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REGULAR RESEARCH ARTICLE

# Towards a diversified agricultural forest-based economy: Community views of planting sandalwood in Timor-Leste

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ABSTRACT

With growing awareness that export revenues derived from non-renewable oil and gas resources are in decline, Timor-Leste seeks to develop a more sustainable and diversified economy. Sandalwood holds significant cultural, economic and historical importance for the Timorese people, and is representative of an internationally competitive export product. Livelihood diversification can alleviate the prevalence of poverty among smallholders in Timor-Leste. Within this context, and with a focus on forestry, we sought to determine the institutional support and smallholder interest and capacity for restoring over-exploited sandalwood. Interviewed households were acutely aware of the high value and benefits derived from sandalwood and expressed strong interest in planting the species for income generation. Land tenure security, essential for long-term forestry investments, was high among those surveyed and not considered a limitation. Improved forestry extension can address many of the respondent-identified risks which were biophysical (lack of water, pests, livestock, and fire destruction). Legal marketing of planted sandalwood, which is currently prohibited, can help growers maximise benefits from their investments and provide a market signal to stimulate wider planting of sandalwood among smallholders.

KEYWORDS

Forestry; Diversified economy; Smallholder livelihoods; Timor-Leste (East Timor); Sandalwood (*Santalum album* L.).

## 1. INTRODUCTION

Timor-Leste is a mountainous island nation with a rich human and political history. The country has a population of 1.3 million (World Bank, 2020) and its economy relies heavily on oil revenues (Doraisami, 2018). In recognition of this over-reliance on non-renewable resources, and ongoing declines in oil revenue (Grigg, 2021; Scheiner, 2021), the Timor-Leste government seeks to develop other, more sustainable non-oil sectors of the economy (Harmadi & Gomes, 2013). Agricultural primary production is the most prominent non-oil rural sector, with most families dependent upon subsistence agriculture for their livelihoods (Harmadi & Gomes, 2013). For emerging economies, robust agricultural growth is prerequisite for broad and sustained national economic development (Pingali, 2007). The contribution of agriculture to the national

economy, food security and socioeconomic well-being of smallholder farmers can be improved through diversification and increasing productivity through technology adoption (Akter et al., 2021).

Livelihood diversification opportunities in Timor-Leste are not strong when compared with other parts of Southeast Asia (Batterbury et al., 2015). While diversification strategies can include adoption of a wider range of crop species and varieties, it can also encompass incorporating commercially valuable tree species into the agricultural system (Inder, 2020). Scheiner (2021) asserted that Timorese agriculture could only compete on international agricultural markets for niche products such as high-quality coffee, spices or organic produce. It is therefore logical that diversification into planted forestry crops should follow a similar trajectory and focus on high value crops where it has a competitive advantage (Fanzo et al., 2017). One such resource, sandalwood (*Santalum album* L.) is a native tree of Timor-Leste, which holds significant cultural, economic and historical importance (McWilliam, 2005; McWilliam, 2007; Yoder, 2011).

Sandalwood is a small tree that produces a fragrant oil-rich heartwood (Arctander, 1960; Yusuf, 1999; da Silva et al., 2016), which has been traded since antiquity (McCrindle, 1879; Schoff, 1912; Aftel, 2004). A trade network emerged in the Java sea from the 2$^{nd}$ to 3$^{rd}$ Century CE with a focus on the trade of sandalwood and spices (King, 2015). Timor trade in sandalwood was facilitated by Chinese (Gungwu, 1958; Mathers & Flecker, 1997) and later Portuguese (Pires, 1944; McWilliam, 2003) merchants. In more recent times (1975-2001) sandalwood was exploited heavily by the occupying Indonesian military (Aditjondro, 1994; CAVR, 2006; Bhattacharya, 2018a). Today the sandalwood trade is prohibited under Timor-Leste national law (RDTL, 2012) and various customary treaties known as *Tara Bandu* (Alonso-Población et al., 2016; Barreto, 2017; Bhattacharya, 2018b). Despite these restrictions on cutting sandalwood, an illegal trade remains of unknown size (Ferreira et al., 2021).

The current economic prospects for sustainable sandalwood production are very favourable, with the global market for sandalwood products, predicted to remain strong up to and beyond 2040 (Thomson, 2020). Although information on sandalwood prices are often not publicly available (Coakley, 2013) they have risen steeply over the past 30 years (Soundararajan et al., 2015; Suresh Ramanan et al., 2020), due to decreasing natural supplies (Rashkow, 2022). Viable production systems have been developed for a range of sandalwood species (Page et al., 2022a), which supports an expanding plantation resource in Australia, Asia and the Pacific Islands (Thomson, 2020). Many of these plantation resources are beginning to mature and can satisfy international demand for sustainably sourced sandalwood products. Financially viable sandalwood production has already been demonstrated in smallholder agroforestry systems for places like Fiji (Harrison & Harrison, 2016), Vanuatu (Page et al., 2010; Ota et al., 2022) and India (Divakara et al., 2018). Recent research in Timor-Leste has also demonstrated the potential for profitable sandalwood production in smallholder systems (Page et al., 2022b).

*S. album* is recognised as the most valuable of all sandalwood species owing to its consistently high quality fragrance (Hettiarachchi, 2013; Kumar et al., 2015). Sandalwood has a high market value because of its scarcity and is used in high-priced consumer products, such as incense, wood carving, food flavouring, perfume, cosmetics and medicine (Akhter et al., 2008; Blank et al., 2008; Burdock, 2010; Kumar et al., 2012; Dove, 2014; Rhind, 2014; Goswami & Tah, 2018). Sandalwood has strong spiritual significance for many religions and cultures across the world (King, 2015; Thomson, 2020) and robust demand for natural sandalwood products continues (Coakley, 2013;

Padmanabha, 2013; Thomson, 2020). Therefore, this natural product has the potential to contribute to local livelihoods and diversify incomes through efforts toward the restoration of the species. With a burgeoning global human population, increasing affluence in sandalwood-consuming countries, and product diversification, the high demand for sandalwood is expected to continue well into the future (Thomson, 2020).

The introduction of agroforestry and tree cropping systems in Timor-Leste has the potential for mitigating further land degradation while improving smallholder income (Fanzo et al., 2017; Bond et al., 2020). Successful adoption of tree-based innovations are dependent upon a range of factors that influence decision-making (Arvola et al., 2020). In this study, we use the locally sacred and highly-valuable sandalwood tree as a case study to determine if tree-based systems are likely to be adopted by rural Timorese people. A range of pre-conditions is required to stimulate landholder interest and enable them to have confidence to establish and maintain plantings. In a broad sense, smallholders require security of land and tree ownership, identified and reliable markets, supportive legal and regulatory environment, and localised technical capacity (Byron, 2001; Midgley et al., 2017; Carias et al., 2022). We assess these factors by surveying landholders, community leaders, and key municipality and national stakeholders to determine those that may enable or limit smallholder tree planting.

This study was conducted under an Australian government-funded project entitled Agricultural Innovations for Communities for Intensified and Sustainable Farming Systems in Timor-Leste (AI-Com). Part of the project was to assess the potential for sandalwood production to provide long-term economic opportunities for rural smallholders and restore iconic and nationally-significant native tree species. Despite the national awareness of sandalwood, most landholders have limited experience planting the tree and it is widely considered to be difficult to grow (Ferreira et al., 2021). Part of the perceived challenge in growing sandalwood is the limited awareness of the tree's parasitic root system, which requires root connections (haustorial) with surrounding host trees to thrive (Ferreira et al., 2021).

With several national programs for reforestation, including sandalwood, increasing in recent years (RDTL, 2015; 2019; Paudel et al., 2022), more information is needed on community perceptions of the suitability of promoting novel tree-based agro-ecosystems. The aim of this study was to determine the institutional, social, economic and environmental factors that may enable or limit the adoption of tree planting generally and sandalwood specifically in Timor-Leste.

## 2. METHODS

This study used a mixed methods approach by drawing on a livelihood-focused questionnaire, agroforestry-focused questionnaire, focus group discussions (FDGs), key informant interviews (KIIs), literature review of relevant legislation and policies related to tree planting and marketing, and synthesis of key data in the 2019 Timor-Leste Agricultural Census (General Directorate of Statistics, 2019). This research was approved by the Human Research Ethics Office in the University of Western Australia [2019/RA/4/20/1031].

### 2.1 Study area & sampling strategy

#### *2.1.1 Livelihood-focused questionnaire*

The AI-Com project was implemented in Natarbora and Maliana which represent two livelihood zones: South coast irrigable areas and inland mid-altitude irrigable watersheds as defined by Williams et al. (2018: 886). A baseline livelihood survey was conducted to determine local experiences in planting perennial trees and interest in

planting sandalwood. This survey randomly sampled 169 households in Natarbora and 125 in Maliana (Table 1). Livelihood surveys were taken from 20-30% of the total population. Both men (51%) and women (49%) were interviewed. The questions relevant to this study include those related to (a) land tenure and tree plantations and (b) prior experiences planting trees. These data align with that collected in the agroforestry survey (see Table 1).

*2.1.2 Agroforestry-focused questionnaire*

Four locations where sandalwood is planted through AI-Com's program in Natarbora and Maliana were selected (Table 1) based on the following criteria:

1) Variation in **land suitability** to grow sandalwood between flat and hilly terrain (i.e., lowland and upland).
2) Variation in **residential population and urbanisation**, which can create competition over land use and land availability for tree planting.

