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Farmers' fruit tree-growing strategies in the humid forest zone of Cameroon and Nigeria

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Abstract

Many studies have stressed the importance of trees to rural households. Few, however, have focused on actual numbers and densities of trees in different land-use systems. Based on community-level participatory research in six communities, semi-structured household interviews and full-farm fruit tree inventories, this study aims to understand farmers' tree-planting strategies. Relationships between the diversity, number and density of fruit trees and farm size, land-use system, land tenure, distance from the homestead, proximity to the forest, market access and household characteristics are investigated. The key factors determining the differences in tree-growing strategies between communities appear to be market access, land use and access to forest resources. Within communities, differences between individual households were less easy to explain but tenure was important as was farm size. Smaller farms had higher fruit tree densities, a relationship that was particularly strong in communities with good market access. Overall there was a great deal of variability both within and between communities and many of the factors affecting tree-planting decisions were found to be highly inter-related. Despite this complexity, trees on farm play an important role in rural household's livelihoods. Therefore, expansion of tree cultivation should be recognized as a promising pathway to achieve increased income and food production by policy makers and extensionists alike. In addition to improved tree propagation and management techniques, farmers should be strengthened in the processing and marketing of agroforestry tree products and more emphasis should be placed on the development of tree enterprises. By doing so, farmers will be able to earn a more important and consistent income from fruit trees, contributing to the Millennium Development Goals.

Introduction

The humid lowlands of West and Central Africa is a region of extreme poverty. In Cameroon for example, 40% of the population of 15.5 million live below the poverty line[1] (GoC 2003). The forest region is the poorest agro-ecological zone with

[1]The Cameroon (2003) Poverty Reduction Strategy Paper defines the poverty line as an annual income of 232,547 CFA francs, approximately equivalent to $1 per day.

55% of people living below the poverty line. Farmers are the poorest occupational group, with 57% below the poverty line. Farmers in the forest zone are therefore amongst the poorest people in the country.

Cropping systems of the region are mainly based on long-fallow rotations and produce food crops for home consumption and local markets. Major food crops include cassava, maize, groundnut, plantain and yam. These are intercropped with a variety of other vegetables. Farmers in the humid forest zone of Cameroon cultivate on average 1.7 ha and have an annual expenditure of only US$ 244 (Gockowski et al. 1998). Although rural populations in southern Cameroon face times of shortages while awaiting the new harvest (from January to April), most households are food self-sufficient all year round. Tree crops, such as coffee and cocoa are usually cultivated as small-scale plantations mixed with other fruit trees, medicinal plants and timber species. Farmers in the southern part of Nigeria usually have two types of farm: home farms are smaller than 1 ha and are the site of most fruit trees, vegetables and livestock; farther from the homestead (sometimes several km away), the much larger bush farms are principally destined for food cropping (cassava, yam, maize, okra). In these fields farmers generally do not plant trees, except oil palm. However they may retain some useful trees such as oil bean (*Pentaclethra macrophylla* Benth.), iroko (*Chlorophora excelsa* (Welw.) Benth. & Hook. f.) and mahogany (*Khaya ivorensis* A. Juss.).

Many studies, such as Chambers et al. (1993) and Falconer (1990), have stressed the importance of trees to rural households around the world. Leakey et al. (2003) highlight the role that the promotion of indigenous fruit trees could play in a poverty alleviation strategy for the humid forest zone of West and Central Africa. Garrity (2004) underscores the potential contribution of indigenous fruit trees in eradicating poverty and hunger, a top priority for the achievement of the Millennium Development Goals.

As in other areas of the world, fruit trees are a particularly important source of incomes, providing regular and fairly low-risk returns (Schreckenberg et al. 2002). Farm level annual value of production in the humid forest zone of Cameroon has been estimated respectively at US$ 93 for *Irvingia gabonensis* Baillon fruits and US$ 78 for its kernels (Ayuk et al. 1999c), US$ 161 for *Dacryodes edulis* (G. Don f.) H.J. Lam (Ayuk et al. 1999a) and US$ 23 for *Ricinodendron heudelotii* (Baillon) Pax (Ayuk et al. 1999b). These benefits are amongst the reasons why farmers have been domesticating indigenous fruit trees, such as *Irvingia gabonensis* and *Dacryodes edulis*, achieving great improvements in fruit and kernel characteristics (Atangana et al. 2001; Leakey et al. 2002).

In spite of the growing evidence of the importance of trees in livelihoods, few studies have focused on actual numbers and densities of trees in the different land use systems of the region and there is little information on farmers' tree planting strategies. The wider body of literature (FAO 1985; Warner 1993; Arnold and Dewees 1995) lists a number of factors that may drive farmers' decisions to retain and plant trees of different species. According to Edwards and Schreckenberg (1997), these can broadly be divided into factors internal to the household (such as farm size, land tenure, access to labour and capital, and education and ethnic background of household decision-makers) and factors external to the household (such as prevailing land-use system, relative availability of off-farm resources, market access and the policy and legislative context).

To improve the potential contribution of fruit trees to the livelihoods of farmers in the humid lowlands of West and Central Africa, this study examines the factors influencing farmers' tree-planting decisions. This is done through an analysis of the absolute numbers, densities and species of fruit trees by farm, community and land-use system. Based on our exploration of the links between site, household characteristics and the distribution of fruit trees, we discuss why farmers engage in intensified tree management on their farms, and draw lessons for tree-planting projects. The research reported here was carried out as part of an integrated project[2] which also included biophysical and marketing components (Leakey et al. 2002; Schreckenberg et al. 2002).

[2]The project entitled 'To investigate the opportunities and constraints faced by resource-poor farmers in the humid lowlands of West Africa (HULWA) in investing in the planting and improvement of indigenous trees for income generation' was funded by DFID's Forestry Research Programme (R7190) from 1999–2004.

Methodology

Study sites

The study was implemented in the humid forest zone of West and Central Africa with four case-study communities in Cameroon: Chopfarm, Elig–Nkouma, Nko'ovos II and Makénéné Est, and two in Nigeria: Ilile and Uguwaji (Figure 1).

