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Analysis of Acacia hybrid timber value chains: A case study of woodchip and furniture production in central Vietnam

La Thi Tham [a,b,*], Dietrich Darr [c], Jürgen Pretzsch [a]

[a] Institute of International Forestry and Forest Products, Faculty of Environmental Sciences, Technische Universität Dresden, 01062 Dresden, Germany
[b] Faculty of Economics and Business Administration, Vietnam National University of Forestry, Xuanmai, Chuongmy, Hanoi, Viet Nam
[c] Faculty of Life Sciences, Rhein-Waal University of Applied Sciences, 1 Marie-Curie Street, 47533 Kleve, Germany

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ABSTRACT

Small-scale producers currently manage approximately half of the plantation forest area in Vietnam; and 80% of the plantation wood is processed into woodchips. To promote higher value uses of the plantation wood, the Vietnamese government has released a number of policies that aim at stimulating the domestic industry, especially the production of furniture and the development of timber value chains (VCs). This paper compares the financial and economic performance of three typical Acacia hybrid timber VCs, comprising woodchip, non-FSC furniture, and FSC-certified furniture in Thua Thien Hue province, central Vietnam. Data were collected from the interviews with 26 key informants, 30 timber producers, eight timber traders, one woodchip, and one furniture processing and exporting company. Results describe main actors in the analyzed timber VCs, their characteristics, functions, profits, and added value. The total added value is 26.3 USD/m^3 in the woodchip VC, 557.2 USD/m^3 for non-FSC furniture, and 663.7 USD/m^3 for FSC-certified furniture. Our comparative analysis also shows that the woodchip VC is financially profitable. However, regarding economic aspects, its performance is lowest, while the FSC-certified furniture VC contributes fundamentally to economic development. This research proves useful for generalization in terms of the analytical framework and the phenomenon of interactions between economic, social, and environmental aspects. The approach of transition towards high added value products, which is expressed in our paper, can further be applied in other comparable contextual cases searching for sustainable utilization of timber and forest-based products at large. A main theoretical proposition is proposed (P1) Stakeholders/VCs that face uncertainty or high competition in terms of essential resources and/or markets can enhance their financial performance through vertical and horizontal coordination.

1. Introduction

The rapid expansion of plantation forests in Vietnam has induced the transition from net deforestation to net reforestation during past decades (Cochard et al., 2017; Meyfroidt and Lambin, 2009). Covering about 4 Mha or 28% of total forest cover in 2015, the area of planted forest was 1.6 times higher than that in 2006 and 5.4 times higher than in 1990 (Hoan, 2014). 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 make important contributions to the livelihood of millions of rural households (Maraseni et al., 2017a; Nambiar et al., 2015). Next to the environmental and social benefits, plantations play a considerable role in sustaining the raw material supply for the Vietnamese wood-based industry, especially after the release of legal restrictions on timber exploitation in natural forests in 2014 (Tham et al., 2018). Accounting for approximately 40% of the total Vietnamese plantation forests in 2016, Acacia species, especially *Acacia auriculiformis* x *Acacia mangium* hybrids are popular and widely cultivated in central Vietnam (Harwood and Nambiar, 2016; Nambiar et al., 2015). This is mainly due to (i) their multi-purpose use for both furniture and woodchip production (Phuc, 2013); (ii) their shorter rotation compared to other plantation species, for example, Pines (Nambiar et al., 2015); (iii) their fast growth reaching a mean annual increment between 10 and 25 m^3/ha/year (Nambiar et al., 2015); and (iv) their ability as nitrogen-fixing species to reclaim and improve the quality of degraded land (Dong et al., 2014; Mendham

* Corresponding author at: Institute of International Forestry and Forest Products, Faculty of Environmental Sciences, Technische Universität Dresden, 01062 Dresden, Germany.
E-mail addresses: la_thi.tham@tu-dresden.de (L.T. Tham), dietrich.darr@hochschule-rhein-waal.de (D. Darr), juergen.pretzsch@forst.tu-dresden.de (J. Pretzsch).

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and White, 2019).

Driven by increasing global demand for timber products and notable foreign direct investments, the wood-based product manufacturing and export sector in Vietnam has developed rapidly. Of the more than 4000 timber processing firms registered in 2018, 35% were foreign-owned, joint-ventures or affiliated enterprises. Approximately 45% of all companies were involved in exports, contributing to the total sector's export turnover of 8.9 billion USD in 2018. The Vietnamese forest-based products are currently exported to over 120 countries with the main destinations of USA (42.5% of revenue in 2018), Japan (12.9%), China (11.6%), Korea (10.2%) and the EU (9.6%) (MARD, 2019). This makes Vietnam the fourth largest global furniture exporter and the largest woodchip exporter (Maraseni et al., 2017a; Phuc, 2013). Supporting factors are the country's large available workforce, low labor costs and the convenient geographical location (Hoang et al., 2015b). With the employment of more than 500,000 people, the sector contributes considerably to rural and overall national development (MARD, 2019; NEPCon and Forest Trends, 2018).

High added value products such as wood furniture generated up to 70% of the total export turnover in the timber and timber product segment in 2017 and caused a round wood requirement of 12 million m^3 (MARD, 2019; Phuc et al., 2018a). While forest plantations yielded around 18 million m^3 of round wood p.a., 80% of this volume was used for low value woodchips (Maraseni et al., 2017b). Plantation owners preferred to grow smaller industrial wood because of the high demand for woodchips, low harvesting and transportation costs and relatively simple cultivation techniques (Maraseni et al., 2017a). In addition, the premature harvest was common among small-scale producers to fulfill urgent cash needs despite the long-term negative consequences given the lower quality and price of harvested logs (Tham et al., 2020a). Hence, to meet the timber demand of the furniture processing sector, 9.7 million m^3 of raw wood material were imported in 2018, primarily from Africa, the USA, Cambodia and the EU (MARD, 2019). However, the sourcing of wood materials from various destinations (Quyen and Nghi, 2011) and the associated fluctuating raw material prices over time have negatively impacted the competitiveness of the Vietnamese wood furniture sector (MARD, 2015). Therefore, the government has introduced several policies directed at increasing the quality and quantity of the domestic timber supply and the promotion of the domestic wood processing industry, especially the furniture sector, e.g. through improving land tenure and cooperation of actors in timber value chains (VC) (Maraseni et al., 2017a; Nambiar et al., 2015).

The geographical focus of this study was on north central Vietnam because of the concentration of timber processing firms as well as the largest areas and high cover rate of plantation forests in this region (Dong et al., 2014; Iwanaga et al., 2020). Existing literature has explored the performance of the timber production and processing sector in this region; yet, the focus of past research was mainly on technical aspects (e.g. Harwood et al., 2017) or financial performance of selected stakeholders (e.g. Maraseni et al., 2017b). Some studies have adopted the VC approach (Gereffi et al., 2001; Porter, 1985; Poschen et al., 2014), however, detailed evidence on the performance of wood-based chains' actors, especially processing firms was lacking (e.g. NEPCon and Forest Trends, 2018; Quang et al., 2018). Besides that, profit was normally used as a proxy for added value leading to the lack of methodological rigor in VC analysis (e.g. Tan, 2011). To our knowledge, no efforts have been made to date to provide a reliable and accurate estimation on value addition at different nodes of timber VCs despite the intended transition towards higher-value products. Therefore, this study thoroughly applies the VC framework to analyze the performance of three typical timber VCs in north central Vietnam, particularly regarding the creation of added value and the distribution of benefits between chain participants. Our overarching goal is to provide improved information for developing the plantation policy in Vietnam. Using information collected by Rapid Rural Appraisal (RRA) tools, we compare the VCs of woodchip and furniture not certified by the Forest Stewardship Council (FSC), and of FSC-certified furniture products. The FSC-certified timber VC was of our consideration as a response to a current trend of encouraging and expanding FSC-certified plantations in Vietnam, as well as strengthening the direct linkage between timber growers and processing firms (Auer, 2012; Maraseni et al., 2017a). The timber was produced in plantations of Acacia hybrids with a rotation of 5 and 8 years. While the 8-year rotation was common practice for FSC-certified plantations, the shorter cycle was common for non-FSC woodchip and furniture products. The results of this study are of relevance for the scientific community, donors, policymakers and practitioners engaged in developing timber VCs and the forest-based products sector at large.

2. Methodology

2.1. Study site

The fieldwork for the study was carried out in Thua Thien Hue province, north central coast region of Vietnam. This province is bordered by Quang Tri province in the North, Da Nang city in the South, Laos in the West and the South Sea in the East (Fig. 1). Its topography is diverse with almost all types of terrain, such as forested mountains, hills, and plains (Tong et al., 2012). Around 62% of its land area of 503,320 ha were covered by forests in 2016. More than 210,000 ha of the total forest area are classified as natural forest and the remaining 100,171 ha as planted forest. Occupying around 85,000 ha, Acacia hybrid plantations contributed 4.2 million m^3 timber in 2016, corresponding to >70% of the total timber supply from plantation forests (Tham et al., 2018).

2.2. Data collection

We applied different RRA tools, such as key informant interviews, in-depth interviews, group discussions and direct observation to collect qualitative and quantitative data. Secondary data was mainly obtained from the Vietnam Administration of Forestry, Vietnam Timber and Forest Product Association, local authority offices and enterprises' documents. Primary data was collected in two phases. The first phase, preliminary investigation, was from March to July 2018 mainly to assess the feasibility of research. The second phase, empirical data collection, was carried out from June to November 2019. Twenty-six key informant interviews were conducted with people who have had firsthand information and experiences on timber production and commercialization system in Vietnam and study area, such as experts in governmental offices and researchers. These interviews mainly focused on the (i) evolution of Acacia timber plantations and contribution of this sub-sector to local and national development, (ii) key actors, their functions and integrations along VCs, and (iii) policy interventions and institutions related to timber production and marketing activities. The collected data were used to initially map timber VCs and adjust questionnaires for VC participants' interviews.