The assessment of land suitability for sandalwood was considered in the broadest sense, where wild sandalwood is reported to be located in uphill forested areas (Freitas & Thu, 2018) along the mountains and hinterland of Timor island (McWilliam, 2005: 298). The use of the term lowland in this study refers to the flat land and lower in elevation relative to the surrounding areas. In Maliana the flat land is located in a river valley at ~400m elevation, which is surrounded by hills and mountains. In Natarbora the flat land is located on the coastal lowland strip (~0-50m ASL) bound by hills and mountains in the north and the Timor Sea in the south.

Each hamlet was stratified by those households participating (growers) or not (non-growers) in the AI-Com project sandalwood planting research, where they received seedlings as part of research in sandalwood culture. A random sample representing 10% of the hamlet population was taken across both stratified populations. While sandalwood growers were selected at random in this study, their participation as growers in the AI-Com project was based on self-selection. Therefore, this study sought to determine if there were differences among these groups. Most respondents were engaged in subsistence (in-kind) farming as their main source of livelihoods. The exception was Maliana lowland where respondents were engaged in a wider range of cash-based employment due to their proximity to the commercial centre of Maliana town.

*2.1.3 Focus group discussions*

FGDs were conducted with groups of individuals that were selected to represent the community in each of the four agroforestry-focused study areas (Table 2). All selected hamlets, except for Dambua Hun have been involved in AI-Com sandalwood planting trials. While our best attempts were made to sample randomly within stratified genders to have equal gender representation, FGDs were comprised of over 65% men participants.

**Table 1.** The total population and number of households in Natarbora and Maliana and those selected for the livelihood and agroforestry questionnaires (by gender).

| Village | Hamlet | Total Pop.* | Total Households | Livelihood Questionnaire | | Total Livelihood Questionnaire | Agroforestry Questionnaires | | Total Agroforestry Questionnaire |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Men | Women | | Men | Women | |
| **Natarbora** | | | | | | | | | |
| **Aubeon (Lowland)** | Bubur Laran | 665 | 164 | 19 | 15 | 34 | - | - | - |
| | Wekadi | 466 | 106 | 8 | 19 | 27 | - | - | - |
| **Sicone Diloli (Lowland)** | We Kanria | 480 | 105 | 15 | 2 | 17 | - | - | - |
| | We Onu | 367 | 78 | 9 | 7 | 16 | - | - | - |
| **Uma Bocu (Lowland)** | Fehuk Rin | 1265 | 273 | 31 | 27 | 58 | 16 | 13 | 29 |
| | Halibur | 404 | 102 | 8 | 9 | 17 | 8 | 5 | 13 |
| **Mane Haat (Upland)** | Issadan | 161 | 66 | - | - | - | 7 | 2 | 9 |
| | Nu Ahuk | 341 | 94 | - | - | - | 7 | 2 | 9 |
| **Natarbora Total** | | **4,149** | **894** | **90** | **79** | **169** | **38** | **22** | **60** |
| **Maliana** | | | | | | | | | |
| **Ritabou** | Halecou (Lowland) | 534 | 94 | 12 | 14 | 26 | - | - | - |
| | Corluli (Lowland) | 318 | 58 | 7 | 12 | 19 | - | - | - |
| | Samelaun (Lowland) | 770 | 162 | 28 | 24 | 52 | 7 | 7 | 14 |
| | Daitete (Upland) | 578 | 105 | 13 | 15 | 28 | 10 | 7 | 17 |
| **Maliana Total** | | **2,200** | **419** | **60** | **65** | **125** | **17** | **14** | **31** |

[Source: (DNAAS, 2017)]

**Table 2.** Participants in focus group discussions and key informant interviews.

| Municipality | Village | No. Respondents | Hamlet | # Participants in FGDs | | | # Participants in KIIs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Men | Women | Total | Men | Women | Total |
| Natarbora | Uma Bocu | Lowland Area | Fehuk Rin | 9 | 4 | 14 | 9 | 1 | 10 |
| | | | Halibur | | | | | | |
| | Mane Haat | Upland Area | Issadan | 14 | 2 | 16 | 6 | 2 | 8 |
| | | | Nu Ahuk | | | | | | |
| | | | Dambua Hun | | | | | | |
| Maliana | Ritabou | Lowland Area | Samelaun | 9 | 7 | 16 | 6 | 0 | 6 |
| | | Upland Area | Daitete | 10 | 7 | 17 | 4 | 0 | 4 |
| | | | Total | 42 | 20 | 63 | 25 | 3 | 28 |
| MAF Staff | Natarbora | | | - | - | - | 3 | 0 | 3 |
| | Maliana | | | - | - | - | 3 | 0 | 3 |
| | Dili | | | - | - | - | 7 | 0 | 7 |
| Total | | | | | | | 11 | 0 | 11 |

### *2.1.4 Key informant interviews*

The Forestry Department in the Ministry of Agriculture and Fisheries (MAF) and local key informants who have knowledge on trees and/or sandalwood in the target locations were interviewed (Table 2). The goal of interviewing local key informants (e.g. village heads and community elders) was to understand whether community members have knowledge on national legislation and policies concerning trees in general and sandalwood. Key informants were identified by AI-Com staff through discussions with community members. The team also conducted interviews with MAF Municipality Directors, Forestry staff (3 MAF informants from each municipality) as well as MAF staff at the National Directorate office in Dili (N=7).

### *2.1.5 Data Analysis*

The results derived from the mixed methods were combined according to their contribution to the capitals and capabilities within the analytical framework for evaluating rural livelihoods (Bebbington, 1999). With respect to livelihoods, people often combine a range of activities in a complex bricolage of enterprises (Scoones, 2009). Of interest is whether smallholder farmers in Timor-Leste consider tree farming as a viable option to incorporate into their portfolio of livelihood activities. We also considered whether external conditions are supportive, obstructive or neutral. We evaluated interview responses in the context of physical, human, social and financial capitals and the policy, regulatory and market environment. The capitals in this framework are assets that give smallholders the capability to be and to act to sustain livelihoods (Bebbington, 1999).

Interview responses were classified as binomial (yes/no) or conforming to one or more multiple categories. For both binomial and categorical data we used a chi-square analysis (Hess & Hess, 2017) to determine relationships between region, respondent group (grower, non-grower), gender each with their response. Where relationships existed we undertook post-hoc pairwise statistical comparison Fisher's exact test to determine the overall source of the significance (Shan & Gerstenberger, 2017). Summary of interview data are presented in this paper using contingency matrices (cross tabulation) to summarise the frequency and percentage distribution of the responses. Matrices were structured according to region and either respondent group (grower, non-grower) or gender, based on their statistical influence over the responses. The statistical significance level between categorical variables was $P<0.05$. Data analysis was carried out using Excel (v16.64, Microsoft) and Jamovi software (The Jamovi Project, 2020) based on R-language (R Core Team 2019).

## 3. RESULTS

### 3.1 Physical resources

*3.1.1 Landholdings, tenure and capacity for tree planting*

Most respondents in Natarbora and Maliana accessed land under customary tenure. Some respondents held multiple claims over land as a result of historical forced resettlement and land titles being issued under the previous Indonesian and Portuguese administrations. The livelihoods survey showed local perceptions of land ownership in both study areas was high with 87% of Natarbora and 89% of Maliana landholders reporting they had secure land tenure. A high proportion of landholders in Natarbora (91%) and Maliana (94%) also held land registration documents received under the Timor-Leste National Cadastral System (SNC) (see Tables A and B in Supplementary Materials). Land registration does not equate to formal land ownership. Claimants who think they have rights over the land must undergo a verification process and resolve any disputes in accordance with the national Land Laws (Law 13/2017) to determine ownership rights and receive a land title (Rede Ba Rai 2019). The availability of agricultural land was also high in both areas with 93% of sampled households reporting they have access to plots of arable land suitable for cultivating commodity crops.

Similarly, almost all respondents in the agroforestry survey considered they owned their land and felt confident in the long-term security of tenure for that land (Table 3). For most landholders their landholdings were between 1.7 and 2.5 ha (excluding one respondent who held a 50 ha plot) with up to 1 ha used for agricultural production and 0.5 to 0.7 ha available for tree planting. The number of sandalwood trees that they perceived they could manage ranged from 31 to 84 trees. Respondents also pointed out that apart from the total land available to plant trees, trees can also be planted along the margins of their agricultural fields.

All growers in Natarbora lowland and upland stated they had suitable land and an interest in planting more sandalwood. Despite some non-growers on the lowland (15%) and upland (21%) stating that they did not have suitable land, all were interested in planting sandalwood, indicating their willingness to experiment. In Maliana two upland respondents (one grower and one non-grower) stated that they did not have suitable land and were also uninterested in planting additional sandalwood.

