Profitability Analysis of Tectona grandis and Chukrasia tabularis: Evidence from Smallholder Forest Plantations in Northwest Vietnam

Article *in* Forestist · July 2024

DOI: 10.5152/forestist.2024.23050

Hsu Yemon Kyaw
Oregon State University

Tran Van Hiep
Hanoi University of Mining and Geology

DOI:10.5152/forestist.2024.23050
Forestist 2024

ISTANBUL UNIVERSITY CERRAHPASA

Original Article

Profitability Analysis of *Tectona grandis* and *Chukrasia tabularis*: Evidence from Smallholder Forest Plantations in Northwest Vietnam

Hsu Yemon Kyaw[1], Aruna Kainyande[1], Tran Van Hiep[2]

[1]Technische Universität Dresden, Institute of International Forestry and Forest Products, Dresden, Germany
[2]Hanoi University of Mining and Geology, Faculty of Economics and Business Administration, Hanoi, Vietnam

ABSTRACT

Despite Vietnam's policy to expand forest plantations to meet the increasing demand for sawlogs, there still exist concerns about the profitability of these plantations for smallholders. Strategies to endorse this policy seek to encourage smallholders to increase the rotation age of their plantations. To bridge this gap of limited information on the profitability of smallholder forest plantations, we compared the land expectation value (LEV) of two major plantation species under long rotation of 25 years. We calculated the LEV based on the Faustmann model using plantation establishment and management-related costs obtained from a survey of 30 households in Yen Chau District, Northwest Vietnam. This data was complemented by in-depth key informant interviews ($n = 7$) for triangulation. Our results found that both plantations, namely *Tectona grandis* and *Chukrasia tabularis,* were profitable under long-rotation conditions because the land expectation values were positive. However, *Tectona grandis* was more profitable with a much higher land expectation value than *Chukrasia tabularis.* The impacts of changes in timber prices and interest rates on the profitability of the plantations were also reported. Both plantations exhibited significant levels of sensitivity to variations in interest rates and timber prices. However, quite striking, these fluctuations did not reduce land expectation values to zero or negative, implying that the plantations were still profitable when subjected to market risks. Our results bear implications for policy that promotes long-rotation plantations by providing empirical evidence of the profitability and resiliency of long-rotation plantations under the socio-economic contexts and scenarios investigated in our study.

Keywords: Faustmann model, land expectation value, long rotation, profitability, smallholder forest plantations, Vietnam

Introduction

In terms of forest plantations, Vietnam is experiencing a massive increase in new forest plantation areas, which, compared to global estimates, positions the country among the global leaders (Cuong et al., 2020). This trend is driven by the global shift in domestic wood supplies over the past 50 years (Cuong et al., 2020), which has seen the area of forest plantations flourish in the country. Forest plantations have been used to replace the wood supply from natural forests due to dwindling areas of natural forests that are rapidly under change from exploitation (Cuong et al., 2020). In addition, the majority of the country's forest plantation areas are under the management of smallholder farmers, which accords them with the decision-making power to choose the type of tree species for their plantations (Crowther et al., 2020). The most preferred tree species are *Acacia mangium*, *Eucalyptus*, and *Manglietia conifera* because of their shorter rotation lengths and early financial returns, which serve as an incentive for their selection over the other plantation species like Pinus, teak, and indigenous species such as *Styrax tonkinensis* and *Manglietia glauca* (Cuong et al., 2020; Nambiar et al., 2015).

The country's model for forest plantation expansion promotes the use of fast-growing tree species in shorter rotations over long-rotation plantations. Approximately, a large part of the roundwood from these short-rotation plantations is intended to feed the country's woodchip production industry (Tham et al, 2021). By 2020, Vietnam had reached a record high in industrial roundwood production at 37,335,420,000 m^3 (Vietnam News Association, 2023). However, there has been a shift in the utilization of roundwood as the furniture industry has grown rapidly, making Vietnam the fourth-largest furniture exporting country in the world (Tham et al, 2021). Despite this, the country heavily relies on imported raw wood products to meet the demand for furniture exports (Arvola et al., 2021). In 2023, Vietnam imported 406,300 m^3 of raw wood materials, equivalent to US$133.0 million, for furniture production (International Tropical Timber Organization, 2023). Furthermore, with

Cite this article as:
Kyaw, H.Y., Kainyande, A., & Van Hiep, T. (2024). Profitability analysis of *Tectona grandis* and *Chukrasia tabularis*: Evidence from smallholder forest plantations in Northwest Vietnam. *Forestist*, Published online July 8, 2024. doi:10.5152/forestist.2024.23050.

Corresponding Author:
Hsu Yemon Kyaw
e-mail: hsuyemonkyaw@gmail.com

Received: August 11, 2023
Revision Requested: January 12, 2024
Last Revision Received: April 1, 2024
Accepted: May 13, 2024
Publication Date: July 8, 2024

a goal to earn 25 billion USD from wood and wooden product exports by 2030 (Vietnam News Association, 2023), there is a pressing need for investment in domestic wood production (Hung et al., 2019). This aligns with the government's encouragement for smallholders to extend rotation lengths, aimed at supporting the national furniture manufacturers and construction industries (Arvola et al., 2021; Maraseni et al., 2017; Ministry of Agriculture and Rural Development, 2015; Pistorius et al., 2016). Previous evidence presented by several researchers (Arvola et al., 2021; Hamrick & Gallant, 2018; White et al., 2018) suggests that long-rotation plantations not only offer diversified income opportunities for smallholders but also contribute significantly to climate change mitigation, allowing smallholders to explore revenue streams from carbon markets. This is crucial because additional income from carbon credit markets could incentivize smallholders to prolong their rotation times. However, progress on this goal is slow, given that smallholders are unsure about the financial prospects of long-rotation plantations since there is limited information on their financial returns under different management regimes (Maraseni et al., 2017).

Therefore, in this study, *Tectona grandis* and *Chukrasia tabularis* plantations were chosen because they are typically established for long rotations, have high economic values, and are most recommended for plantation establishment in the Northwest region of Vietnam according to decision no. 4961/QD-BNN-TCLN issued by the Ministry of Agriculture and Rural Development on November 17, 2014. This decision outlines the catalogue of potent tree species and plants for forest production and afforestation, categorized according to ecological regions. More importantly, since empirical findings on the comparative profitability analysis of *T. grandis* and *C. tabularis* plantations under different spacings and rotation lengths are still limited in Vietnam, our research intends to fill this lacuna of information.

Hence, the main objective of this research was to compare the land expectation value (LEV) for two major plantation species as a basis to judge their profitability under different spacing scenarios. To this end, we analyzed the impact of fluctuations in timber prices and interest rates to better understand how these affect the profitability of the plantations. Our research is intended to contribute to the empirical evidence on the profitability of the two plantation types for smallholder farmers in the study area to inform their decision on tree selection for plantation establishment. The current efforts to increase the share of smallholder farmers growing long-rotation plantations could benefit from our study regarding the financial prospects of the long-rotation plantations under study.

Material and Methods

Model of the Study

This study examined the profitability of *C. tabularis* and *T. grandis* plantations managed by smallholder farmers in Yen Chau District, Son La Province, Northwest Vietnam. Both plantations are even-aged plantations under long-rotation periods of 25 years. We applied the Faustmann model (1849) to compute the profitability of the two even-aged forest plantations to decide which forest management regime is best for the given species on the specific site from a financial standpoint because the model considers the net present value (NPV) of an infinite series of identical, even-aged forest rotations, starting from bare land (see Equation 1). The Faustmann formula's ability to account for long-term considerations, discount future cash flows, and flexibility such that it can be adapted to various forestry scenarios and management regimes over time makes it a valuable tool for economic analysis and decision-making in forestry compared to other models (Hyytiäinen & Tahvonen, 2003). The formula enables the determination of the optimal economic rotation age for both even- and uneven-aged forests across various spacing regimes while taking into account the opportunity costs associated with land.

$$LEV = C_{reg} * q^{T} + C_{weeding} * q^{T-t} + C_{pruning} * q^{T-t} + VS / q^{T} - 1 \quad (1)$$

It is denoted that LEV = land expectation value, C_{reg} = cost of regeneration in the first year measured in (US$/ha), $C_{weeding}$ = cost of weeding in year t measured in (US$/ha), $C_{pruning}$ = cost of pruning in year t measured in (US$/ha), T = the harvest age of forest stand, t = age of the forest stand, q = guiding rate of return factor ($q = 1 + i_g$, where i_g = guiding rate of return), VS = stumpage value (US$/ha) (Faustmann, 1849).

