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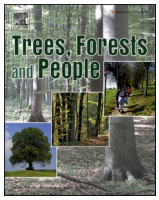

# The acacia plantation boom in Thừa Thiên Huế Province, Central Vietnam: A survey of tree farmers' shifting livelihoods, environmental perceptions, and occupational perspectives

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ABSTRACT

The rise of exotic-species-based plantation forestry in biodiverse tropical countries transforms livelihoods and environmental qualities in various ways. Through 180 structured interviews of different types of acacia plantation owners (producers of woodchips/sawlogs, with/without membership in a recent Forest Stewardship Council [FSC] program) we investigated such transformations in three districts along a lowland-upland gradient in Thừa Thiên Huế Province, Central Vietnam. We focused on how trajectories of livelihood and income changes related to the farmers' perceptions on environmental changes, and how this, in turn, was linked to the farmers' assessments of opportunities, risks, and concrete plans in tree cultivations. Sawlog producers (especially with FSC-certification) in the lowlands had been among the first to plant acacias in the 1990s, and in 2018 usually owned large plantations. In contrast, most farmers producing just woodchips were smallholders. Before acacias the farmers' livelihoods were often more diversified in terms of agricultural products. Since then, many farmers (especially in the lowlands) abandoned rice/cassava production and/or livestock keeping to concentrate on wood production, willingly and/or as an outcome of land conversion (enclosure) to privatised plantations. Farmers' incomes and material assets usually increased (especially FSC-farmers), but most smallholders still depended on incomes from subsidiary wage labor. Within a context of 'development' improvements were also seen in infrastructure (buildings, roads, water provisioning) and public services (education, health). Considering acacia planting most farmers (especially FSC-farmers in the lowlands) saw environmental improvements in terms of soil fertility and landscape amenity, but not wildlife habitat. Most farmers also saw plantation value (especially on longer rotations) in terms of natural hazards mitigation (i.e. floods, droughts, soil erosion), but storms were also noted as the main risk to plantations (especially in the uplands). Another emerging risk was posed by plant diseases affecting acacias in the mid-/lowlands. Projective future plans to change plantation areas and/or crop rotations depended on the farmers' economic strengths in terms of plantation land or other capital. Regarding future risks most farmers noted environmental impacts (storms, plant diseases) rather than economic factors (with wood market prices considered stable). Overall, the results suggest an appreciable value of acacia plantations to farmers, however with some marked distinctions between richer (FSC-certified) and poorer (smallholder) farmers as well as farmers in different regions with distinct terrain and land use management histories. We discuss such distinctions whilst also noting relevant study limitations connected to the complex socio-politics of land titling and uses, especially in the uplands.

## Introduction

During recent decades exotic-species-based plantation forestry has seen increasingly widespread adoption around the world, with significant socioeconomic impacts (positive and/or negative) on rural people's livelihoods and environmental qualities. Such impacts were often particularly profound in fast developing tropical countries where tree plantations may have replaced highly biodiverse types of

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vegetation, and associated traditional land use systems (Malkamäki et al., 2018; D'Amato et al., 2017; Pirard et al., 2017; Kull et al., 2011; Nigussie et al., 2021; cf. Van and Cochard 2017, Nguyen and Kull 2022).

In Vietnam, rapid and wide-ranging transformations – in terms of bio-physical as well as social, political, and economic 'landscape changes' – have occurred as an outcome of an acacia plantation boom that started in the 1990s (McElwee 2016; Cochard et al., 2017, 2020, 2021, 2023). During the 1970s-1980s rural communities in Vietnam still mostly depended on communally used fixed irrigated fields (for rice and other crops), open pastoral lands (intermixed grass-/bushlands), shifting agri-silvi-cultural lands (i.e. staple production on rotating rainfed swidden fields within a mosaic of tree-covered fallows), and natural forestlands (used for collecting timber and non-timber products, and for wildlife hunting/trapping). Only around thirty years later (in the wake of the Đổi Mới policy reforms in 1986) fixed agricultural lands had been allocated to households and are now largely intensively cultivated with commercial crops (Sandewall et al., 2010; Sikor and Baggio 2014). Similarly, large expanses of lands formerly used for pastures and swidden had been allocated as degraded 'forestlands' to households with the specific purpose to 'reforest' these areas with fast-growing commercial tree plantations (Ngo and Webb 2008; De Jong et al. 2006; McElwee 2009; Mai 2016). Such lands are now typically stocked with exotic acacia trees (*Acacia mangium* × *auriculiformis* hybrids) for the production of wood biomass (for pulp and paper factories) and – increasingly – timber (for furniture industries; Nambiar 2021, Nambiar et al., 2015). In contrast, rural communities have been mostly excluded from using remaining natural forestlands which are now mostly owned and managed by state forest organisations (i.e. either commercially oriented 'state forest companies', or forest protection oriented 'state forest management boards'; McElwee 2016, Nguyen and Kull 2022, To et al., 2015, Bayrak et al., 2013, 2015).

In addition to this largely politically-driven wide-ranging 'transition of land tenure and access', recent market demands for specific wood-based products (in particular furniture and building construction) have been shifting the parameters of industrial wood production in plantations (To et al., 2019; Tham et al., 2020; 2021). Accordingly, plantation management for timber production under specific standards (such as by the Forest Stewardship Council, FSC) has been favoured through various government policies and economic incentives (Maraseni et al., 2017a, 2017b; Zhunusova et al., 2019). This, in turn, has often benefitted the better-established owners of large tree plantations (Cochard et al. 2021). Overall, the past and continuing development of acacia plantations has brought new and lucrative incomes for many farmers; yet the acacia boom also partly disadvantaged and marginalised other farmers (with poverty and equity issues often deepening along divergences of ethnicity and gender) and raised new concerns for land management in terms of key sustainability aspects (e.g. soil and biodiversity protection) (cf. Haas et al., 2019, Pham et al., 2023, Bayrak et al., 2013, Nguyen and Kull 2022; Nambiar et al., 2015, 2018).

The aims of this questionnaire-based survey study were to 1.) gain

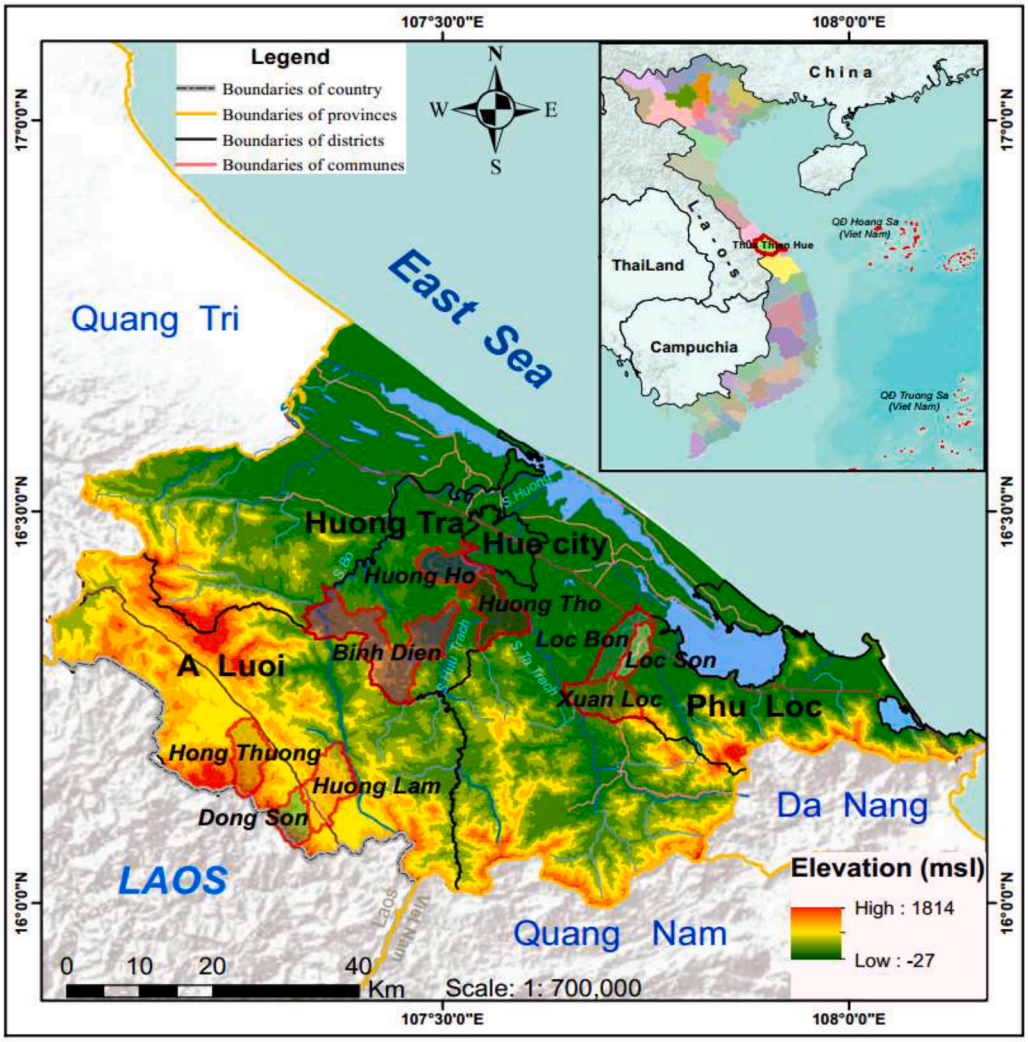


**Fig. 1.** Map showing the location of the nine surveyed communes within three districts in Thừa Thiên Huế Province, Central Vietnam. Map by B.T. Vu.

insights into the past and recent social and environmental changes associated with acacia plantation development; 2.) consequently, appraise ongoing trajectories of change; and 3.) attain a better understanding about the 'sustainability' (in all of its aspects) of these land use and livelihood transforming developments. In the study we focussed on 180 acacia tree farmers in three districts of Thừa Thiên Huế Province in Central Vietnam (Fig. 1). We explored the farmers' experienced livelihood shifts, their views and perceptions of environmental changes, and their contextual outlooks on developments (encompassing aspects of livelihood/environmental opportunities and risks) and on associated future occupational perspectives. The study partly builds on, and extends from, a previous study (Cochard et al. 2021) which provides a more detailed description of socio-environmental and economic contexts, patterns of land ownership, and historically-grounded configurations and trends of plantation management.

## Study site and background

Thừa Thiên Huế Province (TTHP; area of 5033 km$^2$; Fig. 1) includes lowland coastal lagoons and plains (mainly covered by rice fields, and interspersed with different types of woods, including tree plantations), undulating hilly 'midlands' (nowadays largely covered by acacia plantations), and valleys in mountainous uplands (covered by natural forests and partly plantations). TTHP encapsulates many of Central Vietnam's historical and present development trajectories. Huế City was Vietnam's pre-colonial capital. TTHP was located at the center of the 'American War' (1955–1975). Today, TTHP is a magnet of industrialization, and at least since the 1990s it is fast developing new ways in agriculture and industrial forestry. In 2018 around a third (officially 989 km$^2$) of TTHPs total tree cover (3111 km$^2$) was tree plantations, with acacias being the predominant species (GSO 2022; Cochard et al., 2023). Already in 2016 TTHP started to implement programs promoting 'sustainable forestry' in terms of FSC-defined criteria (Cochard et al., 2021; WWF, 2019). Such programs have been promoted by government agencies, in collaboration with international agencies and NGOs (mainly the World Wildlife Fund, WWF) and/or corporations (Scansia Pacific). In 2018 there were 780 farmers with in total 38.6 km$^2$ FSC-certified plantations (ca. 3.8% of total plantation cover). By 2020 this had increased to 1057 farmers and 51.7 km$^2$ FSC plantation cover (ca. 5.2% of total plantations; TTH-FOSDA 2021, GSO 2022).

