,\ Env}$ is the average cost of health costs caused by environmental degradation (e.g., herbicide contamination), captured in terms of medical costs and days of lost labor due to illness as reported by farmers in the households surveys and translated into US\$·ha^{-1}. The available jobs in the region are typically as plantation or farm workers and the average wage is US\$2.90 per day. This is used as the opportunity cost of lost work-days due to illness. The costs of hospitalization and medicines attributed to herbicide or pesticide related illness varied widely depending on the location and land use, and the average cost is calculated at US\$2.80 per hectare. It is assumed that these costs rise by 5% per year after year 5 in the case of rubber plantations when pesticide and herbicide use increase significantly. The positive correlation with health costs is observed from field survey data [8]. The ranges of costs and yields in all four land uses are presented in Table 3. There is no fixed investment cost as farming practices in this region do not use machinery nor is there value-added production. As much of the land is converted from secondary or fallow forests, we did not include the costs of conversion.

Table 3. Costs and production values used in Net Present Value (NPV) analyses. Source: Field survey data [8].

Description	Unit	Upland Rice	Maize	Rubber	NTFP/Forest
Mean total costs	USD/ha	705	544	543	55
(min–max)		(246–1710)	(129–1643)	(149–1021)	
Input costs (seeds and equipment)	USD/ha	33	100	82	9
(min–max)		(11–90)	(47–286)	(60–263)	
Labor costs	USD/ha	672	372	458	46
(min–max)		(229–1665)	(69–1003)	(87–946)	
Environmental health costs	USD/ha	0	72	3	0
(min–max)			(1–1172)	(3–4)	
Average crop yield	kg/ha	874	4495	566	*
(min–max)		(500–1.333)	(1071–17,500)	(319–1014)	
Crop price	USD/kg	0.35	0.14	1.61	*

*A total of 29 NTFP products are included in the calculations of revenue.

$C_{f,CO2}$ is the cost of implementing a REDD project in forest land, f (US\$·ha^{-1}):

$$C_{f,CO_2} = C_{Estab} + C_{Monit} \quad (5)$$

where C_{Estab} is the initial one time initial cost of establishing a REDD project to meet the standards of the World Bank's Forest Carbon Partnership Facility (FCPF). C_{Estab} is US\$25·ha^{-1} to cover the project design document, governance and planning, monitoring and measurement, surveying and research, and other costs. C_{Monit} is the annual maintenance costs to cover infrastructure maintenance, information, education, and communication, monitoring, and finance and administration [16,24] and is estimated at US\$10·ha^{-1}·yr^{-1}.

Households will thus decide whether or not to convert the fallow and secondary forests from which they depend for NTFPs to another land use (*i.e.*, upland swidden rice, maize or rubber) by balancing the expected profits from the other land uses against the revenues that could be generated from keeping the forests intact with REDD incentives. In this case, we assume that households have the option and the right to choose any of the three alternative land uses. Following the classical optimal utility model, the household's decision to deforest for another land use, *d*, depends on:

$$d_{1,0} = \begin{Bmatrix} 0 \ for \ NPV_{forest} > NPV_{maize}, NPV_{rice}, NPV_{rubber} \\ 1 \ for \ NPV_{forest} \leq NPV_{maize}, NPV_{rice}, NPV_{rubber} \end{Bmatrix} \quad (6)$$

where if $d = 0$, households will not deforest; and if $d = 1$, households will deforest.

3. Results and Discussion

Two sets of NPVs were calculated; one which includes all on-farm financial costs, and another which also incorporates environmental health and soil degradation costs. The two sets of NPV results essentially represent private and public cost-benefit analyses. Many studies have shown that private decisions that do not take into account ecosystem service values tend to result in overall lower societal benefits [25,26].

There were data gaps with the longer-term crops (*i.e.*, rubber) and particularly with swidden rotations, NPVs for the four land uses were produced for the extrapolated mean values. Benefit Cost Ratio (BCR) results are also provided in Table 4 as an indicator to capture the overall value for money of the land use activity. A higher BCR indicates better value of the land use activity.

The NPVs from the land use options indicate that rubber plantation is the most profitable land use option, with the 2+3 contract farming arrangement generating about one-third of profits gained in the self-financed model (see Table 4 below). All the other land use systems of swidden farming, maize plantation and forest/NTFP generated economic losses over the long-term. In these three cases, the opportunity cost of labor is the largest share of incurred costs, but this is not factored into the farmer's rational decision-making process as they largely involve family labor, which is considered to be free. As such, farmers continue with these practices because they are traditional and customary livelihood practices of the region as in the case of swidden and forest/NTFP. The analyses demonstrate that in the case of maize and rubber, private land use decisions do not consider the costs of environmental impacts.

