TYPOLOGY OF FARMS IN THE AGROFORESTRY SYSTEM OF THE BATEKE PLATEAU IN THE DEMOCRATIC REPUBLIC OF CONGO

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ABSTRACT
In order to contribute to the improvement of crop productivity in the agroforestry system of the Batéké plateau, a typology of farms was carried out in the sites of Mampu and Ibi village, pioneer sites of agroforestry activities in the Batéké plateau.

Surveys were conducted from June to August 2022 on a sample of 183 farmers chosen according to their voluntary participation. Using the R Console Software, multivariate analyses by hierarchical ascending classification (HAC), using the hierarchical clustering method, were performed to determine the different types of holdings.

The results revealed the existence of three types of farms on the site. With regard to the characteristics of these types of farms, the duration of fallow, the number of varieties used, the duration of use of cuttings, the number of weedings, the number of tubers per plant and the yield are the main parameters of their disparity.

In terms of yield, it is 9.5 tonnes/ha, 13 tonnes/ha and 10 tonnes/ha respectively for type 1, type 2 and type 3 farms.

Keywords: Typology, Agricultural holdings, Agroforestry system.

1. INTRODUCTION
Agricultural production must face new challenges not only to meet the needs of an ever-growing population, but also to reduce negative impacts on the environment so as not to jeopardize the availability of resources for future generations. The challenge of making agriculture more sustainable, economically and environmentally, but also more productive and resilient, requires the development of more ecologically efficient cropping systems. In this context, agroforestry is now seen as a land-use option that can help address some of the environmental threats, particularly in tropical countries where forest destruction is a major challenge (Torquebiau, 2002).

In the Democratic Republic of Congo, the savannah area of the Batéké plateau is one of the vast expanses of the country located in the hinterland of the city province of Kinshasa, reputed to be an agricultural area. It is one of the latter's breadbaskets in terms of food supply (Reyniers, 2019).

Nsombo (2016) states that this savannah is covered by a sandy, homogeneous soil, with low biological and chemical activity, characteristic of all sandy soils spread across the tropics. This low biological and physico-chemical fertility is one of the major problems of agricultural production in this region.

To this end, agroforestry is one of the recommended agricultural practices to overcome this problem (Nsombo, 2016; Reyniers, 2014). It refers to a significant number of practices (agricultural, pastoral and silvicultural) and agro-ecological systems that exploit associations between trees and crops, with the aim of maximizing the long-term yields of the production of goods and services essential to humans (Reyniers, 2012).

These practices are inspired by traditional forms of agriculture (Nair, 1991) and are presented as a sustainable form of land use because they are based on the implementation of management practices in accordance with the environment and its agro-ecological, economic and cultural context. (Bene et al., *1977 cited by Mariel* et al., 2016 and by De Rouvroy et al., 2017).

Since the 1990s, agroforestry systems combining cassava and acacia (*Manihot esculenta* and *Acacia spp*.) in the savannah have been experimented with in order to offer an alternative to forest farming systems. These systems were then disseminated in the environmental programs of the DRC and more particularly in the Batéké plateau, based on the various scientific studies highlighting the ecological virtues (Nsombo *et al*., 2016; Peltier *et al*., 2014; Bisiaux *et al*., 2012; Peltier *et al*., 2010; Kasongo *et al*., 2009) of these agroforestry systems.

Among smallholder farmers in sub-Saharan Africa, crop, silvicultural, agroforestry, agropastoral and agrosilvopastoral practices are strongly anchored in centuries-old endogenous knowledge (Yaméogo *et al*., 2005; Walters, 2010; Ordonez *et al*., 2014; Meunier *et al*., 2014; Dubiez et al., 2014, cited in Biaou *et al*., 2016). They aim to reduce food insecurity and poverty, diversify agroforestry goods and services, ensure sustainable production, and rationally manage plant formations and natural resources (Peltier, 1991; Paris *et al*., 2002; Yossi *et al*., 2006; Barrios, 2007; Jamnadass et al., 2013, *cited in Biaou et al., 2016).*

Promoting agroforestry and agroforestry systems on farms therefore involves assessing how these systems contribute to the overall resilience of the farm (Gallopin, 2002).

In the Democratic Republic of Congo, agroforestry is adopted by local populations in many provinces such as Kinshasa (Mampu and Ibi village), Tshuapa (Monkoto) and Kongo central (Luki), to name but a few cases (Bonkena & Miteu, 2020; Mbumba *et al*., 2020; Tackin *et al*., 2019). In Mampu and Ibi village in particular, agroforestry systems are implemented by alternating acacia plantations with food crops such as cassava and maize (Sente, 2011).

Studies show that in the Batéké plateau, many agroforestry projects have been developed. These projects aim to restore soil fertility, increase agricultural production and produce wood energy (Kachaka, 2020).

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However, most of the studies carried out in this regard focus in most cases on the environmental aspect, with particular emphasis on the production of wood and charcoal in the context of improving farmers' incomes (Proces *et al.*, 2017; Bamongoyo, 2016; Bisiaux *et al*, 2012; Reyniers, 2019; Ziegler, 2012; Paul, 2011; Onemba, 2003 ;) and no study has been carried out focusing on the typology of the farms encountered there.
Knowledge of the typology of farms makes it possible to define the target groups concerned, to compare these farms and to judge their functioning, for effective interventions (Mbetid-Bessane *et al*., 2002). This typology will provide decision-makers with an image of the various local agricultural activities with a view to orienting development actions (Arbelot *et al*., 1997).
Thus, in order to better understand these farms and define the types of interventions to be carried out, the present work aims to establish the typology of farms in the agroforestry system of the Batéké plateau.