Table 3. Land ownership, tenure security, total land holding and land uses (ha), the number of sandalwood trees landholders perceive they can manage, and the number of sandalwood trees for available land.

| Measure | Natarbora (lowland) N=42 | Natarbora (upland) N=18 | Maliana (lowland) N=14 | Maliana (upland) N=17 |
|---|---|---|---|---|
| Perceived land ownership (positive response) | 40 (95%) | 18 (100%) | 14 (100%) | 17 (100%) |
| Perceived tenure security (positive response) | 40 (100%) | 17 (94%) | 14 (100%) | 17 (100%) |
| Mean area of landholding(s) (ha) | 2.5 | 4.8* (2.0) | 2.3 | 1.7 |
| Mean area used for agriculture (ha) | 0.9 | 3.5* (0.7) | 1.0 | 0.8 |
| Mean area available to plant trees (ha) | 0.7 | 0.6 | 0.6 | 0.5 |
| Mean No. of sandalwood trees landholders perceive they can manage | 62 | 84 | 31 | 31 |
| No. sandalwood trees for available land at planting density of 4 x 4 m | 437 | 375 | 375 | 312 |

Note: *One respondent reported to have 50 ha of agricultural land. If this respondent was

excluded, the average total land area among sampled Natarbora upland is 2 ha and 0.7 ha for agriculture.

*3.1.2 Tree plantations*

In Natarbora 44% of surveyed households in the livelihood questionnaire had established tree plantations comprised mainly of teak, coconut and mango. The agroforestry questionnaire showed that mahogany and guava were also commonly planted on the lowland, while on the upland, candlenut, cinnamon, clove, betel nut and teak were planted. A substantial proportion of surveyed households planted trees on their cultivation land (82%), typically as boundary plantings. Only 37% of tree planting families have sold their tree crops or tree products, with most respondents having only immature plantings not yet ready for harvest. Experience in planting trees has been gained through knowledge passed down through generations. Despite this experience, selling timber or forest products is not a well-established income source in Natarbora.

In Maliana, 28% of households in the livelihood questionnaire had established new tree plantings of teak and/or mahogany. Both these species are exotic to Timor-Leste and have been utilised318 by landholders as boundary plantings and to stake claim on vacant land. In the hamlet of Corluli sales of teak trees form an important source of income for many households. In Maliana planting and marketing timber trees was gendered and typically conducted by men.

*3.1.3 Customary owned sandalwood*

1) Wild sandalwood

All four FGDs identified that wild sandalwood thrives in the hills and mountains, particularly upland forested areas in both Natarbora and Maliana. In contrast, they reported that no wild sandalwood grows on the lowlands in Samelaun (Maliana) and Uma Bocu (Natarbora) because the soil and climate conditions are not conducive and the areas are reserved for raising livestock.

Daitete FGD participants considered wild sandalwood trees to be the property of the origin group (*uma lisan*), and more specifically the individual/family who has customary claims to the land on which the sandalwood grows. Similarly, in Samelaun, focus group discussants believed that although the State controls rights over harvesting wild sandalwood, such trees are owned by the customary origin group of the land upon which they grow. Despite a 25-year ban imposed on the sale of sandalwood and local cultural prohibitions (*tara bandu*), some individuals illegally harvest and sell to sustain their livelihoods.

2) Landholder planted sandalwood in Natarbora and Maliana

Historically in both Natarbora and Maliana sandalwood has not been planted by landholders. However, some community members have planted small numbers of sandalwood seedlings either independently or as part of externally-funded projects, such as during the Indonesian occupation, the Department of Agriculture supported two or three families in Samelaun to plant up to 20 trees. In around 2003/04, some Samelaun community members independently planted sandalwood. In recent years, some non-government organisations (NGOs) distributed sandalwood seedlings in Manehaat but only a few trees survived. FGD participants in Natarbora and Maliana upland also stated they collected sandalwood seeds or seedlings on their own, prepared them and produced seedlings in nurseries. Over a period of 4 years (2018-21) AI-Com distributed 20 sandalwood seedlings to each of 111 families around Maliana and 61 families around Natarbora. Survival varied substantially between growers ranging from 0 to 90% with a mean of 53%.

Across all four FGDs the ownership rights of planted trees are consistently recognised as the individual who planted the trees. Anyone wanting to plant sandalwood for later harvest would need to have sufficient land, with secure tenure on which to plant the trees. An individual is less likely to plant sandalwood on another family's land and the ownership rights would rest on the agreement made between the landowner and tree planter. MAF-Forestry stressed the importance of establishing clear land and tree tenures, particularly in the cases of absentee owners, "*we don't have statistical numbers, but there are cases where the landowner is not living on the land, and other people living nearby plant trees, and when the trees are large and the landowner returns to build a house, for example, then, there will be conflict between the landowner and tree owner…Before people plant trees, the status of land needs to be clear*." Therefore, land and tree tenure security are crucial factors, since sandalwood is a long-term investment.

3) Landholder planted trees across Timor-Leste

Over the past five years there has been a range of national, donor- and NGO-supported programs to promote smallholder reforestation (RDTL, 2019; Paudel et al., 2022). Planting trees, including sandalwood has been promoted as a livelihood option for rural smallholders under several development projects (GIZ, 2017; AI-Com, 2019; Tatoli, 2021; Paneli, nd). The National Policy on Forests of Timor-Leste (RDTL 2017b) and The National Agricultural Policy and Strategic Framework (RDTL, 2017a) both support forestry-related activities to improve smallholder income generation. These initiatives potentially address land degradation while providing long-term economic benefits.

The 2019 Agricultural Census recorded total cultivated area (in hectares) for 77 crops/plants/trees over the 12 months prior to the census. Sandalwood was recorded in 60% (271) of the 452 villages (*suco*) surveyed (see Timor-Leste Agriculture Census 2019, Table C5.213) and a total cultivated area for sandalwood was 3,249 ha (RDTL, 2020). This area was greater than reported for cashew and clove, but lower than the remaining nine perennial species. The most widely planted tree crops included coffee, coconut, teak, mango and candlenut (Table 4). These data align well with the response to the household livelihood and agroforestry questionnaires conducted as part of this study.

Sandalwood was documented as being established in compact (1,487 ha), line (96 ha) or scattered (1,666 ha) arrangements and as such it is not possible to determine the numbers of trees established. From this data set it is also not possible to determine the age of the plantings. Considering the lack of a national inventory on existing sandalwood plantings, it is noteworthy that over half the total area planted (2,075 ha) comprised larger stands of over 100 ha (Table 4). Also, the census data recorded over 1,400 ha of sandalwood in the villages of Uai Oli (Venilale, Baucau) and over 600 ha in Ilat-Laun (Bobonaro, Bobonaro). Further investigation is required to determine the presence of such large 'cultivated areas' of sandalwood in Timor-Leste.

*3.1.4 State owned sandalwood resources*

1) Wild Sandalwood

The General Regime of Forests (RDTL, 2017c) states that "The State promotes . . . the equitable access by citizens to forest resources and the benefits that may arise from its use." This indicates the Timor-Leste government's support for local use of forest resources on customary land. There was a consensus among key informants interviewed in the target areas and national MAF office that wild sandalwood which grows on state land belongs to the State.

2) Planted Sandalwood

Over the past two decades, sandalwood plantations have been established nation-wide under several initiatives. Between 2004 and 2016 around 40,000 sandalwood seedlings were established across eight sites (Maudemo (9,998), Coba (4,400), Vatu-I (1,200), Leolima (6,000), Malushun (6,000), Fatulari (6,000), Maudemo (5,000), and Bobometo (7,000)) (Barreto, 2017). MAF in collaboration with the European Union (EU) has also commenced the establishment of a 100 ha sandalwood plantation in Atabae as an initiative to diversify Timor-Leste's economy, and reduce dependence upon oil and gas export revenues (EU, 2017). Between 2016 and 2019, 120,000 sandalwood seedlings and an equivalent number of host trees *Sesbania grandiflora* were planted (MAF, 2019). As part of the State's expansion into tree plantings, MAF is also in the process of surveying potential areas for the development of commercial plantations and sandalwood (MAF, 2019).

MAF key informants reported that MAF-Forestry implemented a program where farmer groups were provided sandalwood seedlings to plant on state land, but monitoring revealed that no group took care of the trees, leading to widespread seedling death and failure of the program. This program transitioned to providing sandalwood trees to individual farmers to plant on their own land. MAF staff observed that the program with individual farmers was more successful than working with groups. They attributed the success of the former to the clear ownership and benefits returned to the farmer/family, therefore they were motivated to attend to the maintenance needs of the sandalwood.

