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Importance of Combretaceae in the Woody Stands in Groundnut Basin Lands (Region of Kaffrine, Senegal)

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Abstract

It was established that the importance of Combretaceae varied in the Groundnut Basin lands from identification and inventory of trees, shrubs and seedlings in the woody stands. The family consisted of nine species in four genera. The genus Combretum was more represented (5 species), followed by Terminalia (2 species), Guiera (1 species) and Anogeissus (1species). Combretum glutinosum represented 85% of the total size (2202 individuals). It was followed by Guiera senegalensis with 11.2% (289 individuals). The other species had a frequency below 2%. The family of Combretaceae reflected a population which functional organization was focused by Combretum glutinosum. The stand structure (basal diameter classes and height) indicated that it was mostly young. The regeneration potential was significant for Combretum glutinosum and Guiera senegalensis while for other species, it was compromised.

Keywords: species –presence of species - structure - regeneration rate

Introduction

The vegetation of the Groundnut Basin is a savannah (Nye and Greenland, 1960). The harsh climatic conditions and anthropic pressures on the natural woody in particular clearings for cultivation have caused a progressive deterioration of woody resources (Touré, 2002; Sanogo, 2000; Coly et al., 2011). The ecosystems are thus increasingly vulnerable and threatened. In this context, despite its still quite diverse floristic composition, the woody is currently dominated by Combretaceae (Bakhoum et al., 2012; Bakhoum et al., sous presse).

It is then necessary to restore and / or to rehabilitate degraded ecosystems through the reintroduction of the tree in the agricultural landscape to better conserve, enhance and manage existing resources to improve livelihood (Belsky et al., 1993; Lawesson, 1990; Diack et al., 2000). In this perspective a good knowledge of the environment in particular the acquisition of relevant information on native species is required (Agbangba et al., 2011). This paper examines the importance of Combretaceae in the South-eastern village lands of the Groundnut Basin in Senegal.

Material and Methods

Site Location

The study was conducted in the Groundnut Basin in Senegal, precisely in the departments of Koungheul and Kaffrine located between longitudes 15 ° 86 'W and 14 ° 58' E and latitude 14 ° 74 'N and 13 ° 74' S (figure 1). The climate is Sudano-Sahelian with a rainy season of short duration ranging from June-July to October and a long dry season from 8 to 9 months. The monthly average temperatures minimum and maximum are respectively 18.2 ° C (January) and 40.7 ° C (April). The average annual temperature is 29.6 ° C.

The analysis of rainfall series 1958-2008 showed that the interannual average rainfall was 640 ± 171 mm. The coefficient of variation was 27%.

The minimum rainfalls were recorded during the year 1979 (408 mm), 1980 (443 mm) and 1983 (437 mm) and the highest in 2006 (910 mm) and 1999 (895 mm). The average rainfall duration was 45 days.

The comparison of the annual precipitation to the interannual average rainfall allowed to show that one year out of two was dry (47% exactly). It also identified the year of failure in the series to 1967 (Figure 2).Thus, two periods could be considered (figure 2):

• the first period from 1958 to 1967, was characterized by years where rainfall was generally above interannual average rainfall: it was the wet period. The average rainfall was 729 ± 182 mm or a variation of 25%;

• the second period, from 1968 to 2008, was characterized by a succession of rainfall deficit years (23) . The average rainfall was 619 ± 162 mm. The variation was 15% over the previous period.

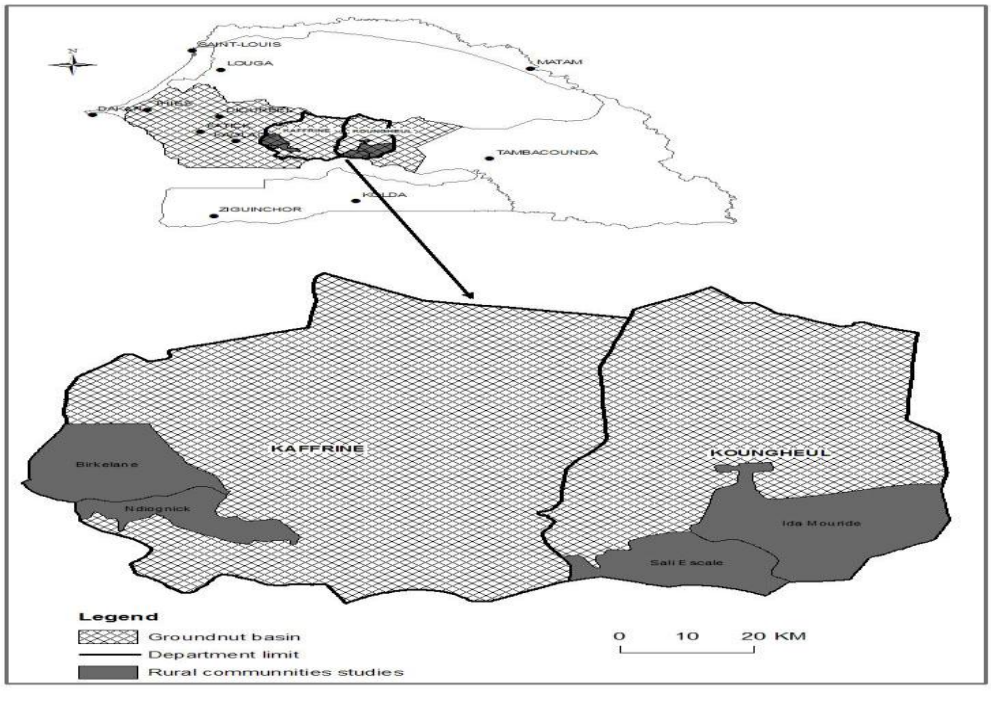


Figure-1: Location of the site (DEFCCS/CSE, 1996)

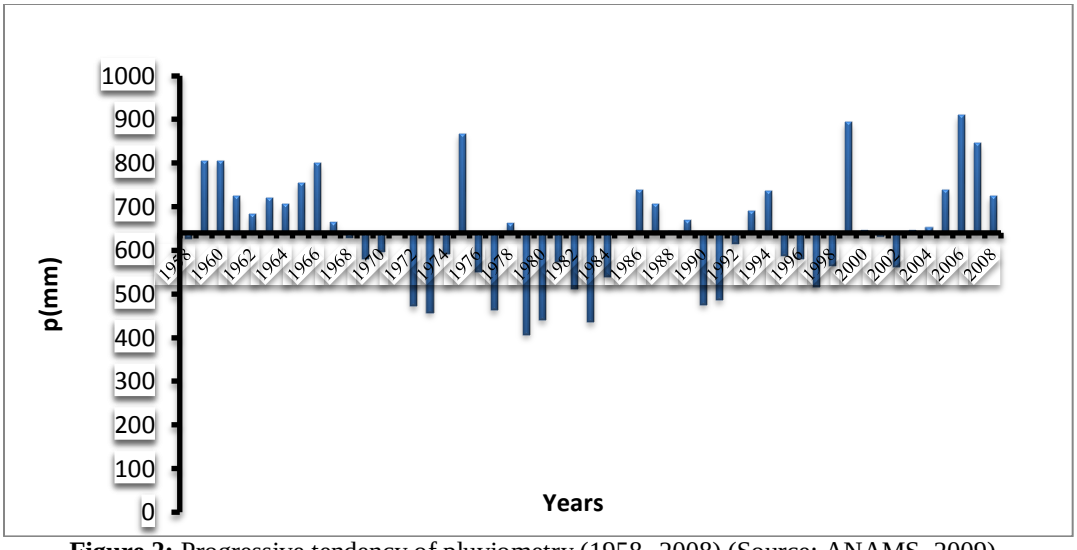


Figure 2: Progressive tendency of pluviometry (1958- 2008) (Source: ANAMS, 2009)

Methods

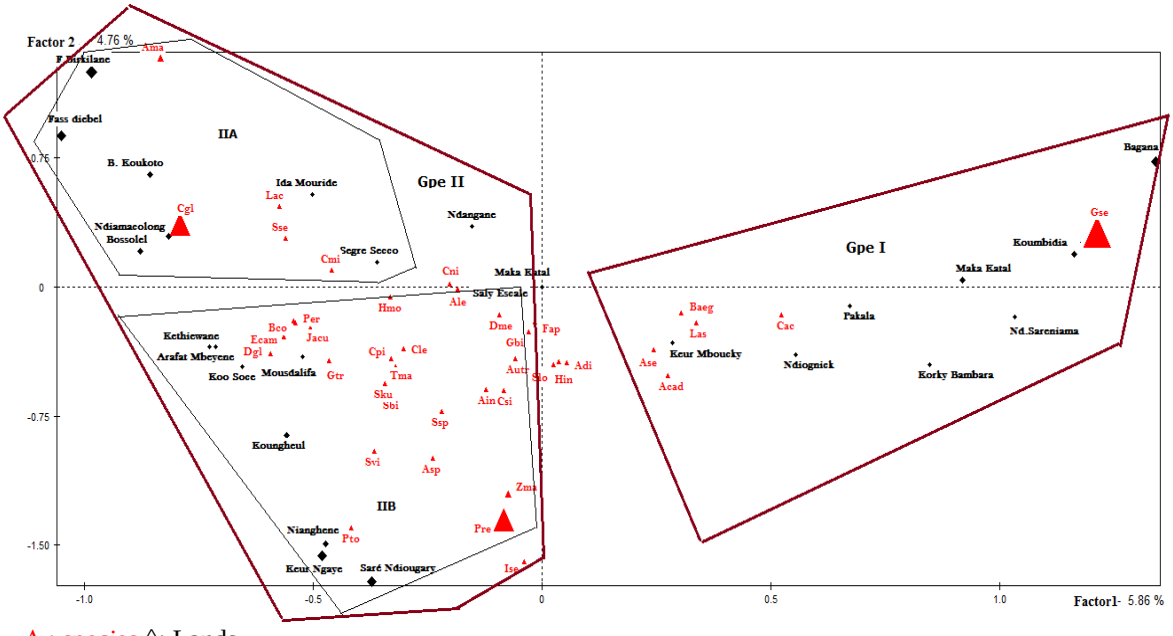
In the studied area, a total of 25 groups of villages were determined according to some cultural practices criterion (intensity of agricultural activity, diversification, mechanization level, presence or absence of fallow, trees density in the fields). In each group, equidistant transects of 500 m oriented East-West were laid down. Following each transects, every 500 m, plots of 50 m x 50 m were delineated in the fields, in the fallows and in the forests plots of 30 m x 30 m were installed. Fifty (50) plots were ultimately laid out in each land.

