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AGROFORESTS' POTENTIALS FOR THE IMPROVEMENT OF THE LIVELIHOODS AND FOOD SECURITY IN GUINEAN HIGHLAND SAVANNAHS

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Abstract
Eliciting the impacts of agroforests on the wellbeing of farmers will provide valuable information for the design of sustainable desirable production systems. Such studies have been relatively few. Eleven types of home gardens existing in the Guinean Highland Savannah zone were surveyed for one year. For each type, 10 farmers were involved. A record list as management tool has been developed in participatory manner with farmers to evaluate flow of products and income generated each month. Households were visited twice a month. The study showed that the total yield was 112.43t year^{-1} among which 35.2t were consumed, 30.12t were commercialized, 16.3t were gifted and the rest of production was kept. The quantity of food bought from the market was 1.6t year^{-1}. The gifts received from relatives were 13.2t year^{-1}. The cereals were the most consumed and bought from the market by the farmers, whereas fruits were the most commercialized. Food products were harvested all the year long. Home gardens occupy an important place in the farmer's life by improving the daily diet, consolidating and creating relationships, generating income and using in treatment of various diseases.

Keywords: *agroforests, production, consumption, gifts, income, wellbeing, Cameroon*

Introduction

Agroforest is a sustainable production system which has been practised for centuries in the tropics. In the Guinean Highland Savannahs (GHS), home gardening is a common practise locally known as ''siraka" in Fulani and "goumsi'' in Niza'a language (Mapongmetsem et al. 2005). Its multiple

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products contribute significantly to the fulfilment of the nutritional and income needs of the household, and its multilayered structures of plants ensure ecological functioning. The structure and high diversity of cultivated and spontaneous plants mimic the configuration of tropical forest ecosystems (Fernandes *et al*. 1984, Michon 1981, Michon, Mary, Bompard 1986, Mapongmetsem *et al*.2009). In the system, crop adaptability, techniques used and local ecological conditions have permitted to reach a certain degree of harmony with the natural environment. One of the main qualities is its high compatibility with other activities and ecosystems. With increasing population, climate change and environmental degradation, there is a surge in food insecurity. Meanwhile, multistrata systems have a huge potential in alleviating this food situation (Bentes-Gama and Vasconellos Gama 2004, Peyre *et al*. 1994, Miller and Nair 2006, Thaman 1990). Sustainable farm management schemes are fundamental to work towards poverty reduction, food security, natural heritage conservation and climate change.

In the context of the humid forest (Sonwa *et al*. 2007, Tchatat, Puig et Tiki 1996, Tchatat 1995) and Guinean Highland Savannahs (Mapongmetsem 2005, Mapongmetsem *et al*. 2009) of Cameroon, various studies documented the structure of the system and the floristic composition. Little information on the functioning of these systems is available to assist its management and improvement despite its significant importance to local farmers. The purpose of the present paper therefore is to elucidate the impact of home gardening on the wellbeing of the farmers. The research hypothesis is that well managed, home gardens could play a catalytic effect for welfare restoration in rural areas of the Adamawa highlands. It is in this perspective that the present work aims to develop, in a participatory manner, a farmer's account in order to help them to master the functioning of their garden and make predictions. The specific objectives are to quantify food production in home gardens, estimate the quantity consumed, sold, purchased and offered or received as a gift.

It is expected that this information will contribute to elaborate strategies aiming at improving this traditional system in the area.

Materials and Methods

Study Site

The study was undertaken in the Vina Division. The 7 villages investigated were Dang, Mbidjoro, Malo, Gangassaou and Selbe Sabongari situated north of Ngaoundere (the headquarter of this division); Marza in the south; Biskewal in the east and Selbe Sabongari in the west. They belong to the Adamawa highlands (LN: 6-8˚ N and LE 10-16˚). The average altitude is 1250m above sea level. The climate is characterized by a rainy (April-October) and a dry (November – March) season. The mean annual precipitation is 1479

mm and the mean monthly temperature is 22˚C (Yonkeu 1993). Natural vegetation varies from shrubby to woody savannah dominated by *Daniellia oliveri* and *Lophira Lanceolata* (Letouzey 1968). It is highly degraded by anthropic activities such as pasture, agriculture and bush fires (Mapongmetsem et al. 2000a, Mapongmetsem et al.2000b). The human environment is composed of numerous ethnolinguistic groups among which Foulbé, Mboum, Péré, Koutine, Haoussa, Niza'a and Dii are the most dominant (MINEF 1994). The main livelihood activities in the area are agriculture, animal husbandry and beekeeping.