The highly negative NPV for swidden is also deceptive due to area of land maintained in fallow. As we had calculated NPV based on overall farm holdings, the fallow area that is not continuously productive tend to bias the results.

In the case of maize plantations, the cash incomes generated are currently the largest cash earnings available in the region by far, but once environmental degradation and environmental health costs were factored into the equation, the NPV was highly negative. These long-term costs are generally not known to local farmers and rarely factor into their decision-making process.

Rubber is the most economically profitable land use option, however it is rather unlikely that the average forest/NTFP or swidden households will be have the upfront capital needed to convert forests into rubber without external assistance. The 2 + 3 contract farming system facilitates this conversion and is the most common arrangement amongst rural farmers, but even so, there is increasing evidence that farmers are becoming seriously indebted while waiting seven years for their trees to become productive [27,28].

Table 4. Results of the mean NPV and Benefit Cost Ratio (BCR) analyses for all land use options (per ha).

	Upland Swidden Rice	Maize	Rubber (Self-Financed)	Rubber (2 + 3 Contract)	Forest/NTFP
NPV private (US$)	−4546	2229	2117	686	−96
BCR private	0.35	1.97	1.59	1.24	0.75
NPV public (US$)	−4546	−4375	1980	662	−96
BCR public	0.35	1.02	1.57	1.22	0.75

$NPV_{rubber} > NPV_{f,\,REDD}$ in all the P_{CO_2} scenarios, indicating the rational farmer will decide to convert forest lands into rubber plantations, based on the higher expected profits from rubber plantations despite availability of REDD+ incentives (see Table 5). There are perhaps nuances to a farmer's decision than pure profits. Even at the modest carbon price of P_{CO2} = US$4.80, the NPV for forest/NTFP will generate positive returns, indicating that REDD and carbon values can be a viable incentive for conserving forest and maintaining ecosystem services relative to commercial crops such as maize (which has negative NPVs). The benefit-cost ratio (BCR) indicator suggests that forest/NTFP land use with REDD+ incentives of at least US$4.80 ton·$CO_2^{-1}$ offers competitive returns for the money invested in maintaining forests. A quick analysis demonstrated that a REDD+ incentive would need to be at least US$15 ton·$CO_2^{-1}$ (generating NPV of US$665 and BCR of 2.61) in order to compete with a 2 + 3 rubber contract farm, and to move closer to a public decision with societal welfare considerations. Whether this is possible given the current carbon market will depend on the global climate negotiations and commitments.

Table 5. Results of NPV analyses for Forest/NTFP with Reducing Emissions from Deforestation and forest Degradation (REDD+) options.

	Forest/NTFP (P_{CO2} = 0)	Forest/NTFP (P_{CO2} = $2)	Forest/NTFP (P_{CO2} = $4.80)	Forest/NTFP (P_{CO2} = $10.30)
NPV (US$)	−96	−69	89	399
BCR	0.75	0.88	1.26	1.99
d (0,1)	**1**	**1**	**1**	**1**

3.1. Implications on Land Change for Poverty Reduction

Returning to our first research question if the development of commercial agriculture would be an effective strategy for reducing rural poverty, the indications from a simple NPV analysis suggest that rubber may be a viable option, but not maize. Maize generates fast profits as an annual crop but the longer term environmental degradation and health impacts need to be seriously considered. In the case of rubber, there needs to be further attention to support access to, and availability of, rural capital. This is a rather serious constraint as there is evidence of rural indebtedness forcing smallholding farmers to end up leasing their land to larger farmers or concession companies and only working as laborers on their land [28–30]. The simple NPV analysis does not however capture fluctuating prices and other longer term effects of commercialization on the livelihoods of the rural poor, such as their social networks, diversity of their coping strategies, resiliency to shocks, and food security [31].

3.2. Implications for Ecosystem Services and Decision-Making

Our study results show that ecosystem services and broader societal costs are not factored in rational decision-making of smallholders. For poor smallholders, the immediate need for cash incomes tends to override longer-term environmental costs. It should also be noted that the smallholders do not have real autonomy over land use decision-making in Lao PDR due to government policy and direct intervention. In all three districts where the research sites are located, the stated goals in the district development plan focuses on development of agricultural and forestry sector and value-added production for the market economy, in line with the provincial and national plans [8]. Similarly, the development plans also call for the "eradication of slash-and-burn cultivation" [8], a practice considered as environmentally destructive. The conversion of fallows to accommodate rapid expansion of cash crops is evident in our research sites, which is merely a microcosm of the broader landscape across northern Lao PDR [10]. Further studies on the impact of the expansion of commercial agriculture on livelihood resilience, risk coping, and food security, and on the role of fallow forests as a provision of ecosystem services and safety net for food are also urgently needed.