**Table 4.** The percentage of Timor-Leste villages planting and total area planted (in ha) by size-class of cultivated area across 12 tree species and two crop species (maize and rice), data derived from RDTL (2017a).

| Tree | % Villages | 0.01 - 0.99 | 1.0 - 3.99 | 4.0-9.99 | 10.0-19.99 | 20 - 49.99 | 50.0-99.99 | 100-999 | 1000-4999 | 5000-10000 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Acacia | 25.2 | 10.9 | 42.6 | 35.2 | 30.9 | 38.3 | 114.3 | 0.0 | 0.0 | 0.0 | 272 |
| Areca nut | 75 | 28.0 | 129.8 | 343.2 | 600.4 | 763.2 | 1126.0 | 1677.4 | 4803.0 | 0.0 | 9,471 |
| Candlenut | 75.8 | 19.9 | 121.3 | 423.7 | 382.4 | 1251.4 | 967.4 | 3309.5 | 4390.0 | 0.0 | 10,865 |
| Cashew | 34.1 | 15.0 | 54.1 | 72.7 | 133.0 | 31.9 | 60.6 | 185.0 | 0.0 | 0.0 | 552 |
| Clove | 12.4 | 5.8 | 17.0 | 40.1 | 11.0 | 30.6 | 66.5 | 0.0 | 0.0 | 0.0 | 171 |
| Coconut | 90.3 | 18.3 | 133.6 | 255.7 | 564.2 | 2462.9 | 3945.1 | 11922.6 | 10006.6 | 0.0 | 29,309 |
| Coffee | 81.4 | 16.8 | 119.5 | 241.5 | 628.1 | 1326.5 | 2637.8 | 19671.4 | 7214.2 | 0.0 | 31,856 |
| Maize | 98.6 | 5.5 | 53.0 | 212.4 | 614.9 | 2504.5 | 4914.0 | 45912.2 | 28675.8 | 8718.4 | 91,611 |
| Mango | 90.9 | 22.5 | 167.9 | 358.8 | 778.9 | 2025.2 | 2413.5 | 6299.4 | 6223.4 | 0.0 | 18,290 |
| Rice | 74.8 | 21.5 | 121.1 | 219.8 | 350.6 | 1281.2 | 2402.1 | 15974.4 | 11831.2 | 6418.4 | 38,620 |
| Sandalwood | 60 | 38.0 | 123.8 | 160.3 | 158.1 | 337.9 | 355.7 | 614.0 | 1461.2 | 0.0 | 3,249 |
| Sheoaks | 61.7 | 20.7 | 114.7 | 214.4 | 376.4 | 580.6 | 800.2 | 3555.9 | 2546.0 | 0.0 | 8,209 |
| Mahogany | 70.1 | 32.8 | 147.0 | 236.0 | 442.6 | 826.1 | 635.9 | 1831.3 | 0.0 | 0.0 | 4,152 |
| Teak | 85.2 | 24.8 | 156.2 | 323.0 | 572.3 | 1993.5 | 2236.4 | 8396.9 | 7587.5 | 0.0 | 21,290 |

*3.1.5 Challenges and risks of planting sandalwood*

Agroforestry questionnaire respondents and FGD participants were asked about perceived challenges and risks to planting sandalwood (Tabel 5). A third of respondents stated that they didn't know of any associated challenge or risk. The main challenges identified were livestock destruction and associated need to build a fence (52% respondents), lack of water during the dry season (40%), fire hazard (26%) and no legal market to sell sandalwood (13%). All remaining constraints including tree theft, pests, and general maintenance requirements were each identified by under 5% of respondents. The pests identified included leaf galling and defoliating caterpillars. Chi-squared analysis revealed that respondent group (grower vs non-grower) influenced the proportion of identified constraints, while region and gender had no effect. The group effect was largely driven by significantly greater proportion of growers (59%) identifying a 'lack of water / long dry season' compared with non-growers (31%). Additionally, a greater proportion of non-growers (38%) claimed they were not aware of the constraints (i.e. 'don't know'), compared with growers (5%).

Table 5. Respondent-identified (%) challenges/risks in planting sandalwood.

| Challenge / Risk | Frequency | % Respondents |
|---|---|---|
| Destroyed by livestock / need fence | 47 | 52 a |
| Lack of water / long dry season | 36 | 40 b |
| Don't know | 27 | 30 bc |
| Fire / Burning of land | 24 | 26 c |
| No legal market to sell | 12 | 13 d |
| Stolen and destroyed | 5 | 5 e |
| No problems /challenges found | 5 | 5 e |
| Pest & diseases | 4 | 4 ef |
| Depends on tree maintenance | 2 | 2 ef |
| Lack of skills to plant sandalwood | 2 | 2 ef |
| Long rotation (time to harvest) | 2 | 2 ef |
| Soil infertility and erosion | 2 | 2 ef |
| Climate change | 1 | 1 f |
| Far from home | 2 | 1 f |
| Lack of mechanisation322 to prepare land | 1 | 1 f |
| No seedlings | 1 | 1 f |
| Random / Unexpected events | 1 | 1 f |
| Total number of respondents | 91 | - |

*note that respondents could select multiple challenges / risks. Those challenge/risks sharing a lower case letter are not significantly different for the percentage respondents identifying them.

**3.2 Human capital conditions**

*3.2.1 Access to sources of advice*

The percentage of respondents with access to sources of advice for agricultural production, tree growing and sandalwood growing was 17, 20, 24% respectively (Table 6). A significant gender effect was recorded for access to both agricultural advice with a significantly greater proportion of men (27%) having access to agricultural advice than women (3%). Neither region or respondent group was found to have an influence on accessibility to agricultural advice or information.

The proportion of respondents with access to forestry advice or information was associated with both region and gender. Generally, more people in Natarbora upland areas had access to forestry advice compared with the other three survey regions (Table 6). A greater proportion of men (35%) had access to forestry advice compared with women (0%), which was consistent across all regions. No influence was recorded

between respondent group (grower and non-grower) and the relative frequency of access to forestry advice.

Accessibility to sandalwood advice was only influenced by respondent group, and not by either region or gender. This result is an artefact of the activities of the AI-Com project, where all those that were participating in the sandalwood planting program also had access to information and extension provided by the project. In contrast, none of the non-growers indicated they had access to sandalwood advice or information (Table 6).

Sources of advice on agricultural production, tree planting and sandalwood planting included international development agencies, government extension agents and domestic NGOs. A greater percentage of people from Natarbora (27%) had access to government extension services (MAF) than in Maliana (9%). Both international development agencies and NGOs provided extension advice for smallholders servicing over a quarter and under 10% of respondents respectively.

*3.2.2 Experience planting trees and sandalwood*

A significantly greater proportion of respondents (67%) (Table 7) have experience in planting trees than have access to any form of grower advice (17 to 24%) (Table 6). While no regional effects were found, a statistically significant 'grower' and gender effect was recorded for the proportion of respondent experience in planting trees generally. A significantly greater proportion of AI-Com supported growers had prior experience planting trees (91%) compared with non-growers (59%) (Table 7). A gender effect was manifest as a statistically greater proportion of men (76%) having previous experience planting trees compared with women (53%). No regional effects were found. In upland Natarbora, FGD participants stated that many community members had experience planting trees and some had the capacity to germinate tree seedlings and distribute to others in the village. FGD participants in Maliana upland (Daitete hamlet) suggested most tree growing experience related to the timber tree teak, and that successful cultivation depended upon building a fence around the trees to protect the young seedlings from animal grazing.

A total of 24% of respondents had prior experience growing sandalwood (Table 7), which reflects the proportion of those with access to advice (24%) (Table 6). The respondent category influenced the frequency of respondents with previous experience growing sandalwood. A total of 95% of AI-Com supported growers had prior experience. Among sampled non-growers, only 1 respondent from Natarbora had prior experience planting sandalwood. This respondent trialled sandalwood in 2014, but stated that none of the sandalwood has survived. No regional or gender effects were found for previous experience with growing sandalwood with all regions and genders having between one- and two-in-five people with previous experience.

The proportion of respondents with the awareness of the need for host species to support sandalwood cultivation ranged from 17 to 39%. Those who held this knowledge named potential host trees, such as *Leucaena*, *Sesbania*, *Casuarina*, and *Gliricidia*. The accurate identification of potential host trees for sandalwood demonstrates that some individuals in the target communities have existing knowledge.

Questions about knowledge on the potential rotation of planted sandalwood revealed that 55% did not know the time it will take for sandalwood to be ready for harvest. Those that provided an estimate included 10 to 19 years (5% of respondents), 20 to 29 years (28%), 30 to 39 years (5%) and over 50 years (7%).

**Table 6.** Percentage growers with access to sources advice for agriculture, tree planting and sandalwood planting. Percent and number of respondents with experience planting trees.

| Region | Group | N | Agricultural advice | Agricultural advice (by gender) | Tree planting advice | Tree planting advice (by gender) | Sandalwood planting advice | Sandalwood planting advice (by gender) |
|---|---|---|---|---|---|---|---|---|
| **Natarbora lowland** | Growers | 8 | 0 (0%) a | F:0 M:0 | 0 (0%) a | F:0 M:0 | 8 (100%) a | F:3 M:5 |
| | Non-Growers | 34 | 6 (18%) b | F:1 M:5 | 6 (18%) bc | F:0 M:6 | 0 (0%) b | F:0 M:0 |
| **Natarbora upland** | Growers | 4 | 3 (75%) c | F:0 M:4 | 4 (100%) d | F:0 M:4 | 4 (100%) a | F:0 M:4 |
| | Non-Growers | 14 | 2 (14%) ab | F:0 M:2 | 5 (36%) c | F:0 M:5 | 0 (7%) b | F:0 M:0 |
| **Maliana lowland** | Growers | 3 | 3 (67%) c | F:0 M:2 | 2 (67%) d | F:0 M:2 | 3 (100%) a | F:1 M:2 |
| | Non-Growers | 11 | 1 (9%) ab | F:0 M:1 | 1 (9%) ab | F:0 M:1 | 0 (0%) b | F:0 M:0 |
| **Maliana upland** | Growers | 7 | 1 (14%) ab | F:0 M:1 | 1 (14%) abc | F:0 M:1 | 6 (86%) a | F:2 M:4 |
| | Non-Growers | 10 | 0 (0%) a | F:0 M:0 | 0 (0%) a | F:0 M:0 | 0 (0%) b | F:0 M:0 |
| Total | Growers | 22 | 7 (27%) x | F:0 M:7 | 7 (30%) x | F:0 M:7 | 21 (95%) x | F:6 M:15 |
| | Non-Growers | 69 | 9 (13%) y | F:1 M:8 | 12 (16%) x | F:0 M:12 | 0 (0%) y | F:0 M:0 |
| | Female | 36 | - | 1 (3%) x | - | 0 (0%) x | - | 6 (17%) x |
| | Male | 55 | - | 15 (27%) y | - | 19 (35%) y | - | 15 (27%) x |
| | All Respondents | 91 | 16 (17%) | 16 (17%) | 19 (20%) | 19 (20%) | 21 (24%) | 21 (24%) |

Note: For factors with a significant effect on accessibility to agricultural, tree planting or sandalwood planting advice (i.e., respondent groups and gender) the treatment combinations sharing lower case letters are not significantly different (P<0.05) within each source of advice.