In-depth interviews were conducted with various VC actors. The main interviewing topics were (i) general characteristics of interviewees, such as experience and drivers for participation in Acacia timber business, (ii) timber production, processing and commercialization of timber products as well as derived cost-benefit structure, and (iii) horizontal and vertical coordination along timber VCs. For farmers, a survey of 300 households, following a stratified random sampling approach, was carried out in six communes located in two Acacia timber production areas: Nam Dong and Phu Loc district. However, the survey results are being published in a separate article (Tham et al., 2020b). Of the interviewed producers, those with excellent communication facilities and demonstrating willingness to provide comprehensive information on timber production and trade were selected for further in-depth interviews. The selection lists were cross-checked with community leaders and representatives of forest association and/or producer groups. Finally, costs and benefits for producers were taken from 20 growers managing 52 ha of non-FSC Acacia hybrid plantations and

Fig. 1. Location of the study area: Thua Thien Hue province, central Vietnam. Source: Google Maps (2020); OCHA (2020).

10 growers managing 48 ha of FSC-certified Acacia hybrid plantations. For traders, we mainly applied snowball sampling and chose eight timber traders who harvested and transported logs to processing companies. The interview mostly took place in private houses, on purchase trips or in the companies and lasted 3–4 h. A list of processing and exporting companies was provided by the provincial Department of Planning and Investment. To facilitate the cost-benefit and consequently added value calculation, we purposively selected two companies, one producing woodchips and one furniture, which were involved in both processing and exporting activities of Acacia wood-based products. At the time of this study, there were four processing and exporting woodchip companies in Thua Thien Hue province with a relatively comparable technological level. However, only one processing and exporting furniture company was functioning. In this paper, the selected chipping firm stood for the woodchip VC, while the furniture company produced both non-FSC and FSC-certified furniture products, and therefore engaged in the respective VCs. We spent 5–7 days in each company and deeply interviewed various employees, for example, director, accountant and production manager. The woodchip and furniture companies selected for this study were established 16 and 18 years ago and are well-experienced in the wood-based product business. In addition, they respectively accounted for 2.2% and 0.1% of the total national chip and furniture export revenue in 2018.[1] While woodchip was exported to China (65%) and Japan (35%), markets for furniture products were the EU (50%) and USA (50%) (Table A1).

Furthermore, eight group discussions and a number of direct observations served to validate the data collected through interviews. Participants in the group discussion included governmental officers, community leaders, producer association/group leaders, traders, companies, timber producers, researchers and practitioners. The additional focuses of these discussions were on (i) resource access and management, (ii) cooperation and integration between timber VC participants, including regulation and support services from government, (iii) roles of timber in rural development and trends for production and commercialization timber products, and (iv) constrains and potential interventions.

2.3. Data analysis

At the production stage of the VCs, costs and benefits were estimated according to the information provided by growers, including costs of plantation, maintenance, harvesting and returns from timber sales. To facilitate added value comparison in the VCs, we assumed that the timber production followed a normal forest scheme (Leslie, 1966; Openshaw, 1980), in which plantation area is divided into 5 or 8 parts of equal size in 5 and 8-year rotations, respectively, each part representing one age class. When one of these parts is harvested and reforested each year, timber growers obtain a more constant stream of annual income from their forest. While this model has not exactly been applied by timber growers in our case study, it was common that producers divided their plantations into smaller sections of different age classes to equalize income over the years. Besides operational costs, such as seedlings and fertilizer applications, the opportunity cost of land was included in the cost stream of producers as land rental value. Furthermore, the opportunity cost of maintaining inventories on the ground was considered given that timber production is a capital acquiring process (Yin et al., 1998; Yin and Newman, 1997). According to Binkley (1993) and Yin et al. (1998), the opportunity cost of maintaining inventories can be expressed as $i*p*v$, of which i refers to interest rate, p refers to current stumpage price and v refers to timber yield. Inventory is valued at current stumpage prices because it generates a capital base for timber yield in the future. In a normal forest scheme, a timber grower decides to continue a capital level of v to maintain his/her annual timber output flow, instead of liquidating it now and receiving a value of p*v. To

[1] Market share = (Company's export revenue of woodchip (furniture)/Vietnamese total export revenue of woodchip (furniture)) *100.The Vietnamese woodchip and furniture export revenue in 2018 were estimated at 1, 096,211,260 USD (annual growth rate: 2.2%) and 5,844,535,775 USD (annual growth rate: 11.8%) respectively (Phuc et al., 2018b).

calculate the opportunity costs of land and inventory, the current average discount rate of 7% was chosen (Maraseni et al., 2017b). We therefore could delineate a cost structure of timber production by compounding the expenses over years to the current year, thereby leading to a forest-level analysis of current values (Li et al., 2020a, 2020b; Yin et al., 1998). Regarding the traders and processing and exporting companies, we observed their activities and documented inputs, outputs and cost-benefit structure information. From the variety of furniture products, we selected the chair which was the most popular product, accounting for around 30% of export value in the analyzed furniture company for the financial and economic analyses.

Computation of financial profitability utilized the average reported quantities, prices, costs, benefits for each actor in the timber VCs. In addition, economic analysis employed various indicators, such as added value, return on labor, labor standard, and resource management. VC analysis serves to understand how value is created and distributed between the different stages of the transformation of products or services. Added value, therefore, is the central focus of VC analysis (Bellù, 2013; Poschen et al., 2014). According to Bockel and Tallec (2005) and Klemperer (1996), added value is the difference between revenues from total sale and cost of externally supplied inputs. Alternatively, this can be presented as the contribution of a firm to employment, government and its investors (Vedeld et al., 2004).

$$VA_i = \text{Labor costs} + \text{taxes} + \text{net profit}$$

where VA_i represents the added value at i^{th} stage. Added value for the entire VC is determined by the summation of values generated at each stage of the chain. To make the value created comparable across the different chains, we calculated the added value per m^3 of final product (Sathre and Gustavsson, 2009). Given that the measurement of price and production productivity were both in m^3 and ton, we used m^3 throughout this study for consistency. In addition, the average wood density of Acacia hybrid is 574 kg/m^3 (Maraseni et al., 2017a). Thus, a conversion factor of $1m^3 = 0.574$ ton of timber product was applied.

3. Findings

3.1. Overview of three Acacia hybrid timber VCs

Our analysis focuses on the three VCs representing the largest flow of Acacia hybrid timber produced by small-scale producers in Thua Thien Hue province, namely non-FSC certified woodchip (hereto: woodchip), non-FSC certified furniture and FSC-certified furniture. In the first two VCs, traders purchased 5-year-old non-FSC timber from plantations in the form of standing trees. After harvesting, the logs were categorized, transported and sold to the woodchip companies at 25.4 USD/m^3 (d = 5–12 cm log, debarked) or to the furniture companies at 31.7 USD/m^3 (d > 12 cm log, with bark). The timber in the FSC-certified furniture VC was produced in an 8-year rotation in FSC-certified plantations. Producers took over responsibility in timber production, harvest, log categorization and delivery to the furniture processing firms. Different institutional actors, such as the provincial People's Committees, Forest Protection Department, producer association (FOSDA),[2] and World Wide Fund for Nature (WWF) have provided administrative, technical and financial assistance to develop high value timber stands and establish the connection between small-scale timber growers and companies. The price of FSC-certified timber in sawlog-size (d > 12 cm) was 35.5 USD/m^3. After processing (and humidity check for woodchips), final products were exported at a FOB price of 75.3 USD/m^3 of dried chip, 12.5 USD/non-FSC chair and 14 USD/FSC-certified chair (Fig. 2).

3.2. Timber producer performance

Small-scale producers generally owned an average of less than 5 ha of Acacia timber plantation and were exempted from forest land tax. Accounting for approximately 50% of total household income, Acacia hybrid timber plantations played a crucial role in the producers' livelihood in the study area. Commonly, producers prematurely harvested Acacia hybrid timber for woodchip production. The main drivers were the financial attraction resulting from high market demand for woodchips and relatively simple cultivation techniques. Producers also reported a high risk of natural disasters occurring every 4–5 years in the central part of Vietnam. For example, destructive typhoons could damage stands and consequently reduce the achievable timber prices. During our interviews and group discussions, timber growers mentioned early timber harvest as a manner to limit these risks.

There was no formal cooperation among the timber growers, except in FSC groups. Most of the interviewees in our research noted that benefit gains through price premium were key incentives to participate in FSC groups. Members of these groups generally had better access to markets, market information, and support services, such as credit or training programs. As members, they 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-certified log transactions, such as filling the harvesting and transportation forms. In Thua Thien Hue province, WWF and Scansia Pacific[3] currently have supported FSC certification (e.g. meeting with certification bodies) and covered related expenditures (e.g. assessment cost). During our interviews in 2018, the annual FSC assessment fee was estimated at around 12,000 USD for a timber producer group.

Plantation forests were managed as even-aged forests. This model prescribed fixed proportions of the plantation area for certain management activities. For an area of 1 ha managed in a 5-year rotation, this implied that 1/5 was harvested, another 1/5 re-afforested, and the remaining 3/5 maintained annually. Therefore, timber sales generated an income of 530 USD/ha and a timber volume of 37 m^3/ha on an annual basis in a 5-year rotation. Similarly, the producers involved in the 8-year rotation plantations sold 39 m^3 annually. This sale made a net profit of only 1.6 USD/m^3 (Table 1).