The communities were selected to test the effect of a number of socio-economic and biophysical factors, such as ethnic group, land-use system, access to forest resources, population density and market access on the interest and ability of farmers to grow and cultivate fruit trees (see Table 1). To fulfil the sampling needs of other components of the study (Atangana et al. 2001; Leakey et al. 2002) dealing specifically with intraspecific variation in two popular farm species (*Dacryodes edulis* and *Irvingia gabonensis)*, all the communities were selected in areas where one or both of these species was known to occur. Makénéné is renowned as one of the principal production and trading posts for *Dacryodes edulis* in Cameroon, and is an area where agroforestry has reversed the trend of deforestation.

Farm fruit tree inventories

Inventories were carried out to collect data concerning the diversity and density of fruit trees in the study villages. Following the household interviews described below, the researcher and farmer visited all of the farmer's fields, whether owned or rented/borrowed. Each field was categorized by land use (homegardens, food crop fields, fallow land, cocoa and coffee plantations, oil palm fields and small orchards) and a record was made of its tenure status, size (based on farmer and researcher estimates), distance from the homestead, age and land-use history. For the 40 Nigerian households, resource constraints and the fact that bush farms contained very few planted trees, meant that inventories were restricted to the interviewees' 'home' fields. The researcher and farmer systematically walked through each field and recorded all exotic and indigenous fruit trees, whether planted or not. For each tree, a record was made of its species and approximate age (estimated from size), the reason it was planted (e.g. for sale, consumption or shade), who planted it and where the planting material had been obtained.

The inventory data were recorded in an Access database and analysed in Excel (in the form of statistical summaries and graphical representations) and SPSS version 9 (for correlation and analysis of variance) to look for relationships between household characteristics and tree numbers, densities and species. Relationships were examined within communities, within each country (combining the data from four communities in Cameroon and two in Nigeria), and for all data sets combined.

Community level research

The community-level work was carried out during the first half of 1999. In each of the four communities in Cameroon a research team spent 1 week carrying out various participatory exercises to explore issues relating to land and tree tenure, seasonality, labour requirements and preferences of species and fruit characteristics. The 10-person team consisted of a core of national and international researchers (agronomists, economists, anthropologists and foresters) and a representative of the national extension service. These were accompanied by NGO, project and government extension agents local to each community. The same participatory exercises were carried out in each community including a historical timeline, land-use mapping (with focus on tenure and location of indigenous fruit trees), matrices on fruit tree preferences, pairwise ranking of preferred characteristics for the project's two focus species (*Irvingia gabonensis* and *Dacryodes edulis*), and seasonal calendars (for labour, income and expenditure). All matrices and calendars were carried out separately with groups of men and women. A detailed description of the participatory methodology is provided in Schreckenberg et al. (1999). At the end of the week, the results of all the exercises were presented back to community for verification and discussion.

Resources did not permit the same intensity of work in the two Nigerian communities. Basic information on tenure, land use and markets was obtained through key informant interviews with community leaders and extension agents and household interviews.

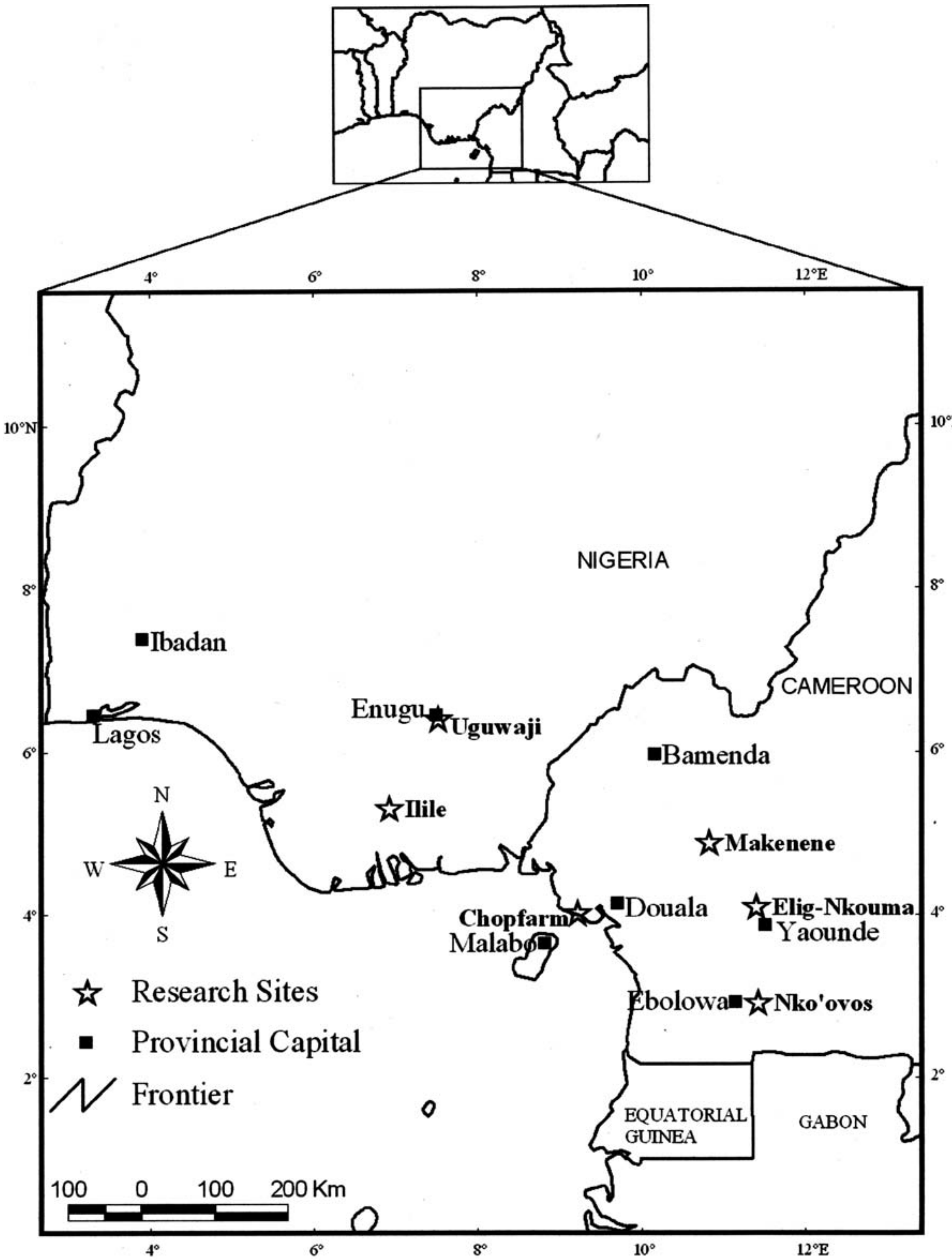

Figure 1. Map showing the six case study communities in Cameroon and Nigeria.