The rise of acacia plantation forestry in TTHP (and other parts of Central Vietnam) occurred within wider historical socio-political developments, and across the specifics of the province's highly variable terrain. In Phú Lộc District (including Lộc Sơn and Lộc Bổn Communes in this study, Fig. 1), people traditionally subsisted on paddy fields in the coastal alluvial plains. Many nearby inland lowland forests were already cut in pre-colonial times and were replaced by woodlands or brushlands which continued to serve the communities as sources of wild foods, and wood for construction and for energy (firewood, charcoal) (Biggs 2018a, 2018b). By contrast, Xuân Lộc Commune, which is located more inland (Fig. 1), was founded in 1975 as part of the national government's Resettlement Program. The communities in Phú Lộc are mainly composed of Kinh people (Vietnam's majority ethnicity), but one village in Xuân Lộc is inhabited by Bru-Vân Kiều people (originating from upland Quảng Trị Province) who settled there after the war (Pietrzak 2010; Salemink 2015). The communes of Hương Trà District were partly based on original villages located west from Hue City (Fig. 1). Much of the area now planted with acacias (including several settlements, especially in Bình Điền Commune, Fig. 1) was previously covered by natural forests that were destroyed during the war (Cochard et al. 2021, 2023).

The history of upland TTHP is quite different from the lowlands and midlands. The territory which now forms A Lưới District, heavily embattled during the war, was (and still is) inhabited by people speaking Katuic languages, namely the Cơ Tu, Tà Ôi, Pa Cô and Bru-Vân Kiều. These people traditionally gained their livelihoods from small-scale shifting swidden agriculture within variable terrain and from wild products derived from the dense surrounding rainforests (Århem 2014). In the years following the war, swiddening was successively prohibited by national laws. Furthermore, under various programs many communities were resettled to the main valley, to make room for state-led developments, such as upland water reservoirs for hydroelectricity production, 'protection forests' and 'production forests' managed by state forestry organizations, and designated nature conservation areas (Mai 2016; McElwee 2016, 2021; Cochard et al., 2023).

As already described to some detail in our companion paper (Cochard et al. 2021; cf. also Cochard et al., 2023), there were notable variations among the study sites in the ways in which acacia plantation development (and an associated wider modernist 'development'; cf. Århem 2014) was fostered by the state, and how such developments were likely received and perceived by different communities, actors, and individuals (pertaining to different groups of ethnicity, gender, etc.). In the largely already deforested lowlands, and especially in the hills of the midlands (i.e. a primary 'frontier' for plantation development, especially during the 'Greening the Barren Hills' Program 327), the development of acacia plantations allowed for a specific form of agro-silvicultural 'reforestation'. For many rural people (especially of Kinh ethnicity) this 'reforestation' rendered the landscape more valuable in terms of one specific product (wood) which could be harvested at regular cycles. In the uplands, in contrast, natural forests of different qualities were still relatively abundant (cf. Cochard et al., 2023). The forest landscape had been traditionally used by upland peoples in ways which combined areas of agro-silvicultural uses ('forests for exploitation') with zones of forest protection for spiritual ('ghost forests' and 'spirit forests') as well as utilitarian ('headwater protection forests') conceptions (Bayrak et al., 2013; Århem 2014). The more recent acacia boom in the uplands therefore has to be considered on the basis of new political (e.g. through state-administered forest land allocation, FLA) and economic incentives which primarily emerged out of a context of significant state-imposed limitations of traditional forestland uses and associated practices (cf. Nguyen and Kull 2022, McElwee 2016, 2021, Bayrak et al., 2015, Pham et al., 2023).

## Methods

### *Questionnaire-based survey*

Our study followed a social-environmental science approach which was based on some general assumptions, namely that 1.) relevant differences existed in terms of farmers' characteristics, including potential determinants such as the farm location (study site), tree plantation management type (cf. below), gender, or other categories (e.g. variables indicating specific types of capital), and that 2.) these characteristics could be expected to have a bearing on the responses of the interviewees. Patterns observed from the data formed a basis for specific interpretations, in conjunction with knowledge derived from other personal observations and discussions in the field, and/or from literature sources.

The questionnaire survey was conducted during September to November 2018. We chose a mixed purposive-systematic sampling strategy. All communes selected by this study had a FSC group. The FSC group leader could provide contacts, and ninety households participating in FSC certification schemes were thus selected (referred to as 'FSC-farmers'). Ninety households not engaged in FSC (i.e. non-certified 'Nc-farmers') were then selected in the vicinity of FSC households. We were careful to include farmers of different plantation management types and ended up with four 'farmer types' (Table 1) along an ordered gradient, i.e. (1.) 62 Nc-farmers who managed plantations for (non-certified) Nc-woodchip production only ('Nc-woodchip-farmers'), (2.) 28 Nc-farmers who had set aside some plantation area for Nc-sawlog production (sawlogs were not yet exploited; 'Nc-sawlog-farmers'), (3.) 63 FSC-farmers with (as yet) unexploited plantations for FSC-certified sawlog production ('FSC(start)-farmers'), and (4.) 27 'pioneering' FSC-

**Table 1**
Summary of the number of respondents interviewed in the communes of the three study districts, i.e. Phú Lộc, Hương Trà and A Lưới by farmer type, i.e. producers of non-certified woodchips only (Nc-woodchip), non-certified sawlogs (Nc-sawlog), and FSC-certified sawlogs which had (FSC⟨exploit⟩) or had not yet (FSC⟨start⟩) been exploited on some plots. The table also summarizes the median of the first year that farmers (in the respective category) planted acacias, and the mean plantation areas (± standard deviation; in hectares) cultivated in 2018 by the farmers (data from survey; for more details see Cochard et al. 2021).

| | | Total | Phú Lộc | Hương Trà | A Lưới |
|---|---|---|---|---|---|
| Number of farmers interviewed per district and farmer type | **Total** | **180** | **70** | **70** | **40** |
| | Nc-woodchip | **62** | 19 | 29 | 14 |
| | Nc-sawlog | **28** | 14 | 10 | 4 |
| | FSC-sawlog | **90** | 37 | 31 | 22 |
| | FSC⟨start⟩ | 63 | 24 | 17 | 22 |
| | FSC⟨exploit⟩ | 27 | 13 | 14 | 0 |
| Median of the first year that farmers planted acacias | **Total** | **1999** | **1997** | **1998** | **2007** |
| | Nc-woodchip | **2000** | 1997 | 1999 | 2008 |
| | Nc-sawlog | **2000** | 1999 | 1998 | 2010 |
| | FSC-sawlog | **1997** | 1995 | 1996 | 2006 |
| | FSC⟨start⟩ | 2000 | 1995 | 1998 | 2006 |
| | FSC⟨exploit⟩ | 1995 | 1994 | 1995 | – |
| Mean (± stdev) plantation area (ha) cultivated per farmer | **Total** | **5.8** ± 7.1 | **8.1** ± 10 | **4.8** ± 4.1 | **3.4** ± 2.8 |
| | Nc-woodchip | **1.8** ± 1.5 | 1.5 ± 1.1 | 2.1 ± 1.9 | 1.6 ± 1.0 |
| | Nc-sawlog | **4.1** ± 2.0 | 3.3 ± 1.4 | 4.2 ± 1.9 | 6.5 ± 2.0 |
| | FSC-sawlog | **9.1** ± 8.7 | 13.4 ± 11.4 | 7.6 ± 4.5 | 3.9 ± 3.0 |
| | FSC⟨start⟩ | **6.6** ± 5.5 | 9.0 ± 6.7 | 6.6 ± 4.7 | 3.9 ± 3.0 |
| | FSC⟨exploit⟩ | **14.8** ± 12 | 21.4 ± 13.9 | 8.7 ± 4.0 | – |

farmers who, in 2018, had already exploited FSC-certified timber ('FSC⟨exploit⟩-farmers'). In addition to plots managed for timber production under FSC-certified standards, many FSC-sawlog producers also owned acacia plots for Nc-woodchip and/or Nc-sawlog production (Cochard et al. 2021). The different categories (1–4) generally followed a certain gradient pattern (however with some differences between study sites) from smaller to larger plantation assets, whereby most 'Nc-woodchip farmers' (with on average 1.8 ha of plantations) could possibly be described as 'tree plantation smallholders' (cf. Table 1 in Results and Discussion; cf. Cochard et al. 2021, Sikor and Baggio 2014).

We employed a questionnaire (tested through a pilot study) with mainly open questions. Questions which were covered and discussed in more detail in our first study (Cochard et al. 2021; Supplementary Materials, Appendix A) were devised to obtain information about (1.) the profile and basic livelihood status of the respondents (questions Q1–9), (2.) the respondents' history of involvement in plantation forestry and past experiences (Q10–16); (3.) current plantation and other agricultural assets (Q17–20), and (4.) acacia plantation management practices (Q21–33). Various data obtained from Q1–33 were also used in the current study in order to assess and explain specific responses.

The current study focuses on an additional set of questions (Supplementary Materials, Appendix B) devised to obtain information on (1) farmers' livelihood asset changes (and associated experiences) before and after becoming an acacia tree farmer (questions Q34–48), (2) their experiences of acacia tree farming and associated environmental changes and risks (Q49–53), (3) their future outlook (perceived risks and opportunities) for acacia plantations (Q54–59), and (4) their knowledge, perceptions and assessments with regard to Forest Stewardship Council (FSC) certification (Q60–64).

The respondents' answers were recorded by the interviewer (Bien Thanh Vu); on average an interview took about one hour. All respondents participated voluntarily. Prior to the interview the respondents were informed about the aims and scope of the study and the prospective length of the interview, and they were explicitly asked whether they would like to participate as respondents.

### *Data treatment and analyses*

Answers to the open questions were later coded according to thematic categories identified from the answers (Bryman 2016). Microsoft Excel was used for data management and basic calculations. Minitab 17 (Minitab Inc., State College, PA, USA) and R software (3.5.2 version) were used to establish significant variable interrelationships by using appropriate statistical methods. Bivariate statistical methods included parametric (T-Test, analysis of variance) and nonparametric (Chi-square, Mann-Whitney, and Kruskal-Wallis) tests. Multivariate statistical methods included multivariate linear regression (MLR; including best subsets regression BSR, to select optimal variable combinations), binary (BLR) and ordinal (OLR) logistic regression, and general linear models (GLM). Before analyses the interval data were checked for normal distribution and if necessary, transformed as appropriate (e.g., logarithm, square root, or other transformation). In the Supplementary Materials (Appendix B), we provide a summary of all questionnaire questions, the corresponding primary or coded data, and the statistical results which are outlined and discussed within this paper.