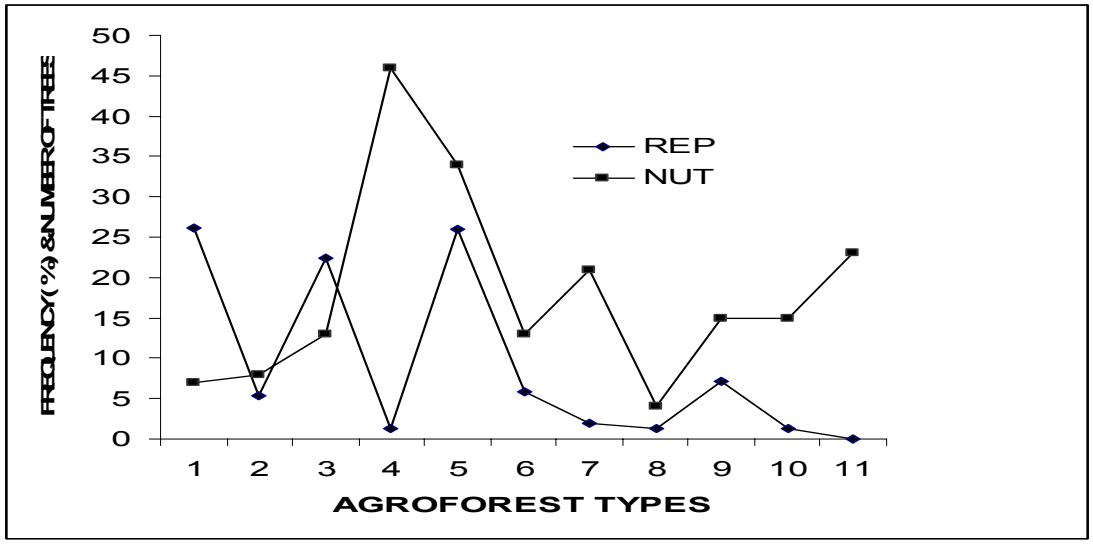
Methodology

Previous studies in the Adamawa show the establishment of 11 types of agroforestsased on structural characters such as age, area, etc. (Mapongmetsem *et al*.2009, Mapongmetsem et Hamawa 2008).

Concerning the age criteria, home garden types 1, 2 and 3 are young (less than 15 years) whereas 9, 10 and 11 are the oldest (more than 45 years old). The rest of types are intermediate.

For the area, home garden types 1, 3, 6 and 9 are very small (less than 1ha) whereas types 5, 8 and 11 are the largest (more than 2ha). Types 2, 4, 7 and 10 are intermediate (1-2ha). Representatively, the most predominant agroforestry home garden types in the sudano-guinea savannah are 1 (26.12 %), 3 (22.15), 5 (26, 0%) and 10 (7.13%) types (Fig.1). Similar characteristics are reported in tropical Asia mainly in India (Mapongmetsem *et al*. 2009; Peyre *et al*. 2009).

Figure 1. Distribution of Home Gardens and Their Floristic Diversity in the Guinean Highland Savannah Zone.



Notes: REP = representativity, NUT= number of trees.

a. Household Survey

Based on the abovementioned structural typology, the first step of the research consisted of meeting farmers in each village. In each household, the main person managing the agroforest was interviewed so as to build farmer capacity in managing a record list. After necessary explanations, their voluntary participation is requested. The farmer's record is a management tool initiated to evaluate the monthly production and income generated, and contains the following rubrics: farmer identity, and garden type, management mode, historic profile, objective, main constraints, role of each family member, gender and social equity, technological innovations and projects; main crops and quantities (produced, consumed, commercialized, bought, received and donated), income generated and business plan. Meetings were organised in each village and potential farmers were identified. Those farmers were chosen who had the most potential to have impact and most knowledge about endogenous knowledge, aptitude to share information, species diversity, production, commercialization, etc. For each agroforest type, ten farmers were chosen.

b. Training of Farmers

In each village, training was organised to build each farmer's capacity to develop a record list. During training session, farmers were trained on the following modules: weighing, marketing strategies, price negotiation, conservation and transformation strategies, climate change, record list, and business plan. As far as accords are obtained from the farmers, one record list was offered to the head of the family with the recommendation that the record list must be filled every day.

Home gardens were visited twice a month and discussion held with the garden operator. The terms of the follow up visits were to monitor progress of activities, identify constraints and formulate recommendations, provide additional training on some technical aspects, plan activities for the next period. We explain to farmers the interest of quantifying their production in order to familiarise to weight products and in connection with the weight and price; make projection on the future of the farm. During a biweekly visit to the garden, the record list is read and data collected. In addition, suggestions are given to the farmers to improve their data collection methods.

After the end of the project, the trained groups were encouraged to set up their own record list and train other farmers in the village.

c. Data Collection and Analysis

Data collected during the various investigations included quantity produced, consumed, commercialized, purchased, offered and received.

These data were subjected to analysis of variance, correlation and regression with the statistical programmes "Statgraphics plus 5.0".

Results and Discussion

Guinean Highland Savannah agroforests present a great biological diversity, as previously identified. A similar result was reported in Nigerian's home gardens (Okafor and Fernandes 1989). Personal preferences and attitudes, socio-economic status, and culture are the main determinant factors for home garden appearance, structure and function. While there are many variations in home garden design and pattern, the basic features, however, remain the same.

