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Contribution of Small-Scale Acacia Hybrid Timber Production and Commercialization for Livelihood Development in Central Vietnam

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Abstract: Forming a backbone of the wood supply in Vietnam, approximately 50% of plantation areas are managed by individual households. Of the planted species, the Acacia (Acacia auriculiformis A. Cunn. ex Benth. × Acacia mangium Willd) hybrid is one of the most preferred by timber growers. Yet, information on the potential of this timber species for rural livelihoods is lacking. Taking Nam Dong and Phu Loc districts in Thua Thien Hue province as case studies, this paper aimed to explore the (i) characteristics of small-scale Acacia hybrid timber producers; (ii) contribution of Acacia hybrid timber production and commercialization to rural livelihoods; and (iii) socio-economic and contextual factors which determine the income from Acacia hybrid timber. We applied a mixed-methods approach including review of secondary data, interviews of 26 key informants, eight focus group discussions, direct observations and a survey of 300 Acacia hybrid producer households selected through multistage and purposive sampling. Qualitative and quantitative data were analyzed using thematic, descriptive and inferential statistics, such as variance analysis, correlation analysis and Bayesian model average (BMA) analysis. The results demonstrated the diversity of socio-economic characteristics, resource access and management as well as determinants of timber income of small-scale timber producers between the cases. Accounting for 33–56% of total household income, Acacia hybrid timber plantations played a crucial role in the current livelihood system. Nevertheless, timber income was skewed toward the wealth status of timber producers and ranged between 327 USD/household and 3387 USD/household in Nam Dong and between 397 USD/household and 9460 USD/household in Phu Loc district. Despite the substantial contribution the income from Acacia hybrid plantations could make to local poverty reduction, it was the main contributor to the overall income inequality. While this income source reduced the Gini coefficient by 1% in Nam Dong, it increased the Gini coefficient by 18% in Phu Loc district. Our study can be of interest for further policy interventions focusing on sustainable reforestation and livelihood development in Vietnam.

Keywords: plantation forests; small-scale producers; livelihood strategy; poverty alleviation; income inequality

1. Introduction

The role of forest resources for rural livelihoods in the tropics and subtropics has been increasingly recognized since the 1970s [1–3]. According to FAO [4], approximately 1.3 billion people depend on
forests for their livelihoods in these regions. Halting deforestation and forest degradation, improving the livelihoods of forest communities, and poverty reduction have been defined as the central forest management priorities in the tropics [1,5]. While the nature and management of forest resources are locally specific, relatively little knowledge has been contributed on specific management regimes and the economic opportunities they provide at the local level [2].

Given the increasing global timber demand, especially since the early 2000s, timber supply has shifted from natural to plantation forests [6]. By engaging small-scale timber producers, forest plantations have expanded in a number of countries, such as China, India and Thailand [7,8]. In Vietnam, the government has released a policy of allocating degraded forest land to smallholder households since the 1990s [9]. This policy aimed to promote environmental sustainability, the development of the domestic wood-based industry and rural livelihoods. As a result, planted forests increased from around 0.7 Mha in 1990 to 4 Mha in 2015 [10]. About half of the plantation forests are under the management of individual households normally holding less than 5 ha of plantation area, mentioned here as small-scale producers, and contribute to the livelihoods of millions of rural households [11]. Accounting for about 40% of the total Vietnamese plantation forests in 2016, Acacia species, especially Acacia auriculiformis × Acacia mangium hybrids, are popular and widely cultivated in Vietnam mainly due to their high suitability for local conditions, their early benefits and the low upfront investment they require [10,12].

The geographical focus of this study was on the northern-central coastal region of Vietnam, which is one of the poorest regions of the country [3] with large areas of plantation forests [13,14]. The existing literature has explored the performance of timber production in this region; yet, the focus has been mainly on technical aspects (e.g., [15]) or the financial viability of timber plantations in different management regimes (e.g., [16]). To our knowledge, no efforts have been made to date to thoroughly examine the impacts of Acacia hybrid timber production and commercialization systems on rural livelihoods. Using a comparative analysis of multiple cases representing the diversity of plantation forests and their management, this study aims to provide an improved understanding of the livelihood development potential of Acacia hybrid timber. This paper specifically aims to (i) understand the general characteristics of small-scale timber producers; (ii) demonstrate the contribution of timber production and commercialization to rural livelihoods; and (iii) explore the socio-economic and contextual factors that determine the timber income. The term “Acacia hybrid timber plantations” was used to refer to stands of Acacia hybrid species planted for industrial purposes in the forest and non-forest zones. Information on rural livelihood development was mainly collected from household surveys and triangulated with the literature, key informant interviews, group discussions and direct observations. The results are of relevance for further evaluation and the formulation of policies promoting reforestation and the improvement of rural livelihoods.

2. Timber Products in Rural Livelihood Development

Discussions on the livelihoods of forest-reliant people have mainly focused on non-timber forest products over the past half century, while timber has been considered as an out-of-reach-resource for rural people [1]. This could be attributed to the high entry costs resulting from the required economies of scale for timber production [17], the shortage of legal rights for wood-based resource access [18] and the high risks related to the long forest rotation [17]. Given the rapid expansion of plantation forests worldwide [19,20], the effects of wood production on local communities are increasingly being considered. However, the interest was initially mainly on large-scale plantations managed by private enterprises or government (e.g., [21]). Since the late 1980s, small-scale, but market-oriented timber plantations have expanded quickly, with a considerable impact on the global timber market [19,22,23]. As a result, the livelihood system of producers, including the relevant impacts of tree planting and marketing activities, has received growing attention.

In most plantation areas, exotic species, especially Acacia spp., Eucalyptus spp. and Pinus spp. dominate due to their simple cultivation, fast-growth and high adaptability to harsh sites [24].
The benefits of timber production vary across regions or even across households within a community. For illustration, timber can serve as a cash income source [8], especially when it is of high value. Tree planting is also a strategy to diversify livestock raising and other livelihood activities, as has been reported in China [8], Ethiopia [25] and Kenya [26]. This is mainly because timber production requires less regular labor than other livelihood activities, such as annual cropping. Furthermore, trees can serve as savings accounts to fulfill urgent cash needs [26,27]. In highland Guatemala, Córdova et al. [28] have shown that timber was mainly used for subsistence purposes, such as construction and firewood, due to the high energy needs.

Some studies assessed the financial profitability of small-scale timber plantations in different management regimes. For example, Maraseni et al. [29] compared the returns from Teak (*Tectona grandis*) plantations in Lao PDR on better and poorer sites with rotation periods of 18 and 24 years, respectively. Results demonstrated that Teak plantations were profitable with an internal rate of return (IRR) between 15% and 20% and a net present value (NPV) between 608 USD/ha and 1659 USD/ha [29]. At the same time, past studies accentuated that timber plantations could increase household income [2,30–32]; however, quantitative evidence was rare. Only a limited number of publications investigated the growers’ livelihood strategies. For example, in mountainous regions of Hainan island, China, Li et al. [8] estimated that net plantation income contributed more than 46% of total annual net household earnings. However, this also included income from intercropping, such as of *Alpinia oxyphylla*, and did not refer to earnings from timber only. A study of McWhirter [33] carried out on Acacia plantations in central Vietnam illustrated their importance for livelihoods given the average profit (not discounted) of around 2000 USD/ha in the first rotation and up to 3000 USD/ha in the second rotation (mean rotation = 5.5 years). However, poor management limited the contribution of forest plantations to livelihood improvement, as reported widely from Asia [34] or Africa [35]. In order to enhance the timber producers’ livelihoods, improvements such as the establishment of outgrower schemes or timber producer cooperatives were proposed [26]. In contrast, with 2–9% of total annual net household income, the contribution of timber to livelihoods in Bhutan and Ghana was relatively low [36,37]. Moreover, Trædal and Vedeld [38] demonstrated the difference between poor and non-poor growers with regards to the particular timber plantation income generated. These and similar accounts clearly illustrate how manifold and varied the impacts of timber production and commercialization on rural livelihoods are. Therefore, comprehensive analyses of specific cases are a necessary pre-condition for planning and strategy development.

3. Materials and Methods

3.1. Study Area

Thua Thien Hue province is located ca. 700 km south of Hanoi, the Vietnamese national capital (Figure 1). Central Vietnam has a complex topography including forested mountains, hills, plains and sea [39]. In 2016, the province’s forest cover was 62%, which was above the national average of 40.8%. With 385,000 ha, Acacia hybrid plantations accounted for approximately 85% of total planted forest area and contributed more than 4 million m³ of timber in 2016 [40].

