SHIFTING CULTIVATION PRACTICES AND SUSTAINABLE FOREST LAND USE IN THE EVERGREEN FOREST OF CAMEROON

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SUMMARY

Studies were conducted conjointly on forest management and farming systems in order to achieve sustainability of the forest production in the Tropenbos-Cameroon research site. Results on some aspects of farming systems are here presented. They show that a farm in the evergreen forest of Cameroon is composed of many subsystems interrelated and influenced by external biophysical and socio-economic parameters. According to 92% of the farmers interviewed, the cropping subsystem remains the first priority activity. In this cropping subsystem, 80% of the farmers considered shifting cultivation involving food crop fields and fallow as their first priority land use type. Four major crop associations highly linked to the preceding fallow type were identified in the food crop fields. Today, 76% of food crop fields in the area shift within fallow of different ages in a rotational system. Only 24% of agricultural fields expand towards undisturbed forest for cucumber (*Cucumeropsis mannii*) production and for establishment of semi-industrial farms by elite. The population pressure, the type and objective of crop production, the limited labour, and the access to new land have prompted more farmers to abandon the traditional expansive shifting cultivation and to adopt the rotational system. The latter consist of shifting in a total area of less than 10 hectares, clearing short length fallow. This reduction in fallow length leads to degradation of topsoil morphology and physical soil properties, and to drastic reduction in plant species diversification. For a sustainable management of the forest zone of southern Cameroon, solutions must be found to two main problems: (1) the shortening of the fallow length leading to soil productivity degradation and (2) the unsustainable non-prosperous subsistence shifting cultivation destroying the forest ecosystem. Solutions in the form of recommendations deal with soil productivity improvement and conservation and the move from subsistence to income generating farming.

Keywords: shifting cultivation, farming systems, soil degradation, sustainability, forest land use, Cameroon.

1. INTRODUCTION

Shifting cultivation is the dominant farming system practised in the tropical forest zone of Cameroon for food crop production. Information on this type of land use in the moist evergreen forest of South Cameroon is very sparse. The Tropical Forest Action Plan (MINAGRI, 1989) does not foresee a significant agricultural pressure on forest land in southern Cameroon. However, the present trends in shifting cultivation practices, under increasing local population growth and influence of market economy as result of local infrastructure development (rural electrification, road construction, etc.), may well lead to agricultural land expansion and a threat on forest management and conservation.

The objective of the Tropenbos-Cameroon Programme is to develop methods and strategies for natural forest management directed at sustainable production of timber and other products and

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services. In order to achieve sustainability of the forest production in the area, sustainability of crop production must be studied conjointly, since shifting cultivation systems represent a threat to forest as well. It was in this regard that a study was carried out on farming systems in order to provide a comprehensive description of the shifting cultivation system practised in the area and an insight on soil fertility degradation related to such agricultural practice.

This paper presents a brief description of the practice of shifting cultivation, discusses its relationship with logging activities and changes in soil and plant species composition, its sustainability and that of the forest land use as a whole.

2. THE STUDY AREA

The research area covers the whole Tropenbos-Cameroon Programme (TCP) site located 70 km east of Kribi between 2° 47' - 3° 14' North, and 10° 24' - 10° 51' East. The physiography is of undulating landscape with relief intensity increasing from west to east and southeast. The altitude varies from 180 to 900 m. The climate is of the equatorial type (Köppen, 1936), characterised by two rainy seasons and two dry seasons. The mean annual rainfall is 2000 mm and the mean annual temperature is 25°C. The vegetation is one of the low and mid-altitude evergreen Atlantic forest (Letouzey, 1985). Soils are derived from metamorphic rocks belonging to the basement complex, traversed in some parts by old intrusions of plutonic rocks (Champetier de Ribes and Reyre, 1959; Champetier de Ribes and Aubague, 1956). From west to east, cristallophyllian series (with ectinites and migmites) change to the calco-magnesian complex of Ntem (with leuco-mesocrate gneiss and pyroxenic granites). Excepted some wetland soils encountered in few inland valleys, soils of the site are mainly Ultisols and Oxisols (van Gemerden and Hazeu, 1999) as classified in the USDA system (Soil Survey Staff, 1992). Ultisols are dominant in dissected plains of low altitude (180 – 350 m) area of the Bipindi region. These soils cover about 30% of the research area. Oxisols are encountered in higher altitude (>350 m) regions of Akom II, Lolodorf and Ebolowa. They cover more than 65% of the whole area.

3. METHODOLOGY

The methodology consisted of the collection of secondary data through consultation of existing documents, interview of key informants, and the collection of primary data through surveys conducted in the research area. The participatory approach was used in the field for exploratory survey in the whole site. Cases studies were used for a more detailed characterisation of farmer's priority setting and strategies for soil fertility management.

Four sub-site areas were selected for soil degradation studies. The sub-site selection was based on the physiographic units described by van Gemerden and Hazeu (1999). The soil degradation study involved many aspects related to soil survey, on-farm studies and analytical studies as well. Soil sampling for bulk density and aggregate stability analyses were carried out at two depths of 0-10 and 10-20 cm, in shifting cultivation fields, skid tracks, fallow and undisturbed forest. Aggregate stability was determined at the TCP laboratory in Kribi by the water-drop method (Imerson and Vis, 1984). Bulk density was determined at IRAD laboratory in Nkolbisson by soil oven dry technique (at 105°C). Skid track raw data utilised in the Analysis of Variance were obtained from Waterloo *et al*. (2000), who used a similar method of sampling. For routine laboratory analyses, composite soil samples were collected with auger at five spots on a diagonal basis in each type of field and type of land use, at three depths (0-10, 10-20 and 20-50 cm). The analyses concerned pH water and KCl (1:2.5 ratio), organic Carbon (Walker and Black method), total Nitrogen (Kjeldahl digestion),

available Phosphorous (Bray II method), exchangeable bases (extraction with 1M NH4OAc), Cation Exchange Capacity (extraction with 1M NH_4O at pH 7), Exchangeable acidity (leaching with 1M KCl and titration by 1M NaOH), particle size distribution (pipette method). The trend of agricultural field expansion was studied based on aerial photographs and field size measurements from selected farmers.

