Macrothink Institute™

Journal of Social Science Studies
ISSN 2329-9150
2022, Vol. 9, No. 2

Yam Cultivation as an Obstacle to Forest Recolonisation in the Subprefecture of Dimbokro

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Received: June 16, 2022 Accepted: August 23, 2022 Published: November 23, 2022

doi: 10.5296/jsss.v9i2.20486 URL: https://doi.org/10.5296/jsss.v9i2.20486

Abstract

As the first cocoa loop, the Dimbokro region was an area of heavy logging. After the collapse of this first cocoa loop around 1980, the population of the Dimbokro subprefecture invested in yam cultivation. However, it has been observed that despite the cessation of intensive cocoa and coffee production in favour of yam cultivation, the forest that had disappeared has still not been able to recover. It is therefore necessary to know what is causing this situation. The study aims to show the causes of the difficult forest recolonisation in the subprefecture of Dimbokro. Through field investigations, the use of various documents consulted, the contribution of remote sensing and the analysis of statistical data, the negative impact of yam cultivation on the forest of the Dimbokro sub-prefecture, which is unable to recover, has been

demonstrated. The importance of yam cultivation for the population of Dimbokro and the harmful effects of the cultivation system used by local farmers are explanatory factors. Thus, forest recolonisation remains difficult, if not impossible.

Keywords: environment, forest recolonisation, yam, factors, cultivation, farmers, Savannah, slash-and-burn