The complete enumeration of the woody stand was then performed in a total of 1143 plots of 262 ha (Bakhoum et *al*., 2012) and the seedlings were identified and counted.

The following parameters were measured on each tree: 1) the total height (m) to establish the stand structure, 2) the basal diameter (cm) of the trunk at 30 cm above the ground (because for many individuals, first branches are located below 1.30 m, height typically recommended in forestry) to estimate basal area, and 3) the distance (m) between trees to assess the distribution of individuals and to calculate the theoretical density; 4) the diameter of the crown to evaluate the recovery. To assess the regenerative potential of the species, we identified and inventoried juvenile plants (plants with basal diameter was less than or equal to 3.5 cm). For this natural regeneration, only the diameter and the height of the highest stem were measured. The other strands and stems derived from the same strain were systematically counted. The importance of the Combretaceae family was carried out in the lands of *Piliostigma reticulatum* and *Combretum glutinosum*, lands of *Guiera senegalensis* and those *Combretum glutinosum*. These lands have been identified in the Goundnut Basin by Bakhoum et *al*., 2012.

Statistical Analysis

The factorial analysis of correspondence (Lands x species matrix) was used to define the main groups of land and to characterize the heterogeneity of the woody stand (Bakhoum et *al*., 2012). The flora of Combretaceae woody stand on the basis of an analysis on the frequency of occurrence of species was done. The stand structure was investigated through parameters of the vegetation physionomy and the structure based on the tree height. To establish the regeneration of woody species, we defined by "seedling," any plant which trunk basal diameter is less than or equal to 3.5 cm or 10 cm in circumference (Akpo et Grouzis, 1996)



Δ : species ◊: Lands

Figure-3: Definition of land groups using factorial analysis of correspondence (FAC)

Results

Typology of the woody stand

The typology of the woody stand has allowed identifying four groups of lands of *Piliostigma reticulatum* and *Combretum glutinosum* and lands of *Guiera senegalensis* and *Combretum glutinosum*. These lands were subdivided into lands of *Guiera senegalensis* and *Combretum glutinosum* (Bakhoum et *al*., 2012).

Analysis of the flora (Frequency of occurrence of species)

The frequency of occurrence varied among species and according to the lands (Table 1). *Combretum glutinosum* showed the highest frequencies with 29.7% in the lands of *Combretum glutinosum*, 13.4% in the lands of *Guiera senegalensis* and 10.6% in those of *Piliostigma reticulatum* and *Combretum glutinosum*. It was followed by *Guiera senegalensis* with 16.7% 5.2% and 3.5% respectively in the lands of *Guiera senegalensis*, those of *Piliostigma reticulatum* and *Combretum glutinosum* and the lands of *Combretum glutinosum*. The frequency of *Combretum glutinosum* were higher in the lands near to the forest reserve of Koungheul and the protected area of Mousdalifa which are strongly colonized by this species. Concerning *Guiera senegalensis*, the presence of the forest of Birkelane explained its highest frequency in lands of *Guiera senegalensis*. All other species had frequencies not more than 1.1% with the exception of *Anogeissus leiocarpus* (4.4%) in the lands of *Combretum glutinosum*, in those of *Guiera seneglensis* (2.8%) and *Combretum micranthum* (4.1%) in the lands of *Combretum glutinosum*. The stand was more represented in the lands of *Combretum glutinosum* (43%), followed by lands of *Guiera senegalensis* (36.3%) and lands of *Piliostigma reticulatum* and *Combretum glutinosum* (19%). All the nine species that made up the Combretaceae were not present neither in the lands of *Piliostigma reticulatum* and *Combretum glutinosum* (7 species), nor in the lands of *Guiera senegalensis* (8 species) and *Combretum glutinosum* (7 species). It appeared a positive correlation between the frequency of occurrence of a species and the number of individuals counted.

Table-1: Frequencies of species occurrence in lands
N = Number; Fq = Frequency; Cgl = *Combretum glutinosum* ; Pre = *Piliostigma reticulatum* ; Gse = *Guiera senegalensis*

Species	Lands					
	Lands of Pre/Cgl		Lands of Gse		Lands of Cgl	
	Ef	Fq (%)	N	Fq (%)	N	Fq (%)
Combretum glutinosum	113	10.6	204	13.4	1885	29.7
Guiera senegalensis	27	5.2	237	16.7	25	3.5
Anogeissus leiocarpus	4	1.1	13	2.8	18	4.4
Combretum nigricans	0	0.0	4	0.7	3	0.9
Combretum micranthum	9	0.5	3	0.7	26	4.1
Combretum leucardii	0	0.0	0	0.0	2	0.3
Terminalia macroptera	3	0.8	6	1.2	0	0.0
Terminalia avicinoides	1	0.3	1	0.2	1	0.3
Combretum aculeatum	2	0.5	3	0.7	0	0.0
Stand	159	19.0	471	36.3	1960	43
Number of species	7		8		7	

Structure of the stand

The lands of *Piliostigma reticulatum* and *Combretum glutinosum*, those of *Guiera senegalensis* and the lands of *Combretum glutinosum* were characterized on the basis of physionomy parameters of the vegetation (Table 2).It was identified in average only one species per plot in the lands. The dominance was defined by the importance of a species as a function of area or volume it occupied. A high index variation was noted in the lands. It was 0.4 in the lands of *Piliostigma reticulatum* and *Combretum glutinosum*, 3.3 in those of *Guiera senegalensis* and 57.3 in lands of *Combretum glutinosum*. The higher index in lands of *Combretum glutinosum* was related to the specific importance of the species (67.1%) (Bakhoum et *al*., 2012). Indeed, field observations showed that the forest reserve of Koungheul and the protected area Mousdalifa were predominantly colonized by this species. The dominance is an important parameter for describing the structure of a stand. It determines in part the functional organization of the stand. The dominance is inversely related to diversity, in other words, a high dominance is associated with a low diversity (Akpo et *al*., 2004). Only the lands of *Combretum glutinosum* contained a characteristic species (*Combretum leucardii*). A characteristic species is generally uncommon or rare, it reveals a specific ecological habitat (Akpo, 1998). Five species (*Combretum glutinosum*, *Guiera senegalensis*, *Anogeissus leiocarpus*, *Combretum micranthum* and *Terminalia avicinoides*) were present in all lands.

Table-2: Variation of the vegetation parameters in lands

Parameters	Terroirs		
	Lands of *Piliostigma reticulatum* and *Combretum glutinosum*	Lands of *Guiera senegalensis*	Lands of *Combretum glutinosum*
Density (individuals/ha)	1.73	4.70	28.23
Surface terrière (m^2/ha)	0.22	0.32	0.79
Recovery (m^2/ha)	14.43	44.73	201.69
Avearge specific richness	1.09	1.18	1.25
Species caracteristics	0	0	1
Index of dominance	0.4	3.3	57.3
Indifferent species	5		

The density

The density is the ratio between the number of a species and the total area of plots inventoried. The average absolute density was 10 individuals per hectare with a variation depending onlands. The lands of *Piliostigma reticulatum* and *Combretum glutinosum*, those of *Guiera senegalensis* and the lands of *Combretum glutinosum* had respectively densities of 1.73; 4.70 and 28.23 individuals per hectare (Table 2). The land of *Combretum glutinosum* were more densely populated. As for the land of *Piliostigma reticulatum* and *Combretum glutinosum*, the low density observed with less than two individuals per hectare could be related to the intensity of agricultural activity (lots of land under crops) which caused many clearings and high pressure on wood (Touré 2002). In these clearings, only certain multipurpose species are preserved in fields (Akpo et *al*., 2004). *Combretum glutinosum* presented the highest density with 8.42 individuals per hectare in the stand and 27.15 individuals per hectare in lands of *Combretum glutinosum* followed by *Guiera senegalensis*, 1.10 at the stand level and 2.37 individuals per hectare in *Guiera senegalensis* lands. The seven other species had less than one individual per hectare. These results showed that the density of the woody of 17 individuals per hectare (Bakhoum et *al*., 2012) was mainly due to the family Combretaceae (10 individuals per hectare) and especially by *Combretum glutinosum* (8.42 individuals per hectare) specifically in the lands that bear the name of the species (27.15 individuals per hectare).

Recovery

The recovery of a tree is the vertical projection of the surface of the crown of the tree to the ground. This indicates the portion of ground covered by the foliage of the tree. The recovery of Combretaceae was 75.73 m2/h, 27.23% overall recovery of the woody stands of 278.1 m2/ha (Bakhoum et *al*., 2012). The variation of the recovery was high between the lands of *Piliostigma reticulatum* and *Combretum glutinosum* (14.43 m2/ha), those of *Guiera senegalensis* (44.7 m2/ha) and the lands of *Combretum glutinosum* (201.7 m2 / ha) (Table 2).The recovery was guaranteed by *Combretum glutinosum* to 53%, 32.21% and 91.52% respectively in the lands of *Piliostigma reticulatum* and *Combretum glutinosum*, in those of *Guiera senegalensis* and *Combretum glutinosum*. *Guiera senegalensis* contributed of 43.85% in lands of *Guiera senegalensis* but was less than 10% in those of *Piliostigma reticulatum* and *Combretum glutinosum* and lands of *Combretum glutinosum* and where it was outperformed by *Anogeissus leiocarpus* and *Combretum micranthum*. The species *Combretum glutinosum* carried at 75.56% of the recovery of the settlement of Combretaceae.

