Journal of Applied Biosciences 55: 4006– 4019

ISSN 1997–5902

Farmers' perceptions on woodlands in the groundnut basin of Kaffrine region in Senegal

Charles Bakhoum[1*], Sékouna Diatta[2], Amy Bakhoum[2], Babou Ndour[3], Leonard Elie Akpo[2]

[1]Department of operations, World Vision Senegal, PO.Box. 3731 RP, Dakar (Senegal).

[2]Laboratoire d'Ecologie végétale et Eco-hydrologie, Faculté des Sciences et Techniques, Université Cheikh Anta DIOP, Sénégal, B.P. 5005 Dakar (Sénégal)

[3]Institut Sénégalais de Recherches Agricoles ISRA (CNRA) de Bambey, B.P. 53 Bambey

[*] Corresponding author, E-mail: charles_bakhoum@wvi.org

Original submitted in on 21st May 2012. Published online at www.m.elewa.org on July 27th 2012.

ABSTRACT

Objectives: The assessment of people on the spatial distribution, the dynamics of the main woody species and its determinant factors, the natural regeneration and preferences of species in lands was sought.

Methodology and results: A perception survey of households, established that the woodland is diversified enough with a wide dominance of *Combretum glutinosum*, *Guiera senegalensis*, *Piliostigma reticulatum,* confirming the floristic composition resulting from the woods inventory. The appreciations on the woodlands evolution showed that the most useful species were threatened because of their multiple uses. It was in particular about *Pterocarpus erinaceus*, *Cordyla pinnata*, *Detarium microcarpum* and *Sterculia setigera*. The abusive exploitation, the bush fire, the drought and the unsuitable cultural practices constitute the main reasons of species threat.

Conclusion and application: The recommended solutions emphasize the artificial regeneration (reforestation), natural (rejection/sowing) and the awareness of the populations. Species preference was related to their use rather than their importance in the area. The choice of the favorite species was related to the area: fields and fallow or forests and uncultivated area. The wood species regenerate and the practice of the natural regeneration was mainly the protection of the shooting seedlings, the natural sowingof the seed trees with constraints related to the monitoring/protection, and the seedlings maintenance. The knowledge by the populations of species that colonize each land use system, the woodland characteristics and practices advocated a strategy of restoration and / or rehabilitation of ecosystems based on local knowledge are carried out.

Keywords: distribution, endangered species, preferred species, natural regeneration

INTRODUCTION

The degradation of the vegetation is the most observed phenomenon because of high population pressure on the resources (Khresat *et al.*, 1998) and climatic risks (Diallo *et al.*, 2011; Ouédraogo, 2006). In Senegal, the density of the species is still decreasing in spite of the high natural regeneration for some tree species (Akpo et Grouzis, 1996), in particular those of the Combretaceae family (*Guiera senegalensis*, *Combretum glutinosum*) due to the pre-farming work (Samba *et al.*, 2000; Bakhoum *et al.*, 2012). According to UICN (2008), 35 endemic wood species in Senegal are threatened by disappearance. The population recognizes many positive effects of several wood species on the soil, the crops, many used species like *Acacia albida* (Dancette and Poulain, 1968),

Cordyla pinnata (Samba, 1997), *Hyphaene thebaica* (Moussa, 1997), *Maerua crassifolia* (Houmey V.K., 2012), *Balanites aegyptiaca and Acacia raddiana* (Akpo and Grouzis, 1996) and *Sterculia setigera* (Bakhoum et *al*., 2001; Bakhoum, 1995). In the Groundnut basin, the modification of the mode of use and management of the woodland is primarily due to population the growth and high occupation of rural areas with intense clearings (groundnut monoculture) (Diatta *et al.*, 1998).

The main recommendation is the restoration and/or the rehabilitation of ecosystems by tree reintroduction in landscape for cash income (Bonkoungou, 1985; Belsky *et al.,* 1993; Akpo and Grouzis, 1996). That must pass not only by wood inventory and characterization but also by knowing producers' perception on the current state of the wood family in order to propose more sustainable management for environment protection. This study focuses on the actual dynamics and the management of the useful wood species in the groundnut basin (in particular the threatened ones) but will specifically try to answer three questions laid out as followed: i) what is population's opinion on the spatial distribution, the dynamic evolution of the main wood species and the determining factors? ii) What is rural population's perception on the natural assisted regeneration of wood species (knowledge, practice, constraints and solutions)? iii) What are the preferred wood species in the village soils and the underlying criteria?

