Impact of Commercial Tree Plantations on Smallholder Livestock Farmers and Their Livelihoods in Lao PDR

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Abstract: We investigated how commercial tree plantations under Lao forest restoration plan toward 2035, influence socio-economic conditions of household. We also seek to calculate environmental income of rural households in Laos. The questionnaire survey was conducted at two villages (Ban Hinheup and Ban Thoulakhom) from Vientiane province (the central) and two villages (Ban Luangnamtha and Ban Viengphoukha) from Luangnamtha Province (the north). Our survey results showed that the economies of the two study villages in central Laos relied moderately on cash and subsistence value of the environment while this only contributed slightly to the other two villages in the north. Villagers around the plantation concession boundary in the plantation village tends to receive benefits from tree plantations while the richest households from Ban Thoulakhom obtained a major proportion of their total household income from rice and livestock production. Several farmers in study area select eucalypt and/or rubber species, which offer profitable and sustainable land-use choices. Our results also revealed that perception towards the effects of Eucalyptus plantation tends to differ from those towards rubber plantations. Rubber plantations in Luangnamtha Province were found to have a higher economic contribution to local livelihoods, but Eucalyptus plantations were perceived to have a less negative environmental impact and could provide more opportunity for local farmers to either intercrop their annual crops in the plantations or obtain income from the plantation employment activities. Given the rapidly dynamic policies, executing complex policy change needs sustained effort, and the related state organisations need to be pro-actively involved in dialogue with industries and the communities to be more effective. Future policy options for sustainable planted forest development in Laos should ensure that commercial forest plantations offer the pathway for economic, environmental, and social benefits for rural communities.

Keywords: agroforestry, livestock, rubber, smallholder farmers, tree plantations

1. Introduction

The global estate of commercial tree plantations has continued to expand in response to modern societies’ demand for the high-quality products derived from these plantations. Global demand for natural rubber, driven by the growing demand for tyres, as well as latex goods, increased from 7 million tonnes in 2000 to 12 million tonnes in 2020 and is expected to reach 16 million tonnes by 2028 (ISRG 2020; Stapleton 2019). In response to this demand, the global area of planted rubber has risen to over 14 million ha (Gitz et al. 2020), 85% of which is in Southeast Asia. This area has increased by more than 2.5 million ha between 2008–18 (Gitz et al. 2020).

Similarly, global demand for commercial wood is increasing with annual timber demand forecast to increase from 3.4 billion m$^3$ in 2010 to 7.5 billion m$^3$ in 2030 and to 13.1 billion m$^3$ by 2050 (WWF 2017) as the populations and prosperity of many developing economies increase at rapid rates. As wood from natural forests is either depleted or set aside in reserves, supply is increasingly expected to come from planted forests which represent 7% of the world’s forests but provide 47% of all harvested wood (Payn et al. 2015). Current predictions forecast a 300% increase in global demand for plantation grown industrial wood over the next 30 years (Hetemäki et al. 2020) largely driven by emerging economies and expectations of a deficit in plantation roundwood of 4.5 billion m$^3$ per year by 2050 (Indufor 2012). The deficits are imminent and have consequences for the Asian region, where the deficit in woodchip production alone is also expected to increase from 20 million m$^3$ to 59 million m$^3$ by 2030 driven by an increase in China’s woodchip deficit to 33 million m$^3$ (Lock et al. 2021).
Eucalypts have become a mainstay in tropical plantation forestry and represent an important resource for pulp, fibre, panels and solid wood. Today, the global area of planted eucalypts exceeds 30 million ha, having increased rapidly from 20 million ha over the last decade (Arnold et al. 2022).

In the cases of both rubber and eucalypt, particularly in Southeast Asia, smallholders have become critical parts of supply chains and commercial supplies have become dependent upon them. Smallholders account for more than 80% of global rubber production (Ali 2020) and in some countries such as Malaysia, Thailand and Indonesia, they account for more than 90% of the production. Similarly, Midgley et al. (2017) highlighted the importance of smallholders’ production of plantation wood for regional supplies and Arnold et al. (2022) estimated that the area of smallholder-grown eucalypts in Asia was about 8 million ha, producing some 63 million m$^3$ of wood annually. In both cases, the smallholder investments have been underpinned by increasing demand and parallel corporate investment in plantations and processing creating market “pull”.