Food Production

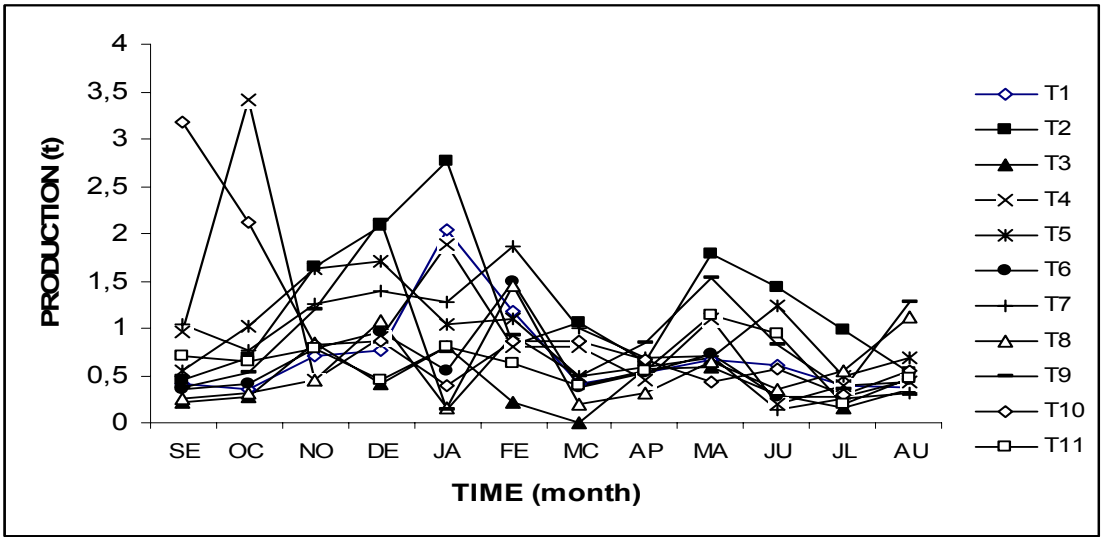
Most gardeners try to optimise their home gardens by planting as many as they can in the limited space available and in the physical constraints of their home environment. It is an advantage to cultivate plants and rear animals on the same land, since the plants provide food and shade for animals, while animals provide manure for plants. The quantity of products collected in home gardens varies significantly ($0.0188 < 0.05$) throughout the year. From September 2004 to August 2005, the total food produced by the eleven types of agroforests is 112.43t $year^{-1}$. The total annual production of home gardens ranges from 4.92 t in the type 3 to 14.87t in type 2. There was a significant difference between the garden types ($0.0072 < 0.01$). The low productivity registered in home gardens from type 3 can be related to their oldness (15 to 30 years). Home gardens from type 2 are very young (less than 15 years) and their area varies from 1 to 2 ha. Shade from the old trees reduces the growth of crops and, consequently, their productivity. The total quantity of food produced in the area is high compared to the previous evaluation in the area (Mapongmetsem *et al*. 2002), indicating that the record list is an efficient tool.

Compared to the mean production of the area, home gardens belonging to type 2 (14.97t), type 5 (10.56 t), type 7 (9.78 t) and type 9 (10.57 t) present consistent production (Figure 2). Similar results have been reported in Cambodian agroforests (Mapongmetsem *et al*. 2000c). Home gardens from type 4 have their peak of production in October and those from type 9 in December. Home gardens belonging to type 2 exhibited two maxima: the first located in January and the second in May. For others, production was quite constant during the year. The least production was observed in type 3 in March. The most productive month for all the types was December, with 12.73t, whereas the least was July with 4.33t of products.

The majority of the curves showed their maximum between October and January, whereas for others it was between May and June. These can be

justified by important harvesting of fruits, cereals and tubers. On the basis of this trend, the famine period was circumscribed between February and April for which production was very low in all the livelihoods of the area (Fig.2).

Figure 2. Variability of the Quantity of Food Produced in Home Gardens



To fully understand the home gardens functioning, we categorised production into cereals (*Zea mays*, *Pennisetum* sp., *Sorghum bicolor*), tubers (*Manihot esculenta*, *Ipomea batatas*, *Dioscorea* spp., *Solanum tuberosum* and *Xanthosoma sagittifolium*), legumes (*Arachis hypogea*, *Vigna unguiculata*, *Voanzou subterrana*, *Phaseolus vulgaris*), fruits (*Persea Americana*, *Mangifera* spp., *Citrus* spp., *Carica papaya*, *Anacardium occidentale*, *Psidium guajava*,…) and others (*Saccharum officinalis*, *Cucumis melo*, vegetables,…). These groups could allow specifying the food behaviour of the farmers in the region.

It was noticed that: fruit production was considerable in all the 11 home gardens compared to other speculations ; home gardens belonging to type 1, 3, 5 and 11 do not produce legumes. Farmers from the gardens purchased some of theirs products from the local market or obtained some of them from neighbours and friends. The legumes production is very low (3.89t).