In addition, forest plantations are considered a long-term investment (Enters et al. 2003), which means they are subject to risks associated with volatility in timber prices and interest rates. Thus, risks should be considered when making forest management decisions, such as the age to harvest the forest plantation. Analyzing risks based on sensitivity is one way to account for risk factors in profitability calculations. Earlier studies have also examined how economic conditions affect forest profitability and rotation length. For instance, Parajuli and Chang (2012) considered fluctuations in timber prices in their sensitivity analysis. Furthermore, Chang (1983) and Newman et al. (1985) investigated the effect of price level changes on optimal rotation lengths. Therefore, in our study, we included the impact of risks associated with changes in timber prices and interest rates on the profitability of smallholder forest plantations in Yen Chau District, Northwest Vietnam.

Study Area

The research was conducted in Yen Chau District, Son La Province, in the northwest part of Vietnam (see Figure 1). The following criteria guided our selection of the study area: (1) the area has one of the highest concentrations of *T. grandis* plantations in Vietnam, (2) the area contains promising areas of *C. tabularis* plantations, and (3) the approach of using land expectation value (LEV) as a proxy to estimate the profitability of smallholder forest plantations is limited in the plantation economic analysis literature for Vietnam because most in-country studies use net present value (NPV) and internal rate of return (IRR).

Yen Chau District is located in the mountainous area that lies within the latitude range of 21° 00′ to 21° 04′ North and the longitude range of 104° 05′ to 104° 40′ East. The total land area of Yen Chau is 85,776 hectares (Official website of Son La Province, 2020). The terrain of Yen Chau is quite complex and sharply divided. The high limestone mountains divide the district into two distinct regions: the basin, with an average elevation of 400 m above sea level, and the highland, with an average elevation of 900–1000 m above sea level (ibid). However, a large part of the region's land area comprises large slopes, representing one of the primary limitations to agricultural intensification.

A tropical monsoon climate with an annual average temperature of 23°C characterizes the climate of Son La province. The area is characterized by two distinct seasons: a rainy season that spans from May ending in October and a dry season typically starting from November to April. The average precipitation is approximately 1042 mm annually (Official website of Son La Province, 2020).

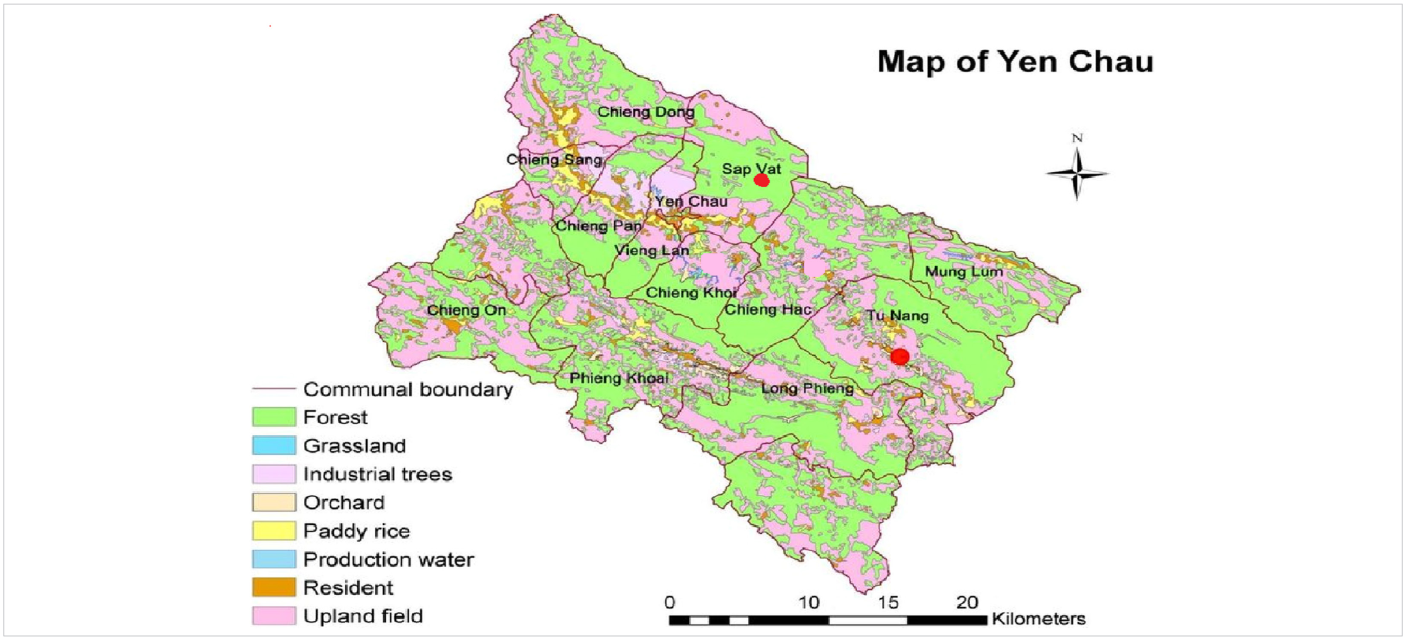

Figure 1.
Map of the study area (modified from Kofler, 2012).

Sampling Strategy and Sample Size

A multi-stage sampling strategy was employed to select Yen Chau district within Son La Province, considering its geographical representativeness as one of the regions with the highest concentration of teak and Indian mahogany. In the next stage, simple random sampling was employed to select two communes—Tu Nang and Sap Vat within the district, considering the tree-growing dependent lifestyles of the inhabitants. In the final stage, we obtained a list of the tree-growing households from the local forestry extension office to develop a sampling frame, from which 30 households were selected by a systematic random approach following a specific set of criteria to allow for the assessment of economic viability. The specific criteria include the size of the plantation, ownership status of the land, willingness to participate, and commitment to a 25-year rotation period.

We chose a sample size of 30 respondents for our analysis because our study focused on a specific target population (smallholder tree growers in this case), which is relatively homogeneous in terms of demographics, given that all the respondents were smallholder tree grower households. In this case, a sample size of 30 can be considered adequate to achieve representativeness. Furthermore, the practical limitations associated with the cost, time, and difficulty to access the target smallholder tree growers living in mountainous terrain further justify our selection of 30 respondents. This enables us to strike a balance between statistical rigor and resource constraints, allowing us to determine a sample size that is both manageable and representative. The small sample size of 30 was also selected to ensure a deeper focus on each individual respondent, allowing us to explore in great detail their respective perspectives, experiences, and tree-growing practices. This approach supports our study's goal of exploring trends and patterns within households involved in teak and Indian mahogany plantation activities.

Data Collection

The study utilized both primary and secondary data. During primary data collection, face-to-face interviews delivered through a semi-structured questionnaire consisting of open- and closed-ended questions were administered to household heads or adult household members above 18 years in the absence of the household heads. The questionnaire was designed to acquire financial data on the associated costs of all plantation and maintenance activities as well as the benefits from the sale of the standing trees at the end of the rotation since the smallholders did not carry out thinning and harvesting operations. So, our financial calculation did not include data on the cost of thinning, harvesting, and transportation. Benefits from the plantations were calculated based on the number of trees per hectare according to the plantation spacing because the trees were not harvested but sold as standing trees.

Since data collection also relied on a recall process that required the smallholders to answer questions on plantation activities, they carried out several years ago, we complemented the household surveys with in-depth key informant interviews for adequate triangulation. We purposively selected seven key informants: two district representatives, two forest rangers, two community members, and one government forest management official. These individuals were considered highly knowledgeable due to their daily engagement in plantation establishment and management activities. Combining a mixed-methods approach ensured the reliability of our data because the weaknesses of one data collection method could be complemented by the other, which is helpful for triangulation (Christie et al., 2008). Secondary sources of data were obtained from published literature archived in reputable databases online and gray literature on the economic analysis or performance of forest plantations in the region.