Table 1. Characteristics of the six case-study communities in Cameroon and Nigeria.

Site	No. of farm inventories (community size)	Agroecology	Ethnic group	Population density	Mean farm size (ha)	Access to land	Market access	Main land use	Main sources of income
Chopfarm Cameroon	14 (14)	Low Montane Forest	Immigrants from NW Province; resident since early 1900s	Fairly low	2.1	Insecure land tenure; squeezed between plantations and forest reserve; renting is common.	Access to main market in Limbe and regular trade to Nigeria; recent access to new *Dacryodes* markets in Gabon	Food crop and oil palm	Food crops, indigenous fruits and oil palm
Elig–Nkouma, Cameroon	20 (40)	Degraded humid forest	Mainly indigenous *Eton*	Medium	2.6	Land is becoming scarce and young households in particular do not have enough fertile land.	Close to capital Yaoundé, but poor road infrastructure, especially in rainy season	Cocoa and food crop	Cocoa and food crops
Nko'ovos II, Cameroon	19 (30)	Humid forest	Mainly indigenous *Ewondo*	Low	6	Families still have a lot of long fallow and secondary forest land for cultivation.	Good tarmac road with access to border with Gabon and Equatorial Guinea	Cocoa	Cocoa
Makénéné Est, Cameroon	19 (80)	Transition between humid forest and savanna	Immigrants from different origins; resident since late 1930s	High	5.3	No forest. Sharecropping very common; some families with large plantations, others with no land.	Key market town on main road between Yaoundé and Bafoussam; Specializes in *Dacryodes*.	Cocoa/coffee	Cocoa and coffee
Ilile, Nigeria	20 (n.r)	Degraded humid forest	Mainly indigenous *Igobo*	High	0.7	Land availability is variable, but most households have some secure land; a land owner may lease land on a yearly/seasonal basis if he is in need for cash.	Good tarmac road with access to Port Harcourt market	Homegarden and food crop	Food crops
Uguwaji, Nigeria	20 (n.r)	Transition between forest and savanna	Mainly indigenous *Igbo*	High	0.8	No forest. Land is becoming scarce as population densities are growing	Good tarmac road; close to Enugu market	Homegarden and food crop	Petty trade, labouring, firewood indigenous fruits

Household interviews

A stratified sampling procedure based on the well-being of households was used to capture the intra-community variation in interest in and dependence on the use of fruit tree products. First, in each community a list of all households was established. Then, four key informants from the village, two men and two women, ranked households into well-being categories which were grouped to give five categories per village using standard wealth-ranking techniques described in Pretty et al. (1995). From each category, four households were chosen at random. The total number of households interviewed per community was 20, except for the small community of Chopfarm where all 14 households were sampled. It should be noted that the well-being ranking was used primarily to ensure that the interviewee sample was representative of the range of well-being in each community and to prompt a discussion about different factors influencing well-being, including how these did or did not relate to tree-planting. As well-being categories cannot be compared between communities, they were not taken into account in the analysis of the combined data set.

The household interviews were carried out by a socio-economic researcher with an interpreter where necessary. They followed a checklist designed to determine basic household characteristics, the number and location of the household's fields, and interest in and reliance on fruit trees as part of livelihood strategies. Results of this survey were reported in detail in Mbosso (1999).

Results

Profile of sample communities and households

Land-use systems and tenure

Land use in Cameroon was dominated by cocoa and coffee plantations, which together made up nearly 85% of the inventoried land area (Table 2). Cocoa and coffee-based cropping systems also harboured 83% of the fruit trees inventoried. Land use in Nigeria was quite different with 74% of the land used as food crop or fallow fields. The majority (54%) of fruit trees, however, were found in the homegardens, in spite of the smaller area they occupied (26%).

Across the whole data set, size of farmers' fields varied greatly by land-use type (ANOVA with fallow, homegarden and food crop fields as factors: df = 151, $F = 12.824$, $p = 0.000$). Food-crop fields were significantly larger than homegardens ($p = 0.000$) and slightly but not significantly larger than fallow fields ($p = 0.057$). In Cameroon, cocoa, coffee, combined cocoa–coffee, oil palm and orchard land uses all tended to be at the larger end of the field area spectrum.

Property rights on the fields under study were generally secure. Only 21 out of 250 fields were rented or 'borrowed': 19 in Chopfarm and two in Elig–Nkouma. This 'borrowed' sample was too small to carry out a statistical analysis of the effect of tenure on tree management practices. However, the participatory community-level work indicated that tree tenure is closely related to land tenure.

Characteristics of household heads

Heads of sampled households were generally male, middle-aged, married and responsible for an average of eight (Cameroon) and nine (Nigeria) persons. Women headed only 13% of the households. In Nigeria all interviewees originated from the area, whereas two of the Cameroon communities (Chopfarm and Makénéné Est) were primarily inhabited by people originating from other parts of the country. Many of these people were, however, already second-generation settlers rather than recent immigrants. Only 15% of interviewees had not had schooling of any kind.

Household income sources and well-being

Table 3 shows that indigenous fruits, after cocoa and food crops are emerging as important income[3] generators for rural households. Cocoa stands out as particularly important in Cameroon, though this varies by community. Food crops were the next most important source of income, followed by indigenous fruit trees, which 12.5% of the households said were their main source of income. In Nigeria, food crop commercialization was the main income-generating activity in Ilile. Uguwaji households relied more on 'other activities' (e.g. petty trade, temporary jobs, etc) and indigenous fruit trees (particularly *Irvingia gabonensis*) for their income.

[3]Households were not asked to quantify their levels of income as this is often considered an intrusive question to which it is difficult to get a reliable answer quickly.

Table 2. Area under different land uses in the Cameroon and Nigeria study sites and proportion of fruit trees recorded in each.