The Lao People’s Democratic Republic (hereafter Laos) has responded to these trends and market signals and the positive experience in neighbouring Thailand, Vietnam and China (Phoutthavong et al. 2020). Laos aspires to restore forest cover to 70% of the country’s terrain by 2035, by restoring 8.2 million ha of protection forests, 4.7 million of conservation forests, 3.1 million ha of production forests and establishing 500,000 ha of industrial tree plantations on degraded land (DOF 2022). To achieve this aim, the Government of Laos (GoL) has put in place policy instruments for promoting forest plantation investment together with the protection, restoration, development of forests and forest lands in line with the Socio-Economic Development Plan of 2021 - 2025, aiming to establish 200,000 ha of new plantations and restore the remaining 1.8 million ha of natural forests as well as conserving the environment, water resources, biodiversity and livelihoods while generating income sources for the rural communities (MPI 2021).

In Laos, the soils, rainfall, and climate provide good growing conditions for both rubber and eucalypts. Some 500,000 ha of productive forest plantations have been established (DOF 2022), of which 55% is rubber, 15% eucalypt and acacia and 10% teak (Smith 2022). In the absence of significant domestic industry investors, larger foreign-funded companies have been responsible for the establishment of most fast-growing plantations of eucalypts in Central Laos. Smallholder rubber plantations have been fostered by mainly Chinese investment in the north of the country and Thai and Vietnamese investments in the centre and the south (Phimmavong and Keenan 2020), each bringing their own investment characteristics. Approaches to successful smallholder engagement for both species have varied, but all have required extensive community engagement and corporate and industry links to guarantee market access. Major existing and proposed wood processing investments aim for smallholder/outgrower resource supply of between 30 and 70%. A variety of approaches to smallholder participation have been tried. In their diagnostic assessment of outgrower schemes for commercial fast-grown wood in Lao PDR, IFC (2018) found that smallholder engagement is slow if market access cannot be guaranteed because of immature industry development. Approaches are being adopted which accommodate both farmer and company needs and willingness to invest and commit resources.

Agroforestry is even more important in Laos: the agroforestry system which has been practiced on upland land by rural farmers in Laos under traditional land use rights for several centuries could provide a wide range of cash and non-cash income over time. More recently, some forest enterprises started to emphasize on meeting community needs in their production systems, by supplying for integration of food with timber production. Incorporating trees and agricultural production in agroforestry systems could be more financially profitable than either tree or crop monoculture (Ota et al. 2018).

This paper aims to assess the Lao response to global demand for both rubber and eucalypts and examine the socio-economic conditions of industrial tree plantations in Laos. We quantify environmental income$^{1}$ in household income portfolios in selected rural communities based on the field studies and reviews of available literature review to develop a foundation of knowledge to assist achieving sustainable forest management in Laos. The questionnaire survey was conducted at two villages (Ban Hinheup and Ban Thoulakhom) from Vientiane province and two villages (Ban Luangnamtha and Ban Viengphoukha) from Luangnamtha Province.

$^{1}$The ‘environmental income’ is defined as “rent captured through alienation or consumption of natural capital within the first link in a market chain” (Sjaastad et al. (2005), p.45) and more detail explanation is described by van der Meer Simo et al. (2019).
2. Methods