Plan of Calculation

For the optimal economic forest plantation rotation simulation, 25-year old *C. tabularis* and *T. grandis* were chosen using the spacings at the time of plantation establishment. The spacings adopted in our simulation ranged from 2.5 × 2.5 m, 3 × 3 m, to 4 × 4 m. Our simulation accounts for a 90% survival rate, considering factors such as wind damage, pests, and diseases despite smallholders' replanting efforts.

We applied the cost and revenue data derived from the face-to-face interviews with the smallholder farmers and the key informants in the study region to compute the cost and revenue structure for the two plantations (see Supplementary Material for the detailed breakdown). Timber prices were obtained from the household survey data and cross-checked during the key informant interviews for coherency. For a comprehensive understanding, all the financial data was converted from Vietnamese dong to US$ to provide a generalized comparable monetary unit (Šálek & Sloup, 2012).

For our financial analysis, we used labor costs reported by the participants in our study. We opted for this approach to better understand the distinctive characteristics of each farm, such as their operations, the types of trees they cultivate, the time it takes for these trees to mature, and the interest rates in their specific regions. By relying on the detailed information provided by the participants rather than more generalized market data, we gained a deeper insight into how labor is allocated and utilized on the farms. This method took into account factors like the types of crops grown, seasonal variations, and farming practices, resulting in a more accurate representation of the actual labor costs for our study group. To ensure the precision and reliability of our financial calculations, we conducted sensitivity analyses using the reported data from the sample participants.

To determine the real interest rate to use, the nominal interest rate of 6% was applied, along with a 2.89% inflation rate obtained from the General Statistics Office in August 2022. This corresponds to the common nominal interest rate used in the region by the Bank for Social Policies to charge the lowest loans to poor households or ethnic minorities (Cuong et al., 2020; Vietnam Government, 2012). Additionally, the Five Million Hectares Reforestation Program gives out loans at annual interest rates of 6–7% to households that have a contract with the State Forest Enterprise for afforestation activities (Cuong et al., 2020). Therefore, we chose a real interest rate of 3% after subtracting the inflation rate from the 6% nominal interest rate (Table 1).

Concerning the sensitivity analysis, we employed interest rates at both 6% and 18% to assess how variations in these rates impact the profitability of *C. tabularis* and *T. grandis* plantations. Additionally, the sensitivity analysis included changes in timber prices, ranging from a 50% increase to a 50% decrease, to understand their effects on the profitability of forest plantations. This manual sensitivity analysis involved adjusting interest rates and timber prices to explore their respective impacts on profitability.

Statistical Analysis

Qualitative and quantitative methods were used to analyze the collected data. Qualitative data obtained from the interviews were recorded and then transcribed into text, which we used in framing our discussion of the results. The quantitative data were analyzed with Microsoft Excel to evaluate the profitability of the smallholder forest plantations under the different management regimes. The analyzed data was presented in descriptive statistics as tables and figures with the aid of ggplot package in R Studio version 3.6.2 (R Core Team, 2020).

Table 1.
Overview of the Conducted Simulation Scenarios

Plantation/Rotation	Spacing (m)	Real Interest Rate (*i*) (%)
Indian mahogany *(Chukrasia tabularis)* 25	2.5 × 2.5	3
	3 × 3	
	4 × 4	
Teak *(Tectona grandis)* 25	2.5 × 2.5	3
	3 × 3	
	4 × 4	

Note: m = Meter; *i* = Real interest rate; LEV = Land expectation value.

Results and Discussion

Smallholder Farmers' Motivations for Growing *Chukrasia tabularis* and *Tectona grandis* Plantations

Our result clearly establishes the existence of four prevailing drivers that motivated the smallholder farmers to grow *C. tabularis* and *T. grandis* plantations in the study area. Slightly above 50% of the respondents emphasized that the economically attractive nature of *Tectona grandis* was a very important reason that influenced their decision to choose the species over *C. tabularis* (see Figure 2). The perception that *C. tabularis* was also economically attractive was not acknowledged by most farmers, with a large majority expressing neutral claims about the species' economic attractiveness. However, the need to obtain income was similarly considered an important factor for growing both tree species. This finding confirms those reported by Tham et al. (2020) that financial incentives are the driving factors that influence smallholders' decisions to engage in plantation establishment.

While the existence of a supportive policy environment that promotes the establishment of the two species in plantations was revealed as one of the most important reasons that motivated smallholder farmers to grow them in their plantations, the support services from the government have been identified as the underlying reason for widening the divide between poor and rich households because the latter are more likely to access support services such as loans, land rights, and seedlings for plantation activities than poorer households (Nguyen & Tran, 2018; Sikor & Baggio, 2014; Tham et al., 2020). Therefore, the administration of government subsidies for investment in forest plantations should prioritize poorer households due to their financial incapability to shoulder the enormous initial investment cost associated with plantation establishment (Cuong et al., 2020). However, the need for obtaining fuelwood and timber by the smallholders was of low importance in their decision to select either of the two species for plantation establishment.

Profitability of Smallholder *Chukrasia tabularis* Plantations

The profitability of *C. tabularis* forest plantations was evaluated at various spacings in the study area. LEV was highest at 2.5 × 2.5 m planting intervals for the 25-year rotation of *C. tabularis* plantations. The LEV also showed patterns of reduction with an increase in planting density, which implies that the LEV was lower in the wider spacings. However, the LEVs at the 3 x 3 m spacing showed a striking similarity between the 25-year rotation plantations of *C. tabularis* and *T. grandis* (see Tables 2 and 3). The LEVs obtained in our results fall in the same range as those reported by Ota et al. (2022) for 15- and 20-year-old rotations of Sandalwood at an interest rate of 8%. However, our computed LEVs are considerably higher than the LEVs for long-rotation plantations at a 4% discount rate in Australia (Venn, 2005). These differences in LEVs across global case studies reflect varying conditions influenced by growth rates, management regimes, input costs, and stumpage prices (Cubbage et al., 2020).

Profitability of Smallholder *Tectona grandis* Plantations

As shown in Table 3, the LEV at the real interest rate of 3% was highest at the 2.5 × 2.5 m spacing for 25-year rotation of *T. grandis* plantations