3.3. Timber trader performance

In each village, there were about 3–6 traders with more than 10 years of experience in Acacia timber production and trade. Each of them normally owned a truck used for log transportation. With an average annual volume of about 4363 tons handled from small-scale timber producers, the Acacia hybrid timber trade constituted up to 30%–45% of their household income. To maintain their commercial benefits, they have established strong social relations with timber producers and processors. They did not have permanent employees, but each of them had close relationships with at least one harvesting team. Traders made cash payments to timber growers at the time of harvest, or even in advance. In addition, they covered various regulatory costs including income tax, business and road fees.

The financial cost-benefit structure of traders in the non-FSC Acacia hybrid timber VCs was assessed through the receipts from timber selling and cost of harvesting, transportation and sale of timber from 5-year rotation plantations. The price paid to timber producers was 2650 USD/ha, representing the most elevated part of the traders' total cost (62.2%), followed by harvesting cost (21.1%). Transportation costs, including depreciation, reparation, energy and insurance were 255.5 USD/ha. Traders graded and marketed logs by size, thereby generating revenue from 47.4 m^3 sold at 31.7 USD/m^3 (sawlog-size, with bark) and

[2] https://info.fsc.org/details.php?id=a023300000d4nr8AAA&type=certificate

[3] http://scansiapacific.com/

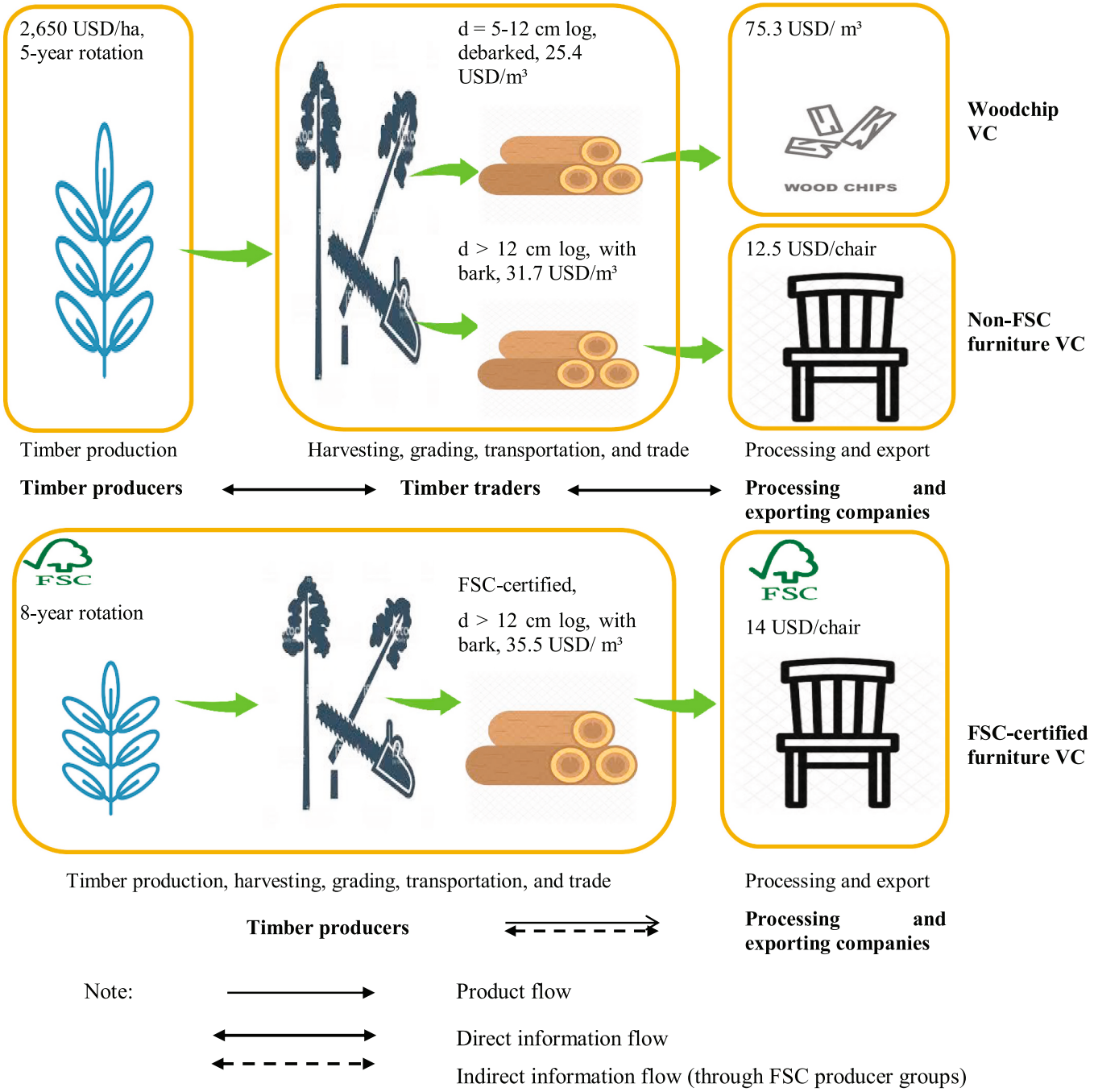

Fig. 2. Overview of main actors in the analyzed timber VCs.

130.7 m^3 sold at 25.4 USD/ m^3 (woodchip, debarked) (Table 2).

3.4. Processing and exporting company performance

3.4.1. Company overview

According to the Thua Thien Hue Department of Planning and Investment, there were currently seven woodchip firms with their annual chip revenue ranging from 5.6–35 million USD. To facilitate the export activities, they mainly were located within 10 km radius of Chan May seaport.[4] Regarding the sawn-size logs, 154 companies were registered in the province as the processors and exporters of various products, such as sawn wood or furniture. These products were traded locally, nationally and internationally, creating revenue of 0.1–2.5 million USD annually. The location of these firms was mainly in proximity to industrial plantations and convenient for timber product transportation. Given the increasing competition in raw log material, the processing firms have built up social linkages with traders , even pre-finance them, to sustain their timber supply. In general, firms demonstrated better

[4] Chan May is one of the main seaports in Vietnam which is located about 65 km from Hue city. The volume of chip exported from this seaport accounts for 8–10% of the total annual Vietnamese woodchip export volume.

Table 1
Annual costs and benefits of timber producers in the three timber VCs, based on 1 ha of timber plantation following normal forest scheme, Thua Thien Hue province, central Vietnam.

Description	Woodchip and non-FSC furniture VC (Volume = 37 m^3)		FSC-certified furniture VC (Volume = 39 m^3)	
	Total (USD)	USD/ m^3	Total (USD)	USD/ m^3
A. Costs				
Operational costs	155.8	4.2	559.3	14.3
I. Material and services	42.9	1.2	448.8	11.5
1.Seedings	21	0.6	13.0	0.3
2.Fertilizer	21.9	0.6	26.5	0.7
3.Thinning and harvesting			220.6	5.7
4.Transportation			139.1	3.6
5.Road reparation for truck			49.7	1.3
II. Labor costs	110.2	3.0	100.7	2.6
1.Land preparation	17	0.5	19.9	0.5
2.Planting and replanting	31.8	0.9	15.9	0.4
3.Fertilizing	19.1	0.5	10.6	0.3
4.Tending	42.4	1.1	31.8	0.8
5.Protection			22.5	0.6
III. Regulatory cost	2.7	0.1	2.8	0.1
1.Environmental fee	2.7	0.1	2.8	0.1
IV. FSC related fee			7.0	0.2
1.FSC annual fee			2.2	0.1
2.FSC fees on the logs price			4.8	0.1
Opportunity cost of maintaining inventories	185.5	5.0	558.3	14.3
Opportunity cost of land (rental value)	10.5	0.3	17.9	0.5
Total costs	351.8	9.5	1135.5	29.1
B. Benefits				
Revenue	530	14.3	1199.7	30.8
Net profit	178.2	4.8	64.3	1.6

Note: No revenues from intermediate thinning in the 5-year rotation; sale of standing trees occurred at year 5 with a price of 2650 USD/ha. In 8-year rotation plantations, thinning in year 5 in which 30% of trees were felled, created benefits of 61 m^3 of debarked log sold to woodchip companies. At year 8, the area was clear cut yielding 255 m^3 of logs, of which up to 55% were sawlogs. Tables B1 and B2 present detailed operational costs and benefits of producers. Land rental value was reported at 40% of the timber producer's revenue after deducting operational costs. 8% of log volume was bark (Maraseni et al., 2017a). Some figures could vary due to rounding errors.

Table 2
Costs and benefits of traders in the non-FSC certified timber VCs, based on sale of logs from 1 ha of 5-year rotation Acacia hybrid plantation, Thua Thien Hue province, central Vietnam.