2. MATERIALS AND METHODS

2.1. Study Environment

Located between 4° and 5° south latitude and between 15°30' and 16°30' east longitude, the Bateke plateau in DR Congo covers an area of about 21,823 km2 and forms the eastern border between the city of Kinshasa and the province of Kwango. It is bounded to the north by the Congo River, which forms the border between DR Congo and the Republic of Congo, and extends south into the province of Bas-Congo, up to the border with Angola (Nsombo, 2016).
The climate of the Bateke plateau, like that of the city of Kinshasa, is of the Aw4 type according to the classification of Köppen (1931) (Bultot, 1950, cited by Nsombo 2016 and Biloso, 2008).
The soils of the plateau are generally Kaolisols of the Arenoferralsols group (WRB, 2006; Sys, 1961, cited by Nsombo, 2016),. The profiles are mineral horizons of the AC type, with a low accumulation of organic matter in the upper layers. These soils with an acidic pH (Khasa et al., *1995) are poor for agricultural practice (Kasongo* et al., 2009; cited by Lubalega, 2016).
The grassy and shrubby vegetation of the Guinean-Congolese genus represents the dominant formation of the landscape of the Bateke plateau.

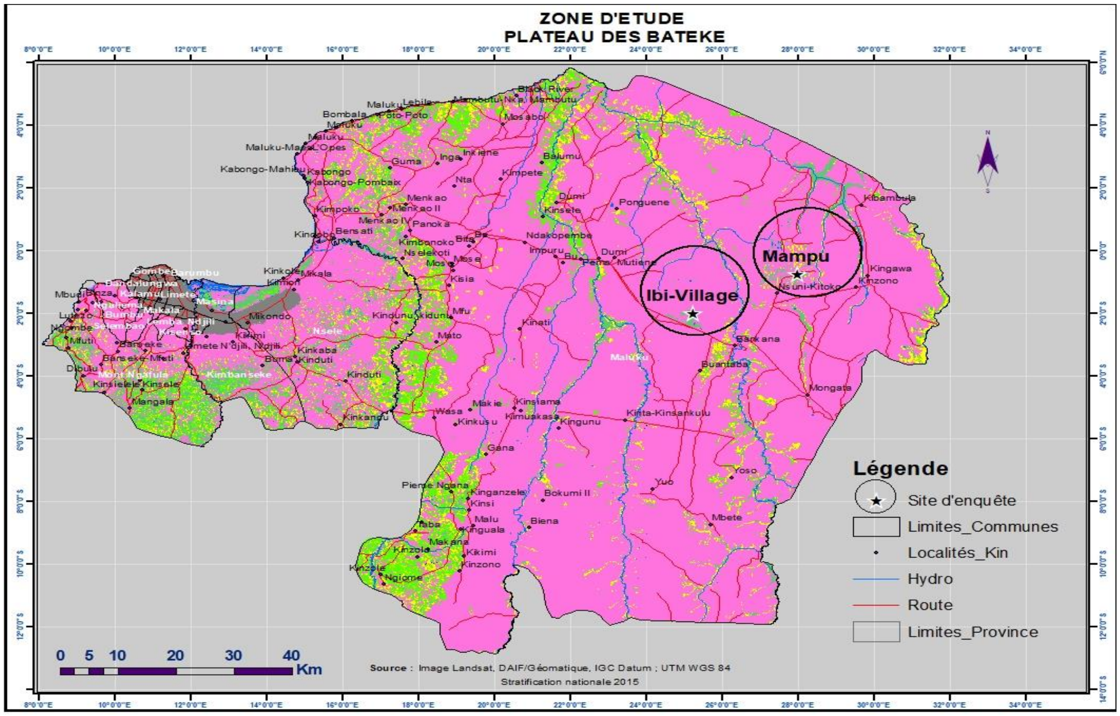

Figure 1. *Location of the study area*

2.2. Methods

2.2.1. Data collection

Both quantitative and qualitative data were collected during the period from June to August 2022 using a questionnaire administered to farmers in order to collect information on socio-demographic characteristics, agroforestry systems and their perceptions as well as cropping systems and technical itineraries practiced.

Farmer selection was conducted using the voluntary non-probability sampling method (Statistics Canada, 2003; Lukombo, 2013). A total of 183 farmers representing 183 farms, including 110 in Mampu and 73 in Ibi Village, were surveyed.

To collect yield data and parameters, we used the yield square approach (Hountondji, 2019; Nijimbere, 2014; Izza, 2017; FAO, 2000). This approach was chosen because of the uncertainties observed during the exchanges on the part of the farmers to estimate the yield.

It consisted of randomly installing or placing squares in peasant fields, which is a naturally uncontrolled environment, materialized by measurement using a tape measure. The yield square size was 5m x 5m and the number varied according to the size of the field (2 to 5 squares laid). Because there were several yield squares on each farm/field, they were averaged (Izza, 2017). The results were extrapolated by hectare.

2.2.2. Statistical analysis of data

Two tools allowed us to analyze the data, namely, the R Console software and the Excel 2016 spreadsheet.

We used multivariate statistical analyses that are commonly used to identify explanatory variables that can help group individuals into homogeneous groups (Alvarez *et al.*, 2018, cited by Ndjadi, 2021). A hierarchical ascending classification (HAC) was carried out for this purpose. The main results of these analyses were to group farms into homogeneous clusters that represent farm types. The hierarchical clustering method was used to obtain the farm types in the study site. The categories of parameters considered for the classification concern socio-demographic characteristics, agroforestry systems and their perceptions of them, as well as cropping systems and technical itineraries practised.

Once obtained, the different farm types were characterized by examining them according to their inherent structure (i.e., descriptive statistics of each variable for each cluster or class) (Mugumaarhahama et al., *2021), followed* by an analysis of the relationship between them (the type of farm) and the other variables deemed relevant by the Chi-square test for categorical variables (Ndjadi et al., 2019) and ANOVA for quantitative variables considered to be main characteristics of different classes obtained.

It should be noted that this typology took into account yield data alone for cassava because it is the main crop and is farmed by all farmers.

3. RESULTS

3.1. TYPOLOGY OF HOLDINGS

3.1.1. Dendrogram cluster of farm types

The figure below shows the dendrogram cluster of different classes (types) of farms encountered in the study site.