Land use type	Area inventoried (m^2)		% of total area inventoried		% of fruit trees occurring in land use type	
	Cameroon	Nigeria	Cameroon	Nigeria	Cameroon $n = 7368$	Nigeria $n = 1839$
Homegarden	68,600	154,577	2.3	26	5.5	53.5
Foodcrop	252,100	116,315	8.5	59	6.9	37.6
Fallow	51,700	24,520	1.7	15	2.0	8.9
Cocoa	2,033,000	n/a	68.3	n/a	66.9	n/a
Coffee	115,000	n/a	3.9	n/a	4.9	n/a
Coffee–cocoa	370,000	n/a	12.4	n/a	11.3	n/a
Oil palm	64,000	n/a	2.1	n/a	1.5	n/a
Orchard	17,000	n/a	0.6	n/a	1.0	n/a
Forest	5,000	n/a	0.2	n/a	0.0	n/a
Total	2,976,400	295,412	100	100	100	100

Source: inventory data.

Table 3. Proportion (%) of households in Cameroon and Nigeria naming a specific crop as their primary or secondary source of income.

Income source	Cameroon								Nigeria		
	Ellg Nkouma ($n = 20$)		Chopfarm ($n = 14$)		Nko'ovos II ($n = 19$)		Makénéné Est ($n = 20$)		Ilile ($n = 20$)		Uguwaji ($n = 14$)
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Secondary
Cocoa	65	15	7	7	37	26	75	20	0	0	0
Exotic fruits	5	0	22	14	0	0	4	0	0	5	0
Food crops	20	55	50	29	16	53	0	10	75	60	45
Indigenous fruit	0	15	14	7	21	16	15	30	0	20	55
Coffee	0	0	0	0	0	0	0	20	0	0	0
Other	10	15	7	43	26	5	10	20	25	15	0

The importance of farming to household well-being was reinforced by the well-being ranking carried out in each community. The concept of well-being in all communities was dominated by land ownership, size of cash crop plantations (in Cameroon) or farms (in Nigeria) and their maturity. Households with large, mature farms were considered well-off. The emphasis on maturity of farms links well-being to phases in the household life-cycle. Younger households may not be well-off but may have scope for upward mobility. Large numbers of young children tend to depress well-being, whereas a good supply of adolescent labour was considered an asset. Households at the end of their life-cycle were often placed in the less well-off category unless they had access to a state pension. Access to fixed state salaries was another criterion for households to be considered more well-off, as was the ability to hire labour. At the other end of the spectrum, the less well-off households often had to hire out their own labour to make ends meet. In Makénéné Est, where almost all interviewees were immigrants, the extent to which a person was 'settled' (with their own farm, own house and own family) was considered particularly important. In all communities, personal characteristics such as sobriety, capacity for hard work and ability to manage money were frequently mentioned as determinants of a person's well-being.

Effects of community and household characteristics on numbers and densities of fruit trees

Market access

Consumption is by far the most important reason farmers give for retaining or planting trees, with the importance of 'sale' strongly reflecting market access (Table 4). The lowest proportions of trees planted for sale were found in Elig Nkouma and Chopfarm, both of which are linked to market by a dirt road. The other four villages all have a tarmac road to their main market town, and Makénéné Est is itself a market.

Land use

Tree densities were calculated using the mean and the median. The mean fruit tree density is subject to very high standard deviations because of the effect of a number of unusually large or small fields. Using the median fruit tree density or calculating the density based on the total area under each land use and the total trees recorded on it, give similar results, with the exception of that for homegardens (Table 5). All methods show clearly that fruit tree densities vary by land use.

The relationship between field size and fruit tree density differed in the three most common land use types (Figure 2). In the case of homegardens (combined data for Nigeria and Cameroon), there was a strong and highly significant relationship of increasing fruit tree density as field size declines (Pearson's $r = -0.8554$; $p = 0.0000$). Fully 73% of variation in tree density could be explained by differences in field size. A less strong but still significant relationship between declining field size and increasing fruit tree density was found in food crop fields (Pearson's $r = -0.3785$; $p = 0.0005$). In the case of cocoa, however, there was almost no change in density as field size changed (Pearson's $r = -0.3035$; $p = 0.01$).

Farm size

Farm size varied both within and between communities as did the mean number and density of fruit trees per household (Table 6).

In all communities, tree density decreased with increasing farm size although the relationship is not a simple linear one (Figure 3). The relationship is particularly strong in Nigeria, where the inventories only included the smaller home farms. Here 83% of variation in tree density can be

Table 4. Proportion (%) of farmers in Cameroon and Nigeria case study communities giving specific reasons for planting or retaining fruit trees.

Community (and market access)	Chopfarm (dirt road)	Elig Nkouma (seasonal dirt road)	Nko'ovos II (tarmac road)	Makénéné Est (in community)	Ilile (tarmac road)	Uguwaji (tarmac road)
Sample size (number of fruit trees)	$n = 635$	$n = 1845$	$n = 1694$	$n = 3184$	$n = 951$	$n = 888$
Consumption	56	62	49	19	68	47
Sale	14	12	27	69	27	50
Shade	0	4	4	5	0	0
Border marking	2	3	2	1	1	0
Other or unknown	28	19	18	6	4	3

Table 5. Field size and fruit tree densities in different land use types in Cameroon and Nigeria.

Land use type	Number of fields	Mean field size (ha)	Median field size (ha)	Fruit tree density for all fields combined[a]	Mean fruit tree[b] density	Median fruit tree density
Homegarden	64	0.23 ± 0.33	0.1	96	306 ± 340	200
Foodcrop	74	0.58 ± 0.80	0.39	28	83 ± 164	33
Fallow	24	0.4 ± 0.57	0.19	33	163 ± 240	50
Coffee	8	1.44 ± 0.86	1.25	31	42 ± 26	38
Coffee–cocoa[c]	5	7.4 ± 8.73	3.0	23	52 ± 46	39
Cocoa	63	3.23 ± 3.08	2.0	24	29 ± 23	26
Oilpalm	7	0.9 ± 0.55	1.0	17	15 ± 15	11

[a]This figure is calculated by taking the total number of trees recorded in a land use type and dividing by the total area under that land use.
[b]This figure is calculated by taking the mean of all the separate field densities in a land use type.
[c]Land uses with presence of both coffee and cocoa trees and no dominance of one or the other were classified as 'coffee–cocoa fields'.