Two Acacia production areas, named Nam Dong and Phu Loc districts, were selected as embedded case study areas based on (i) the abundant distribution of Acacia hybrid plantations; (ii) the widespread involvement of local households in Acacia hybrid timber production and commercialization; (iii) the representation and diversity of environmental and socio-economic conditions; and (iv) the possibility to collect data on socio-economic characteristics of the local communities, including timber production and trade. While Nam Dong is one of the mountainous districts in Thua Thien Hue province, Phu Loc district is located in the lowland with relatively developed infrastructure and a number of wood processing companies. The households’ livelihoods depend on traditional activities such as agriculture, forestry, livestock and wage labor. Acacia hybrid plantations in particular have been reported as one of the main contributors to the development of the residents’ livelihoods (Table 1).
Figure 1. Location of the study areas. Source: Google Maps [41] and OCHA [42].

Table 1. Main characteristics of study areas.

| Variable                        | Nam Dong District          | Phu Loc District            |
|---------------------------------|-----------------------------|-----------------------------|
| Study communes                  | Huong Phu, Thuong Nhat, Thuong Quang | Loc Bon, Loc Hoa, Loc Tien |
| Geographical location           | Central Vietnam 16.2725° N, 107.9395° E | Central Vietnam 16.1250° N, 107.6707° E |
| Topography                      | Undulating with mountains and hills, Mountainous area | Plain with undulating areas, Mountainous area Mixed with upland, lowland and coastal areas |
| Accessibility                   | Low level of infrastructure, Remote areas 2 | High level of infrastructure, No remote areas |
| Dominant ethnic groups          | Kinh 3, Co Tu 4             | Kinh                        |
| Economic structure              | Traditional cultivation     | Traditional cultivation     |
| Acacia hybrid plantation forest area (ha) | 4214 (81% of plantation area) | 11,640 (82% of plantation area) |
| Number of households involved in Acacia hybrid timber production (No.) | 1781                        | 3213                        |
| Number of wood processing firms (No.) | 1–3                        | 18–20                       |

Source: Field research (2018, 2019). 1 Commune is the smallest officially recognized administrative unit in Vietnam. 2 A commune was considered remote when (i) its center was far away from the provincial center or the national highways, or (ii) its geographical location made it rather difficult to access as compared to other communes in the same province [43]. Table S1 presents the relative locations of study communes. 3 Kinh is the majority ethnic group in Vietnam, accounting for more than 80% of the total national population. 4 Co Tu is one of the main ethnic minorities in central Vietnam, accounting for approximately 41% of total population in Nam Dong district in 2012 [44].

3.2. Data Collection

Qualitative and quantitative data collection methods were combined to gather primary and secondary data [45,46]. Prior to the fieldwork, secondary data was examined to obtain an overview
of the study areas and the production and commercialization system of Acacia hybrid timber in these regions. Primary data was collected in two phases. The first phase, from March to July 2018, mainly aimed at a preliminary examination of the feasibility of research. The second phase, from June to November 2019, served to collect empirical data in both sites. The main data collection methods were a household survey with household heads and (or) senior household members; interviews with 26 key informants; eight group discussions; and direct observation to acquire a deeper understanding and to substantiate the information gathered through interviews. The Vietnamese or required ethnic language was used to conduct surveys. Data were recorded in Vietnamese and translated into English by the first author.

To select our sample, three communes in each district were firstly selected, and then three villages in each commune were chosen primarily based on the abundance of Acacia hybrid plantations. The lists of timber producers were extracted from the commune household databases, and households were classified based on income status. According to the decision number 59/2015/QD-TTg of the Prime Minister of Vietnam, households are classified into five income groups including lowest, low-mid, middle, mid-upper and upper based on a multidimensional approach. For example, a household is considered part of the lowest group if the monthly average income per capita is 30.92 USD and below, or if it is between 30.92 USD and 44.17 USD and the household is simultaneously deprived of at least three indicators measuring deprivation of access to basic social services. Given that there were no households in the upper income group involved in Acacia hybrid timber production in all cases, households were classified into four groups including lowest, low-mid, middle and mid-upper. Finally, a total of 150 households were selected in each study site for the household survey by applying a stratified random sampling approach [47]. The questionnaires used during the household interviews were structured into four sections: (i) general household characteristics, such as demographics or income sources; (ii) Acacia hybrid plantation resource endowment and management, such as establishment ways or harvesting activities; (iii) Acacia hybrid timber commercialization, such as customers and market access; and (iv) cooperation of producer households with other value chain actors, policy instruments to manage and assist plantation establishment and their perception regarding the impacts and effectiveness of government support (Appendix A).

3.3. Data Analysis

The main types of livelihood activities that producer households were involved in within the last 12 months were initially explored. The income accounting method presented by Vedeld et al. [48] was applied to estimate income from each activity. Revenue from livelihood activities was computed by multiplying the quantities sold by actual producer prices for cash income and by the average local consumer price for subsistence income. Given that mutual labor sharing was common among farmers, it was difficult to calculate labor inputs for collective activities. Therefore, income achieved from each income source was derived from the gross monetary value of the sale, and use of all relevant products (revenue), from which the sum of estimated production costs, except family labor, was subtracted.

The qualitative data from interviews, group discussions and observations were condensed, coded, categorized, compiled into themes and interpreted using content analysis. The reflective process followed sequential and repeated steps of describing complex phenomena, classifying resultant data and determining causal links and interrelationships among the data [49,50]. Besides that, a combination of descriptive and inferential statistics, such as variance analysis (ANOVA), correlation analysis and regression analysis was employed to examine the contribution of Acacia hybrid timber income to household economies and related socio-economic attributes. Furthermore, the determinants of household Acacia hybrid timber income were defined by applying Bayesian model average (BMA) analysis [51,52] in R software (Appendix B). Compared to standard approaches relying on p-values, the Bayesian approach for model selection using BIC (Bayesian information criterion) approximation is a coherent mechanism for considering model uncertainties and providing reliable results [53]. The list of socio-economic and contextual factors used for BMA analysis is presented in Table S2. Although the
identification of attributes determining household timber income could be done by using ordinary regression methods alone, the application of BMA prior to regression made the method more robust and thereby produced a more optimal variable subset [54].

To determine the relative importance of Acacia hybrid timber income, the three Foster–Greer–Thorbecke (FGT) poverty measures including poverty headcount ratio, poverty gap ratio and poverty severity index were computed by using the equation proposed by Foster et al. [55]. The FGT indices with and without Acacia hybrid timber income were compared to demonstrate the impacts of this income source on poverty reduction.

\[ P_\alpha = \frac{1}{n} \sum_{i=1}^{q} \left[ \frac{z - y_i}{z} \right]^\alpha \]

where \( P \) refers to the poverty measure defined by \( \alpha \geq 0 \) (if \( \alpha = 0 \), \( P \) measures the poverty headcount ratio; if \( \alpha = 1 \), \( P \) measures the poverty gap ratio; and if \( \alpha = 2 \), \( P \) measures poverty severity); \( y \) refers to household income in increasing order; \( z \) refers to the national poverty line; and \( q \) is the number of poor individuals. Households in rural areas were considered poor if their average income per capita was <30.92 USD/month (corresponding to the Vietnamese national poverty line for the 2016–2020 period).

In addition, the Gini decomposition method was used to measure the effect of Acacia hybrid timber income on reducing income inequality. According to Lerman and Yitzhaki [56], the marginal effects of each income source were expressed using the following equations:

\[ G_T = \sum_{k=1}^{k} S_k G_k R_k \]

\[ \frac{\partial G_T}{\partial k} = \frac{S_k G_k R_k}{G_T} - S_k \]

where \( G_T \) refers to the Gini coefficient of total household income; \( S_k \) refers to the share of total income by each income source; \( G_k \) refers to the Gini coefficient of each income source; and \( R_k \) refers to the Gini correlation between each income source and the cumulative distribution of total income.