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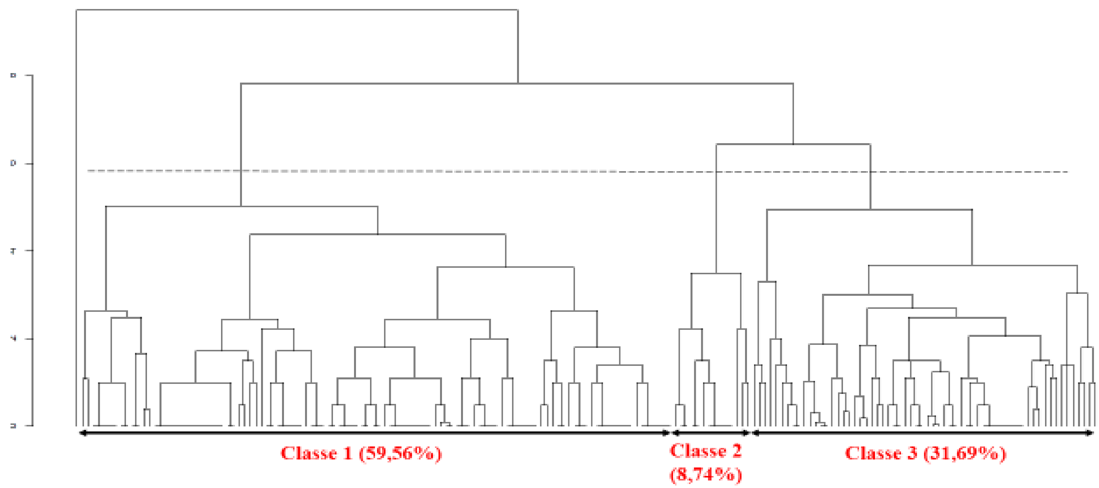

***Figure 2**: Hierarchical Clustering Dendrogram*

The results of the dendrogram cluster reveal the existence of three types or classes of holdings in the agroforestry system of our study site. These are class 1 (CL1), class 2 (CL2) and class 3 (CL3) which represent respectively 59.56%, 8.74% and 31.7% of the farms studied.

3.1.2. Socio-demographic characteristics of operators

The classification of farms according to the socio-demographic characteristics of the operators is presented in Table 1.

Table 1: socio-demographic characteristics of operators

VARIABLE	MODALITY	CL1	CL2	CL3	Tot.	Kh2	P-Value
Gender	Feminine	33,95	25	67,24	43,72	19,55	0,000
	Masculine	66,05	75	32,76	56,28		
Age	> 50 years	49,54	31,2	15,52	37,16	31,45	0,000
	18-28 years old	14,68	6,3	18,97	15,3		
	29-39 years old	4,59	25	29,31	14,21		
	40-50 years	31,19	37,5	36,20	33,33		
Marital status	Bachelor	9,18	6,2	15,52	10,93	6,99	0,136
	Married	84,40	81,3	84,48	84,15		
	Widower	6,42	12,5	0	4,92		
Educational attainment	Upper	8,26	25	5,18	8,74	17,37	0,008
	Primary	22,01	31,2	46,55	30,6		
	None	16,52	6,3	13,79	14,75		
	Secondary	53,21	37,5	34,48	45,91		
Seniority in the site	< 5 years	39,45	43,7	60,34	46,5	11,25	0,023

	> 10 years	55,96	50	29,31	46,9		
	5-10 years	4,59	6,3	10,35	6,6		
Household size	> 10 pers	14,68	18,7	15,52	15,3	13,45	0,009
	1-5 pers	31,2	18,8	55,17	37,71		
	6-10 pers	54,12	62,5	29,31	46,99		
Workforce	Cooperative	5,51	6,3	8,63	6,56	15,01	0,02
	Family	40,37	56,2	67,25	50,27		
	Mixed	35,78	25	12,06	27,32		
	Pay	18,34	12,5	12,06	15,85		
Membership in an organization	No	27,52	25	50	34,43	9,16	0,01
	Yes	72,48	75	50	65,57		
Acquisition Mode earthen	Gift	48,62	56,2	29,31	43,17	33,24	0,000
	Rental	6,43	6,3	0	4,37		
	Sharecropping	33,95	25	22,41	29,51		
	Usufruct	11	12,5	48,28	22,95		

The results presented in Table 1 show that Class 1, which accounts for 59.56% of holdings, is mainly made up of male holders, most of whom are married and over 50 years of age. They are mostly at secondary level and have been in the site for more than 10 years with the number of people in the household between 6 and 10 people. With a workforce made up mostly of family members, most of them belong to at least one organization. The most noticeable mode of land acquisition in this class of farms is by gift and sharecropping for some.

Class or type 2, representing 8.74% of holdings, is made up of men between 40 and 50 years of age, the majority of whom are married and have either secondary education. This class also includes farmers who have attended higher education. They have been with the site for either more than 10 years or less than 5 years. The number of household members, for the most part, varies between 6 and 10 persons and employs either family or mixed labour. Belonging to an organization, the majority of them acquired the land by donation.

Class 3, which accounts for 31.7% of holdings, is mostly made up of women aged between 40 and 50 and between 29 and 39. Married, the majority of them are primary and secondary school graduates who have been on the site for less than 5 years. The majority of their households range in size from 1 to 5 people and employ family labour. Half of them belong to an organization. The usufruct is the mode of acquisition of land in this class.

3.1.3. Perception of agroforestry systems

The classification of farms according to farmers' perceptions of agroforestry systems is presented in Table 2.

