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Article

Smallholders' Tree Planting Activity in the Ziro Province, Southern Burkina Faso: Impacts on Livelihood and Policy Implications

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Abstract: Climate variability and change significantly affect smallholder farmers' food security and livelihoods in sub-Saharan Africa. Tree planting is one of the measures promoted by development programs to mitigate and adapt to climate change. Tree planting is also believed to positively contribute to livelihoods. This paper examines factors influencing smallholders' tree planting activities in four villages in the Ziro province, Southern Burkina Faso. Furthermore, it analyses the challenges encountered and willingness to continue tree planting under current tenure arrangements. The data was obtained through key informants, household interviews, focus group discussions, and field observations. Results indicate that the majority of farmers interviewed planted *Mangifera indica* (50%), *Anacardium occidentale* (32%) and *Moringa oleifera* (30%). In a number of trees planted, *Eucalyptus camaldulensis*, *Mangifera indica* and *Anacardium occidentale* dominated. Tree planters were mainly farmers who held large and old farm areas, were literate and relatively wealthy, had favorable attitudes toward tree planting, and with considerable years of participation in a farmers' group. The main reasons for planting trees included income generation from the sale of tree products, access to markets and local support for tree planting. Preference for agriculture, tenure insecurity and lack of sufficient land were the main reasons cited for not planting trees. Farm households that were relatively poor, had

smaller workforces and smaller farm sizes were not willing to continue tree planting. To effectively engage farmers in tree planting and to make it more attractive, policies are needed that address tenure insecurity for migrants, enable better access to markets, and support fair pricing structures for wood and other tree resources.

Keywords: tree resources; perceptions; markets; capacity strengthening; tree/land tenure; Sahel

1. Introduction

It is estimated that 10%–20% of the world's drylands are degraded [1]. In dry Africa, annual net changes of tree cover and other wooded land have been estimated at −0.91 M ha (0.34% annual rate of loss) and −0.89 M ha (0.20%), respectively, between 1990 and 2000 [2], while the annual net change from dense to open tree cover was −0.39 M ha [3,4]. In Burkina Faso, the annual deforestation rate ranged from 0.91 to 1.03% between 1990 and 2010 [5], while total forest area accounted for 56,490 km^2 (21% of the national territory). The annual deforestation rate for the southern region of Burkina Faso was estimated to be 0.96% per annum between 1986 and 2006 [6]. Conversion of forest and woodland to crop and rangeland [7], fuelwood extraction [8,9], over-exploitation, and unsustainable land management [10] have been identified as the main drivers of deforestation in the country.

Furthermore, the difficult conditions for agriculture and livestock production in the north and central regions, due to the country's biophysical setting together with its long experience of drought and desertification [11], are acting as a push factor to further intensify competing land uses in the southern region [7]. Due to an increase in population through migration and natural population growth the demand for land is increasing and affecting livelihood management strategies in the region. Studies in Southern Burkina Faso found that conversion of forest to cropland affects both the sustainability of the environment [10], and the consumptive values collected from the forest [7].

Following the devastating drought and famine that occurred in the 1970s and 1980s, and because of the importance of trees for soil fertility management, re-greening as a strategy to rebuild resilience in the Sahel has been the focus of scientists, development agencies, the government, and non-governmental organizations [12]. As a result, tree planting has been extensively promoted and adopted as a policy intervention to restore and enhance ecosystem goods and services such as carbon sequestration and enhancing soil fertility [13–15], as well as to support and sustain livelihoods and build economic and environmental resilience [16–18]. Due to the magnitude of the effects of climate variability and change on food security and the livelihood strategies of smallholder farmers, tree planting has been identified as being especially important in the Sahel and Burkina Faso [12]. In fact, tree planting has been found to provide substantial economic and environmental benefits, whether it is a part of agricultural systems (e.g., agroforestry), tree plantations, or to enrichment secondary growth areas [19,20].

Despite the importance of rainfall to the re-greening process in the West African Sahel [21,22], this would not have been possible without farmers' and communities' efforts in planting trees and assisting natural regeneration activities [12,23]. The government of Burkina Faso and other research and development agencies such as the World Agroforestry Center (ICRAF), the National Seed Centre of Burkina Faso (CNSF), SOS Sahel (international NGO whose vocation is to improve the living conditions

of the people in sub-Saharan Africa), TREE AID (international development organization which focuses on unlocking the potential of trees to reduce poverty and protect the environment in Africa), FRUITEQ (*Fruit du commerce équitable*), Foods Resource Bank, African Cashew Initiative (ACI), *etc.* are promoting tree planting activities in different parts of the country that provide seedlings to farmers for free or at a discounted price. However, the efforts of these organizations to establish nurseries and raise seedlings for tree planting do not guarantee the effective participation of smallholders. These programs often fail to consider the different abilities of households to participate in tree planting and ignore household characteristics that guide tree planting decisions.

Related studies have shown that smallholder tree planting activity is influenced by socioeconomic characteristics such as access to land with secure land/tree tenure [24–26]; suitable management skills, knowledge and labor force; interaction with peer farmers' through either social groups or cooperative organizations [24]; environmental factors [16,19]; and access to markets [27–29].

Understanding the socioeconomic factors and perceptions of smallholders related to tree planting activities in Burkina Faso will be valuable for informing and supporting related policy interventions. The perceptions of local people examine their views on how they consider tree planting activity. A study in Burkina Faso [23] and Indonesia [29] applied local perceptions in relation to woody species dynamics and smallholder tree planting activity. If the incentives and disincentives to tree planting activities are understood, it will be easier to improve participation of smallholders and increase benefits from tree planting. This study aims to contribute to the debate on tree planting for the re-greening of the Sahel, and is guided by the following main research questions: (i) what are the socioeconomic characteristics and perceptions of tree planters and non-tree planters, (ii) what are the challenges encountered in planting trees, and (iii) are farmers willing to continue planting trees under the existing tenure arrangements. The introduction of the research objectives is followed by the description of the study sites, method of data collection and analysis, results, discussion, further areas for research and conclusions.

2. Methods

2.1. Study Sites

This paper focuses on four study villages located in three districts in the Ziro province of Southern Burkina Faso. The study villages include Cassou, Vrassan, Dao and Kou (Figure 1). The sites were selected under the framework of the project entitled: "Sustainable Rural Development through High Value Biocarbon Approaches: Building Multifunctional Landscapes and Institutions in West Africa (BIODEV)". The site selection criteria for the project included a distance of less than 10 km from the village to the forest, accessibility to villages, existence of an ongoing project, and a long history of development projects. Ziro province occupies an estimated area of 5291 km^2 and is situated in an area of low relief with a mean altitude of 300 m above sea level (a.s.l.). This region lies within the South-Sudanian climate zone with annual rainfall ranging from 700 to 900 mm with temperatures that range from 30 °C on average to peaks of 40 °C during the dry season. The main World Reference Base soil types are silt-clay cambisols, sandy lixisols, and loamy ferric luvisols [30].