Data were analysed statistically using Systat software. Cumulative frequency was performed for priority setting. Analysis of variance (ANOVA) was performed for changes in soil properties under various fields and land use types.

4. SHIFTING CULTIVATION IN THE FARMING SYSTEM

4.1. Farm as a system

Generally, the production systems of a farm (Farming Systems) in the evergreen forest of Cameroon is composed of the subsystems Household, Cropping, Animal, Soil, and Non-agricultural activities such as Hunting, Fishing, Off-farm activities, etc. (see Figure 1). These subsystems are interrelated and are under the influence of external biophysical and socio-economic parameters such as climate, road and market infrastructures, market price, land tenure law, credit availability, etc.
According to 92% of the farmers interviewed, cropping subsystem activities (Crop production) are the first priority activities, followed by animal husbandry, then fishing, palm wine tapping, wild fruits collection, hunting, and oil palm exploitation (Table 1). In the cropping subsystem, shifting cultivation involving food crop fields and fallow is the first priority land use type according to 80% of the farmers, followed by perennial plantations, then home gardens (Table 2).

Table 1. Farmers' priority activities

Major Activities	**Rank**	**Frequency of farmers ranking responses**	**Reasons of Importance**
		%	
Crop production	1	92	Diverse consumption & revenues
Animal husbandry	2	29	Guests reception, dowry, ceremonies
Fishing	3	35	Local consumption, less revenue
Palm wine tapping	4	45	Consumption and unstained revenues
Wild fruits collection	5	22	Seasonal consumption and revenues
Hunting	6	32	Diverse consumption and revenues
Palm oil extraction	7	48	Simple local consumption

Sample size n = 200

Table 2. Farmers' priority land use in a farm

Land use type	**Rank**	**Frequency of farmers ranking responses**	**Reasons of Importance**
		%	
Shifting cultivation	1	80	High consumption and revenues
Perennial plantations	2	56	Decreasing revenues
Home garden	3	72	Various consumption with low revenues

Sample size n = 200

4.2. Spatial Land Use on the Farm

Farm land use for crop production begins with small gardens adjacent to the house, where the farmer maintains an ecosystem of plants and animals composed of useful domesticated forest trees, local and introduced fruit trees, annual/biannual and perennial food crops (Table 2), and chickens, goats, pigs, sheep and ducks (Table 3). Perennial plantations with oil palm and cocoa - the major export cash crop - lie further away.