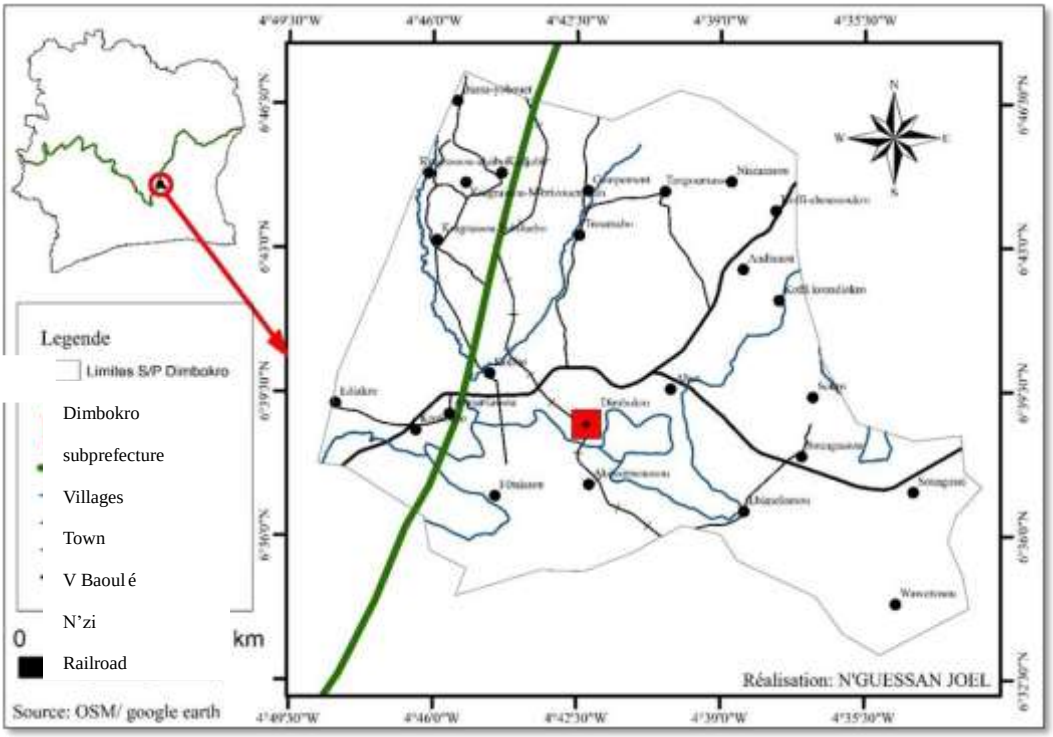
1. Introduction

Dimbokro area was the main coffee and cocoa producing region from 1960 to 1980. Known as the 'cocoa loop', this region enjoyed real prosperity thanks to the income derived from the coffee-cocoa binomial (KAKOU, 2013, p8). However, the serious financial crisis that began in the late 1970s due to the fall in world coffee and cocoa prices seriously affected coffee and cocoa production in Dimbokro (BEKER and N'GUESSAN, 2004 p2). In addition, the degradation of ecological conditions favourable to coffee and cocoa crops will lead to the decrease in the cocoa loop (ALOKO, 2014, p309). As a result, part of the population will migrate to the forest areas. Motivated by a policy of diversification, the people who stayed behind, began to cultivate rubber trees, oil palm, cashew nuts and rice (BEKER and N'GUESSAN, 2004, p2). Unfortunately, this diversification policy did not have the desired effect, because after a few years, yam cultivation alone occupies about 80% of the cultivated areas in the Dimbokro sub- prefecture. However, it is clear that despite this agricultural transformation from coffee and cocoa production to food crops, mainly yams, the forest is still not recovering. Thus, the present study aims to show the causes of the difficult forest recolonisation in the subprefecture of Dimbokro.

2. Materials and Method

2.1 Introduction to the Study Area

The subprefecture of Dimbokro is located between longitudes 6 °45'33.99", 6 °35'38.37 North and 4 °48'56.14", 4 °31'28.74" West (map 1).



Map 1. Presentation of the Dimbokro subprefecture

Dimbokro subprefecture has enormous natural potential. Among them, the V Baoulé, which offers 2 types of vegetation, namely forest at about 75% and savannah at 25%. The hydrographic network marked by the N'zi river which drains it from the East to the South West. In addition, the road network is composed of a main road and several secondary roads allowing the evacuation of agricultural products. These potentialities make it possible to grow many crops, the main one being yams.

2.2 The Data

The data we used in this article is several kinds. They are satellite images, cartographic data, statistical data, and field survey data:

- Landsat satellite images of 24-12-1988 and 01-01-2018 obtained from the website www.earthexplorer,usgs.gov

- A base map of the Dimbokro subprefecture at a scale of 1/5000; produced by the

National Institute of Statistics (INS) in 2014;

- Household data for the different villages in the Sous-préfecture obtained from the

National Institute of Statistics (INS) in 2014;

- Data on tools for agricultural practices;

- Data on socio-professional status;

- Data on the crops grown.

2.3 Methods of Data Collection and Processing

Given the absence of a statistical database on the agricultural sector at the level of the sub-prefecture, data collection was based essentially on documentary research, direct observation, surveys with interview guides and quizzes. The documentary research made it possible to draw up a report on agriculture and vegetation in the Dimbokro sub-prefecture. The direct observation consisted in visiting fields and some fallow lands, which allowed to see the reality of the field and to understand the studied phenomenon. The direct observation and documentary research were supported by quizze and interview guide surveys. They targeted agricultural households (head of household) and the authorities in charge of the agricultural and forestry sectors. The surveys made it possible to obtain statistical data on the tools used, the areas cultivated, the socio-professional situation of the farmers, support and supervision.

To achieve this, the reasoned choice and quota methods were used. Thus, based on the position of the locality in the rural forest area, and the volume of households per village, 6 villages were selected, which is equivalent to 27.27% of the localities of the sub-prefecture. The selected localities are: Campement, Troumabo, Tangoumansou, Soungassou, Ahua, Ebimolossou.

To determine the sample size of agricultural households the following mathematical formula was used.

$n = \frac{z^2(PQ)N \times Q}{e^2(N-1)+(PQ)}$ With *n*: sample size, N: size of the parent population (848), Z: margin coefficient, E: margin of error, P: proportion of persons assumed to have the characteristic sought. This proportion varies between 0 and 1 and is a probability of occurrence of an event. In the case where no value of this proportion is available, it is fixed at 50% (0.5). Q = 1 - P.
- Application of the formula

Assuming that P = 0.50, then Q = 0.50; At a 95% confidence level, Z = 1.96 and the margin of error e = 0.05.

$$n = \frac{1{,}96^2(0{,}5 \times 0{,}5)848 \times 0{,}5}{0.05^2(848-1) + (0.5 \times 0.5)}$$

n = 172 Households

To determine the number of households to be surveyed per village, we opted for the quota method. Since households in different villages are not quantitatively equal, then the proportion of households to be surveyed for each village should correspond to the proportion of each village in the total population. Thus, Table 2 shows the number of households to be surveyed per village according to the quota sample.