These results demonstrated that the family of Combretaceae contributed quite significantly to the recovery of woody. Within the lands of Combretaceae, *Combretum glutinosum* was dominating. In lands of *Guiera senegalensis*, it was outperformed by this species which was strongly represented in the forest of Birkelane therein. The basal area was very low. It was less $1m^2$/ha for Combretaceae and per species. It was as if the frequency of *Combretum glutinosum*, most isolated species of Combretaceae was inversely proportional to the size of the trunk.

Structure according to size and height

Size distribution

The examination of the distribution of trees and shrubs by basal diameter classes showed that the class less than or equal to 4.7 cm was the most represented both in the stand than in lands. (figure 4). The first three classes contained in lands of *Piliostigma reticulatum* and *Combretum glutinosum*, *Guiera senegalensis* and *Combretum glutinosum* respectively of 73%, 79% and 68.2% of individuals indicating a relatively young population.

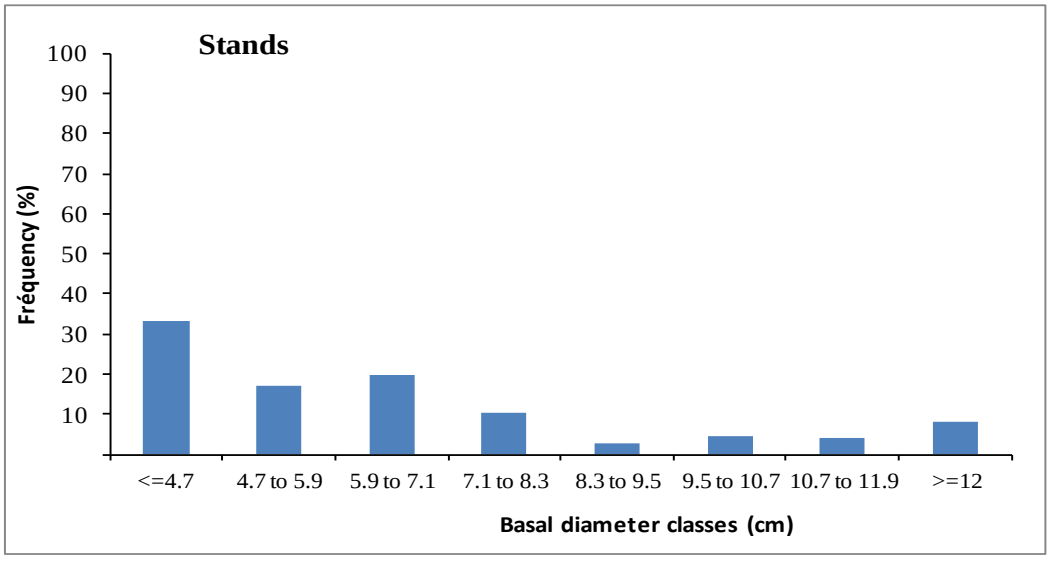
For the class less than or equal to 4.7 cm, only 9.1% of individuals (78) were found in lands of *Piliostigma reticulatum* and *Combretum glutinosum*, while lands of *Guiera senegalensis* indicated 22% (189 individuals) and lands of *Combretum glutinosum* included 68.9% or 593 individuals. The classes 5.9 to 7.1 cm and 4.7 to 5.9 cm indicated respectively 3.9 and 4% in thelands of *Piliostigma reticulatum* and *Combretum glutinosum*, 13.6 and 25.2% in the lands of *Guiera senegalensis*, 82.5% and 70.8% in those of *Combretum glutinosum*.

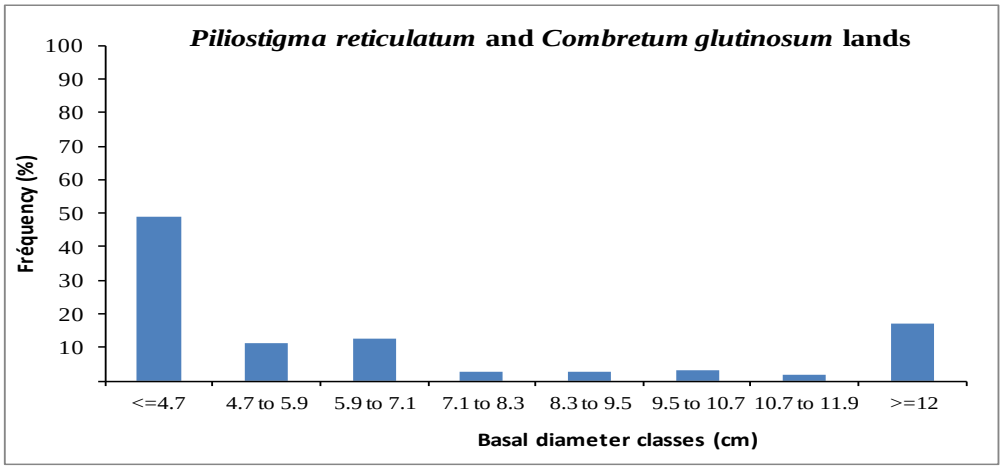
The individuals with large basal diameters (≥ 12 cm) were very weakly represented with frequencies below 10% in lands of *Guiera senegalensis* and *Combretum glutinosum* except in lands of *Combretum glutinosum* and *Piliostigma reticulatum* (17%). In the latter, the intensity of agricultural activity leads to removal of young trees when clearing land and only a few individuals of multipurpose species were preserved.

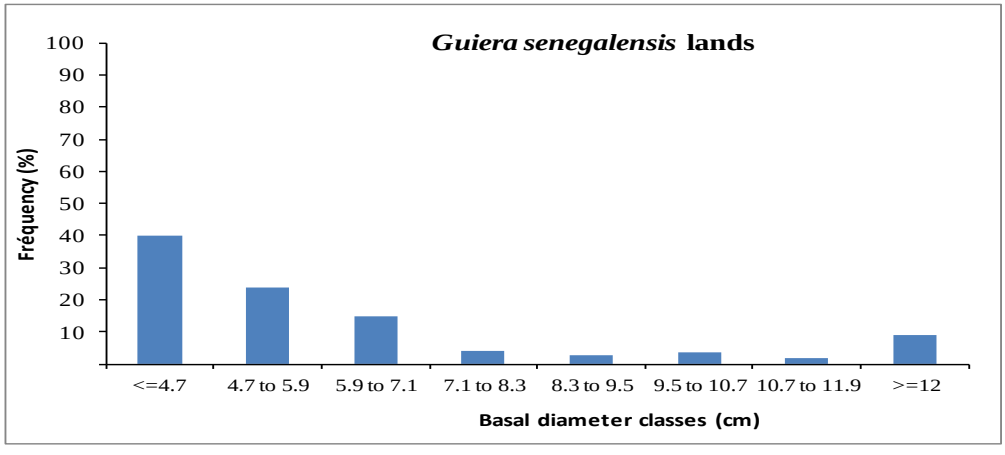
The structure of trees and shrubs size classes of nine species of the family Combretaceae seemed to fit an exponential decay tendency: this was evidence of a settlement in ecological balance. However, this balance was driven mainly by *Combretum glutinosum* as shown in figure 4 and figure 5A. The population distribution of *Guiera senegalensis* (figure 5B) tended to a lognormal distribution with the dominant classes of small basal diameter.

As for *Anogeissus leiocarpus*, the distribution of its population was rather marked by a group of individuals in the class of large diameters greater than 12 cm. The population distribution of *Combretum micranthum* apparently Gaussian, reminiscent of a deficient renewal especially for class 8.4 to 9.6 cm in particular linked to human action because of its many uses (figure 5C 5D).

We have examined the mean of the basal diameter distribution of the 4 most important species (*Combretum glutinosum*, *Guiera senegalensis*, *Combretum micranthum* and *Anogeissus leiocarpus*) based on lands. The results (Figure 6) showed that this parameter varied little for the first three species mentioned above and with low values for more than 13 cm for *Combretum micranthum* in lands of *Piliostigma reticulatum* and *Combretum glutinosum*. As for *Anogeissus leiocarpus*, the diameter values were significantly higher than the other three species. This species occured most commonly in the site as mature tree with more number in fields / fallows than in forests. The scarcity of lower categories could be related to young trees which were usually cut when preparing pre winter fields, destroyed by bush fires.