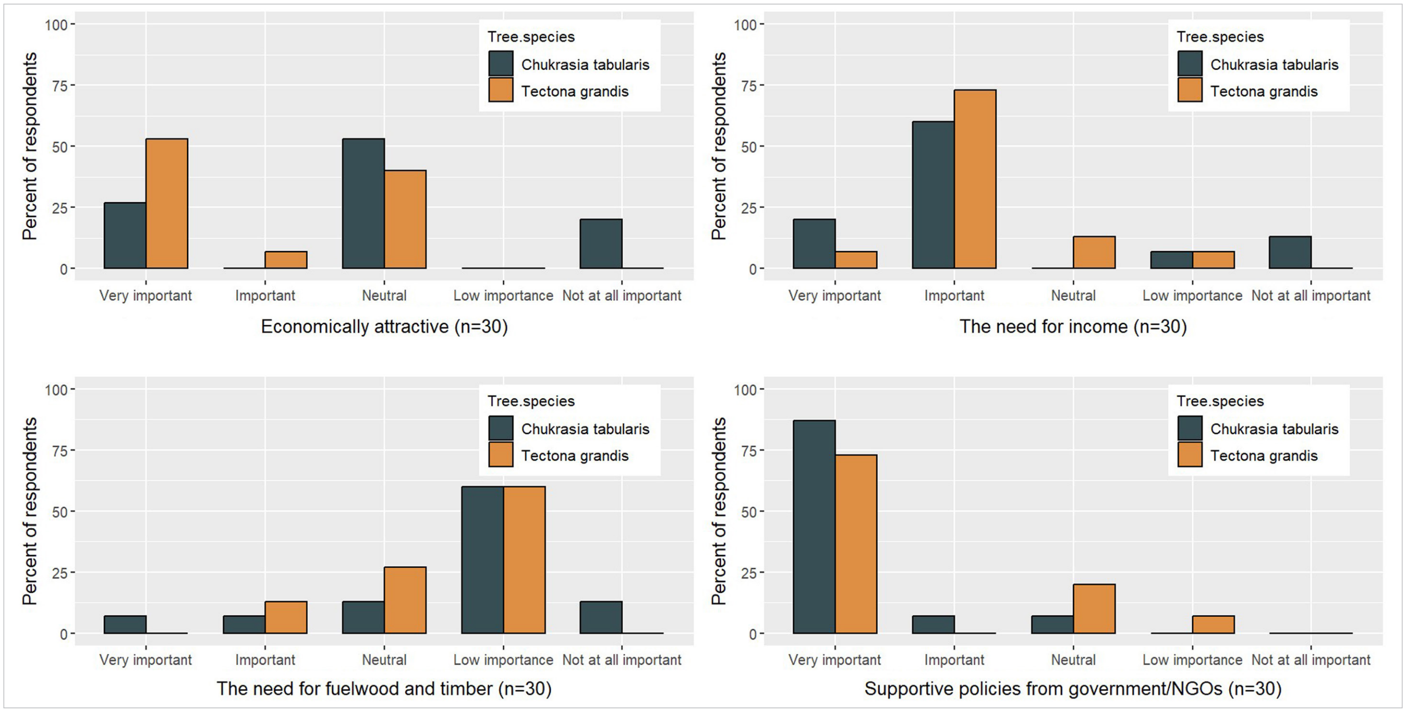

Figure 2.
Smallholder farmers' motivations for growing Chukrasia tabularis *and* Tectona grandis *plantations.*

with values of 61,709 US$ ha^{-1}. The result is quite similar to the previous one for *C. tabularis* plantations, in which the 2.5 × 2.5 m was also the most profitable in terms of LEV. The common trend clearly visible from the results showed that for 25-year rotation, *T. grandis* performed better in terms of profitability measured in LEV than the *C. tabularis* plantations across all the spacings at the real interest rate of 3%. Therefore, compared with *C. tabularis* plantations under 25-year rotations, *T. grandis* plantations proved to be the most profitable and optimal land use for the smallholder farmers in the study area. The results obtained in our study present LEVs that are significantly higher than those reported by Cubbage et al. (2020) for *T. grandis* at an 8% discount rate in Laos but are within the same range with LEVs for *T. grandis* in Mexico at the same discount rate.

Table 2.
Land Expectation Values Across the Different Spacings for Chukrasia tabularis *Plantations*

Rotation (Years)	Spacing (m)	LEV at *i* = 3% (US$/ha)
25	2.5 × 2.5	35,516
	3 × 3	25,003
	4 × 4	14,723

Note: m = Meter; *i* = Real interest rate; LEV = Land expectation value.

Table 3.
Land Expectation Values Across the Different Spacings for Tectona grandis *Plantations*

Rotation (Years)	Spacing (m)	LEV at *i* = 3% (US$/ha)
25	2.5 × 2.5	61,709
	3 × 3	25,039
	4 × 4	27,678

Note: m = Meter; *i* = Real interest rate; LEV = Land expectation value.

Sensitivity Analysis for Changes in Interest Rates for 25-Year Rotation Plantations

The impact of changing interest rates on the profitability of *C. tabularis* and *T. grandis* 25-year rotations is shown in Figure 3. Our findings revealed that a change in interest rates impacted the profitability of the two forest plantations, which is consistent with earlier studies (Bessaad et al., 2021; Blackburn et al., 2020; Cuong et al., 2020; Ota et al., 2022). When interest rates increased from 3% to 6% and then 18%, the LEV of a 2.5 × 2.5 m *T. grandis* plantation decreased dramatically from 61,709 to 21,376 and then to 2,378 US$ ha^{-1}, respectively. This is consistent with the assertion by Bessaad et al. (2021) that plantation profitability is mostly higher under low discount rates, with profitability lowering as the discount rate rises. This is visible in our result, in which the LEVs of the 25-year *C. tabularis* plantations at 2.5 × 2.5 m experienced a significant decline from 35,516 to 12,814, and 2,120 US$ ha^{-1} when the interest rate was increased from 3% to 6% and 18%. Therefore, we could confirm that the *T. grandis* plantations in our study are more susceptible to fluctuations in interest rates than *C. tabularis* plantations (See Figure 3). A plausible explanation for this might be that *T. grandis* plantations require more financial investment during the initial plantation establishment phase than *C. tabularis*, making the former more sensitive to interest rate change. This agrees with Guo et al. (2006), who attributed the high investment cost associated with establishing and managing rubber–tea intercropping as the underlying reason why the land use system was more vulnerable to interest rate changes than monoculture plantations of rubber and tea. Maraseni and Cockfield (2011) further explained why financial returns from forest plantations are reduced when interest rates are increased. They attributed the heavy discounting of benefits more than costs since benefits are realized in the later years while costs are incurred earlier.

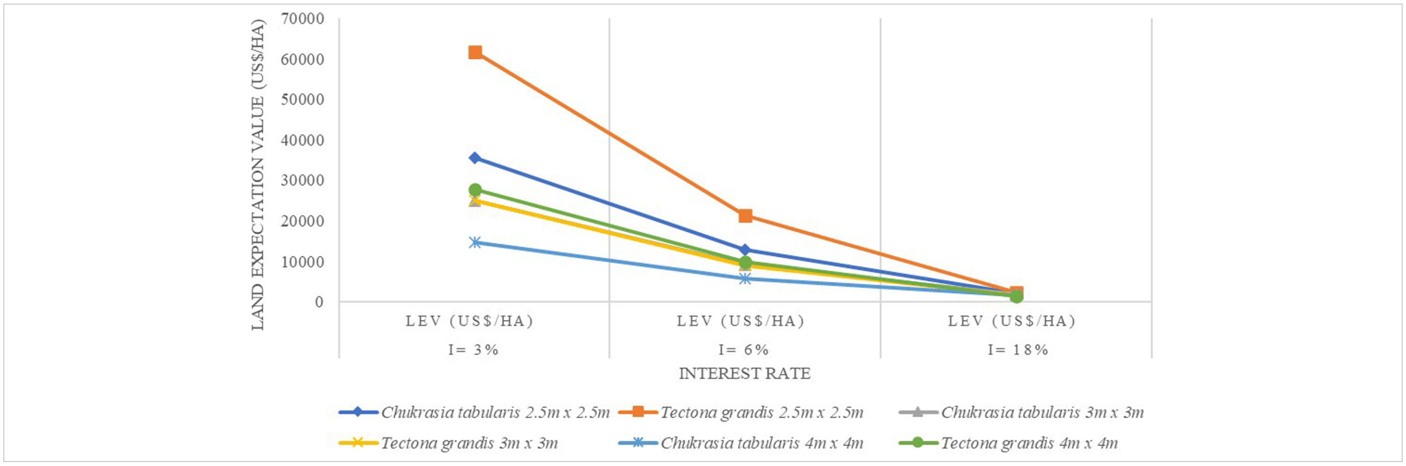

Figure 3.
Effect of changing interest rates on the profitability of 25-year-old forest plantations.

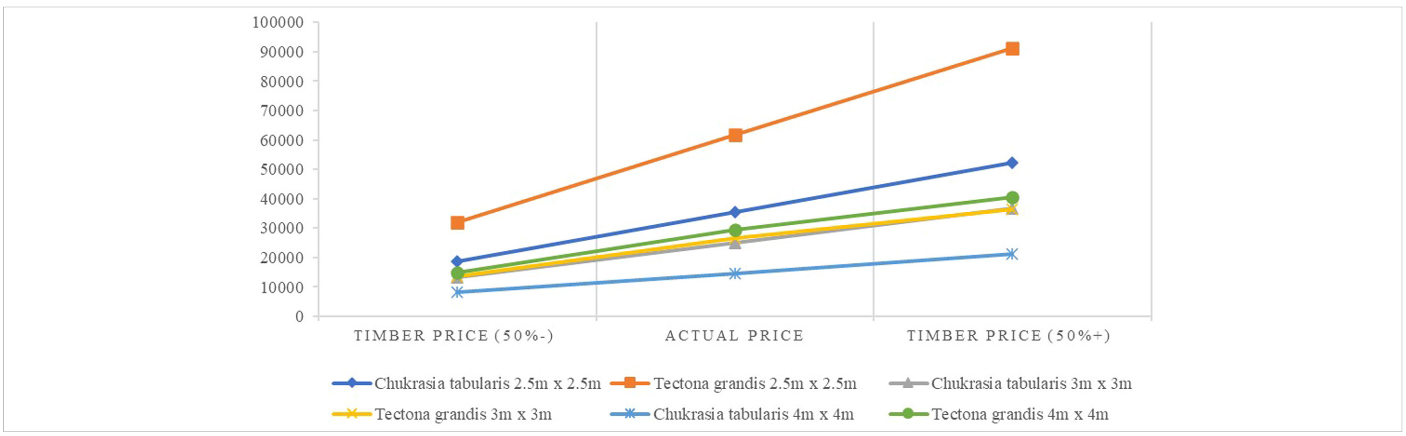

Figure 4.
Effect of changing timber prices on the profitability of 25-year-old forest plantations.