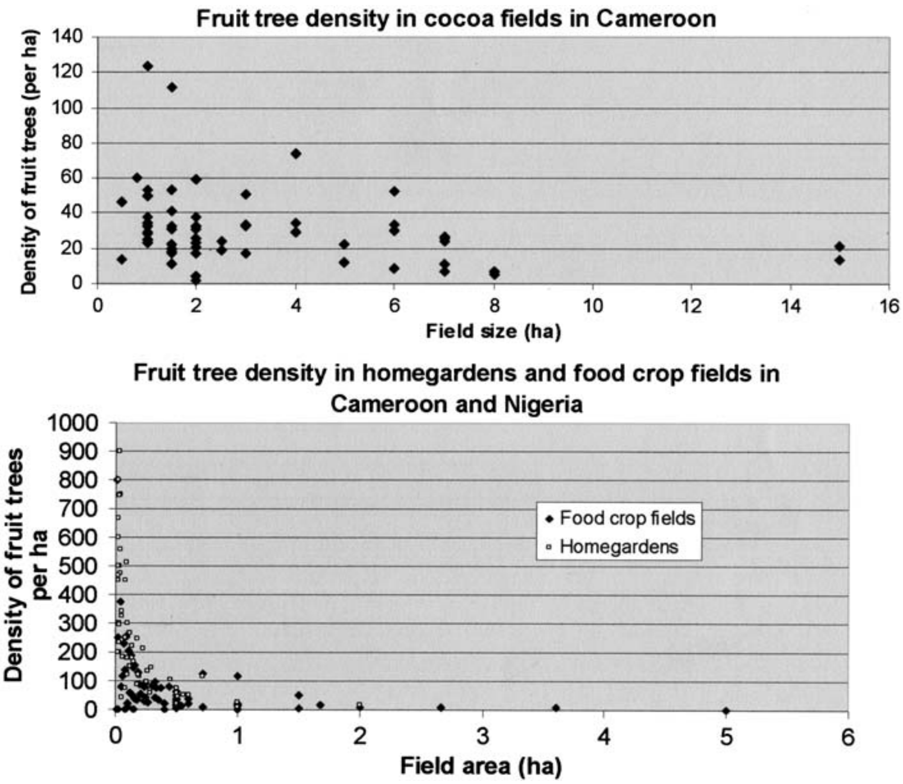

Figure 2. Field area and fruit tree density in different land-use types in Cameroon and Nigeria.

explained by changes in farm size. This compares with only 20.5% in Cameroon, where the correlation is only strong in two communities (Chopfarm and Makénéné Est).

Household characteristics

Of all household characteristics (well-being category, household size, household labour force, and origin, age, education level and gender of the household head), only the age of the household head had a correlation with tree density, though weak and negative in three of the villages: Elig Nkouma (Pearsons $r = -0.501$, $p = 0.024$, $n = 20$), Nko'ovos II (Pearsons $r = -0.475$, $p = 0.046$, $n = 18$) and Makénéné Est (Pearsons $r = -0.371$, $p = 0.09$, $n = 19$). In two of these villages (Nko'ovos II and Makénéné Est), age of household head was in turn negatively correlated

Table 6. Farm size, numbers and densities of fruit trees in the case study communities in Cameroon and Nigeria.

	Sample size	Mean farm size[a] (ha) and standard deviation	Mean number of fruit trees per household	Mean fruit tree density (numbers ha^{-1}) per household
Cameroon				
Chop Farm	14	2.1 ± 2. 3	45 ± 38	29 ± 22
Elig–Nkouma	20	2.6 ± 2.0	92 ± 80	46 ± 47
Nko'ovos II	19	6.0 ± 4.3	89 ± 80	17 ± 9
Makénéné Est	19	5.3 ± 5.5	168 ± 82	47 ± 26
Nigeria				
Ilile	20	0.7 ± 0.7	48 ± 2	188 ± 297
Uguwaji	20	0.8 ± 0.9	44 ± 14	101 ± 73

[a]In Cameroon, all of a household's fields were included in the farm inventory. However, in Nigeria, the distant bush farm was excluded so the figures presented here are for the 'home' farms only.

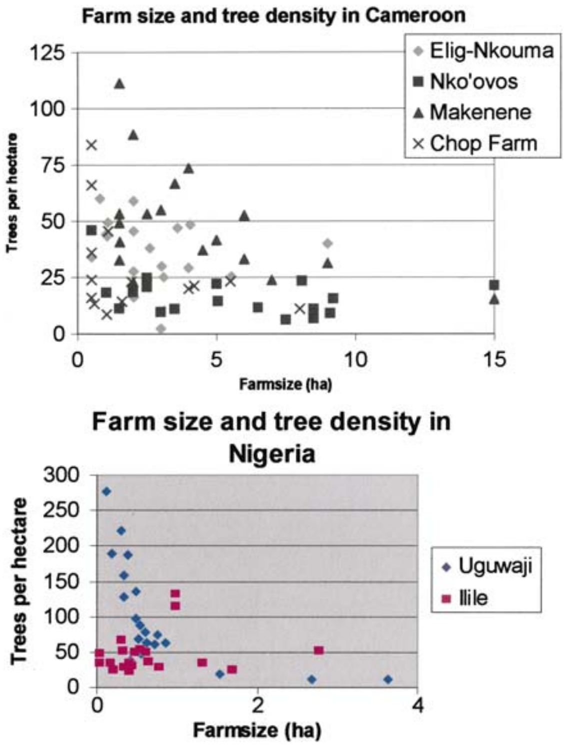

Figure 3. Farm size and tree density in the communities studied in Cameroon and Nigeria.

with education level, but education was not found to be directly correlated with tree density.

Although the inventory showed that households headed by women tended to have fewer fruit trees than those headed by men, they also had smaller farms. Once farm size was accounted for, gender of household head was found to have no effect on tree density.

Effects of community and household characteristics on tree species diversity

Most common fruit tree species

In total, 41 fruit species from 20 families were identified at the six sites (Table 7). Of the 41 species, 28 were indigenous. While the set of exotic species was very similar from place to place, with nine out of 12 exotics occurring in all six villages, only three indigenous species (*Dacryodes edulis*, *Irvingia gabonensis* and *Cola acuminate* (Pal.) Schott & Endl.) occurred in all six sites. Of the 28 indigenous species, 20 were found only in one or two of the villages, indicating high levels of biodiversity and site specificity of species distribution.