The total production of fruits for the 11 home gardens types was estimated at 29.06t, whereas that of cereals and tubers was 32.76 t and 27.51t respectively (Table 1). These results are less than those of Mapongmetsem *et al*. (2002) in the same region. This is due to the choice of the farmers and their food strategies. The results also indicate that the method of recording improved the quantification of farmer products and also their marketing strategy. This method was satisfactory because it avoided errors. The previous estimations of the farmer products were based on recall and it is not easy for

farmers to remember what they harvested, consumed, purchased, sold or donated.

Table 1. Repartition of the Quantity of Food Produced in Home Gardens per Grouping

Home garden types	Production (t)					
	Cereals	Tubers	Fruits	Legumes	Others	Total
1	1.48±0.40	3.58±1.15	2.14±1.34	0	0.80±0.59	8.00
2	3.92±1.24	1.44±0.40	4.96±1.89	1,81±045	4.24±1.57	16.37
3	0.75±0.15	1.39±0.36	1.20±0.56	0	0.63±0.15	4.16
4	3.29±0.94	3.73±1.23	2.59±1.44	0.02±0.00	0.82±0.63	10.45
5	2.27±0.85	4.39±1.56	3.37±1.27	0	0.70±0.56	10.73
6	1.80±0.43	1.52±0.34	2.53±0.75	0.14 ± 0.01	5.30±2.03	11.29
7	2.43±0.81	3.81±1.15	2.86±0.88	0.43± 0.03	1.18±0.97	10.71
8	3.40±1.01	1.53±0.45	1.31±0.12	.14±0.37	0.63±0.15	8.28
9	3.29±1.10	2.85±0.52	3.53±0.95	.28±0.06	0.63±0.15	10.58
10	3.76±1.18	5.05±1.81	1.19±0.83	.07±0.02	2.63±1.17	12.7
11	0.65±0.01	2.45±1.06	3.40±1.87	0	0.13±0.05	6.63
Total	27.01	35.07	29.06	3.89	18.4	113.43

The type of crops grown was influenced by ecological, socio-economic and cultural factors. The nutritional contribution of home gardens varied with garden types and their socio-economic status.

Livestock also contributed to production figures. For the animal production, the figures registered were: 93 chickens, 50 cows and 43 goats and cheeps. Cattle are reared in the following garden types: 4 (3 heads), 8 (25 heads), 9(4 heads) and 10 (18 heads). For the small livestock, garden types 4 and 11 did not rear goats or sheep, whereas chicken were produced in all the garden types.

Nevertheless, home garden products are used for both home consumption and market, depending on the size of the type of crops grown, the distance to the market and the economic status of the owner.

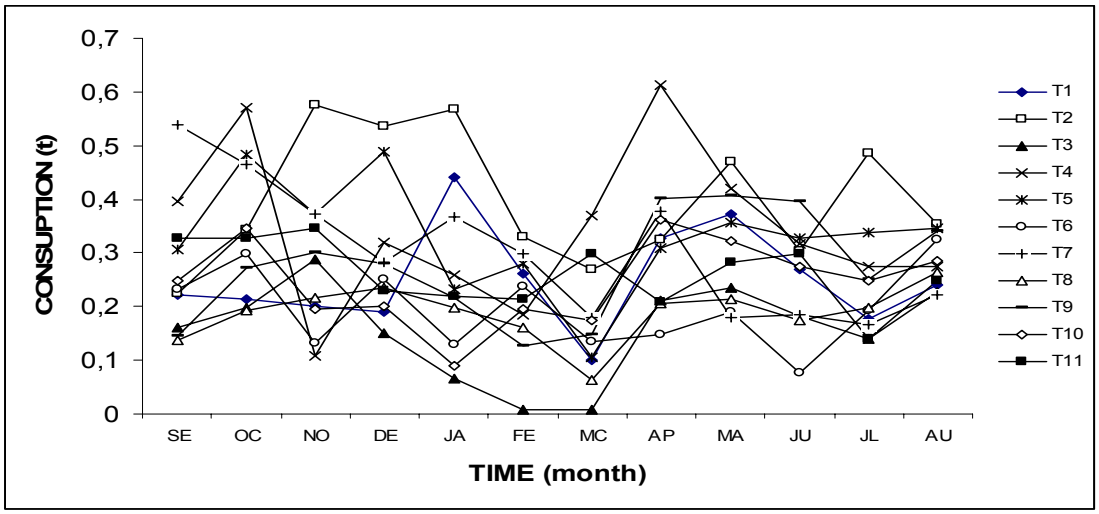
Dynamic of Food Products in Home Gardens

a. Food Consumption

The quantity of food consumed in home gardens was related to the family size and the objectives of the farmers. The total annual consumption was 35.2t year^{-1}. Different trends were observed along the year (Fig.3). The consumption varies significantly from September to August ($0.0013 < 0.01$). Among the 11 types, it ranges from 0 t in type 3 to 0.65 t for type 4 suggesting that there was significant difference among home gardens ($0.000 < 0.001$). About 80 % of the production of home gardens was self consumed. The

consumption was consistent and constant in home gardens belonging to type 2 from November to March and May to July (Fig.3). Those from type 4 presented important consumption in October and April. The great quantity of products consumed by the two types is in relation to their family size which is high. There was a significant correlation between food production and food consumption ($r = 0.93$; $0.0003 < 0.001$). Based on the above result, food consumption could be predicted from the following equation where production and consumption are in tons: Production = 2.85 x Consuption+0.345.