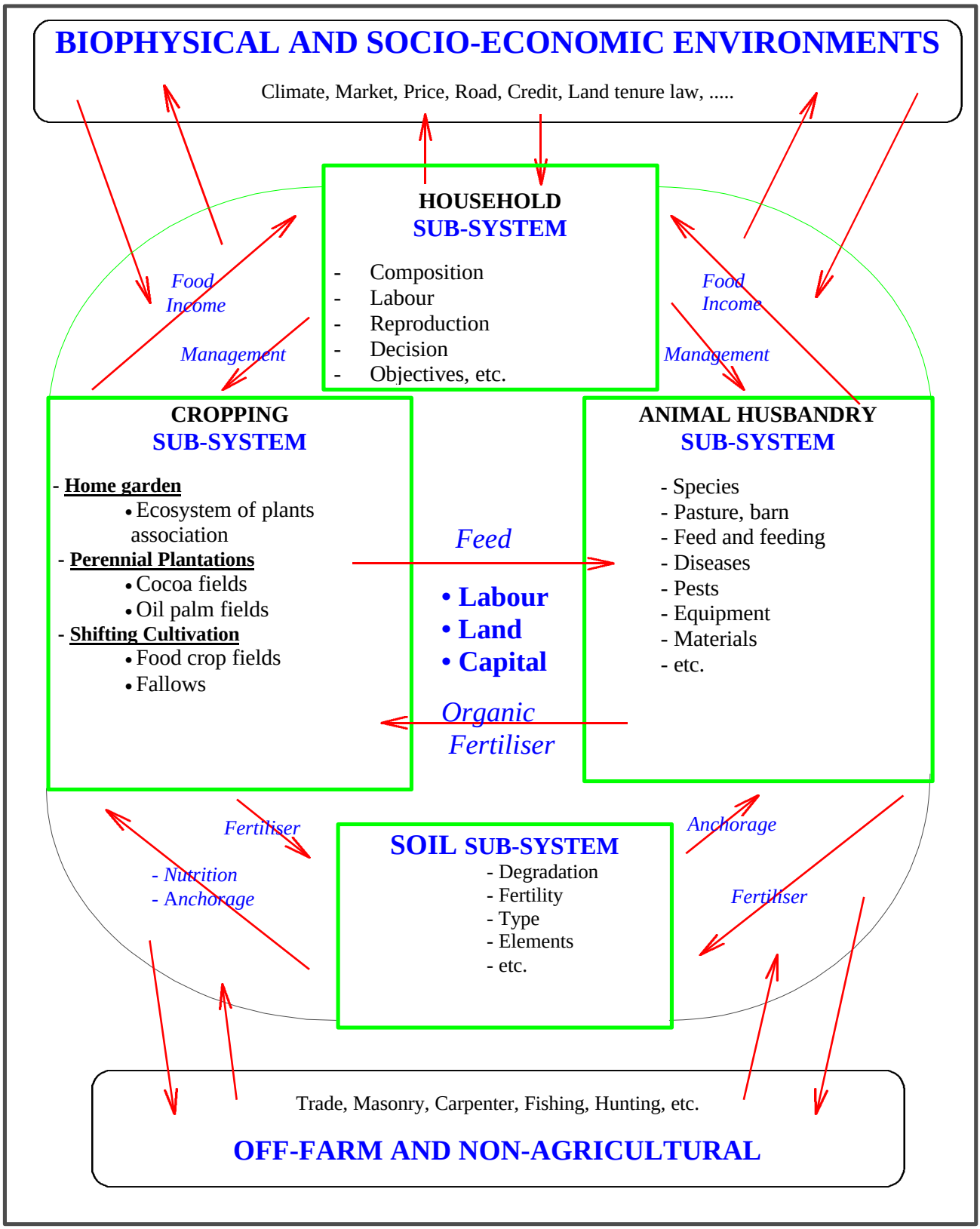


Figure 1. Subsystems of the farms in the forest zone

Farthest from the house, at the forest's edge, food crop fields are found where more than 20 species of crops (cassava, cocoyam, banana/plantain, cucumber, groundnut, maize, sweet potatoes, fruit

trees, sugar cane, pineapple, vegetables, etc.) are grown in association alternates with short and/or long length fallow. Crops represented in higher density in the association are termed major crops (cassava, cocoyam, banana/plantain, cucumber (*C. mannii*), groundnut, maize, yam). Crops represented in lower density are termed minor crops (vegetables, fruit trees, sugar cane, pineapple, etc.).

Four major crop associations, highly linked to the type of preceding fallow, have been identified:

- Cucumber (*C. mannii*) / cocoyam / plantain / maize (from a cleared and burned forest fallow);
- Groundnut / maize / cassava / cocoyam / plantain (from a cleared and burned bush fallow);
- Groundnut / maize / cassava / cocoyam (from a cleared and burned Chromolaena fallow);
- Cucumber (*Cucumis sativum*) cocoyam / plantain / maize (from a cleared and burned bush fallow).

Minor crops are more or less found in all these associations.

Table 3. Farmers' priority reared animal species

Priority species		**Rank**	**Frequency of ranking**	**Reasons of importance and constraints**
Pilot name	Scientific name or race		**%**	
fowl (chicken)	*Gallus sp.*	1	37	Local consumption during guests' reception and ceremonies; pests are frequent.
pig	African local race	2	39	Guests reception and ceremonies; pests are frequent; divagation
goat	Guinean thin race	3	40	Wedding and traditional ceremonies; diarrhoea; divagation
sheep	Djalonke	4	43	Wedding ceremonies and guests' receptions; divagation.

Sample size : n = 200

4.3. Shifting Cultivation and Agricultural land Expansion

Today, the shifting characteristic of this cropping system is defined in two directions:

- The first direction is that of shifting within fallow plots of different ages. This constitutes a rotational system, which is normally the more stable part of the system. It concerns mainly food crop fields and 76% of food crop fields in the area rely on this rotational system.
- The second direction is that of agricultural fields expanding towards new lands under undisturbed forest. This is the pure expansive system, which constitutes more threats to forest conservation and sustainable management systems. This system (24% of the food crop fields) is practised mainly for cucumber (*C. mannii*) production and for the establishment of semi-industrial farms by the elite. For this system an average of 2200 m² of new forest land is opened by each household per year in the TCP area. This average surface corresponds to about 300 m² per inhabitant. Ebimimbang plains and Mvié uplands have highest rate of forest encroachment per year and per household with values of 2450 m² and 2650 m² respectively. These higher rates can be explained by the fact that their landscape is more accessible for agricultural practices, and that these areas have been under commercial logging many times.

From the Landscape Ecological Survey of the study area based on aerial photograph of 1984/1985, over a total area of 51 180 ha were used for low to high intensity agriculture. This agricultural area represented about 31% of the total area (Table 4). The expansion of agricultural fields in the TCP area is a function of many factors such as the population growth, the increasing roads network, the landform accessibility, etc. From 1984 to 1997, the proportion of land under agricultural use

changed from 31 to 40.3%. This corresponds to an average annual expansion of 0.71% of the total land area, for an absolute value of 1,267 ha.

Table 4: Extent of the areas influenced by shifting cultivation in 1984 and 1997 (adapted from van Gemerden and Hazeu, 1999)

Intensity of shifting cultivation	**Extent**			
	ha		%	
	1984	1997	1984	1997
No to hardly any	116 170	99 472	69	59.7
Low to High intensity	51 180	67 652	31	40.3

4.4. Fallow types

The limited labour and access to new land have prompted more farmers to abandon the traditional and expansive shifting cultivation and adopt the rotational system. The latter consist of rotating in a total area of less than 10 hectares, where the farmer clears each season, either Chromolaena fallow (age: 3 to 5 years), either bush fallow (age: 7 to 9 years), or forest fallow (age: more than 10 years). The above classification of fallow based on vegetation age is the farmers' definition. It is difficult for farmers to recall the precise age of a fallow. The corresponding local words for the different types of fallow are *Afan* for virgin forest or forest fallow, *Nnom ekotok* for bush fallow, and *Ekotok Ngoumgoum* for Chromolaena fallow. The type of fallow cleared is highly linked to the major crops to be grown. Virgin forest and forest fallow (*Afan*) are cleared to grow *ngon* (*C. mannii*) with associated crops. Bush fallow (*Nnom ekotok*) is cleared to grow *ngon/seng'le* (*C. sativum*) and groundnut with associated crops, or to grow groundnut and plantain with associated crops. Chromolaena fallow (*Ekotok Ngoumgoum*) is cleared to grow groundnut and associated crops. The choice of the virgin forest or forest fallow to clear is based on the presence of some tree species indicating good or bad soil fertility (see Tables 5 and 6).