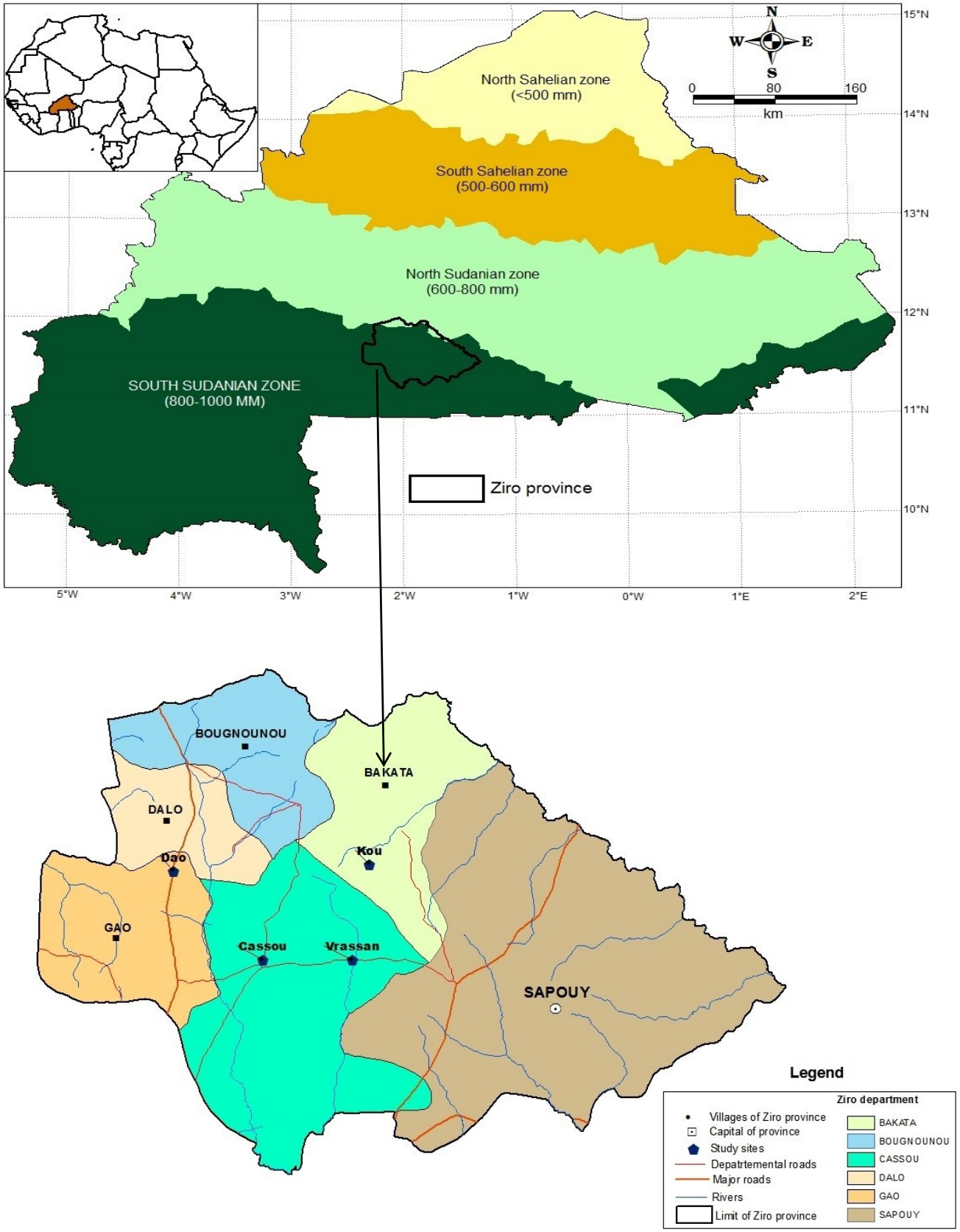

Figure 1. Location of the study villages in the Ziro province, Southern Burkina Faso.

The population density was estimated at 28 persons/km^2 in 2007 [31]. The area is composed of three ethnic groups: Gourounsi, Mossi and Fulani with the first group being indigenous while the last two

groups are migrants. The Mossi and Fulani originate from the central plateau and northern region of Burkina Faso. The exposure of the central plateau and northern regions to drought and desertification affects farming and livestock activities and explains the push factor for migrants to the southern region [32]. Aside from better opportunities for rain-fed agriculture, fuelwood supply, and wood and forest products offered by the southern region compared to other regions, the climate and soils also support tree growing activities with very little inputs. In contrast to Cassou, where 80% of the population consists of indigenous people, in Vrassan, Dao and Kou, 75% of the population consists of migrants. Livelihood activities include food and tree crop cultivation and extraction of wood and other forest products. The farming system is a mixture of subsistence and commercial crop cultivation of cereals such as sorghum, sesame, maize, *etc.* Cotton cultivation is a common feature of the farming system in addition to livestock herding such as cattle, donkey, sheep and goats. The farm size varies amongst individual farmers ranging from 1 to10 ha [7,10].

The flora is dominated by perennial grass such as *Andropogon gayanus* Kunth, *A. ascinodis* C.B. Clarke and *Schizachyrium sanguineum* (Retz.) Alston [33]. The main tree species in the forests are *Afzelia africana* Sm., *Khaya senegalensis* A. Juss. and *Pterocarpus erinaceus* Lam. Other tree species are scattered on the croplands including *Vitellaria paradoxa* C. F. Gaertn, *Parkia biglobosa* (Jacq.) R. Br. ex G. Don. and *Tamarindus indica* L., and their presence is a common feature in the study area. The different types of forests in the study villages are protected forests (*Chantiers d'Aménagements Forestiers—CAF*, also known as community forest management) and village forests (*forêts villageoises)*.

2.2. Data Collection

Data were obtained through focus group discussion (FGD), as well as key informant and household surveys. The key informants identified tree growers, land chiefs, households that were members in farmer or forest management groups (FMG), and three representatives from each of the ethnic groups who were contacted for the FGDs. An FGD was conducted in each of the four villages with six participants per study village. The research questions were read out and explained to participants in the common local language. A research assistant was used who understood and spoke the local language. The participants were also asked to provide information on previous or ongoing tree planting projects, species planted and their perceptions on socioeconomic and institutional factors influencing tree planting activities such as different social/farmers groups in the village, markets for tree resources, government extension support services, land and tree tenure arrangements, *etc.* During the FGDs, participants were asked to list tree species planted in the region. A total of ten species were identified and those planted by ≥10 farmers were considered for further study while those planted by ≤10 farmers were left out. This criterion was adopted from an earlier study conducted in Burkina Faso and other countries in sub-Saharan Africa on farmers' planting practices [34]. Based on this criterion, the following six species from the ten were selected for this study: *Adansonia digitata* L. *Anacardium occidentale* L. *Azadirachta indica* A. Juss. *Eucalyptus camaldulensis* Dehn. *Mangifera indica* L. and *Moringa oleifera* Lam.

For the survey, an equal sample size of 50 households was selected in each of the four villages. Only farmers with a total land area of ≥2 ha who planted at least one of the six species were considered for the survey. According to national census statistics [31], the numbers of households as at 2006 are as follows in the study villages: Cassou (400), Vrassan (155), Dao (258) and Kou (269). Parkland species

such as *Parkia biglobosa* and *Vitellaria paradoxa* grown through farmer managed natural regeneration (FMNR) were not considered in this study. These two species are protected by law and constitute the dominant species in parkland systems in Burkina Faso [35]. The species considered in this study provide both timber and food value and include trees planted around agricultural plots and woodlots. Smallholders that did not plant any of the studied species were considered as non-planters while those that planted trees were considered as tree planters.

The socioeconomic characteristics of non-planters and planters were then considered for the selected species. With the assistance of the youth leaders, 200 respondents who fulfilled the land and species requirements were selected. A survey was designed to capture the socio-economic, perceptional and institutional characteristics of farmers planting the selected species. Using closed-ended questionnaires based on the six selected species, data was collected on farmers' socio-economic characteristics, farm characteristics, tenure arrangements, silvicultural practices, and perceptions on tree planting. Based on the literature review, socio-economic, perceptional and market related variables to be used in this study were modified from other studies to suit the objectives of this paper [25,29].