4. Results

4.1. General Characteristics of Small-Scale Acacia Hybrid Timber Producers

Table 2 presents the characteristics of small-scale Acacia hybrid timber producers in the study areas. Male-headed households accounted for up to 90% of the samples in both districts, with their average age ranging from 50 to 60 years. The mean household size in Nam Dong district was 18% higher than that in Phu Loc district, which could be an indicator of family labor availability. Regarding educational level, 44% of the interviewees in Nam Dong and 43% in Phu Loc district only attained primary school.

Standing at 75% in Nam Dong and 84% in Phu Loc, Acacia hybrid plantations occupied a major part of the average producers’ land holding in both districts. The travel time from the villages to the plantations was 48 ± 65 min in Nam Dong district, which was three times higher than the time required in Phu Loc district (17 ± 14 min). In addition, Acacia hybrid plantations were located further away from processing firms (32 ± 14 km) in Nam Dong district compared to Phu Loc (19 ± 9 km).
Table 2. Characteristics of small-scale Acacia hybrid timber producers in Nam Dong and Phu Loc district.

| Indicators                                | Unit            | Nam Dong (n = 150) | Phu Loc (n = 150) |
|-------------------------------------------|-----------------|--------------------|-------------------|
|                                           | Mean Sd         | Mean Sd            |
| Socio-economic characteristics            |                 |                    |
| Household head’s age                      | Years           | 50.4 14.2          | 60.3 11.8         |
| Family size                               | No.             | 5.1 1.2            | 4.3 1.7           |
| Educational level                         | Schooling years | 5.6 4.0            | 6.0 3.8           |
| Total land holding                        | ha              | 3.3 2.8            | 4.0 6.0           |
| Total income                              | USD/year        | 4415.4 3553.6      | 5219.2 8791.2     |
| Acacia hybrid timber plantation characteristics |                 |                    |
| Acacia hybrid plantation area             | ha              | 2.4 2.4            | 3.4 5.5           |
| Acacia hybrid income                      | USD/year        | 1451.4 1751.1      | 2947.1 8201.7     |
| Experience                                | Years           | 12.7 7.6           | 16.3 7.3          |
| Distance to Acacia hybrid plantation area | Minutes         | 48.0 65.3          | 16.8 14.0         |
| Distance to processing companies          | km              | 32.3 14.4          | 19.4 9.4          |

Source: Field research (2018, 2019).

4.2. Involvement of Producers in Acacia Hybrid Timber Production and Commercialization

4.2.1. Acacia Hybrid Woodland Resource Access

In the study areas, small-scale Acacia hybrid plantations could be established through three main ways: (i) the allocation of mostly barren and degraded land from government; (ii) reclaiming of uncultivated land; or (iii) conversion from other land uses, such as crops (Table 3). Forest land allocation (FLA) in Thua Thien Hue province was implemented in the early 1990s with the financial support of the FAO [57]. The FLA procedure is normally initialized with a request letter prepared by individual households, indicating their desired land size, land type (e.g., barren or covered by trees, etc.), land location and land use purpose. The letter has to be certified by the commune office. After considering the available land resource, household conditions and the number of household residents, the commune office submits the approval to the district people’s committees for releasing a written land allocation decision for households [58]. Our correlation analysis has shown that the current Acacia hybrid plantation holdings and household size were statistically correlated in Nam Dong (p = 0.008), even at low levels of explanation (R-square = 0.017), but not in Phu Loc district (p = 0.500, R-square = 0.037, sig. = 0.05). Furthermore, most timber growers owned land use certificates called “Red Books” with a duration of 50 years (Table S3).

Table 3. Acacia hybrid plantation establishment ways in Nam Dong and Phu Loc districts.

| Acacia Hybrid Plantation Establishment Methods | Proportion of Respondents (%) |
|-----------------------------------------------|-------------------------------|
|                                               | Nam Dong (n = 150) | Phu Loc (n = 150) |
| Government allocation                         | 24.7                         | 36.0             |
| Reclaiming uncultivated land                  | 55.3                         | 61.3             |
| Converting other land uses                    | 20.3                         | 11.3             |
| Others                                        | 25.7                         | 18.2             |

Note: Interviewed households could report more than one way for Acacia hybrid plantation establishment. Source: Field research (2018, 2019).

Poor and non-poor households were found to be involved in Acacia timber production and commercialization to different extents (Table 4). While agricultural land was distributed between income groups in a relatively egalitarian way, Acacia hybrid plantation holdings varied remarkably
between households and increased with the wealth status of the producers (Figure 2). The analysis of variance (ANOVA) indicated a statistically significant variation in Acacia hybrid plantation holding size across the income groups in both districts (F = 26.523 in Nam Dong and F = 37.773 in Phu Loc district). Similarly, the correlations between the households’ Acacia hybrid planted area and their total land holdings (R-square = 0.879, p = 0.000 in Nam Dong and R-square = 0.988, p = 0.000 in Phu Loc) and total income (R-square = 0.662, p = 0.000 in Nam Dong and R-square = 0.365, p = 0.000 in Phu Loc) were significant.

**Figure 2.** Distribution of main land-use types by income groups in Nam Dong and Phu Loc districts. Source: Field research (2018, 2019).
Table 4. Acacia hybrid plantation holdings by income groups in Nam Dong and Phu Loc districts.

| Income Groups | Nam Dong (n = 150) | Phu Loc (n = 150) |
|---------------|-------------------|-------------------|
|               | Mean (ha) | Sd   | Mean (ha) | Sd   |
| Lowest        | 0.9   | 0.6  | 0.6  | 0.5  |
| Low-mid       | 1.5   | 0.8  | 0.8  | 0.6  |
| Middle        | 2.5   | 1.3  | 2.1  | 1.9  |
| Mid-upper     | 5.0   | 3.8  | 9.7  | 8.1  |

Source: Field research (2018, 2019).

4.2.2. Acacia Hybrid Woodland Management

Up to 90% of timber growers in Nam Dong and 75% in Phu Loc used low-quality local seedlings, leading to the production of easily breakable wood. Given that the major tending, such as weeding and thinning (if any), was only performed during the first years after establishment and only minimum protection was implemented, such as against browsing, the management of Acacia hybrid planted areas required low amounts of regular labor. The planting of Acacia hybrids required relatively low funds as compared to alternative investment options. For example, participants in group discussions estimated that the capital requirement for rubber (Hevea brasiliensis) plantations reached up to 2650–3534 USD/ha, while the costs for Acacia hybrid establishment ranged from 663 to 883 USD/ha. These costs represented the total establishment cost per ha of rubber (5–6 first years) and Acacia plantations (4–5-year rotation plantations). As they were roughly estimated by timber producers in the group discussions, these monetary values were not discounted. Plantation owners preferred to grow Acacia hybrids as single-tree species in a high density of approximately 4000 trees/ha, while the recommended density for high-value Acacia hybrid plantation was 1333–1600 trees/ha.

Producers prematurely harvested Acacia hybrid timber before the end of the rotation of 4 years in Nam Dong and 5 years in Phu Loc district, mainly for woodchip production. All respondents reported that plantations were clear cut at the rotation age, and fields were normally burned after timber harvest (93% of households in Nam Dong and 86% in Phu Loc district). FSC certification schemes were introduced in Thua Thien Hue province and have been implemented in Phu Loc district since the 2000s. As a result, approximately 22% of the interviewed households in Phu Loc were involved in FSC-certified forest plantations. In Nam Dong, only 10% reported their current involvement in this certification scheme. Members of FSC groups generally applied more sustainable cultivation techniques, such as no pesticide utilization and longer rotations of 7–8 years.

4.2.3. Drivers of Involvement in Acacia Hybrid Timber Production and Commercialization System

According to the data collected from local authority offices and group discussions, around 80% of the households in Nam Dong district were engaged in Acacia hybrid timber production. In contrast, only 35% of the households in Phu Loc participated in this system, primarily driven by the shortage of woodland resource access and/or the availability of alternative economic activities. However, all the village members were interested in the Acacia timber business.

Various reasons were given by timber producers for their participation in Acacia hybrid timber production and commercialization. The most frequent motivations were related to the favorable financial and technical conditions and suitability of this production system with local soil conditions (Figure 3). A large proportion of growers (66% in Nam Dong and 87% in Phu Loc district) considered Acacia hybrid timber production and trade as a financially attractive business for early cash income. More than 70% of the respondents emphasized that Acacia hybrid species fit well to the locally eroded and stony soil conditions. The integration of Acacia hybrid plantations into existing livelihood strategies was another driving factor for small-scale producers, as stated by approximately 35% of interviewees in Nam Dong and 30% in Phu Loc. Due to the low productivity of upland crops and
the notable reduction of the natural rubber price recently, the gains from the Acacia hybrid timber business played an important role in supplementing the producers’ incomes, especially in Nam Dong (31% of respondents).