Table 5. Some plant species used by farmers as indicators of good soil fertility

Local or Pilot name	**Scientific name**	**Family**	**Frequencies of farmers responses**	
			Number	Relative frequency
				%
Eteng/Ilomba	*Pycnanthus angolensis*	Myristicaceae	49	16.3
Doum/Fromager	*Ceiba pentandra*	Bombacaceae	38	12.7
Akom/Fraké	*Terminalia superba*	Combretaceae	36	12.0
Essombo	*Rauvolfia macrophylla*	Apocynaceae	24	8.0
Asseng	*Musanga cecropioides*	Moraceae	20	6.7
Ekouk	*Alstonia boonei*	Apocynaceae	20	6.7
Others	-	-	113	37.6
Total			300	100

Table 6. Some plants species used by farmers as indicators of poor soil infertility

Local or Pilot name	**Scientific name**	**Family**	**Frequencies**	
			Number	Relative frequency
				%
Elon / Tali	*Erythrophleum ivorense*	Caesalpiniaceae	44	18.6
Alan	*Hylodendron gabonense*	Caesalpiniaceae	28	11.8
Adjom	*Afromomum citratum*	Zingiberaceae	21	8.9
Ebay	*Pentaclethra macrophylla*	Mimosaceae	16	6.7
Eyen	*Distenomanthus benthamianus*	Caesalpiniaceae	14	5.9
Others	-	-	114	48.1
Total			237	100

In the rotational system, the length of the fallow period gets shorter. Most farmers are now clearing short fallow such as Chromolaena fallow (Table 7).

Table 7. Farmers' priority fallow types

Fallow Types	**Rank**	**Frequency of farmers ranking responses**	**Reasons of importance**
		%	
x <= 3 years	3	60	Good for few crops; less difficulties tilling.
Chromolaena fallow 3 < x <= 5 years	1	64	Less labour for clearing; Enough fertility to grow many crops.
Bush fallow 7 < x <= 9 years	2	46	Good fertility recovery; but labour for clearing and difficulty tilling because of tree stubs.
Forest fallow x >= 10 years	4	36	Labour demanding for clearing. More difficulties tilling because of tree trunks and stubs. Few crops grown, mainly *Cucumeropsis mannii*.

Sample size : n = 200

4.4.1. Commercial logging and agricultural farming activities

Shifting cultivation and commercial logging are the two main man activities in the study area, which contribute to deforestation and represent threats to forest conservation. Although logging is mainly an industrial and temporary activity of Logging Companies, it has a strong influence on the shifting cultivation of rural population in the area. The relationship between the two activities is highlighted in the following aspects:

- Roads and skid tracks opened by logging activity are used by farmers to create new farms in the virgin forest for shifting cultivation. This is confirmed by the pattern of agricultural land distribution along the roadsides.
- The presence of Logging Companies always improves the food crop market system in the villages and the neighbourhood. This forces farmers to increase their production by increasing the farm size.
- Logging and farming activities are both contributing to degradation of soils. Bulk density and aggregate stability of the top A-horizon of Oxisols were significantly higher ($p<0.05$) in soils under agriculture and on skid tracks compared to the undisturbed forests (Table 8).

Table 8. Bulk density and Aggregate stability variation with land use type

Character	**Land Use type**			
	Shifting cultivation fields	Skid track (Waterloo *et al*., 2000)	Fallows	Undisturbed forest
Bulk density (g/cm^3)	1.10 - 1.24 **a** (n = 28)	1.27 - 1.30 **a** (n = 46)	1.05 - 1.11 **b** (n = 32)	0.99 = 1.09 **b** (n = 24)
Aggregate stability (Number of water drop)	50 -70 **a** (n = 18)	30 - 60 **a** (n =25)	100 - 180 **b** (n = 18)	> 180 **b** (n=12)

N.B. **a** and **b** are significantly different at $p<0.05$

4.4.2. Causes and effects of the reduction in fallow length

For the poor farmers of southern Cameroon, the prime functions of fallow within the shifting cultivation system are production (food crops, fishing, hunting, medication, crafting and construction) and soil productivity reconstitution. The land inventory carried out in the area (van Gemerden and Hazeu, 1999) showed that only dissected plains and uplands mapping units were mainly used for shifting cultivation. These units suitable to agricultural activities represent only less than 50% of the total area. Sixty four percent of the farmers are today considering and clearing short length Chromolaena fallow as their first priority fallow. This reduction in fallow length leads to continuous degradation of soil, poor yields, and biodiversity losses.

4.5. Causes of fallow length reduction

4.5.1. Agricultural land shortage and land tenure

In the TCP area, less than 50% of the total area are accessible for crop production because of their flatness or their gentle sloppiness. But in the traditional land tenure system, the land claim is by kin

group according to first clearing of the forest (Nounamo and Yemefack, 1997). Access to land is limited because user rights are not given to farmers not belonging to the family. These family rights to land limit people's access to more land and restrict each member of the family to only their own fallow land.

4.5.2. Population pressure

The rural population growth was moderate due to constant urban migration. But with increasing city jobless today, young people are coming back to the village for agricultural occupation. Actually the population growth due to backward migration (16.5%) and birth rate (7.3%) is increasing needs for arable land, leading to the decrease in fallow periods.