MATERIAL AND METHODS

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

Methods: A socio-economic study was carried out in 4 rural communities (Birkelane, Ndiognick, Ida mouride and Saly escale) where the wood vegetation inventory was done. Questions selected at the village and households levels were of the stratified methods.(ANSD, 2005) .

a) **Choice of the target villages:** Ten villages based on their demographic weight and the number of households in 4 rural communities were selected.

b) **Choice of survey respondent panel:** Two out of five households were selected sampled in each village. The probability with the second degree was then fixed and equal to 2/5 (WVI, 2003). The resort to a method with two stages to obtain the number of households requires that the same attention must be paid to the choice of the households belonging to the primary units of sampling. However, for reasons related to the lack of reliable survey based on second units (here households), the random walk method was used to select the households in a bunch (village) based on a calculated step of survey. To have opinion of people of various statutes in the households (head of households, spouse and dependent, etc.), 50% of the questioned people were heads of households and the others, 50% distributed between the spouses, (25%) and the dependent ones (25%). Overall, 574 households were surveyed in 40 villages.

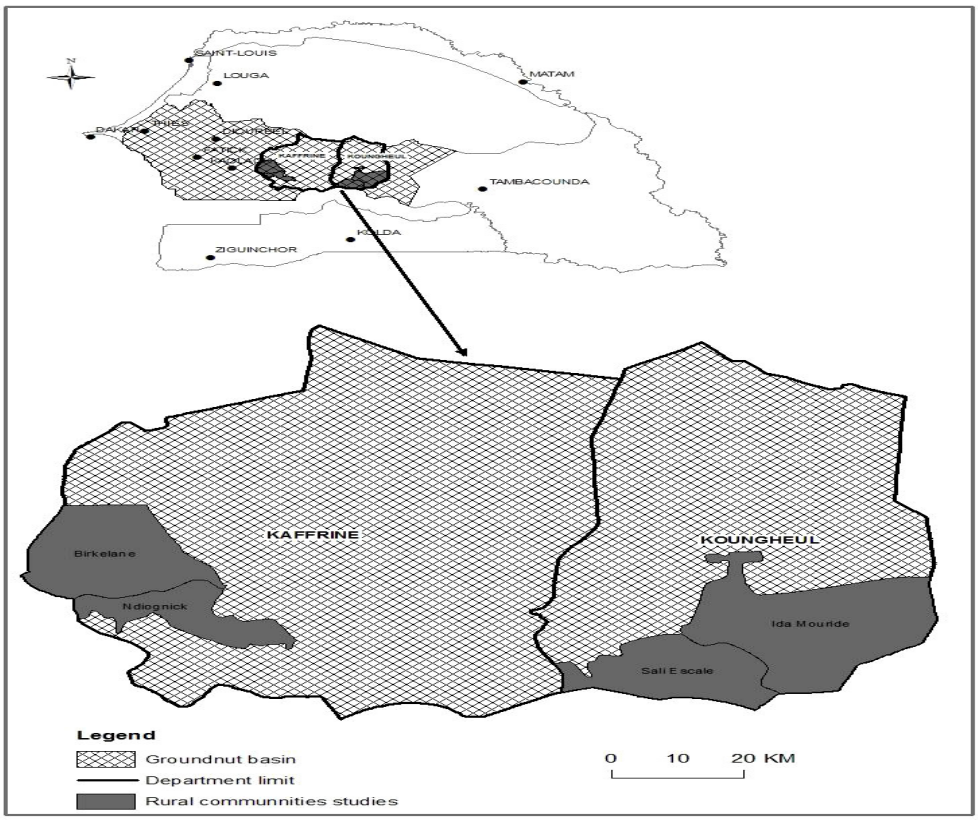


Figure 1: Site location of the studied area (DEFCCS/CSE, 1996)

c) **Calculation of unit's probability of inclusion (village and household):** The primary unit of survey was the Village. The probabilities of survey were calculated for each degree of pulling and in each stratum (EDS IV, 2005).

For each stratum H, the notations were:

P_{1hi}: probability of survey at the first degree of Village i

P_{2hi}: probability of survey at the second degree of the households in Village i

Be a_h the number of villages pulling in the stratum h, M_{hi} the number of households in village i,

M_h the total number of households of the layer h.