We adopt the purposive sampling methods for four villages in the field survey. The villages are from four districts in two provinces of Laos: 1) Ban Hinheup and 2) Ban Thoulakhom in Vientiane Province, and 3) Ban Luangnamtha and 4) Ban Viengphoukha in Luangnamtha Province. Figure 1 shows their locations in the country. These four villages are distinct in terms of demographics, geographical location, quantity and quality of remaining natural forests, and ethnographic characteristics. To avoid bias in the research findings, the four villages were selected purposively with preconditions that they were within 5 km of the boundary of a commercial tree plantation and had no record of violent conflicts prompted by the plantations. The number of total households per village in the field survey ranges from 75 to 325 as shown in Table 1. The largest ethnic groups in Ban Hinheup and Ban Viengphoukha are Khamu while those from Ban Thoulakhom and Ban Luangnamtha are Laoloum and Leu, respectively. We divide four villages into two categories based on the size of commercial forested area. The first category includes three villages with commercial tree plantation establishment exceeding 100 ha (hereafter called ‘plantation village’), and the second category is the one village which has less than 100 ha of commercial tree plantations (hereafter called ‘the comparable non-plantation village’). The reason behind this figure was used by the National Assembly of Laos believing that this commercial plantation size can have negative impact on socio-economic condition. Some examples of the conversion of the natural secondary forests into rubber plantations also appeared in some northern provinces of Laos such as Luang Namtha and Oudomxay provinces. Because the economies of rural communities are tightly interlinked with subsistence production sector such as swidden farm, grazing lands and non-timber forest products, plantation concession rights granted to large companies can have a negative impact on the income sources of rural communities which live in, and adjacent to, the plantation areas when there is lack of effective policy tools and efficient governance. For instance, due to the complaints from local Lao people to the National Assembly, this brought about in the suspension of the granting of concessions greater than 100 ha in 2007 (Smith et al. 2021).

We conducted a questionnaire survey in all four field villages. The questionnaire consisted of 61 questions which were structured into five sections; 1) household demographics; 2) income sources; 3) expenditure; 4) livelihood assets; and 5) perceptions of well-being. The questionnaire used in this study was modified from that developed by van der Meer Simo et al. (2019). We collected information on household demographics, income sources, expenditure, livelihood assets, and perceptions of well-being of different household income sectors such as paddy rice, upland rice farms, livestock, and bamboo sectors by a semi-structured questionnaire and household observations. Wages and prices for farm products were obtained by asking the direct selling prices from farmers in the village and in local markets in the case study districts.

Non-timber forest products (NTFPs) or environmental income data were obtained from 40 households (10 in each village) where respondents were requested to write down collection diaries of all NTFPs sold and consumed over a two-week period in a fashion following van der Meer Simo et al (2019). The head of the household was chosen as the primary respondent. If the head was absent, another household member such as an elder or couple that could recognise and deliver reliable responses was selected. Selected households are interviewed in their houses to keep their responses free from influence from others and some clarifications were arranged by the research team regarding the livelihoods of the associated farmers. For confidentiality, a pseudonym for village names is used, representing the District in which they are located.

Perceptions on the effect of commercial tree plantations were defined as the general perceptions of households towards the changes brought about by tree plantation development on their wellbeing and environment. To measure this, two perception indices; 1) index for wellbeing impacts and 2) index for environment impacts, were developed. For the former, households are invited to show their opinion with each statement in one of five options; 1) “Made things better”, 2) “No effect”, 3) “Made things worse”, 4) “Not relevant”, and 5) “Respondent does not know”. For the index for environmental impacts, five types of effects are used; 1) Positive effects, 2) Neutral effects, 3) Negative effects, 4) Do not know, and 5) Other (specify).
| Village pseudonym | Ban Hinheup | Ban Thatkham | Ban Luangnamtha | Ban Viengphoukha |
|------------------|-------------|--------------|-----------------|-----------------|
| Total households | 241         | 216          | 325             | 75              |
| Number of households | 22        | 25           | 26              | 26              |
| Ethnic groups     | Khamu (73%) | Laoloum (100%) | Leu (90%); Khmu (10%) | Laoloum (100%); Khmu (100%) |
| Total area (ha)   | 9,143       | 1,487        | 854             | 1,464           |
| Permanent agriculture (ha) | 1,306     | 933          | 158             | 127             |
| (include grazing and cash crops) | 183 (Eucalyptus) | 16 (Rubber) | 60 (Rubber)     | 127 (Rubber)    |
| Commercial tree plantations (ha) | 1,121 (Community Production) | 87 (National Production) | 2,414 (Conservation) | 1,689 (Conservation) |
| (include growing and cash crops) | 609 (Rehabilitation) | 129 (Forests); 9,143 (River Protection) | 1,578 (Protection, conservation, bamboo, etc.) | 183 (Eucalyptus) |
| Forest Composition (Protection, conservation, bamboo, etc.) (ha) | 120 (Rehabilitation) | 120 (Rehabilitation) | 1,121 (Community Production) | 609 (Rehabilitation) |
| Cattle population (head) | 120         | 70           | 180             | 180             |
| Buffalo population (head) | 75          | 0            | 12              | 12              |
| Average income (per HH) | 4,200       | 5,222        | 10,233          | 6,326           |
| Income from NTFP (average annual) | 1,218       | 831          | 1,301           | 442             |
| NTFP (% of annual income) | 26          | 18           | 31              | 7               |
| Income from commercial trees | 1,474       | 31           | 2,703           | 3,077           |
| Commercial Trees (% of annual income) | 34          | 1            | 26              | 49              |
3. Results and Discussions