Table 2: Classification of Farms by FAS Perceptions

VARIABLE	MODALITY	CL1	CL2	CL3	Tot.	Kh2	P-Value
SAF Benefits	Increases. yield	24,7	56,2	67,24	40,9	34,76	0,000
	Product diversification.	7	5	3,45	8		
	Income Diversification	4,59	12,5	29,31	4,92		
	Subv. Family Needs	65,1	31,2	0	50,8		
		4	5		2		
		5,50	0		3,28		
SAF Disadvantages	Concur. Tree & Culture	4,59	0	25,86	10,9	29,03	0,001
	High cost of SAF	52,3	62,5	50	3		
	Animal Wandering	7,34	6,25	0	52,4		
	Duration of the work	14,6	12,5	3,45	6		
	Reduc. Cultivation area	8	18,7	17,24	4,92		
	Fire risk	13,7	5	3,45	10,9		
		6	0		3		
		7,33			15,3		
					5,46		
Adoption Factors	Increases. yield	28,4	31,2	41,38	32,7	2,99	0,558
	Income Diversification	4	5	39,65	9		
	Profitability	49,5	50	18,97	46,4		
		4	18,7		5		
		22,0	5		20,7		
		2			6		

Increases. = increase product. = Concur production. = Competition Reduct. = subsidy reduction. = subsidy

The results presented in Table 2 show that the majority of farmers belonging to Class 1 farms perceive the advantages of agroforestry systems as income diversification, and perceive a high cost of agroforestry systems as a disadvantage of the latter. Income diversification is a factor that has motivated them to adopt agroforestry systems.

Class 2 farms are mainly made up of farmers who perceive the increase in yield as an advantage of agroforestry systems and the high cost of the latter as disadvantages. This category of farms is also full of farmers who have adopted agroforestry systems by diversifying the income they provide.

Class 3 is made up of farmers who mostly perceive the increase in yield as an advantage of agroforestry systems. Either the high cost of the latter or the competition caused by trees on crops constitute for this class, the disadvantages of agroforestry systems. Increased yield and income diversification are the main factors driving the adoption of these farmers in this class.

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3.1.4. Agroforestry systems encountered in the site

The classification of farms according to the agroforestry systems encountered in the site is presented in Table 3.

Table 3: Classification of farms according to agroforestry systems

VARIABLE	MODALITY	CL1	CL2	CL3	Tot.	Kh2	P-Value
Exploitation of other woody trees	No	33,02	12,5	55,17	38,25	12,78	0,001
	Yes	66,98	87,5	44,83	61,75		
Husbandry Practice	No	58,72	43,75	56,90	58,83	1,27	0,528
	Yes	41,28	56,25	43,10	43,17		
Beekeeping practice	No	75,23	75	84,48	78,14	1,99	0,368
	Yes	24,77	25	15,52	21,86		
Agroforestry practice	Improved fallow	99,08	93,75	98,28	98,36	2,46	0,291
	Interlayer system	0,92	6,25	1,72	1,64		
Arrangement Mode	Scattered in the field	77,06	68,75	63,79	72,13	3,41	0,181
	Online	22,94	31,25	36,21	27,87		
Soil fertility assessment	High	50,46	50	93,10	63,93	34,04	0,000
	Weak	7,34	0	3,45	5,47		
	Average	42,20	50	3,45	30,60		
Reasons for not using fertilizers	Soil depletion	38,53	37,5	29,31	35,52	4,26	0,371
	Use of fertilizer trees	24,77	25	39,66	29,50		
	High cost of fertilizers	36,7	37,5	31,03	34,98		
Cultural Precedent	Improved fallow	99,08	93,75	98,28	98,36	2,46	0,291
	Natural savannah	0,92	6,25	1,72	1,64		

The results in Table 3 indicate that Class 1 farms are characterized by the majority of farms that farm other species in addition to acacias, and many of them do not raise domestic animals or conduct beekeeping. Farmers only exploit food crops and trees with a low rate of those who practice animal husbandry. As noted in all other classes, the practice of improved fallow is prevalent with almost all farmers in this class allowing trees to be scattered in their fields. Soil fertility for them is either high or medium and claim not to use fertilizers because of their high cost and the depletion of the soil they cause. The previous crop used by almost all farmers is fallow, particularly improved.

Like Class 1 farms, Class 2 farms have almost the same characteristics. The difference is that they are made up of farmers who mainly practice domestic livestock farming.

Class 3 holdings are mainly made up of farmers who do not harvest other woody species. Almost all of them believe that the fertility of their soils is high and say that they do not use fertilizers because of the fertilizer trees they cultivate.

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In general, these results demonstrate the existence of three agroforestry systems practiced, namely, the agroforestry system, the agrosilvopastoral system and the other systems (beekeeping)

3.1.5. Cropping systems and technical itineraries

The classification of holdings according to cropping systems and technical itineraries is presented in Table 4.

Table 4: Classification of holdings according to cropping systems and technical itineraries

VARIABLE	MODALITY	CL1	CL2	CL3	Tot.	Kh2	P-Value
Crops Practiced	Cassava	25,69	37,5	31,03	28,42	3,53	0,473
	Cassava-maize	45,87	25	46,55	44,26		
	Man-ms-other	28,44	37,5	22,42	27,32		
Crop Association	No	25,69	37,5	31,03	28,42	1,24	0,537
	Yes	74,31	62,5	68,97	71,58		
Association last season	No	38,53	25	39,66	37,70	1,22	0,541
	Yes	61,47	75	60,34	62,30		
Type of varieties	Improved	96,33	93,75	82,76	91,80	9,35	0,009
	Local	3,67	6,25	17,24	8,20		
Source of seeds	Market Purchase	10,1	18,75	24,14	15,30	17,64	0,001
	Neighbouring	33,94	56,25	50	40,98		
	provenance	55,96	25	25,86	43,72		
	Rest of last season						
Planting date	Early April	11	25	25,86	16,94	28,15	0,005
	Early February	17,43	31,25	0	13,11		
	Early May	1,84	0	1,72	1,64		
	Early March	33,03	25	39,66	34,44		
	End of April	1,84	0	0	1,09		
	End of February	11	12,5	20,69	14,20		
	End of March	23,86	6,25	12,07	18,58		
Row Planting	No	79,82	56,25	68,97	74,32	5,33	0,069
	Yes	20,18	43,75	31,03	25,68		
Weed recovery rate	High	57,80	75	75,86	65,03	10,44	0,033
	Weak	15,60	12,5	17,24	15,84		
	Medium	26,60	12,5	6,90	19,13		

Trouble encountered in the fields	Pests	8,26	6,25	0	5,46	33,06	0,0009
	Expensive cuttings	5,50	12,5	12,07	8,2		
	Concur. acacias	0,92	18,75	10,35	5,46		
	Weeds	20,18	12,5	29,31	22,40		
	Divag. anmx	8,26	6,25	1,72	6,01		
	Lack of framem.	15,6	0	1,72	9,84		
	Dear M.O	41,28	43,75	44,83	42,63		

Concur. = Divag competition. anmx = wandering of supervised animals. = Supervision
M.O = labour Man-ms-other = Cassava-maize-other crop

From Table 4 it can be seen that the farms in class 1 are made up of farmers who grow cassava in combination with maize only, with the use on their farms of improved varieties and seeds/cuttings from the previous season for the majority of farmers. Many of them do not plant/sow in rows and the fields are planted either at the beginning or at the end of March. In this class, the high weed cover rate results in expensive labour as a problem faced by farmers.