Socio-economic questions included amongst others age, education, number of household members, estimated annual income and expenditures, and participation in farmers group or other social groups (e.g., member of FMG). Household wealth categories were developed through participatory methods using twelve local livelihood indicators and included in the questionnaire. Three wealth categories, based on a detailed methodology, are identified amongst farmers in the study region and include non-poor, fairly poor and poorest [36]. The silvicultural questions included farmers' reasons for planting or not planting trees, attitudes towards tree planting, challenges related to tree planting, and farmers' willingness to continue tree planting under their existing tenure arrangements.

The collected data were entered and processed in Excel spreadsheet and analyses were run with Stata version 12.1. Descriptive statistics, two-sample Wilcoxon rank-sum (Mann-Whitney) and Pearson Chi square tests were applied in the analyses. The Mann-Whitney *U*-test is suitable for analysing differences between two independent groups [37]. Similar methods have been applied in other studies on tree planting in Indonesia [29] and local perceptions of woody vegetation in Burkina Faso [23].

3. Results

3.1. Planted and Preferred Species by Smallholders

Results (Figure 2) indicate that ≥30% of the 200 respondents planted *Anacardium occidentale*, *Mangifera indica* and *Moringa oleifera*. On the other hand, <20% planted *Adansonia digitata*, *Azadirachta indica* and *Eucalyptus camaldulensis*. The most planted species was *Mangifera indica* (50%) while the least was *Adansonia digitata* (11.5%). The differences in proportions of planted species indicate unequal preferences of smallholders based on their socio-economic and perceptional characteristics. Information gathered during the FGDs indicated that TREE AID (from the year 2000) and FRUITEQ (2005 onward) had provided farmers with *Mangifera indica* grafting trainings. In addition to technical support, FRUITEQ is an export company and buys fruits of *Mangifera indica* from farmers. These benefits explain why a higher percentage of farmers planted this species.

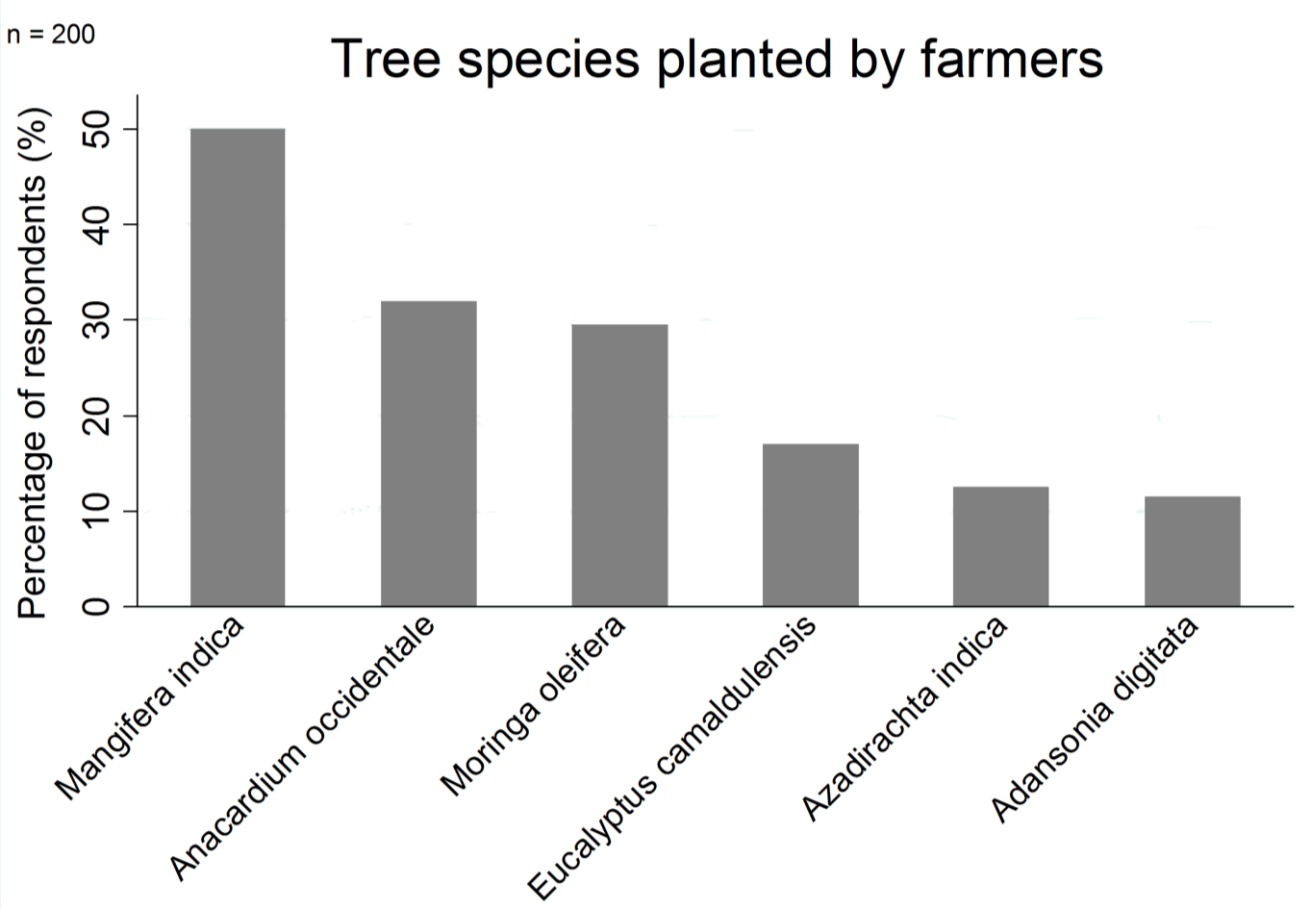

Figure 2. Proportion of the respondents planting the six selected species.

On the other hand, the high proportion of *Anacardium occidentale* in the study area is attributed to spill-over from the neighboring Sisilli province where an intervention by the ACI project is being implemented (2009–2016). The nurseries established by the ACI project produced seedlings in excess. Farmers from the Cassou district benefited from this project by buying seedlings at a reduced price.

Across the four study sites, smallholder farmers planted or were currently managing a total of 6604 trees of the six selected species (Table 1). The highest number of trees planted or managed was found in Cassou. This dominance is seen in five of the six species with the exception of *Mangifera indica*, which is a little higher in Vrassan. Cassou had a long history of development projects owing to its administrative role as the District head of the Ziro province. In Cassou, there is an ongoing project supported by CNSF) through a farmers' group of thirteen called Cayendé. This project (2010–2016) supports a nursery of *Adansonia digitata* and *Moringa oleifera*. Members of this group get seedlings for free while non-members buy seedlings at a reduced price. Because the intervention area of this project is in Cassou, smallholders have to travel from Vrassan, Dao and Kou, which are 15, 35 and 40 km away to buy seedlings. Access to seedlings contributed to tree planting, which explains why, of the six selected species, the highest numbers of planted species are in Cassou followed by Vrassan.

Table 1. Number of trees currently planted or managed.

Total number of trees currently planted/managed by genera in study sites								
Study sites	***Adansonia digitata***	***Anacardium occidentale***	***Eucalyptus camaldul***	***Moringa oleifera***	***Mangifera indica***	***Azadirachta indica***	**Total**	**%**
Cassou	85	726	1476	336	411	70	3104	47
Vrassan	21	280	640	140	441	52	1574	24
Dao	2	291	193	108	182	18	794	12
Kou	22	313	304	147	278	68	1132	17
Total	130	1610	2613	731	1312	208	6604	-
%	2	24	40	11	20	3	-	100
Average number of trees currently planted/managed at household level								
Sample's Mean	0.65	8.05	13.07	3.66	6.56	1.04	33.04	-
Std. Dev	2.27	16.47	45.81	6.60	10.46	3.09	75.41	-
Min.	0	0	0	0	0	0	0	-
Max.	15	100	350	30	50	16	545	-

Where (–) implies "not applicable" and Std. Dev means "Standard Deviation"

The dominant species in numbers planted were *Eucalyptus camaldulensis*, *Anacardium occidentale* and *Mangifera indica*. Despite the relatively high maximum number of trees planted by smallholders, especially for *Eucalyptus camaldulensis* and *Anacardium occidentale*, not all farmers planted each of the six species, as shown by the minimum values and very high standard deviation of the data (Table 1).