Table 1. Distribution of villages and households surveyed

Villages surveyed	Number of households	Number of households surveyed
Ahua	244	48
Camp	10	2
Ebimolossou	235	47
Tangoumassou	144	28
Troumabo	70	14
Soungassou	165	33
Total	848	172

Source : RGPH, 2014

The choice of households surveyed was based on certain criteria in order to collect data that would allow the analysis of the evolution of forest cover and cultivation practices. The age criterion made it possible to survey farmers who had witnessed the evolution of vegetation cover and cultivation practices. The age ranges for these heads of household varied between [70; 43] and [43; 15], which made it possible to understand and understand the recent evolution of cultivation practices and to appreciate the evolution of vegetation.

In addition, the satellite image data have been processed in various ways, as summarised in the table2.

Table 2. Processing of satellite images

Steps / Images Satellites	Radiometric calibration	Correction Atmospheric	Classification Supervised	Vectorization	Dressing
Landsat 7 24-12-1988	Yes	Yes	Yes	Yes	Yes
Landsat 8 01-01-2018	No	No	Yes	Yes	Yes

www.earthexplorer.usgs.gov

All processing was carried out on Erdas Imagine 2015 software, with vectorisation and dressing on ArcGIS 10.5. The GPS points surveyed during the surveys were used for supervised classification by maximum likelihood.

3. Results

Yam, cassava, chilli, eggplant and groundnuts are the most common food crops grown in the Dimbokro sub-prefecture. Farmers combine these crops on the same plot of land in a slash-and-burn system. However, priority is given to yams, which provide daily food and often foreign exchange earnings.

3.1 The Importance of Yam in the Socio-Economic Life of the Populations of the Dimbokro Subprefecture

The overall perception of the changing role of yam cultivation is complex, as it is linked to several factors (socio-demographic, economic, pedoclimatic...) that are not always easy to identify. Thus, in general, yam is the main crop of the farmers in the Dimbokro sub-prefecture. Indeed, 100% of the farmers surveyed own at least one plot of yam, the size of which varies according to their socio-professional situation. Thus, for farmers with a second activity outside agriculture, the size of the field is very often between 0.25 ha and 1 ha. For those whose only activity is farming, the field area is between 0.5 ha and 2 ha. This is not always the case, as some people use their administrative earnings to obtain labour to expand their fields. It should also be added that the role of yam changes according to the socio-professional situation and the Size of the harvest. For most farmers engaged in other activities, the yam crop is only for consumption. For the other category, the role of the harvest is conditioned by its quantity. That is, when the harvest is good, part of it is for consumption while the rest is for sale.

Even though, people who only grow yams engage in other activities such as hunting and charcoal making, these activities do not have the capacity to fill the gap left by the total dependence of their agriculture on natural conditions that are not always favourable.

It should therefore be stated that the role of yam cultivation for those who practise, it changes according to the socio-professional situation, the objectives and the natural conditions.

3.2 Yam Cultivation Techniques at the Root of Deforestation

Cultivation of any plant follows a precise system using its own tools. Our investigations revealed that slash-and-burn agriculture is used in Dimbokro.

3.2.1 Description of Slash-and-Burn Agriculture in Dimbokro

There are several definitions of slash-and-burn agriculture. The one most often referred to is proposed by CONKLIN (1957) quoted by CARRIÈRE (1999, p 17). Thus, slash-and-burn agriculture is described as 'any agricultural system in which fields are cleared by fire and cultivated for a short period of time before being left fallow, usually in forest areas, for a long period of time. This is the system used by yam farmers in the Dimbokro Sub-Prefecture. More precisely, slash-and-burn agriculture used in yam cultivation in Dimbokro works as follows: first, the plot is grubbed with a machete, then fire is used to burn the grub on the spot. Then the roots are removed, followed by earthing up, sowing, harvesting and fallowing of the plot. The tools used are rudimentary, as can be seen on Plate 1.