The survey was conducted by a research team of six people from the Faculty of Forest Science, National University of Laos with the help of one local staff from each District Office for Agriculture and Forestry (DAFO) who oversaw the forestry management in the district as Research Assistants (RAs). Before conducting the survey, the RAs were informed about the aims of the research, use of the questionnaire, and ethical procedures of interviewing. Data collection was undertaken between September and November 2020. Based on the lists of households from the headmen of each village, a simple random sampling method (Abbott 2013; Sekaran 2016) was used to select the respondents, with a total of 95 farm households from four villages mentioned above. The survey took approximately 1.5 hours for each respondent (or household) to complete.

3.1. Household livelihood strategies adopted by farm households

The economies of the two study villages in central Laos relied moderately on cash and subsistence value of the environment while this only contributed slightly to the other two villages in the north. Most of the household incomes were generated through the following seven broad categories; (1) rice production, (2) tree plantation (employment and wages), (3) crop production, (4) livestock production, (5) small household business, (6) remittance/government wage, and (7) NTFPs. Figures 2 to 5 demonstrate the comparisons of the household income structure (cash and non-cash income) in the four villages. The poorest household refers to the first tercile group representing 33.3% of the
population in the lowest income range, while the richest refers to the third tercile group representing the 33.3% of population in the highest income range.

We observed that the household livelihood strategies were highly diverse, and heavily dependent on the agriculture and forestry sectors in all four villages. The greatest proportion of the average total household income of Ban Hinheup was obtained through the employment activities in eucalypt plantations, which accounted for 34% of the average income ($1,474 USD) and this was followed by NTFPs income (28%) (Figure 2). The proportion of the income from livestock production was comparatively small ($595 USD).

![Image](image_url)

**Figure 2.** Structure of annual household cash and non-cash incomes ($US) in Ban Hinheup.

In Ban Hinheup, significant household income streams were obtained from the Burapha company-farmer cooperation system, where local people had the opportunity to be employed in the activities related to plantation eucalypts. This contract farming is also called “1+4 system” in GoL terminology, in which the land is provided by the farmers, leased by the company where individual households are paid for a 30-year lease of the land, and other inputs are provided by the company. In this system, farmers participate in most plantation activities.

In the comparable village (Ban Thoulakhom), Figure 3 shows that commercial tree plantations were the lowest source of income for the poorest and middle households, where households earned only $31 USD on average. This is not surprising because this village has an area of only 60 ha of rubber plantations. In this village, NTFPs only play a major role in the poorest household income formation (18%) while the richest household’s livelihood strategies are more diverse, streaming from government wages (27%), rice production (21%), small household business activity (9%), and livestock production (20%).