### *Specifications and potential limitations of the study*

Some specifications and potential limitations of our study may be noted. *First*, the study may not be representative for all farmers and rural people in Central Vietnam. The study only focussed on officially recognised acacia tree farmers present in 2018; it did not focus on those who had previously given up on agriculture and/or plantations (e.g. emigrants to industries in cities), those farmers who never participated in the 'acacia boom', or farmers which may have planted acacias on lands for which they had not (yet) obtained any legal titles (i.e. lands registered in Red Book certificates, usually granted for a period of fifty years; McElwee 2016). Furthermore, because the study was designed to compare farmers using different types of plantation management (cf. above), plantation smallholders were in reality relatively underrepresented. Plantation smallholders are by far the largest group of tree farmers, and many of these farmers (especially in the uplands) are of a relatively more disadvantaged status (cf. Nguyen and Kull 2022, Pham et al., 2023, McElwee 2016, McElwee and Nghi 2021, Cochard et al. 2021, Haas et al., 2019).

*Second*, some results (and associated interpretations) may contain specific biases. In contrast to closed questions, the open questions of the questionnaire did not limit the range of possible answers, but to some degree the responses were perhaps influenced by the respondents' interaction with the interviewer. In addition, as the study collected recall-based historical information, certain perceptive biases relating to the memory (and perhaps associated desires) of respondents may have

occurred. Biases may also result from differences of socio-political context and past exposure to specific perspectives. For example, certain training programs may have implanted specific environmental ideas which are now considered important. Whilst respondents who had not participated in such programs may be less explicit and/or focussed on particular issues, this does not exclude the possibility that they also apply certain potentially effective strategies to deal with such issues, within the constraints of their potentials.

*Third*, some results (and associated interpretations) may contain specific ambiguities. In some cases we asked questions about 'developments' which may or may not have been directly linked to the acacia plantation boom. Answers to such questions may be considered within contexts of wider processes of 'modernization' and/or 'development'; such contexts could however be relevant to explain specific answers that were directly related to changes in (or perceptions about) land use systems. Similarly, answers relating to specific perceptions (e.g. about natural processes and ecosystem functions) may be primarily considered in relative terms rather than as inherently reliable indicators of 'nature' *per se*. Notwithstanding any such noted study limitations, careful analyses and corresponding interpretation of multivariate data patterns (as well as additional 'triangulating' questions, direct observations, or information derived from literature) helped to introduce more clarity about the dispositions of specific answers (e.g. identify potential biases among certain groups of respondents).

## Results and discussion

### *The respondents' profiles and the development of acacia plantations*

This section mostly summarises information which is described in more detail in the companion publication (Cochard et al. 2021). As could be expected, most of the interviewed tree farmers in the upland district (A Lưới) belonged to a Katuic ethnic minority group (97%), whereas in the mid- and lowland districts (Hương Trà and Phú Lộc) most of the respondents were Kinh (98%). Respondents were mostly men (82%), aged between 28 and 79 (on average 52) years, had spent 0–16 (average 7.4) years in school, and had 0–6 (average 2.2) children. Some respondents (21%) had served in a leadership position, e.g. as a commune leader, or in another political or social-service function.

According to respondents' information, acacia tree planting started in the mid- and lowlands already in 1990, with a planting peak around 1994–2000 (Table 1). Tree planting during the 1990s was promoted by largely internationally funded tree planting programs such as the Program 327 (named 'Greening the Barren Hills' Program) or the Program PAM 4304 (funded by the UN World Food Programme). In A Lưới District, in contrast, the first acacia plantations were set up by farmers only in 2004, and tree planting peaked between 2005 and 2010. Forestland allocation and associated tree planting in the uplands, and also by some farmers (mostly smallholders) in the mid- and lowlands, was mainly promoted in conjunction with the largely World Bank sponsored Programs WB3 and 661 (named the 'Five Million Hectares Reforestation Program'), as well as other government-led development programs (cf. McElwee 2016, Cochard et al. 2021).

In 2018, FSC-farmers in the mid- and lowlands usually owned the largest plantation areas (on average 10.7 ± 9.3 hectares, range 0.9–46.0 ha), whereas the plantation landholdings of Nc-sawlog-farmers (4.1 ± 6.0 ha) and Nc-woodchip-farmers (1.8 ± 1.5 ha, range 0.4–9.0 ha) tended to be significantly smaller (Table 1). FSC-farmers (and especially those farmers in the lowlands who had already exploited FSC-certified wood) had often been pioneers of tree plantation development (cf. Table 1); sometimes they had been working on eucalypt and/or rubber tree plantations before actively engaging in acacia planting during the 1990s. Many of these farmers therefore had a marked headstart into the plantation-based acacia wood production business (cf. Cochard et al. 2021). In contrast, more marginalised and poor farmers were often less successful in obtaining forestland tenure for acacia planting (i.e. Red Book land certificates granted through processes of FLA; cf. McElwee 2016), and in capitalizing on their plantation assets (cf. Nguyen and Kull 2022, Pham et al., 2023, Cochard et al. 2021).

In 2018, FSC-farmers in general had more resources and options to diversify production (including both FSC-timber and woodchips from acacia, as well as from other tree species) and to tend their plantations (e.g. using fertilizers instead of post-harvest burning of residues, short intervals between harvesting and plot replanting, and planting/keeping some native trees; cf. Cochard et al. 2021). Such advantages were however hardly a mere outcome of FSC-membership which was indeed only obtainable since 2016. Rather, well-established and connected tree farmers who owned large plantation areas (and who had established themselves as tree farmers early in the 1990s) were more likely to be engaged in new market options and to obtain FSC-membership. Hence, 'FSC-membership' essentially can be seen as an indicator of a somewhat more privileged farmer status in general; it is not by itself a determinant of such a status.

### *Farmers' livelihood sources before and after the establishment of acacia plantations*

In order to assess the transformation of livelihoods, the farmers were asked about changes in their income sources from before to after the setting-up of their acacia plantations. Considering their answers, one needs to keep in mind the different timelines and associated developments, i.e. some farmers in the lowlands and midlands already became acacia farmers in the 1990s whereas other farmers (mainly in upland A Lưới) took up acacia-based silviculture in 2010 or even later (cf. Cochard et al. 2021, 2023; Table 1). Due to local socio-cultural configurations and partly in accordance with differing timelines, there were marked differences among the studied districts (Table 2).

Before acacia planting, many farmers in the lowlands at Phú Lộc District noted to have subsisted on several types of incomes (70% listing more than three important income items). Here, most farmers (93%) had been engaged in non-acacia agriculture, particularly in rice production (84%) and/or livestock keeping (37%). In addition, many farmers had gained some income from wage labor (80%) and/or had already been employed on tree plantations (52%; stocked with eucalypt trees at the time) (Table 2). In contrast, in 2018 few farmers at Phú Lộc (20%) depended on more than two income items, with 35% of FSC-farmers and 3% of non-certified farmers listing acacia plantations as their only 'major' income source. Rice-based (22% in 2018) and other non-tree based agricultural income sources (10%) had markedly declined in importance. In the case of FSC-farmers (but not Nc-farmers) the importance of wage labor had equally decreased from before (81%) to after (11%) acacia planting, whereas other non-agricultural income sources (administrative/official jobs, shop-keeping, pensions, remittances, and others) had become more important (overall 41% of FSC-respondents at Phú Lộc and 46% at Hương Trà; Table 2).

Within the undulating hills of Hương Trà, acacia plantations (and in some locations rubber tree plantations) were largely established on natural bushlands and forests destroyed during the war; cf. Cochard et al., 2023). This 'frontier history' largely explains why most of the respondents at Hương Trà (84% FSC-farmers, 97% non-certified farmers) had gained their pre-acacia incomes from wage labor. Fewer respondents had initially been rice farmers (44%) and/or livestock farmers (8%). The importance of rice farming declined from before (45%) to after acacia planting (29%) in the case of the better-off FSC-farmers, but rice farming remained important for non-certified farmers (increasing from 36% to 41%) – i.e. among those newly settled poorer farmers who through their labor largely contributed to developing agricultural activities within this district (Table 2). Accordingly, at Hương Trà the number of 'major' incomes noted by non-certified farmers somewhat increased from before (46% of respondents noting only one item, i.e. mostly wage labor) to after (81% noting more than one item) acacia planting, whereas the number noted

**Table 2**
Summary of changes in overall incomes and main income sources from 'before' acacia planting to 2018 (i.e. after the establishment of acacia plantations), as indicated by non-certified and FSC-certified acacia tree farmers in the three study districts. All the numbers represent percentages of responses within the respective categories.

| *District →* | Phú Lộc (70) | | | | Hương Trà (70) | | | | A Lưới (40) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Farmer Type →* | non-certified | | FSC-certified | | non-certified | | FSC-certified | | non-certified | | FSC-certified | |
| *Changes before-after(2018) →* | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 |
| one 'main' incomes noted | 12 | 3 | 3 | 35 | 46 | 8 | 19 | 19 | 6 | 6 | 18 | 0 |
| two 'main' incomes noted | 30 | 73 | 16 | 49 | 33 | 74 | 48 | 42 | 89 | 89 | 64 | 59 |
| three 'main' incomes noted | 52 | 24 | 43 | 11 | 15 | 18 | 23 | 29 | 0 | 6 | 14 | 36 |
| four 'main' incomes noted | 6 | 0 | 38 | 5 | 5 | 0 | 6 | 10 | 0 | 0 | 0 | 5 |
| **eucalypt [acacia] plantations** | **39** | **[100]** | **65** | **[100]** | **36** | **[100]** | **45** | **[100]** | **0** | **[100]** | **0** | **[100]** |
| plantation middlemen | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 |
| tree nursery | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| work as carpenter | 0 | 0 | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| firewood collection | 9 | 15 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| **non-acacia agriculture** | **91** | **36** | **95** | **27** | **36** | **56** | **52** | **42** | **94** | **50** | **82** | **91** |
| rice production | 76 | 21 | 92 | 22 | 36 | 41 | 45 | 29 | 94 | 44 | 82 | 73 |
| cassava production | 24 | 0 | 22 | 5 | 0 | 0 | 3 | 0 | 0 | 22 | 0 | 50 |
| livestock keeping | 24 | 9 | 49 | 5 | 5 | 3 | 10 | 3 | 0 | 0 | 14 | 14 |
| rubber production | 0 | 0 | 3 | 0 | 5 | 15 | 6 | 16 | 0 | 0 | 0 | 0 |
| aquaculture (fish) | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **non-agriculture** | **79** | **91** | **84** | **43** | **97** | **69** | **87** | **55** | **89** | **89** | **91** | **91** |
| wage labor | 79 | 82 | 81 | 11 | 97 | 56 | 84 | 26 | 89 | 89 | 91 | 64 |
| keeping a shop | 0 | 3 | 0 | 8 | 0 | 5 | 0 | 23 | 0 | 0 | 0 | 0 |
| having an official job | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 27 |
| receiving a pension | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| receiving remittances | 0 | 3 | 0 | 8 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| other incomes | 3 | 0 | 0 | 5 | 0 | 0 | 3 | 13 | 0 | 0 | 0 | 0 |
| income decreased before-after | 0 | | 0 | | 5 | | 0 | | 0 | | 0 | |
| income stayed about the same | 9 | | 0 | | 31 | | 0 | | 44 | | 23 | |
| income only slightly increased | 61 | | 16 | | 38 | | 13 | | 33 | | 50 | |
| income fairly increased | 30 | | 30 | | 21 | | 33 | | 17 | | 9 | |
| income significantly increased | 0 | | 54 | | 5 | | 55 | | 6 | | 18 | |

by FSC-farmers stayed about the same (Table 2).