4.5.3. Type and objective of crop production

The choice of the type of fallow to clear is also a function of the crop to be grown and the land availability. The choice of the type of crop to grow is a function of production objectives (income, consumption, or both), of the availability of the market and of the easy evacuation of the produce. Cassava, maize, cocoyam, and groundnut are the first priority crops of the farmers because they are cultivated for revenue and consumption. Their production requires the clearing of the more suitable fallow, which in this case is short length Chromolaena and Bush fallow. Old fallow and undisturbed forests are mainly cleared for *Ngon* (*C. mannii*) production, or for establishment of semi-industrial farms by the elite for the production of high income generating crop.

4.5.4. Soil Al-toxicity reduction

Short fallow, especially Chromolaena fallow, produces an important biomass for burning. The burning releases soil ashes which act as a lime and significantly ($p<0.05$) increases soil pH, reduces Al-toxicity, increases phosphorous and exchangeable bases (specially Calcium), and reduces C/N ratio. Farmers prefer to clear more young Chromolaena fallow lands to grow groundnut. These young fallow lands are more suitable for groundnut production because of their relative richness in available phosphorous.

4.5.5. Labour shortage to clear forest land

Food crop production is mainly women activity. The use of hired labour is rare and is not easily affordable. The most labour demanding activity in food crop production is tree felling and land clearing. The cost to clear 1 ha of forest fallow now averages to 40,000 to 50,000 F CFA. Farmers who cannot afford to clear forest fallow will restrict themselves to clearing short length Chromolaena fallow.

4.6. Effects of fallow length reduction

4.6.1. Soil morphology degradation

The topsoil (3-5 cm) A_1 horizon is a characteristic horizon for climax tropical rain forest soils. It is a humic horizon, very rich in fine roots, very friable, very porous, with a granular subangular structure induced by the fine rooting system. It is within this A_1 horizon that farmers plant with zero-tillage, cucumber (*C. mannii*) and maize (*Zea mays*) after the clearing of old forest. After these crops are harvested, systematic clearing, burning and tilling take place for groundnut and cassava field establishment. The A_1 horizon disappears under this systematic tilling. It reappears when the land is left under fallow for more than 10 years. Figure 2 shows the development of this horizon with the age of the natural fallow.

4.6.2. Chemical soil properties changes

In the two main soils (Ultisols and Oxisols) of the study area, the top 20 cm are significantly ($p<0.05$) affected by shifting cultivation practices involving short fallow systems.

Organic matter: As the length of fallow reduces, the organic carbon decreases, though slightly, and the C/N ratio diminishes significantly (Figure 3):

- Available Phosphorous: The available phosphorous is generally very low in the soils of the whole study area. It is less than 5 PPM in the first 20 cm of the soil profile. But, the decrease in fallow period length increases very significantly ($p<0.01$) its availability in 0-10 cm of the surface layer. The availability of phosphorous in the cropped land is multiplied at least by a factor three after burning of the vegetal material as compared to the values obtained in the virgin forest. The highest values are obtained when the cropped land is opened from a short fallow land. The availability of phosphorous is reduced by the increasing age of the fallow. After about eight years of natural fallow, the situation becomes similar to that of the virgin forest.
- Cation Exchange Capacity (CEC), Bases Saturation Percentage: The CEC is low in all the soils of the area (less than 14 $Cmol^{+}/g$ of soil). It is relatively higher in 0-20 cm layer of Ebom and Nyangong soils. The fallow age has low influence on the CEC, but the general tendency is a decrease in CEC and ECEC in short fallow and cropped land. Bases Saturation Percentage (BSP) increases under shorter fallow. This increase of BSP is more sensible in Ultisols (Ebimimbang soils) with significant differences ($p<0.05$) between cropped land and the virgin forest (FV).