Description	USD/ ha	Woodchip VC (Volume = 127.5 m^3)		Non-FSC furniture VC (Volume = 46.2 m^3)	
		Total (USD)	USD/ m^3	Total (USD)	USD/ m^3
A. Costs					
I. Material, equipment and services		2368.9	18.6	801.6	17.4
1.Purchase of logs	2650	1986.9	15.6	663.1	14.4
2.Truck depreciation[a] and reparation	163.5	120	0.9	43.5	0.9
3.Enery and insurance	92	67.5	0.5	24.5	0.5
4.Road preparation for truck	265	194.5	1.5	70.5	1.5
II. Labor costs		727.5	5.7	263.9	5.7
5.Harvesting (and grading, loading)	899.4	660	5.2	239.4	5.2
6.Truck driver	92	67.5	0.5	24.5	0.5
III. Regulatory costs		75	0.6	27.2	0.6
7.Taxes, fees and local duties	20.4	15	0.1	5.4	0.1
8.Unofficial costs[b]	81.8	60	0.5	21.8	0.5
Total costs	4263.8	3171.4	24.9	1092.7	23.7
B. Benefits					
Revenue	4816.4	3315	26	1501.4	32.5
Net profit	552.6	143.6	1.1	408.7	8.8

Note: The distribution of traders' costs for harvest, transportation and sale was based on the volume of logs sold in each VC. At 5 years, a ha of 5-year rotation Acacia hybrid plantation yielded 184.8m^3 logs (with bark). Of this volume, around 25% was of sawlog-size and sold to furniture companies, while the remaining amount with diameter ranging from 5 to 12 cm was sold to woodchip companies after debarking. Some figures could vary due to rounding errors.

[a] A truck costed 26,502 USD and was depreciated over 10 years.

[b] Apart from legal taxes and fees, a "law making fee" of 8.8 USD has to be paid for each truck with a load capacity of 17.5–20.9 m^3 of logs.

access to capital, technology and market compared to actors in the timber supplying node of VCs. This resulted in their control of log prices over traders or producers.

3.4.2. Woodchip production

The woodchip company produced fresh woodchips. No drying process was recorded at the chipping firm, but there was a company named Vinacontrol providing humidity checking service which cost 0.2 USD/ m^3 of fresh chip. With a recovery rate of 99.6% and average humidity of 57% (Fig. 3), 2.33 m^3 raw logs were required as input to produce 2.32 m^3 fresh chips which were equal to 1 m^3 dried chip after humidity check. Table 3 presents the costs and benefits per m^3 of dried woodchips. At the company's gate price of 25.4 USD/ m^3, direct material cost occupied up to 91% of the total cost. With around 0.5 USD/ m^3 dried chip, the expenditure for direct labor was marginal. Payment for export services, such as humidity check, transportation and loading fees was 2.4 USD/ m^3. Taxes[5] and fees, such as business or environmental fee cost 1.4 USD/ m^3. The production process generated 0.01 m^3 of sawdust, marketed at 12.7 USD/ m^3 and creating a benefit of 0.1 USD. The net profit was 8.9 USD/ m^3 dried woodchip.

3.4.3. Furniture production

At the furniture company, the recovery rate was reported at 92% from logs (with bark) to small logs (without bark), at 46% from small logs to small battens, at 96% from fresh to dried battens, at 66% from dried battens to wood billets and 65% from wood billets to finished chair. Thus, the net recovery rate from raw log (with bark) to final product (chair) was 17.4% (Fig. 4). This rate was applied for both FSC and non-FSC products. To produce 1m^3 of chair, the company needed around 5.7 m^3 logs. As reported by the furniture company, the net volume of a chair was about 0.0102 m^3. The marketed price was 1225.5 USD/m^3 for non-FSC chair and 1372.5 USD/m^3 for FSC-certified chair.

Direct labor cost was 306 USD/m^3 of final product, representing the most elevated item in the total cost structure (approximately 30%), followed by the expenditures for indirect materials, such as metal accessories, glue, paint, etc. (18%) and direct material (16–18%). The difference between the total production cost of FSC and non-FSC furniture was mainly driven by raw log price and Chain of Custody (CoC) certification maintenance cost.[6] The total cost for the certified chair was 1147 USD/m^3, which was only 2% higher than the costs for non-certified chair production and export. The waste after processing included bark, sawdust, shavings and logs or sawn logs, which did not meet the required standard. They further could be sold as firewood (70%) and sawdust (30%) at 3.75 USD/m^3 and 12.7 USD/ m^3

[5] Besides income tax, business fee, environmental fee, land fee, etc. woodchip firm is obligated for fulfilling export tax at a rate of 2% of total annual exporting revenue.

[6] In the furniture company, CoC certification maintenance cost was around 1000 USD/year and applied only for FSC-certified products.

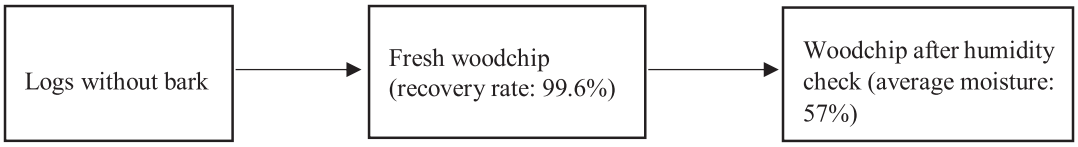

Fig. 3. Woodchip production and humidity check process.

Table 3
Costs and benefits per m^3 of woodchip production and export for woodchip company, woodchip VC, Thua Thien Hue province, central Vietnam.

Description	Woodchip VC (Volume = 1 m^3)
	USD/m^3
A. Costs	
I. Direct material	60.6
1. Raw logs	60.6
II. Direct labor	0.5
1. Chipping	0.4
2. Insurance and allowance	0.1
III. Overhead costs	5.4
1.Management	0.7
- *Of which*: indirect labor	0.6
2.Exporting (including humidity check)	2.4
3.Depreciation	0.2
4.Enery (for machine)	0.4
5.Interest and insurance (for factory and products)	0.4
6.Taxes and fees	1.4
Total costs	66.5
B. Benefits	
1.Woodchip	75.3
2.Sawdust	0.1
Revenue	75.4
Net profit	8.9

Note: According to the International Accounting Standard (IAS) 2- Inventories: The costs of inventories include cost of purchase (direct material cost), direct cost of conversion (direct labor cost), and overhead costs (all the costs apart from direct material and direct labor cost that are incurred in bringing the inventories to their present location and condition) (IAS, 2020). Information was collected from the company's financial and production cost statements. Some figures could vary due to rounding errors.

respectively. About 78.6% of the log input or 4.5 m^3 was recovered as by-products, adding the benefit of 29 USD/m^3 final product (Table 4).

3.5. Comparative analysis on financial and economic performance of Acacia hybrid timber VCs

Table D1 presents the key information on financial and economic performance of the analyzed VCs. On one hand, the woodchip VC demonstrated its profitability as characterized by the high profit-investment ratio (50.5%) and FOB price share (19.1%) of timber cultivators, the high commercialization margin of traders (15.5%) as well as the high profitability of the woodchip company (11.9%). However, standing at only 26.3 USD/m^3, the total added value in this chain was lowest as compared to non-FSC furniture (557.2 USD/m^3) and FSC-certified furniture VC (663.7 USD/m^3) (Table 5).

Accounting for 58–70%, the remuneration of workers amounted to a major part of the total surplus in the furniture VCs (Fig. 5). This fact, associated with a higher level of labor qualification and working safety (Table D1), underlined the social benefits generated by the furniture as compared to the chip production and export sector. In contrast to the monoculture of Acacia species in the non-FSC timber plantations, producers involved in the FSC-certified timber production were strongly encouraged to mix Acacia hybrid with native species such as Golden Oak (*Hopea odorata*) or Ironwood (Tali) (*Erythrophleum fordii*) to diversify cultivated species. Participants in the interviews and group discussions also pointed out the positive impacts of more proper cultivation techniques and management practices applied in the FSC-certified timber plantations, such as longer rotation and therefore less frequent land impact and no burning field after timber harvest, on improving land use efficiency (Table D1).

4. Discussion

4.1. Generalization of Acacia hybrid timber value chains in Central Vietnam

Given the net profit and added value in all stages of the Acacia hybrid timber VCs, our analysis partially underlined the contribution of these chains to economic development. The results were in line with the finding of Maraseni et al. (2017a) and Tan (2011) reporting the positive benefits of Acacia timber production and commercialization system in north and central Vietnam. However, these scholars employed profit, a popular approach (Tham et al., 2020a), instead of added value. Despite its popularity, profit implies limitations in VC analysis since capital is only one component of the production process (Gereffi et al., 2001). Profit does not explain thoroughly labor achievement or productivity of the economy in general. In contrast, added value represents the wealth creation to different stakeholders, including the state, in this case resulting from wood production and transformation chains. It, therefore, proves useful in measuring benefit shares along the VCs, especially in an increasingly interlinked economy.

Characterized by large-scale production of standardized low-value products, woodchip production followed a cost leadership strategy which was relatively common in the Asian wood-based industry (Tham et al., 2020a). The investigated woodchip VC was financially profitable. However, the financial measures alone do not sufficiently recognize the social and/or environmental outcomes of business behaviors (Haugh, 2006; Schmithüsen et al., 2014). From a more general perspective, Acacia hybrid timber VC improvement was concerned with the long-term development of the national economy, such as labor provision, staff qualification and export gains (Schmithüsen et al., 2014). This could be achieved through a transition from woodchip towards higher added value products as furniture. Our study is useful in the analytical generalization of lessons learned as a base to discuss comparable

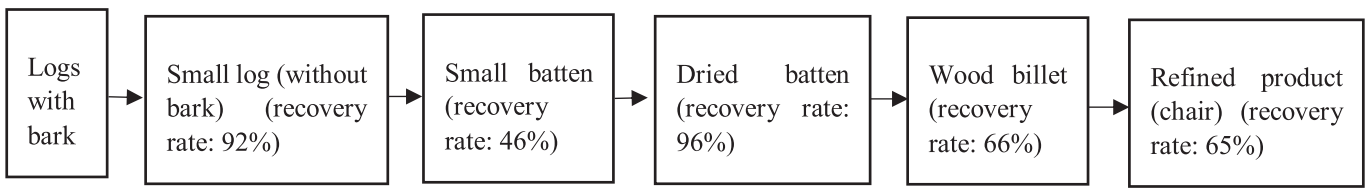

Fig. 4. Chair production process.