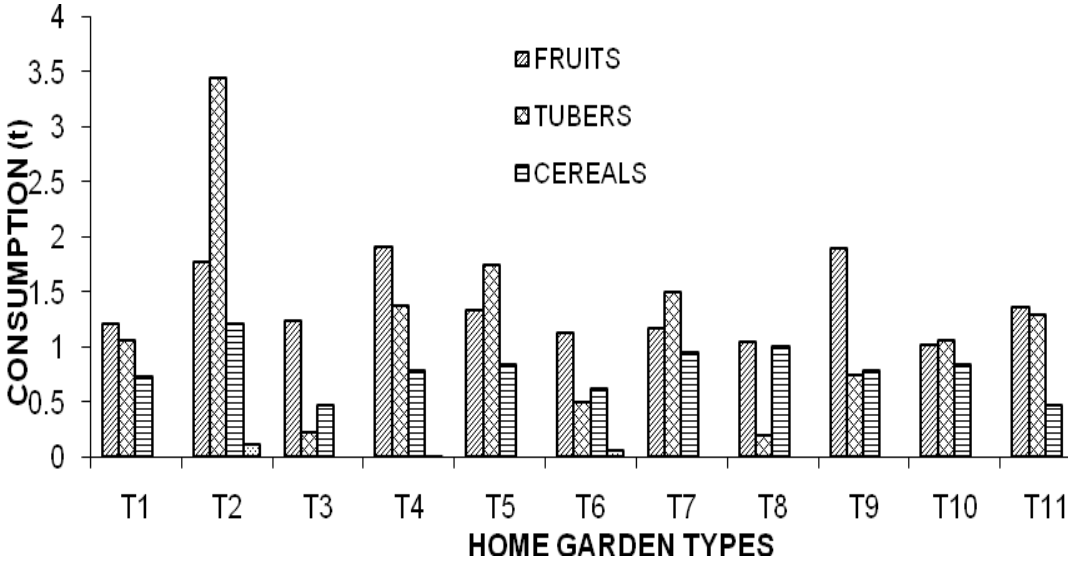
Figure 3. Variation of Food Consumption (t) in Home Gardens during 12 Months of Survey.



Products consumed in different home gardens were influenced by the food behaviour of the families. They vary significantly among the home gardens. Tubers were highly consumed in home gardens from types 2. The food preference of these farmers was tubers. The farmers from these types are in majority from the Dii and Gbaya ethnics'groups. The food behaviour of these groups is dominated by tubers (Mapongmetsem *et al*. 2002). *Manihot esculenta* is regularly transformed into flour locally known as ''Gourka'' in fulani.

The consumption of tubers (3.449 t) was higher than that of other products in home gardens from type 2 (Fig.4). These farmers are in majority from Dii ethnic group. Their food preferences were tubers. For the fruits, the consumption is consistent (more than a ton in all the home gardens. In general, the consumption of fruits in home gardens ranks second and cereals third. In addition to the low consumption of cereals, there are Legumes.

Figure 4. Variation of Food Consumption (t) in Home Gardens per Grouping.



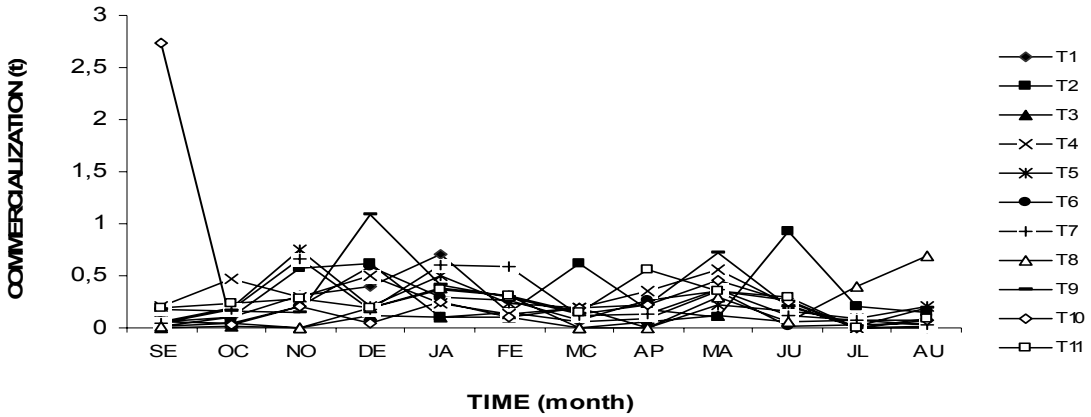
The main consumers (more than 3t year^{-1}) are from gardens belonging to the following types: 1, 2,4,5,7 and 9. For the total production, the annual quantity of food consumed was 35.2t, while 30.12 t were commercialized.