Picture 1: Farmer working with a hoe

Picture 2: Using fire to kill a tree

Board 1. Tools used in yam cultivation

Source: N'GUESSAN P Jo el, 2018

Picture 1 shows a farmer making mounds with a hoe. The second photo shows a second use of fire, which consists of burning the tops of the trees on the plot to kill them and let in the sunlight. Slash-and-burn agriculture consists of clearing the space for the fields with machetes. Once this is done, the farmer sets fire to the cleared and dry land to improve the quality of the soil. Then they use hoes to plough or to make mounds for the yam cuttings. In such a plot, the farmer often combines maize, chilli, eggplant and tomato. After the harvest, the plot is left fallow so that it can recover. The farmer either takes another plot the following year or does the same thing again, and so on year after year, to the detriment of the vegetation. In short, it is the practice of slash-and-burn agriculture in yam cultivation that prevents the forest from recovering. Thus all 171 households surveyed use the hoe, machete and fire in a slash-and-burn system. All of this follows the cropping schedule shown in Table 3.

Table 3. Agricultural calendar for yam

	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug	Sept.	Oct.	Nov.	dec.
Clearing	Ev	Ev	Lv	Lv	Lv							
Buttressing				Ev	Ev /Lv	Lv	Lv					
Planting and mulching						Lv	Lv					
Staking						Ev /Lv	Lv	Lv				
Weed control						Ev/Lv	Lv	Lv				
Harvest	Lv								Ev	Ev		Lv

Source: Personal survey, 2018 Inspired by BAKO Ferdinand, 2002, p44

The sowing period for yam extends, for the late variety (Lv), from mid-March to July. For the early varieties (Ev), sowing is done from the first rains in March. Harvesting takes place in September for early varieties and from December to January for late varieties. Harvesting

often goes on until March for the late farmers. It should be noted that several varieties of yams exist in the Dimbokro sub-prefecture. It is according to these that the harvests are made. Thus, in the early yam family, the earliest varieties are harvested from mid-July and the least early ones are harvested until October. These varieties are harvested twice in the same growing season. The first is for household consumption (August-October). The second is used as seed for the future field. All this work follows the clearing phase, which takes place from February to March. While yams are the dominant crop in cropping associations or crop rotations, this is not the case for field crops. In the latter case, sowing is done at the same time as early yam sowing.

In sum, the technique used by the yam farmers of the Dimbokro subprefecture is at the root of the difficulty of forest recovery.

3.3 Difficult Recolonisation of the Forest in the Dimbokro Subprefecture

This part of the study is based on the analysis of satellite imagery. The analysis of satellite images allowed the detection of changes in the evolution of each type of land use over time.

3.3.1 Land Use from 1988 to 2018

First, the different types of land use were identified and then the extent of each of these land uses was measured by determining the changes that have taken place over the years. Table 4 presents the land use with details of the land use types, the area in ha and the percentage proportion of each land use type.