Table 4
Costs and benefits per m^3 of chair production and export for furniture company, furniture VCs, Thua Thien Hue province, central Vietnam.

Description	Non-FSC furniture VC (Volume = 1 m^3)	FSC-certified furniture VC (Volume = 1 m^3)
	USD/m^3	USD/m^3
A. Costs		
I. Direct material	182	203.8
1.Raw logs	182	203.8
II. Direct labor	306	306
1.Material preparation	107.9	107.9
2.Refining process	52.6	52.6
3.Assembling, finishing and packaging	89.5	89.5
4.Loading	2.2	2.2
5.Insurance and allowance	53.8	53.8
III. Overhead costs	636.9	637.4
1.Indirect material	210.3	210.3
2.Management	86.2	86.7
Of which: indirect labor	74.1	74.1
3.Exporting	192.8	192.8
4.Depreciation	30.7	30.7
5.Energy for machine	86.6	86.6
6.Interest and insurance (for factories and products)	5.3	5.3
7.Taxes and fees	25	25
Total costs	1124.9	1147.2
B. Benefits		
1.Chair	1225.5	1372.5
2.Firewood and sawdust	29	29
Revenue	1254.5	1401.5
Net profit	129.6	254.3

Note: Information was collected from the company's financial and production cost statements. Some figures could vary due to rounding errors.

Table 5
Value creation (USD/m^3) in timber VCs, Thua Thien Hue province, central Vietnam.

VC stages	Woodchip VC		Non-FSC furniture VC		FSC-certified furniture VC	
	USD/m^3	%	USD/m^3	%	USD/m^3	%
Primary production	7.9	30.0	7.9	1.4	4.3	0.6
Local trading	6.9	26.2	14.6	2.6	–	–
Production and export	11.5	43.8	534.7	96.0	659.4	99.4
Total	**26.3**	**100**	**557.2**	**100**	**663.7**	**100**

contextual cases. It finally contributes to further theoretical proposition as (P1) Stakeholders/VCs that face uncertainty or high competition in terms of essential resources and/or markets can enhance their financial performance through vertical and horizontal coordination.

4.2. Performance of chain participants

4.2.1. Timber producer performance

Our results demonstrated the net benefits of producers in three analyzed timber VCs, thereby emphasizing the positive contribution of timber or forest product VCs at large to rural livelihoods (Nambiar, 2019; Pretzsch, 2005). A study of McWhirter (2016) carried out in Thua Thien Hue province reported that the average profit of small-scale producers from Acacia plantations was 1942 USD/ha in the first rotation (1R) and 2769 USD/ha in the second rotation (2R). Given the mean rotation length of 5.5 years, annual profit probably ranged from 353 USD/ha/year (1R) to 503 USD/ha/year (2R) which was higher than the average benefit of timber growers in our study. This might be explained by the exclusion of land and inventory opportunity costs in McWhirter's, study. Distinct results might also be resulted from using different datasets or different survey time. In terms of benefit appropriation, only a marginal proportion of the value created was captured by the government given a number of incentive policies for timber growers, such as land tax exemption (Phuc et al., 2019a, 2019b).

Comparing to the growers involved in the 5-year rotation plantations, those producing FSC-certified timber generated less profit and added value in both relative and absolute terms. This contrasted with the recent findings on the financial benefits of FSC certification schemes in Vietnam (e.g. Maraseni et al., 2017a). Reasons might be associated with the price premium between FSC and non-FSC sawlogs of approximately 12% which was lower than the price premium reported in other studies, for example, 18.5% (Maraseni et al., 2017a) or 19–22% (Hoang et al., 2015a)). Aspects such as the inconsistent, low timber quality and limited market awareness of producers could be reasons contributing to the below-average price premium. Furthermore, the FSC-certified timber production regime indicated substantially higher operational and inventory costs than the non-FSC plantations driven by the extra responsibility of timber growers, such as for harvesting activities or paying FSC related fees as well as its longer rotation age feature. The application of longer plantation rotations in central Vietnam may also increase production risks associated with, for example, natural hazards or market uncertainty for growers whose livelihoods strongly rely on income from timber production (Flanagan et al., 2019).

Our findings and discussions have been based on the current context in which most of the certification expenditures were not carried by timber producers. High dependence on external technical and financial supports for certification even was considered as a prevalent characteristic of small-scale producer engagement in southeast Asia (Flanagan et al., 2020). Handling full FSC-related costs to them might change our results notably. For illustration, with the FSC-certified timber plantation area of 2875 ha in 2018, certification assessment cost could be calculated at approximately 4.2 USD/ha/year in Thua Thien Hue province. The management of FSC-related paperwork was time-consuming and might have cost up to 60 USD/ha for a 7-year rotation (Hoang et al., 2015a) or even more than 85 USD/ha for a 10-year rotation (Maraseni et al., 2017a). These costs varied by forest conditions such as plantation area, level of forest management and implied a high financial burden for small-scale timber growers. This requires strong support, coordination and collective action in handling the application and management of FSC certification for smallholder forest plantations. An alternative verification approach simplifying current certification schemes could also be introduced to remove the aforementioned challenges and ensuring the profitable participation of timber producers (Flanagan et al., 2020).

4.2.2. Timber trader performance

During our interviews, respondents were generally of the view that traders had control over timber price, thus gaining large benefits from their business. This was comparable with other studies carried out in Vietnam (Bien et al., 2006) or Indonesia (Perdana et al., 2012). Given that most timber producers owned small and dispersed plantation areas and were disconnected from the market (Nambiar et al., 2015), this study highlighted the crucial roles of traders in the VCs of woodchip and non-FSC furniture products. In such chains, for example, they improved timber value by grading and facilitated timber trade by linking producers and processing firms. Moreover, traders sometimes offered advance payment for timber growers. This was precarious, especially in the context of changing market price. For example, during the period from 2013 to 2018, the log price for woodchip production decreased by approximately 20% (Fig. C1). Therefore, along with expenditures for log purchase, harvest and delivery to processing firms, traders also carried the risks and opportunities related to their timber trades. Our findings suggested that the traders' share of added value was somewhat modest than that of other chains' stakeholders, and was commensurate with their covered expenditures and risks. Similar results were reported from

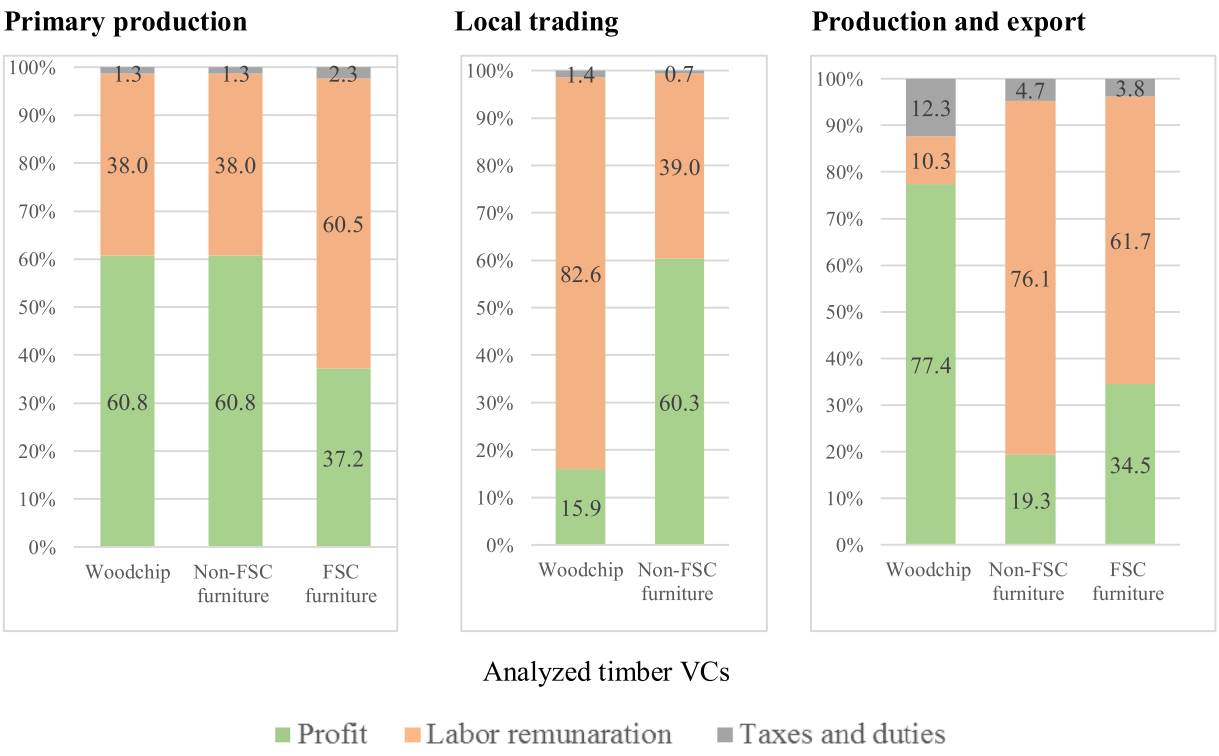

Fig. 5. Added value appropriation by VC stages in analyzed timber VCs, Thua Thien Hue province, central Vietnam.

Indonesia (Perdana and Roshetko, 2015) and Lao PDR (Maraseni et al., 2018).