3.3. Role of REDD+ as an Incentive for Maintaining Forests

Whether incentives such as REDD+ can be an effective mechanism for supporting sustainable livelihoods and maintaining forests remains to be seen. While the surveyed households generally express concerns over loss of access to ecosystem services and NTFPs [8], and numerous studies have documented the role of NTFPs as a critical component of rural Lao households risk coping strategy [32,33], it remains uncertain if the environmental incentives can compete with the seemingly lucrative pull of markets for commercial crops, forest and fallow conversion, and intensification of land use. Such incentives would clearly have to be supplemented by alternative development and livelihoods activities. Experience has shown that many of the current REDD+ projects globally have livelihood enhancement activities in place that pre-date REDD+ and which is considered to be an important part of the enabling framework for REDD+ to succeed [34].

4. Conclusions

This research contributes to a small but growing literature examining the potential impacts of REDD+ on livelihoods and land use [16,17,35–37]. Their findings highlighted the constraints and economics of commercial agriculture and concessions, importance of local ownership, challenges of whether a REDD+ incentive is sufficient for maintaining long-term carbon sinks and livelihoods, and the importance of evaluating policy impacts on income. Our case study of land uses in Oudomxay province has generated similar findings, and provided some illustration on the political-economic linkages between ecosystem services and rural poverty in Lao PDR:

- Planting commercial crops of maize and rubber has improved cash incomes for the households and, hence, contributed towards alleviating rural poverty. It has however exposed the area to environmental risks, such as soil depletion and water contamination due to poor soil management practices and improper chemical use, leading to environmental health issues. The costs of these environmental impacts are not fully factored within the households' rational decision-making process as much of this information is not immediately known or well understood at the local level.
- Swidden farming and collection non-timber forest products are currently considered as sustainable practices in our research sites, but these systems are increasingly vulnerable under the pressure of expanding maize and rubber plantations into old fallows and secondary forests. This transition is also precipitated by the Lao government policy, whose rationale is to integrate marginal lands into the global market and lead to the end of swidden farming, a practice considered as backward, unproductive and environmentally destructive [4,10,13]. The loss of swidden rice fields to commercial crop plantations also increases the risks of local food insecurity and loss of a safety net in future as rice production declines and forest fallows are lost.
- Environmental incentives such as REDD+ can be an important mechanism to compensate farmers for maintaining important ecosystem services and forgoing alternative agriculture land use. While REDD+ is shown here to have potential to positively impact farmer land use decisions towards forest conservation, it can only be effective if the REDD+ benefits are sufficient, equitably distributed and properly targeted to those households who are incurring the opportunity costs. Whether REDD+ can be sufficient also depends on the markets for carbon credits and how it can compete or interact within other economic and market transformations occurring in rural Lao PDR. At the time of this research, the GoL does not yet have a national strategy for REDD+ and how it will define the forests or areas eligible for REDD+ and who will have the right to benefit. The national strategy and corresponding policies will shape how REDD+ can be effective, efficient and equitable, and this can be a challenge particularly within the Lao PDR's push towards economic growth and agriculture industrialization.
- In certain instances, upland swidden agriculture may still be the most rational land use for farmers from economic and environmental perspectives, and for cultural reasons [12,13,38]. REDD+ policies can be directed towards maintaining or rehabilitating traditional swidden systems with sufficiently long fallow periods to allow for regeneration of mature secondary forests and maintenance of ecosystem services.

In order to further this area of study and to understand the true costs and trade-offs in land use decisions, there is an urgent need for comprehensive assessments of ecosystem services and of local livelihoods in the different land use systems in rural and forested regions of Lao PDR. Evidence on how the expansion of commercial agriculture impacts on livelihood resilience, risk coping, and food security, and on the role of forests and fallows within the local livelihood systems are also needed. There is still little knowledge that can allow for a systematic assessment as demanded by the policy and overall ambition for sustainable development. A baseline of environmental information and rigorous assessments on economic, livelihood and conservation trade-offs are critical to generate consistent evidence that can support informed decision-making beyond political and economic rhetoric.

Acknowledgments

The manuscript extends on the research under the UNDP-UNEP Poverty Environment Initiative (PEI) study on Economic Valuation of Ecosystem Services and Poverty Alleviation (NERI 2012). The authors are grateful to the PEI-NERI team for providing access to their data. The authors are also grateful to Cornelia Hett of the Center for Development and Environment (CDE), University of Bern, based in Vientiane for her help in producing the two maps for this manuscript.

Author Contributions

Grace Yee Wong integrated the carbon and REDD+ component into the cost-benefit analyses of land use systems, and led the writing of this manuscript. Souphith Darachanthara led the overall research study on land use change and ecosystem service valuation in Oudomxay province and development of project report. Thanongsai Soukkhamthat carried out the initial land use cost-benefit analyses, co-authored the project report, and contributed to this manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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