**Table 7.** Prior experience planting trees and sandalwood (by respondent group and gender).

| Region | Group | N | Tree Exp | Tree Exp (by gender) | Sandal Exp | Sandal Exp (by gender) |
|---|---|---|---|---|---|---|
| Natarbora lowland | Growers | 8 | 8 (100%) a | F:3 M:5 | 8 (100%)a | F:3 M:5 |
| | Non-growers | 34 | 20 (59%) b | F:6 M:14 | 0 (0%) b | F:0 M:0 |
| Natarbora upland | Growers | 4 | 3 (75%) ab | F:0 M:3 | 3 (75%)a | F:0 M:3 |
| | Non-growers | 14 | 9 (64%) b | F:2 M:7 | 1 (7%) b | F:0 M:1 |
| Maliana lowland | Growers | 3 | 3 (100%) a | F:1 M:2 | 3 (100%a) | F:1 M:2 |
| | Non-growers | 11 | 7 (64%) b | F:2 M:5 | 0 (0%) b | F:0 M:0 |
| Maliana upland | Growers | 7 | 6 (86%) a | F:2 M:4 | 7 (100% a) | F:3 M:4 |

| Region | Group | N | Tree Exp | Tree Exp (by gender) | Sandal Exp | Sandal Exp (by gender) |
|---|---|---|---|---|---|---|
| | Non-growers | 10 | 5 (50%) b | F:3 M:2 | 0 (0%)b | F:0 M:0 |
| | Growers | 22 | 20 (91%) x | F:6 M:14 | 21 (95%) x | F:7 M:14 |
| | Non-Growers | 69 | 41 (59%) y | F:13 M:28 | 1 (1%) y | F:0 M:1 |
| Total | Female | 36 | - | 19 (53%) | - | 7 (19%) |
| | Male | 55 | - | 42 (76%) | - | 15 (27%) |
| | All Respondents | 91 | 61 (67%) | - | 22 (24%) | - |

Note: Growers and non-growers are defined as those being supported by AI-Com to plant sandalwood and those without support respectively. Those regional respondent groups sharing lower case superscript letters are not significantly different ($P<0.05$) within each experience type.

### 3.3 Social capital conditions

*3.3.1 Meanings attached to trees and sandalwood*

Respondents in both Natarbora and Maliana attached diverse meanings to trees, including their various uses in housing, furniture, shade, firewood and other construction purposes (Figure 1). A small percentage (≤5%) of respondents also associated trees with protecting soils and water, contributing to fresh air, or providing protection (which might refer to cultural beliefs and/or medicinal properties).

Minor cultural significance of sandalwood was recorded in both target locations. Respondents associated sandalwood as a source of income, its scented oil (for use in church and high market price), as well as a unique timber and native natural resource in Timor-Leste (Figure 1). Two non-growers in Natarbora lowland stated that the scent of sandalwood (by cutting and burning the timber) can ward off evil spirits. Sandalwood had no subjective meanings for approximately one third of respondents (Figure 1).

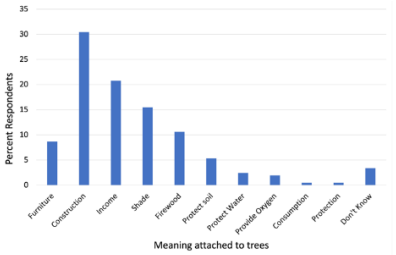


**Figure 1-A.** Meanings attached to Trees for all household respondents across both Natarbora and Maliana.

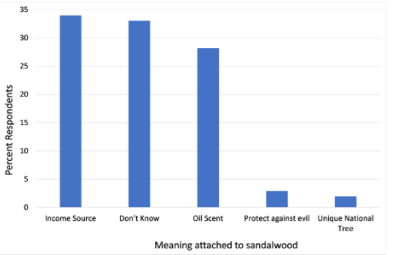


**Figure 1-B.** Meanings attached to Sandalwood for all household respondents across both Natarbora and Maliana.

*3.3.2 Perceived benefits from planting sandalwood*

A total of 67% of the agroforestry questionnaire respondents across both Natarbora and Maliana listed the high market values and associated future income generation as the primary benefit from planting sandalwood. The remaining benefit was for its oil scent (5% respondents), while 27% suggested they didn't know the benefits of planting sandalwood. Chi-squared analysis revealed no influence between respondent's region of residence, grouping (grower vs non-grower) or gender over their perspectives of benefit sharing, therefore we compared the pairwise statistical differences among the total number of respondents. Respondents considered that the future income derived from the sale of planted sandalwood would be put towards supporting family needs (45%), distributing the wealth among family members (40%), sending children to school (39%), and fulfilling ritual obligations (23%) (Table 8). Proportions sum added up to greater than 100% in this instance, because respondents listed all the ways in which they would distribute the benefits.

**Table 8.** Frequency of planned sharing of benefits derived from future sandalwood plantings (% respondents in parentheses).

| Region | N | Support family needs | Send children to school | Distribute among family members | Cultural uses | House construction | Have not sold yet |
|---|---|---|---|---|---|---|---|
| Natarbora lowland | 42 | 19 (45%) | 19 (45%) | 19 (45%) | 8 (19%) | 2 (5%) | 1 (2%) |
| Natarbora upland | 18 | 6 (33%) | 5 (28%) | 9 (50%) | 2 (11%) | 1 (6%) | 1 (6%) |
| Maliana | 14 | 8 (53%) | 8 (53%) | 3 (20%) | 8 (53%) | 4 (27%) | 0 (0%) |

| Region | N | Support family needs | Send children to school | Distribute among family members | Cultural uses | House construction | Have not sold yet |
|---|---|---|---|---|---|---|---|
| lowland | | | | | | | |
| Maliana upland | 17 | 8 (47%) | 4 (24%) | 6 (35%) | 3 (18%) | 3 (18%) | 2 (12%) |
| Total | 91 | 41 (45%) a | 36 (39%) a | 37 (40%) a | 21 (23%) b | 10 (11%) c | 4 (4%) d |

Note: Responses that share lower case letters in the total row are not significantly different ($P < 0.05$).

*3.3.3 Community Support and Peer Networks*

In terms of local grower cooperatives/associations for agriculture and forestry, Natarbora lowland only has a cooperative for rice. By contrast, no such groups function in Natarbora upland, with community members citing a lack of external support. Maliana lowland has a seed association for rice, maize, peanut, soybean and mung bean. Maliana upland has a new agricultural group, which has approximately 17 to 30 members and they plan to expand their activities to include planting trees such as orange, mango, mahogany, breadfruit and jackfruit.

Even though 68% of respondents reported that their community had people with experience planting trees, only half of respondents considered them good sources of information (Table 9). Region and gender were not found to influence responses regarding the presence of people in their community with experience growing trees. Respondent group and its interaction with region were found to be associated with the perception of the presence of community members with tree growing experience such that a greater percentage of growers (83%) considered they had people in the community with experience planting trees compared with non-growers (64%). The exception to this was found in Natarbora upland where there were fewer growers (33%) than non-growers (50%) that held this perception.

Region and group were not found to influence the proportion of respondents indicating that other tree growers in the community were a good source of information, although there were interactions among the two. A significant association was found between respondent gender and this perception, where less than a third of women but almost two thirds of men considered other tree growers as a good information source.

Less than half of respondents (42%) across all areas perceived they had good community support for growing trees (Table 9). None of the three factors evaluated (region, group or gender) had a statistical effect on frequency of respondent perception of community support for tree growing despite some interaction between existing region and group (Table 9).

While there is a reasonable level of experience for tree planting in the community (68%) and some level of community support as such (42%), only 8% considered \ had a good peer network to support them in any prospective tree planting activities (Table 9). Apart from Natarbora upland growers, most respondents relayed they did not have a good peer network that provides access to agricultural and forestry information. None of the factors (region, group or gender) had any statistical influence on their perception of peer support in tree planting and management.

*3.3.4 Household decision-making and responsibility to plant and maintain trees*

The highest percentage of men and women surveyed in Natarbora lowland (79%, 78%) and upland (64%, 75%) stated that decisions to plant trees on family-owned land are jointly made by men and women heads of households. The next most frequent response was that decisions were made by the male headed household. A small number of respondents in both Natarbora lowland and upland also listed the involvement of other

family members in decision-making, noting that all these respondents held land under customary tenure. In Maliana upland, surveyed men and women shared the perspective that both household heads made such decisions together (80% and 86% respectively). A gender discrepancy was recorded among surveyed men and women in Maliana lowland where most surveyed men suggested male heads of household (75%) was the main decision-maker whereas most surveyed women stated joint decision-making (86%).