4.2.3. *Processing and exporting firm performance*

Our results clearly show the high proportion of the commercialization margin of companies. This was commensurate with their efforts in processing and exporting, capital investment and carried risks in timber product commercialization, such as the increasing competition for timber raw material and market (Vu et al., 2019). Manufactures in all the analyzed VCs, both FSC and non-FSC appropriated a larger proportion of surplus compared to the traders or timber producers, similar to results reported from India (Zachariah, 2008) or Lao PDR (Maraseni et al., 2018). Considering the downstream node in the Acacia hybrid timber VCs, furniture production gave the larger added value per m^3 of final product compared to woodchip production. Our findings affirmed the conclusion by Sathre and Gustavsson (2009) that more structural timber products were able to create more value. Furthermore, our study clearly showed that investment in FSC-certified products in a long run brings more profit and more added value than in non-FSC products. As better structured with the qualified staff, including accountants and business administrators, relatively transparent annual audit and lower cost for CoC certification, this was more comfortable for processing companies to engage in certification scheme than producer households. These findings corroborated the comparison presented by Maraseni et al. (2017a) at a sawmill located in central Vietnam. Characterizing as a labor-intensive process (Athukorala, 2007), most of the created value in furniture company was appropriated as labor remuneration. Given the proximate location to industrial plantations, its performance possibly captured the associated benefits, such as job generation in the primary production region. The large share of surplus in woodchip production and trade, on the other hand, was profit, followed by government capture in the form of taxes and duties. Levying a high level of taxes on woodchip processing and exporting firm partially indicates the efforts of the Vietnamese government in decreasing woodchip export, thereby increasing sawlogs production and improving the domestic wood-based industry (Phuc et al., 2019a, 2019b).

4.3. *Limitations of the study*

Firstly, this study employed a case study research design and investigated a localized set-up not amenable to statistical, but very useful for analytical generalization. We used cross-sectional data representing the average of current prices and consequently costs, benefits and added value. This may limit us in capturing the changes in performance outcomes of VCs participants over time. Despite that, our profound examination on a holistic approach of interrelated production, manufacturing and trading activities as components of the Acacia hybrid timber production and commercialization system proved useful in analyzing timber VCs performance (Velde et al., 2006). Secondly, the study presented a snapshot of VC participants. Except for processing and exporting firms, there were no official records of timber growers and traders . Their cost and benefit data, thus, were based on recall and possibly posed limitations to data reliability. However, our strict and transparent application of different data collection methodologies facilitated data triangulation and ensured the reliability of results. Moreover, potential risks, and uncertainty of, for example, timber growers in holding forests for longer rotation have not been included. Our model also did not examine the regulation compliance on the ground. For example, a truck assigned to carry 10–12 tons of logs may transport up to 16–18 tons in practice. Future in-depth risk and policy-compliant analyses are recommended. Lastly, sustainable chain management requires economic, social and environmental analysis in conjunction (Gimenez et al., 2012; Golini et al., 2018), especially when the negative impacts of excessive timber exploitation are undoubtable (Darr et al., 2014). For a complete analysis, the social and environmental costs and benefits, therefore, need to be taken comprehensibly into account.

5. Conclusion

Tree cultivation and timber product commercialization have been

innovative business opportunities for different actors along timber VCs. However, forest land and forest-based products including timber are limited. Therefore, sustainable management of these resources is required that sustains and enhances a sustainable contribution to the local, national and international economy (Sathre and Gustavsson, 2009). The competitive pressure in the timber industry is growing recently (e.g. Han et al., 2009). This calls for a transition from low value to higher added value timber products. Taking Thua Thien Hue province in central Vietnam as a case, this study investigated the performance of three typical Acacia hybrid timber VCs, i.e. woodchip, non-FSC and FSC-certified furniture.

Our results demonstrated the positive returns of all three main timber VC participants. Despite the profitability of woodchip VC, the expansion of single Acacia hybrid species in short-rotation plantations may lead to other land use competition, livelihood vulnerability as well as environmental cost increment resulting, for example, from land overexploitation or low level of biodiversity (Li et al., 2020a, 2020b; Liu et al., 2018). Due to the low level of investment in added value activities and labor provision, the woodchip VC has shown the lowest performance in economic sphere. In contrast, FSC-certified furniture VC contributed considerably to economic development. Despite that, the application of FSC certification implied difficulties, especially for small-scale timber producers given its complicated administrative procedures and high costs (Maraseni et al., 2017a). The additional low price premium, high risks and financial constraints originated from a long rotation of timber plantations potentially made FSC certification less attractive on the ground (Maraseni et al., 2017a). As an attempt to address these problems, the Vietnamese government has established the Vietnam Forest Certification Scheme (VFCS), which is in accordance with the Programme for the Endorsement of Forest Certification (PEFC) in 2018 (PEFC, 2020). Even though this scheme is promising for sustainable forest management, it takes time to obtain a large area of certified forests. Thus, the transition from low to higher added value timber VC requires changes in the political, social and economic conditions, such as administrative arrangement simplification, financial and technical support distribution and VC participants' partnership consolidation.

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Declaration of Competing Interest

None.

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Appendix A. Profiles of selected companies for the financial year 2018

Table A1
Summary of selected company profiles, financial year 2018.

Description	Unit	Woodchip company	Furniture company
Type of company		Limited liability-joint venture company	Joint-stock company
Annual export capability	m^3 of final products	452,962 (equal volume after humidity check)	1920
Annual raw log required	m^3	522,648	5511
FSC-certified timber demand	%	20%	50%
CoC certification requirement		Yes, only for FSC-certified products	Yes, only for FSC-certified products
Total asset	USD	4,651,357	1,362,260
Revenue of goods and services	USD	34,280,126	2,996,774
Return on asset (ROA)	%	26.9	5.9
Return on equity (ROE)	%	64.3	14
Number of employees	People	72	176
Of which: direct labor		35	155
Total salary fund	USD	464,011	627,335
Market share	%	2.2	0.1
Export market		China (65%), Japan (35%)	EU (50%), US (50%)

Note: Total salary fund represents all the annual payments of the company to its employees (both direct and indirect employees), including salaries, insurances and endowments. Information was collected from the company's financial statements and computed by authors.

Appendix B. Financial cost-benefit structure for Acacia hybrid plantations in Thua Thien Hue province

Table B1
Costs and benefits for 5-year rotation Acacia hybrid plantation (USD/ha).

Description	Year 1	Year 2	Year 3	Year 4	Year 5
A. Costs					
I. Material and services					
1.Seedling (3000 seedling/ha, no replanting)	105				
2.Fertilizer (1st year 250 kg/ha, 2nd year 60 kg/ha)	88.3	21.2			
II. Labor costs					
1.Land preparation	84.8				
2.Planting (manually, no replanting)	159				
3.Fertilizing	53	42.4			
4.Tending (grass cutting, weeding and pruning)	106	63.6	42.4		
III. Regulatory cost					
1.Environmental fee					13.3
Total cost	596.1				
B. Benefits (184.8 m^3 as standing tree)					2650

Note: Labor costs were calculated based on the man-days needed and the average labor wage in market. Some figures could vary due to rounding errors.

Table B2
Costs and benefits for 8-year rotation Acacia hybrid plantations, FSC certified (USD/ha).

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
A. Costs								
I. Material and services								
1.Seedling (2250 seedling/ha, 100 seedling/ha for replanting)	103.4							
2.Fertilizer (1st year 450 kg/ha, 2nd year 150 kg/ha)	159	53						
3.Environmental fee								22.1
4.Thinning and harvesting fee					492.8			1272
5.Transportation					217			896
6.Road preparation for truck					265			132.5
II. Labor costs								
1.Land preparation	159							
2.Planting and replanting	127.2							
3.Fertilizing	53	31.8						
4.Tending (grass cutting, weeding and pruning)	106	53	42.4	31.8				21.2
5.Protection					74.2			106
III. FSC related costs								
1.FSC annual fee	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
2.FSC fees on the logs price								38.1
Total cost	709.8	140	44.6	34	1051.2	2.2	2.2	2489.7
B. Benefits								
1.From thinning 66.2 m^3 (wood chip: 61 m^3 @ 26.6 USD/m^3)					1622.6			
2.From final harvest 255 m^3 (wood chip: 115 m^3 @ 26.6 USD/m^3, FSC saw log: 140 m^3 @ 35.5 USD/m^3)								7975.3

Note: Labor costs were calculated based on the man-days needed and the average labor wage in market. Some figures could vary due to rounding errors.

Appendix C. Change in price of Acacia hybrid logs for non-FSC woodchip production

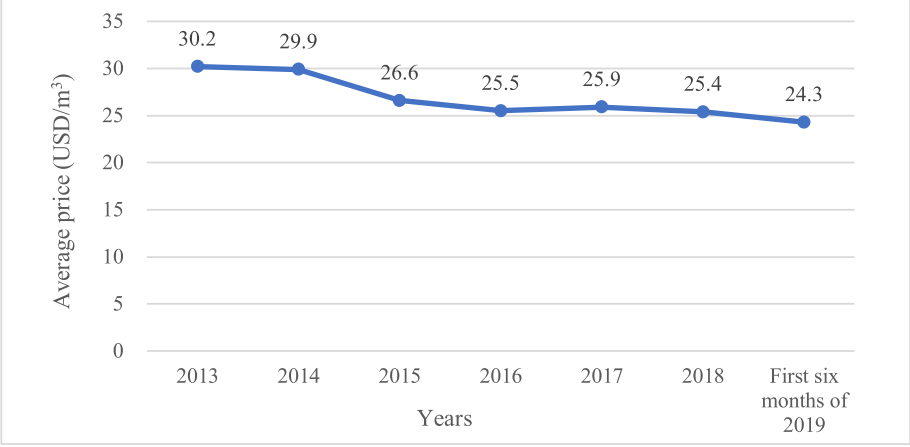

Fig. C1. Average price of Acacia hybrid logs, d = 5–12 cm, for woodchip production.