At the first degree, inclusion probability of the bunch i in the sample was:

$$P_{1hi} = \frac{a_h \times M_{hi}}{M_h}$$

At second degree, b_{hi} number of households were selected from L_{hi} households so that the probability was fixed and equal to 2/5. We had:

$$P_{2hi} = \frac{b_{hi}}{L_h} = \frac{2}{5}$$

At the end, the probability of selecting households in a village i was:

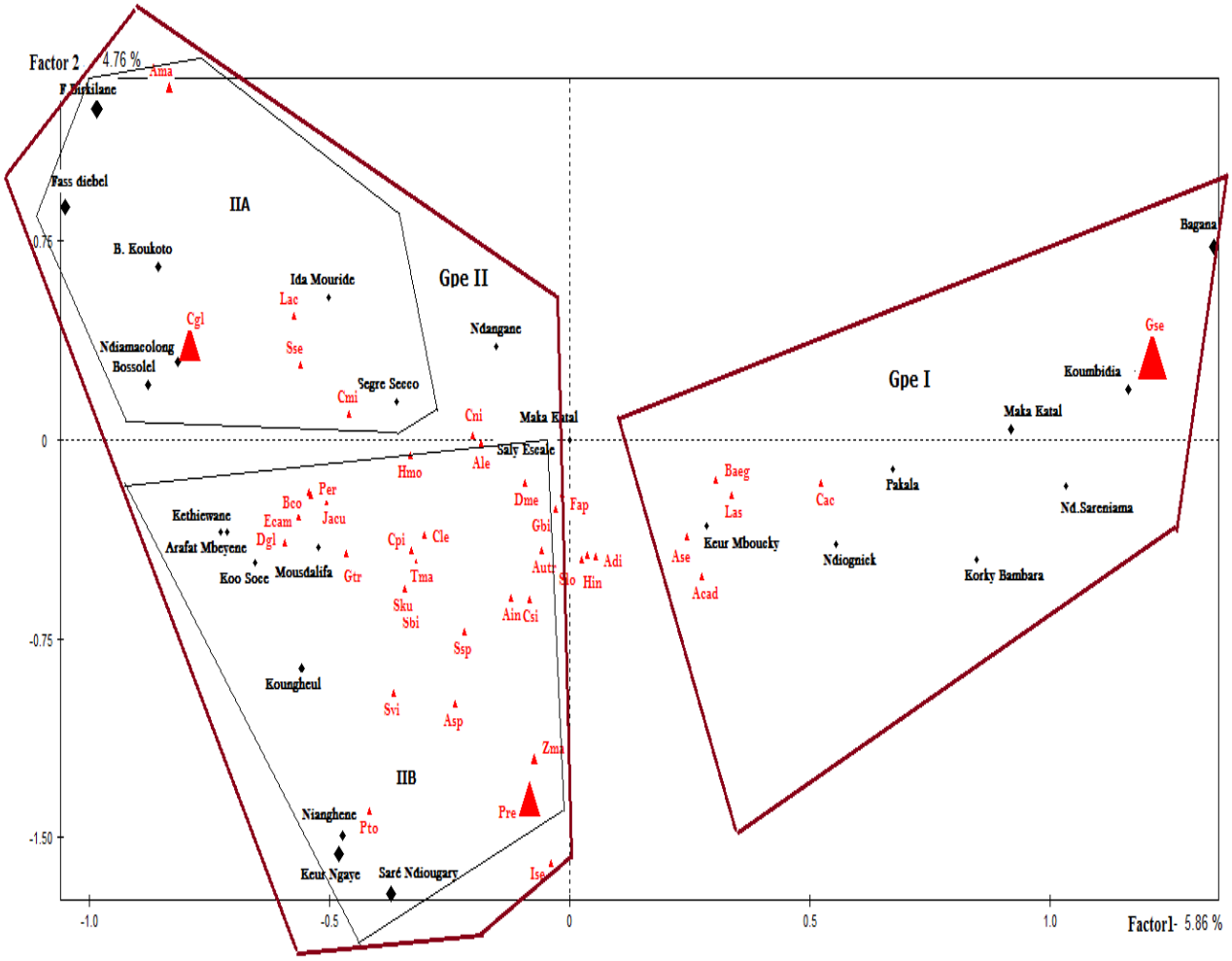
$$W_{hi} = P_{1hi} \times P_{2hi} = \frac{2}{5} \times \frac{a_h \times M_h}{M_h}$$

All analyzes were performed using SPSS software (Statistical Package for Social Science) after entering data in CSPRO (Census and Survey Processing System). The main tools used were descriptive statistics and the method of multiple attributes for the treatment of multinomial variables (multiple choices).