4.2.4. Engagement Level in the Acacia Hybrid Timber Production and Commercialization System

In both regions, the financial income from Acacia hybrid timber production was well recognized by the local community as a major source of livelihood. Their experience in the Acacia hybrid timber business correlated statistically with the household heads’ age in both cases (R-square = 0.254, p = 0.000 in Nam Dong and R-square = 0.051, p = 0.013 in Phu Loc). Table 5 presents the number of years in which producers were involved in the Acacia hybrid timber business. Approximately 50% of the interviewed households in Phu Loc had been engaged in Acacia hybrid timber business for more than 15 years, while the majority of producers in Nam Dong entered Acacia hybrid timber production during the last 5–10 years.

**Table 5.** Producers’ levels of involvement in the Acacia hybrid timber business in Nam Dong and Phu Loc districts.

| Producers’ Experience (Years) | Nam Dong (n = 150) | Phu Loc (n = 150) |
|------------------------------|--------------------|-------------------|
| <5                           | 12.7               | 7.3               |
| 5–10                         | 39.3               | 20.7              |
| 11–15                        | 17.3               | 22.7              |
| >15                          | 30.7               | 49.3              |

Source: Field research (2018, 2019).
4.3. Livelihood Contribution of Acacia Hybrid Timber Production and Commercialization System

4.3.1. General Livelihood Portfolio of Small-Scale Hybrid Timber Producers

According to interviews with producers, six major income sources were recorded, including agriculture, forest, fishery, livestock, wage labor and non-farm activities (Table 6). The net household average income ranged from 4414 USD/year in Nam Dong to 5219 USD/year in Phu Loc district. In addition, the annual income per capita was estimated at 865 USD/capita in Nam Dong and 1214 USD/capita in Phu Loc. However, there was no significant difference in total income between households located in the highland and lowland area (F = 1.081, p = 0.299), partially due to the similarity of their incomes derived from forest (F = 1.724, p = 0.190) and fishery (F = 0.180, p = 0.672) activities. Forest by far was the most important source of income, accounting for 49% of total income in Nam Dong and 59% in Phu Loc district. Next to the forest, agricultural crops (12%) and non-farm employment (11%) contributed to income in Phu Loc. Due to the limited land area per holding and lower productivity of upland crop production, wage and non-farm labor constituted 32% of the total smallholder income in Nam Dong district.

| Income Source (USD)         | Nam Dong (n = 150) | Phu Loc (n = 150) |
|-----------------------------|--------------------|-------------------|
| Agricultural income         | 450.5              | 632.3             |
| Total forest income         | 2157.8             | 3085.4            |
| Acacia hybrid timber income | 1451.4             | 2947.1            |
| Fishery income              | 48.9               | 58.1              |
| Livestock income            | 331.9              | 432.7             |
| Wage                        | 875.1              | 420.1             |
| Other incomes               | 551.1              | 590.6             |
| Total                       | 4415.4             | 5219.2            |

Source: Field research (2018, 2019).

4.3.2. Contribution of Acacia Hybrid Timber Income to Producers’ Livelihoods

Accounting for more than 80% of the total Acacia plantation areas in both cases, Acacia hybrid timber production and marketing provided business opportunities for producer households. An inter-case comparison suggested variations related to the level of Acacia hybrid timber income. While the households in Nam Dong earned 1451 USD/year from Acacia hybrid timber trade on average, this business made an average income of 2947 USD/year for households in Phu Loc (Table 6). ANOVA also displayed a statically significant difference in the average annual Acacia hybrid timber income between the two case studies (F = 4.771, p = 0.030).

With a share of 33% and 56% of the total household income in Nam Dong and Phu Loc, respectively, Acacia hybrid timber production and commercialization considerably contributed to rural livelihoods, especially as compared to limited income alternatives such as petty trade or salaries. The correlation between Acacia hybrid timber income and total household income was significant in both cases (R-squared = 0.663, p = 0.000 in Nam Dong and R-squared = 0.965, p = 0.000 in Phu Loc). In addition, Acacia logs constituted a considerable share of the forest income. In Nam Dong district, plantation and trade of Acacia hybrid timber logs created two times higher income than the aggregated other forest earnings (16% of total household income), for example, from natural rubber or other Acacia species. Driven by the over-representation of Acacia hybrid plantations in total households’ land holdings, this proportion was even substantially higher in the Phu Loc district. These results demonstrated that the producer households in Phu Loc depended more on Acacia hybrid timber income than those in Nam Dong.
4.3.3. Distribution of Acacia Hybrid Timber Income across Income Groups

In absolute terms, annual Acacia hybrid timber income ranged between 327 USD/household and 3387 USD/household in Nam Dong and between 397 USD/household and 9460 USD/household in Phu Loc district (Figure 4). The productivity of plantations was between 386 USD/ha/year and 680 USD/ha/year in Nam Dong, while it ranged from 651 USD/ha/year to 978 USD/ha/year in Phu Loc (Figure S1). The variance analysis confirmed statistically significant differences in the timber income between the four income groups in both sites ($F = 36.472, p = 0.000$ in Nam Dong and $F = 21.546, p = 0.000$ in Phu Loc). Regarding the extent of producers’ dependence on Acacia hybrid timber income, poor households in both cases were less dependent on income from Acacia hybrid timber business than higher-income households. The variation in the relative dependence across income groups was also statistically significant ($F = 21.02, p = 0.000$ in Nam Dong and $F = 45.01, p = 0.000$ in Phu Loc).

![Figure 4. Absolute (USD/year/household) and relative Acacia hybrid timber income by income groups in Nam Dong and Phu Loc district (relative Acacia hybrid timber income by income groups (%) = (average Acacia hybrid timber income in each group/average total income in each group) * 100) (%). Source: Field research (2018, 2019).](image)

4.3.4. Determinants of Producers’ Acacia Hybrid Timber Income

To assess how the various socio-economic and contextual factors contributed to the producers’ timber income, BMA analysis was applied. The models selected by BMA are presented in Figure 5. We selected the first model with minimum BIC (BIC = −501.69; post prob = 0.36 in Nam Dong and BIC = −69.53, post prob = 0.19 in Phu Loc) for further regression analysis.

As indicated by the adjusted R-squared values, the regression models explained between 49% and 96% of the variance in the data. In both case districts, the plantation area was the variable that had the largest impact on income. The models suggested that for every increase in Acacia hybrid plantation area by 1 Sd, there would be a 696.6 Sd increase in Acacia hybrid timber income in Nam Dong and a 1039.9-unit increase in Phu Loc (Table 7).
Nam Dong

Other significant predictor variables in Nam Dong were distance to processing company ($p = 0.000$) and to plantation area ($p = 0.000$). A 1 Sd increase in distance to companies where Acacia hybrid logs were sold led to a 10.5-unit Sd decrease in this timber income. Similarly, a 1 Sd increase in distance to plantation area caused a 1.5 Sd decrease in Acacia hybrid timber income. However, these factors only explained less than 3% of the Acacia hybrid timber income change in Phu Loc district (Table S5).

Phu Loc

Figure 5. Models of socio-economic and contextual attributes impacting Acacia hybrid timber income of producers, selected by BMA analysis in Nam Dong and Phu Loc districts. Source: Field research (2018, 2019). Note: Blue color referred to positive relation, red color referred to negative relation. The socio-economic and contextual attributes used in the regression model are presented in Table S2.
Regarding the livelihood strategy of timber cultivators, other income from agriculture, wage and non-farm activities had no significant impact on Acacia hybrid timber income in Nam Dong district. In Phu Loc district, households with higher non-farm income, such as from trading or salaries, tended to invest more in timber production, thereby generating higher relevant timber income ($\beta = 1.560, p = 0.000$). In contrast, the regression model predicted that a 1 Sd increase in other forest income resulted in a 7.6-unit Sd decrease in Acacia hybrid timber income.