Appendix D. Comparative analysis on financial and economic performance of analyzed Acacia hybrid timber VCs

This section compared the performance between stages of chains as well as the whole VC of woodchip, non-FSC certified furniture, and FSC-certified furniture. While indicators such as producer share of FOB price, profit investment ratio were for financial analysis, value addition, labor standard, resource management, etc. implied economic performance of actors and chains.

Table D1
Key indicators on financial and economic performance of Acacia hybrid timber VCs.

Analytical level	Indicators	Woodchip VC	Non-FSC certified furniture VC	FSC-certified furniture VC
Primary production	Value addition (USD/m^3)	7.9 (30.0%)	7.9 (1.4%)	4.3 (0.6%)
	Producer share of FOB price (%)	19.1	1.2	2.7
	Profit investment ratio (%)	50.5	50.5	5.5
	Return on labor for producer (USD/day)	27.7	27.7	17.5
Local trading	Value addition (USD/m^3)	6.9 (26.2%)	14.6 (2.6%)	–
	Profitability (%)	4.3	27.2	–
	Profit investment ratio (%)	4.5	37.3	

(*continued on next page*)

Table D1 (*continued*)

Analytical level	Indicators	Woodchip VC	Non-FSC certified furniture VC	FSC-certified furniture VC
	Commercialization margin (%)	15.5	1.5	–
Production and export	Value addition (USD/m^3)	11.5 (43.8%)	534.7 (96.0%)	659.4 (99.4%)
	Profitability (%)	11.9	10.3	18.1
	Profit investment ratio (%)	13.5	11.5	22.2
	Commercialization margin (%)	65.5	97.4	97.5
	Average salary for direct labor in processing company (USD/person/day)	7	8.8	8.8
	Taxes and duties	High	Tax incentives	Tax incentives
Value chain	Total value addition (USD/m^3)	26.3	557.2	663.7
	Local value addition	Largely absent	Largely absent	Primary processing
	Investment in value added processing	Low (chipping)	High (different forms of processing)	High
	Labor standard	Low	Medium. Knowledge generalization	High. Knowledge generalization
	Working safety	Low	Medium	High
	Resource management	Premature harvest, pure-specie planting tendency, land overexploitation	Premature harvest, pure-specie planting tendency, land overexploitation	Longer rotation, mixed species encouragement (e.g. mixing Acacia hybrid with Golden Oak (*Hopea odorata*) or Ironwood (Tali) (*Erythrophleum fordii*), land protection
	External intervention	Mainly regulatory	Mainly regulatory	Resource development, financial services, training and extension, local market development.

Note: Monthly salary for direct labor in the woodchip and furniture processing company was 220.8 USD and 276.0 USD respectively. The research team assumed that a working month = 30 days. Profit investment ratio, return on labor, profitability, commercialization margin was calculated as below:

Profit investment ratio

$$Profit\ invement\ ratio\ (\%) = \frac{Net\ profit}{Total\ cost} * 100\% \quad \text{(D1)}$$

Return on labor

$$\text{Return on labor (8hrs per day)} = \frac{\text{Total revenue} - \text{total cost excluding labor costs}}{\text{Total annual working days}} \quad \text{(D2)}$$

Profitability

$$\text{Profitability}\ (\%) = \frac{\text{Net profit}}{\text{Total revenue}} * 100\% \quad \text{(D3)}$$

Commercialization margin

$$\text{Commercialization margin}\ (\%) = \frac{\text{Sale price} - \text{Purchase price at each stage}}{\text{End market price}} * 100\% \quad \text{(D4)}$$

References

Athukorala, P., 2007. Multinational Enterprises in Asian Development. Edward Elgar Publishing, Cheltenham, UK.

Auer, M., 2012. Group forest certification for smallholders in Vietnam: an early test and future prospects. Hum. Ecol. 40, 5–14. https://doi.org/10.1007/s10745-011-9451-6.

Bellù, L.G., 2013. Value chain analysis for policy making. In: EASYPol Series 129. FAO, Rome, Italy.

Bien, N.N., Tuan, N.V., Nghia, B.C., Thoai, T.Q., 2006. Why Do Farmers Choose to Harvest Small-Sized Timber? A Survey in Yenbai Province, Northern Vietnam. Technical Report. Economy and Environment Program for Southeast Asia (EEPSEA), Laguna, Philippines.

Binkley, C.S., 1993. Long-run timber supply: price elasticity, inventory elasticity, and the use of capital in timber production. Nat. Resour. Model. 7, 163–181. https://doi.org/10.1111/j.1939-7445.1993.tb00145.x.

Bockel, L., Tallec, F., 2005. Commodity chain analysis: financial analysis. In: EASYPol Module 044. FAO, Rome, Italy.

Cochard, R., Ngo, D.T., Waeber, P.O., Kull, C.A., 2017. Extent and causes of forest cover changes in Vietnam's provinces 1993–2013: a review and analysis of official data. Environ. Rev. 25, 199–217. https://doi.org/10.1139/er-2016-0050.

Darr, D., Vidaurre, M., Uibrig, H., Lindner, A., Auch, E., Ackermann, K., 2014. The challenges facing forest-based rural development in the tropics and subtropics. In: Pretzsch, J., Darr, D., Uibrig, H., Auch, E. (Eds.), Forests and Rural Development. Springer, Berlin, Germany, pp. 51–83.

Dong, T.L., Doyle, R., Beadle, C.L., Corkrey, R., Quat, N.X., 2014. Impact of short-rotation Acacia hybrid plantations on soil properties of degraded lands in central Vietnam. Soil Res. 52, 271–281. https://doi.org/10.1071/SR13166.

Flanagan, A.C., Midgley, S.J., Stevens, P.R., McWhirter, L., 2019. Smallholder tree-farmers and forest certification in southeast Asia: productivity, risks and policies. Aust. For. 82, 18–28. https://doi.org/10.1080/00049158.2018.1560569.

Flanagan, A.C., Midgley, S.J., Stevens, P.R., 2020. Smallholder tree-farmers and forest certification in southeast Asia: alternative approaches to deliver more benefits to growers. Aust. For. 83, 52–65. https://doi.org/10.1080/00049158.2020.1762150.

Gereffi, G., Humphrey, J., Kaplinsky, R., Sturgeon, T.J., 2001. Introduction: globalisation, value chains and development. IDS Bull. 32, 1–8. https://doi.org/10.1111/j.1759-5436.2001.mp32003001.x.

Gimenez, C., Sierra, V., Rodon, J., 2012. Sustainable operations: their impact on the triple bottom line. Int. J. Prod. Econ. 140, 149–159. https://doi.org/10.1016/j.ijpe.2012.01.035.

Golini, R., De Marchi, V., Boffelli, A., Kalchschmidt, M., 2018. Which governance structures drive economic, environmental, and social upgrading? A quantitative