The results were overall carried out according to the lands (land of *Piliostigma reticulatum* and *Combretum glutinosum*, land of *Guiera senegalensis*and and *Combretum glutinosum*) identified from the factorial correspondence analysis (lands x species matrix). The lands were selected from the gradients of topography and recovery (Bakhoum *et al.*, 2012). A threatened species was one which population was significantly declining (IUCN, 2000)

RESULTS

Typology of the woodland: The typology of the woodland allowed identifying four groups of stands of *Piliostigma reticulatum* and *Combretum glutinosum* and stands of *Guiera senegalensis* and *Combretum glutinosum*. These stands are subdivided into lands of *Guiera senegalensis* and *Combretum glutinosum* (Bakhoum et al., 2012).



Δ : species, ◊: Lands

Figure 2: Definition of land groups using factorial analysis of correspondence (FAC)

Distribution of woody species in the lands: Households indicated 140 species on their land including 101 identified in fields, 94 in the fallows and 123 in forests. The forest areas were more densely populated than the crops areas (fields, fallows). In the fields, during clearing some multipurpose species were preserved. Five species recorded more than 50% infrequency of occurrence: *Combretum glutinosum* (91.8%) followed by Cordyla pinnata (88.8%), *Guiera senegalensis* (83.7%), *Piliostigma reticulatum* (74.0%) and *Adansonia digitata* (60.3%). *Acacia macrostachya* part of the five most represented species in the floristic composition had a relatively low citation frequency (21.9%). That could be explained by its presence in the protected area of Mousdalifa. From a set of 140 listed species, 114 were identified in the lands of *Piliostigma reticulatum* and *Combretum glutinosum*, 100 in the lands of *Guiera senegalensis* , 83 in the lands of *Combretum glutinosum* with respectively 78 (68.4%), 71 (71%) and 57 (68.7%) of species with a frequency of occurrences less than 10%. The order of importance of species citations showed weak variations between lands (Figure 3). In lands of *Piliostigma reticulatum* and *Combretum glutinosum*, *Combretum glutinosum* recorded a high frequency (92.0%), followed by *Guiera senegalensis* (85.1%), *Cordyla pinnata* (83.7%),

Piliostigma reticulatum (76.4%) and *Adansonia digitata* (55.4%). In lands of *Guiera senegalensis*, the most cited species were: *Combretum glutinosum* (93.2%), *Cordyla pinnata* (92.7%), *Guiera senegalensis* (83.6%), *Piliostigma reticulatum* (70.9%) and *Adansonia digitata* (68.2%). As for the lands of *Combretum glutinosum*, *Cordyla pinnata* (96.1%), *Combretum glutinosum* (86.8%), *Guiera senegalensis* (78.9%), *Piliostigma reticulatum* (73.7%) and *Adansonia digitata* (55.3%) were the most cited.