Chi-squared statistical analysis revealed that both the respondent's region of residence and gender had a significant influence over their perspectives towards tree management responsibilities. In Natarbora lowland, the majority of respondents considered tree management to be the joint responsibility of adult family members of both genders. In the three other regions of study, there was a greater tendency for respondents to suggest that tree management was the responsibility of male adult members of the family (Table 10).

The responsibility to plant and maintain trees within the family showed gendered divisions in labour within households (Table 10). Men and women respondents in Natarbora lowland mostly shared the view that adult men and women in the family were responsible together, followed by those who stated adult men, adult women and all family members, including children. Three quarters of the women surveyed (3/4) in Natarbora upland stated men were responsible for tree planting and maintenance while almost equal number of surveyed men in the upland were split between stating both adult men and women (5/15) and adult men (4/15). Overall, although some men in Natarbora stated women family members were responsible for such tasks, none of the women respondents shared this perspective. Across all respondents, almost all women (97%) did not consider themselves as being the sole managers of tree plantations on their landholdings, but a part of a partnership with male adults (42%). While most men considered themselves as being the manager as a partnership with their female counterparts (40%) or by themselves (24%), just over a quarter (26%) of male respondents suggested that women could potentially be the sole managers of tree plantations.

In lowland Maliana, surveyed men and women stated adult men were primarily responsible for planting and maintaining trees, followed by both adult men and women, and adult women and other family members. Most surveyed men and women in Maliana upland, by contrast, stated that both adult men and women were responsible for tree planting and maintenance, followed by adult men and other family members.

*3.3.5 Gendered dimensions of owning sandalwood*

Respondents were asked if women can plant and own sandalwood. A significantly greater proportion of respondents indicated a 'yes' (80%) compared with 'no' (20%) response. While the region in which the respondent was located was found to have a significant influence over their response to this question, gender was not found to have any statistical influence. In Natarbora, most surveyed men (86%) and women (92%) stated "yes". Both the upland and lowland sites are comprised of Tetun Terik ethnolinguistic group whereby men and women can typically inherit family land and resources. In Maliana, where most respondents are of Kemak ethnolinguistic group that typically follow a patrilineal land tenure system, only 43% of lowland and 50% of upland men respondents agreed that women could plant and own sandalwood. By contrast, most Maliana lowland and upland women interviewees agreed with this statement (86% respectively).

Chi-squared analysis revealed no influence of any three factors (i.e., region, group or gender) on respondents' perspectives on women's rights to own sandalwood. The top

four reasons given by respondents for why women can plant and own sandalwood trees aligned with local cultural norms and intra-household decision-making: 1) because women are also family members (39%), 2) men and women make decisions together (26%), 3) women have ownership rights (16%) and 4) men and women work together in the family (14%) (Table 11).

### 3.4 Financial capital

Microcredit and informal loans were available for 41% and 56% of livelihood questionnaire respondents in Natarbora and Maliana respectively. In Natarbora respondents identified more formal livelihood sources, such as banks (38%), NGOs/agencies (25%), saving and loans cooperatives (12%), Timor-Leste government (12%), family or friends (7%). Adopters did not necessarily have access to mobilise credit to implement their plantings. They were supported through the financial inputs of the project that were provided for free. It may be misleading to make any links between credit availability and adoption, since this was not even a consideration for those that adopted sandalwood planting. In Maliana, informal lenders (family, friends and neighbours) were the most common source of micro-loans of money and resources (e.g., tractors) during times of hardship (60%). Recipients of the veteran's pension were a recognised source of informal financial assistance. Respondents stated that they had access to formal sources of finance from NGO Moris Rasik, Lanamona and co-operatives named Bee Manas Marobo and Tuba Rai Metin (35%). Only 4% borrowed from a bank and 1% from the government.

### 3.5 Institutional factors

#### *3.5.1 Laws and regulations*

In terms of selling timber, to date, the sale of trees such as teak, gmelina, mahogany and others are permitted and regulated. Tax is imposed at 5% of market price on the sale of timber. However, other timbers are permitted to be cut for "social purposes", such as building ritual houses, residential house renovation/repair etc., with the quota of 3 cubic metres.

Although sandalwood can be planted, and has been actively encouraged by the Timor-Leste government, currently no formal markets for or regulations supporting the sale of its timber exist. The primary reason for a lack of formal markets is the national moratorium on trade of sandalwood. With the ongoing decline in the abundance of natural sandalwood (Marques et al., 2010; RDTL, 2011), the Timor-Leste government introduced a prohibition in 2012 specifically for harvesting and marketing of sandalwood for a period of 25 years (RDTL, 2012).

MAF is currently reviewing the 2012 Dispatch in a step towards establishing a formal market and to minimise illegal trade. Despite the sandalwood harvesting moratorium and environmental and natural resource protections outlined in the Timor-Leste Constitution (Section 61, Article 139) and Penal Code (Articles 215, 217, 218 and 221), sandalwood continues to be exploited due to challenges in controlling its remote harvest and trade. Sandalwood has also been susceptible to general forest degradation associated with increasing demand for residential, crop and grazing land (FAO, 2008).

**Table 9.** Community experience, support and peer networks (Natarbora and Maliana).

| Region | Group | N | Are there people with experience growing trees? | If yes, are they a good source of information? | Is there good community support for growing trees? | Do you have a good peer network? |
|---|---|---|---|---|---|---|
| Natarbora (lowland) | Growers | 8 | 8 (100%) a | 3 (37%) b | 2 (25%) ab | 0 (0%) c |
| | Non-growers | 34 | 23 (68%) bc | 15 (44%) b | 14 (41%) a | 1 (3%) c |
| Natarbora (upland) | Growers | 3 | 1 (33%) d | 1 (33%) a | 1 (33%) ab | 3 (100%) a |
| | Non-growers | 14 | 7 (50%) cd | 2 (14%) c | 8 (57%) a | 3 (21%) b |
| Maliana (lowland) | Growers | 4 | 4 (100%) a | 3 (75%) ab | 0 (0%) b | 0 (0%) c |
| | Non-growers | 11 | 9 (82%) ab | 4 (36%) b | 6 (55%) a | 0 (0%) c |
| Maliana (upland) | Growers | 7 | 6 (86%) ab | 2 (29%) b | 3 (43%) a | 0 (0%) c |
| | Non-growers | 10 | 5 (50%) cd | 2 (20%) b | 4 (40%) a | 0 (0%) c |
| Total | Growers | 22 | 19 (83%) x | 9 (47%) x | 6 (27%) x | 3 (13%) x |
| | Non-growers | 69 | 44 (64%) y | 23 (52%) x | 32 (46%) x | 4 (6%) x |
| | Female | 36 | 24 (67%) t | 7 (29%) t | 15 (42%) t | 1 (3%) t |
| | Male | 55 | 38 (69%) t | 24 (63%) u | 23 (42%) t | 6 (11%) t |
| | All respondents | 91 | 63 (68%) | 32 (50%) | 38 (42%) | 7 (8%) |

Note: Region-group categories that share lower case letters are not significantly different ($P < 0.05$) for that response (column). Significance letters are also presented for total data for group and gender.

**Table 10.** Responsibility within the family to plant and maintain trees, sorted by respondent's gender in each site (% response).

| Region | Gender | N | All Adults | Male adults | Female adults | Male Children | Female Children | All Children | Whole Family |
|---|---|---|---|---|---|---|---|---|---|
| Natarbora lowland | Female | 18 | 11 (58%) | 7 (37%) | 0 (0%) | 1 (5%) | 0 (0%) | 0 (0%) | 0 (0%) |
| | Male | 24 | 10 (42%) | 4 (17%) | 9 (37%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (4%) |
| Natarbora upland | Female | 4 | 0 (0%) | 3 (75%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (25%) |
| | Male | 14 | 5 (33%) | 4 (27%) | 4 (27%) | 0 (0%) | 0 (0%) | 1 (6%) | 1 (7%) |
| Maliana lowland | Female | 7 | 2 (25%) | 3 (37%) | 1 (12%) | 1 (12%) | 0 (0%) | 0 (0%) | 1 (12%) |
| | Male | 7 | 2 (25%) | 4 (50%) | 1 (12%) | 1 (12%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Maliana upland | Female | 7 | 3 (43%) | 4 (57%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| | Male | 10 | 6 (55%) | 2 (18%) | 1 (9%) | 1 (9%) | 0 (0%) | 0 (0%) | 1 (9%) |
| Total | Female | 38 | 16 (42%) | 17 (45%) | 1 (3%) | 2 (5%) | 0 (0%) | 0 (0%) | 2 (5%) |

| Region | Gender | N | All Adults | Male adults | Female adults | Male Children | Female Children | All Children | Whole Family |
|---|---|---|---|---|---|---|---|---|---|
| | Male | 58 | 23 (40%) | 14 (24%) | 15 (26%) | 2 (3%) | 0 (0%) | 1 (2%) | 3 (5%) |
| | Grower | 71 | 28 (38%) | 24 (35%) | 14 (20%) | 2 (1%) | 0 (0%) | 0 (0%) | 4 (6%) |
| | Non-grower | 24 | 11 (46%) | 7 (29%) | 2 (8%) | 2 (8%) | 0 (0%) | 1 (4%) | 1 (4%) |
| | All Respondents | 91 | 39 (41%) a | 31 (32%) a | 16 (17%) b | 4 (4%) c | 0 (0%) d | 1 (1%) cd | 5 (5%) c |

Note: Responses that share lower case letters in the total row are not significantly different (P < 0.05).