Before the relatively recent (after ~2005) acacia boom in the uplands, farmers in A Lưới District had largely subsisted on crops grown on irrigated and non-irrigated (mostly shifting/swidden) agricultural lands (88%) but had also earned important incomes from wage labor (90% of responses; Table 2). In the case of the non-certified (smallholder) farmers the importance of wage labor remained high (at 89%), but rice production declined in significance from before (94%) to after (44%) acacia planting – a development which is probably partly associated with more limited land in conjunction with the increasingly stringent prohibition of swidden agriculture and associated FLA (cf. Bayrak et al., 2015, Nguyen and Kull 2022, Cochard et al., 2023). This decline was less marked in the case of the better-off FSC-farmers (from 82% to 73%), who had also been more likely to take up official job positions (27%) and/or keep livestock (14%). In addition, FSC-farmers were more likely to cultivate fields of cassava (50%) compared to non-certified farmers (20%). During the 2000s-2010s cassava became a booming 'cash crop' in the uplands (cf. Mai 2016, Kim et al., 2008, Mahanty and Milne 2016), whereas cassava (reportedly still grown in pre-acacia times as a staple food by 23% of the respondents in Phú Lộc) has largely disappeared from the lowlands (Table 2).

Besides these differences among districts and farmer types, farmers' reported income sources – previous and current – showed also other broad patterns (cf. Supplementary Materials, Appendix B). Farmers who in 2018 produced sawlogs (with or without FSC), older respondents, and/or owners of relatively larger acacia plantations were generally more likely to have depended on diverse income sources during pre-acacia times, and notably from rice farming and/or livestock keeping. Conversely, farmers with relatively lower educational backgrounds and/or fewer acacia plots (and especially those not previously working on eucalypt plantations) were more likely to have previously earned simple incomes from wage labor (as opportunities arose) and cassava staple crops (mostly produced on lesser valued non-irrigated lands). In 2018 lesser educated farmers with fewer connections to development programs and administrations, and/or owning smaller acacia plantations (mostly for woodchips) were still likely to depend on incomes from wage earning rather than from more stable and gainful proceeds.

Farmers with relatively large plantations in 2018 (especially sawlog producers connected to WWF, and those who had already worked on eucalypt plantations during 'pioneer times') had often specialized in wood production. Hence, in comparison to 'late-comer' acacia farmers they were more likely to depend on fewer income sources compared to pre-acacia times. Thus, well-established tree farmers did not necessarily transit towards more 'diversified' livelihoods but mainly fostered their livelihood resilience via building up their acacia plantation 'capital'. Controlling for this, the data however also shows that very well educated farmers were more likely to practice widened entrepreneurship (i.e. more than one 'major' incomes), in addition to investing in the lucrative acacia tree farming business (cf. Cochard et al. 2021).

### *Farmers' income levels before and after acacia plantation establishment*

When asked about the changes in income levels from before to after the transition to acacia farming, most of the respondents (83%) stated that their incomes had increased. Yet, there were marked differences between the study sites and farmer types (Table 2). The changes were assessed most positively in Phú Lộc District where only 9% of the non-certified farmers stated that their incomes had stayed about the same. In contrast, in Hương Trà 36% of the non-certified respondents, and in A Lưới 44% of non-certified and 23% of FSC-members noted no real improvements of incomes. The better-off FSC-farmers (and especially those with large plantation estates in 2018) generally reported the highest income improvements. In Phú Lộc and Hương Trà 54% of FSC-farmers (and 78% of FSC(exploit)-respondents) noted that their incomes had "significantly increased" (Table 2). Again, the results should be seen against the backdrop of differing histories and timelines of the different study sites, with many tree farmers of Kinh ethnicity in the lowlands (especially at Phú Lộc) having a head start in the acacia business

compared to upland minority communities who were often pressured to abandon traditional ways of managing forested environments (Table 1; cf. Cochard et al. 2021, 2023, Thulstrup 2015, Bayrak et al., 2015, Nguyen and Kull 2022).

*Farmers' livestock assets before and after acacia forestry*

Increases in farmers' incomes could possibly facilitate new investment in specific assets, e.g. extension of plantations and/or other agricultural lands/resources (cf. Cochard et al. 2021) and/or increases in livestock herds on farms. The fast transition to acacia-based livelihoods was however accompanied by significant land cover changes (cf. Cochard et al. 2021, 2023, McElwee 2009, Sandewall et al., 2010; cf. also Gironde and Peters 2015) whereby transformation from variably 'open' spaces (i.e. mostly bushlands often used as commons) to a largely closed cover of 'acacia forests' (on privatised lands) substantially reduced the spaces and pastoral resources needed for livestock keeping, and related agricultural activities.

Our survey data revealed no significant pre-acacia differences in levels of livestock keeping between FSC-certified and non-certified farmers, except in Phú Lộc where FSC-farmers had already been somewhat better-off (Table 3). By 2018 most farmers had significantly reduced their livestock herds or entirely abandoned husbandry in Phú Lộc and Hương Trà, with the most significant reductions among FSC-farmers (up to a 25-fold decrease in average livestock asset values at Phú Lộc). In contrast, in A Lưới some non-certified farmers decreased and others increased their livestock herds (0.8-fold decrease in average asset values) whereas the generally better-off FSC-farmers on average increased the size of their herds 1.7-fold (Table 3). Members of ethnic minorities were most likely to maintain or increase their livestock numbers. In addition to the importance of capital for livestock keeping (cf. Parsons et al., 2013), animal husbandry has a certain traditional status in the uplands where there were possibly also more open spaces for grazing (cf. Kyeyune and Turner 2016). In addition to cattle and buffalo, the number of pigs also tended to increase in A Lưới (Table 3). In contrast, lowland farmers connected to NGOs (in particular WWF), and especially the older and/or those with leadership positions were most likely to have abandoned or reduced any livestock keeping.

The main reason which was presented by farmers to explain why they had abandoned or reduced livestock farming was that they had shifted their focus to acacia farming, i.e. farmers no longer had sufficient time or other resources to tend livestock. This was particularly often noted among FSC-farmers in Phú Lộc (62%) and in Hương Trà (52%), especially by those who owned many acacia plots (Table 3). In addition, the older and better-educated farmers frequently noted that they were short on time because they did not receive sufficient support from their children (who may have pursued other non-farming careers). Additional important reasons were reductions in land access. According to some farmers in Phú Lộc (20%) livestock grazing was no longer possible because of a lack of grazing resources (i.e. openly accessible grazing lands). Others noted (13%, in Phú Lộc; 23% of FSC-farmers in Hương Trà; Table 3) that livestock grazing now clashed with acacia farming because livestock feeds on (or may otherwise damage) the now privatized acacia plantations. Four farmers in the lowlands however mentioned that they maintain livestock because they receive government support for specific livestock business developments.

*Material assets before and after acacia forestry*

A look at changes in material assets (as assessed through a Likert scale and some specific asset indicators, namely two types of transport means [motor-cycles and cars], a work tool [chainsaws], and a luxury good [television sets]) provides some additional insights into changing living standards and associated perceptions (Table 3). According to the responses, pre-acacia material assets were lower among the non-certified farmers (average asset value index of ~135 USD) as compared to FSC-farmers in the lowlands (~1210 USD), but still tended to be higher than all farmers in the uplands (~65 USD; Table 3). In terms of changes to assets after farmers started to grow acacias, increases were highest among farmers with large acacia plantations areas (mostly FSC-farmers and other sawlog producers), and especially those who had started acacia planting during early pioneer times. Relative increases

**Table 3**
Summary of changes in livestock assets and specific types of material assets from 'before' acacia planting to 2018 (i.e. after the establishment of acacia plantations), as indicated by non-certified and FSC-certified acacia tree farmers in the three study districts. If not otherwise indicated, the numbers represent the percentage of responses in the respective categories.

| *District* → | Phú Lộc (70) | | | | Hương Trà (70) | | | | A Lưới (40) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Farmer Type* → | non-certified | | FSC-certified | | non-certified | | FSC-certified | | non-certified | | FSC-certified | |
| *Changes before-after* → | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 | 'before' | 2018 |
| no livestock | 42 | 64 | 22 | 78 | 49 | 74 | 58 | 94 | 28 | 50 | 41 | 41 |
| a few livestock | 30 | 27 | 24 | 19 | 31 | 15 | 16 | 3 | 67 | 28 | 54 | 27 |
| some livestock | 27 | 9 | 35 | 3 | 21 | 8 | 23 | 3 | 6 | 22 | 5 | 27 |
| many livestock | 0 | 0 | 19 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 5 |
| mean (± stdev) estimated[1] livestock assets in 2018 USD | 1103 (1756) | 431 (789) | 2600 (3414) | 106 (236) | 665 (846) | 372 (917) | 881 (1635) | 191 (1007) | 786 (735) | 645 (869) | 488 (554) | 850 (1045) |
| mean (± stdev) number of cattle | 1.7 (3.9) | 0.9 (1.8) | 3.8 (6.3) | 0.1 (0.4) | 1.1 (1.7) | 0.8 (2.1) | 1.4 (2.8) | 0 | 1.3 (1.4) | 0.7 (1.8) | 0.6 (1.0) | 1.7 (2.3) |
| mean (± std.) number of buffalo | 0.3 (0.9) | 0 | 1.2 (2.6) | 0 | 0.1 (0.9) | 0 | 0.3 (1.0) | 0.3 (1.8) | 0.2 (0.6) | 0.4 (0.8) | 0.2 (0.8) | 0 |
| mean (± stdev) number of pigs | 1.6 (1.8) | 0.4 (0.9) | 3.2 (2.5) | 0.6 (1.4) | 1.8 (2.3) | 0.3 (0.9) | 1.2 (2.2) | 0.1 (0.5) | 0.8 (1.3) | 0.9 (1.6) | 0.6 (1.1) | 0.7 (1.5) |
| mean (± stdev) number of goats | 0.3 (1.7) | 0.3 (1.2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 (2.4) | 0 | 0 |
| change reason: land trade-off | 12 | | 27 | | 0 | | 3 | | 0 | | 0 | |
| change reason: tree damage risk | 12 | | 14 | | 3 | | 23 | | 0 | | 0 | |
| change reason: work trade-off | 18 | | 62 | | 46 | | 52 | | 11 | | 18 | |
| very few material assets | 85 | 18 | 41 | 0 | 74 | 13 | 39 | 0 | 89 | 22 | 87 | 14 |
| a few material assets | 15 | 46 | 51 | 5 | 18 | 41 | 29 | 6 | 11 | 56 | 14 | 59 |
| some material assets | 0 | 33 | 8 | 49 | 8 | 41 | 10 | 26 | 0 | 17 | 0 | 23 |
| many material assets | 0 | 3 | 0 | 46 | 0 | 5 | 23 | 68 | 0 | 6 | 0 | 4 |
| mean (± stdev) estimated[2] index material assets in 2018 USD | 33 (154) | 1407 (662) | 382 (460) | 10454 (10873) | 221 (412) | 1586 (595) | 2199 (5904) | 7806 (9787) | 84 (258) | 1300 (486) | 49 (93) | 1422 (531) |
| mean (± std) numb. motor cycle | 0.1 (0.2) | 1.3 (0.7) | 0.3 (0.5) | 1.9 (0.5) | 0.2 (0.4) | 1.4 (0.6) | 0.7 (0.8) | 1.9 (0.4) | 0.1 (0.2) | 1.2 (0.5) | 0 | 1.3 (0.6) |
| mean (± std) number car/truck | 0 | 0 | 0 | 0.4 (0.5) | 0 | 0 | 0.1 (0.2) | 0.3 (0.4) | 0 | 0 | 0 | 0 |
| mean (± std) number chain saw | 0 | 0.1 (0.3) | 0.1 (0.2) | 0.5 (0.8) | 0 | 0.1 (0.3) | 0 | 0.2 (0.4) | 0 | 0.1 (0.2) | 0 | 0 |
| mean (± stdev) number of TV | 0.1 (0.2) | 1.4 (0.6) | 0.7 (0.5) | 2.2 (0.5) | 0.3 (0.5) | 1.6 (0.6) | 0.8 (0.7) | 2.0 (0.5) | 0.1 (0.3) | 1.3 (0.6) | 0.5 (0.8) | 1.3 (0.5) |

Notes: [1] calculated from 2018 values as 432 US$ for a cow, 104 US$ for a pig, 561 US$ for a buffalo, and 47 US$ for a goat; [2] 2018 values as 863 US$ for a motorcycle, 22'000 US$ for a car, 86 US$ for a chainsaw, and 216 US$ for a TV set.

were also somewhat higher in the uplands when one controls for plantation size (and especially among farmers who no longer planted cassava as intercrops; cf. Cochard et al. 2021), even if A Lưới was still the poorest of the three districts in 2018 (average asset value index of ~1302 USD, compared to ~3243 USD in Hương Trà and ~5972 USD in Phú Lộc; Table 3). This confirms the patterns shown in other studies (Thulstrup 2015; Thulstrup et al., 2013; Epprecht et al., 2011).