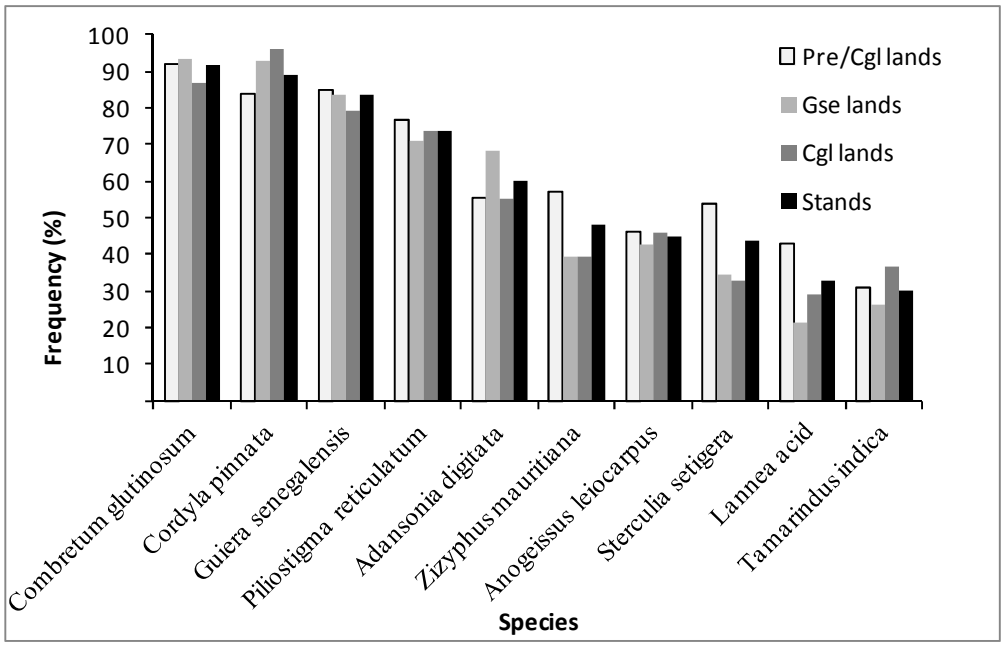


Figure 3 : Frequency distribution of 10 most cited species. Pre = *Piliostigma reticulatum*, Cgl = *Combretum glutinosum*, Gse = *Guiera senegalensis*

Table 1: Variation of the most frequent species according to land use system

Most cited species	Frequence of citation (%)					
	Fields		Fallows		Forests	
	Citation	%	Citation	%	Citation	%
Combretum glutinosum	443	77.4	340	73.0	412	76.3
Cordyla pinnata	489	85.5	295	63.3	267	49.4
Guiera senegalensis	395	69.1	301	64.6	331	61.3
Piliostigma reticulatum	381	66.6	275	59.0	183	33.9
Adansonia digitata	277	48.4	147	31.5	168	31.1
Zizyphus mauritiana	216	37.8	145	31.1	152	28.1
Anogeissus leiocarpus	173	30.2	115	24.7	163	30.2
Sterculia setigera	136	23.8	93	20.0	186	34.4
Lannea acida	-	-	-	-	137	25.4
Tamarindus indica	102	17.8	-	-	-	-
Heeria insignis	97	17.0	-	-	-	-
Sclerocarya birrea	-	-	66	14.2	-	-
Balanites aegyptiaca	-	-	65	13.9	-	-
Pterocarpus erinaceus	-	-	-	-	120	22.2

Adansonia digitata, species weakly recorded during the inventory, got a high number of citations. These occurrences could be guided by importance given to this species because of its multiple uses. The Table 1 showed the distribution of the most common species in fields, fallows and forests. of the 14 most cited species, eight (*Combretum glutinosum*, *Cordyla pinnata*, *Guiera senegalensis*, *Piliostigma reticulatum*, *Adansonia digitata*, *Zizyphus mauritiana*, *Anogeissus leiocarpus* and *Sterculia setgera*) were present in fields, fallows and forests with only a difference in the ranking. The six other species were found only in one system of land use (SUT): *Tamarindus indica* and *Heeria insignis*in fields, *Sclerocarya birrea* and *Balanites aegyptiaca* in fallows, *Lannea acida* and *Pterocarpus erinaceus*in forests. People seemed clearly to appreciate the colonizing species of each land use system. Besides the above-mentioned species, the presence of species that could be considered rare was noted in the studied area because of their very weak frequencies (lower than 0.5 %). They were 37 species (Table 2). These results showed that people know the woodlands characteristics.

Table 2: Species with weak citation frequency

Rare species		
Lophira lanceolata	*Saba senegalensis*	*Mitragyna inermis*
Discorea praehensilis	*Ficus vogelii*	*Diospyros mespiliformis*
Combretum aculeatum	*Albizzia chevalieri*	*Grewia flavescens*
Detarium microcarpum	*Psorospermum corymbiferum*	*Prosopis africana*
Acacia sieberiana	*Acacia raddiana*	*Cissus populnea*
Nauclea latifolia	*Daniellia oliveri*	*Phyllanthus reticularus*
Landolphia heudelotii	*Anthostema senegalense*	*Gardenia triacantha*
Sclerocarya birrea	*Baissea multiflora*	*Securinega virosa*
Grewia villosa	*Erythrina senegalensis*	*Leucaena sp*
Hexalobus monopelatus	*Dialium guineense*	
Acacia holosericea	*Acacia albida*	
Carica papaya	*Salix coluteoïdes*	
Psidium guajava	*Balanites aegyptiaca*	
Parkinsonia aculeata	*Centaurea perrottetii*	