Table 7. Determinants of Acacia hybrid timber income of producer households in Nam Dong and Phu Loc districts.

| Significant Attributes                  | $\beta$  | SE   | t     | Sig.  | Model Summary                        |
|----------------------------------------|---------|------|-------|-------|--------------------------------------|
| Nam Dong                               |         |      |       |       |                                      |
| (Intercept)                            | 160.710 | 78.334 | 2.052 | 0.042 | *                                    |
| Acacia hybrid plantation area (ha)      | 696.616 | 11.380 | 61.214 | 0.000 | *** R-square = 0.960; F = 1476; $p < 0.000$ |
| Distance to plantation area (minutes)   | $-1.524$ | 0.426 | $-3.582$ | 0.000 | ***                                    |
| Distance to processing company (km)     | $-10.538$ | 2.014 | $-5.233$ | 0.000 | ***                                    |
| Phu Loc                                |         |      |       |       |                                      |
| (Intercept)                            | $-2906.974$ | 1127.903 | $-2.577$ | 0.011 | *                                    |
| Acacia hybrid plantation area (ha)      | 1039.932 | 115.403 | 9.011 | 0.000 | *** R-squared = 0.489; F = 28.74; $p < 0.000$ |
| Other forest income (USD)              | $-7.593$ | 2.304 | $-3.296$ | 0.001 | **                                    |
| Non-farm income (USD)                  | 1.560   | 0.437 | 3.568 | 0.000 | ***                                    |
| Number of family labor involved (No.)   | 960.307 | 366.617 | 2.619 | 0.010 | **                                    |

Note: Signif. codes: 0 ***, 0.001 **, 0.01 *, 0.05, 0.1, 1. Source: Field research (2018, 2019).

4.4. Role of Acacia Hybrid Timber Income in Poverty Mitigation and Reducing Inequality

The FGT poverty analysis showed that Acacia hybrid timber income was relatively important in mitigating poverty in both case districts. By including Acacia hybrid timber plantations in household livelihood activities, the poverty headcount ratio was reduced from 28.7% to 10.0% in Nam Dong and from 32.0% to 8.0% in Phu Loc. As a result, around 66% of poor households in Nam Dong and up to 75% in Phu Loc district were lifted above the national poverty line due to Acacia hybrid timber income. Moreover, the poverty gap and poverty severity indices were reduced from 7.6% to 1.3% and 3.3% to 0.4%, respectively, in Nam Dong and from 8.1% to 0.7% and 3.1% to 0.2%, respectively, in Phu Loc district. Despite the similar effect on poverty reduction, the impact of timber income on income inequality differed between cases. Achieving financial benefits from Acacia hybrid timber trade reduced the Gini coefficient by 1% in Nam Dong district (from 38% to 37%). In the more developed market of Phu Loc district, in contrast, the total income Gini coefficient with and without Acacia hybrid timber income was 51% and 33%, respectively, indicating an increase of overall inequality when including this timber income.

Among the other livelihood activities, agriculture emerged as the most equally distributed income source, with the Gini coefficient varying from 0.4 to 0.5 in both cases, followed by livestock income ($G_k = 0.5$ and 0.4 in Nam Dong and Phu Loc, respectively). Other sources, especially fishery and non-farm income, demonstrated a considerably more unequal distribution (Table 8). This could be linked to a large proportion of respondents involved in and obtaining income from agricultural and livestock activities. Our survey revealed that 100% households in both cases reported crop income. In addition, up to 94% in Nam Dong and 99% in Phu Loc district received livestock income. However, the proportion of households with fishery and non-farm income was only 12% and 36% in Nam Dong, and 16% and 52% in Phu Loc, respectively.

While Acacia hybrid timber income contributed 37.7% to total inequality in Nam Dong district, a substantially higher contribution was observed in Phu Loc with 77.9%. Furthermore, the relative marginal effect of Acacia hybrid timber income was 0.05 in Nam Dong, meaning that a 10% increase would increase income inequality by 0.5%. A similar trend with even higher impact was reported in Phu Loc, where a 10% increase in Acacia hybrid timber income would increase total inequality by 2.2% (Table 8).
Table 8. Gini decomposition by income sources in Nam Dong and Phu Loc districts.

| Income Sources        | Nam Dong | Phu Loc |
|-----------------------|----------|---------|
|                       | $S_k$    | $G_k$   | $R_k$ | $G_T$ | $S_G$ | $MEF_G$ | $S_k$ | $G_k$ | $R_k$ | $G_T$ | $S_G$ | $MEF_G$ |
| Agriculture           | 0.1      | 0.5     | 0.7   | 0.03  | 0.1   | $-0.01$ | 0.1   | 0.4   | 0.5   | 0.03  | 0.06  | $-0.1$ |
| Acacia hybrid timber  | 0.3      | 0.5     | 0.8   | 0.1   | 0.4   | 0.05    | 0.6   | 0.7   | 0.9   | 0.4   | 0.8   | 0.2    |
| Other forest products | 0.2      | 0.8     | 0.7   | 0.1   | 0.2   | 0.07    | 0.03  | 0.8   | 0.7   | 0.01  | 0.03  | 0.000  |
| Fishery               | 0.01     | 0.9     | 0.3   | 0.003 | 0.01  | $-0.002$| 0.01  | 0.9   | 0.4   | 0.004 | 0.01  | $-0.003$|
| Livestock             | 0.1      | 0.5     | 0.4   | 0.02  | 0.04  | $-0.03$ | 0.08  | 0.4   | 0.5   | 0.02  | 0.03  | $-0.1$ |
| Wage                  | 0.2      | 0.6     | 0.2   | 0.02  | 0.1   | $-0.1$  | 0.08  | 0.8   | $-0.1$| $-0.01$| $-0.02$| $-0.1$ |
| Non-farm              | 0.1      | 0.8     | 0.7   | 0.1   | 0.2   | 0.1     | 0.11  | 0.8   | 0.7   | 0.06  | 0.1   | $-0.002$|
| **Total income**      |          |         |       |       |       |         | 1.0   | 0.4   | 1.0   | 0.4   | 1.0   | 0.5    |

Note: $S_G$ = share of total Gini, $MEF_G$ = marginal effect on total Gini. Gini coefficient for north central and central coastal area was 0.39 and for Vietnam was 0.43 in 2016 [59].

5. Discussion

5.1. General Characteristics of Small-Scale Acacia Hybrid Timber Producers

Our analysis has explicitly revealed that the socio-economic attributes and resource endowments of the interviewed Acacia hybrid producers differed between cases. Producers’ household heads were dominated by men at the middle and upper age classes. The educational level of timber growers was generally low, with around six schooling years in both case areas (Table 2). Despite that, they have accumulated traditional knowledge and skills for the management and production of Acacia hybrid timber. In addition, the producers have employed their social networks, for example with timber traders to commercialize their products [60]. Acacia hybrid plantations were perceived as key natural capital for the household economy. However, they were relatively small and dispersed (Table S4), corroborating the results of Nambiar et al. [11]. Given the hilly terrain, poor infrastructure and limited number of wood processing companies in Nam Dong, the travel time from the villages to the plantations as well as the distance from Acacia plantations to processing firms was higher than that in Phu Loc district. These factors affected the productivity of timber production and the producers’ benefits from timber sale [61,62].

5.2. Involvement of Producers in Acacia Hybrid Timber Production and Commercialization

During our interviews, it was reported that in the first years of FLA implementation, poor households were less interested in forest plantation mainly due to their limited investment capability. They, therefore, did not request or were not granted large areas of forest land, or transferred or sold the land use rights they were granted (allowed since 2003) to other households [9]. The recognition of land use rights resulted in the concentration of land in the hands of a reduced number of producer households, specifically those with economic advantages. This contributed to the substantial variation of Acacia hybrid plantation holdings between households. The loss of forest resource access for marginalized households increased their vulnerability. Given the availability of support services, such as loans and the distribution of seedlings, as well as the high returns from Acacia hybrid timber production, differences between poor and advantaged households further increased, and the reclamation of uncultivated land and conversion from other land uses into Acacia tree plantations progressed rapidly. Our findings also underlined the resource control of better-off households, in line with Arnold and Townson [63]. Similarly, studies in China pointed out the unequal land distribution, in which wealthier households owned significantly more land than the lower income households [8,64].