Table 4. Evolution of land use areas

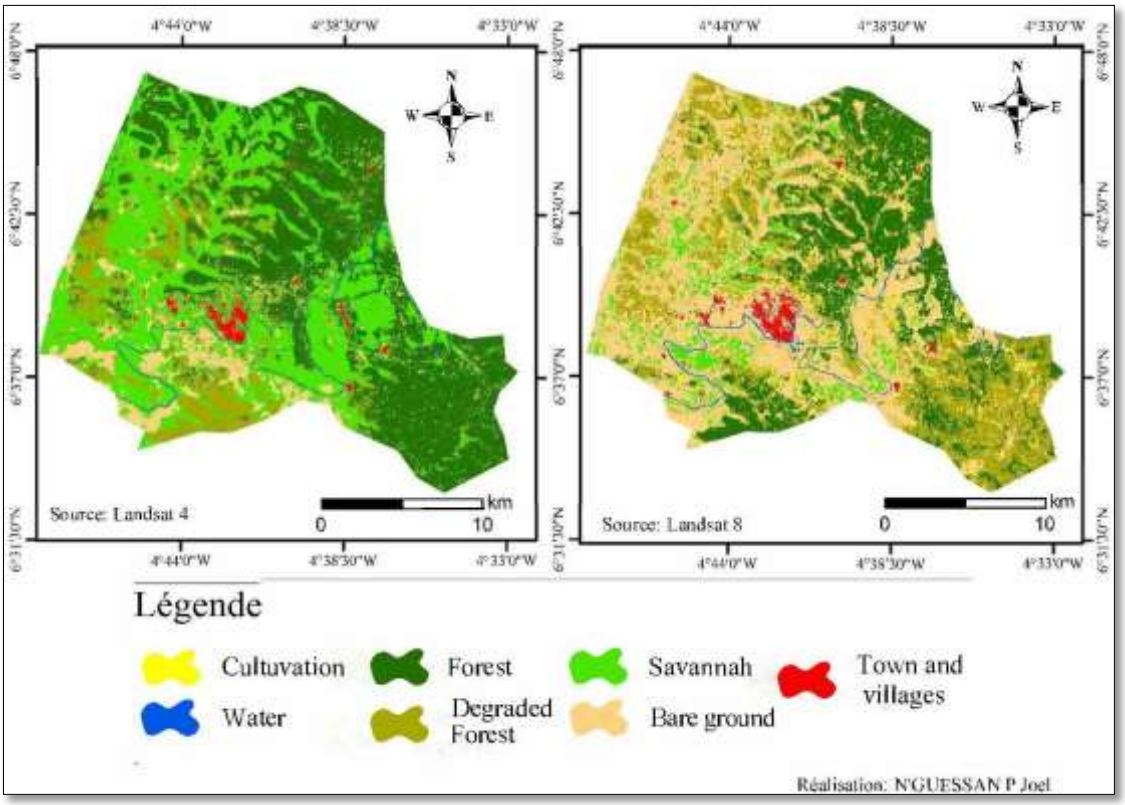
Types of landuse	Area in (ha)		
	1988	2018	
Forest	18 586.636	10 427.13	-8159.506
Degraded forest	5 164.042	10 551.69	5387,648
Savannah	16 612.299	2 901.06	-13 711.239
Culture	1 025.791	2 052.09	1 026.299
Bare ground	2 995.253	18 130.59	15 135.337
Towns and villages	658.085	700.11	42.025
Water	325.956	616.23	290.274

Source: www.earthexplorer.usgs.gov, Landsat 4 24-12-1988 and Landsat 8 01-01-2018

Land in Dimbokro Subprefecture was largely occupied by mesophilic forest in1988 (18586.63 ha). It is followed by savannah, the proportion of which is close to that of the forest with 16 612.299 ha. Next comes degraded forest with 5 164.042 ha. The smallest

proportions are bare land (7%), water, the town and villages, each with 1% of the land corresponding to

2 995.253 and 658.085 ha and 325 ha respectively. 30 years later, i.e. in 2018, the same types of land use are counted, but in different proportions than in 2018. Thus1988., in 2018, bare land dominates with a surface area of 18,130.59 ha or 40%. Next come forests and degraded forests with 23% each, corresponding to 10 427.13 and 10 551.69 ha. They are followed by the savannah which has experienced a significant regression with a surface area of ha 2901.06. There has been a growth in cultivated land, which now covers ha 2 052.09. Finally, water and inhabited areas with 616.23 and 700.11 ha. Map 2 shows these land uses are distributed over the two years.