Furthermore, 45% of the total respondents mentioned five species they would have preferred to plant, if given the opportunity (Figure 3). The percentage of farmers who preferred each of the different species include *Anacardium occidentale* (26%), *Parkia biglobosa* (21%), *Vitellaria paradoxa* (12.5%), *Tectona grandis* Linn. (23%), and *Eucalyptus camaldulensis* (17.5%). During the FGDs, when questioned about the unavailability of preferred tree species, farmers reported a lack of seedlings for *Anacardium occidentale*, because the Ziro province was not part of the intervention area for the ACI and farmers had to travel to the neighboring Sissili province to buy planting materials.

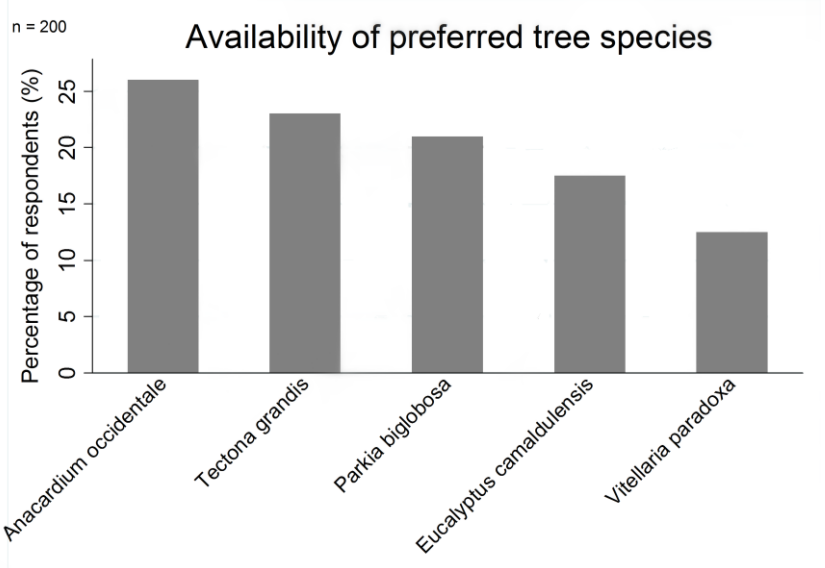

Figure 3. Percentage of respondents citing preferred species.

For *Parkia biglobosa* and *Vitellaria paradoxa*, which grow naturally in parklands and multipurpose indigenous trees, FMNR is important for supporting regrowth. Though these two species are protected by law, *Parkia biglobosa* is suitable for wood fuel, and the high demand for fuel wood now exposes this species to harvesting. Though respondents complained of a lack of seedlings and high water requirements for *Tectona grandis*, they maintain their preference for this species due to its high economic benefit. Finally, another species preferred by smallholders is *Eucalyptus camaldulensis* because of its importance as a building material with existing local markets.

3.2. Socio-Economic Characteristics and Perceptions of Tree Planters and Non-Tree Planters

Tree planters and non-tree planters exhibited significant variations in their socioeconomic characteristics and perceptions. In general, tree planters were smallholders with large land areas. In addition, they had more years of belonging to farmers' groups aiming to manage forests. Furthermore, they were those who had a more favorable attitude towards tree planting (Tables 2 and 3). Farm size showed high significance at ≤0.001 level for *Adansonia digitata*, *Anacardium occidentale*, *Eucalyptus camaldulensis*, *Moringa oleifera*, and *Azadirachta indica* planters, but less significance (≤0.05) for *Mangifera indica* planters. Likewise, membership in FMG was highly significant at ≤0.001 level for *Adansonia digitata*, *Anacardium occidentale*, *Eucalyptus camaldulensis*, *Moringa oleifera*, and *Azadirachta indica* planters, and at <0.01 level of significance for *Mangifera indica* planters.

Apart from owning large farm areas, belonging to an FMG or a farmers' cooperative is an incentive to actively participate in tree planting. In these farmers' groups, seedlings are provided to the farmers for free or at discounted prices and accompanied by trainings in tree management. Smallholders in this region have received training from TREE AID in mango grafting. The grafting method is widely applied in the study villages to generate planting materials. This explains the differences in significance for *Mangifera indica* planters from the other five species in relation to FMG membership. In addition, tree planters belonged more often to a farmers' group ($p \leq 0.001$), and had more favorable attitudes towards tree planting ($p \leq 0.001$) than the non-tree planters in all six species.

Aside from the above four factors, which influenced planting of all six species, other factors considered in our study affected only particular species and at different levels of significance. Households with older heads had more members and a greater work force, and planted *Eucalyptus camaldulensis*, *Moringa oleifera* and *Azadirachta indica* predominately ($p \leq 0.001$). Household work force is important because agriculture is not mechanized. According to the key informants, a work force is necessary for transporting seedlings, planting, and harvesting trees and tree products. During the field survey, it was observed that rudimentary, labor intensive and time-consuming hand tools such as axe heads were used for logging *Eucalyptus camaldulensis*. Farmers with older farms planted *Eucalyptus camaldulensis* ($p \leq 0.001$), *Moringa oleifera* ($p \leq 0.05$), *Mangifera indica*, and *Azadirachta indica* ($p \leq 0.01$).

Table 2. Socio-economic and perceptional characteristics between *Adansonia digitata* planters ($n = 23$) and non-planters ($n = 177$), *Anacardium occidentale* planters ($n = 64$) and non-planters ($n = 136$), *Eucalyptus camaldulensis* planters ($n = 34$) and non-planters ($n = 166$).