**Table 11.** Respondents' reasons why women can plant and own Sandalwood (% response).

| Region | Gender | N | Women also family members | We work together | We make decisions together | Women have rights to be the owner | Women are also the owner of the land |
|---|---|---|---|---|---|---|---|
| Natarbora lowland | Female | 19 | 8 (53%) | 1 (7%) | 2 (13%) | 4 (27%) | 0 (0%) |
| | Male | 24 | 8 (33%) | 4 (17%) | 8 (33%) | 2 (8%) | 2 (8%) |
| Natarbora upland | Female | 4 | 1 (20%) | 1 (20%) | 1 (20%) | 1 (20%) | 0 (0%) |
| | Male | 15 | 6 (67%) | 0 (0%) | 2 (22%) | 1 (11%) | 0 (0%) |
| Maliana lowland | Female | 8 | 3 (50%) | 0 (0%) | 2 (33%) | 1 (17%) | 0 (0%) |
| | Male | 8 | 1 (33%) | 1 (33%) | 1 (33%) | 0 (0%) | 0 (0%) |
| Maliana uspland | Female | 7 | 0 (0%) | 2 (33%) | 3 (50%) | 1 (17%) | 0 (0%) |
| | Male | 11 | 2 (40%) | 1 (20%) | 0 (0%) | 2 (40%) | 0 (0%) |
| Total | Female | 38 | 12 (38%) | 4 (13%) | 8 (25%) | 7 (22%) | 0 (0%) |
| | Male | 58 | 17 (41%) | 6 (15%) | 11 (27%) | 5 (12%) | 2 (5%) |
| | Grower | 49 | 4 (22%) | 4 (22%) | 4 (22%) | 5 (27%) | 1 (6%) |
| | Non-grower | 58 | 25 (45%) | 6 (11%) | 15 (27%) | 7 (13%) | 1 (2%) |
| | All Respondents | 73 | 29 (39%) a | 10 (14%) c | 19 (26%) b | 12 (16%)bc | 2 (3%) d |

Note: Responses that share lower case letters in the total row are not significantly different (P < 0.05).

*3.5.2 Market to Sell Sandalwood*

Chi-squared analysis revealed no influence between respondent's region of residence, grouping (grower vs non-grower) or gender over their knowledge of sandalwood markets. In both Natarbora and Maliana respondents did not know where they might sell sandalwood when it is time for harvest representing 78% of respondents (Table 12). A further 6% of respondents suggested that there was no market (5%) or regulations (1%) for selling sandalwood. For the remaining respondents, places nominated to sell sandalwood included the buyer approaching growers at home (2%), in the market (unnamed) (4%), selling illegally to local or foreign buyers (5%), or that the government might come to buy from them (2%). Focus group discussion participants in both the lowland and upland also affirmed that there are as yet no markets to sell sandalwood.

**Table 12.** Frequency and percentage of respondents' knowledge of sandalwood markets.

| Region | N | Don't Know | There is no Market Place | Sell at Market Place | No Regulations | Government will buy | Sell illegally | Sell from home to buyers |
|---|---|---|---|---|---|---|---|---|
| Natarbora (Lowland) | 42 | 35 (83%) | 3 (7%) | 2 (5%) | 0 (0%) | 0 (0%) | 2 (5%) | 0 (0%) |
| Natarbora (Upland) | 18 | 11 (61%) | 2 (11%) | 1 (5%) | 0 (0%) | 1 (5%) | 1 (5%) | 1 (5%) |
| Maliana (Lowland) | 14 | 12 (85%) | 0 (0%) | 1 (7%) | 0 (0%) | 0 (0%) | 1 (7%) | 0 (0%) |
| Maliana (Upland) | 17 | 13 (76%) | 0 (0%) | 0 (0%) | 1 (5%) | 1 (6%) | 1 (6%) | 1 (6%) |
| Total | 91 | 71 (78%) a | 5 (5%) b | 4 (4%) bc | 1 (1%) c | 2 (2%) bc | 5 (5%) b | 2 (2%) bc |

Note: Responses that share lower case letters in the total row are not significantly different ($P < 0.05$).

## 4. DISCUSSIONS

This study focused on two livelihood zones in Timor-Leste where sandalwood occurs naturally in the upland areas to investigate smallholder interest and capacity for planting the species. The State of Timor-Leste views the commercialisation of timber and sandalwood trees as part of its strategy to diversify its economy and address land degradation through reforestation. Our findings confirmed that Timorese smallholders have an interest in diversifying their agricultural livelihoods to incorporate long-term tree crops and are receptive to innovations and projects that support this diversification.

### 4.1 Decision making and intent

Decision-making by smallholders to adopt new innovations is often less about 'technology transfer' and more dependent on risk perceptions, resource constraints and livelihood portfolio in a given cultural setting (Grünbühel & Williams, 2016). We found strong interest among respondents to adopt tree planting, including sandalwood. A significantly greater proportion of respondents (67%) (Table 7) have experience in planting trees than have access to any form of grower advice (17 to 24%) (Table 6). This suggests that growers are progressive and willing to test new practices without formal support or other forms of advice. This result supports the findings of Batterbury et al. (2015) who suggested that Timorese communities seek to diversify their livelihood strategies and incorporate new income sources. Within this context, respondents considered sandalwood as a valuable timber with its highly priced scented oil. They perceived the main benefits of planting sandalwood as a future source of income to support family needs, including sending children to school. Also, among AI-Com supported sandalwood growers, they expressed interest in planting more sandalwood.

Co-operative planting of sandalwood on customary land was not raised as an option by respondents or within any of the FGDs. Based on government experience, pursuing the communal approach to forest or tree restoration comes with its challenges, with

maintenance issues limiting success. Within the current context in Timor-Leste, the promotion of tree planting, as an income diversification strategy, is only likely to be successful on a family basis. This simplifies decision-making and maintenance responsibilities and clarifies that the benefits accrue to the family that plants trees on their own land.

### 4.2 Land tenure

Land tenure security among the surveyed groups was high and not considered a limitation for planting long-lived perennial trees. This high degree of confidence in customary land tenure supports local innovation, which aligns with the findings of Fitzpatrick et al. (2008), who suggested that "customary land tenure systems in Timor-Leste were not a significant constraint on agricultural productivity" (pp.4-5). Since sandalwood is a long-term investment, clear land ownership status will ensure tree tenure security and minimise future conflicts.

### 4.3 Tree tenure

For smallholder sandalwood planted on their own landholdings, there was consensus among landholders, local leaders and MAF staff that tree tenure is retained by the said individual. Among interviewed households, their landholding area was sufficient to support the establishment of small plots of commercial trees. Land size was found to vary among smallholders ranging from 1.7 to 2.5 ha, with most respondents prepared to allocate between a quarter and a third of their landholding (0.5 to 0.7 ha) to long term rotation tree crops. The number of sandalwood trees that the available land could support (312 to 437 trees at 4 x 4 m spacing) was in excess of the number of sandalwood trees they perceived they could manage (31 to 84 trees).

By law, harvesting rights for wild trees existing on customary land are identical to that of planted trees. There was consensus on landholder's accepted rights to harvest naturally-occurring trees for wood products and non-wood forest products such as honey, root crops like wild yam and ginger, and palm fruit on customary land. However, wild and planted trees require harvest permits from relevant authorities. This is important to ensure the trees are permitted for harvest (i.e. ownership is unchallenged), they are of commercial maturity and any associated government fees are applied. da Silva et al. (2019) suggested there was an absence of policies in Timor-Leste for legal forest management rights for customary landholders. Uncertainty over the boundaries of state land, or overlapping claims of state and customary land ownership also persists (Fitzpatrick et al., 2008). The extent of the sandalwood resource on state land is unclear and land ownership ambiguity could be a potential issue when the harvesting moratorium is lifted.

Among the interviewed families, tree tenure and maintenance reflected local cultural norms and variations in intra-household decision-making, resource control and transfer. Both the upland and lowland sites in Natarbora are predominately of Tetun Terik ethnolinguistic group whereby men and women can typically inherit family land and resources, hence there was a high positive response regarding joint household heads decision-making and women's ownership of sandalwood. Comparatively, Maliana respondents are of Kemak ethnolinguistic group that traces descent through the paternal line, which might account for the much lower percentages of surveyed men, particularly in Maliana lowland, who agreed that women can own sandalwood. Maliana upland respondents were more likely to state shared decision-making and responsibilities between genders. Kemak-Leosibe culture of Maliana upland area (Daitete Hamlet) has been previously reported to have a flexible land inheritance arrangement where parents may transfer their land to both daughters and sons.

However, when daughters get married and their bride wealth is given by their husbands' family, then the daughters will leave their land and transfer it to their brothers. If the bride wealth is not given, the daughters can still live on and use their parents' land. Respondents in Maliana who stated "no" to women's ownership of sandalwood pointed out that women typically left their natal family upon marriage, suggesting that upon harvest time, the income from sandalwood sale will be divided among the natal family who maintain the sandalwood.