However, this does not discard the evidence that *C. tabularis* plantations at the 2.5 × 2.5 m and 3 × 3 m spacings were also somewhat sensitive to changes in interest rates, albeit the extent of their sensitivity was less pronounced compared to the *T. grandis* plantations. The *C. tabularis* plantation at 4 × 4 m was the least sensitive to rising interest rates for 25 years of rotation length (see Figure 3). This result is consistent with Blackburn et al. (2020), who reported high economic performance and resiliency for thinned smallholder acacia plantations under 6–8 years of rotations at a discount rate of 12%. This emphasizes that thinned stands, supposedly of wider spacing, could be more resilient than their narrow-spaced counterparts. Therefore, it is in the best interest of smallholders that are currently growing plantations at narrow spacings without carrying out thinning to consider the benefits of early thinning because the wide spacings that result from thinning will contribute to increasing the resilience of the plantation to high interest rates while also providing wood for household use or market sale. Despite the relevance of thinning to build resilience against interest rate change, there is evidence that the practice also predisposes trees to wind damage (Nambiar et al., 2015), representing a potential natural risk that was not considered in our sensitivity analysis. However, thinning has been widely recommended for long-rotation plantations because it contributes to the overall health of the stand by removing inferior trees so that growth is concentrated in the few remaining trees (Maraseni et al., 2018)

Sensitivity Analysis for Changes in Timber Prices for 25-Year Rotation Plantations

Additionally, we proceeded to examine the influence of changing timber prices on the profitability of the two forest plantations for the 25-year rotation, which are reflected in Figure 4. The results show that the LEVs of both forest plantations under all the spacings were affected when the timber prices were increased or decreased by 50%. This agrees with earlier studies by Bessaad et al. (2021) that fluctuations in wood prices ranging from +50 to −50% significantly impact the LEV of long-rotation oak plantations. The LEVs in our study increased with an increase in the timber price and decreased with a reduction in the timber price. This implies that if the timber price increase by 50%, the LEVs for a 25-year plantation of *T. grandis* at 2.5 × 2.5m would increase from 61,709 US$ ha^{-1} to 91,325 US$ ha^{-1}. The reverse trend is similar in that a 50% reduction in timber price would cause the LEV to decrease from 61,709 US$ ha^{-1} to 32,094 US$ ha^{-1}. This is consistent with the assertion of Maraseni et al. (2017) that plantations exhibit high sensitivity to decreases in timber prices. However, the consequences of such high sensitivity are often more pronounced on shorter rotation plantations, thereby supporting their claim that long-rotation plantations are better off dealing with the risk of fluctuations in timber prices. Despite their supposed capability to adapt to variations in timber prices, long-rotation plantations could also be dramatically affected by changing timber prices, which contradicts Maraseni et al. (2017), who opined that timber price changes might not greatly affect long-rotation plantations. Our results provide empirical evidence that the impacts of timber price changes are significantly greater, particularly for *T. grandis* plantations. A probable reason to support our results could be the assertion of Bessaad et al. (2021) that economically valuable timber species are more sensitive to timber price fluctuations, which holds true for *T. grandis*, whose timber commands a higher economic value than *C. tabularis*.

Among the scenarios, the *T. grandis* plantation with 2.5 × 2.5 m was the most sensitive to timber price changes for 25 rotation lengths (see Figures 4). Contextually, this generally implies that a decrease in the price of *T. grandis* timber does not make switching to *C. tabularis* plantations the optimal land use profitable for the smallholders because the profitability of both species types was influenced by timber price variation in a similar trend.

Conclusion

Even though the Vietnam government intends to encourage smallholder farmers to grow long-rotation plantations to meet sawlog and furniture demand, smallholder farmers still have concerns about the financial returns from long-rotation plantations because of their high time preference rate for money to sustain their livelihoods (Maraseni et al., 2017). Our study compared two long-rotation plantations, namely *C. tabularis* and *T. grandis* smallholder plantations in Northwest Vietnam, to ascertain their potential profitability as a basis to inform the decision-making capability of smallholders in dealing with the trade-offs between the choice of short rotations with early financial returns—suited to meet their immediate cash needs and long-rotations with delayed financial returns.

Our results found that despite the long periods of waiting for trees to reach harvest age in long rotations, the plantations were substantially profitable under the scenarios investigated in our study since all the LEVs for the two plantation species were positive under both rotation lengths. Therefore, we provide empirical evidence to confirm the profitability of these plantations for the smallholder farmers in our study area. However, since we did not compare the profitability against short-rotation plantations, we could only propose the profitability under long-rotation conditions. More importantly, because the LEVs from our study were substantially higher at the end of 25-year rotations, we are in a position to advise that the financial returns for waiting extra years on long- rotation plantations might be worthwhile from an economic standpoint because the returns on investment were considerably higher as compared to other short rotation and long-rotation plantations from other parts of the world that we reviewed in our results and discussion section. The high LEVs obtained from the long-rotation plantations in our study incentivize smallholders to grow their trees for longer periods. However, this alone is insufficient to convince smallholders to change their land use from short to long rotations. Support systems are highly recommended to incentivize them by facilitating their access to land, loans, and cost-sharing schemes. Through this, smallholders can reduce their desire for rapid cash flow, giving them the flexibility to wait extra years for their long-rotation plantations to reach harvest age. Furthermore, smallholders cultivating long-rotation plantations can benefit from additional income streams via carbon credit markets. Long rotations are known to sequester more carbon compared to short rotations. Therefore, facilitating smallholders' access to the carbon credit market could serve as a powerful incentive for them to embrace longer rotations as a strategy for diversifying their income.

Our results confirm that smallholders in our study area in Vietnam can potentially profit from contemporary timber production by growing *T. grandis* and *C. tabularis* plantations. However, the *T. grandis* plantations outperformed *C. tabularis* plantations under the prevailing investigated scenarios, confirming our earlier results that the perceived economic attractiveness of *T. grandis* is the primary motivation for its selection by smallholder farmers in the region. Thus, the species may be more economically beneficial for smallholder farmers to grow over *C. tabularis* because it produced the highest profits in terms of LEV under 25-year rotation lengths at a 3% interest rate.

Limitations of the Study

Although the findings from this study are useful for decision-makers and smallholder farmers, our study bears limitations that should be acknowledged. The wages used to calculate labor cost in our study were obtained from smallholder farmers, and this constitutes mainly labor from family members. So, the labor cost used in our financial calculation might be lower than the actual labor cost in the market, resulting in higher profitability. Furthermore, the seedling cost was subsidized through the government's cost-sharing programs, so the cost used in our estimation was lower than the actual market cost, which could potentially overestimate our profits. Finally, since our results are based on a small subset of respondents from a particular region, care must be taken to avoid generalization when applying the results to other areas in Vietnam with different socio-economic and ecological contexts. However, incorporating aspects of genetic or silvicultural improvements in future studies may potentially help mitigate this limitation.

Note

1. Conversion rate of Vietnamese Dong (VND) to US dollar (US$) at the time of the study (August 2022): 0.0000423 USD = 1 VND.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.Y.K.; Design – H.Y.K.; Supervision – T.V.H.; Materials – H.Y.K.; Data Collection and/or Processing – H.Y.K.; Analysis and/or Interpretation – H.Y.K., A.K.; Literature Search – H.Y.K.; Writing – H.Y.K., A.K.; Critical Review – T.V.H.