The most common fruit tree species recorded during the on-farm inventories in Cameroon were *Dacryodes edulis* (42% of all fruit trees), *Persea americana* (16%) and *Mangifera indica* (11%). In Nigeria, the list of top three species includes *Irvingia gabonensis* (26%), *Citrus* spp. (13%) and *Dacryodes edulis* (10%). Overall, *Dacryodes edulis* and *Irvingia gabonensis* were mostly planted for sale (62% and 87% respectively), while the main reason for planting *Mangifera indica* and *Persea americana* was consumption (73% and 72% respectively.)

Species diversity by community

The number of fruit tree species differed by community, as did the proportions of species and trees which were indigenous (Table 8). The same range of fruit tree species was found in both the savanna and forest sites.

Taking all the communities together, 52% of the 9202 fruit trees inventoried were indigenous. When asked whether they preferred[4] indigenous or exotic fruit trees, all 40 farmers in Nigeria preferred indigenous fruit trees, while 73% of the interviewees did so in Cameroon.

Species diversity by land use, field and farm size

Species diversity varied by land-use type. Cocoa–coffee fields, cocoa fields, homegardens and coffee fields had the highest numbers of fruit tree species. Taken together, this group of land-uses had a mean number of species of 7.09 ± 0.23, which is significantly different (one-way ANOVA: $F = 94.715$, $p = 0.000$) from the other major grouping of land-uses (food crop, fallows, oil palms and orchards), which taken together had a mean number of species of 3.8 ± 0.25.

The number of species increased significantly as tree numbers per farm increased (Pearson's $r = 0.379$, $p = 0.000$). In turn, an increase in number of species leads to an increased proportion

[4]This was a very broad question in which it was left up to farmers to decide in what sense they defined 'preference'. Farmers generally referred to a combination of market value, food value and combinability with other crops. A more detailed discussion of farmer preferences (based on the matrix ranking exercises carried out in the Cameroonian communities) is presented in Mbosso (1999).

Table 7. Fruit tree species occurrence in the study villages in Cameroon and Nigeria.

	Species	Number of trees					
		Chop-farm	Elig-Nkouma	Nko'ovos 11	Makénéné Est	Ilile	Uguwaji
Indigenous fruit tree species (Total = 28)	*Afrostyrax lepidophyllus*	3					
	Anacardium occidentale					2	12
	Anonidim mannii			3			
	Antrocaryon klaineanum			4			
	Baillonella toxisperma			6			
	Buchholzia tholloniana		6				
	Chrysophyllum albidum					16	2
	Cola acuminata	13	43	80	64	76	2
	Cola lepidota			126			
	Cola nitida		9	1		1	
	Coula edulis		8	53	6		
	Dacryodes edulis	275	510	352	1898	133	48
	Dacryodes excelsa					8	
	Dacryodes macrophylla			34			
	Dennettia tripetala					13	
	Garcinia kola	1	3	4	1	17	
	Garcinia lucida			3			
	Irvingia gabonensis	3	30	178	4	78	401
	Irvingia wombolu				2		
	Myrianthus arboreus		4	2			
	Parkia biglobosa						5
	Pentaclethra macrophylla					72	30
	Ricinodendron heudelotii	2	32	18	2		
	Tetrapleura tetraptera			5			
	Treculia africana		2			21	11
	Trichoscypha abut		10	22			
	Trichoscypha arborea			1			
	Vitex cienkowskii		6	7			
No. of indigenous fruit tree species		6	12	18	7	11	8
No. of indigenous fruit trees		297	663	899	1977	437	511
Exotic fruit tree species (Total = 13)	*Annona muricata*	3	22	9	14	55	30
	Carica papaya	6	35	9	15	115	113
	Citrus grandis	8	7		44	1	1
	Citrus limon	6	5	21	22	10	4
	Citrus reticulata	1	143	6	201	7	1
	Citrus sinensis	88	68	19	336	177	30
	Citrus spp.						4
	Cocos nucifera	31	7	16	5	35	12
	Eugenia sp.	54					
	Mangifera indica	49	340	228	229	38	99
	Persea americana	35	478	446	251	52	25
	Psidium guajava	57	71	33	89	24	58
	Spondias mombin		12	8			
No. of exotic fruit tree species		11	11	10	10	10	11
No. of exotic fruit trees		338	1188	795	1206	514	377
Total no. of fruit tree species (41)		17	23	28	17	21	19
Total no. of fruit trees (9202)		635	1851	1694	3183	951	888
% Indigenous fruit species		35	52	64	41	52	42
% Indigenous fruit trees		47	36	53	62	46	58

of indigenous species (Pearson's $r = 0.257$, $p = 0.006$, $n = 112$). This is probably due to the fact that the majority of fruit tree species (68%) are indigenous and so farms with greater numbers of species are more likely to contain indigenous species.

Table 8. Diversity of fruit tree species, proportions and numbers of indigenous fruit trees in each case study community in Cameroon and Nigeria.

	Number of fruit tree species per farm	Number of fruit tree species recorded in community	Proportion of species which are indigenous (%)
Chopfarm	6	17	35
Elig-Nkouma	9	23	48
Nko'ovos	10	28	64
Makénéné Est	7	17	41
Ilile	11	21	52
Uguwaji	9	19	42

Species diversity and household characteristics
A weak positive relationship was found between the age of the head of household and numbers of species per farm (Pearson's $r = 0.211$, $p = 0.026$, $n = 111$). The study did not find any other correlations between either species numbers or the proportion of indigenous species and household (head) characteristics.

Discussion

This study confirmed that farmers' decisions about whether or not to plant or retain fruit trees, and which species to choose, are based on a complex interaction of different factors. Some of these act at community level and lead to community-specific patterns of fruit tree density and species diversity (Figure 4). Others are more important at the level of individual households and lead to the very varied patterns of fruit tree distributions observed within communities. While some factors appear to be more important in determining tree density, others influence species selection. Overall, there is a great deal of interdependence between factors.

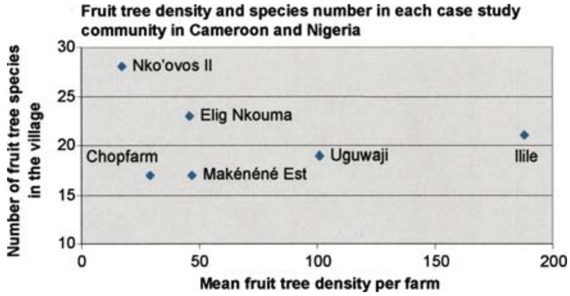

Figure 4. Fruit tree densities and species numbers by case study community in Cameroon and Nigeria.