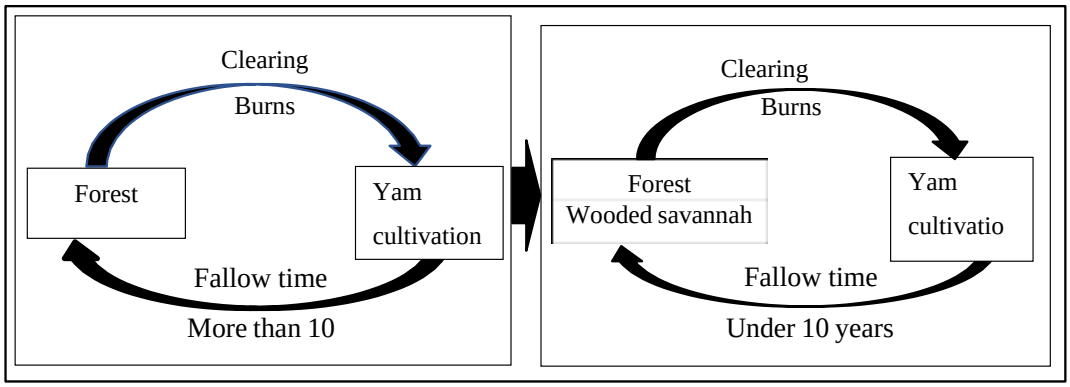


Map 2. Land use from 1988 to 2018

Map 2 shows the land use of the Dimbokro subprefecture in 1988 and 2018. On the 1988 map, we can observe the presence of a mesophilic forest. This forest is made up of very young trees. It results from the fall of the cocoa loop and the agricultural and socio-demographic changes that followed. Indeed, the fall of the Dimbokro region as a cocoa production area led to the departure of several planters to new production areas. The remaining populations then gradually abandoned cocoa cultivation in favour of crops such as oil palm and, above all, yams. The low density of the population having almost abandoned cocoa and coffee, which requires a lot of space, has led to a small recovery of the forest. This gives us a coverage of 41% of the total area of the Dimbokro sub-prefecture. However, this forest is not mature and is again subject to increasing anthropic pressure. The results of this anthropic pressure, this

time characterised by the cultivation of yams in a slash-and-burn system, are clearly visible on the 2018 map.

The simultaneous observation of the two maps makes it possible to apprehend the changes made over the 30 years in the different types of land use. The area of forest in 1988 was almost halved. Thus, it went from ha 18 586.636 to ha 10 427,13, a loss of ha 8 159.506 in the space of 30 years. The main factor in this conversion from forest to savannah, from degraded forest to bare soil, is the cultivation of yams. According to the farmers' perception, the forest is suitable for the yam fields. Indeed, the forest allows good yields and the work is reduced at the level of staking, thanks to the presence of trees, which unfortunately are stripped of their leaves by the farmers who apply fire to their tops. If we estimate the average area of yam field in the subprefecture to be 0,5 ha, which we multiply by the number of farming households in the subprefecture of Dimbokro. This gives an estimate of the area of forest cleared each year in Dimbokro. Thus, the area of forest cleared = 3 631 X 0.5 ha = 1 815.5 ha/year. This is equivalent to 4.02% of the total area of Dimbokro subprefecture and 10% of the total area of forest present in 1988. So, losing 10% of the forest area, and even more every year when we know that the perfect reconstitution of a plot left fallow lasts 10 to 30 years depending on the climate (CAMARA, 1997, p8). It can be seen that from 1998 onwards, the Dimbokro subprefecture no longer had any completely reconstituted fallow land, and therefore, no more young forests. The figure shows figure 1 the summary diagram of the impossibility of forest recolonisation in the Dimbokro sub-prefecture.



Source: N'GUESSAN P Joel, 2019 Inspired by: Guillemen, 1956

Figure 1. Summary 1diagram of the difficult forest recolonisation

The first phase presents a slash-and-burn system in which the starting point is a young forest resulting from fallow during the period of high cocoa production. This period is marked by good production, low anthropic pressure and fallows that have ample time to recover (more than 10 years). This allowed farmers to return to the same plot a little more than a decade later and have good production. It started well before 1988 and stopped in 2000.

The second shows the same system, the starting point is always a young forest that is cleared and burnt for the cultivation of yams. However, some disturbances resulting from strong anthropic pressure have led to the expansion of cultivated plots, the shortening of the fallow period to less than 10 years and therefore the impossibility for the forest to recover, leading

toa wooded savannah which becomes the starting point of the same process. In short, it is from this process, with the end result of a plot of land that cannot be reconstituted and put back into cultivation, that the impossibility of forest reconstitution in the subprefecture of Dimbokro results.

4. Discussion

Food crop farming in Dimbokro uses rudimentary tools (hoe, machete, axe, pickaxe) and the cultivation system used is slash-and-burn agriculture. This is a system where the farmer clears the forest or savannah before setting fire to it. He then uses the plot for a few years before leaving it for a more or less long rest (fallow) while the plot regenerates. The main food crop grown in Dimbokro is yam, with which several other crops such as maize, cassava, groundnuts and okra are associated.