Variables		*Adansonia digitata*					*Anacardium occidentale*					*Eucalyptus camaldulensis*				
		Non-planters	Planters	Stat.-value [a]	Prob.	Signi-ficance	Non-planters	Planters	Stat.-value [a]	Prob.	Signi-ficance	Non-planters	Planters	Stat.-value [a]	Prob.	Signi-ficance
		Mean (sd)	Mean (sd)				Mean (sd)	Mean (sd)				Mean (sd)	Mean (sd)			
HH Head Age		44.77 (14.37)	45.65 (12.45)	−0.627	0.5308	NS	44.87 (14.49)	44.88 (13.48)	−0.058	0.9540	NS	43.82 (14.23)	50 (12.63)	−2.534	0.0113	**
HH Size		12.6 (7.84)	14.48 (8.59)	−1.402	0.1610	NS	11.93 (6.66)	14.72 (9.92)	−1.497	0.1344	NS	11.72 (6.49)	18.21 (11.51)	−3.168	0.0015	**
HH Work force		9.34 (5.79)	10.93 (6.55)	−1.337	0.1813	NS	8.85 (4.97)	10.97 (7.31)	−1.67	0.0950	NS	8.69 (4.86)	13.61 (8.37)	−3.495	0.0005	***
Farm Size		5.88 (4.41)	13.04 (6)	−6.195	0.0000	***	5.25 (2.79)	9.79 (7.26)	−5.151	0.0000	***	5.32 (2.73)	13.47 (8.09)	−6.756	0.0000	***
Farm Age		22.01 (11.97)	25.65 (12.8)	−1.253	0.2079	NS	21.58 (12.17)	24.23 (11.81)	−1.6	0.1096	NS	21.21 (11.89)	28.38 (11.41)	−3.367	0.0008	***
HH Annual Income (estimated from 2013 data F CFA)		270,000 (220,000)	280,000 (190000)	−0.707	0.4794	NS	250,000 (210,000)	300,000 (230,000)	−1.37	0.1707	NS	260,000 (210,000)	310,000 (250,000)	−0.887	0.3785	NS
HH Expenditures (estimated from 2013 data F CFA)		180,000 (110,000)	210,000 (86,411.9)	−1.159	0.2466	NS	180,000 110,000	200,000 (110,000)	−1.253	0.2104	NS	180,000 (110,000)	200,000 (120,000)	−0.812	0.4167	NS
Membership of FMG (% of Yes)		4.50	43.5	37.7217	0.000	***	0.70	26.60	35.4454	0.000	***	3.60	35.30	34.5807	0.000	***
Years belonging to cooperative/farmers' group		0.9 (1.93)	5.78 (2.95)	−7.485	0.0000	***	0.74 (1.8)	2.98 (3.28)	−5.647	0.0000	***	1.06 (2.08)	3.41 (3.75)	−3.94	0.0001	***
Favorable attitude toward tree planting (% of Yes)		64.40	100.00	11.9510	0.001	***	53.70	100.00	43.2804	0.000	***	62.00	100.00	18.8374	0.000	***
Education level (%)	Non-literate	81.40	47.80	13.1235	0.000	***	79.40	73.40	0.8908	0.345	NS	79.50	67.60	2.2806	0.131	NS
	Literate	18.60	52.20				20.60	26.60				20.50	32.40			
Wealth status (%)	Non-poor	18.10	26.10	6.4926	0.039	**	17.60	21.90	5.9187	0.052	NS	16.90	29.40	8.3856	0.015	**
	Fairly poor	46.90	65.20				44.90	57.80				47.00	58.80			
	Poorest	35.00	8.70				37.50	20.30				36.10	11.80			

[a] Either two-sample Wilcoxon rank-sum (Mann-Whitney) or Pearson Chi square test is run. NS ≥ 0.05; ** ≤ 0.01; *** ≤ 0.001. Household (HH); sd, Standard Deviation; FMG, Forest Management Group; NS, Not Significant; F CFA, Franc des Colonies Francaises d'Afrique; Prob, Probability; Stat-Value, Statistical value.

Table 3. Socio-economic and perceptional characteristics between *Moringa oleifera* planters (n = 59) and non-planters (n = 141), *Mangifera indica* planters (n = 100) and non-planters (n = 100), and *Azadirachta indica* planters (n = 25) and non-planters (n = 175).

Variables		*Moringa oleifera*					*Mangifera indica*					*Azadirachta indica*				
		Non-planters	Planters	Stat.-value [a]	Prob.	Signi-ficance	Non-planters	Planters	Stat.-value [a]	Prob.	Signi-ficance	Non-planters	Planters	Stat.-value [a]	Prob.	Signi-ficance
		Mean (sd)	Mean (sd)				Mean (sd)	Mean (sd)				Mean (sd)	Mean (sd)			
HH Head Age		44.28 (14.25)	46.29 (13.89)	−0.998	0.3185	NS	42.97 (13.24)	46.77 (14.81)	−1.657	0.0975	NS	43.98 (13.69)	51.12 (15.86)	−2.104	0.0354	*
HH Size		11.75 (7.23)	15.37 (8.96)	−3.369	0.0008	***	11.94 (6.83)	13.7 (8.85)	−1.007	0.3139	NS	11.93 (6.91)	19.08 (11.36)	−3.467	0.0005	***
HH Work force		8.73 (5.46)	11.43 (6.45)	−3.517	0.0004	***	8.83 (4.97)	10.22 (6.62)	−1.039	0.299	NS	8.86 (5.2)	14.2 (8.08)	−3.798	0.0001	***
Farm Size		5.4 (3.08)	9.83 (7.33)	−4.952	0	***	5.48 (2.98)	7.93 (6.42)	−2.511	0.0121	*	5.66 (3.32)	14.04 (8.67)	−6.013	0.0000	***
Farm Age		21.28 (11.77)	25.19 (12.48)	−2.043	0.0411	*	19.5 (10.35)	25.36 (13.01)	−3.219	0.0013	**	21.43 (11.63)	29.44 (13.14)	−2.865	0.0042	**
HH Annual Income (estimated from 2013 data F CFA)		260,000 (210,000)	280,000 (220,000)	−0.736	0.4617	NS	270,000 (220,000)	260,000 (210000)	0.501	0.6161	NS	260,000 (200,000)	350,000 (270,000)	−1.623	0.1045	NS
HH Expenditures (estimated from 2013 data F CFA)		180,000 (110,000)	200,000 (110,000)	−0.885	0.3763	NS	190,000 (110,000)	190,000 (110,000)	0.232	0.8162	NS	180,000 (110,000)	210,000 (120,000)	−1.30	0.1936	NS
Membership of FMG (% of Yes)		3.50	22.00	17.3591	0.000	***	3.00	15.00	8.7912	0.003	**	4.60	40.00	33.5252	0.000	***
Years belonging to cooperative/farmers' group		0.84 (1.94)	2.93 (3.29)	−4.985	0.0000	***	0.44 (1.51)	2.48 (3.02)	−6.051	0.0000	***	1.14 (2.26)	3.68 (3.57)	−4.1	0.0000	***
Favorable attitude toward tree planting (% of Yes)		55.30	100.00	38.4842	0.000	***	37.00	100.00	91.9708	0.000	***	64.00	100.00	13.1387	0.000	***
Education level (%)	Non-literate	84.40	61.00	13.0393	0.000	***	86.00	69.00	8.2867	0.004	**	78.30	72.00	0.4956	0.481	NS
	Literate	15.60	39.00				14.00	31.00				21.70	28.00			
Wealth status (%)	Non-poor	17.00	23.70	4.051	0.132	NS	19.00	19.00	0.4133	0.813	NS	17.70	28.00	10.323	0.006	**
	Fairly poor	46.80	54.20				47.00	51.00				46.30	68.00			
	Poorest	36.20	22.00				34.00	30.00				36.00	4.00			

[a] Either two-sample Wilcoxon rank-sum (Mann-Whitney) or Pearson Chi square test is run. NS ≥ 0.05; * ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001. Household (HH); sd, Standard Deviation; FMG, Forest Management Group; NS, Not Significant; F CFA, Franc des Colonies Francaises d'Afrique; Prob, Probability; Stat-Value, Statistical value.

In addition, it was found that farmers considered literate planted *Adansonia digitata* ($p \leq 0.001$), *Moringa oleifera* ($p \leq 0.001$) and *Mangifera indica* ($p \leq 0.01$). This implies that education contributes to a better understanding of the benefits provided by trees. In the context of our study, literate farmers are those who can read or write, while those who can neither read nor write are illiterates. The cultural belief that *Adansonia digitata* planters are likely to die along with the tree when it matures is a myth that affects its planting potential. However, the literate farmers transcended this barrier and continue planting this species. In addition, the relatively wealthier households planted *Adansonia digitata*, *Eucalyptus camaldulensis*, and *Azadirachta indica* ($p \leq 0.01$). The amount of resources available to households is important because those with more resources can afford to wait for longer periods for trees to mature. On the other hand, farmers with fewer resources prefer agriculture and have limited opportunities for livelihood diversification.

Planters of *Eucalyptus camaldulensis* were those with larger farm areas because it is considered the worst in terms of damaging the soil. During the FGDs, participants mentioned that, although it provides multiple products, managing it on small farms together with crops is challenging. Aside from the myth about *Adansonia digitata*, those who planted this species tended to have larger farms. Because it has a maximum diameter in excess of 15 m for a single tree, this species requires a large farm area to cultivate, which explains why farm size was significant ($p \leq 0.001$) for this species.