Class 2 farms are made up of farmers growing either cassava alone or cassava in combination with maize and other crops. The other crops are chili peppers, cucumbers, squash and cowpeas. As in the other classes, these farms are also dominated by crop associations and use improved varieties. On these farms, seeds often come from neighbours and are planted at the beginning of February. Farmers plant or sow either in rows or broadcast because of the high weed cover rate. Among the problems encountered by farmers, the high cost of labour and competition from acacia trees for crops are identified.

Class 3 farms are made up of farmers who cultivate either the cassava-maize combination or cassava alone. Also combining their crops, these farmers use improved varieties whose seeds have come from neighbours. They plant either in early March or early April for some other farmers. Also included in this category are farmers who do not plant or sow in rows with a high weed cover rate. The problems faced by these farmers include the high cost of labour and the density of weeds in their fields. In this class, farmers push themselves not to sow late.

3.1.6. Characteristics of holding classes

The classification of holdings according to the characteristics of the holdings classes and is shown in Table 5.

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Table 5: classification of holdings according to the characteristics of the holding classes

VARIABLES	CL1	CL2	CL3	P-VALUE
Field area	1.52±0.98	1.87±1.44	1.38±0.95	0,234
Fallow period	7.38±0.87 A	9.18±1.51 b	6.98±0.71 c	0,000***
Number of cassava varieties used	1.21±0.40 A	1.06±0.25 b	1.05±0.22 b	0,012*
Duration of use of cuttings	4.43±1.06A	2.18±1.04 b	1.55±0.56 c	0,000***
Number of weedings	3±0.44 A	3.31±0.47 b	3.24±0.57 b	0,003**
Density/ha	12600±2491	11750±2600.55	12461.5±2642.89	0,47
No. tub./plant	2.91±0.83 A	4±0.75 b	3.42±1.06 A	0,0376*
Tub. weight/plant	0.79±0.30	1.17±0.33	0.87±0.39	0,0784.
Yield/ha	9508.33±2550.9a	13092±1641.4b	10155.07±3169.9a	0,0174*

*Legend: *= significant difference, **= very significant difference, ***= very highly significant difference at 0.05 thresholds; 0.01 and 0.001. Values with the same letters are not statistically different while those without the same letters are different at the 5% significance level of the Tukey test.*

The results in Table 5 show that Class 1 farms have an average area of 1.52±0.98 ha, with a fallow and seed/cuttings duration of 7.38±0.87 years and 4.43±1.06 years respectively. The number of cassava varieties used and the number of weeds are 1.21±0.40 and 3±0.44 respectively. In this type of farm, the average yield is around 9508.33 kg/ha (low-yielding farms).

Class 2 farms have an average surface area of 1.87±1.44 ha, with a fallow period and use of seeds/cuttings of 9.18±1.51 years and 2.18±1.04 years respectively. The number of cassava varieties used and the number of weeds are 1.06±0.25 and 3.31±0.47 respectively. The average yield is 13092 kg/ha (high-yielding farms).

Class 3 holdings have an average area of 1.38±0.95 ha, with a fallow period and use of seeds/cuttings of 6.98±0.71 years and 1.55±0.56 years respectively. The number of cassava varieties used and the number of weeds are 1.05±0.22 and 3.24±0.57 respectively. These farms have an average yield of 10155 kg/ha (medium-yielding farms).

4. DISCUSSION

The aim of this study was to establish the typology of farms in the agroforestry system of the Batéké plateau. Two sites, including Mampu and Ibi Village, were chosen because of their history in agroforestry activities and their importance in the practice of agroforestry.

Generally speaking, the study demonstrates the existence of three agroforestry systems practiced, namely, the agroforestry system, the agrosilvopastoral system and the other systems (beeforestry). These results join those of Mbumba et al., 2020 *on the Luki Biosphere Reserve in Kongo Central and those of Kitanu et al., 2020 in Menkao.*

The results on the advantages as well as the disadvantages of agroforestry systems are in line with Mbumba *et al*., 2020; Lukombo *et al*., 2021; and Boisset, 2005.

The exploitation of other species, in addition to acacias, proves the development of agroforestry in this study area. Nsombo (2016) reports that the development of new sectors such as theplanting of fruit trees (*Dacryodes edulis,* Persea americana, *Mangifera indica*, etc.) and other woody forest species (such as *Maesopsis eminii* and *Millettia laurentii)* approves that the farmer should settle in the area. She adds that the planting of perennial crops, such as fruit trees, and the practice of livestock farming are all indicators of farm maturation and diversification of sources of income.

The crops grown are cassava monoculture and mixed farming characterized by either cassava-maize or cassava-maize-other crops. These results are similar to those found by Kitanu *et al.*, 2020 in Menkao.

The majority of farmers at the site said their soil fertility is high. This is due to the ability of *Acacia sp* to restore soil fertility. These results consolidate the work of Bisiaux et al., (2009), Tartera et al., *(2012), Malézieux et al*., (2009).

The results on the typology demonstrate the existence of three classes or types of holdings in the site of our study. In terms of performance, Type 1 farms have a low cassava yield (9508.33 kg/ha) compared to high-yielding Type 2 (13092 kg/ha) and Type 3 (10155.07 kg/ha) intermediate (medium) yield. These results are similar to those of Razinatou *et al*., (2021) who find 3 types of farms in his study and whose performance varied from one to the other. They are also similar to those obtained by Lufuluabo *et al*., (2021) who found 3 types of farms in Maluku in the DRC whose yield is among the factors of their difference.