Endangered species in the lands: The surveys revealed *Pterocarpus erinaceus* as the most endangered species with 57.3% of the citations. It was followed by *Cordyla pinnata* (38.8%), *D. microcarpum* (31.5%) and *Sterculia setigera* (30.2%). According to the lands, some variations were noted in the ranking but the most endangered species were still the same. In lands of *Piliostigma reticulatum* and *Combretum glutinosum*, *Pterocarpus erinaceus* (61%), *Cordyla pinnata* (48.9%), *Bombax costatum* (33.1%), *Heeria insignis* (30.9%), *Detarium microcarpum* (28.3%) and *Sterculia setigera* (24.3%) totaling the highest number of citations. The lands of *Guiera senegalensis* showed *Pterocarpus erinaceus*, *Sterculia setigera*, *Cordyla pinnata*, *Detarium microcarpum*, *Ficus iteophylla*, *Lannea acida* and *Heeria insignis* with respectively the frequence of occurrence of 51.1%, 35.7%, 32.1%, 30.3%, 28.5% and 27.6%. In lands of *Combretum glutinosum*, the following species were cited: *Pterocarpus erinaceus* (61.8%), *Detarium microcarpum* (43.4%), *Sterculia setigera* (35.5%), *Ficus iteophylla* (34.2%) and *Lannea acida* (28.9%). The figure 4 showed the ranking of the ten most endangered species. The most threatened species were multipurpose for local people. They were used particularly in services, in food, in pharmacopeia, energy and fodder. Their threat could be strongly related to their various uses. These species considered as the most threatened by the people presented frequencies lower than 5.3% in the floristic composition of woodlands. *D.microcarpum* was particularly cited by respondents whereas it was not listed in the stands composition (fields, fallows and forests).This could reflect a threat of this species in these land use systems. The main causes (Table 3) of wood species threat cited by people were unfair exploitation (84 %), bushfires (43.6 %), drought (35.9 %) and inappropriate cultivation techniques (17.8%). In each land, this ranking was the same to that of stands with a variation in the frequency of citations. Generally, the lands of

Piliostigma reticulatum and *Combretum glutinosum*, presented the highest values.

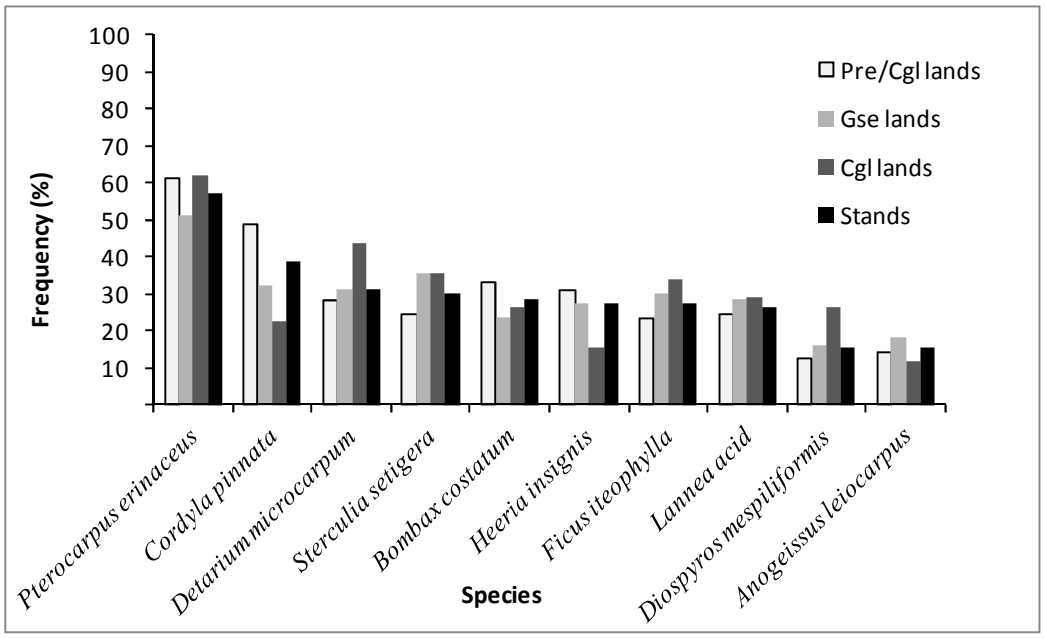


Figure 4: Citation frequencies of the ten most endangered in the lands. Pre = *Piliostigma reticulatum,* Cgl = *Combretum glutinosum,* Gse = *Guiera senegalensis*