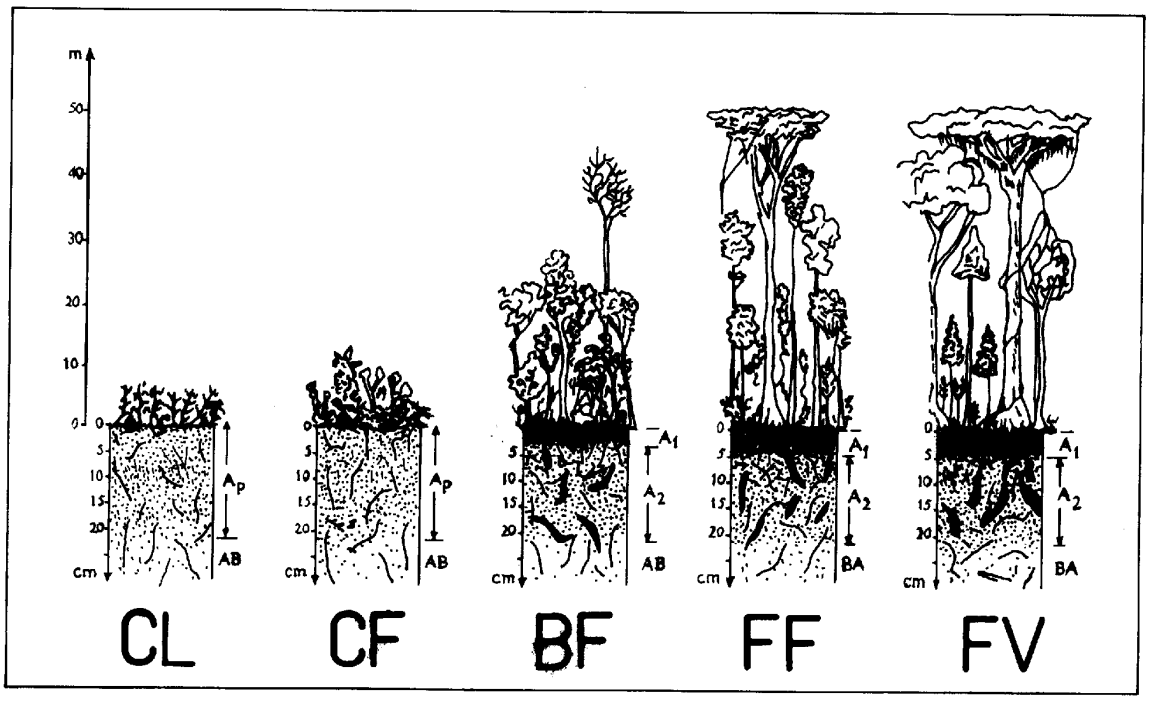


Figure 2. Development of the topsoil layer with the age of the natural fallow (after Yemefack and Nounamo, 1999). CL = Crop Land (based on groundnut-maize-cassava); CF = Chromolaena Fallow (3 to 5 year old); BF = Bush Fallow (7 to 9 year old); FF = Forest Fallow (more than 15 year old); FV = Virgin Forest (control).

- pH and Exchangeable Bases: pH and Exchangeable Bases increase very significantly ($p<0.01$) when land is taken into short fallow practice. They decrease progressively with the fallow age increase. This increase in pH and Exchangeable Bases is ascribed to the effect of ashes from burned vegetation biomass at the beginning of the cropping period, which act as lime fertiliser. The contribution of Calcium in these variations of pH and Exchangeable Bases is about 85%.

- Exchangeable Aluminium: In Oxisols (of Ebom, Mvié and Nyangong) the decrease in fallow length reduces the availability of exchangeable aluminium and therefore the Al-toxicity (Figure 3).

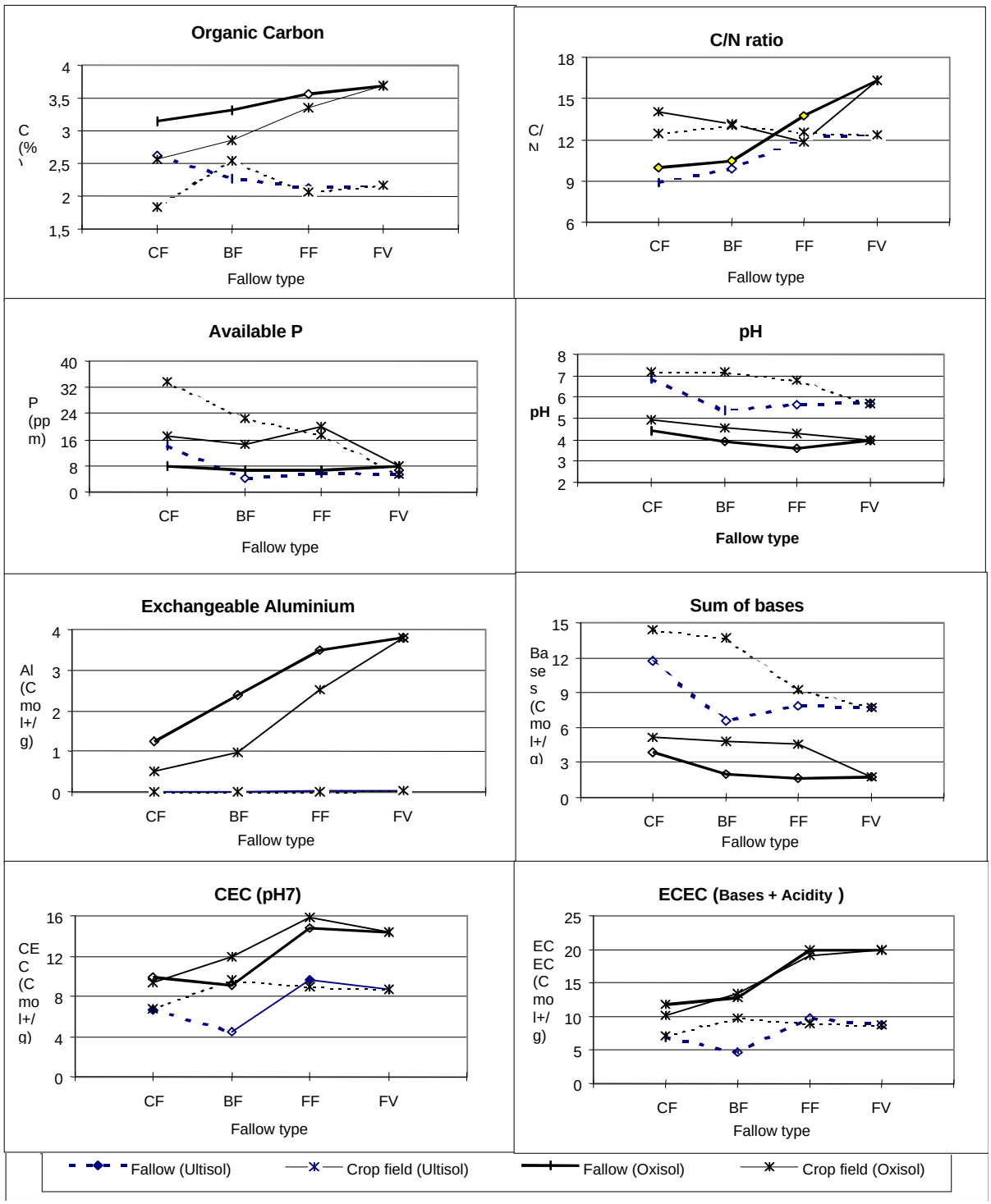


Figure 3: Chemical soil properties (0-10 cm) variation within the shifting cultivation system between fallow type and the adjacent crop field.