*Perceived developments in infrastructural and social capital*

Between 1998 and 2018 the per-capita gross domestic product (GDP) in Vietnam increased about threefold (from 1070 USD to 3063 USD; WB Data 2022), and the changes in farmers' assets and incomes evidently partly correspond with other wider developments that may or may not have influenced (or been influenced by) the development of acacia plantations in various direct or indirect ways. Here we focus on an assessment of changing 'life quality' in terms of indicators of (1) specific built infrastructural capital (i.e. private housing, road transport, and water provisioning) and (2) social capital (i.e. access to medicines and education).

The 'pre-acacia' quality of their housing was rated by most farmers as either 'bad' (48%) or 'very bad' (34%), with a slightly better rating in the lowlands as compared to the uplands (Table 4), and more positive responses among younger farmers as compared to the older. Regarding the housing in 2018 the ratings were however markedly better, with most farmers stating that housing was either 'good' (50%) or 'very good' (33%), with relatively higher ratings in the lowlands, and among rich and well-educated farmers. Improvements in housing quality ratings were generally highest among older and longer-established owners of large plantations, and also among those who had taken up a loan to set up their plantations. Late-comers to plantation forestry (i.e. those who had 'learned from others about the benefits of acacia planting') and women were more likely to indicate no or minor improvements.

Similar to housing, the 'pre-acacia' transport facilities (road infrastructure and associated services and means) were rated by most farmers as either 'difficult' (50%) or 'very difficult' (33%; Table 4), with a tendency for more positive ratings by women and respondents who recently took up acacia farming, who did not take up loans, and whose plantations were in rather mildly sloping terrain. Regarding road transport in 2018, the ratings were markedly better, with most farmers stating that

**Table 4**
Assessment of life quality indicators (infrastructure development, social services and engagement, and environmental services), considering the situation 'before' acacia planting to 2018 (i.e. after the establishment of acacia plantations). Data as indicated by farmers of the three districts, respectively non-certified (*Nc-woodchip, Nc-sawlog*) and FSC-certified (*FSC-sawlog*) farmers.

| **all↓** | **housing quality[1]** | | | | | | | | **road transport[2]** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| district↓↓ | 'before' | | | | assessment 2018 | | | | 'before' | | | | assessment 2018 | | | |
| *resp. type↓↓↓* | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **overall** | **34** | **48** | **16** | **2** | **1** | **16** | **50** | **33** | **33** | **50** | **16** | **1** | **3** | **15** | **49** | **33** |
| in Phu Loc | 24 | 57 | 17 | 2 | 0 | 14 | 46 | 40 | 33 | 57 | 10 | 0 | 4 | 19 | 43 | 34 |
| in Huong Tra | 37 | 42 | 17 | 4 | 2 | 11 | 47 | 40 | 28 | 47 | 23 | 2 | 0 | 7 | 50 | 43 |
| in A Luoi | 45 | 45 | 10 | 0 | 3 | 27 | 60 | 10 | 47 | 40 | 13 | 0 | 5 | 23 | 60 | 12 |
| *Nc-woodchip* | *37* | *57* | *6* | *0* | *3* | *32* | *57* | *8* | *32* | *52* | *16* | *0* | *2* | *27* | *58* | *13* |
| *Nc-sawlog* | *29* | *47* | *18* | *7* | *0* | *14* | *43* | *43* | *29* | *50* | *21* | *0* | *11* | *7* | *54* | *28* |
| *FSC-sawlog* | *33* | *44* | *21* | *2* | *0* | *6* | *47* | *48* | *38* | *48* | *13* | *1* | *1* | *9* | *42* | *48* |
| **all↓** | **access to medicine[3]** | | | | | | | | **investment and access in education[4]** | | | | | | | |
| district↓↓ | 'before' | | | | assessment 2018 | | | | 'before' | | | | assessment 2018 | | | |
| *resp. type↓↓↓* | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **overall** | **39** | **46** | **11** | **4** | **10** | **25** | **34** | **31** | **46** | **30** | **18** | **6** | **11** | **27** | **41** | **21** |
| in Phu Loc | 34 | 56 | 7 | 3 | 3 | 24 | 37 | 36 | 37 | 37 | 21 | 5 | 9 | 26 | 47 | 19 |
| in Huong Tra | 47 | 40 | 10 | 3 | 14 | 23 | 34 | 29 | 40 | 30 | 20 | 10 | 14 | 19 | 37 | 30 |
| in A Luoi | 32 | 40 | 20 | 8 | 15 | 30 | 30 | 25 | 70 | 18 | 10 | 2 | 10 | 45 | 38 | 7 |
| *Nc-woodchip* | *65* | *35* | *0* | *0* | *27* | *47* | *23* | *3* | *65* | *24* | *8* | *3* | *26* | *32* | *36* | *7* |
| *Nc-sawlog* | *14* | *64* | *18* | *4* | *0* | *14* | *50* | *36* | *36* | *32* | *29* | *3* | *4* | *21* | *46* | *29* |
| *FSC-sawlog* | *29* | *48* | *17* | *6* | *1* | *13* | *38* | *48* | *36* | *33* | *22* | *9* | *3* | *26* | *43* | *28* |
| **all↓** | **water provisioning[1]** | | | | | | | | **soil fertility[1]** | | | | | | | |
| district↓↓ | 'before' | | | | assessment 2018 | | | | 'before' | | | | assessment 2018 | | | |
| *resp. type↓↓↓* | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **overall** | **2** | **14** | **16** | **68** | **2** | **12** | **16** | **70** | **13** | **51** | **32** | **4** | **4** | **19** | **52** | **25** |
| in Phu Loc | 0 | 4 | 10 | 86 | 1 | 4 | 13 | 82 | 7 | 53 | 37 | 3 | 4 | 11 | 56 | 29 |
| in Huong Tra | 2 | 4 | 10 | 84 | 0 | 1 | 6 | 93 | 6 | 52 | 39 | 4 | 0 | 10 | 61 | 29 |
| in A Luoi | 8 | 47 | 38 | 7 | 8 | 42 | 40 | 10 | 35 | 47 | 13 | 5 | 12 | 50 | 28 | 10 |
| *Nc-woodchip* | *3* | *18* | *15* | *64* | *2* | *13* | *11* | *74* | *16* | *42* | *37* | *5* | *6* | *31* | *53* | *10* |
| *Nc-sawlog* | *0* | *7* | *11* | *82* | *0* | *4* | *11* | *86* | *7* | *68* | *25* | *0* | *0* | *11* | *71* | *18* |
| *FSC-sawlog* | *2* | *13* | *19* | *66* | *3* | *14* | *21* | *62* | *12* | *52* | *31* | *5* | *4* | *14* | *45* | *37* |
| **all↓** | **wildlife habitat quality[5]** | | | | | | | | **landscape amenity[6]** | | | | | | | |
| district↓↓ | 'before' | | | | assessment 2018 | | | | 'before' | | | | assessment 2018 | | | |
| *resp. type↓↓↓* | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **overall** | **4** | **34** | **53** | **9** | **36** | **58** | **5** | **1** | **37** | **48** | **14** | **1** | **4** | **13** | **49** | **33** |
| in Phu Loc | 6 | 26 | 58 | 10 | 20 | 67 | 12 | 1 | 33 | 53 | 14 | 0 | 0 | 9 | 53 | 38 |
| in Huong Tra | 1 | 29 | 59 | 11 | 47 | 53 | 0 | 0 | 31 | 52 | 16 | 1 | 0 | 9 | 47 | 44 |
| in A Luoi | 5 | 60 | 32 | 3 | 45 | 50 | 5 | 0 | 55 | 35 | 10 | 0 | 17 | 30 | 45 | 8 |
| *Nc-woodchip* | *5* | *40* | *50* | *5* | *44* | *53* | *3* | *0* | *37* | *42* | *19* | *2* | *3* | *21* | *42* | *34* |
| *Nc-sawlog* | *0* | *43* | *53* | *4* | *25* | *64* | *7* | *4* | *32* | *46* | *21* | *0* | *3* | *4* | *57* | *36* |
| *FSC-sawlog* | *4* | *28* | *55* | *13* | *34* | *59* | *7* | *0* | *39* | *53* | *8* | *0* | *5* | *11* | *51* | *33* |

Notes: Likert scales were ⌈[1] very bad [1], bad [2], good [3], very good [4]; ⌈[2] very difficult [1], difficult [2], sometimes difficult [3], easy [4], ⌈[3] bad [1], fair [2], good [3], very good [4]; ⌈[4] education investment almost none [1], little [2], to some degree [3], a lot [4]; ⌈[5] observe never [1], rarely [2], sometimes [3], often [4]; ⌈[6] unsightly [1], tolerable [2], beautiful [3], very beautiful [4]

transport was either only 'sometimes difficult' (49%) or generally 'easy' (33%), with relatively more positive ratings in the lowlands (especially Hương Trà), among FSC-farmers with connections to NGOs, and among wage-earners (Table 4). Improvements in transport quality ratings were generally higher among sawlog producers, but tended to be particularly low among the 'late-comer' woodchip-producing tree farmers, especially those who were still engaged in cassava intercropping. These farmers were likely to have their acacia plantations in remote and poorly developed areas whilst also lacking adequate means for transport (e.g. motor cycles and cars).

Farmers' assessments of 'water provisioning services' in villages differed considerably from housing and transport. The assessments of 'before' and 'after' (2018) acacia planting did not markedly differ, with generally high ratings in the lowlands ('very good water provisioning' stated by 85% of farmers for 'before' and by 87% for 'after') and medium ratings in the uplands ('bad' or 'good' stated by 85% for 'before', and 83% for 'after'; Table 4). Relative improvements in water provisioning were mostly noted by female and/or better-educated respondents. Among the fifteen farmers noting devaluations in water provisioning nine were from Phú Lộc. Overall, however the results indicate that – in contrast to contexts of eucalypt plantations (cf. D'Amato et al., 2017, McElwee 2016) – most farmers saw 'water provisioning' as not being negatively affected by acacia tree cover.