Among the factors that differentiate the various farms identified, the most decisive are gender, age, level of education, length of time on the site, household size, workforce, membership of an organization, method of land acquisition, exploitation of other woody crops, assessment of soil fertility, type of varieties, source of seeds, etc. the date of planting, weed cover, duration of fallow, duration of use of seeds/cuttings, number of weeds and yield.

These results complement Lufuluabo *et al*., 2021, who report that the groups of variables capable of differentiating farms are the age of the farm manager, experience, level of education, level of access to resources, area, product diversification, and environmental conditions.

The results on the area of farms (on average of 1.5 hectares) are in line with Bisiaux *et al*., 2009. As for the fallow period in the site, it is on average 7 years. This is justified by the perception of the reduction in the duration of this fallow, which is 8 years in Mampu (Nsombo, 2016) and 6 to 7 years in Ibi village (Emamba, 2022).

The average yield of cassava is 10 tonnes per hectare (10335 kg/ha). This yield is higher than that indicated by the FAO (2014) in peasant areas (8 tons/ha) in the DRC and is in line with that indicated by Badingwaya (2020) cited by Emamba *et al.*, (2022) in the Ibi site. On the other hand, it is lower than that reported by Bisiaux *et al*. (2012) in Mampu (20 tonnes/ha). This yield gap is due to the fact that farmers are no longer supervised or supported, and within those that are grouped together in associations, issues related to the yield increase mechanism are not addressed.

5. CONCLUSION

The overall objective of this study was to establish the typology of agricultural holdings in the agroforestry system of the Batéké plateau. Two sites (Mampu and Ibi village) were chosen because of their history in agroforestry activities.

To achieve our objective, surveys were conducted on a sample of 183 farmers using the voluntary non-probability method. Yield squares were set to collect data on the various related parameters studied. Multivariate analyses were performed on all the data in order to allow us to visualize the results.

The categories of parameters studied for the classification focused on the socio-demographic characteristics of farmers, agroforestry systems, their perceptions of them, as well as cropping systems and technical itineraries.

The results revealed the existence of three types of farms. Type 1 accounts for 59.56% of the site's holdings, Type 2 accounts for 8.74% and Type 3 accounts for 31.69% of holdings.

With regard to their disparity, gender, age, level of education, length of time in the site, household size, labour force, membership of an organization, method of land acquisition, perceptions of the advantages and disadvantages of agroforestry systems, exploitation of other woody trees, assessment of soil fertility, type of varieties, source of seeds, The date of planting, the cover of weeds, the problems encountered in the fields, the duration of fallow, the number of varieties used, the duration of use of seeds/cuttings, the number of weedings as well as the yield, are all parameters that differentiate the three types of farms from our typology.

As regards the characteristics of these classes or types of holdings, the main parameters that caused their disparity were the duration of fallow, the number of varieties used, the duration of use of cuttings, the number of weeds, the number of tubers per plant and the yield.

In relation to yield, type 1 farms, which are dominant in the site, have a low yield (9.5 tonnes/ha) while type 2 farms, which are less dominant in the site, have a high yield (13 tonnes/ha). Type 3 farms, intermediate between type 1 and type 2 farms, also have an intermediate yield (10 tonnes/ha).

REFERENCES

1. Arbelot B, Foucher H, Dayon JF, Missohou A. 1997. Typology of poultry farmers in the Cape Verde area of Senegal. Pupil Med. Vét. Country too., **50**(1): 75-83.
2. Bamongoyo B., 2016. Socio-economic analysis of agroforestry systems in Ibi-village and its hamlets on the Batéké plateau on the outskirts of Kinshasa, Diplôme d'Etude Supérieur, University of Kisangani, Online thesis. https://www.memoireonline.com/03/19/10660/Analyse-socioeconomique-des-systemes-agroforestiers--Ibi-village-et-ses-hameaux-au-plateau-des.html.
3. Bene J.G., Beall H.W., Côté A., 1977. Trees, food, and people: land management in the tropics, Ottawa (Canada), International Development Research Centre, 52 p.
4. Biaou S.S.H., Natta A.K., Dicko A., Kouagou M'M., 2016. Typology of agroforestry systems and their impacts on the satisfaction of the needs of rural populations in Benin, Bulletin de la Recherche Agronomique du Bénin (BRAB), Special Issue Rural Economy and Sociology, December 2016, 43-56.
5. Biloso, M. A., 2008. Valorization of non-timber forest products from the Batéké plateaus on the outskirts of Kinshasa (DR Congo). Ph.D. thesis in agricultural and environmental economics, EIB, Université libre de Bruxelles, 252 pp.
6. Bisiaux F., Peltier R., Muliele J.C., 2009. Industrial plantations and agroforestry for the benefit of the populations of the Batéké and Mampu plateaus in the Democratic Republic of Congo, Bois et Forêts des Tropiques, 301 (3): 21-31.
7. Bisiaux F., Peltier R., Muliele J.C., 2012. Mampu, on the Batéké plateaus, in D.R. Congo, the project that reconciles agroforestry and wood energy production, In: Erosion control: Rehabilitation of tropical soils and protection against exceptional rainfall [online]. Marseille: IRD Éditions, 2012 (generated on 30 August 2020), https://doi.org/10.4000/books.irdeditions.13775.
8. Boisset K. 2005. Prospects for the development of agroforestry in Sarthe. Master's thesis for the title of agricultural engineer. École nationale d'ingénieurs agricoles de Bordeaux, France, 134 p, Consulted on 20/04/2022 http://www.agroforesterie.fr/CASDAR/20062008/rapports0608/R73.pdf.
9. Bonkena B. P., Miteu K. A. R., 2020. Performance of the "Model Farms" of the Monkoto Corridor in the Province of Tshuapa, Democratic Republic of Congo. *European Scientific Journal*, 16(24): 207-232.
10. Chambers R., 1994. The origins and practice of participatory rural appraisal. World Development, 22(7), 953-969, accessed 24/08/2020.
11. De Rouvroy C., Penot E., Le Grusse P., Danthu P., 2017. Income analysis and economic and climatic modelling of agroforestry systems, based on clove trees, in the district of Mananara (Madagascar), Working document Project FORECAST UMR INNOVATION/UR HORTSYS/IAMM,

https://www.researchgate.net/publication/333649898.