Table 3: Citation frequencies of main causes threatening woodland species

Causes	Frequence of citation							
	Lands of Pre/Cgl		Lands of Gse		Lands of Cgl		Stands	
	Citation	%	Citation	%	Citation	%	Citation	%
Bushfires	142	52.2	71	32.1	35	46.1	248	43.6
Unfair exploitation	227	83.5	191	86.4	60	78.9	478	84.0
Inappropriate cultivation techniques	54	19.9	40	18.1	7	9.2	101	17.8
Drought	101	37.1	71	32.1	32	42.1	204	35.9

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

If people paid special attention to endangered species, it seemed attesting the importance of these wood species in their life. Indeed, the main consequences related to the disappearance of the species were the lack of products for pharmacopeia (57.1%), agricultural low yields (43.8%), rainfall decreasing (43.1%), and lack of wood (23.7%), firewood (19.3%) and fodder (12.7%). These effects confirmed the ecological, socio-economic and agronomic roles played by wood species. The people recommended solutions for habitat recolonization with endangered wood species were reforestation (80.7% of the citations), followed by assisted natural regeneration (34.3%), the fight against bushfires (25.5%) and people awareness (25.3%). In lands of *Guiera senegalensis* and those of *Combretum glutinosum*, awareness and the fight against bushfires were respectively the third and fourth rank. The lands of *Piliostigma reticulatum* and *Combretum glutinosum* indicated a reverse ranking. People recommend artificial and natural regenerations and awareness. These results showed the households observed the ligneous evolution in their habitat and seemed to know the appropriate solutions.

Preference of wood species in the lands: *Cordyla pinnata* was widely preferred by households (82.7%). It was followed by *Combretum glutinosum* (50.9%), *Zizyphus mauritiana* (40.9%) and *Adansonia digitata* (38.5%). *Guiera senegalensis* got 35.3% of responses and *Piliostigma reticulatum* (30.6%) (Figure 5). Preferred species distribution according to the lands showed some variations in the ranking. The analysis showed that households in lands of *Combretum*

glutinosum and *Piliostigma reticulatum* preferred in their majority *Cordyla pinnata* with 88.3% of the response occurrences, followed by *Combretum glutinosum* (53.1%), *Zizyphus mauritiana* (46.2 %), *Pterocarpus erinaceus* (41.5%), *Adansonia digitata* (33.8%), *Piliostigma reticulatum* (32%) and *Guiera senegalensis* (30.5%). More than 4/5 of respondents in the lands of *Guiera senegalensis* preferred *Cordyla pinnata* (81.9%), followed by *Combretum glutinosum* (49.8%), *Adansonia digitata* (45.7%), *Guiera senegalensis* (39.4%), *Zizyphus mauritiana* (33.5%), *Piliostigma reticulatum* (28.5%) and *Pterocarpus erinaceus* (28.1%). In lands of *Combretum glutinosum*, *Cordyla pinnata* got 82.9% of occurrences, followed by *Combretum glutinosum* (46.1%), *Zizyphus mauritiana* (43.4%), *Guiera senegalensis* (40.8%) *Adansonia digitata* (34, 2%) and *Piliostigma reticulatum* (31.6%) (Figure 5). The figure 5 showed the households preference of species. The population's responses clearly demonstrated that *Cordyla pinnata* was the most preferred species. Its wide choice could be due to its various uses especially in food. The choice of preferred species according to the cultivated areas (fields, fallows), the forest and uncultivated area was studied. *Cordyla pinnata* was cited in 76.9% of responses in fields and fallow's and 31% in forests and uncultivated area. It was followed by *Combretum glutinosum* with 33.4% of occurrences (fields and fallows) and 31.4% (forest and uncultivated area). If *Adansonia digitata* was more preferably in fields and fallows, *Zizyphus mauritiana* was the most cited in forests and uncultivated area (Table 4).