Acknowledgment: We would like to express our sincere gratitude to Prof. Dr. Habil. Peter Deegen for his constructive feedback and suggestions on earlier drafts of this paper. We are incredibly grateful to all key informants and smallholder farmers for taking the time to meet with us, participate in discussions, and conduct interviews. Additionally, we greatly appreciate the anonymous reviewers for their valuable and informative comments and suggestions, which helped improve the manuscript.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

References

- Arvola, A. M., Ha, H. T., Kanninen, M., Malkamäki, A., & Simola, N. (2021). Financial attractiveness of wood production in smallholder plantations of central Vietnam in the context of developing carbon markets. *Journal of Tropical Forest Science*, *33*(2), 137–148. [CrossRef]
- Bessaad, A., Terreaux, J. P., & Korboulewsky, N. (2021). Assessing the land expectation value of even-aged vs coppice-with-standards stand management and long-term effects of whole-tree harvesting on forest productivity and profitability. *Annals of Forest Science*, *78*(3), 57. [CrossRef]

- Blackburn, D., Huong, V. D., & Mendham, D. (2020). Returns to Vietnamese smallholder farmers from managing acacia plantations for sawn wood over 4–10 year rotations. *Forest Policy and Economics*, *121*, 102318. [CrossRef]
- Chang, S. J. (1983). Rotation age, management intensity, and the economic factors of timber production: Do changes in stumpage price, interest rate, regeneration cost, and forest taxation matter? *Forest Science*, *29*(2), 267–277.
- Christie, M., Cooper, R., Hyde, T., & Fazey, I. (2008). *An evaluation of economic and non-economic techniques for assessing the importance of biodiversity to people in developing countries; No. I* p. 22. London, UK: Defra.
- Crowther, J., Zimmer, H., Le Thi, H., Quang, T. L., & Nichols, J. D. (2020). Forestry in Vietnam: The potential role for native timber species. *Forest Policy and Economics*, *116*, 102182. [CrossRef]
- Cubbage, F., Kanieski, B., Rubilar, R., Bussoni, A., Olmos, V. M., Balmelli, G., Donagh, P. M., Lord, R., Hernández, C., Zhang, P., Huang, J., Korhonen, J., Yao, R., Hall, P., Del La Torre, R., Diaz-Balteiro, L., Carrero, O., Monges, E., Thu, H. T. T., Frey, G., et al. (2020). Global timber investments, 2005 to 2017. *Forest Policy and Economics*, *112*, 102082. [CrossRef]
- Cuong, T., Chinh, T. T. Q., Zhang, Y., & Xie, Y. (2020). Economic Performance of Forest Plantations in Vietnam: Eucalyptus, Acacia Mangium, and Manglietia conifera. *Forests*, *11*(3), 284. [CrossRef]
- Enters, T., Durst, P., & Brown, C. (2003). What does it take? The role of incentives in forest plantation development in the Asia-Pacific Region. *Unasylva*, *54*, 11–18.
- Faustmann, M. (1849). Berechnung des Wertes welchen Waldboden sowie noch nicht haubare Holzbestande fur die Waldwirtschaft Besitzen. *Allg. Forst- und Jagdz*, 440–455
- General statistics office of Vietnam (2022). Vietnam inflation rate. Retrieved from https://tradingeconomics.com/vietnam/inflation-cpi
- Guo, Z., Zhang, Y., Deegen, P., & Uibrig, H. (2006). Economic analyses of rubber and tea plantations and rubber-tea intercropping in Hainan, china. *Agroforestry Systems*, *66*(2), 117–127. [CrossRef]
- Hamrick, K., & Gallant, M. (2018). *Voluntary carbon market insights: 2018 outlook and first-quarter trends*. Washington DC: Forest Trends.
- Hung, T. T., Almeida, A. C., Eyles, A., Ratkowsky, D., Lam, V. T., & Mohammed, C. (2019). Maximising growth and sawlog production from Acacia hybrid plantations in Vietnam. *New Forests*, *50*(5), 785–804. [CrossRef]
- Hyytiäinen, K., & Tahvonen, O. (2003). Faustmann, satisficing and optimizing. *Forest Science*, *49*(6), 837–847.
- International Tropical Timber Organization (2023). Tropical timber market report, 27.
- 18. Kofler, J. (2012). Possibility of increasing the abundance of inflorescences and fruit retention of the northwestern Vietnamese mango variety 'Hôi' by choosing the most appropriate cropping system. [CrossRef]
- Maraseni, T. N., & Cockfield, G. (2011). Crops, cows or timber? Including carbon values in land use choices. *Agriculture, Ecosystems and Environment*, *140*(1–2), 280–288. [CrossRef]
- Maraseni, T. N., Phimmavong, S., Keenan, R. J., Vongkhamsao, V., Cockfield, G., & Smith, H. (2018). Financial returns for different actors in a teak timber value chain in Paklay District, Lao PDR. *Land Use Policy*, *75*, 145–154. [CrossRef]
- Maraseni, T. N., Son, H. L., Cockfield, G., Duy, H. V., & Nghia, T. D. (2017). Comparing the financial returns from acacia plantations with different plantation densities and rotation ages in Vietnam. *Forest Policy and Economics*, *83*, 80–87. [CrossRef]
- Ministry of Agriculture and Rural Development (2014). *Decision no. 4961/QD-BNN-TCLN dated 17/11/2014 of the Ministry of Agriculture and Rural Development of Vietnam on promulgating a list of main tree species for planting production forests and a list of main tree species for afforestation according to forest ecological regions.*
- Ministry of Agriculture and Rural Development (2015). *Forest sector development program*. Hanoi, Vietnam: Ministry of Agriculture and Rural Development
- Ministry of Agriculture and Rural Development (2016). EU agreements a chance to eradicate illegal timber trade. Retrieved from http://www.mard.gov.vn/en/Pages/news_detail.aspx? NewsId=1108#, (24/05/2023).
- Nambiar, E. S., Harwood, C. E., & Kien, N. D. (2015). *Acacia* plantations in Vietnam: Research and knowledge application to secure a sustainable future. *Southern Forests: A Journal of Forest Science*, *77*(1), 1–10. [CrossRef]
- Newman, D. H., Gilbert, C. B., & Hyde, W. F. (1985). The optimal forest rotation with evolving prices. *Land Economics*, *61*(4), 347–353. [CrossRef]
- Nguyen, T. V., & Tran, T. Q. (2018). Forestland and rural household livelihoods in the north central provinces, Vietnam. *Land Use Policy*, *79*, 10–19. [CrossRef]
- Official website of Son La Province (2020). *Available on Geographical location*. Retrieved from sonla.gov.vn
- Ota, L., Page, T., Viranamangga, R., Kalsakau, T., & Herbohn, J. (2022). How financially viable is smallholder forestry? A case study with a high-value tropical forestry species. *Small-Scale Forestry*, *21*(3), 505–525. [CrossRef]
- Parajuli, R., & Chang, S. J. (2012). Carbon sequestration and uneven-aged management of loblolly pine stands in the Southern USA: A joint optimization approach. *Forest Policy and Economics*, *22*, 65–71. [CrossRef]
- Pistorius, T., Hoang, H. D. T., Tennigkeit, T., Merger, E., Wittmann, M., & Conway, D. (2016). *Business Models for the Restoration of Short-Rotation Acacia Plantations in Vietnam*. (A project supported by the German International Climate Initiative).
- R Core Team (2020). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.
- Šálek, L., & Sloup, R. (2012). Economic evaluation of proposed pure and mixed stands in Central Vietnam highlands. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, *113*(1), 21–29.
- Sikor, T., & Baggio, J. A. (2014). Can smallholders engage in tree plantations? An entitlements analysis from Vietnam. *World Development*, *64*, S101–S112. [CrossRef]
- Tham, L. T., Darr, D., & Pretzsch, J. (2020). Contribution of small-scale acacia hybrid timber production and commercialization for livelihood development in Central Vietnam. *Forests*, *11*(12), 1335. [CrossRef]
- Tham, L. T., Darr, D., & Pretzsch, J. (2021). Analysis of Acacia hybrid timber value chains: A case study of woodchip and furniture production in central Vietnam. *Forest Policy and Economics*, *125*, 102401. [CrossRef]
- Venn, T. J. (2005). Financial and economic performance of long-rotation hardwood plantation investments in Queensland, Australia. *Forest Policy and Economics*, *7*(3), 437–454. [CrossRef]
- Vietnam Government (2012). *Decision No. 852, bank for social policies development strategy period 2011–2020.* The prime minister government office: Hanoi, Vietnam.
- Vietnam Daily News (2016). Wooden Furniture Industry a Global Contender, but Still Faces Problems. Retrieved from https://viipip.vn/news/daily-news/wooden-furniture-industry-a-global-contender-but-still-faces-problems
- Vietnam News Association (2023). Wood and wooden product exports projected to rake in 25 billion USD by 2030. Retrieved from https://en.vietnamplus.vn/wood-and-wooden-product-exports-projected-to-rake-in-25-billion-usd-by-2030/247210.vnp?utm_source=link.gov.vn#source=link.gov.vn
- White, A. E., Lutz, D. A., Howarth, R. B., & Soto, J. R. (2018). Small-scale forestry and carbon offset markets: An empirical study of Vermont Current Use forest landowner willingness to accept carbon credit programs. *PLOS ONE*, *13*(8), e0201967. [CrossRef]