b. Commercialization of Food Products

The home gardens food products are self consumed for about 80%. The rest of 20% is managed differently according to farmer strategies: sell, gift and for seeds. Marketing of the home garden food products is in connection with the needs of farmers (School fees, purchasing new manufactured products and animals, celebrations, keeping money for future uses, etc.). Between home gardens, the quantities commercialised vary from 0.71 t (type 3) to 4.54 t (type 10) (Fig.5). The marketing activity in home gardens is not homogenous along the year and implies that period of high and low activities cohabit.

The figure 5 shows that the great quantity of products sold was from home gardens belonging to type 10 and the period of maximum activities was September. The low quantity sold was obtained from those of type 3. Gardens from types 2, 9 and 11 commercialize important quantities of products in March, April and May whereas those from type 2 have their peak of marketing in June. Type 8 is particularly active in July and August. However, in home gardens from type 11, marketing of food products is observed all the year round. This permanent activity was attributed to the floristic richness and diversity of those home gardens. The phenology decay of the various trees allows the farmers to harvest and sell fruits at any period of the year.

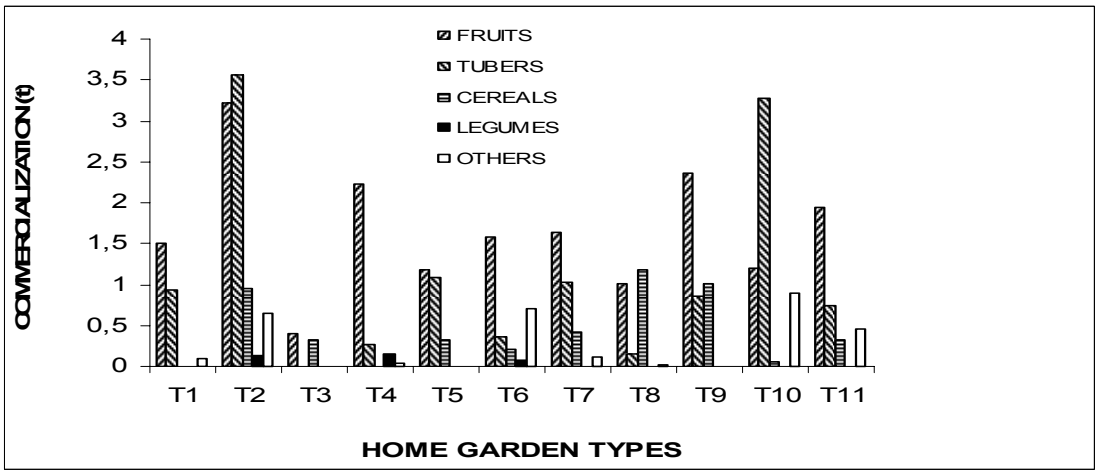
Figure 5. Commercialization of Food Products in Home Gardens During 12 Months of Survey



Lack of post harvest structures (storage, transformation) in the area was one of the reasons which encouraged the marketing of products. Fruits were the most commercialized products. These products are sold in local or regional markets. In general, periods of November – February, April – June were the ones during which most of the products were sold in home gardens (Fig.5). This trend could be explained by the increase of farmer needs or by the high fruit production in home gardens.

Fruits were the most commercialized products from home gardens, with a total quantity of 18.17t sold. Farmers from the home gardens belonging to type 2 sell more fruits and tubers whereas those from type 10 distinguish themselves in tubers (Fig.6). These behaviours demonstrate that some farmers were specialised in producing certain products over others. In home gardens from types 1, 3 and 4, cereals, tubers and legumes are not commercialized. Their production is insufficient or their production was totally self consumed.

Figure 6. Variation of Food Sold (t) in Home Gardens per Group of Speculation



Commercialization of food products in different markets of the Vina Division follows the law of demand and supply. The selling price varies according to the type of products and period (scarcity, abundance, etc…). In terms of illustration 4 fruits (mango or avcado) coasted 0.15€, 4 tubers 1.53€, one kilogramme of cereals 0.15€ while that of legumes is 0.53€. The total income generated in home gardens is estimated at 4693.74€ among which 2130.39€ for fruits, 1203.74€ for tubers and 1359.62€ for cereals, legumes and vegetables. In Sumatra, agroforests usually provide between 50 and 80% of total agricultural income of villagers (Mary 1987, Mary et Michon 1987). Agroforest income allows farmers to cover the day to day expenses. In general, it helps farmers to purchase products which are not produced in homesteads (rice, pineapples, plantains) and manufactured products (soap, sugar, salt, clothes, etc.), or to pay children's school fees. In addition, they purchase products during famine and for celebrations.