Most farmers deemed that 'access to medicines' had been either 'bad' (39%) or 'fair' (46%) in the times before acacia farming, with marginally better assessments in the uplands and/or by farmers well-endowed in 2018 with acacia plantations. Medicinal services have however generally improved, with a majority of farmers judging that access to medicines was 'good' (34%) or 'very good' (31%) in 2018 (Table 4). Improvements in medicinal services were perceived as particularly high among the older and richer (in plantations and material assets) farmers and among those who had taken up a loan.

Farmers were also asked about their own 'investments for education' which may be influenced by both possible improvements in state educational services and the farmers' own changing resources, time, and priorities. Most farmers deemed that 'investments into education' had been either 'none' (46%) or 'little' (30%) in the times before acacia farming, with generally lower assessments in A Lưới (70% stating 'none') and especially by farmers who were still intercropping their plantations with cassava. For 2018, educational efforts/possibilities were assessed as significantly higher, with a majority of farmers judging that they invested in education 'to some degree' (41%) or 'a lot' (21%; Table 4). As may be expected, farmers with a high education level in 2018 and/or richer farmers (in terms of assets owned) were more likely to state comparatively higher 'investments for education' for the times 'before' as well as 'after' acacia planting. Increases in education efforts (as stated) were however fairly uniform among different farmer types, yet with marginally higher improvements among sawlog producers (as compared to woodchip producers) and farmers who had taken up a loan (as compared to those without a loan).

### *Perceived changes in environmental qualities*

The development of tree farming transformed the landscape from a natural bushland intermixed with remnant forests to an acacia tree monoculture that was clear-cut and replanted in regular cyclic rotations. Here we focus on an assessment of farmers' perceptions about some of the associated changing 'environmental qualities'.

Various studies have shown that the establishment of acacia plantations can improve (to some degrees) the soil structure, carbon content, plant nutrient conditions (in particular nitrogen content), and microbial bio-activity in previously heavily impacted sites (Koutika and Richardson 2019; Harwood et al., 2017; Hung et al., 2016; Dong et al., 2014; Schiavo et al., 2009). Conversion of natural forest (or other dense woody vegetation) to fast-rotation acacia plantations may however also induce soil degradation, especially as an outcome of erosion processes during the post-harvest phase as well as perhaps other modifications in the soil chemistry (Cochard et al. 2021; Sidle et al., 2006; Yamashita et al., 2008; D'Amato et al., 2017).

In our survey, a majority of farmers deemed that the 'soil fertility' in the agricultural landscape had been either 'bad' (51%) or 'very bad' (13%) before acacia planting (Table 4). These pre-acacia ratings were particularly low among farmers from A Lưới and farmers who had owned many livestock before acacia planting, but the ratings tended to be less negative among the 'late-comers' in acacia planting. In contrast, most farmers deemed that the soil fertility was either 'good' (52%) or 'very good' (25%) in 2018 (Table 4), with the highest ratings amongst the richer lowland farmers who generally owned large plantations (as well as many material assets) and – notably – those farmers who applied fertilizers on their plots, in addition to other measures of soil improvements and erosion controls (e.g. not burning soil residues after harvesting; cf. Cochard et al. 2021). Increases in soil fertility under acacia cover were more often noted (60%) than decreases (8%), with above-average increases indicated by relatively richer and older farmers using fertilizers, but – controlling for these factors – also by farmers in A Lưới and those practicing intercropping with cassava (despite generally lower ratings in A Lưới also for 2018; Table 4).

While much has been written about the benefits of plantations for the wood industry, much less is known about people's general perceptions about the amenity of the land cover change. In our survey the pre-acacia landscape amenity was rated positively by only a few (15%) respondents, but many deemed that the landscape had become either 'beautiful' (49%) or 'very beautiful' (33%) when being covered with acacia 'forests' (Table 4). The landscape amenity was generally rated lower by farmers in A Lưới (where also the increases in the ratings were less distinct) and by non-certified tree farmers, and especially farmers who still gained some of their incomes from wage labor. This indicates that assessments of 'landscape amenity' are not independent of other work-related experiences and perceptions of the farmers (cf. Pirard et al., 2016).

In marked contrast to the generally perceived improvements in soils and landscape scenery, the survey confirmed a decline of wildlife in a landscape covered by mono-cultures of exotic acacias, as has also been documented in studies focussing on biodiversity changes in 'plantation-forested' landscapes (cf. Ng et al., 2021, Styring et al., 2018, Van and Cochard 2017; cf. also Pirard et al., 2016). During pre-acacia times most farmers (53%) reportedly still 'sometimes' observed wildlife, but wildlife was either 'rarely' (58%) or 'never' (36%) seen in 2018 (Table 4). The most striking decline of wildlife apparently occurred at Hương Trà where an extensive bushland was converted to an almost unbroken new 'forest' of acacias. In contrast, wildlife declines at Phú Lộc (which had been largely deforested already before the war) were generally considered less dramatic, with four famers even noting higher levels of wildlife. Wildlife decreases were noted to be higher if acacias had been planted relatively earlier (e.g. during the 1990s). In addition, farmers connected to NGOs and/or engaged in livestock keeping tended to note less dramatic declines in wildlife.

### *Experiences and perceptions of environmental risks to tree plantation farming*

The development of plantations markedly transformed the characteristics of farming and associated risks. Acacia tree biomass can only be harvested after several years; yet, as trees are grown in monocultures (unlike biodiverse natural forests) the biomass crop is effectively exposed to a similar range of risks as any other agricultural crop. Here we focus on an assessment of farmers' perceptions about major 'risks' to their acacia plantations.

During the monsoon season (September to November) TTHP regularly experiences extreme rainfalls and storm winds brought about by storms, including typhoons (Tong et al., 2011; Pham et al., 2018; Locatelli and Nicoll 2017). It is therefore not surprising that many

**Table 5**
Assessment of environmental risks to plantations (impacts of storms and plant diseases), and environmental services of acacia plantations. Numbers represent the percentage of responses in the respective categories, i.e. responses by farmers of the three districts, respectively by non-certified (*Nc-woodchip, Nc-sawlog*) and FSC-certified (*FSC-sawlog*) farmers.

| **all↓** | **storm risk to plantations** | | | | | | **plant disease risk to plantations** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| district↓↓ | damage frequencies[1] | | | | main | future | damage levels[2] | | | | main | future |
| *resp. type*↓↓↓ | 0 | 1 | 2 | 3 | risk | worry | 0 | 1 | 2 | 3 | risk | worry |
| **overall** | **15** | **28** | **39** | **18** | **73** | **43** | **46** | **28** | **16** | **10** | **26** | **24** |
| in Phu Loc | 11 | 36 | 39 | 14 | 86 | 46 | 10 | 44 | 29 | 17 | 14 | 33 |
| in Huong Tra | 27 | 21 | 44 | 7 | 46 | 43 | 56 | 23 | 13 | 9 | 53 | 30 |
| in A Luoi | 0 | 25 | 33 | 42 | 100 | 40 | 92 | 8 | 0 | 0 | 0 | 0 |
| *Nc-woodchip* | 15 | 24 | 39 | 23 | 66 | 45 | 52 | 23 | 13 | 13 | 29 | 23 |
| *Nc-sawlog* | 36 | 18 | 36 | 11 | 75 | 32 | 39 | 25 | 29 | 7 | 25 | 32 |
| *FSC-sawlog* | 9 | 33 | 41 | 17 | 78 | 46 | 44 | 32 | 14 | 9 | 24 | 23 |
| **all↓** | **perceptions on risk mitigation services provided by acacia plantations[3]** | | | | | | | | | | | |
| district↓↓ | **flood mitigation** | | | | **drought mitigation** | | | | **soil erosion mitigation** | | | |
| *resp. type*↓↓↓ | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| **overall** | **6** | **23** | **45** | **26** | **13** | **23** | **51** | **13** | **2** | **8** | **40** | **49** |
| in Phu Loc | 4 | 26 | 44 | 26 | 10 | 21 | 47 | 21 | 0 | 10 | 47 | 43 |
| in Huong Tra | 4 | 21 | 47 | 27 | 11 | 26 | 54 | 9 | 1 | 6 | 39 | 54 |
| in A Luoi | 10 | 23 | 43 | 25 | 20 | 23 | 50 | 8 | 8 | 10 | 30 | 53 |
| *Nc-woodchip* | 6 | 29 | 45 | 19 | 18 | 24 | 48 | 10 | 5 | 13 | 47 | 35 |
| *Nc-sawlog* | 4 | 36 | 29 | 32 | 7 | 21 | 46 | 25 | 0 | 4 | 46 | 50 |
| *FSC-sawlog* | 6 | 16 | 50 | 29 | 11 | 23 | 53 | 12 | 1 | 7 | 33 | 59 |

Notes: Likert scales were [1] no recorded impact [0], damaged one time [1], damaged two times [2], damaged three (29 farmers), four (2) or five (1) times [3]; [2] no disease impact recorded [0], minor damage [1], medium damage [2], severe damage [3], [3] plantations have no effect [0], plantations help to mitigate maybe with a minor effect [1], plantations help to mitigate to some degree [2], plantations help to mitigate significantly [3]

farmers had already experienced significant storm damages to their plantations either one (28%), two (39%), three (16%), four (1%) or five (0.5%) times since they started to plant acacias (Table 5). The reported number of damages was highest in the uplands, with a storm damage rate around three times higher in A Lưới (0.23 ± 0.12 impacts per year) as compared to the lowlands (0.07 ± 0.05). This striking upland-lowland difference may be due to more intense storms and wind constellations in the uplands as well as higher risks in generally steeper terrain (cf. Tran and Shaw 2007, Locatelli and Nicoll 2017, Sidle et al., 2006). In addition to this, tree stand management and characteristics (tree density/sizes, post-harvest intervals, etc.; Cochard et al. 2021) apparently played a contributing role as farmers with most plantation areas reserved for woodchip production and/or farmers who still practiced cassava intercropping reported comparatively higher frequencies of storm damages. Statistical analyses furthermore indicated that – controlling for other factors – sloping terrain and farmers' education level (the better educated tending to note higher damage rates) partly explained the reported storm damage data patterns.

Single-species tree monocultures can be highly susceptible to plant diseases and insect pests. Several diseases have already been reported to affect acacia plantations (Thu et al., 2010), but in 2018 the situation has not (yet) been as problematic as compared to acacia plantations in other countries in Southeast Asia (cf. Nambiar et al., 2018, Lee 2018). In our study, trees were reported to 'have died' due to 'unknown plant diseases' (probably wilt diseases caused by the fungus *Ceratocystis manginecans* and/or other *Ceratocystis* spp.; Le Nhan Tien, pers. comm.; cf. Tarigan et al., 2011, Chi et al., 2019) by a majority of farmers (54%), but experiences with plant diseases differed markedly between regions (Table 5). In the uplands where acacia farming had started fairly recently (~2007; Table 1), only very few farmers (8%) noted 'minor damages' whereas the other farmers (92%) did not (yet) note any problems. In contrast, issues with plant diseases were more pressing in the lowlands, particularly in Phú Lộc where most farmers reported either 'minor' (44%), 'medium' (29%) or 'severe' (17%) damages to trees in their plantations (Table 5). In addition to regional differences, somewhat higher damages were also reported by the 'late-comers' in plantation farming. Additional studies may be needed to further investigate whether the differences in patterns could be mostly explained by local factors (in particular elevation; cf. Booth et al., 2000), time factors, and/or different farmers' perceptions.