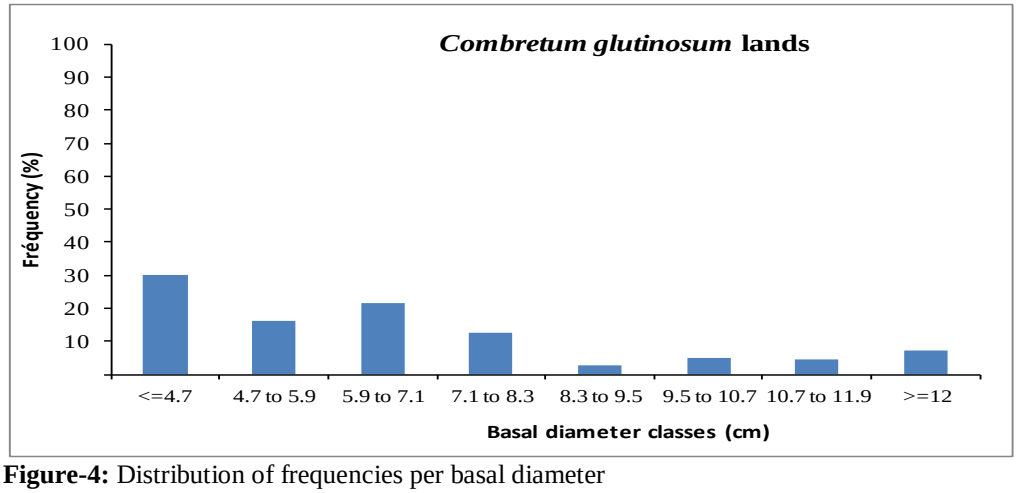
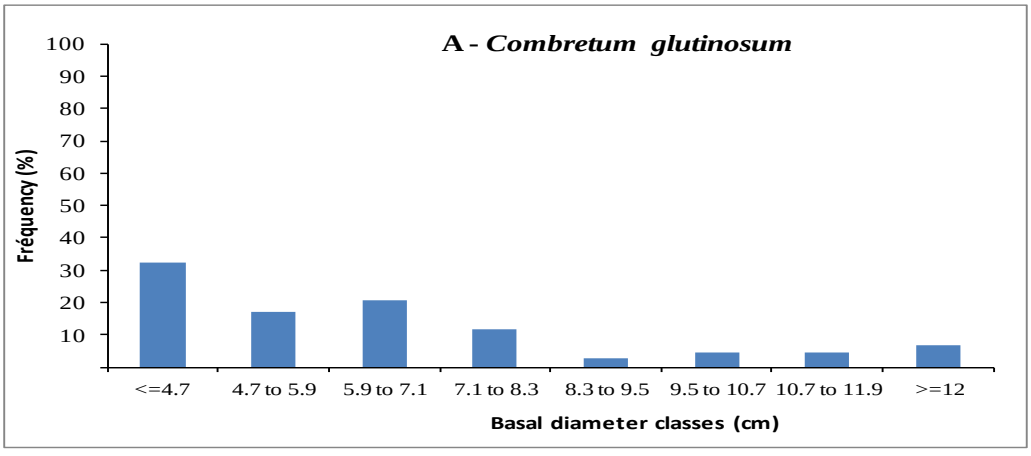
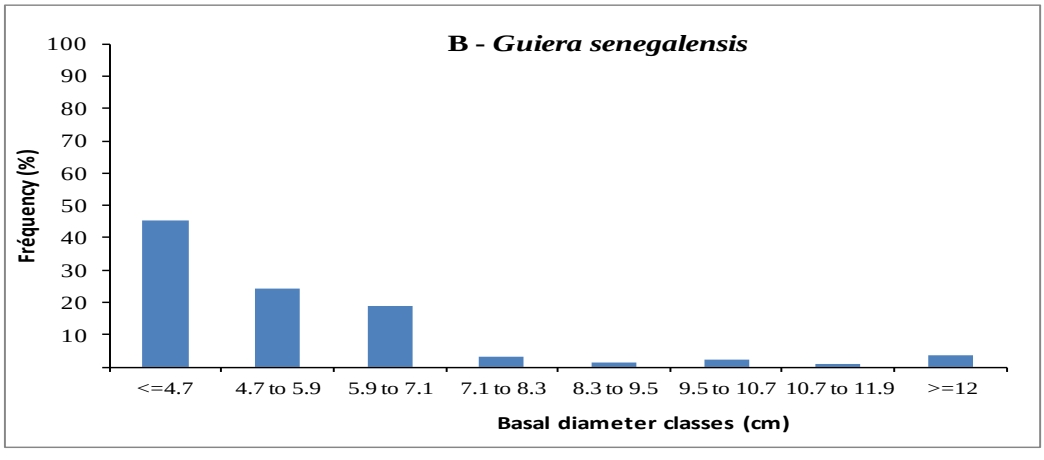
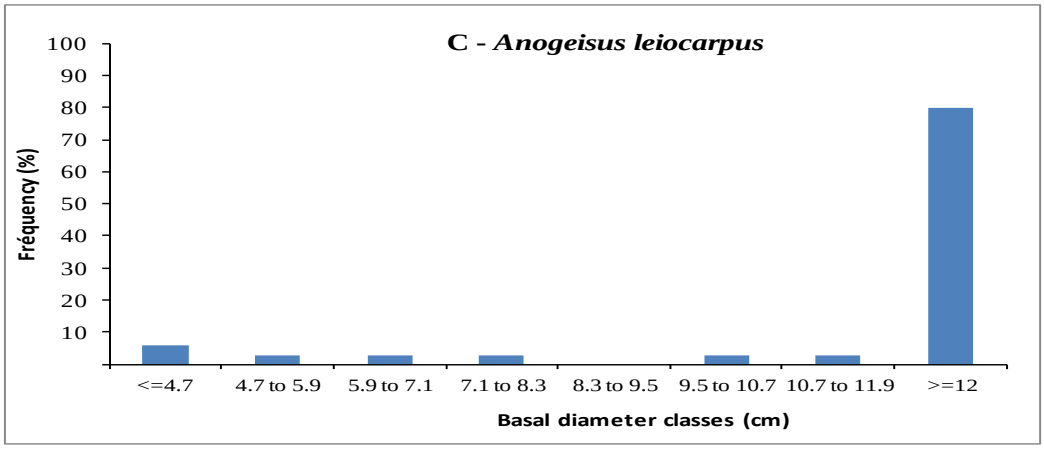


Figure-4: Distribution of frequencies per basal diameter


A - Combretum glutinosum
Fréquency (%)
100
90
80
70
60
50
40
30
20
10
<=4.7
4.7 to 5.9
5.9 to 7.1
7.1 to 8.3
8.3 to 9.5
9.5 to 10.7
10.7 to 11.9
>=12
Basal diameter classes (cm)


B - Guiera senegalensis
Fréquency (%)
100
90
80
70
60
50
40
30
20
10
<=4.7
4.7 to 5.9
5.9 to 7.1
7.1 to 8.3
8.3 to 9.5
9.5 to 10.7
10.7 to 11.9
>=12
Basal diameter classes (cm)


C - Anogeisus leiocarpus
Fréquency (%)
100
90
80
70
60
50
40
30
20
10
<=4.7
4.7 to 5.9
5.9 to 7.1
7.1 to 8.3
8.3 to 9.5
9.5 to 10.7
10.7 to 11.9
>=12
Basal diameter classes (cm)

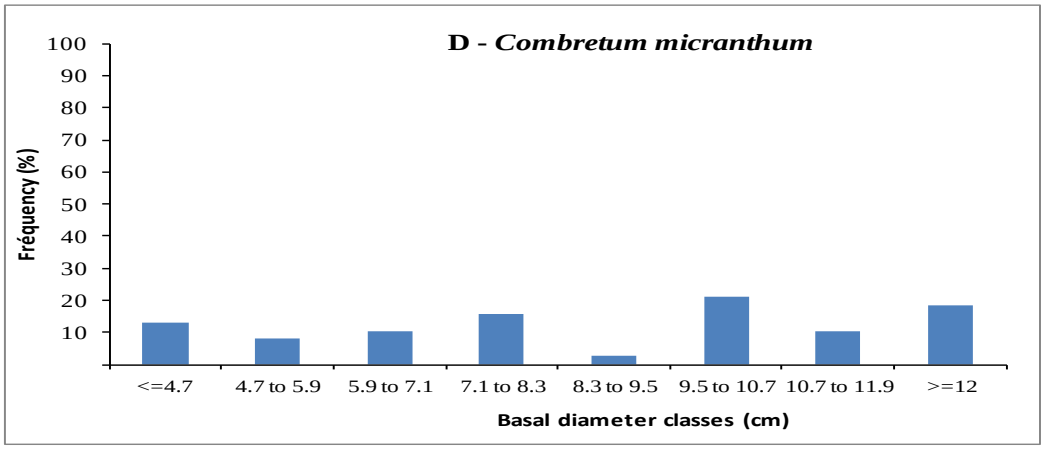


Figure-5: Distribution variation of the most represented according to basal diameter classes

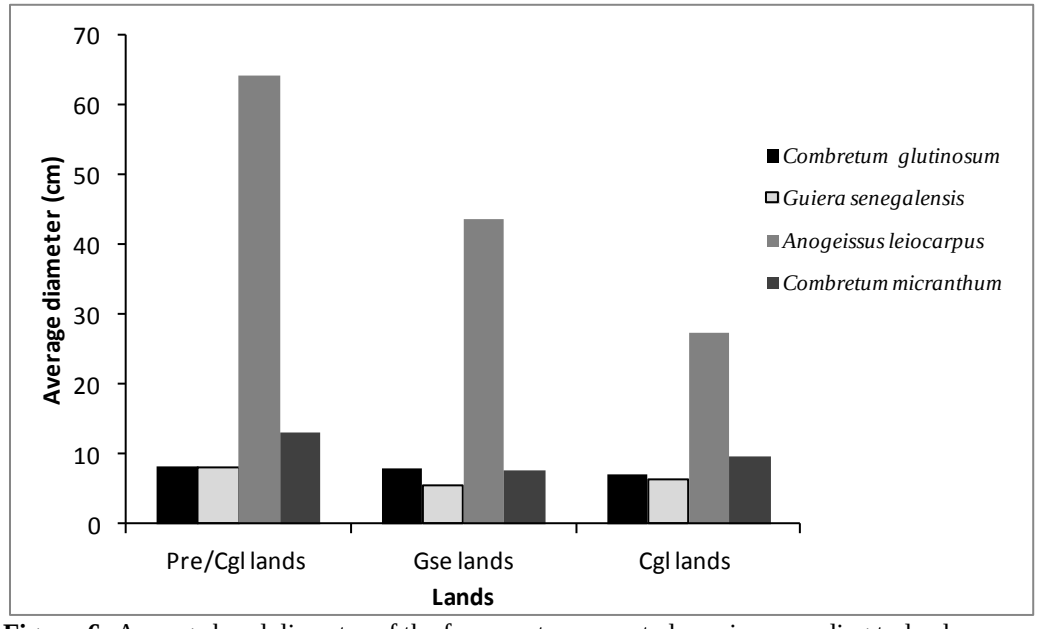


Figure-6: Average basal diameter of the four most represented species according to lands

Pre = *Piliostigma reticulatum* Cgl = *Combretum glutinosum* Gse = *Guiera senegalensis*