With a Red Book, small-scale producers benefited in some ways, as they could receive compensation at a designated rate in cases of land repossession, e.g., for governmental projects, or they could access loans from financial organizations for timber production. Besides that, it was a prerequisite for the
verification of legal timber production and thus crucial for international market access [9]. Nonetheless, the plantation management practices of these timber producers were typically at a low level with a preference for premature harvests. Causes could be the high demand for woodchips from the paper and particle board industry, ease in harvesting and transportation and a relatively simple cultivation technique [65,66]. In addition, there is a high risk of natural disasters occurring every 4–5 years in the central part of Vietnam. Floods and storms can damage stands, even in few hours, thereby reducing the attainable timber price [43]. During our interviews and group discussions, timber growers perceived early timber harvest as a manner to limit the risks from destructive typhoons. The additional prevalence of clear cut and burning fields after timber harvest may increase the risks of fungal infection and land degradation according to reports from Vietnam [67] and Indonesia [68]. The implementation of FSC certification schemes in Thua Thien Hue province was in line with the government policy directed at improving the quality and quantity of domestic timber sources [11,66]. Most of the interviewees in our research underlined that beneficial gains through price premiums between FSC and non-FSC sawlogs of approximately 12% were key incentives for participating in FSC groups. Members of these groups generally had better access to markets, market information and support services such as credit or training programs. They also had to follow the groups’ regulations, such as paying annual membership fees of 2.2 USD and a fee of 7% on the price differential between certified and non-certified logs. Additional paperwork was required by members for FSC-log transactions, such as filling in harvesting and transportation forms. (In Thua Thien Hue province, World Wide Fund for Nature and Scansia Pacific (https://www.scansiapacific.com) recently have supported FSC certification and covered related expenditures (e.g., assessment cost)). However, the advantages of FSC certification for the producers’ livelihoods and social and environmental enhancement were still questionable [69,70].

Even considered as a new land use system [11], Acacia hybrid plantations have been accepted as a stable and long-term income source for small-scale timber growers. As Phu Loc was the first district in which Acacia species were planted in Thua Thien Hue province, the producer households typically had more experience in timber production and trade than those in Nam Dong district. In Nam Dong district, forest land allocated for plantations was originally swidden land of local communities, and plantations were of low quality. Therefore, FLA compliance was generally not of interest to most local households in this area at the beginning [58]. The subsequent introduction of high-yielding forestry tree species, such as *Acacia* spp., *Eucalyptus* spp. and rubber led to a rapid expansion of tree plantations in this district. Due to the attractive market conditions for rubber latex, a large proportion of households established rubber plantations [57,58], especially during the early 2000s. At the same time, Acacia hybrids were introduced in Thua Thien Hue province that were more profitable and adaptable than parent species [71]. The decrease of the natural rubber price in recent years induced the communities to engage in the production and trade of Acacia hybrid timber regardless of their social and financial status. This confirmed that the land-use change towards Acacia hybrid timber plantations was mainly driven by financial income options, in alignment with a study by Thiha [72].

5.3. Livelihood Contribution of Acacia Hybrid Timber Production and Commercialization System

The households in the two cases engaged in similar livelihood activities that were mostly related to natural resource extraction. This is common in other parts of Vietnam [73] and elsewhere [74]. Given the variation in socio-cultural and environmental conditions, however, the income contribution from each income source differed across the two cases. Among the income sources of producer households, our findings highlighted the importance of forest-based products for livelihoods, corroborating similar reports from elsewhere [75,76].

Our analysis also clearly demonstrated the potential of Acacia hybrid timber in generating cash income for improving and diversifying livelihoods [77]. The financial benefits derived from the timber business were even higher than the aggregated earnings from farming and livestock, which traditionally were important rural livelihoods. This confirmed the financial significance of woodlands and tree resources in Vietnam [73,78]. Across the study areas, the Acacia timber income source differed at a
statistically significant level. Contributing factors could be the poorly developed timber markets and
managed timber plantations in Nam Dong as compared to Phu Loc district.

In both cases, the earnings from Acacia hybrid plantation forests increased with the income of
timber producers. This implied that better-off households generated higher incomes from timber
production and commercialization than the poorer ones, which could be attributed to their better access
to resources and markets. This was a commonly reported trend in Vietnam [38,73] and elsewhere [79].
In addition, the absolute Acacia hybrid income of mid-upper timber growers was substantially higher
than that of those in the three lower income groups, especially in Phu Loc district. Our results, therefore,
concurred with the argument that the development of forest product commercialization may increase
barriers for the poor to participate in the economic benefits from these resources, driven by the better
resource and market access of their better-off counterparts [63,74]. Similarly, the relative contribution
of Acacia hybrid timber income to the household economy increased from the lowest to mid-upper
income group. These findings contradict results that identified a strong forest-poverty link and higher
relative reliance of poor households on forest and other environmental incomes [28,64,80]. On the other
hand, they underline the commercial potential of Acacia hybrid timber for both poor and non-poor
producers. Yet, as a matter of fact, with the increasing commercialization of timber products, wealthier
households seem to capture potential business opportunities more successfully [74,81].

The results of the regression analysis indicated that income from Acacia hybrid timber production
and commercialization was determined by different socio-economic and contextual attributes. In both
case districts, the Acacia hybrid plantation area was positively related to timber income. This was
commensurate with other studies in China [8] and Ethiopia [74]. In contrast, the coefficients of distance
to plantation area and distance to processing company in Nam Dong district had negative signs. Potential explanations were related to the limited access to processing firms and poor infrastructure
in this area. Past studies also have highlighted that small-scale timber growers whose plantations
were close to processing companies or their homes could receive higher log prices [82] or reduce tree
planting costs [83] and hence obtained higher returns. In Phu Loc district, non-farm income had a
positive relation with timber income. The main driver was no labor competition between Acacia
hybrid plantation and these non-farm activities. On other hand, households achieving higher incomes
from other forest products, such as Pine (Pinus) or Acacia mangium were less interested in Acacia
hybrid income, demonstrating the substitutive relationship between Acacia hybrid timber and other
forest income.

5.4. Role of Acacia Hybrid Timber Income in Poverty Mitigation and Reducing Inequality

The FGT poverty analysis indicated that timber income contributed to reduce poverty in both
case districts. Furthermore, the effect of Acacia hybrid timber business on poverty alleviation is
higher in Phu Loc than that in Nam Dong district. This was because timber was the most important
income source for producer households, especially in Phu Loc district. Our results were, therefore,
comparable to the contribution of aggregated forest-based income to poverty alleviation in Nigeria [84]
and Ethiopia [74]. Moreover, a comparison between the three poverty indices revealed the relatively
higher impact of Acacia hybrid timber income on poverty severity compared to the poverty gap and
the poverty headcount across cases. Thus, Acacia hybrid income was more important for reducing the
depth and distribution of poverty than for simply scaling down the number of poor in these areas [85].
Even though the reduction was quite modest, our results confirmed that Acacia hybrid timber income
contributes to mitigating the income disparity in the mountainous area. This was consistent with
the findings of Li et al. [8] pointing out the contribution of plantations to reducing income inequality,
especially in rural communities where markets for plantation products were not well developed and/or
these products were of low value.

Among household’s income sources, Acacia hybrid timber income was one of the main contributors
to overall income inequality. Causes were that (i) Acacia hybrid timber income was the largest
contributor to total income; (ii) Acacia hybrid timber income source was unequally distributed;
and (iii) it was most closely correlated with the distribution of total income as compared to other sources ($R_k = 0.8$ and $0.9$ in Nam Dong and Phu Loc, respectively) (Table 8). The higher impact of Acacia timber hybrid income on total income inequality was also recorded in Phu Loc than that in Nam Dong district. This was associated with the larger share of Acacia hybrid income in total income, the more unequal timber income distribution and the stronger correlation of Acacia hybrid income with total income in Phu Loc.

As presented previously, Acacia hybrid timber and forest income were skewed towards the high-income groups. This reflected that an increment in Acacia hybrid timber income likely benefited the better-off households more than poorer households. Similar findings were reported by Nguyen and Tran [3] who recorded that productive forestland and forest products were more accessible and profitable for the better-off households and that forest income could increase total income disparity among populations in north central coastal Vietnam. On the other hand, Tuyen [86] found that forest income had a negative marginal effect on total Gini ($-0.035$), and therefore enhancing forest income could reduce the income inequality among ethnic minorities in northwest Vietnam. This might be attributed to the more even distribution of forest income among households in the mountain areas of northwest Vietnam [86], and the difference between these studies in terms of databases, study locations and study time [3].