12. De Zeeuw H., & Wilbers J., 2004. PRA tools for studying urban agriculture and gender.
13. Dery B., Otsyina B., Ng'atigwa R., 1999. Indigenous knowledge of medicinal trees and setting priorities for their domestication in Shinyanga Region, Tanzania. ICRAF, 87p.
14. Emamba D. M. L., Mbandakulu M. F. M., Fournier A., Malassi J. L., Dembo M.C. Y., Mpia P. N., Mayele D., Kabasele A., Ngongo J., Lejoly J., Manzombi L., Ngulungu P., Mvula P., Kaputu B., Badingwaya R., Mulenda T., 2022. Ibi Village Model: a contribution to the achievement of the Sustainable Development Goals in DR Congo. Ciradd-GI Agro, Edition Feu Torrent, ISBN: 978-99951-641-0-7, 203p.
15. FAO, 2000. Sub-regional technical meeting on methods for forecasting food crop harvests. Synthesis report, AFRISTAT, Bamako, Mali, 128 p.
16. FAO, 2014. Farmer Field Schools on Cassava: Resources for Facilitators in Sub-Saharan Africa, Rome, 233p.
17. Gallopin G., 2002. Resilience: scenarios, surprises and branch bridges. In: Panarchy: Understanding Transformations in Human and Natural Systems. Island Press. Lance H. Gunderson, C. Holling, p. 21,
18. Hountondji E., 2019. Agroeconomic performance of maize production in the taungya system with *acacia auriculiformis* in the classified forest of Itchede-Toffo in the commune of Adja-Ouere. End-of-training report for obtaining a professional license, plant production, Ecole Polytechnique, Université D'Abomey Cavali, Togo, 67p.
19. Intercooperation, 2005. Participatory monitoring and evaluation Field Experiences. Hyderabad: Intercooperation; Delegation – India.
20. Izza I. B., 2017. Relationship between state variables and agricultural yield as a function of cropping practices: the case of the Tougou watershed (northern Burkina Faso). Master's thesis in civil and hydraulic engineering option: infrastructure and hydraulic networks/agricultural water, International Institute for Water and Environmental Engineering (2iE), 106p.
21. Kabambi F., 2010, influence of acacia on the improvement of chemical parameters of sandy soils of Mampu/Batéké plateau, end-of-study work, FacAgro, Unikin, Inédit, 32p.
22. Kachaka E. Y., 2020. Effects of age of Acacia auriculiformis *agroforestry fallows* on soils, crop yields and adoption by farmers in the Batéké plateau, Democratic Republic of Congo. Ph.D. thesis in forest sciences, Laval University, Quebec, Canada, 128p.
23. Kasongo R., Van E., Verdoodt A., Kanyankagote P., & G. Baert, 2009. Impact of *Acacia auriculiformis* on the chemical fertility of sandy soils on the Batéké plateau, D.R. Congo. Soil Use and Management 25, pp: 21-27.
24. Kasongo R.K., Van Ranst E., Verdoodt A., Kanyankagote P. & Baert G., 2009. Impact of *Acacia auriculiformis* on the chemical fertility of sandy soils on the Bateke plateau, D.R. Congo. Soil Use and Management (25). 21 - 27 pp.

25. Kitanu T.T., Biloso A.M., Mbumba B.M., Mayimba C.A., Luvunu P., Mwengi A.I., Lamba M.N., 2020. Analysis of agroforestry systems present in Menkao on the outskirts of Kinshasa. African Journal of Environment and Agriculture, 3(1), 43-48, http://www.rafea-congo.com
26. Lele N.B., 2016. Potential to improve the fertility of sandy and acidic soils in Kinshasa (DRC) through the use of charcoal (biochar), plant biomass and mineral fertilizers. Ph.D. thesis, Regional Postgraduate School for Integrated Development and Management of Tropical Forests and Territories (ERAIFT), 243p.
27. Lubalega T., 2016. Natural evolution of the savannahs defended in Ibi-village, on the Bateke plateau, in the Democratic Republic of Congo. Ph.D. thesis in forest sciences, Laval University and University of Kinshasa, 151p.
28. Lufuluabo M.M., Mobula M.V., Kizungu V.R., Muayila K.H., Typology of family farms and climate change sensitivities: The case of Maluku farms in DR Congo. Africa Science 18(2) (2021)56-68.
29. Lukombo L.J.C., Mumba D.A., Mvunzi N. J., Bwamameyi M., Mudibu W. K. J., 2021. Determinants of Adoption and Strategies for Promoting Agroforestry in Central Africa. *Congosciences*, 9(6), 2021, 108-124.
30. Lukombo J.C.L., Kizungu R.V., Nkongolo C.K., Lumpungu K., 2013. Characterization of cultivation techniques for the production of grain maize (*Zea mays* L.) for the promotion of sustainable agriculture in Gandajika (DRC), Congo Sciences, Vol. 1 (1), 9p.
31. Malézieux, E., Crozat, Y., Dupraz, C. *et al.*, 2009. Mixing plant species in cropping systems : concept, tools and models. A review. *Agronomy for Sustainable Development*, 29(1), 43 - 62.
32. Mariel J., 2016. Analysis of agroforestry systems in the Vavatenina territory in Madagascar: development strategy, peasant perception and resilience. Master's thesis, BIOGET, University of Montpellier, France.
33. Mariel J., Penot E., Michel I., Danthu P., 2016. Analysis of agroforestry systems in the territory of Vavatenina in Madagascar: Development strategies, farmers' perceptions and resilience, https://www.researchgate.net/publication/317065889 accessed 24/8/2020.
34. Mbetid-Bessane E, Havard M, Djamen NP, Djonnewa A, Djondang K, Leroy J. 2002. Typologies of farms in the savannahs of Central Africa. Proceedings of the Colloquium, 27-31.
35. Mbumba B. M., Bitijula M. M., Minengu JDD., Khasa P. D., Mafuka M. M., 2020. Opportunities and challenges of agroforestry in and around the Luki Biosphere Reserve in Kongo Central in the Democratic Republic of Congo. *African Journal of Environment and Agriculture*, 3(1): 23-31.
36. Meunier Q., Boldrini S., Moumbogou C., Morin A., Ibinga S., Vermeulen C., 2014. The Place of Family Shifting Farming in Community Forestry in Gabon, Bois et Forêts des Tropiques, 319 (1): 65-69.