Supplementary Materials

Appendix (1): Cost and Revenue Structure for *Chukrasia tabularis* Plantation for 25 Years at 2.5 × 2.5 m

Year	Activities	Unit	Quantity	Unit Cost	Total Cost (US$/ha)	Revenue (US$/ha)
Year 1	Site preparation	Man-day	21	7.65	159.63	
	Cleaning the burned waste	Man-day	33	7.65	248.88	
	Planting materials	No/ha	1,600	0.085	136	
	Planting materials transport cost		12	7.65	91.8	
	Pitting and planting	Man-day	40	7.65	308.55	
	Weeding	Man-day	22	7.65	170	
	Tools	No/ha	6	8.49	50.94	
	Fertilizer application	kg	300	0.11	33	
Year 2	Weeding	Man-day	5	7.65	38.25	
	Replanting	Man-day	8	7.65	61.2	
Year 3	Weeding	Man-day	10	7.65	76.5	
	Tools	Man-day	3	7.65	22.95	
Year 4	Weeding	Man-day	4	7.65	27.54	
	Other cost (Pruning)	Man-day	6	7.65	45.9	
Year 5	Weeding	Man-day	3	7.65	22.95	
Year 6	Weeding	Man-day	3	7.65	22.95	
Year 25	Final harvest	trees/ha	1,440	25.48		36,691.2

Appendix (2): Cost and Revenue Structure for *Tectona grandis* Plantation for 25 Years at 2.5 × 2.5m

Year	Activities	Unit	Quantity	Unit Cost	Total Cost (US$/ha)	Revenue (US$/ha)
Year 1	Site preparation	Man-day	17	7.65	131.58	
	Cleaning the burned waste	Man-day	24	7.65	181.56	
	Planting materials	No/ha	1,600	0.085	136	
	Planting materials transport cost	Man-day	14	7.65	107.1	
	Pitting and planting	Man-day	34	7.65	260.1	
	Weeding	Man-day	20	7.65	153	
	Tools	No/ha	3	8.49	25.47	
	Fertilizer application	Man-day	280	0.11	30.8	
Year 2	Weeding	Man-day	8.5	7.65	65.025	
	Replanting	Man-day	6	7.65	45.9	
Year 3	Weeding	Man-day	6	7.65	45.9	
	Other cost (Pruning)	Man-day	4	7.65	30.6	
Year 4	Weeding	Man-day	5	7.65	38.25	
Year 5	Weeding	Man-day	5	7.65	38.25	
Year 6	Tools	No/ha	2	8.49	16.98	
Year 25	Final harvest	trees/ha	1,440	44.99		64,785.6

Appendix (3): Cost and Revenue Structure for *Chukrasia tabularis* Plantation for 25 Years at 3 × 3m

Year	Activities	Unit	Quantity	Unit Cost	Total Cost (US$/ha)	Revenue (US$/ha)
Year 1	Site preparation	Man-day	21	7.65	159.63	
	Cleaning the burned waste	Man-day	33	7.65	248.88	
	Planting materials	No/ha	1,111	0.085	94.435	
	Planting materials transport cost	Man-day	10	7.65	76.5	
	Pitting and planting	Man-day	34	7.65	260.1	
	Weeding	Man-day	22	7.65	170	
	Tools	No/ha	6	8.49	50.94	
	Fertilizer application	kg	200	0.11	22	
Year 2	Weeding	Man-day	5	7.65	38.25	
	Replanting	Man-day	8	7.65	61.2	
Year 3	Weeding	Man-day	10	7.65	76.5	
	Pruning	Man-day	10	7.65	76.5	
Year 4	Weeding	Man-day	0	7.65	0	
	Pruning	Man-day	6	7.65	45.9	
Year 5	Weeding	Man-day	3	7.65	22.95	
Year 6	Weeding	Man-day	3	7.65	22.95	
Year 25	Final harvest	trees/ha	999	25.48		25,454.52

Appendix (4): Cost and Revenue Structure for *Tectona grandis* Plantation for 25 Years at 3 × 3 m

Year	Activities	Unit	Quantity	Unit Cost	Total Cost (US$/ha)	Revenue (US$/ha)
Year 1	Site preparation	Man-day	17	7.65	131.58	
	Cleaning the burned waste	Man-day	24	7.65	181.56	
	Planting materials	No/ha	1,111	0.085	94.435	
	Planting materials transport cost	Man-day	12	7.65	91.8	
	Pitting and planting	Man-day	30	7.65	229.5	
	Weeding	Man-day	20	7.65	153	
	Tools	No/ha	3	8.49	25.47	
	Fertilizer application	Man-day	150	0.11	16.5	
Year 2	Weeding	Man-day	8.5	7.65	65.025	
	Replanting	Man-day	6	7.65	45.9	
Year 3	Weeding	Man-day	10	7.65	76.5	
	Other cost (Pruning)	Man-day	0	7.65	0	
Year 4	Weeding	Man-day	0	7.65	0	
Year 5	Weeding	Man-day	0	7.65	0	
Year 6	Tools	No/ha	0	8.49	0	
Year 25	Final harvest	trees/ha	999	25.11		25,084.89

Appendix (5): Cost and Revenue Structure for *Chukrasia tabularis* Plantation for 25 Years at 4 × 4 m

Year	Activities	Unit	Quantity	Unit Cost	Total Cost (US$/ha)	Revenue (US$/ha)
Year 1	Site preparation	Man-day	21	7.65	159.63	
	Cleaning the burned waste	Man-day	33	7.65	248.88	
	Planting materials	No/ha	625	0.085	53.125	
	Planting materials transport cost	Man-day	10	7.65	76.5	
	Pitting and planting	Man-day	34	7.65	260.1	
	Weeding	Man-day	22	7.65	170	
	Tools	No/ha	6	8.49	50.94	
	Fertilizer application	kg	100	0.11	11	
Year 2	Weeding	Man-day	5	7.65	38.25	
	Replanting	Man-day	8	7.65	61.2	
Year 3	Weeding	Man-day	10	7.65	76.5	
	Pruning	Man-day	10	7.65	76.5	
Year 4	Weeding	Man-day	0	7.65	0	
	Pruning	Man-day	6	7.65	45.9	
Year 5	Weeding	Man-day	3	7.65	22.95	
Year 6	Weeding	Man-day	3	7.65	22.95	
Year 25	Final harvest	trees/ha	562	25.48		14,319.76

Appendix (6): Cost and Revenue Structure for *Tectona grandis* Plantation for 25 Years at 4 × 4m

Year	Activities	Unit	Quantity	Unit Cost	Total Cost (US$/ha)	Revenue (US$/ha)
Year 1	Site preparation	Man-day	17	7.65	131.58	
	Cleaning the burned waste	Man-day	24	7.65	181.56	
	Planting materials	No/ha	625	0.085	53.125	
	Planting materials transport cost	Man-day	5	7.65	38.25	
	Pitting and planting	Man-day	28	7.65	214.2	
	Weeding	Man-day	20	7.65	153	
	Tools	No/ha	3	8.49	25.47	
	Fertilizer application	Man-day	25	0.11	2.75	
Year 2	Weeding	Man-day	13	7.65	99.45	
	Replanting	Man-day	6	7.65	45.9	
Year 3	Weeding	Man-day	6	7.65	45.9	
	Other cost (Pruning)	Man-day	0	7.65	0	
Year 4	Weeding	Man-day	0	7.65	0	
Year 5	Weeding	Man-day	0	7.65	0	
Year 6	Tools	No/ha	0	8.49	0	
Year 25	Final harvest	trees/ha	562	50.22		28,223.64