4.6.3. Physical soil properties changes

Figure 4 shows that the clay content decreases slightly in young fallow while coarse sand content and bulk density increase significantly ($p<0.05$). These changes are the consequences of the disappearance of A_1 -horizon under short fallow.

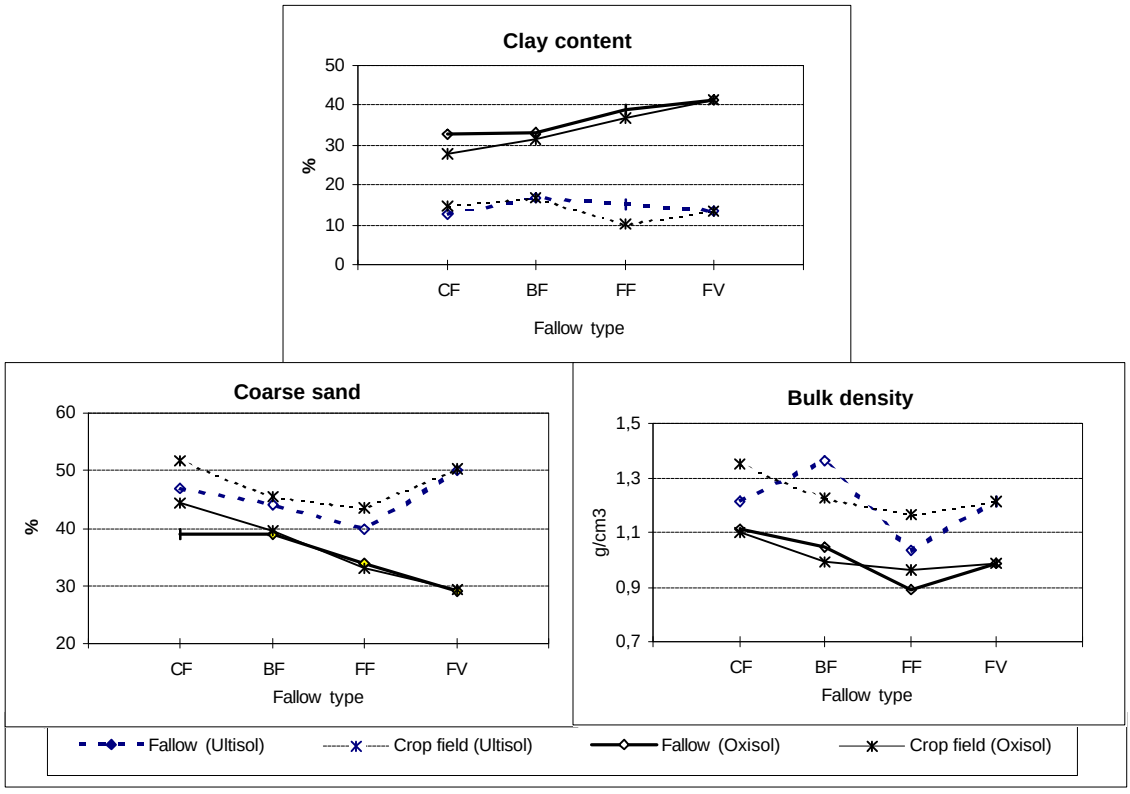


Figure 4. Physical soil properties (0-10 cm) variation within the shifting cultivation system between fallow type and the adjacent crop field.

4.6.4. Soil regeneration, forest growth and species diversification

From clearing a piece of forestland for cropping to the formation of a secondary forest during the fallow period, soil constituents undergo important changes. But the effects of these changes vary from one property to another. The results on the effects of fallow reduction study groups roughly the soil properties in two categories according to their behaviour vis-à-vis the fallow length. The pH, exchangeable bases, exchangeable acidity and available phosphorous are improved under short fallow systems. In contrast, the morphological development of A_1 subhorizon, organic matter, soil texture, and bulk density are relatively degraded under short fallow.

Ashes from burned vegetation biomass at the beginning of the cropping period act as lime fertiliser and influence significantly some chemical soil properties. This liming effect of ashes is reduced by crop harvesting, leaching of cations, and sheet erosion due to heavy and strong rainfalls on bare soil at the beginning of the cropping season. According to many authors (Tulaphitak *et al*., 1980; Prat, 1990), the most important loss of ash nutrients during the cropping period in shifting cultivation takes place in the period between burning and soil surface covering by crops. This process of soil exhaustion continues during the whole cropping period. After two to three years of cropping the land is abandoned for natural fallow.

The beginning of the natural fallow phase constitutes an era of new vegetation dynamics. The natural vegetation grows rapidly, partly from new seedlings, partly from root systems inherited from the previous fallow. The erosion and leaching processes are considerably reduced by the vegetation cover. Besides, the biotic processes between the new vegetation and the soil surface are intensified. Nutrient elements released from litter decomposition are either used immediately by the vegetation in place or added directly to the topsoil. The increase in nutrients content of the topsoil and the humus content occurs simultaneously. The vegetal population develops a dense fine root criss-crossing system in this topsoil horizon to better ensure plant nutrition. This results in the formation of A_1 horizon. This A_1 horizon, although very humic, is very thin (3-5 cm) and its contribution to the organic carbon content of 0-20 cm layer is not enough to provide significant differences between various cover types. In this process of natural reforestation, a number of physical soil properties seem to really benefit from these changes. Also, the soil structure and the porosity of the topsoil layer are highly influenced by erosion and the development of the A_1 horizon. The fine rooting system in this A_1 horizon changes the subangular blocky structure of the eroded topsoil into a porous granular structure.