analysis in the assembly industries. Int. J. Prod. Econ. 203, 13–23. https://doi.org/10.1016/j.ijpe.2018.05.021.
Google Maps, 2020. Thua Thien Hue. https://goo.gl/maps/5gXRwn8TSuYD4rwg8 (accessed 2.26.20).
Han, X., Wen, Y., Kant, S., 2009. The global competitiveness of the Chinese wooden furniture industry. Forest Policy Econ. 11, 561–569. https://doi.org/10.1016/j.forpol.2009.07.006.
Harwood, C., Nambiar, S., 2016. Acacia Plantations in Vietnam: Policies and Research to Enhance Their Contribution to Economic Growth and Rural Development. Discussion Paper. CSIRO Land and Water, Black Mountain, Australia.
Harwood, C.E., Nambiar, E.K.S., Dinh, P.X., Toan, L.X., Quang, L.T., 2017. Managing wood production from small grower Acacia hybrid plantations on eroded soils in central Vietnam. Aust. For. 80, 286–293. https://doi.org/10.1080/00049158.2017.1395200.
Haugh, H., 2006. Social enterprise: beyond economic outcomes and individual returns. In: Mair, J., Robinson, J., Hockerts, K. (Eds.), Social Entrepreneurship. Palgrave Macmillan, New York, USA, pp. 180–206.
Hoan, L.T., 2014. Forest resources and forestry in Vietnam. J. Viet. Environ. 6, 171–177. https://doi.org/10.13141/jve.vol6.no2.pp171-177.
Hoang, H.T.N., Hoshino, S., Hashimoto, S., 2015a. Forest stewardship council certificate for a group of planters in Vietnam: SWOT analysis and implications. J. For. Res. 20, 35–42. https://doi.org/10.1007/s10310-014-0472-z.
Hoang, N., Toppinen, A., Lähtinen, K., 2015b. Foreign subsidiary development in the context of a global recession: a case of the furniture industry in Vietnam. Int. Forest. Rev. 17, 427–437. https://doi.org/10.1505/146554815817476495.
IAS, 2020. IAS 2 Inventories. https://www.ifrs.org/issued-standards/list-of-standards/ias-2-inventories/ (accessed 7.20.20).
Iwanaga, S., Duong, D.T., Minh, N.V., 2020. Impact of policies on raw material procurement in the Vietnamese timber processing industry: a case study of sawmills in Hue city. J. For. Res. 1–10. https://doi.org/10.1080/13416979.2020.1735612.
Klemperer, W.D., 1996. Forest Resource Economics and Finance, first ed. McGraw-Hill Inc., New York, USA.
Leslie, A.J., 1966. A review of the concept of the normal forest. Aust. For. 30, 139–147. https://doi.org/10.1080/00049158.1966.10675407.
Li, X., Lu, G., Yin, R., 2020a. Research trends: adding a profit function to forest economics. Forest Policy Econ. 113, 1–4. https://doi.org/10.1016/j.forpol.2020.102133.
Li, R., Zheng, H., Zhang, C., Keeler, B., Samberg, L.H., Li, C., Polasky, S., Ni, Y., Ouyang, Z., 2020b. Rural household livelihood and tree plantation dependence in the central mountainous region of Hainan island, China: implications for poverty alleviation. Forests 11, 248. https://doi.org/10.3390/f11020248.
Liu, C.L.C., Kuchma, O., Krutovsky, K.V., 2018. Mixed-species versus monocultures in plantation forestry: development, benefits, ecosystem services and perspectives for the future. Global Ecol. Conserv. 15, 1–13. https://doi.org/10.1016/j.gecco.2018.e00419.
Maraseni, T.N., Son, H.L., Cockfield, G., Duy, H.V., Nghia, T.D., 2017a. The financial benefits of forest certification: case studies of Acacia growers and a furniture company in central Vietnam. Land Use Policy 69, 56–63. https://doi.org/10.1016/j.landusepol.2017.09.011.
Maraseni, T.N., Son, H.L., Cockfield, G., Duy, H.V., Nghia, T.D., 2017b. Comparing the financial returns from Acacia plantations with different plantation densities and rotation ages in Vietnam. Forest Policy Econ. 83, 80–87. https://doi.org/10.1016/j.forpol.2017.06.010.
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. https://doi.org/10.1016/j.landusepol.2018.03.037.
MARD, 2015. Forest Sector Development Report 2014. Ministry of Agricultural and Rural Development, Hanoi, Vietnam.
MARD, 2019. The overall status of Vietnam timber and Forest products processing and exporting sectors. In: Presented at the Processing and Exporting Sectors of Timber and Forest Products in 2018-Sucess, Lessons Learned and Breakthrough Solutions for 2019, Hanoi, Vietnam.
McWhirter, L., 2016. Economic Sustainability of Second Rotation Acacia Plantations in Central Vietnam. Master's Thesis. Southern Cross University, Lismore, Australia.
Mendham, D.S., White, D.A., 2019. A review of nutrient, water and organic matter dynamics of tropical Acacias on mineral soils for improved management in southeast Asia. Aust. For. 82, 45–56. https://doi.org/10.1080/00049158.2019.1611991.
Meyfroidt, P., Lambin, E.F., 2009. Forest transition in Vietnam and displacement of deforestation abroad. Proc. Natl. Acad. Sci. 106, 16139–16144. https://doi.org/10.1073/pnas.0904942106.
Nambiar, E.K.S., 2019. Tamm review: re-imagining forestry and wood business: pathways to rural development, poverty alleviation and climate change mitigation in the tropics. For. Ecol. Manag. 448, 160–173. https://doi.org/10.1016/j.foreco.2019.06.014.
Nambiar, E.S., Harwood, C.E., Kien, N.D., 2015. Acacia plantations in Vietnam: research and knowledge application to secure a sustainable future. South. Forests 77, 1–10. https://doi.org/10.2989/20702620.2014.999301.
NEPCon, Forest Trends, 2018. Diagnoses and Regulatory Assessment of Small and Micro Forest Enterprises in the Mekong Region: Vietnam Report. Goviet, Hanoi, Vietnam.
OCHA, 2020. Viet Nam Administrative Level 0–2 Boundaries. https://data.humdata.org/dataset/viet-nam-administrative-boundaries-polygon-polyline.
Openshaw, K., 1980. Cost and Financial Accounting in Forestry: A Practical Manual, first ed. Pergamon Press, Oxford, UK.
PEFC, 2020. Viet Nam Forest Certification System (VFCS). https://www.pefc.org/discover-pefc/our-pefc-members/national-members/viet-nam-forest-certification-system-vfcs (accessed 6.22.20).
Perdana, A., Roshetko, J.M., 2015. Survival strategy: traders of smallholder Teak in Indonesia. Int. For. Rev. 17, 461–468. https://doi.org/10.1505/146554815817476477.
Perdana, A., Roshetko, J.M., Kurniawan, I., 2012. Forces of competition: smallholding Teak producers in Indonesia. Int. For. Rev. 14, 238–248. https://doi.org/10.1505/146554812800923417.
Phuc, T.X., 2013. Vietnam's Wood Chip Industry: Status of the Sector in 2012 and Challenges for Future Development. Information Brief. Forest Trends, Washington, D.C, USA.
Phuc, T.X., Huy, T.L., Cam, C.T., Quyen, N.T., Hanh, H.V., 2018a. Vietnamese Import-Export Situation of Timber and Timber Products in the Period 2015-June 2018. Market Information. Goviet, Hanoi, Vietnam.
Phuc, T.X., Huy, T.L., Cam, C.T., Quyen, N.T., Hanh, H.V., 2018b. Vietnam Import-export Wood and Wood Products-reality and Sustainable Integration Tendency. Goviet, Hanoi, Vietnam.
Phuc, T.X., Huy, T.L., Cam, C.T., 2019a. Woodchip Exports in Vietnam: Current Situation and Policy Changes. Goviet, Hanoi, Vietnam.
Phuc, T., Mahanty, S., Wells-Dang, A., 2019b. From "land to the tiller" to the "new landlords"? The debate over Vietnam's latest land reforms. Land 8, 120. https://doi.org/10.3390/land8080120.
Porter, M.E., 1985. Competitive Advantage: Creating and Sustaining Superior Performance. New York, NY, USA, The Free Press: A Division of Macmillan Inc.
Poschen, P., Sievers, M., Abtew, A.A., 2014. Creating rural employment and generating income in forest-based value chains. In: Pretzsch, J., Darr, D., Uibrig, H., Auch, E. (Eds.), Forests and Rural Development. Springer, Berlin, Germany, pp. 145–166.
Pretzsch, J., 2005. Forest related rural livelihood strategies in national and global development. Forests Trees Livelihoods 15, 115–127. https://doi.org/10.1080/14728028.2005.9752515.
Quang, N.V., Phuc, T.X., Treanor, N.B., Quyen, N.T., Cam, C.T., 2018. Linking Smallholder Plantations to Global Markets: Lessons from the IKEA Model in Vietnam. Forest Trends, Washington, D.C, USA.
Quyen, N.T., Nghi, T.H., 2011. How Viet Nam Is Prepared to Meet Legal Requirements of Timber Export Markets. Tropenbos International Viet Nam, Hue City, Viet Nam.
Sathre, R., Gustavsson, L., 2009. Process-based analysis of added value in forest product industries. Forest Policy Econ. 11, 65–75. https://doi.org/10.1016/j.forpol.2008.09.003.
Schmithüsen, F., Kaiser, B., Schmidhauser, A., Mellinghoff, S., Perchthaler, K., Kammerhofer, A.W., 2014. Entrepreneurship and Management in Forestry and Wood Processing: Principles of Business Economics and Management Processes, first ed. Routledge, Oxfordshire, UK.
Tan, N.Q., 2011. Chopping for Chips: An Analysis of Wood Flows from Smallholder Plantations in Vietnam. Working Paper. CIFOR, Bogor, Indonesia.
Tham, L.T., Pretzsch, J., Darr, D., 2018. Acacia Wood Production and Commercialization Systems for Smallholder Livelihood Development in Central Vietnam. Presented at the Tropentag, Ghent University, Ghent, Belgium.
Tham, L.T., Pretzsch, J., Darr, D., 2020a. Asian timber value chains-a systematic review and research agenda. Forest Policy Econ. 112, 1–12. https://doi.org/10.1016/j.forpol.2020.102116.
Tham, L.T., Darr, D., Pretzsch, J., 2020b. Contribution of small-scale Acacia hybrid timber production and commercialization for livelihood development in central Vietnam. Forests 11, 1335. https://doi.org/10.3390/f11121335.
Tong, T.M.T., Shaw, R., Takeuchi, Y., 2012. Climate disaster resilience of the education sector in Thua Thien Hue province, central Vietnam. Nat. Hazards 63, 685–709. https://doi.org/10.1007/s11069-012-0178-5.
Vedeld, P., Angelsen, A., Sjaastad, E., Berg, G.K., 2004. Counting on the Environment: Forest Incomes and the Rural Poor. World Bank, Washington, D.C, USA.
Velde, D.W., Rushton, J., Schreckenberg, K., Marshall, E., Edouard, F., Newton, A., Arancibia, E., 2006. Entrepreneurship in value chains of non-timber forest products. Forest Policy Econ. 8, 725–741. https://doi.org/10.1016/j.forpol.2005.06.010.
Vu, T.T.H., Tian, G., Zhang, B., Nguyen, T.V., 2019. Determinants of Vietnam's wood products trade: application of the gravity model. J. Sustain. For. 1–16. https://doi.org/10.1080/10549811.2019.1682011.
Yin, R., Newman, D., 1997. Long-run timber supply and the economics of timber production. For. Sci. 43, 113–120. https://doi.org/10.1093/forestscience/43.1.113.
Yin, R., Pienaa, L.V., Aronow, M.E., 1998. The productivity and profitability of fiber farming. J. Forest. 96, 13–18. https://doi.org/10.1093/jof/96.11.13.
Zachariah, O., 2008. Rubber Wood Industry in Kerala- A Value Chain Analysis. Doctor of Philosophy. Mahatma Gandhi University, Kottayam, India.