3.3. Reasons for Planting or Not Planting Trees

The main reasons cited by the farmers for planting trees were economic, including income generation by selling wood, fruit and other tree products. In addition to financial motivation, farmers mentioned a market for certain tree species and support for tree planting from public projects as motives for tree planting. On the other hand, the most important reasons for not planting trees included farmers' preferences for agriculture, tenure insecurity and lack of sufficient land (Table 4a,b).

Table 4. Farmers' reasons for **(a)** planting trees and **(b)** not planting trees.

	***Adansonia digitata* (%)**	***Anacardium occidentale* (%)**	***Eucalyptus camaldulensis* (%)**	***Moringa oleifera* (%)**	***Mangifera indica* (%)**	***Azadirachta indica* (%)**	**Average (%)**
a) Reasons for planting trees							
Economic (income/investment)	22	55	70	40	82	11	46.7
Building material	0	0	50	0	0	15	10.8
Fuel wood	4	0	28	0	0	20	8.7
Incentives	20	50	6	30	4	2	18.7
Access to markets	6	18	60	35	45	10	29
Support for tree planting	30	30	5	55	4	2	21
Environmental reason (Erosion control, greening)	15	0	2	20	8	8	8.8
For land security	0	0	0	0	0	0	0
Low labor requirements	0	45	3	16	20	5	14.8

Table 4. *Cont.*

	***Adansonia digitata* (%)**	***Anacardium occidentale* (%)**	***Eucalyptus camaldulensis* (%)**	***Moringa oleifera* (%)**	***Mangifera indica* (%)**	***Azadirachta indica* (%)**	**Average (%)**
b) Reasons for not planting trees							
Land is not sufficient	45	20	5	2	38	4	19
Lack of seedlings/higher prices for seedlings	20	35	14	10	2	12	15.5
Farmers prefer-agriculture	50	15	50	16	22	35	31.3
Not profitable (low prices)	28	25	5	2	6	20	14.3
Lack of markets	15	45	3	25	10	40	23
Longer rotation period	40	10	20	4	12	18	17.3
Health problem	0	0	0	0	0	0	0
No time/labor	0	2	6	1	0	2	1.8
Land not suitable	0	0	25	0	0	14	6.5
Lack management knowledge of trees	10	3	2	2	0	15	5.3
New comer in the village	0	1	0	4	2	0	1.2
Lack tenure security to land and trees	30	22	35	28	12	20	24.5

Remark (a): Farmers could mention several reasons for planting trees. Data on reasons for planting or not planting trees from *Adansonia digitata* planters (n = 23) and non-planters (n = 177), *Anacardium occidental* planters (n = 64) and non-planters (n = 136), *Eucalyptus camaldulensis* planters (n = 34) and non-planters (n = 166), *Moringa oleifera* planters (n = 59) and non-planters (n = 141), *Mangifera indica* planters (n = 100) and non-planters (n = 100), and *Azadirachta indica* planters (n = 25) and non-planters (n = 175).

3.3.1. Economic Reasons

Results (Table 4a) indicate that *Mangifera indica* (82%), *Eucalyptus camaldulensis* (70%), *Adansonia digitata* (22%) and *Azadirachta indica* (11%) were primarily planted for economic reasons. This is because income derived from tree resources constitutes an important component of household expenditures for daily consumables such as food and transportation and anticipated expenditures e.g., school fees, marriage, *etc.* Furthermore, income from trees provides additional economic security for unexpected expenditures such as health related issues, death, and as a safety net during years of crop failure, *etc.* (Figure 4). The preferred species for daily income are *Moringa oleifera*, *Mangifera indica* and *Anacardium occidentale*. More than 50% of *Anacardium occidentale*, *Eucalyptus camaldulensis* and *Mangifera indica* planters mentioned an economic reason for planting these species.

3.3.2. Existing Markets

Access to existing markets varies among tree species and there are much better markets for certain species than others. The most cited species with a market (Table 4a) included *Eucalyptus camaldulensis* (60%), *Mangifera indica* (45%) and *Moringa oleifera* (35%). During the FGDs, it was mentioned that, although *Eucalyptus camaldulensis* is not a fruit tree, it has better access to local markets because it is one of the preferred species for building, electricity poles and wood fuel. The leaves of *Moringa oleifera*

are known for their medicinal values and are sold in local markets. It is consumed as tea and also a preferred condiment used in preparing food sold in local restaurants. The key informants indicated that FRUITEQ buys fruits of *Mangifera indica* from smallholders, thereby improving access to markets. Markets for *Anacardium occidentale*, *Azadirachta indica* and *Adansonia digitata* are poorly developed. Such differences amongst species imply that improvements are needed in existing local markets to create better access for wood and tree products.

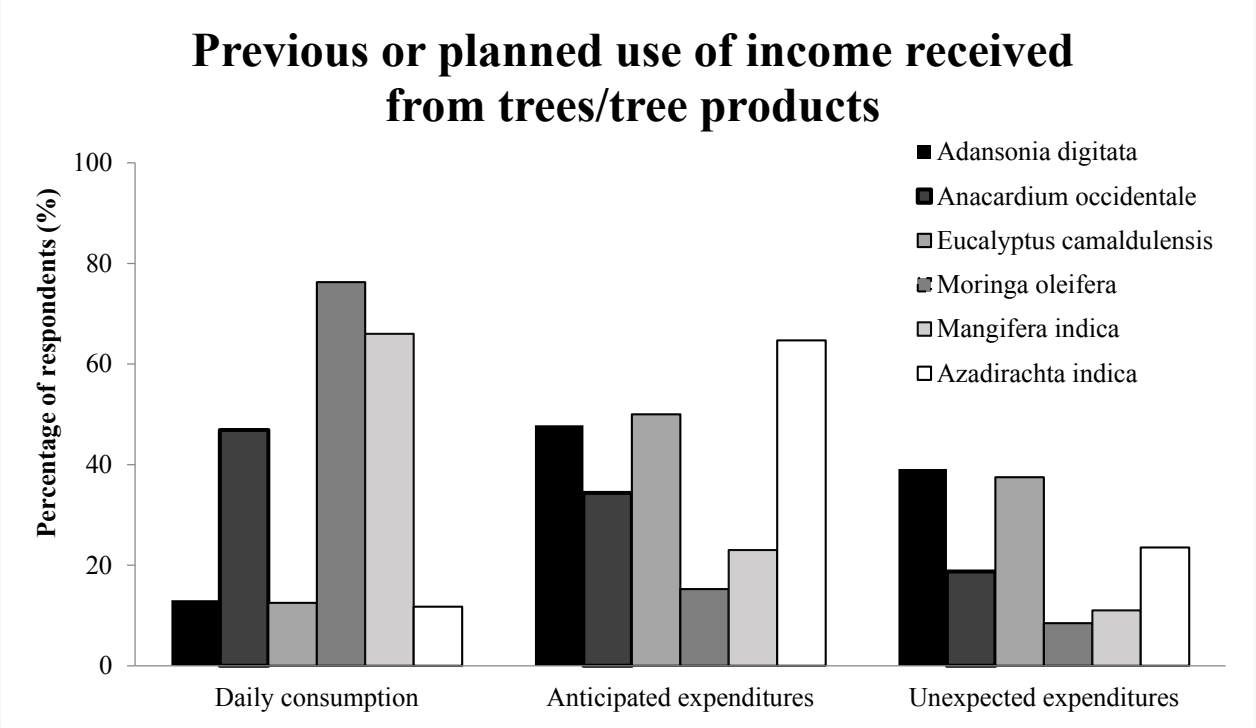

Figure 4. Previous or planned use of income received from trees/tree products.