In Ban Viengphoukha, Luangnamtha province, rubber plantations accounted for the highest household livelihood strategy (49% of total income). More precisely, households obtained a cash income of $3,077 USD from sales of rubber and employment from the rubber companies (Figure 4). Conversely, the richest households from Ban Thoulakhom obtained a major proportion of the total household income from rice and livestock production. In Ban Luangnamtha, government wages were the highest source of income for the richest households and tree plantation remained the second highest income (Figure 5).

Descriptive statistics of tree plantation incomes are summarised in Table 2. Figure 6 shows the boxplot of tree plantation incomes for four villages. It seems that the mean annual contribution of tree plantations to households from the plantation villages tends to be higher than in the comparable village. Average household income from rubber plantations in Ban Viengphoukha is $3,071 USD per annum and that in Ban Luangnamtha was $2,703 USD which are much higher than *Eucalyptus*
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plantsations in Ban Hinheup ($1,476 USD per annum) and Ban Thoulakhom ($250 USD per annum). We then conducted ANOVA to investigate if this trend is statistically significant. Table 3 shows the result of ANOVA test, supporting significant difference in the mean income. We further conducted Dunnet test against the comparable village, Ban Hinheup for plantation. Its result is shown in Table 4. Except Ban Thoulakhom, the mean income in Ban Viengphoukha and Ban Luangnamtha was significantly higher than that of Ban Hinheup.

Figure 3. Structure of annual household cash and non-cash incomes ($US) in Ban Thoulakhom.

Figure 4. Structure of annual household cash and non-cash incomes ($US) in Ban Viengphoukha.
Table 2. Characteristics for tree plantation incomes in the sample villages ($US/year/household). (1$US=9281Kip)

| Village pseudonym      | Total sample | Mean      | Standard Deviation |
|------------------------|--------------|-----------|--------------------|
| Ban Hinheup            | 22           | 1,473.749 | 1,329.873          |
| Ban Thoulakhom         | 22(20*)      | 2,747.549 | 2,971.357          |
| Ban Viengphoukha       | 26           | 3,066.646 | 1,742.501          |
| Ban Luangnamtha        | 25(5*)       | 3,464.066 | 2,143.077          |
| All four villages      | 95(25*)      | 2,670.453 | 1,931.19           |

* No tree plantation income cases were excluded for calculation

Figure 5. Structure of annual household cash and non-cash incomes ($US) in Ban Luangnamtha.

Table 3. Results of ANOVA for tree plantation incomes among the sample villages.

|                  | Degree of freedom | Sum of Square | Mean Square | F-value | Pr(>F) |
|------------------|-------------------|---------------|-------------|---------|--------|
| Income           | 3                 | 0.5595        | 0.18651     | 5.07    | 0.00321|
| Residuals        | 66                | 2.4280        | 0.03679     |         |        |

Table 4. Results of Dunnet test against the controlled village, Ban Hinheup for plantation.

|                  | Estimated Value   | Stdard Error | t-value | Pr(>|t|) |
|------------------|-------------------|--------------|---------|---------|
| Ban Thoulakhom   | 1,273.8           | 1,314.7      | 0.969   | 0.67703 |
| Ban Viengphoukha | 1,592.9           | 515.7        | 3.089   | 0.00851 |
| Ban Luangnamtha  | 1,990.3           | 550.0        | 3.619   | 0.00170 |

Large variations were observed in average household income from tree plantations within each village. The lowest tree plantation income in the comparable village corresponded to cases where tree growers in this village had only 60 hectares of rubber plantations.

As mentioned earlier, household income sources are highly diverse and largely based on tree plantations and environmental income. This finding is consistent with other research results in Laos (Kimura et al. 2015; Russell et al. 2015; van der Meer Simo et al. 2019). As plantations and agroforestry play a vital role in the community income and livelihoods in the case study villages, this could potentially provide a pathway for poverty reduction.