Moreover, we notice that many of the farmers in rural areas were much better than most of the settled farmers in Ngaoundere neighbourhoods, as many of the former have permanent and beautiful housing, material goods such as motorcycles, television, more recently satellite dishes, etc. Very often, such material goods were related to agroforest development. Motorcycles are now equipment which help farmers in many ways to move easily from place to place in the rural area and to carry goods and persons. The money earned helps to also invest in the agroforest sector.

c. Purchase of Other Products

The total quantity of food products bought from local markets is low (1.68t year^{-1}) compared to the quantity consumed. This result demonstrates the diversity of products harvested and consumed in home gardens year round. The quantity of bought products ranges from 0t in type 7 to 0.31t year^{-1} in type 1. The maximum of purchased products was generally in October, November, December, February, April and June. These periods corresponded to celebrations (feast of the Ram, Christmas, New Year, etc.). Homesteads from type 1, 6, 8 and 11 have their maximum buying periods in September while those from types 2 and 5 in October, type 10 in April, type 4 in February, type 9 in May, and type 3 in October and January.

In general, cereals were the most purchased products at 0.82t year^{-1}, whereas fruits were the least (0.01t year^{-1}). Cereals represented 48.81 % of bought products. Home gardens from type 1 and 7 are those that purchased products the most, 18.45 and 17.85 % respectively. In the phenological point of view, fruits were produced all over the year in home gardens. They represent standing capital and constitute the basis of a family or lineage patrimony. Very often, farmers have to purchase food products during famine and

celebration periods or when the given products are not produced in cultivable quantities.

The low quantity of food products purchased by farmers could be justified by the fact that from the social point of view, gifts exist in the rural communities and farmers consume what they produce.

d. Gifts

The movement of food products between farmers can be seen in terms of what quantity that farmers give to another or what they receive from the others. Harvest products were usually shared with neighbours. This custom was reported in rural areas of West Java as well (Christanty 1990).

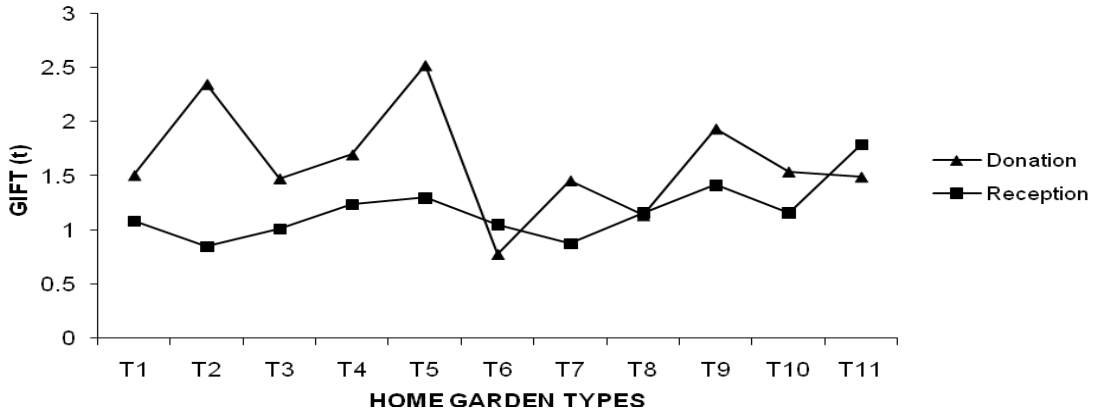
d.1. Donation

The total quantity of food products offered to other farmers was 17.90t whereas the quantity received from them is 12.92t. Nevertheless among home gardens, the mean quantity offered ranges from 0.78t for type 6 to 2.52t in type 5 (Fig.7).

d.2. Reception

Similar trends were observed on receptions. The quantities received by farmers varied from 0.85 t in type 2 to 1.79 t for type 11 (Fig.7). Comparison between donation and reception shows that farmers offer more than they receive from others. However in each case, variations were noticed among home gardens. Farmers from home gardens belonging to type 5 and 2 were those who offer the most. In type 6 and 11, farmers receive from others more than what they offer themselves. Equality subsists between offers and receptions in type 8. These flows of products testimony the social importance of home gardens in consolidating relationships among the communities.