3.3.3. Support for Tree Planting

In terms of support, species such as *Moringa oleifera* (55%), *Adansonia digitata* and *Anacardium occidentale* (30%) are currently receiving support from different projects by CNSF, FRUITEQ, Food Resource Bank, ACI, SOS Sahel, *etc.* On the other hand, there are very few programs that support *Eucalyptus camaldulensis* (5%), *Mangifera indica* (4%) and *Azadirachta indica* (2%). Furthermore, in addition to training on tree management, tree planting programs acted as motivation by providing seedlings at discounted prices for *Anacardium occidentale* (50%), *Moringa oleifera* (30%) and *Adansonia digitata* (20%) planters (Table 4a).

3.3.4. Farmers' Preferences for Agriculture

A total of 31.3% farmers preferred to plant agricultural crops rather than trees, which provide income and food more regularly than trees that require longer waiting times (Table 4b). Findings from key informants revealed that the cultivation of cereals such as millet, sorghum, maize, sesame, *etc.* occurs twice a year, whereas trees need at least five years before harvesting. Trees such as *Adansonia digitata*

(50%), *Eucalyptus camaldulensis* (50%) and *Azadirachta indica* (35%) are considered to have even longer rotations. Thus, agricultural crops are preferred to the planting of these species by farmers.

3.3.5. Tenure Insecurity

Lack of tenure to land and trees was mentioned on average by 24.5% of the respondents (see Table 3). Having rights to land and trees is important in tree planting decision making. Access to land is through customary institutions, and land chiefs assign a portion of land to migrants without monetary compensation but in exchange for gifts. Such lands are considered as borrowed and the conditions governing the land rights are uncertain. Permission is needed for tree planting on the land from land chiefs, who reserve the right for approval or not. Because improving the land implies a guarantee to the land, such rights are hardly granted, which affects the effective participation of migrants in tree planting, except for species such as *Moringa oleifera* and *Mangifera indica*. Though these two species can also generate income for migrant households, findings from FGDs and key informants indicated that rights are granted based primarily on their food value. As such, migrant farmers are more likely to engage in the planting of these species.

3.3.6. Lack of Sufficient Land

Despite the provision of seedlings through projects, lack of sufficient land is one of the reasons for not planting *Adansonia digitata* (45%), *Mangifera indica* (38%) and *Anacardium occidentale* (20%). Farm size is important, especially for *Adansonia digitata* planters, given the tree's requirements for plantation. *Adansonia digitata* has a trunk diameter ranging from 7 to 11 m and requires ≤40 planted seedlings on 1 ha of land with a distance of 15 m between poquets. On the other hand, *Eucalyptus camaldulensis* can take as much as 400 seedlings in 0.5 ha of land, which explains why only 5% complained of insufficient land for the latter species.

3.4. Willingness to Continue Tree Planting

Aside from perceived tenure insecurity (24.5%), which acts as a disincentive to tree planting (Table 4b), households perceived as poor and those with reduced members and workforce, small farm size, low annual income and expenditures were not willing to continue tree planting (Table 5). Thirty-two percent of *Anacardium occidentale*, 15% of *Eucalyptus camaldulensis*, and 32% of *Azadirachta indica* planters were unwilling to continue tree planting. During the FGDs, farmers complained that eucalyptus plantations destroyed the soil, which, in turn, affected crop cultivation.

Table 5. Socio-economic and perceptional characteristics of tree planters that were willing or not willing to continue planting *Anacardium occidentale, Eucalyptus camaldulensis* and *Azadirachta indica.*

Variables		*Anacardium occidentale planters (n = 64)*					*Eucalyptus camaldulensis planters (n = 34)*					*Azadirachta indica planters (n = 25)*				
		Not willing (*n* = 21)	**Willing (*n* = 43)**	**Stat.-value [a]**	**Prob.**	**Signi-ficance**	**Not willing (*n* = 5)**	**Willing (*n* = 29)**	**Stat.-value [a]**	**Prob.**	**Signi-ficance**	**Not willing (*n* = 8)**	**Willing (*n* = 17)**	**Stat.-value [a]**	**Prob.**	**Signi-ficance**
		Mean (sd)	**Mean (sd)**				**Mean (sd)**	**Mean (sd)**				**Mean (sd)**	**Mean (sd)**			
HH Head Age		39.43 (11.17)	47.53 (13.82)	−2.14	0.0323	*	55.2 (14.24)	49.1 (12.38)	1.096	0.2732	NS	53.38 (12.47)	50.06 (17.48)	0.613	0.5401	NS
HH Size		8.52 (3.72)	17.74 (10.6)	−4.117	0	***	12 (4.47)	19.28 (12.05)	−1.201	0.2298	NS	14.63 (5.53)	21.18 (12.87)	−0.855	0.3928	NS
HH Work force		6.35 (2.81)	13.22 (7.77)	−4.161	0	***	9.9 (3.76)	14.24 (8.82)	−0.9	0.3682	NS	11.28 (4.25)	15.58 (9.15)	−0.758	0.4487	NS
Farm Size		4.64 (2.22)	12.3 (7.55)	−5.451	0	***	8 (3.16)	14.41 (8.33)	−1.759	0.0785	NS	9.88 (5.03)	16 (9.43)	−1.792	0.0731	NS
Farm Age		20.76 (11.68)	25.93 (11.63)	−1.792	0.0732	NS	36 (13.87)	27.07 (10.66)	1.404	0.1605	NS	31.5 (13.4)	28.47 (13.32)	0.529	0.5971	NS
HH Annual Income (estimated from 2013 data Fr CFA)		190,000 (170,000)	360,000 (240,000)	−3.156	0.0016	**	150,000 (180,000)	340,000 (260,000)	−1.729	0.0839	NS	250,000 (220,000)	400,000 (290,000)	−1.225	0.2207	NS
HH Expenditures (estimated from 2013 data Fr CFA)		150,000 (110,000)	230,000 (99559.3)	−3.167	0.0015	**	120,000 (120,000)	210,000 (110,000)	−1.571	0.1163	NS	170,000 (110,000)	230,000 (130,000)	−1.002	0.3163	NS
Membership of FMG (%)		14.30	32.60	2.4150	0.120	NS	40.00	34.50	0.0568	0.812	NS	37.50	41.20	0.0306	0.861	NS
Years belonging to cooperative/farmers' group		2.14 (2.57)	3.4 (3.53)	−1.241	0.2147	NS	2 (2.83)	3.66 (3.88)	−0.875	0.3815	NS	3.38 (3.25)	3.82 (3.8)	−0.242	0.8091	NS
Favorable attitude toward tree planting (%)		100.00	100.00	-	-	-	100.00	100.00	-	-	-	100.00	100.00	-	-	-
Education level (%)	Non-literate	90.50	65.10	4.6518	0.031	*	80.00	65.50	0.4087	0.523	NS	62.50	76.50	0.5267	0.468	NS
	Literate	9.50	34.90				20.00	34.50				37.50	23.50			
Wealth status (%)	Non-poor	4.80	30.20	21.2179	0	***	20.00	31.00	0.5159	0.773	NS	12.50	35.30	3.2192	0.2	NS
	Fairly poor	42.90	65.10				60.00	58.60				75.00	64.70			
	Poorest	52.40	4.70				20.00	10.30				12.50	0.00			

[a] Either two-sample Wilcoxon rank-sum (Mann-Whitney) or Pearson Chi square test is run. NS ≥ 0.05; * ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001. Household (HH); sd, Standard Deviation; FMG, Forest Management Group; NS, Not Significant; F CFA, Franc des Colonies Francaises d'Afrique; Prob, Probability; Stat-Value, Statistical value.