37. Mugumaarhahama Y., Ayagirwe R.B.B., Mutwedu V.B., Cizungu N.C., Wasso D.S, Azine A.C., Karume K., 2021. Characterization of small-scale cattle production systems in South Kivu province, eastern Democratic Republic of Congo. Pastoralism: Research, Policy and Practice, (2021) 11: 4, 15p, https://doi.org/10.1186/s13570-020-00187-w.
38. Ndjadi S.S., Basimine G.C., Masudi G.F., Kyalondawa A.M., Mugumaarhahama Y., Vwima S.N., 2019. Determinants of farm performance in Kabare, South Kivu, Eastern Democratic Republic of Congo, African Agronomy 31 (2): 199 - 212 (2019), 14p.
39. Nijimbere S., 2014. Physico-chemistry of salinity-affected rice soils in the lower Rusizi valley in Burundi. Ph.D. Thesis in Agricultural Sciences and Biological Engineering, Université Catholique de Louvain, 358p, http://hdl.handle.net/2078.1/151616.
40. Nsombo B.M., 2016. Evolution of nutrients and soil organic carbon in the agroforestry system of the Batéké plateau in the Democratic Republic of Congo. Ph.D. thesis, ERAIFT, University of Kinshasa, 198p.
41. Onemba N.S., 2003. The environmental and socio-economic benefits of a planted forest. Case of the 8,000-hectare reforestation project on the Batéké plateau, Kinshasa, Democratic Republic of Congo, National Association for Environmental Assessment, XIIth World Forestry Congress, Quebec City, Canada.
42. Panek J., 2013. Participatory mapping as a tool for community development – a case study Koffiekraal, South Africa. Geographic Perspectives, Appendix 1(25)2-5.
43. Paul C., 2011. Contribution of agroforestry activities to the financial, socioeconomic and environmental sustainability of a carbon sink project in the province of Kinshasa, Research report submitted in partial fulfilment of the requirements for the MSc in Applied Environmental Economics for Distance Learning Students of the University of London, Centre for Development, Environment and Policy (CeDEP), School of Oriental and African Studies (SOAS);
44. Peltier R., Bisiaux F., Dubiez E., Marien J.N., Muliele J.C., Procès P., Vermeule C., 2010. From slash-and-burn cultivation to enriched charcoal-producing fallow land in DR Congo. ISDA, Montpellier, France. 16 p. HAL-00512274.
45. Procès P., Dubiez E., Bisiaux F., Péroches A., Fayolle A., 2017. Production *of Acacia auriculiformis* in the Mampu agroforestry system, Batéké plateau, Democratic Republic of Congo. Bois et Forêts Des Tropiques, 2017, N° 334 (4) Focus/ Agroforestry with *Acacia auriculiformis*, 14p.
46. Razinatou Y.A., Boubacar S., Mahamadou I.S., 2021. Typology of millet and rainfed cowpea producing farms in the rural commune of Karma. Int. J. Biol. Chem Sci. 15(4): 1385-1397.
47. Reyniers C., 2014. The Interactionist Approach for the Analysis of a Village Agroforestry Project on the Batéké Plateau (Democratic Republic of Congo), VertigO - The Electronic Journal in Environmental Sciences [Online], Volume 14 Number 1 | May 2014, published on 05 May 2014, consulted on 25 August 2020.

48. Reyniers C., Karsenty A., Vermeulen C., 2015. Landless peasants and REDD+ in the DRC: local logics in the face of international interventions. REDD+ project in the DRC, Congolese Conjunctures 2015, 28p.
49. Reyniers C., 2019. Agroforestry and deforestation in the Democratic Republic of Congo. Miracle or environmental mirage? Developing Worlds, De Boeck University, 187(3), 113-132, www.cairn.inforevue-mondes-en-developpement-2019-3-page-113.htm.
50. Sente A., 2011. Impact of *Acacia auriculiformis* on the properties of sandy soils of the Batéké plateau, Democratic Republic of Congo. Master's thesis in Bio-engineering in environmental science and technology, Université Catholique de Louvain, 97p.
51. Statistics Canada, 2003. Survey Methods and Practices. No. 12-587-X, Ottawa, Canada, 434p, www.statcan.gc.ca.
52. Tackin Tate K. T., Biloso M. A., Mbumba B. M., Akalakou M. C., Luvunu P., Ikonso M. A., Mukanyimi L. N., 2019, Analysis of agroforestry systems present in Menkao on the outskirts of Kinshasa, *Revue Africaine d'Environnement et d'Agriculture*, 3, 1, 44-49.
53. Tartera, C., Rivest, D., Olivier, A., Liagre, F. & Cogliastro, A., 2012. Agroforestry in development: comparative paths of Quebec and France. *The Forestry Chronicle*, 88(1), 21-29.
54. Yaméogo G., Yélémou B., Traoré D., 2005. Peasant Practice and Perception in the Creation of Agroforestry Parks in the Vipalogo Terroir (Burkina Faso), Biotechnology, Agronomy, Society and Environment.
55. Ziegler A., 2012. Study of the possibilities for improving the cassava production and agro-industrial processing chain in Ibi village (Kinshasa province, DRC). DES in Bioengineering, University of Liège, Gembloux Agro-Bio Tech, Passage des Déportes 2, BP 5030, Gembloux, Belgium.