In this process of natural forest regeneration, species richness of some timber species is highly influenced by the fallow age (Bongjoh and Nsangou, 1999). Species richness was higher in the understorey than in the nearby fallow fields. In general, clearing forest for cultivation reduces drastically scope for species diversification.

5. THE SUSTAINABILITY OF THE PRESENT FARMING SYSTEMS

Shifting cultivation is an agricultural practice where a short period of mixed cropping alternates with a long period of natural fallow. The role of the natural fallow in the system is to recycle nutrient elements for soil fertility restoration and to suppress weeds, pests, and diseases (Nye and Greenland, 1960). As long as there is enough land, the population pressure is low, the road infrastructures are poor, prices for agricultural products are low, and the market is limited, this shifting cultivation will remain an efficient system of soil management. This holds only for subsistence farming since it is difficult to find prosperous shifting cultivators in the evergreen forest of Cameroon.

Soil can recover its optimum equilibrium under natural fallow only if this fallow is left undisturbed for at least ten years after cropping area (Yemefack and Nounamo, 1999). This shifting cultivation system can then be replaced by a “Rotational Fallow System” in which a farmer comes back to a piece of fallow land only after ten years. But, with the actual practice in the area, farmers are more and more shortening the fallow length because of unsuitable land tenure rights, market driving production and soil chemical gains from burned vegetation biomass. More farmers (64%) are clearing Chromolaena fallow (3-5 years) or Bush fallow (7-9 years) for food crop production. In these conditions, the cycle of weed, pests and diseases control, and nutrient replenishment is broken. Physical and organic soil fertility are drastically reduced, the vigour of the forest regrowth also. This renders the shifting cultivation practices unsustainable.

The sustainability of the shifting cultivation practice is a dilemma. On one hand, farmers must produce more for consumption and revenue gain in order to move from poverty subsistence farming to security guarantee and poverty alleviation. On the other hand, shifting cultivation involving clearing long fallow land must be practised to efficiently restore soil productivity after cropping.

For a sustainable management of the forest zone of southern Cameroon, solutions must be found to two main problems: (1) the shortening of fallow length leading to soil productivity degradation, and (2) the sustainable but non-prosperous subsistence farming practice destroying the forest ecosystem:

- Soil productivity conservation: researches have to be carried out on possibilities to intensify crop production within this rotational system. This intensification can be achieved by prolonging the cropping period without complete degradation of soil fertility or by shortening the fallow period by applying improved fallow technologies. To extend the cropping phase, a solution can be found in the Integrated Nutrient management methods defined by Janssen (1993), based on combined application of mineral and organic fertilisers. Improved fallow and agro-forestry technologies are available at ICRAF.
- Prosperous farming: shifting cultivation should move from subsistence farming to income generating farming to guarantee food security and alleviate poverty of the local population. This can be possible if the following subsystems are improved or adopted: land tenure rights and laws, market system, integrated low input and short fallow agricultural system, improved fallow, integrated cropping system and improved animal husbandry, and diversification of farmers' crop. A survey carried out in the area (Table 9) shows the willingness of the farmers to adopt changes in the actual farming system.

Table 9. Farmers' predisposition to innovations in the area.

	Activities				
	New crops	Integration of improved animal husbandry	Agricultural intensification	Bee keeping	Other innovations
Frequencies of responses (%)	97	78	75	60	97

n = 200

6. CONCLUSIONS AND RECOMMENDATIONS FOR SUSTAINABLE FOREST LAND USE

6.1. Conclusions

The study has produced information amongst which the following are to be highlighted in order to provide reliable tools for the sustainable management of the forest zone of southern Cameroon:

- The cropping system is far the most important activity system for the farmers of the area. Animal husbandry comes second in their ranking.
- Dissected plains of Ebimimbang area and undulating uplands are the most important land mapping units for this cropping system.
- Some tree species are used as indicators of suitable or unsuitable lands.
- The food crop production is mainly for the subsistence of the household.
- Due to land shortage, land tenure rights, population pressure, etc., farmers are replacing the expanding shifting cultivation by rotational short fallow.
- Seventy six per cent (76%) of food crop fields rely actually on this rotational system, which consists of rotating in a total area of less than ten hectares.
- Nevertheless, agricultural land is expanding into forest because of the needs for *C. mannii* production. The *C. sativum* variety adapted to short fallow fields may be a good substitute for *C. mannii*. Some farmers are already introducing it.
- Current rate of agricultural land expansion into virgin forest is greater at Ebimimbang and Mvié areas, and the average for the whole area is 2200 m² per household per year.
- An optimum fallow length is at least ten years.

- Needs are raised to intensify this agricultural system, either by improving the natural fallow system or to extend the cropping period using external input such as organic manure or other fertiliser, with the aim to guarantee food security of the local people.
- Non-Timber Forest Products should also be taken into account in the agricultural system. Research must find ways to domesticate them.

6.2. Recommendations

For a sustainable land use of the forest zone:

- Cropping practices must be considered as the prime activity that involves more users of the forest resources.
- This agricultural system must move from subsistence farming to income generating farming. For that, the following subsystems must be improved: market and road system, animal husbandry, etc.
- Crop diversification should be considered.
- Only improvement of the actual system is required, not a complete change of the whole system.
- Research ahead must develop and test sedentarising technologies to improve farmers' unsustainable subsistence shifting cultivation and to link these technologies with socio-economic policies providing disincentives for further deforestation.
- The Government must be sensitised on the necessity to review land tenure rights and laws.

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