5.5. Limitations of the Study

While we believe that this study represents a useful analysis of the impacts of Acacia hybrid timber production and trade on rural livelihood in Vietnam that can guide further policy considerations, we are aware of its limitations. Firstly, our income data was based on recall, which possibly may have limited data reliability. We aimed to tackle this potential weakness through triangulation with village leaders and group discussions. In addition, the impacts of current timber management mechanisms, for example, the clear cut of premature plantations or field burn after harvesting on the environment displayed in this study, were rather simple. Thus, further studies are recommended to more profoundly investigate the influence of such timber plantations on the environment, e.g., in terms of resources overexploitation and biodiversity loss. Lastly, the use of cross-sectional data limited us in capturing the changes in household livelihoods and poverty status over time. Future studies should use panel data to complement our results.

6. Conclusions

Our comparative analysis found that Acacia hybrid timber production in the study areas was market-oriented. The plantations provided an income-generating activity which formed an essential part of rural livelihoods in central Vietnam. Yet, the financially advantaged households were more likely to own larger woodlots than the poorer households. As a result, Acacia hybrid timber income was skewed toward the wealthy producers, especially in cases of increased timber product commercialization. Given economies of scale in establishing and managing plantations that are related, e.g., to increased labor costs for small and dispersed areas, poor timber growers could be trapped in poverty. Furthermore, well-developed market conditions facilitated the establishment of Acacia hybrid plantations and induced a higher level of livelihood dependence on Acacia hybrid timber. Hence, while Acacia hybrid timber income reduced rural poverty, it tended to intensify income inequality.

Our findings may have important implications for policies that attempt to enhance the contribution of industrial timber plantations to rural livelihoods. In Vietnam, forestry policies have created prerequisite conditions such as the availability of land and financial resources required for the remarkable expansion of small-scale plantation forests. Nevertheless, local communities, especially poor households can only benefit from these incentives if they are able to access forest land and other productive assets. Further policy interventions are therefore needed that directly aim to narrow the differences in land availability between producer households and particularly improve land access for the poor. To facilitate investments, a rural micro-finance system should also support poor producers.
Improving income from plantations can also improve overall social development by providing better access for households to other services. However, poverty alleviation programs should also consider the potential risks emerging from the increased dependency of households on timber plantations, such as through price fluctuations, tree diseases and natural hazards. Furthermore, forest landscapes serve multifunctional objectives including economic growth, environmental protection and social development. In order to achieve sustainable development, all these concerns should be dealt with in conjunction. A multi-stakeholder approach is therefore required, taking into account the legitimate needs of all stakeholders’ groups. Further studies should deepen the understanding of the economic, ecological and social contributions of Acacia hybrid plantations to sustainable development.

Supplementary Materials: The following are available online at http://www.mdpi.com/1999-4907/11/12/1335/s1, Figure S1: Productivity/ha by income groups in Nam Dong and Phu Loc district, Table S1: Study communes and their relative locations, Table S2: Socio-economic and contextual attributes used in regression model to identify Acacia hybrid timber income determinants, Table S3: Producers’ Acacia hybrid plantation land use certificates in Nam Dong and Phu Loc districts, Table S4: Acacia hybrid plantation areas owned by producers in Nam Dong and Phu Loc districts, Table S5: Best five models of Acacia hybrid timber income determinants in Nam Dong and Phu Loc district selected by BMA analysis.

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Appendix A. Questionnaire for Producer Household Survey

| Interviewer: | Date: |
|-------------|-------|
| Interviewee: | Village/commune/district: |
| Code: | |

I. Household socio-economic characteristics

1. Household head

| Sex | Age | Marital status |
|-----|-----|---------------|

2. Education status

(1) Do not read and write | (2) Primary school | (3) Secondary school | (4) High school or higher (specify) |
|--------------------------|-------------------|-------------------|-----------------------------------|
| Schooling years |

3. Family size

| Total | Male | Female |
|-------|------|--------|
| People of working age | Male | Female |
| Number of main workers | Male | Female |

4. Ethnic group

5. Financial status

(1) Lowest | (2) Low-mid | (3) Middle | (4) Mid-upper | (5) Upper |

6. Residential status

(1) Native to the area | (2) Long-time immigrant | (3) Recent immigrant | (4) Temporary resident |
|----------------------|--------------------------|---------------------|-----------------------|
| (>5 years) | (<5 years) |

If not native, specify years of living in the area
7. Landholding

| Source | Type | Volume | Uses | Price | Important Level | Remarks (If Any) |
|--------|------|--------|------|-------|----------------|------------------|
|        |      |        | Self-Consumption | Sell |                |                  |
| Total  |      |        |                  |       |                |                  |
| Agriculture |      |        |                  |       |                |                  |
| Total forest |      |        |                  |       |                |                  |
| Acacia hybrid plantations |      |        |                  |       |                |                  |
| Fishery |      |        |                  |       |                |                  |
| Livestock |     |        |                  |       |                |                  |
| Wage |      |        |                  |       |                |                  |
| Non-farm |      |        |                  |       |                |                  |

8. Annual income sources

9. How important is the income of Acacia hybrid in your livelihood?

(1) Remarkably important, as it is the main income source
(2) Important to fill income gaps during cash shortage period
(3) Important for saving
(4) Important for capital accumulation
(5) Additional income, but not significant

10. What are the main reasons for your involvement in Acacia hybrid plantation?

(1) Economically attractive
(2) Accessibility to forest land
(3) Simple technique
(4) Reduction of other incomes
(5) Suitability for local soil conditions
(6) Ability to improve soil
(7) Labor does not compete with other activities
(8) Lack of alternative income sources
(9) Supportive policy framework
(10) Others (specify)

II. Acacia hybrid plantation resource endowment and management

11. What kind of timber species do you plant?

12. How long have you been involved in Acacia hybrid timber production (years)?

(1) <5
(2) 5–10
(3) 11–15
(4) >15
Specify how many years

13. How do you learn about Acacia hybrid plantation techniques?

(1) From family members
(2) From training/extension
(3) By doing
(4) By looking at others
(5) Other training/extension

14. Do you attend any training courses on (Acacia hybrid) timber production, harvest and trade?
15. How large is your Acacia hybrid plantation area (ha)?
(1) <5
(2) 5–10
(3) 10–15
(4) >15
Specify the area
Plantation density Age

16. How are your Acacia plantation areas established?
(1) Government allocation
(2) Reclaiming uncultivated land
(3) Converting other land uses
(4) Others (specify)

17. Do you have ownership of your Acacia hybrid plantation areas?
(1) Yes
(2) No
If yes, for how long? If no, why? who owns the Acacia woodlots?

18. Are the land resources equally accessed by timber producer households?
(1) Yes
(2) No
If no, why?

19. How do you reach your Acacia hybrid plantations?
How far? (km) By which mean of transport? In how long (minutes)?
Estimated cost (if possible)

20. Are you involved in FSC-certified timber plantations?
(1) Yes
(2) No
If yes, how large the area, how long have been involved? current age of plantations?

21. In your household, how many people involved in Acacia hybrid plantation, harvest and trade?
Specify who: sex, age group and activities involved.

22. Do you need to hire laborers for Acacia hybrid timber production and commercialization?
(1) Yes
(2) No
If yes, how many (people/ha, working days/ha), for what activities, why, estimated costs?

23. What are the main capital sources for your Acacia hybrid timber business?
(1) Self-financing
(2) Borrowing from relatives
(3) Loans from financial institutions
(4) Loans from money lenders
(5) Advance payment from buyers
(6) Other (specify)

24. Have you ever faced financial shortages to accomplish your timber production, harvest and marketing?
(1) Yes
(2) No
If yes, when, why, impacts on timber business, solutions?

25. What tools do you use in Acacia hybrid timber producing, harvesting and marketing?

| Activities | Tools | Remarks (Purpose of Use, Ownership, etc.) |
|------------|-------|-----------------------------------------|
26. Where do you buy Acacia hybrid seedlings?
(1) From seedling production companies, forestry companies, and nurseries (verified origin)
(2) From local seedling providers (no verified origin)
(3) Other (specify)
Why do you decide to buy seedlings there? Apart from your regular providers, do you know any other seedling providers?