4. Discussion

Generally, our results indicated differences in socioeconomic characteristics and perceptions of tree planters and non-tree planters, which are consistent with several previous studies [24,25,29,38]. The study revealed that, for all the species, tree planting farmers owned larger land areas compared to non-tree planters, a pattern that is consistent with other studies [19,29]. Farmers with limited land resources preferred agriculture or off-farm employment over tree planting, as was also found by other studies [24,39]. This was because, in addition to inputs such as seedlings, herbicides, *etc.*, tree planting also requires longer rotations for which the poor could not afford to wait.

For all the species, membership in an FMG, considerable years belonging to that farmers' group, and a favorable attitude towards tree planting were the most significant determinants of tree planting. Participation in farmers' groups encouraged tree planting by providing easier access to seedlings and training on tree management. For example, the farmers' group Cayendé in Cassou runs a tree nursery of *Moringa oleifera* and *Adansonia digitata* in the Ziro province. Smallholders have shown a favorable attitude towards tree planting because they understand the livelihood and environmental importance of trees, suggesting a strong influence on the development of a positive attitude towards tree planting. A related study [38] arrived at a similar finding that farmers' attitudes towards tree planting influenced their decisions to plant trees.

In Ethiopia, a previous study [40] found that a majority of tree growers were educated farmers with little participation from the illiterate farmers. This study confirms such findings as the tree planting household heads had higher levels of education than the non-tree planters for three out of six species studied. Aside from education, the perceptions of smallholders towards tree planting contributed to their willingness to continue tree planting. The wealthier and educated households were willing to continue planting *Anacardium occidentale*. One of the reasons given by some smallholders for their unwillingness to continue planting *Eucalyptus camaldulensis* was its high water requirements, which then caused drying of the soil, as also found by other studies in sub-Saharan Africa [41,42].

It was found that *Azadirachta indica*, *Adansonia digitata* and *Eucalyptus camaldulensis* planters were wealthier than households not planting these species. This implies that the amount of resources available for farmers influences the number of trees and species planted. As such, relatively poor households are likely not to participate effectively in planting species that require greater land areas and longer rotations. Though farmers mentioned several reasons for planting trees, the main reason was economic, which is similar to what was highlighted in previous studies [25,29]. Tree species such as *Eucalyptus camaldulensis* have a high potential to produce wood for energy, while *Mangifera indica* and *Moringa oleifera* produce food for the local markets.

In addition, *Eucalyptus camaldulensis* and *Adansonia digitata* planters indicated the importance of these species for reforestation of degraded areas and soil fertility improvement. The former is a fast growing species that thrives even in degraded areas, while the latter produces large quantities of biomass from the leaves and trunk, which are known to improve soil fertility. As such, tree planting provides both livelihood value and environmental protection. These findings are confirmed by other studies in Ethiopia [41], the Sahel [12], sub-Saharan Africa [43], Asia [39] and Latin America [19].

Though economic motivation was the most important driver of tree planting, other related issues are invaluable for it to succeed. Ownership of trees is a complex issue in Burkina Faso that is rooted in

tenure issues. There is no formal rule but the village order where it does exist determines rights to access and ownership. Those who perceive their land tenure to be unsecure are more likely to plant only fruit trees and not wood producing trees. Despite increases in tree domestication in sub-Saharan Africa, markets and tenure issues still constitute disincentives to tree planting [27,28]. Some factors are considered to be "keys" to successful tree planting [24]. Land/tree tenure issues, preference for agriculture and access to markets are some of the "key" factors identified in the current study. The income gained from tree planting contributed to farmers' daily consumption, anticipated and unexpected expenditures. In India, scholars have concluded that trees are not just a form of saving accounts to farmers but also act as safety nets [44].

In Burkina Faso, access and securing land, and trees ownership rights is controlled by customary legal arrangements managed by land-chiefs from the indigenous population, and varies from one village to another [45]. A farmer who has the right to own, transfer and to sell land is considered to have secure tenure in the context of Burkina Faso [46] while those without such bundles of rights are perceived to be insecure. The lands allocated to migrants are not linked to cash, but borrowers do show gratitude through gifts. These traditional patterns of borrowing have changed over the past two decades with the advent of money-based forms of access. Long-term loans to migrant farmers are being replaced with short-term loans and informal leases. Traditionally, loaned lands are not withdrawn unless there was a serious violation of rules of conduct [47]. As land reserves are exhausted in the southern region of the country, it is becoming more common for locals to withdraw land from migrants without violation of the rules. Farmers who perceive their own tenure to be insecure are not willing to invest in the land, a finding that is consistent with other studies in Burkina Faso [45,48].

The preference for species such as *Anacardium occidentale*, *Parkia biglobosa*, *Vitellaria paradoxa*, *Tectona grandis* and *Eucalyptus camaldulensis* by ≥10% of farmers is linked to economic reasons and farmers pointed out their unavailability. For *Parkia biglobosa* and *Vitellaria paradoxa*, which grow through farmer-managed natural regeneration (FMNR), population increase resulting in land scarcity was identified as a driver of forest degradation. Two studies in Southern Burkina Faso identified similar causes for the decline of dry forests and degradation in Southern Burkina Faso [6,10].

5. Conclusions

In general, it has been demonstrated that increased land area influences smallholders' tree planting activities in the Ziro province, Southern Burkina Faso. Other factors include long years of membership in a farmers' group that aims to manage forests and has a favorable attitude towards trees. The main reasons farmers cited for planting trees include generating income from the sale of wood and tree products such as fruits, existing local markets for *Eucalyptus camaldulensis*, *Mangifera indica* and *Moringa oleifera*, and participation in a tree planting program. On the other hand, reasons for not planting trees were farmers' preferences for agriculture because crops provided income and food more regularly, tenure insecurity for migrant farmers and lack of sufficient land. Farmers with fewer resources did not participate effectively in planting *Adansonia digitata*, *Eucalyptus camaldulensis* and *Azadirachta indica* because of the longer waiting times and larger land requirements of these species. The education level of the household head also contributed to tree planting for three of the six species.

Though free or discounted seedlings are routinely provided to farmers, those with small land areas and tenure insecurity are hesitant to engage in tree planting. In addition, markets for some tree resources still need developing, affecting the actual benefits gained from tree planting. Tree planting projects should consider farmers' preferences for species to avoid a mismatch between species promoted by projects and those preferred by farmers. To effectively engage farmers in tree planting and to make it attractive, policies are needed that address tenure issues for migrants, enable better access to markets both locally and regionally, and establish a favorable pricing structure for wood and other tree resources.

Further research is needed in the following areas: (1) smallholders' responsiveness to policies that affect tree planting/tree resources such as pricing mechanisms (such studies are important because the main motivation for tree planting is economic, and government policies can either increase or reduce prices on tree resources, which will affect planting potential amongst farmers), (2) silvicultural practices of smallholder plantations, (3) studies that assess the success rate of planted trees and local perceptions of successful or failed tree planting projects, (4) differences in tree planting activities between migrants and indigenous farmers. The lack of a cash-based system on access to land considers migrants as borrowers often associated with unsecure tenure that might act as a disincentive for investment on the land.

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Author Contributions

Daniel Etongo designed the research for this paper and collected the data. Daniel Etongo and Ida Nadia S. Djenontin analyzed the data. Markku Kanninen commented on the analysis and made suggestions for improvement while Kalame Fobissie provided the outline for presentation of results. Daniel Etongo wrote the first draft of the manuscript which later received contributions from all the authors. All the authors are co-responsible for the introduction section and for the discussion and conclusions.

Conflicts of Interest

The authors declare no conflict of interest.

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