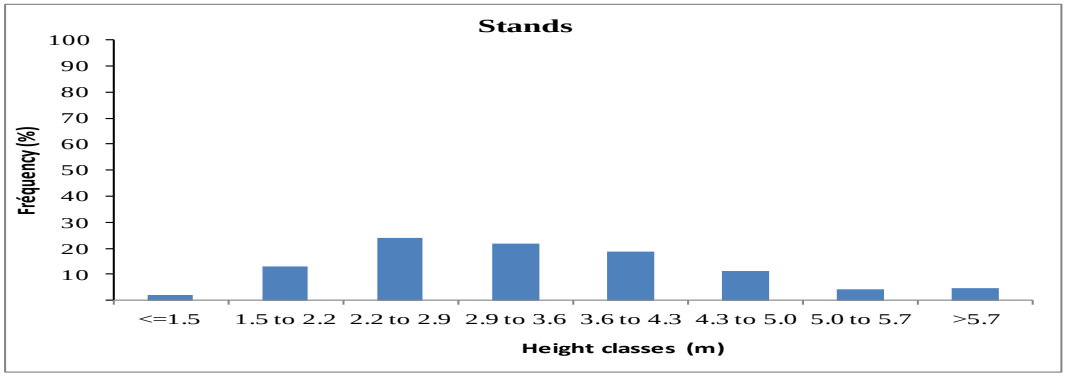
Height Distribution

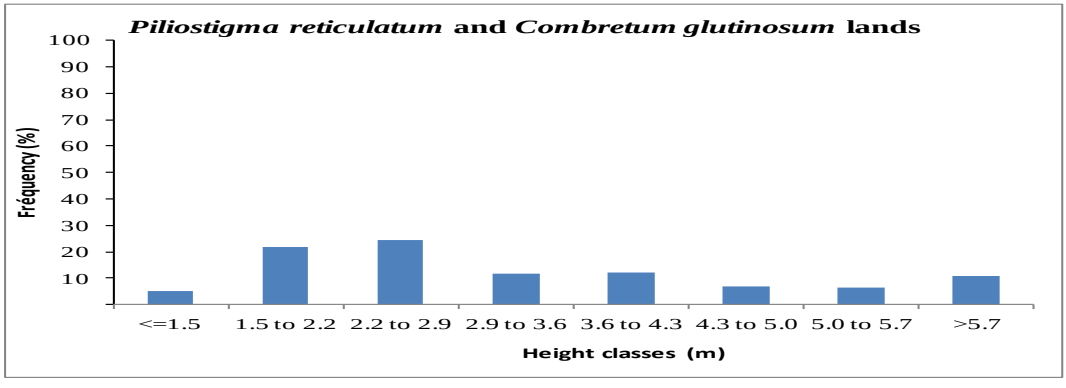
The distribution of individuals by height classes presented variations in lands. The individuals in the class exceeding 1.5 m were quite poorly represented with at most 5.2% in land of *Piliostigma reticulatum* and *Combretum glutinosum*. The class 2.2 to 2.9 m was best represented in lands with the exception of *Combretum glutinosum*. Almost all individuals had diameters between 1.5 and 5 m (figure 7). This illustrated the character pretty shrub of most individuals. For all height classes, the number of individuals identified in lands of *Guiera senegalensis* (456 individuals) and *Combretum glutinosum* (1949 individuals) was much higher than in lands of *Piliostigma reticulatum* and *Combretum glutinosum* (159 individuals). The difference was related to the location of forests Koungheul, Birkelane and the protected area of Mousdalifa densely populated in the first two groups of lands.

The distribution of individuals in Combretaceae stand seemed to a Gaussian distribution but with relatively high frequencies not particularly

high for individuals in the class up to 1.5 m what you might think of a deficient renewal (Figure 7). The stand structure was similar to lands of *Combretum glutinosum* confirming that individuals of the family Combretaceae were mainly represented (figure 7 and figure 8A). The distribution of individuals of the most four represented species as a function of height classes showed that *Combretum glutinosum* was a potential wearer of the stand structure. Each of the three other species had a specific structure. *Guiera senegalensis* had a unimodal structure with a remarkable peak for class 2.2 to 2.9 m. This species was mainly present in the area at young state as shrub. As for *Anogeissus leiocarpus*, these individuals had colonized mainly the class of height greater than 5.7 m. This species lead to think of a deficient renewal because the other lower classes were very poorly represented and in particular less than or equal to 1.5 and 3.6 m to 4.3 m. The distribution of *Combretum micranthum* was marked by a distribution of individuals in different height classes except the one of less than or equal to 1.5 m. The frequencies were low with the maximum of 21.6% registered for the class from 2.2 to 2.9 m (figure 8A to 8D).

Combretum micranthum existed in shrubs because under strong anthropogenic pressure due to the use of its leaves for a tea for breakfast in the family and fodder for small ruminants. Its stems are used by people as reinforcement of roofs and attic spaces and for firewood.





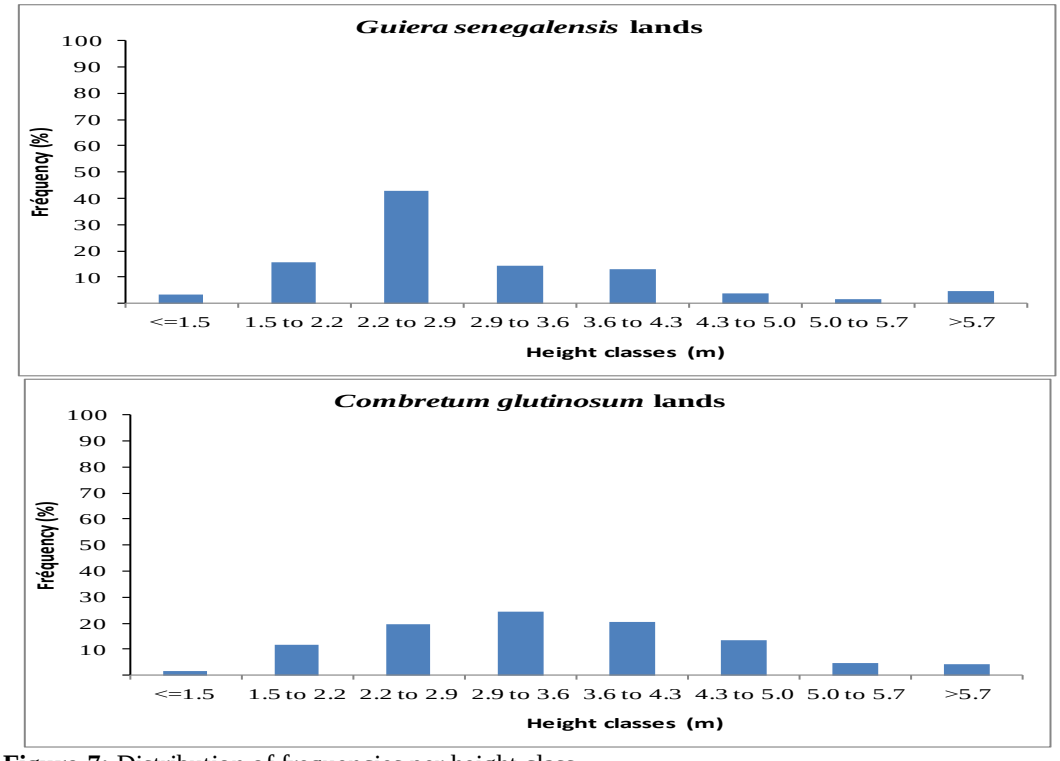
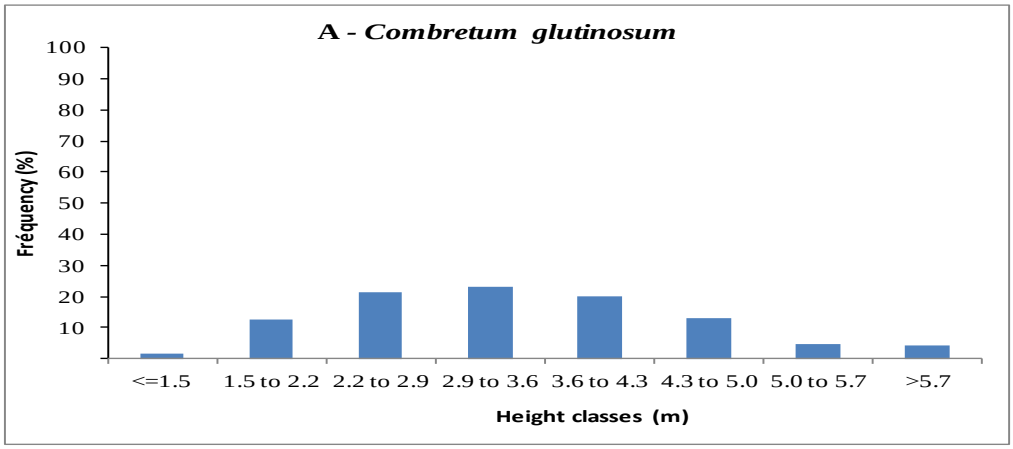
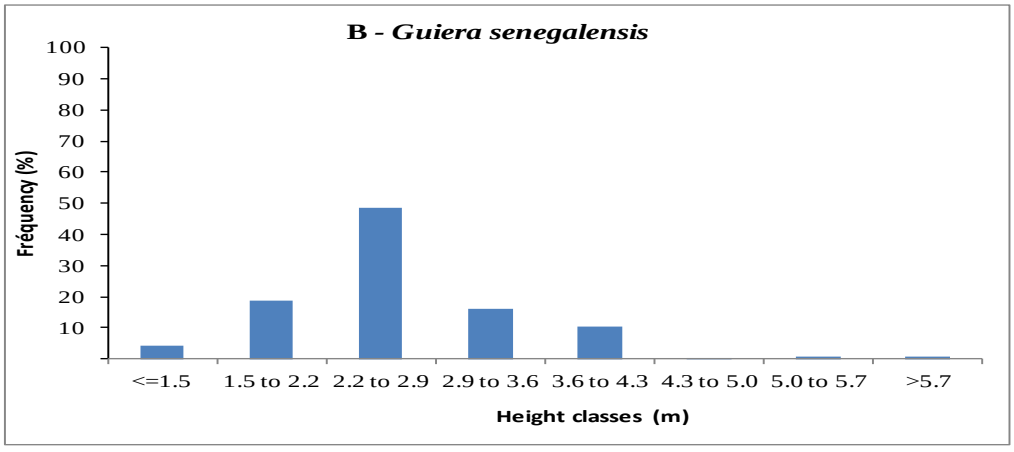
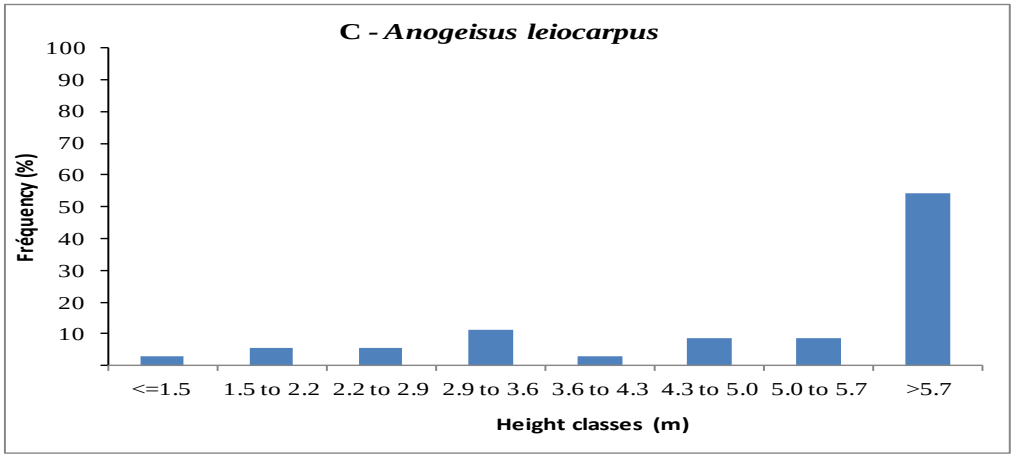