While some communities have been reported to receive positive benefits from the expansion of planted forests such as the creation of employment, poverty reduction (Maraseni et al. 2018;
Phimmavong and Keenan 2020; Phimmavong et al. 2020; Phimmavong et al. 2019), rehabilitation of degraded land (Hue et al. 2017; MAF 2005; Newby et al. 2014), as well as climate change mitigation and adaptation (Nunes et al. 2019; Smith et al. 2017), other communities have concerns about the negative impacts on local communities and the environment (Hanssen 2007; Kenney-Lazar 2012). These concerns have existed over the past decades as plantations have encroached into natural forest areas. Despite a comprehensive legal and regulatory framework, the systems of oversight of social and environmental impacts and benefits of plantations have not been well implemented or well enforced, and local peoples’ customary rights are also not well clarified when investors access land before land concessions for plantations are approved (Arnold et al. 2022).

The implications of recent established large scale commercial plantations require all plantation investments to be consistent with international standards, guidelines and codes of practices related to planted forests and trees such as FAO’s voluntary guidelines for Planted Forests and Trees (FAO 2006), and ITTO guidelines (Bruenig 1993) for the establishment and sustainable management of planted tropical forests. Three of the four major plantation companies in Lao PDR are committed to the FSC Forestry Standard. A major challenge for the companies is the adoption of the processes for Environmental and Social Impact Assessments (ESIA) which have been designed to meet the needs of mining and hydro-energy. The relevant authorities must be encouraged to develop a specific form of ESIA for plantation investment, particularly new plantations inside the National Production Areas on degraded or barren forestland. On these sites, environmental impacts are more likely if ESIAS and Environmental and Social Management and Monitoring Plans (ESMMPs) are not properly implemented and enforced.

3.2. Large animal production and grazing land

The majority of villagers in the study areas raise livestock (Table 5). Farmers in Ban Thoulakhom own the largest number of cattle, having on average, seven heads compared to just below two heads in Ban Luangnamtha. Most smallholder farmers in the study area and elsewhere in Laos normally treat their livestock as cash reserves and not only sell their livestock but also consume them. For this reason, the households of Ban Thoulakhom village possess the largest pasture and grazing land in the forest area on average (1.9 ha) with a maximum of two and a minimum of one hectare compared to
Ban Hinheup (1.5 ha). In addition, grazing opportunities remain available in other villages, and the quality of that land for grazing were reported to be unaffected by the tree plantation development.

Table 5. Farmland use proportions of the interviewed households.

|                      | Ban Hinheup | Ban Thoulakhom | Ban Viengphoukha | Ban Luangnamtha | All Four Villages |
|----------------------|-------------|---------------|------------------|-----------------|-------------------|
| Cattle population (head) | 4.36        | 7.45          | 5.84             | 1.92            | 4.94              |
| Cattle sold (head)     | 0.27        | 1.54          | 2.11             | 0.28            | 1.07              |
| Cattle consumed (head) | 0.09        | 0.13          | 0.76             | 0.00            | 0.07              |
| Buffalo population (head) | 0.00      | 3.5           | 0.19             | 0.00            | 0.86              |
| Buffalo sold (head)    | 0.00        | 0.90          | 0.04             | 0.00            | 0.22              |
| Buffalo consumed (head) | 0.00      | 0.00          | 0.00             | 0.00            | 0.00              |
| Pasture, grazing land in the forest | 1.5 | 1.9 | 1.7 | 1.6 | 1.7 |
| Quantity of land (ha)  | 1 (27%)     | 1 (5%)        | 0 (15%)          | 0 (24%)         | 0 (11%)           |
| Security*              | 1 (27%)     | 1 (5%)        | 0 (19%)          | 0 (24%)         | 0 (12%)           |

* Remark: *Code for changes: 1= Increased; 2= Same; 3 = Decreased; 0= Non-applicable

There is a statistically significant difference in the mean cattle population among these four villages ($P < 0.05$). The mean number of cattle from all plantation villages tends to be relatively smaller than the comparable village. The average number of cattle in Thoulakhom is 7.45 heads/household which is much higher than that in the Ban Hinheup (4.3 heads/household).