### 4.4 Smallholder knowledge of planting trees and sandalwood

The production of trees requires specific knowledge related to their environmental tolerances and maintenance requirements. Sandalwood is unique with respect to its root parasitism of nearby trees and shrubs. This makes growing sandalwood a particular challenge since it must be grown in polyculture with root access to other plants. During Portuguese colonial times Cinatti (1950) suggested that lack of understanding of the parasitic nature of sandalwood made successful planting difficult. Our study demonstrated that the awareness of host tree requirement varied between households. However, those that held this understanding were also aware of the sandalwood preference for leguminous trees. Given that this knowledge was not universally held among respondents, further extension and/or smallholder knowledge exchange is necessary to ensure well-planned smallholder sandalwood plantings.

Cinatti (1950) reported that sandalwood finds its optimum clime in the zones that combine the dryness of the coast with the first humidity of the mountains. This knowledge of suitable climates should be used to guide scarce resources towards promotion and support of sandalwood culture in such locations. A widely held view among respondents was that sandalwood performs well in the higher elevation upland slopes. They identified that climatic conditions in upland areas were more suitable and grazing pressures were lower than those found in lowland and coastal areas.

The length of the rotation of a particular tree crop has a negative influence on the financial returns accrued, mainly due to the process of financial discounting. In this study landholders are not necessarily aware of the rotation of trees such as sandalwood, and therefore such knowledge transfer should be incorporated into extension initiatives. For respondents that were aware of the rotation of over 20 years for sandalwood, they did not consider this a disincentive for planting. This is in contrast with Inder's (2020) economic return argument that views the long rotations of forestry trees challenges the motivation of Timorese farmers, with costs incurred in the first few years, but benefits accruing long into the future. In our study, key informants recognised that while there has been much interest among landholders in planting timber trees over the past 20 years which is expected to continue, for some families the long period of investment can limit their participation.

Sources of advice for agriculture, forestry and sandalwood was a mix of government extension officers, international development agency staff and local NGO staff with little evidence of co-ordination. There has been much activity in promoting tree planting since Timor-Leste's independence, however outcomes could be enhanced with a more coordinated and national approach to forestry extension (Batterbury et al., 2015; Paudel et al., 2022). In addition, this study found a lack of co-ordination at the village level, with few forestry-focused landholder groups and limited village-level support or knowledge transfer for tree planting. MAF and development partners should seek to upskill government forestry guards and local NGO practitioners. To this end, respondents showed interest in gaining knowledge on planting sandalwood, recommending the AI-Com program to engage with local MAF extension officers and requested for AI-Com or MAF technical staff to visit annually to monitor progress of

sandalwood and share relevant information with growers. Reid (2017) has also demonstrated clear benefits for social innovations that promotes knowledge exchange among smallholders and industry stakeholders to ensure sustainability beyond the scope of individual projects.

### 4.5 Resources

Most smallholders rely on rainfed agriculture in Natarbora and Maliana with some having supplementary water sources for irrigation. Survival in tree plantings during the first year of establishment is highly influenced by soil water availability, particularly over the dry season. Water availability is a major cause of mortality and considered by smallholders as one of the main risks to successfully establishing tree plantations like sandalwood. A constraint highlighted from Maliana upland FGD participants was that they needed a water tank and hose to water sandalwood, particularly during extended periods of dry weather. Water availability and labour associated with carting water to seedlings is likely to remain a significant constraint to expanding the planted resource. Appropriate timing of planting could be one of the most important local innovations to increase survival. Typically the northern parts of Timor-Leste experience one wet and one dry season annually, whereas the central highlands and south coast have a bimodal rainfall pattern with two wet seasons per year (Molyneux et al., 2012). Almeida et al. (in press) reports that sandalwood survival after planting can be increased through planting at the start of the wet season on the north coast to promote establishment of a root system prior to the onset of the dry season. Along the south coast, planting is recommended during the second wet season, to avoid the deleterious effects of localised inundation on seedling establishment.

The time required to tend to sandalwood seedlings was not identified specifically as a challenge to planting sandalwood. While it may be tempting to assume that all growers have sufficient time, time constraints may be embedded in labour involved in weed maintenance and fence construction etc., which can demand considerable time. This finding aligns well with Fitzpatrick et al. (2008), who asserted labour was a constraint to agricultural productivity. Planting sandalwood nearby one's residence can potentially address the problems of labour, water availability, keeping livestock out and the threat of theft.

### 4.6 Markets

During Indonesian occupation, a marketplace for sandalwood was said to be located in Becora, Dili, run by Batara Indra Company (Aditjondro, 1994: 58; Carey & Bentley 1995: 13). At present, there is no formal sandalwood market in Timor-Leste due to its history of over-exploitation and cultural significance as an indigenous "emblematic national plant", resulting in a 25-years ban on the sale of this timber. As such, households raised concerns about the risks of adopting sandalwood and not being able to sell it in the future. Key informants suggested that the Timor-Leste government is currently focusing on conserving and replenishing sandalwood stock. However, the current ban is being reviewed to combat the illegal trade of wild sandalwood by working towards a regulatory framework for its commercialisation. Furthermore, mature standing trees are at a high risk of theft. The continuing illegal trade is indicative of the high international demand for sandalwood. This combined with historical recognition (Hamilton, 1930) and recent empirical evidence of the high quality of sandalwood from Timor-Leste (Almeida et al., in press), gives the nation a competitive advantage in the international marketplace.

With an expected harvest rotation of at least 20 years for sandalwood in Timor-Leste, the national prohibition of commercial sandalwood harvesting from 2012 to

2037 restricts the marketing of any sandalwood plantation established prior to 2017. Given no reliable data on the extent of such plantings is available, it is not yet clear how many sandalwood smallholder woodlots might be affected. Over 3,200 ha of sandalwood were recorded in the agricultural census, however further work is recommended to conduct an inventory of planted sandalwood stands in Timor-Leste.

The high value of sandalwood in the international marketplace (Ananthapadmanabha, 2022), attracts smallholder investment in planting this forestry crop (Page et al., 2020; Rome et al., 2020; Lee et al., 2019; Thomson et al., 2020; Viswanath & Chakraborty, 2022). Smallholders are primarily interested in sandalwood production for its potential financial benefits, specifically for meeting family necessities, education, and cultural commitments. It is therefore important to know if sandalwood can meet these farmer expectations. Despite the long term nature of this tree crop, its production in agroforestry systems has been demonstrated to be financially viable across a number of other countries. The net present value (NPV) of such systems were between USD 21,786 and 37,792 (10% discount rate) in Vanuatu (Page et al., 2010; Ota et al., 2022), USD 23,631/ha (8% discount rate) in Fiji (Harrison & Harrison, 2016), and USD 34,500/ha (IRS 2,584,914) (15% discount rate) India (Divakara et al., 2018). In Timor-Leste, Page et al. (2022a) compared growing sandalwood in combination with forage tree legumes and cattle production, with sandalwood as an enrichment of existing savannah vegetation. At a discount rate of 10%, this research revealed a NPV of USD 21,729 and land expectation value (LEV) of USD 23,928 for the former and NPV of USD 9,718 and a LEV of 10,706 for the latter system respectively. Therefore, the incorporation of sandalwood with cattle production can help landholders realise short-, medium- and long-term income. In contrast, sandalwood enrichment systems can secure a long-term income with only part-time labour inputs (Page et al., 2022b). These positive financial results for sandalwood production mean that this land use option can meet the livelihood aspirations of prospective producers in Timor-Leste.

## 5. CONCLUSION

This study has found that government- and donor-funded efforts to facilitate commercial tree planting among smallholders in Timor-Leste addresses landholder needs to diversify their income sources. Although land tenure security and the long rotation of sandalwood were not identified as constraints for tree planting, clarity in land and tree ownership is required to prevent future disputes. According to the views of customary landowners, tree tenure closely follows land tenure and so smallholders invariably seek to establish trees on their own land. Almost all interviewed smallholders had land that was surplus to agricultural crop production that they were seeking to devote to tree planting. Further extension is needed to ensure that landholders are aware of their rights and restrictions with respect to harvesting trees for commercial purposes.

Tree plantations are widely accepted by landholders as a supplementary source of livelihood and income. For such plantations to be competitive in the international marketplace they need to comprise of tree species where Timor-Leste has a significant local market (e.g., teak and mahogany) or a competitive advantage for export. The main constraints found for diversifying into sandalwood growing included limited access to labour (water provision, site maintenance and fence construction), germplasm (seed bearing trees, commercial seed/seedlings), markets and agricultural extension services/knowledge exchange systems.

Significant smallholder sandalwood plantings have been recorded through the national agricultural census. However, these data need to be ratified through a targeted inventory of planted sandalwood. An inventory of planted sandalwood can provide benefits such as (1) knowing the extent of the resource and the derived wood flows over time, (2) determining the commercial costs of the ban on smallholders that have already established woodlots, and/or (3) developing a system of registration and policy such that planted sandalwood may be marketed as distinct from wild sandalwood. By having a legal avenue for marketing sandalwood from plantations that will mature during the moratorium, it may: (a) provide competition and thus higher prices for sandalwood growers than would be achieved by selling through clandestine means; and (b) provide a market signal that encourages wider planting of sandalwood among smallholders. Given high international demand, continued high prices for sandalwood and the recognition that the native *S. album* produces a high quality product, we can confirm that sandalwood has the capacity to achieve income diversification for the government and smallholder families.

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