Figure-7: Distribution of frequencies per height class







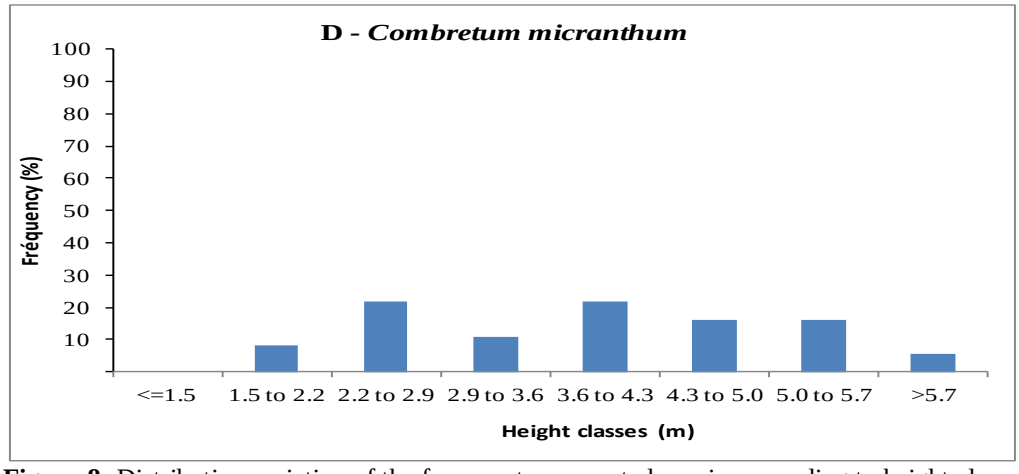


Figure-8: Distribution variation of the four most represented species according to height classes

Regeneration of the woody stand

The change in values of measured parameters to evaluate the regeneration of woody species identified nine of the family Combretaceae according to lands was presented in Table 3. *Combretum glutinosum* and *Guiera Senegalensis* were the dominant species. *Combretum glutinosum* had its workforce

which varied from a minimum of 4872 individuals in lands of *Piliostigma reticulatum* and *Combretum glutinosum* to a maximum of 8646 individuals in lands of *Combretum glutinosum*. As for *Guiera senegalensis*, it showed its minimum number in lands of *Combretum glutinosum* and the maximum in *Guiera senegalenisis*.

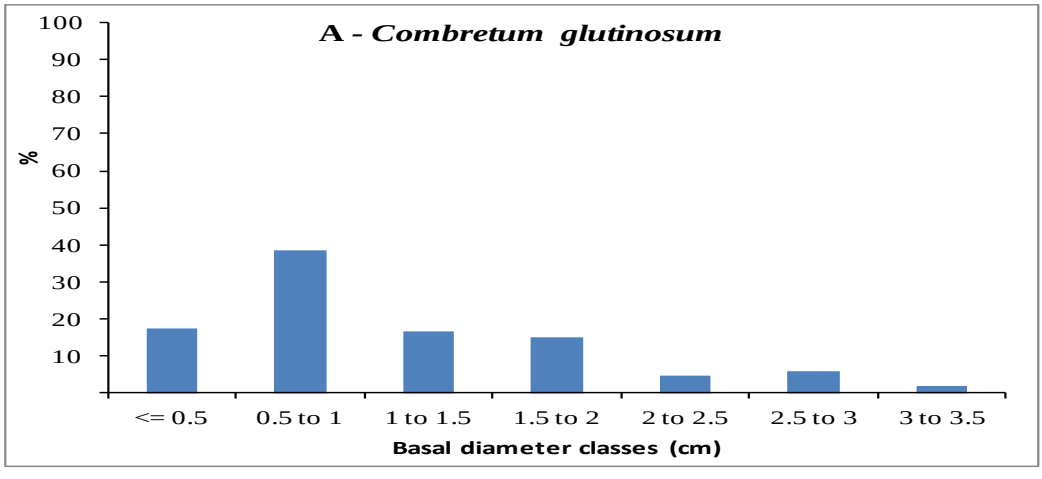
Combretum aculeatum was better represented in the form of seedlings that six other species of the family except in lands of *Combretum glutinosum* where it did not present seedlings.

It was followed by *Combretum micranthum* which was present in all lands (Table 3). The regeneration rate of a species being the ratio between population size and seedling stand identified (Diatta et *al*., 2007), it appeared that *Guiera senegalensis* and *Combretum glutinosum* were the best species in regeneration. The regeneration rate of *Combretum glutinosum* varied from a low 9.4% in lands of *Piliostigma reticulatum* and *Combretum glutinosum* to a maximum of 16.6% in lands of *Combretum glutinosum*.

For *Guiera senegalensis*, the minimum rate was 4% in lands of *Combretum glutinosum* and the maximum of 17.4% in the same lands. For other species, the rate of regeneration varied between 0 and 0.4% in lands.

Combretum glutinosum and *Guiera senegalensis* being the two best regenerating species, we examined the distribution of juveniles depending on the size and height. In size classes, the first classes (less than 0.5 to 2 cm) containing more than 4/5 of individuals, or 87.4% of juvenile plants of *Combretum glutinosum* and 85.3% of *Guiera senegalensis*. Seedlings, in many fields and reject after being cut off (year) when preparing pre winter could explain (figure 9).

An examination of the figure 10 of juvenile plants distribution by height class showed that if for *Combretum glutinosum* the first two classes (0.1 to 0.6 and from 0.6 to 1.1 m) were the most represented with 70.7% frequency, for *Guiera senegalensis* , they were the second and third classes (0.6 to 1.1 and 1.1 to 1.6 m) which recorded the highest number of seedlings (63%). This difference in the distribution of height classes between these two species may be related to intrinsic factors to the species (growth) and to anthropic action (use).