27. Do you use fertilizers to cultivate Acacia hybrid timber?
(1) Yes
  If yes, which fertilizers, how much, when?
  If no, why?
(2) No

28. Do you burn the field after harvest?
(1) Yes
  If yes, why?
  If no, why?
(2) No

29. How long is the normal rotation of your Acacia hybrid timber plantations?
(1) \( \leq 5 \) years
  Specify how many years. Why?
(2) >5 years
  Quality of timber (diameter, branches, etc.)?
  Harvested month(s)/season(s)?

30. What constraints do you face in timber producing, harvesting and marketing?

31. Do you need to protect your Acacia hybrid plantations?
(1) Yes
  If yes, from what, previous experiences?
  If no, why?
(2) No

32. Do you harvest your Acacia hybrid plantations?
(1) Yes
  If yes, when, with whom?
  If no, why, who harvest?
(2) No

33. How much costs do you spend on Acacia hybrid timber production and harvest?

| Types of Cost       | Relevant years | Remarks (If Any) |
|---------------------|----------------|-------------------|
| I. Material and services |                |                   |
| Seedling           |                |                   |
| Fertilizer         |                |                   |
| II. Labor          |                |                   |
| Land preparation   |                |                   |
| Planting           |                |                   |
| Fertilizing        |                |                   |
| Tending            |                |                   |
| III. Other costs   |                |                   |
| Total              |                |                   |

34. How much Acacia hybrid timber do you produce in the last 3–5 years?

35. How has the productivity of your Acacia hybrid plantations changed in recent years? Why?

36. What proportion of your Acacia hybrid timber production is consumed within the households? For what purposes?
37. What benefits other than cash do you receive from Acacia hybrid timber production and commercialization?

38. For what purposes do you use the cash income from Acacia hybrid timber production and commercialization?

III. Acacia hybrid timber commercialization

39. What processing activities do you perform before selling your products?
(1) No processing (2) Peeling the bark (3) Shortening (4) Grading (5) Other (specify)

40. Do you store Acacia hybrid logs before selling?
(1) Yes (2) No
If yes, why, where, for how long, impacts the log quality If no, why?

41. Where do you sell your products?
(1) At production areas (2) At storage areas (4) At processing companies (5) Other (specify)

42. In case you sell the products outside your production areas,
(1) How far do you need to transport your products?
(2) What are transportation means?
(3) How much is the transportation cost?

43. How do you sell your products?
(1) As standing trees (2) As actual volume (3) Both

44. Who are buyers of your products?
(1) Local traders (2) Processing companies (3) Timber wholesalers (or agents)
(4) Directly to consumers (5) Sawmills or carpenters (6) Others (specify)

45. Why do you decide to sell your products to these buyers?

46. Do you face any challenges to sell your products?
(1) Yes (1) No
If yes, specify

47. Are these buyers available for your products?
(1) Yes (2) No
If yes, how many If no, why?

48. What are the buyers’ requirements for the quality of Acacia hybrid timber?

49. At which price do you sell your products?

50. Do the quality and quantity of Acacia hybrid logs sold affect the price?
(1) Yes (2) No
If yes, how? If no, why?

51. How has the Acacia hybrid log price changed in the last 5 years?
(1) Stable (2) Increase (3) Decrease (4) Fluctuating
Do you know the reasons for these changes?

52. Can you bargain the price with your buyers?
(1) Yes (2) No
If yes, how? If no, why, who decides the price?
53. Can you access price and/or market information before selling your products?
   (1) Yes  (2) No
   If yes, by which ways?  If no, why?

54. Do you satisfy with the current price of your products?
   (1) Yes  (2) No
   If no, how much the price should be, why?

55. Do you know the price at which your buyers sell to their next buyers?
   (1) Yes  (2) No
   If yes, by which ways, how much?

56. Do you think that the benefit sharing along Acacia hybrid timber value chains is fair?
   (1) Yes  (2) No
   If no, why, who benefits most?

57. Do you know the end users of Acacia hybrid wood-based products?
   (1) Yes  (2) No
   If yes, who, how do you know?

58. How much cost do you spend on marketing your products?

| Types of Cost       | Relevant Costs | Remarks (If Any) |
|---------------------|----------------|------------------|
| Processing costs    |                |                  |
| Transportation costs|                |                  |
| Taxes and fees      |                |                  |
| Others (specify)    |                |                  |
| **Total**           |                |                  |

59. How has the number of Acacia hybrid timber producer households changed in the last 5 years?
   (1) Stable   (2) Increase   (3) Decrease   (4) Do not know
   If known, specify the reasons, impacts to your timber business

60. What do you expect about the market demand for Acacia hybrid timber in the next 5 years?
   (1) Will remain stable  (2) Will increase  (3) Will decrease  (4) Do not know

61. What are the main challenges that restrict your income from Acacia hybrid timber?

**IV. Timber producers’ cooperation with other actors in Acacia hybrid timber value chains**

62. What are your relationships with other timber producers in your area?
   (1) Plant in group  (2) Transport in group  (3) Process in group  (4) Sell in group
   (5) Share tools and techniques  (6) Share information  (7) No relationship  (8) Other (specify)

63. Are there any producer’s cooperatives/organizations in your area dealing with Acacia hybrid timber production and trade?

| Name | Year of Establishment | Main Concerning Products | Membership Requirements | Services | Remarks (If Any) |
|------|-----------------------|--------------------------|-------------------------|----------|------------------|
64. Do you participate in any producer' cooperatives/organizations dealing with Acacia hybrid timber production and trade?

(1) Yes  
(2) No
If yes, what cooperative/organizations?  
If no, why?

65. How are the impacts of these cooperatives/organizations on Acacia timber production and commercialization of their members?

66. Do you receive any supports from processing companies or traders who buy your products?

(1) Yes  
(2) No
If yes, which supports, from whom?

67. Do you sign any contracts with the buyers of your products?

(1) Yes  
(2) No
If yes, with whom, for how long, your rights and responsibilities?  
If no, why?

68. Do you receive any advance payment or financial supports from the buyers of your products?

(1) Yes  
(2) No
If yes, from whom, when, how much, payment method?

69. Do you have any disputes with other actors in the Acacia hybrid timber value chains?

(1) Yes  
(2) No
If yes, with whom, when?

70. What services and supports, related to Acacia hybrid timber production and trade, have you received from individuals, governmental and non-governmental organizations?

71. Do you think that government policies and regulations are influencing your Acacia hybrid timber production and commercialization?

(1) Yes  
(2) No
If yes, which policies and regulations, how impact?  
If no, why?

72. Which traditional norms and customs have been a effecting the Acacia hybrid timber business?

73. What are your suggestions to enhance the producer’s benefit from Acacia hybrid timber production and commercialization?

Thank you very much!

Appendix B. R Code for the BMA Model

BMA analysis was employed to identify the determinants of producers’ Acacia hybrid timber income. The R code applied in BMA model is presented below. In this code, Aincome refers to Acacia hybrid income. The list of socio-economic and contextual attributes used in the regression model are presented in Table S2.

```r
#install.packages#########################
install.packages("tidyverse")
install.packages("DescTools")
install.packages("lawstat")
install.packages("Hmisc")
install.packages("MASS")
install.packages("BMA")
library("tidyverse")
library("DescTools")
library("lawstat")```
library("Hmisc")
library("MASS")
library("BMA")

# Import data
Merged_data_29_5_20 <- read_excel("R/Merged data 29.5.20.xlsx")
View(Merged_data_29_5_20)
data <- Merged_data_29_5_20 %>% mutate(district = as.character(dist))
dataND <- data %>% filter(dist == "Nam Dong")
dataPL <- data %>% filter(dist == "Phu Loc")

# Nam Dong
attach(dataND)
X = cbind(Age, Size, Edu, Land, Plan, Agri, Live, Wage, Offf, Othe, Expe, Disp, Numb, Dism)
Y = dataND$Aincome
search = bicreg(X, Y, strict = FALSE, OR = 20)
summary(search)
imageplot.bma(search)
x <- lm(formula = Aincome ~ Plan + Dism + Disp, data = dataND)
summary(x)

# Phu Loc
attach(dataPL)
X = cbind(Age, Size, Edu, Land, Plan, Agri, Live, Wage, Offf, Othe, Expe, Disp, Numb, Dism)
Y = dataPL$Aincome
search = bicreg(X, Y, strict = FALSE, OR = 20)
summary(search)
imageplot.bma(search)
x <- lm(formula = Aincome ~ Plan + Othe + Offf + Numb, data = dataPL)
summary(x)

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