We also queried the potential threats of the widespread vine species *Merremia eberhardtii* which had been considered as a potential 'invasive species' (Le et al., 2012). The survey results indicated that this species was generally known to widely occur around unused areas (i.e. 'wastelands' particularly in steep areas and near streams). Only a few farmers however stated that they needed to weed the plant on their plots with a 'small' (14%) or 'medium effort' (0.5%), either during/after harvesting or during seedling growth. Several respondents noted that the plant had become a lesser problem since acacia planting.

When asked about the most pressing environmental risk to their plantations, most farmers in Phú Lộc (86%) and A Lưới (100%) noted that severe storm impacts represented the main threat, whereas a majority at Hương Trà (54%) considered that plant diseases constituted a greater risk (Table 5). Three farmers at Hương Trà specifically noted 'soil erosion risks' as a main threat; such risks may however also be included in other farmers consideration of 'storm risks', as storms may affect the plantations mechanically through winds (tree breaking) and/or erosion effects during high rainfall events. Controlling for these regional differences, women and major sawlog producers tended to be somewhat more likely to consider storms as the main threat to plantations.

### *Perceptions on natural hazards mitigation services provided by acacia plantations*

In TTHP weather-induced natural hazards such as floods, droughts, and soil erosion have always represented a threat to livelihoods and food security (Tong et al., 2011; Tran and Shaw 2007). With increasing climate change such hazards can be expected to become more frequent and intense (Pham et al., 2018; Cochard 2013). Here we look at farmers' perceptions about the potential role of the acacia cover to reduce such natural hazards within the landscapes.

Most farmers deemed that acacia plantations can help to mitigate floods either 'to a minor effect' (23%), 'to some degree' (45%), or even 'significantly' (26%). The assessments did not markedly differ among regions and farmer types (Table 5), but women and farmers with

connections to NGOs, and/or farmers who had noted to apply measures for environmentally sensitive plantation management (i.e. soil protection through residue management, keeping of native vegetation; cf. Cochard et al. 2021), tended to be more likely to provide higher ratings. Most farmers also deemed that acacia plantations can help to mitigate droughts either 'to a minor effect' (23%), 'to some degree' (48%), or 'significantly' (10%), with a minor (marginally significant) tendency for more positive assessments in the lowlands as compared to the uplands (Table 5). Soil erosion mitigation services were rated highest among the investigated environmental services of tree plantations, with most farmers indicating that plantations were either effective 'to some degree' (40%) or 'to a significant degree' (49%) (Table 5). There was a slight tendency for sawlog producers (and especially those with long plot rotation times and who kept native vegetation) to indicate higher ratings.

These results can provide indications about patterns of perceptions, but – again – the ratings may be considered judiciously in that the survey questions were rather generally framed, without reference to a specific baseline. It may be noted that in reality the flood hazard mitigation functions of (stable) tropical forests are far from trivial (cf. Cochard 2013, Bruijnzeel 2004, van Dijk and Keenan 2007), and acacia plantations are not actually stable 'forests' as they are repeatedly clear-cut, thus intermittently losing any potential 'forest functions' (cf. Cochard et al. 2021). The role of plantations in mitigating droughts can be similarly complex and controversial. In some cases exotic tree plantations have been reported to actually increase drought conditions (especially eucalypts: D'Amato et al., 2017, Vilhervaara et al. 2012, van Dijk and Keenan 2007, Albaugh et al., 2013; for acacias cf. Kull et al., 2011, Cochard et al., 2014), yet in the wet tropics transpiration measurements in *Acacia mangium* plantations have been shown to be similar to surrounding rainforest vegetation (Cienciala et al., 2000). Accordingly, the observed slight increase in ratings along the upland-lowland gradient may partly mirror the generally more or less densely forested surrounding landscape which serves as a perceptual background reference for effects of differently-stocked acacia plantations (cf. Domec et al., 2015). The effect of a dense tree cover to prevent (or mitigate against) soil erosion can be expected to be more immediately evident on acacia plots, and the observed response patterns reflect the fact that older and more densely growing tree stands are more effective than smaller and more frequently cut short-rotation tree stands (cf. Sun et al., 2018, Dung and Kim 2021, Podwojewski et al., 2008; cf. also Pirard et al., 2017).

**Table 6**
Summary of information regarding the wish of farmers to expand (or decrease, keep the same) their plantation areas, to prolong (or keep the same) the acacia harvest interval, and to plant (or not) native tree species. Numbers represent the percentage of responses in the respective categories, i.e. responses by farmers of the three districts, respectively by non-certified (*Nc-woodchip, Nc-sawlog*) and FSC-certified (*FSC-sawlog*) farmers.

| **all↓** district↓↓ | **expand/decrease plantation lands** | | | **rotation interval** | | **native species** | |
|---|---|---|---|---|---|---|---|
| *resp. type*↓↓↓ | -1 | 0 | 1 | 0 | 1 | no | yes |
| **overall** | **6** | **51** | **43** | **43** | **57** | **63** | **37** |
| in Phu Loc | 7 | 57 | 36 | 40 | 60 | 57 | 43 |
| in Huong Tra | 7 | 37 | 56 | 39 | 61 | 57 | 43 |
| in A Luoi | 0 | 63 | 37 | 55 | 45 | 82 | 18 |
| *Nc-woodchip* | 8 | 79 | 13 | 74 | 26 | 85 | 15 |
| *Nc-sawlog* | 4 | 50 | 46 | 39 | 61 | 68 | 32 |
| *FSC-sawlog* | 4 | 31 | 65 | 22 | 78 | 46 | 54 |

Likert scales were: decrease [-1], keep the same [0], increase [1]

*Farmers' future plans for acacia plantations*

Specific risks and limitations may influence the farmers' further plans for plantation development and management. Here we focus on the future outlook as stated by the farmers, asking questions about their plans in terms of plantation landholding, harvesting cycles, and the incorporation of native tree species with higher-grade wood.

A majority of farmers (51% overall; 79% of smallholder woodchip producers) stated that they wanted to keep the area of their plantations as it currently was, whereas 43% of the farmers (46% of Nc-sawlog producers; 58% of FSC⟨start⟩-farmers; 81% of FSC⟨exploit⟩-farmers) wanted to expand. Six percent (all in the lowlands) wanted to reduce their plantations (Table 6). There were also regional differences: in the former 'frontier' district of Hương Trà the potentials for expanding plantations were presumably still somewhat higher (56% of respondents having plans/desires to expand) than in coastal Phú Lộc (36%) and upland A Lưới (38%) (Table 6). In general, those most likely to plan for plantation expansions were farmers who already owned large plantations (mostly timber producers), and especially the rich ones (in terms of material assets) who had previously already expanded their plantations through land acquisitions (cf. Cochard et al. 2021). In contrast, poorer farmers still dependent on wage earning and/or farmers engaged in sizeable livestock keeping were less likely to aim for plantation expansions.

Of those stating plans to expand their acacia plantations, 82% noted that they intended to buy additional plantation lands, 5% said that they planned to work with others on additional conjointly-managed acacia plots, and 14% (mostly those owning rubber plantations) said they wanted to convert other plantations or agricultural lands to acacia plantations. When asked about the specific reasons why they wanted to expand their plantations, farmers either noted that they 'gained good incomes from acacia wood' (44%; mostly lowland sawlog producers with no livestock), that they could capitalize on the 'opportunities to increase forestland ownership' (19%; mostly self-sufficient richer farmers), or because they wanted to convert their non-lucrative rubber plantations to acacias (6%; in accordance with decreasing rubber prices, cf. Mai 2016). Of the few farmers wanting to decrease their plantations, most stated that they were old and therefore wanted to sell part of their plantations (100%; mostly poorer farmers with few material assets) and/or to divide their plantations to give a part to their children (60%). One farmer noted that he wanted to convert an acacia plot to fruit tree plantations.

Most of the sawlog producers (61% of Nc-sawlog producers; 70% of FSC⟨start⟩-farmers; 96% of FSC⟨exploit⟩-farmers) stated that they wanted to increase the rotation period of their acacia plantations in the future. In contrast, amongst the woodchip producers most (74%) wanted to maintain the current stand rotation regime. No farmers stated that they planned to decrease the rotation periods (Table 6). In general, farmers who were richer (in terms of material assets), older and/or better educated were more likely to increase the acacia tree rotation periods, in contrast to poorer and younger farmers, and especially those practicing cassava intercropping.

Of the farmers stating (57% overall) that they wanted to increase the rotation periods of their acacia plantations, some (33%; mostly rich farmers in Phú Lộc) explained as their main motivation that they expected to earn more money from higher wood biomass production (mostly in terms of sawlogs, but sometimes also for woodchips); others (17%; mostly old and rich farmers) noted that higher rotation times required less maintenance and that they were not immediately dependent on the revenue gained from the acacia plots. Of the farmers stating (43% overall) that they wanted to maintain the rotation periods, some (26%; mostly poorer farmers, sometimes practicing cassava intercropping) explained that they needed the money and could not wait for too long, whereas others (8%; mostly in the uplands) noted that they were worried about the storm risks (and shorter rotations alleviated this risk).

Many FSC-farmers (54%) and several non-certified sawlog (32%)

and woodchip (15%) producers stated that they wanted to plant native tree species (e.g. *Hopea odorata, Homalium zeylanicum, Chukrasia tabularis*, or others; cf. Cochard et al. 2021) for the production of high-grade timber (with possibly some additional benefits in terms of ecosystem services; Table 6). In general, farmers who were richer (in terms of material assets), older and/or better educated, and/or who already planted native species (e.g. *Hopea*) or preserved some native vegetation (e.g. along riverine-riparian zones) were most likely to envisage planting (more) native species on their plots. Among the poorer farmers those who still practiced cassava intercropping also tended to be attracted to the idea of planting native species.

The farmers who intended to plant native species (37% overall) explained their rationales in several ways. Some farmers thought that planting native species would bring additional economic benefits (25%; mostly richer farmers, and/or those engaged in intercropping), or that native species would 'benefit the next generation' (19%; often noted by older respondents). Others however emphasised that native species would be 'environmentally beneficial' (43%; mostly richer farmers, and/or those already keeping native vegetation) either in terms of 'soil erosion mitigation' (25%), as a 'wind break' (16%; stated only by FSC-farmers in the lowlands), and for carbon sequestration (3%). Six farmers (9%) thought of planting native species because they believed that the government would provide specific subsidies and support for such activities. Farmers who did not intend to plant native species (63% overall) noted various trade-offs as reasons. Many farmers (48%; mostly woodchip producers, and relatively often women) drew attention to the fact that native species are 'very slow growing', and – having to wait a long time for economic returns – they could not afford the investments. A few farmers (5%) also noted that for them the tree seedlings of the usual commercially marketed native species were too expensive (cf. Cochard et al. 2021). Similarly, some farmers (10%) remarked that native trees were not a lucrative option for them because such trees 'required a lot of space'.