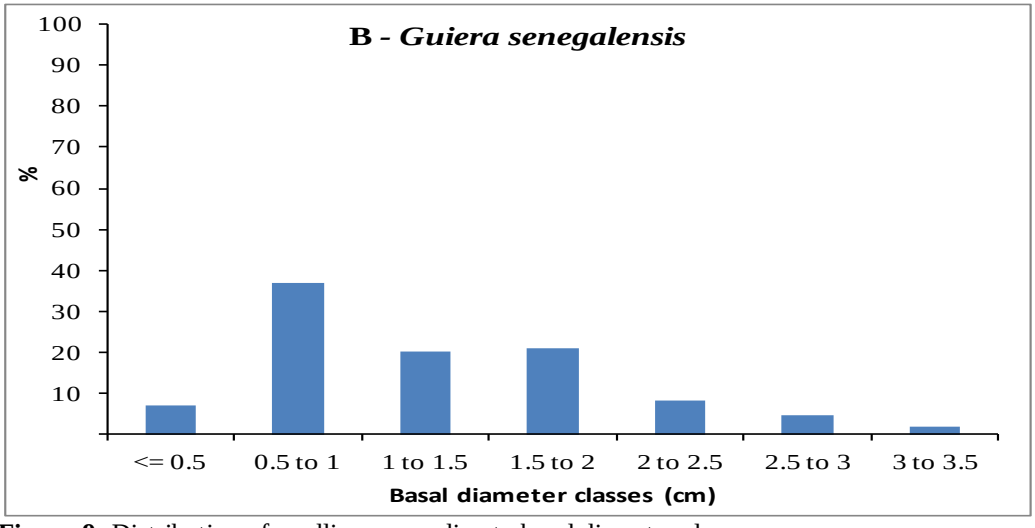


Figure-9: Distribution of seedlings according to basal diameter classes

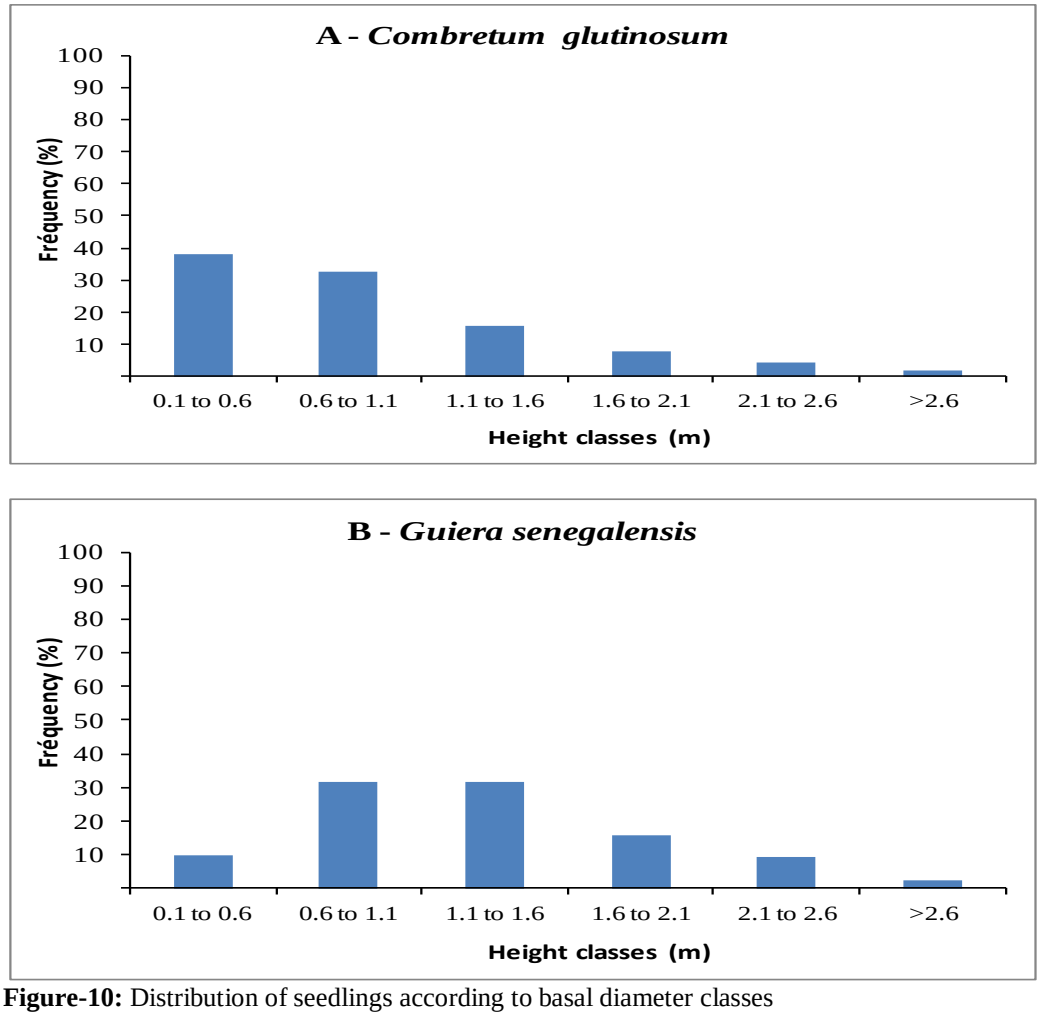


Figure-10: Distribution of seedlings according to basal diameter classes

Table-3: Variation of the importance, density and du regeneration rate of the woody species
N = Number; SI (%) = Specific importance De (individuals/ha) = Density
RT (%) = Regeneration rate

Species	Lands											
	Lands of *Piliostigma reticulatum* and *Combretum glutinosum*				Lands of *Guiera senegalensis*				Lands of *Combretum glutinosum*			
	N	SI	De	RT	N	SI	De	RT	N	SI	De	RT
Combretum glutinosum	4872	53.7	53.0	9.4	5344	36.5	10.4	10.3	8646	79.9	124.5	16.6
Guiera senegalensis	4106	45.3	44.6	7.9	9046	61.8	90.3	17.4	2091	19.3	30.1	4.0
Anogeissus leiocarpus	8	.1	0.1	0.0	6	0.0	0.1	0.0	8	0.1	0.1	0.0
Combretum nigricans	4	0.0	0.0	0.0	12	0.1	0.1	0.0	3	0.0	0.0	0.0
Combretum micranthum	16	0.2	0.2	0.0	10	0.1	0.1	0.0	41	0.4	0.6	0.1
Combretum leucardii	6	0.1	0.1	0.0	6	0.0	0.1	0.0	16	0.1	0.2	0.0
Terminalia macroptera	2	0.0	0.0	0.0	11	0.1	0.1	0.0	16	0.1	0.2	0.0
Terminalia avicinoides	6	0.1	0.1	0.0	8	0.1	0.1	0.0	4	0.0	0.1	0.0
Combretum aculeatum	53	0.6	0.6	0.1	185	1.3	1.8	0.4	0	0.0	.0	0.0
Total	9073	100	98.6	17.4	14628	100	146.0	28.0	10825	100	155.9	20.7

Discussion

This work examined the importance of the family Combretaceae in the woody land of groundnut basin of Senegal. It revealed the presence of nine species in four genera of which *Combretum* (5 species), *Terminalia* (2 species), and *Guiera* and *Anogeissus* with one species.

Combretum glutinosum and *Guiera senegalensis* are the most represented species in the environment as more resistant to climatic and anthropic action (Touré 2002). This resistance may be related to intrinsic factors to the species themselves (Wezel, 2000; Lufafa, 2008).*Guiera senegalensis* residues can release nutrients in the environment (C, N, P) depending on their composition. Shrubs of this species are small islands of the chemical soil fertility, through the rate of carbon mineralization and release of nutrients absorbed by themselves but also by annual crops in the fields (Dossa et *al*., 2009). The shrubs of *Guiera senegalensis* extract preferably water from the bottom to 1.10 m and even beyond the maximum measured depth of 3.5 m. They capture the drainage losses beyond the effective rooting depth of annuals showing a decrease in losses of 25-50% compared to the deep drainage fields with annual crops only (Kizito et al., 2007). As for *Combretum glutinosum*, a study of ENSA-Agroconsult (1998) demonstrated that it had no direct influence on soil chemical fertility but may exert a protective effect against the wind, evaporation of soil water and sweating mass cultures. Nevertheless, it is marked by a static density even for large strains, showing an ability to resist pressure for each individual regardless of size (Faye et *al*., 2002).Diarra (1985) found in the Sudan zone in Mali, that the physiognomy of vegetation was influenced by two factors mentioned above (climatic and anthropic action).

The other species (*Anogeissus leiocarpus*, *Combretum micranthum*, *Combretum nigricans*, *Combretum leucardii*, *Terminalia*

macroptera, *Terminalia avicinoides* and *Combretum aculeatum*) weakly represented seemed to develop fewer adaptation strategies to disturbances and climatic changes. This might be related to their growth and their different uses in food, pharmacopoeia (Padonou et *al*., 2012).

Previous studies in semi-arid showed that the distribution of wood was strongly related to variable climatic conditions (Diedhiou et *al*., 2009) and the impact of human activities that may cause changes in plant succession and environmental degradation (Khresat et *al*., 1998; Gaze et al., 1998). Faye et *al*. (2002) indicated in a study on woody regeneration dynamics that Combretaceae had the capacity to resist to land clearings for cultivation regardless of their size.

The rainfall series 1958-2008 showed every two years out of three was dry with a large inter-annual variability of precipitation contributing to the climatic deterioration that lead to the weakening of ecosystems. Previous work Batterbury and Warren (2001) and Noy-Meir (1973) had highlighted the correlation. It was shown that irregular rainfall increased when the annual rainfall decreased (Akpo et *al*., 1993). The climatic factors and human actions were critical in controlling the Sahel ecosystem (Vincke et *al*., 2010), changes in flora and vegetation (Ozer et al., 2010, Diouf and Lambin, 2001; Diallo et *al*., 2011). The woody resource dynamics of croplands is showed by the floristic composition that plays a key role in woody stands reactions to the factors above mentioned. Some characteristics of the flora and vegetation on the basis of the measured parameters indicated differences in management of the woody stand in lands resulting in a pressure that was specific to each type of environment (Gonzalez, 2001). This was illustrated by Akpo et *al*. (2004) in the land of Nema in semiarid Senegal. The functional organization of the stand of Combretaceae was carried by lands of *Combretum glutinosum*, especially by the species *Combretum glutinosum*. It was illustrated by results on dominance, the size distribution at the base and height of trees and shrubs. Indeed the forest of Koungheul and the protected area of Mousdalifa which are more populous in woody species and dominance of *Combretum glutinosum* are located in these lands that bear the name of the species. The family of Combretaceae being composed species resistant to land clearings for cultivation, it is as if *Combretum glutinosum* was the one with more presented this ability (Faye et *al*., 2002).

To allow comparison of structure between species, we chose an identical amplitude classes for each of the parameters of diameter and height. It was important to note for example that this value had not the same significance for a species with large diameter than for small diameter, it was the same with height (Bakhoum et *al*., 2012). The natural regeneration in the family of Combretaceae was provided *Combretum glutinosum* and *Guiera senegalensis*. Previous works by De Rouw, (1993), Faye (2000), Faye et *al*. (2002) and our field observations suggested that it was essentially asexual (vegetative). Indeed the potential seminal species ran out much faster than the vegetative potential in croplands for woody species. Extended cultivation destroys the seeds available in the soil. The species such as *Combretum glutinosum*, *Guiera senegalensis* presenting capacity to reject and / or suckers, which are maintained with time in culture area. This mode of reproduction appears to be a survival mechanism, that is to say an adaptation strategy (Lehmann et *al*., 1998) against disturbances and climatic changes.