Community level factors

The main factors operating at community level are access to forest resources, land use systems and market access.

Access to forest resources
The study highlighted some interesting trends with increasing distance from the forest. In Cameroon, the lower density of fruit trees in the forest communities (17 trees per ha in Nko'ovos and 29 in Chopfarm) compared to both the degraded forest (46 trees per ha in Elig-Nkouma) and transition zone (47 trees per ha in Makenene) villages agrees with Arnold and Dewees (1995) that farmers react to a decrease in availability of tree products off-farm by increasing the density of trees on their farms, In the forest and degraded forest communities, fields were cleared from the forest with useful trees being retained for shade and desired products and services. But in Makénéné Est (transition zone), fruit trees were planted together with food crops in order to create a shady environment needed to establish the commercially important cocoa and coffee plantations 3 or 4 years later (Schreckenberg et al. 2002). Similarly, in Uguwaji, there was no cocoa or coffee, but farmers commented that *Irvingia* trees were being planted for shade as well as to combat soil erosion on steep slopes.

In terms of species diversity, with the exception of Chopfarm, there was a clear decrease as access to the forest declined. It could be argued that the diversity was greater in forest communities because they had better access to a greater diversity of parent trees in the forest. But even in Nko'ovos II, the most forested community, only 3.5% of fruit trees were sourced from forest germplasm (mostly as transplanted wildings) so the fact that the community had very large farms may have been a more important determinant of species diversity. The anomalously low tree density and species diversity in Chopfarm was probably due to its tenure constraints (it was the only community with many rented fields) and land use focus on food crop farms and some oil palm plantations, both of which combine less well with fruit trees than the cocoa–coffee plantations, more common in the other Cameroon sites.

Land use

Land use as a factor consists not just of compatibility between trees and crops in terms of physical space, but also of labour requirements and income/expenditure patterns. Our results show that land-use type determines both how many and what species of fruit trees farmers plant. The highest density of fruit trees was found in homegardens, fallows and food crop fields. In Cameroon, the highest absolute number of fruit trees occurred in the cocoa and coffee plantations because of the larger area they occupy and their need for shade. Farmers also mentioned that trees were better protected against fire in cocoa–coffee plantations. The very weak correlation between field size and tree density for cocoa fields suggests that farmers plant or retain trees until an 'ideal' density – in terms of shade provided – is reached, and do not easily exceed this.

The integration of fruit trees in food crop fields raises problems of competition for light and nutrients. The planting of trees in these fields was therefore often limited to the boundaries. Nevertheless, the significant relationship between declining field size and increasing fruit tree density clearly indicates that farmers have some room for manoeuvre when it comes to choosing how many trees to include in their food crop fields. This is true to an even greater extent in homegardens where shade is often a desired characteristic and farmers will plant high densities of trees to the point that some very small fields are almost entirely given over to trees.

Different land-uses were associated with different levels of diversity, which were much higher in the cocoa (and coffee) plantations and in the homegardens than in the food crop fields and fallows. In the case of the cocoa plantations, high species diversity may in part be a result of the larger size of the fields meaning that there would have been more trees and hence more species to choose from when the fields were first cleared. In the case of the homegardens, high species diversity is likely to be by design as farmers use this field close to the house to produce a varied range of products for household consumption. In food crop fields farmers are likely to be most selective about species choice to ensure compatibility (in terms of light and nutrient demands) with the food crops.

Market access

The study revealed just how important changes in market access can be in determining farmers' tree management strategies. Farmers considered the advent of a new tarmac road a key catalyst for tree planting in Makénéné Est. Market access is particularly important with respect to species choice. The relationship between decreasing farm size and increasing fruit tree density was strongest in communities with a single species' market focus. It may be that it is only when the market really provides an incentive for a particular species, that small farmers find it attractive to devote increasing amounts of their limited land resources to trees. However, this study also showed that increased market demand has not always led to deliberate tree planting, but rather to increased collection from the wild (e.g. in the case of *Irvingia gabonensis* in Nko' ovos II and Chopfarm). These cases suggest that, in spite of high market demand, for some species biophysical constraints (unreliability of income and the time lag between planting of the tree and harvesting, for example) mean that it is still more economically interesting for farmers to harvest from the wild than to invest in cultivation.

Household level factors

The key factors operating at household level are tenure and farm size. The small sample sizes and the interdependent nature of many of the characteristics made it difficult to see clear patterns in relation to other household characteristics.

Tenure

The study confirmed findings by Egbe (1997), that lack of property rights might influence farmers' decisions about retaining and planting trees. The lowest fruit tree densities and lowest number of fruit tree species were recorded in the community where 51% of farmers' fields were rented. Comparing rented (17.6 trees per ha) and owned fields (24 trees per ha) in the same community also suggested that more secure tenure leads to a greater interest in tree-growing.

Wealth
Arnold and Dewees (1995) found that in western Kenya poor farmers had higher densities of trees per hectare than wealthy farmers, probably because the latter had access to more farmland. In this study, no relationship was found between well-being categories and tree numbers or densities, probably because the sample size for each well-being category was five or less. Although several factors, many of them inter-related, determine 'well-being', the single most important factor was farm size and, in Cameroon, ownership of cocoa and/or coffee plantations. Farm size was therefore used as the closest proxy to household wealth.

Farm size
There was no obvious trend in either fruit tree density per farm or numbers of fruit tree species between communities with smaller or larger farm sizes. Within communities, however, there was a significant trend of increasing density of fruit trees as farm size decreased. The relationship was stronger in Nigeria, where the inventory was only carried out in the small 'home' farms in which planted fruit trees are concentrated. And, as discussed above, the relationship was strongest in communities with the greatest market demand for a single species, suggesting that here the demand was high enough for farmers to accept the opportunity cost (in terms of lost food crop or other crop production) of putting in more fruit trees than might otherwise be the case.

Ethnic group
Ethnobotanical research (Dounias 2000) emphasizes the importance of indigenous knowledge in the management of natural resources. Indigenous populations are often said to be more knowledgeable about the ecology and to have more secure property rights, favouring tree planting in terms of number and diversity. In this study, however, it was difficult to investigate whether the origin of the farmer influenced the number of trees on farm, because of the small number of immigrants in the sample. However, the example of the immigrants of Makénéné Est who have integrated large numbers of trees in their cropping system, suggests that factors such as tenure and market access have much more influence on tree-planting decisions than whether a farmer is indigenous or not.