The importance of yam is not the same everywhere. Indeed, the changing role described above for the people of the Dimbokro subprefecture is totally different from the role that the people of Midébdo in Burkina Faso give it (DOLI, 2015, p46). Therefore, regardless of the quantity of the harvest, yam is essentially used for consumption and marketing. As such, it is the main cash crop for these populations. In addition, yams play a ritual and spiritual role for some peoples. Thus, for these peoples, yams are often offered as wedding gifts, or are offered to the gods to appease them. It is in this context that yam plays an important role in rituals such, as weddings and annual festivals, to the extent that BACO et *al* (2007) quoted by ADIFON et *al*, (2019, p11) state that yam has a significance that goes far beyond that of other cultures in the tropics. They present a reverse situation of role of yam, where the varieties grown are conditioned by the role it plays. Thus, some yams are grown specifically for the culinary quality of the tubers, productivity, commercial value, ease of propagation, quality of pods, earliness of tuberization, preservation, ease of cultivation, role in food and importance for ritual ceremonies (ADIFON et *al* 2019, p11).

However, the displacement of fields with the use of fallow land, the term of which is getting shorter every year, has led to an impossible forest recolonisation in the Dimbokro subprefecture. Thus, according to DOUNIAS et *al* (2000, p69) the detractors of slash-and-burn agriculture blame it for 70% of deforestation in Africa, 50% in Asia and 35% in Latin America. FLORET et *al*, (1993, p13) make the same analysis but focus on fallow time. They highlight the shortening of fallow time, which not only prevents the biomass and other nutrients of the soil and vegetation from being replenished. But, to achieve the prevention of reforestation, deforestation would have to take place first. Thus, SEMEKI (2005, p10) describes that in the N'djeli-Brasserie fire station or slash-and-burn agriculture intended solely for self-consumption is the main cause of deforestation. But this situation is not quite the same everywhere. Indeed, BOUET (1972) reveals the inability of small-scale food crop farmers to deforest a heavily forested area. This is the same observation made by FEARNSIDE (1991, p247) in the Brazilian Amazon where farmers are unable to trigger deforestation despite the cultivation system used, which is nothing other than slash-and-burn agriculture. This same idea is defended by TSAYEM and MANUSSET (2008, p8) when they quote DOUNIAS, (2000), ROSSI, (1999) and GELY (1984). These authors show that studies conducted by ethnobotanists and

anthropologists in particular emphasise the benign and non-disruptive nature, in the ecological sense, of this agricultural system as it is traditionally implemented by the indigenous populations of tropical forest regions. And that the Amerindian and Black Maroon communities indicate that felling is part of the "natural sylvigenetic" cycle and respects the balance of the environment. Furthermore, according to CARRIÈRE (1999, p211) the slash-and-burn agriculture practised by the Ntumu in Cameroon plays a positive ecological role, which consists of modifying the floristic composition of the future forest thanks to the spared trees that serve as a perch for dispersal birds.

Impossibility of forest recolonisation highlighted in our study results from the increasing practice of yam cultivation, and especially from the very considerable reduction in fallow time, which does not allow it to have the expected effect of reconstituting the vegetation. This is the same state of affairs described by MASSE et *al*, (1998, p323) in relation to the reduction of fallow time, which does not allow the soil to recover its physicochemical and biological fertility.

5. Conclusion

In a subprefecture with a declining economy such as Dimbokro, food crop farming is proving to be an escape route from evils such as food insecurity, famine and banditry. However, food crop farming is confronted with the thorny problem of deforestation which worsens the food situation. This study presented the characteristics of food crop farming in Dimbokro, which are the use of rudimentary tools such as the hoe, the machete, the pickaxe and the axe. The main crop in this area is yam, with several other crops such as cassava, maize, okra and groundnuts. The system used for this practice is slash-and-burn agriculture. The annual displacement of fields and the shortening of fallow periods make it impossible to recolonise the forest. This situation raises the alarm about the regression of the forest cover multiplied by yam cultivation.

Cultivating yams in the forest zone ensures good yields, whereas it is precisely this forest that disappears every year and cannot be reconstituted. So, it is time for the authorities and the population to find a solution to reconcile food agriculture and forest protection.

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