Conclusion

The family of Combretaceae consisted of nine species could be considered as that which best subsisted to human pressure and climate change in the studied area. It was particularly the species *Combretum senegalensis* and *Guiera glutinosum* that seemed more resistant to the two factors. *Combretum glutinosum*, a species more widely represented in the area and especially in lands with of *Combretum glutinosum* carried the functional organization of the stand.The distribution of individuals according to their basal diameter and height certify that the stand was young; it was often to say to the shrubs state. The regeneration potential was significant for *Combretum glutinosum* and *Guiera senegalensis* and while for other species, it was compromised. It would

be useful for investigation of *Combretum glutinosum* and *Guiera senegalensis* for a better understanding of the mechanisms developed for their resistance to climatic shocks and human actions.

References

Agbangba, E.C., Dagbenonbakin, G.D., Diatta, S., Akpo L.E. (2011) "DRIS model parameterization 'Smooth Cayenne' nutrient status in Benin (West of Africa)" Journal of Asian Scientific Research, Vol. 1, No.5, pp. 254-264.

Akpo, L.E., Grouzis, M., Gaston A. (1993) "Pluviométrie et productivité des herbages de l'aire pastorale de Wiindu Thiengoli (Nord-Sénégal)" Estimation des charges fréquentielles. Rev. Elev. Med. Pays trop. Vol. 46, No. 4 :pp. 687-701.

Akpo, L. E. (1998) "Effet de l'arbre sur la végétation herbacée dans quelques phytocénoses au Sénégal selon le gradient de variation climatique" Thèse de doctorat d'état en sciences naturelles, option écologie, Faculté des sciences et Techniques, Université Cheikh Anta DIOP de Dakar. 51p.

Akpo, L. E., **Coly, I., Sarr, D., Ngom, D and S. Ndao (2004)** "Modes d'utilisation des terres et diversité floristique dans le terroir de la Néma en zone Semi-aride (Sénégal, Afrique de l'Ouest)" Journal of agriculture and environment for international development, Vol. 98, No. ¾.

Akpo, L. E., Grouzis M. (1996) "Influence du couvert sur la régénération de quelques espèces ligneuses sahéliennes (Nord Sénégal, Afrique occidentale)" Webbia Vol. 50, No. 2 : pp.247-263.

Bakhoum, C., Ndour, B., Akpo L.E. (2012) "Typology of woody stands in Senegal: case of the Groundnut Basin" International Journal of Science and Advanced Technology (ISSN 2221-8386,) Volume 2 No 2 February, http://www.ijsat.com.

Bakhoum, C., Ndour, B., Akpo L.E. sous presse "Diversité du peuplement ligneux des terroirs du bassin arachidier du Sénégal" sous presse, IJBCS.

Batterbury, S. and A Warren (2001) "The african Sahel 25 years after the great drought : assessing progress and moving towards new agendas and approaches" Global Environmental Change Vol. 11 :pp. 1 - 8. Pergamon, Elsevier.

Belsky, A. l., Mwonga, S.M., Duxbury l.M. (1993) "Effects of widely spaced trees and livestock grazi.ng on understoreyenvironnements in tropical savannas" Agroforestry System, 24: 1-20. FAO Foreslly Genetic Ressources Information, Vol. 13: pp.30-36.

Coly I., Diome, F., Dacosta, H., Malou, R. et L.E Akpo (2011) "Typologie des exploitations agropastorales de la NEMA (Sénégal, West Africa)" Int. J. Biol. Chem. Sci.

De Rouw, A. (1993) "Regeneration by sprouting in slash and burn rice cultivation, Taï rain forest, Côte d'Ivoire" Journal of tropical ecology, Vol. 9 : pp. 387-408.

Diack, M., Sene, M., Badiane, A.N., Diatta, M., Dick R.P. (2000) "Decomposition of a native shrub, *Piliostigma reticulatum*, litter in soils in semiarid Senegal" Arid Soil Research and Rehabilitation Vol. 14, pp. 205–218.

Diallo, H., Bamba, I., Barima, S., Sadaiou, Y., Visser, M., Ballo, A., Mama, A., Vranken, I., Maiga, M., Bogaert J. (2011) "Effets combinés du climat et des pressions anthropiques sur la dynamique évolutive de la végétation d'une zone protégée du Mali (Réserve de Fina, Boucle du Baoulé)" Sécheresse, Vol. 22, No. 3, pp. 97-107.

Diarra, M. (1985) "Opération de développement intégré du Kaarta (ODIK) vue à travers les terroirs de Diaman Konkan et de Kourgue. Une étude de la conservation des ressources naturelles dans le cadre des Opérations de Développement Rural (O.D.R) du Mali" Thèse de doctorat, Université de Caen.

Diatta, S., Douma, S., Houmey, V. K., Banoin, M. et L.E. Akpo (2007) "Potential de régénération naturelle d'un ligneux fourrager (*Maerua crassifolia* Forsk.) en zone sahélienne" Revue Africaine de Santé et de Productions Animales, E.I.S.M.V. de Dakar, Vol. 5, No.1-2 : pp. 23-28.

Diedhiou, S., Dossa, E.L., Badiane, A.N., Diedhiou, I., Sene, M., Dick R.P. (2009) "Decomposition and spatial microbial heterogeneity associated with native shrubs in soils of agroecosystems in semi-arid Senegal" Pedobiologia Vol. 52, pp. 273-286.

Diouf, A., Lambin E.F. (2001) "Monitoring land-cover changes in semi-arid regions:

remote sensing data and field observations in the Ferlo, Senegal" Journal of Arid Environments Vol. 48, pp. 129–148.

Dossa, E.L., Khouma, M., Diedhiou, I., Sene, M., Kizito, F., Badiane, A.N., Samba, A.N.S., Dick R.P. (2009) "Carbon, nitrogen and phosphorus mineralization potential of semiarid Sahelian soils amended with native shrub residues" Geoderma Vol. 148, pp. 251–260.

ENSA – AGROCONSULT (1998) "Etude de l'impact de la régénération naturelle assistée de *Combretum glutinosum* sur les écosystèmes cultivés" PREVINOBA, DEFCS, MEPN, Sénégal, pp. 4-25.

Faye, E. (2000) "Dynamique des souches ligneuses dans le cycle culture-jachère en zone soudanienne" Mémoire d'Ingénieur, IDR/UPB, 103 p.

Faye, E., Masse, D., Diatta M. (2002) "Dynamique de la régénération ligneuse durant la phase de culture dans un système de culture semi-permanente du sud du Sénégal" Actes du colloque, 27-31 mai 2002, Garoua, Cameroun.

Gaze, S.R., Brouwer, J., Simmonds, L.P., Bromley J. (1998) "Dry season water use patterns under *Guiera senegalensis* L. shrubs in a tropical savanna" Journal of Arid Environments Vol. 40, pp. 53–67.

Gonzalez, P. (2001) "Desertification and a shift of forest species in the West African Sahel" Climate Research Vol. 17, pp. 217–228.

Khresat, S.A., **Rawajfih, Z., Maohammad M. (1998)** "Land degradation in north-wester Jordan : causes and processes" Journal of Arid Environments Vol. 39 : pp. 623-9.

Kizito, F., Sene, M., Dragila, M.I., Lufafa, A., Diedhiou, I., Dossa, E., Cuenca, R., Selker J.J., Dick R.P. (2007) "Soil water balance of annual crop–native shrub systems in Senegal's Peanut Basin: The missing link" Agricultural water management Vol. 90: pp. 137 – 148

Lawesson, J.E. (1990) "Sahelian woody vegetation in Senegal" Vegetation 86, 161–174.

Lehmann, J., Peter, I., Steglich, C., Gebauer, G., Huwe, B., Zech W. (1998) "Below-ground interactions in dryland agroforestry" For. Ecol. Manage. Vol. 111, pp. 157–169.

Lufafa, A., Bolte, J., Wright, D., Khouma, M., Diedhiou, I., Dick, R.P., Kizito, F., Dossa, E., Noller J.S. (2008) "Regional carbon stocks and dynamics in native woody shrub communities of Senegal's Peanut Basin" Agriculture, Ecosystems and Environment Vol 128, pp. 1–11.

Noy-Meir, I. (1973) "Desert ecosystems: environment and producers" Annu. Rev. Ecol. Syst. Vol. 4, pp. 25–51.

Nye, P.H. and D.J Greenland (1960) "The soil under shifting cultivation" Commonwealth Agricultural Bureau. Farnham Royal. Boucks. England, 153 p.

Ozer, P., Hountondji, Y.C., Niang, A.J., Karimoune, S., Manzo, O.L., Salmon M. (2010) "Déserfication au Sahel : historique et perspectives" BSGLg 54 pp. 69-84.

Padonou, E. A., Kindomihou M. V., Diègo, J. G and B.A Sinsin (2012) "Diversity of Medicinal Plants and Preliminary Parameterization of their Uses in Benin (Western Africa" Journal of Asian Scientific Research Vol. 2, No. 4, pp. 212-220.

Sanogo, D. épouse Diaité (2000) "La haie vive dans le Sud bassin arachidier du Sénégal : adoption et conséquences agro-écologiques" Thèse de doctorat de 3èrnc cycle de Biologie Végétale- Faculté des Sciences et Techniques – UCAD – Sénégal, pp.1-4.

Touré, A. (2002) "Contribution à l'étude de l'évolution des réservoirs de carbone en zone nord soudanienne au Sénégal**"** Thèse N° 2585, Faculté Environnement Naturel, Architectural et Construit (ENAC), Ecole Polytechnique Fédérale de Lausanne (EPFL), pp I-3-11, II-4 p.

Vincke, C., Diedhiou, I., Grouzis M. (2010) "Long term dynamics and structure of woody vegetation in the Ferlo (Senegal)" Journal of Arid Environments Vol. 74, pp. 268–276.

Wezel, A., (2000) "Scattered shrubs in Pearl millet fields in semiarid Niger. Effect on millet production" Agroforestry Systems Vol. 48, pp. 219–228.