3.3. Perception of the effects of planted forest on wellbeing

Figures 7–9 show the farmer respondents’ opinions in four villages towards tree plantations development in their community. It shows that almost all household respondents in Ban Hinheup and Ban Viengphoukha believe that the current situation of plantation development has made things better (benefits their income from plantation employment activities and sale of rubber latex).

In Ban Luangnamtha, almost 70% of the total respondents indicated that rubber plantations play an important role in their livelihood with respondents managing their own rubber plantations, tapping the rubber and selling to the local rubber market throughout the year. The rubber plantations are said to be crucial for formal and informal employment and for rural households in Luangnamtha, in general and particularly in the case study villages. Local villagers believed that rubber labour is relatively better than other livelihood options such as upland rice cultivation especially when the price of latex increased more recently. Rubber liquid latex price stayed around 5,000 to 8,000Kip/kg at farm gate\(^2\). Tapping rubber trees has become a good source of household income in the two northern villages with larger areas of rubber plantations.

For Ban Hinheup, the Burapha plantation system adopts a collaborative *Eucalyptus* Agroforestry plantation where villagers can grow rice between the trees. This usually occurs only in the first year of the 7-year tree rotation. Villagers are also employed to plant, tend the trees during the rotation and harvest the trees. Therefore, participating villagers receive wages for preparing and

\(^2\)Middle men pick up liquid latex at the plantation sites using their own vehicles.
clearing land, planting, fertilising, weeding, pruning, thinning (if undertaken), and harvesting (IFC 2020; Phimmavong et al. 2019). Before the establishment of plantations in and adjacent to their villages, some of the Hinheup villagers did not have sufficient rice. Currently, these poor villagers use their income from plantation employment activities to buy rice during hard times. Thus, the tree plantation has been viewed positively in this village. Overall, villagers around the plantation concession boundary in the plantation village tend to receive significant benefit from tree plantation compared to the comparable village.

Figure 7. General perception of the effects of the planted forest on the wellbeing of local people in Ban Hinheup.

Figure 8. General perception of the effects of the planted forest on the wellbeing of local people in Ban Viengphoukha.
Figure 9. General perception of the effects of the planted forest on the wellbeing of local people in Ban Luangnamtha.

3.4. Perception of effects of tree plantations on environment

The villagers were asked to report on their general perceptions of the effects that the plantation has had on the surrounding environment (Figures 10 – 13). Figure 10 shows that almost a quarter of the respondents in Ban Hinheup think that *Eucalyptus* plantation has had a negative impact on the environment while half of them think that it is neutral. Similarly, about 36% of them believe that the *Eucalyptus* plantation intervention might negatively affect the quality of soil, namely compaction, erosion, organic matters, and fertility. This is quite surprising since local people have these views as eucalypts have been in the village for a very short time (4 years). In addition, only 5% of the total respondents said that the planted forest has negatively affected the climate and landscape in their village. By contrast, most of the respondents in the comparable village (Ban Thoulakhom) mentioned that the rubber plantation has positively affected the environment namely on soil, biodiversity, climate and landscape while many of them expressed their neutral opinion though Ban Thoulakhom has the smallest area and the least exposure to rubber (Figure 11). The majority of respondents in Ban Viengphoukha and Luangnamtha (Figures 12 and 13) agreed that rubber plantations are likely to negatively affect the environment in their villages. For instance, rubber latex odour from rubber latex factories and soil erosion were said to be a major problem for the rubber development in the two districts, especially in the Ban Viengphoukha due to the physical attributes of the terrain, slope stability and close proximity of rubber factories near the village. The respondents were concerned about changes to their environment such as climate, habitat, water, biodiversity, and landscape. However, they believed that long term planning by the government could control the environmental impacts of rubber development.
3.5. Effects of village types upon households’ perception

This section examines the differences in perception of smallholder livestock farmers in relation to the village type. A Chi-square test was used to test the association between the two categories of villages conditioning on levels of the perception of household farmers in the stated opinions (Table 6).
Figure 13. General perception of the effects of the planted forest on environment in Ban Luangnamtha.