Gender
Due to differences in property rights on land and trees, women are often said to be constrained in tree growing (Berry 1988). It was therefore hypothesized that female-headed households would have fewer fruit trees than male-headed households. Although this was indeed the case, the differences were accounted for by the smaller farm size of women-headed households, and there were no gender-related differences in fruit tree density or species numbers once farm size was accounted for. However, the fact that the fruit tree inventory did not find significant evidence that gender affects tree-planting decisions may, in part, be due to the small sample of female-headed households (14 overall).

Age and education
Older farmers may have a stronger interest in tree-planting because of their longer experience (and history of experimentation with different species). They may also be at the end of the household lifecycle when labour can be a constraint, making less labour intensive tree crops an attractive option (Arnold and Dewees 1995). In this study, age of household head did not correlate with household labour availability except in Chopfarm, nor did labour availability correlate with tree numbers or densities in any of the communities. Older household heads were, however, less well-educated and their farms had slightly higher numbers of species. We do not have data on how long farmers had been on their respective farms, but it may well be that older farmers had had more time to experiment with and retain a greater variety of species.

Farmers' tree-growing strategies summarized

The key factors that determined differences in tree-growing strategies between communities were market access, land use and access to forest resources. A decline in access to forest resources tended to lead to an increase in fruit tree density, but often linked to a decrease in species diversity. Land use was an important factor in determining both density and species diversity though its effects could not be completely separated from those of changing field size. Homegardens (usually very small) had the highest densities of fruit trees and considerable species diversity. Food crop fields (usually small) had lower fruit tree densities and species diversity. The large cocoa and cocoa–coffee plantations had the lowest fruit tree densities but their larger size meant that they tended to have higher species diversity. Densities in the cocoa fields were fairly constant regardless of field size as farmers were predominantly concerned to provide their cocoa trees with a constant level of shade. In homegardens and food crop fields, there was much greater variation in fruit tree densities as farmers selected trees to respond to a variety of home consumption and sale requirements.

Market access was a very important factor at community level. The presence of a tarmac road immediately raised the fruit tree density and markets for particular species had a strong influence on which species farmers selected to retain and plant.

Within communities, the variation in fruit tree density and species choice was harder to explain. Where tenure varied within a community, more secure tenure clearly gave farmers a greater interest in planting more trees. Tenure aside, farm size was the most important determinant of fruit tree density with smaller farms having higher densities. In terms of species numbers, there was a slight trend for older household heads to have farms with greater fruit tree diversity but species diversity tended to be determined more by community level factors than differences at household level.

Implications for support strategies

This study confirms the view that there is enormous potential to further diversify and enhance the productivity of tree-based cropping systems of the region (Tchatat et al. 1995; Duguma et al. 1998). But the many factors that shape farmers decisions about tree-growing mean that support strategies must be carefully differentiated. A first step in any community must always be to identify whether or not support to tree-growing is a priority. In general, the findings of this study suggest that farmers in communities with relatively good forest access and poor roads are less likely to benefit from support around tree planting and management. Nevertheless, as is clear from the very different situation in the two Cameroon forest communities, Chopfarm and Nko'ovos II, it is important to understand locally specific conditions of tenure and market access before deciding on a support strategy.

The importance of understanding local land-use systems and the role of trees within them is highlighted by the difference between the Nigerian and Cameroon communities in this study. Trees in cocoa plantations must provide the right levels of shade in addition to fulfilling a household's consumption or sale needs. The fact that tree densities are fairly constant within cocoa plantations suggests that strategies here need to focus not on increasing densities, but rather on replacing existing stock with improved varieties. The large size of cocoa fields means that replacing every tree with a cultivar that yields twice the amount of fruit or produces it outside the normal season could have a huge impact on household incomes. ICRAF is successfully using this approach in several communities in Cameroon, where farmers are being taught vegetative propagation techniques to reproduce their best fruit, timber and medicinal trees (Leakey et al. 2003).

In the homegardens and food crop fields, tree density is very variable and there is scope for increasing numbers. To respond to farmers' concerns about incompatibility between trees and food crops, efforts in food crop fields must be focused on finding species or cultivars and management techniques that allow for greater combinability in terms of physical competition for light, water and nutrients as well as household labour and income flow issues.

Extension agents are often able to provide support to farmers on just a few major species. The degree of site specificity of fruit tree species distribution found in this study suggests that this approach does not respond to farmers' real interests. To provide adequate support for the variety of species farmers retain and plant, extension agents need to focus less on information about individual species. The study showed that income generation is only one reason why farmers plant trees on their farm and that home consumption, medicinal value and environmental services (shade) also represent important functions. Farmers therefore need to be provided with full information on the benefits and disadvantages of species in different functional groups as well as on available propagation methods.

As highlighted by Russell and Franzel (2004), the importance of markets in influencing farmers' decision-making suggests the need for a much greater focus on supporting farmers in accessing markets, both with respect to organizing themselves for processing and marketing, and in the selection and propagation of cultivars with marketable characteristics. Informing people about the diversity of market options available could guarantee the maintenance of a good range of species, in spite of possible concentration on one or a few species in terms of absolute numbers.

Within communities, support programmes need to look at individual farm circumstances, particularly farm size, as smaller farms tend to be more densely planted.

Conclusion

This study demonstrates that farmers' decisions on retaining and planting trees are determined by a complex set of interrelated factors. Despite this complexity, trees form an integral part of rural household livelihoods in the humid tropics of West and Central Africa, because they provide income and improve nutrition and health of rural families. Therefore, expansion of indigenous tree cultivation on farms has recently been recognized as one of the promising pathways to achieve increased income and food production, contributing to the Millennium Development Goals (Garrity 2004). Policy makers in developing countries should thus ensure that tree domestication is part of their poverty reduction strategies and programmes to achieve the MDG.

The study also showed that market access is amongst the most important factors explaining tree planting choices. Consequently, projects promoting tree planting should not only look at tree propagation and management options, but also focus on tree enterprise development and enhancement of tree product marketing. This would involve strengthening farmers' capacities to select, propagate, integrate and manage indigenous trees, while also improving community-based processing and marketing of the tree products. Appropriate support of this kind can enable farmers to earn a more important and consistent income from fruit trees, turning them into the new generation of 'cash crops', and thus make an important contribution to poverty alleviation in the region.

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