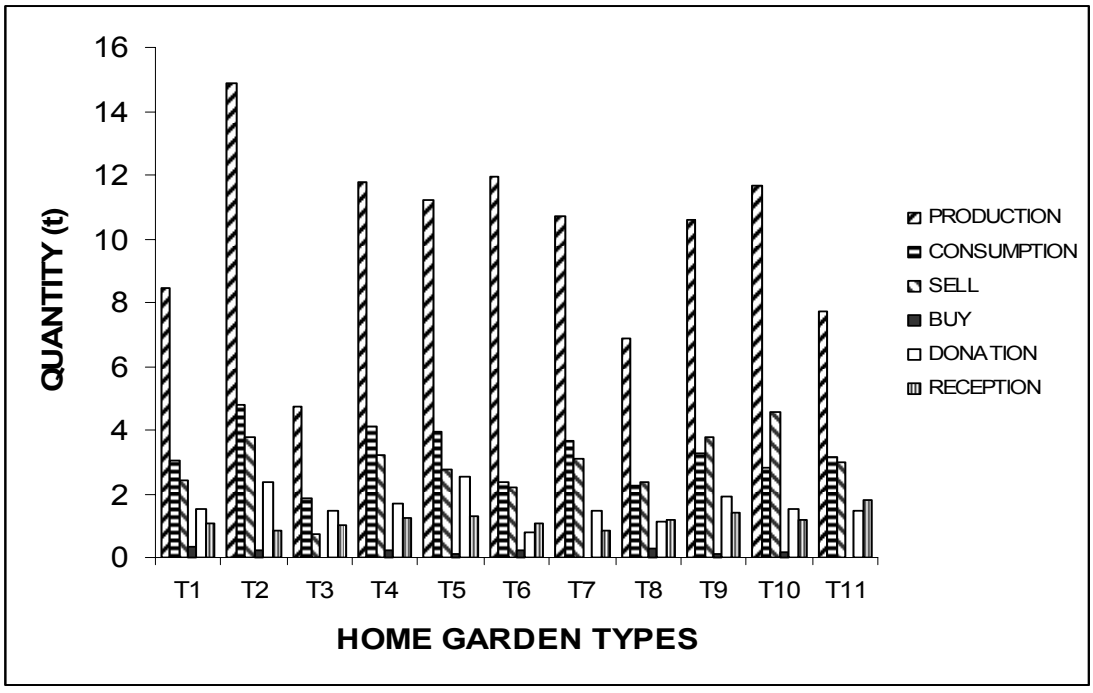
Figure 7. Variation of the Gift in Home Gardens during 12 Months of Survey



Concerning the functional aspect of this traditional system and based on the present results, the 11 types of home gardens can be classified into three categories according to the role they played in the communities:

- *Economic role:* The objectives of the farmers here were market oriented. The greater part of the food products is sold. The farmers engaged were from types 10, 9 and 8.
- *Social role:* The production was for subsistence. The great quantity of the production is auto consumed. Farmers who highly self consume their production belong to home gardens from types 1, 2, 4, 5 and 7.
- *Socio-economic role:* This type was intermediary between the two above. For this type, farmers consume a part of their products and sell the other. They are from types 3, 6 and 11. Variations existed within and between the different types (Fig.8). This result demonstrates that management of those products depend on the objectives of the farmers. Some quantities of the products were conserved for future use mainly for seeds or for the famine period. This suggests that households use their home gardens as a reserve of food or money for when their supply of other resources becomes short.

Figure 8. Flow of Food Products in Home Gardens



Generally in tropics, indigenous agroforestry systems represent a fine-tuning of knowledge concerning the interaction of plants and their environment, and involve as well interaction between agricultural, social, and cosmological systems (Mapongmetsem 2005, Miller et Nair 2006, De Clerk and Negreros Castillo 2000, O'Bede 1990). Among these systems, agroforests

are an original model from small holder farmers for environmental conservation and sustainable development (Michon et De Foresta 1996). The multiple uses of their products attest the on going importance of these resources to local populations for subsistence as part of their cultural heritage. This study gives evident answers to some pertinent questions raised in literature (Nair 2001, Oekan 1990).

The management of this system is not without difficulties. The major constraints faced by the home garden operators are discussed below. The majority of fruit trees were old. There are difficulties to get good quality seeds. Communication and post harvesting infrastructures are lacking. The main consequences were post harvest loses. Crops, and mainly fruit trees, were affected by various diseases and plant parasites. The marketing strategy was not well mastered by farmers. In addition they were not used to quantifying their production. Nevertheless, the diversity of income sources, as well as secondary productions which meet subsistence needs, was an essential asset in the economic security and welfare of villagers.

Conclusion

Various food products such as fruits, tubers, cereals and legumes are produced in the Guinean Highland home gardens. The total annual production is 113.45t. From the functional point of view, the 11 home garden types can be classified in three categories: economic, social and socio-economic. Varying flows of products exist. In general, there are more donations than receiving of gifting. Fruits are the most commercialized products, while cereals are the most consumed and bought. The period of famine is usually between February and April. The farmer record list is an important tool which merits popularisation. It could help farmers to quantify products as well as predict the period of hunger. Farmers consume what they produce and the excess is sold or offered to others. The main constraints faced by farmers include the difficulty selling their products, diseases, lack of transportation and post harvest structures. Home gardens contribute significantly in consolidating relationships among community members in the rural area. Production of home gardens as well as consumption and gifts vary within and among home garden types. Trees represent standing capital and constitute the basis of a family or lineage patrimony. The flow of products in this system clearly represents a process of wealth accumulation which opens new options for further development in agroforestry.

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