Questionnaires for Households With Teak (*Tectona grandis*)/Indian Mahogany *(Chukrasia tabularis)* Plantation

Section 1: General information about household

1.1 Name of village: ______________________________

1.2 Name of commune ______________________________

1.3 Name of district______________________________

1.4 Name of Enumerator: ______________________________

1.5 Date of Interview: ______________________________

1.6 Name of Respondent: ______________________________

1.7 Household size: In total, how many people live in the household? ______________

1.8 What is the total size of land managed by the household? ______________ (ha)

1.9 Mode of acquiring land
Own [ ] = 1 Rent [ ] =2 Other: ______________[ ] =3

1.10 If you rent the land, what is the fee for renting? ______________ (VND/month)

1.11 How long do you rent the land? ______________________________

Section 2: Information related to plantation establishment

2.1 Which kind of forest plantation do you have?
Teak (*Tectona grandis*) [ ] = 1 Indian mahogany (*Chukrasia tabularis*) [ ] = 2

2.2 What are the reasons for growing this species? Please use a scale from 1 to 5 to rank the following factors in order of importance to you. (1= Most important factor(s) and 5 = Least important factor(s))

Possible Underlying Factors		Rank
1	Economically attractive	
2	The need for income	
3	The need for fuelwood and construction materials	
4	Decrease in prices of agricultural products	
5	Supportive policies from local government/NGOs	
6	Other (Specify)	

2.3 How large your forest plantation is? ______________ (ha)

2.4 How did you finance your forest plantation?
Self-financed [ ] =1 Loan (from ______________) [ ] =2 Credit (from ______________) [ ] =3

2.5 If you receive loan/ credit, what is the interest rate? ______________ %

2.6 If you receive loan/credit, how long do you borrow money?
Less than 1 year [ ] =1 One year [ ] =2 Other: ______________ [ ] =3

2.7 Which kind of planting materials do you use?
Seed [ ] = 1 Seedling [ ]= 2 Stump [ ]= 3 Other ______________ [ ] = 4

2.8 How do you obtain the planting materials for your plantation?
Self-collection [ ] =1 buying [ ] = 2 Donation [ ]= 3 Other ______________ [ ] = 4

2.9 Where do you obtain the planting materials?
Forest [ ] = 1 Private nursey [ ] = 2 Government [ ] = 3 Other farmers [ ] = 4 Other ______________ [ ] = 5

2.10 What is the cost of 1 kg of seeds if you buy the seeds? _ (VND)

2.11 The spacing of teak/Indian Mahogany plantation? And what is the initial stock?

____

2.12 What silvicultural activities do you carry out on your plantation? (*Multiple answers possible)*
Weeding [ ] = 1 Pruning [ ] = 2 Thinning [ ] = 3 Other: ______________ [ ] = 4

2.13 What type of labor do you use for plantation activities?
Family labor [ ] =1 Hired labor [ ] = 2 Both [ ] = 3

2.14 Please quantify the number of laborers you use per hectare.

Type of Labour	No. of Laborers for Plantation Activities	Activities
Family labor		
Hired labor		

2.15 How many hours per day do you spend on plantation activities?
8 hours [ ] = 1 More than 8 hours [ ] = 2 Less than 8 hours [ ] = 3

2.16 Do you need to register the plantation? Yes [ ] = 1 No [ ] = 2

2.17 If yes, how much do you pay for registration fee? ______________ (VND)

Section 3: Economic performance of Teak/Indian Mahogany plantation

3.1 *Please specify year**

Activities		Unit	Unit Price	Quantity	Cost (VND/ha)	Revenue Cost (VND/ha)
Year 1	Site preparation	Man-day				
	Cleaning the burned waste	Man-day				
	Planting materials	No/ha				
	Planting materials transport cost	–				
	Lining/ marking	Man-day				
	Pitting and planting	Man-day				
	Weeding	Man-day				
	Firebreak	Man-day				
	Tools	No/ha				
	Fertilizer Application	Man/day				
	Administrative/ Management cost	–				
	Other costs (Specify)					
Year 2	Fire Protection	Man-day				
	Weeding	Man-day				
	Replanting	Man-day				
	Other costs (Specify)					
Year 3	Fire Protection	Man-day				
	Weeding	Man-day				
	Other costs (Specify)					
Year 4	Fire Protection	Man-day				
	Weeding	Man-day				
	Other costs (Specify)					
Year 5	Fire Protection	Man-day				
	Weeding	Man-day				
	Other costs (Specify)					
Year 6	Fire Protection	Man-day				
	Pruning	Man-day				
	Other costs (Specify)					
Year*	Thinning	Man-day				
	Other costs (Specify)					
Year 25	Harvesting cost	Man-day				
	Final harvest	Man-day				

3.2 Do you transport your plantation product to the buyers?
Yes [ ] =1 No [ ] = 2

3.3 If yes, how do you transport your products, and what is the cost of transportation (Specify unit)?

____

3.4 What products do you get from your forest plantation?
Timber [ ] = 1 Pole [ ] = 2, Fuelwood [ ] = 3, Other ________________ [ ] = 4

3.5 How much timber do you produce per hectare from your plantation? (m^3/ha)

____

3.6 Please mention the products you sold and the amount of money you received.

Products	Buyer	Quantity sold	Unit price	Total income generated (VND)
Fuelwood				
Pole				
Timber				
Other (specify)				

3.7 How has the timber price changed in the last 5 years?
Stable [ ] =1 Increase [ ] =2 Decrease [ ] =3 Fluctuating [ ] =4

3.8 Do you know the reasons for these changes?

____

3.9 Indicate your perception about future demand for the plantation products.
Increase [ ] = 1 Decrease [ ] = 2 Remain the same [ ] = 3 Don't know [ ] = 4

3.10 Indicate what you think the future prices for plantation products will be like
Increase [ ] = 1 Decrease [ ] = 2 Remain the same [ ] = 3 Don't know [ ] = 4

Checklist for Key Informant Interview (District Officer)

Name of Respondent: ____________________
Designation: _ Office: ____________________
Name of District: ____________________
Date of Interview: ____________________

(1) How long have you been in this District? ____________________
(2) What are the sources of wood supply in the district?
Private plantation [ ] = 1 Government plantation [ ] = 2 Other(specify) ____________________ [ ] = 3
(3) What kinds of support are offered to the farmers?
Loans [ ] = 1 Seeds [ ] = 2 Technology [ ] = 3 Extension [ ] = 4 Other: ____________________ [ ] = 5
i. If your answer is loan, what are the interest rate and duration?
____
ii. How much does the government supply seeds per household if the answer is the seed?
____
iii. If the answer is technology, which kinds of technology/extensions do you offer to the farmers, and how many times?
____
iv. If other, please answer more details (e.g., type, duration)
____
(4) Which species do smallholder farmers prefer to grow on their farms between teak and Indian mahogany in the study area?
Teak *(Tectona grandis)* [ ] = 1 Indian Mahogany (*Chukrasia tabularis)* [ ] = 2
(5) What are the reasons for growing this species?
____
(6) How much do you think is the rough estimate for the cost per hectare for teak/ Indian mahogany plantation (from establishment to harvesting)?
____________________ (VND)
(7) Is there any market access for the smallholder farmers for their teak/ Indian mahogany plantation products?
____
(8) What is the price of timber per tree?
Teak: ____________________ (VND) Indian mahogany: ____________________ (VND)
(9) What do you think is the future demand for plantation products?
Increase [ ] = 1 Decrease [ ] = 2 Remain the same [ ] = 3
(10) What do you think the future prices for timber from teak and Indian mahogany will be like?
Increase [ ] = 1 Decrease [ ] = 2 Remain the same [ ] = 3