*Farmers' outlooks: future risks and opportunities of tree farming*

Farmers were specifically asked about what they see as future risks and opportunities of acacia tree farming. With regard to 'future risks' the farmers' responses largely mirrored their answers on past and current 'risks to plantations' (Table 5), i.e. many farmers stated that they were worried about the impact of storms (43%; possibly including future increases of this threat through effects of climate change) and/or soil erosion (6%; mostly in A Lưới), or plant diseases (24%). Only four respondents (2%) noted that they were primarily concerned of future price reductions in acacia wood products. Respondents referring to 'future storm risks' were largely those who also saw storms as the 'main current risk', yet markedly fewer respondents voiced this 'future' concern (especially in A Lưới, and among sawlog producers; Table 5). This is largely explained by the fact that 25% of the respondents did not provide any concrete answer at all (many said they did 'not know'; often respondents with a lower education).

Likewise, only 24% of the respondents provided explicit answers to the question about 'future opportunities'. Some respondents (17%; mostly the older, with connections to NGOs, and/or large landholdings) noted that they expected the market prices for acacia wood to increase in general (10%) or due to FSC-certification (7%), whereas other respondents (7%; mostly well-educated respondents in Phú Lộc) saw future opportunities mainly through continued 'government support' provided to the acacia plantation industry.

*Farmers' engagement, knowledge and outlooks with regard to FSC timber certification*

The FSC certification program for acacia sawlogs had started in 2016 in the lowlands of TTHP with the implicit aim to gain access to highly lucrative markets through a 'ticket' of 'sustainable sawlog production'. As such there were supposedly both economic as well as environmental benefits to be gained through processes of standardized auditing of plantations; yet, the program mostly focussed on owners of large plantations, and thus (at the time) barely provided any livelihood benefits and improved 'sustainability' to the many smallholders of plantations (Cochard et al. 2021; To et al., 2019).

Many respondents with FSC-certification in Phú Lộc (65%; especially those with large plantations and/or those who had taken up a loan) had joined the FSC-program from the start (2016), whereas FSC-members in Hương Trà (68%) and A Lưới (100%) mostly joined the program in 2017. In 2018 only about a third of the FSC-sawlog producers (31%; mostly respondents with a leadership role, and often those owning comparatively smaller plantation estates) had all their acacia plots under FSC-certification. The other FSC-members had on average only about half of their plantations (47% ± 23% of plot areas; range 10%–88%) under FSC-certification, with comparatively higher ratios among richer farmers and farmers who had not depended on any help from NGOs to manage their plantations and/or certification arrangements.

Among the FSC-farmers who still had only a part of their plantations under FSC-certification (61 respondents, 68%) a majority (66%) noted that they planned to increase the coverage of FSC-certification for their plantations. These tended to be mostly richer and better educated farmers with no/few livestock who in 2018 still had many of their acacia plots assigned to woodchip production. The main argument to expand the cover of FSC-certification (explicitly stated by 21 farmers) was that they gained more money from certification. Some of those who did not plan to expand FSC-certification (34%) stated logistical ("plots in remote areas"), economic or social ("need money", "regular income", "plots co-managed with others", "plots will be inherited by children"), and/or environmental reasons ("worried about plant diseases, storms").

All the ninety FSC-members in our survey indicated they were either 'satisfied' (55%) or 'very satisfied' (45%) with the FSC-program, whereby farmers with a leadership role and/or very rich farmers (in terms of material assets) tended to give somewhat less enthusiastic ratings. Among the FSC-members who already had exploited FSC-certified sawlogs (27 respondents, 30%) all stated to have sold their wood for a 'better' (41%) or a 'much better' (59%) price (again with generally less enthusiasm shown among the richer farmers). When asked about the 'main benefits of FSC', farmers either noted that they "saved time, efforts and inputs" to manage their plantations (34%; mostly the better educated, richer, and especially farmers in Hương Trà), that they gained more money (23%, mostly farmers connected to NGOs and owners of large estates) or that the price of wood could be expected to remain stable under FSC (2%). Others mentioned environmental benefits associated with FSC (12%). Some farmers (16%; mostly in A Lưới) remarked that they "had no idea", which suggests that they participated mainly because of social-political reasons to help foster the FSC-program (cf. Cochard et al. 2021). When asked about 'major drawbacks of FSC' a majority of FSC-farmers stated that there were no drawbacks (62%; mostly the richer farmers and/or farmers with honorary positions), others noted that they did not know (17%; mostly in A Lưới), and four farmers (4%) noted that the procedures for producing and selling wood under FSC were complex.

Among the ninety respondents in our survey who were not FSC-members in 2018 a few sawlog producers (18%) and two thirds of the woodchip producers (65%) said they 'did not really know' about FSC-certification and its possibilities. Farmers who had been in the acacia business for only a short time (and especially women) were particularly unlikely to know about FSC. Two respondents indicated that they had been members of FSC but had left the program because they needed money (and thus harvested the acacias before the assigned date). Among those knowing about FSC, nineteen farmers (42%; mostly sawlog producers in Hương Trà) said they had plans to join FSC, whereas twelve farmers (27%; mostly woodchip producers in Hương Trà) explicitly stated they had no such plans; no information was provided by other respondents. Some of those who had plans to join (six respondents)

noted that they now had a sufficiently high income so they could afford the needed investments in prolonged plantation rotation times; at the same time they could save some labor and expect higher incomes from FSC-certified sawlogs. In contrast, some of those who did not have such plans noted that they needed the money and/or that the rotation times were too long (six respondents); others were worried about storm risks (two respondents).

## Concluding remarks

Unlike neighbouring countries in Southeast Asia (e.g. Dwyer 2015, McAllister 2015, Pirard et al., 2017) Vietnam has – until recently – not seen any substantial direct 'land grabbing' by large international corporate investors (cf. Sikor 2012). In this regard, the course of plantation development in Vietnam has been less overtly conflict-laden, as compared to cases in other countries (cf. Gerber 2011, Schirmer 2007). Despite of this, many experiences of plantation forestry development in Vietnam do not fundamentally differ from experiences elsewhere (cf. Malkamäki et al., 2018), and some fuzzy issues of formal/informal land control and management are festering at different spatial scales, especially in the upland regions (To et al., 2015; McElwee 2016; Nguyen and Kull 2022).

In TTHP the acacia boom in the physical landscape (which followed certain spatial gradients) has been in close interaction with a significant restructuring of the social-political landscape since the 1990s. As fast-growing trees which can grow on heavily degraded sites (Evert 2014), exotic acacias emerged as economically valuable during 'reforestation' programs in the 1990s, and plantations have since spread to the valleys in the uplands, where acacias have been taken up as a 'politically accepted' and – within constrained contexts – relatively lucrative option for 'forest cultivation' (Cochard et al. 2021; Nguyen and Kull 2022; Thulstrup et al., 2013; Arvola et al., 2020). The 'plantation boom' has thereby been linked to a re-distribution of forestlands, i.e. lands which are now largely under the management of state forestry organisations (mostly on designated 'protection forest' areas; Cochard et al., 2020) and private forestland owners (on designated 'production forest' areas; Cochard et al. 2021, 2023; To and Dressler, 2019).

On the one side, the plantations overall have certainly contributed (at least in the short term) to general industrial-economic growth; this includes significant industrial labor creation along the value chain of wood products (cf. Tham et al. 2021, Maraseni et al., 2017a, Nambiar 2021). On the other side, it needs to be noted that the plantations have largely displaced other important, potentially more diversified (and insofar perhaps more 'sustainable') land uses which were based on long-established socio-environmental customary systems (cf. Bruun et al., 2009, Ziegler et al., 2009). Especially in the upland regions, such land redistributions and transformations often side-lined the poorer and more marginalised sections of rural societies, notably ethnic minorities and women (cf. Sowervine 2004, Bayrak 2019, Haas et al., 2019, McElwee 2016, 2021, McElwee and Nghi 2021, McElwee et al. 2009, Pham et al., 2023, Richards 2019).

Overall, acacia development thus implied substantial shifts in the control and valuation of forestlands, with some farmers who could substantially benefit, many who somewhat benefited or managed to get by ('jumping on the bandwagon' of plantation development), and still others who essentially lost out (i.e. mostly those who remained without legal Red Book land titles). Our study did not capture the entire range of rural households and livelihoods; many households in upland TTHP may still be without officially recognised land ownership and subsist on marginal incomes from 'wild' acacia plots, small-scale rice fields and gardens, NTFP collection in the forests, and/or occasional wage labor (Nguyen and Kull 2022; Mai 2016). This noted, most of the respondents in our study (all with Red Book certificates) could profit to some degree from tree farming and associated developments – however evidently with more positive experiences and assessments among the generally richer FSC-farmers (and other sawlog producers) as compared to the poorer (smallholder) woodchip producers (which represent the predominant majority of tree farmers in TTHP).

The so-called 'forest transition' in TTHP mostly came in the form of this 'boom' of exotic acacia trees, i.e. a novel 'forest cover' which is of limited direct value in terms of biodiversity conservation (and ecological resilience, Ennos 2015) and – correspondingly – provisioning ecosystem services other than woody biomass. Unlike bushlands and natural forests (cf. Van and Cochard 2017, Cochard et al., 2018, 2021) or other types of planted woodlands (e.g. less densely stocked pine plantations; Pirard et al., 2017) these new forests evidently no longer left much room for livestock keeping, NTFP collection, or hunting of wildlife. In terms of other (regulating, supporting, amenity) ecosystem services, however, the farmers' perceptions and assessments tended to be somewhat more positive as compared to other studies (e.g. D'Amato et al., 2017, Pirard et al., 2017). This may be largely explained by the fact that in TTHP most plantations (especially in the low-/midlands) had been established on lower-biomass natural bushlands, i.e. a land cover baseline that most farmers had already perceived as comparatively 'degraded' (perhaps through previous over-uses of grazing or cultivations, and/or sometimes war impacts; cf. Cochard et al. 2021, 2023). It may however partly also be explained by certain perceptive biases whereby 'tree plantations' are mostly thought of as a 'forest cover' rather than as a 'clear-cutting' after tree harvesting.

Acacia plantations represent anthropogenic ecosystems whose functions and services (including soil protection and fertility) are inherently dynamic and multifaceted; such functions/services still require research that accounts for the entire range of socio-environmental systemic complexities (cf. Cochard et al. 2021, Cochard 2013, Ziegler et al., 2009). Within a context of increasing risks from extreme weather (brought about by climate change) and newly spreading plant diseases, this importantly includes a better understanding of the resilience of acacia plantations *per se*, set in relation with alternative land uses. Farmers need to carefully assess their investment options, opportunities and risks, and in the case of tree farming some future avenues may well lie in diversifying cultivations (in terms of species and spatial arrangements), including some review of time-honoured experiences, techniques and strategies of tree planting and land management. Within this changeable context, timber certification schemes (such as FSC) could potentially perform specific beneficial and diversifying roles by adding value to the wood (through allowing farmers' access to new lucrative markets) and by fostering more environmentally friendly and socially considerate standards of planation management – provided the certification schemes will essentially be accessible and of assistance to all the farmers which are engaged in acacia wood production.

## CRediT authorship contribution statement

**Bien Thanh Vu:** Conceptualization, Methodology, Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing, Funding acquisition. **Roland Cochard:** Conceptualization, Methodology, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Funding acquisition, Project administration. **Dung Tri Ngo:** Conceptualization, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tfp.2023.100405.

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