Table 6. Differences in opinion among the smallholder livestock households.

| Opinion                       | Pearson Chi-square (4) | P-value       |
|-------------------------------|------------------------|---------------|
| Wellbeing of local people     | 65.68                  | $P = 1.850119e-13$ |
| Habitat (birds, mammals)      | 33.45                  | $P = 9.660754e-07$ |
| Soil                          | 28.68                  | $P = 9.079094e-06$ |
| Water (availability and quality) | 44.56                  | $P = 4.90797e-09$ |
| Biodiversity (internal and external) | 20.28                  | $P = 4.396825e-04$ |
| Climate                       | 28.47                  | $P = 1.001522e-05$ |
| Landscape (aesthetic value)   | 9.14                   | $P = 0.058$   |

There were significant differences in the opinions of farmer respondents in the four villages towards tree plantation development in the community. The respondents appeared to believe that tree plantation development has improved their livelihood as mentioned above.

Chi-square tests were also used to test whether there was any difference in the stated opinion of the respondents towards the preference for effects of tree plantations on their environment. All opinions differed significantly by village type, except for the opinion towards the effects on landscape.

4. Conclusions

Global markets for plantation-grown wood and rubber are positioned for strong, long-term growth, fundamentally driven by increases in population, prosperity, urbanization and demand for renewable resources. This paper investigated the socio-economic impact of commercial tree plantations in Laos by conducting a field survey covering rubber and eucalypt plantations, across two provinces in central and northern Laos. A total of 95 farm households from the plantation villages and a comparable “non-plantation” village were interviewed.

Results show that villagers in the study areas have incorporated eucalypts and rubber into their land-use systems to improve household livelihoods. This has been done to make best use of their limited land resources through the adoption of agroforestry systems that could provide more opportunities to either intercrop annual crops or obtain income from plantation employment activities. Furthermore, villagers around the plantation concession boundaries in the plantation villages tend to receive benefits from tree plantations while the richest households from Ban Thoulakhom (the comparable “non-plantation” village) obtained the major proportion of their total household income from rice and livestock production.

The analysis indicated that cattle populations from all plantation villages tend to be smaller than those in the comparable “non-plantation” village. Limited access to land for grazing in the plantation villages may be attributed to the expanding commercial plantations in the provinces. Furthermore, since rubber plantations are labour intensive, farmers spend most of their time tapping the trees daily, both in the morning and night to collect latex over two seasons, so opportunities to undertake other livelihood activities are limited.
Given the rapidly changing market environment and improved logistics and road and rail networks, executing complex policy change requires adaptability and sustained effort and related state organisations need to be pro-actively involved in dialogue with industries and communities to be more effective. Future policy options for sustainable plantation forest development in Laos should ensure that commercial forest plantations offer a pathway for economic, environmental, and social benefits for rural communities.

The conversion of degraded forest land and regenerating swidden lands for commercial tree plantation development needs to be carried out in accordance with the national laws such as the Land Law, Forestry Law and related regulations and engagement with affected communities. This will enhance outcomes and mitigate the potential negative impacts and ensure that the land is used appropriately in accordance with intentions and facilitate the management and the protection of adjacent intact natural forests. Some companies in Laos have made substantial progress through adopting integrated agroforestry systems (IFC 2020; Phimmavong et al. 2019) which utilise highly productive germplasm and silvicultural techniques. Therefore, it is important that smallholders in other parts of Laos can have access to knowledge for best agroforestry practices as well as high quality germplasm and silvicultural knowledge so that their plantations can be more productive and profitable, offering a pathway away from rural poverty. By adopting integrated agroforestry systems, as experienced elsewhere in Laos and neighbouring countries, Laos can restore degraded lands to achieve national targets and support local livelihoods by improving food security and providing pathways to reduce poverty. The results from this study are based on a small number of observations. Future studies could draw conclusion from a relatively larger number observations and explore more combinations suited to different types of site or local community requirements.

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