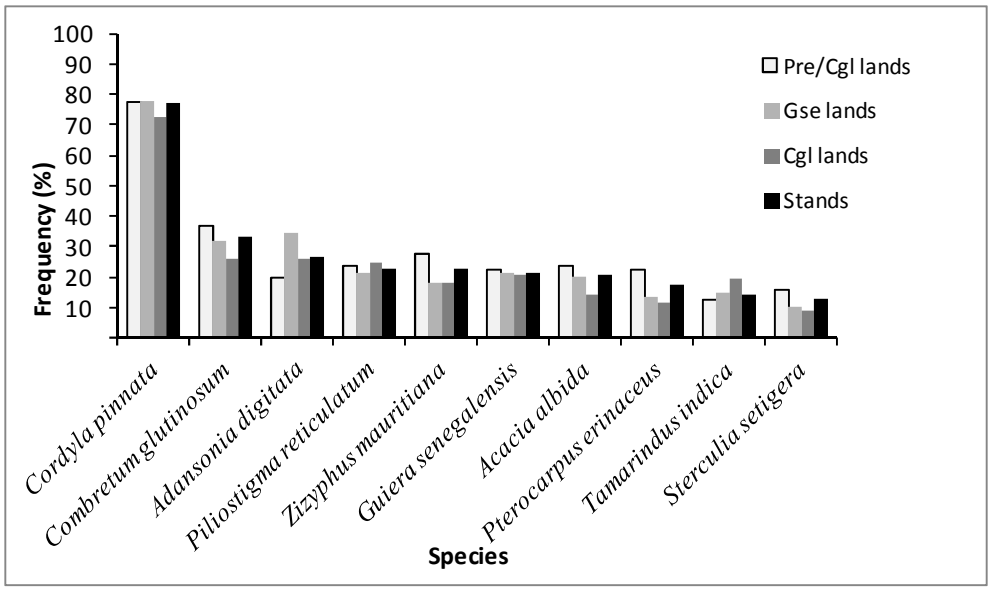


Figure 5: Frequencies of the 10 most preferred species in the lands
Pre = *Piliostigma reticulatum* Cgl = *Combretum glutinosum* Gse = *Guiera senegalensis*

Piliostigma reticulatum, *Tamarindus indica* and *Acacia albida* were preferred only in fields and fallows while *Diospyros mespiliformis*, *Bombax costatum* and *Balanites aegyptiacia* were in forests and uncultivated area. A Species preference was not related to its abundance in the habitat. Uncommon species such as *Pterocarpus erinaceus* were among the eight most preferred species. *Guiera senegalensis*, and *Piliostigma reticulatum* which were listed among the four most common species (species composition) were outclassed by *Zizyphus mauritiana* and *Adansonia digitata* in the list of preferred species. A species preference could be related to its uses. The main uses of species were as food (96.6%), pharmacopeia (89.5%), timber service (65.7%), firewood (58.3%), fodder (40.1%), fertilizer (37.2%) and lumber (36.8%). In lands of *Piliostigma reticulatum* and *Combretum glutinosum* and in those of *Combretum glutinosum*, there were variations in the woodlands overall ranking for the first seven uses. As for lands of *Guiera senegalensis*, the classification of these species main uses was identical to the stand one. Of the 10 most preferred species, seven met these seven main uses with variations in the order of importance. *Cordyla pinnata*, *Zizyphus mauritiana* and *Adansonia digitata* were very appreciated in food. *Guiera senegalensis*, *Piliostigma reticulatum* and *Combretum glutinosum* were widely used in pharmacopoeia (leaves, fruits and

bark). *Pterocarpus erinaceus* was more used in the pharmacopoeia (leaves, fruits and bark) and as service wood (trunk and branches). The species parts used were various. There were fruits and leaves that got high frequencies for the most preferred species with 95.3% and 88.7%. They were followed by bark (78.2%), branches (75.1%) and roots (33.3%).

Table 4: Frequencies variation of the most preferred species according to the land use system

Preferred species	Frequency of citation			
	Cultivated area (fields and fallows)		Forestand uncultivated area	
	Citation	%	Citation	%
Cordyla pinnata	440	76.9	169	31.0
Combretum glutinosum	191	33.4	171	31.4
Zizyphus mauritiana	130	22.7	145	26.6
Adansonia digitata	152	26.6	109	20.0
Guiera senegalensis	124	21.7	112	20.6
Sterculia setigera	73	12.8	104	19.1
Pterocarpus erinaceus	100	17.5	130	23.9
Piliostigma reticulatum	132	23.1	-	-
Diospyros mespiliformis	-	-	97	17.8
Tamarindus indica	83	14.5	-	-
Acacia albida	120	21.0	-	-
Bombax costatum	-	-	98	18.0
Balanites aegyptiaca	-	-	87	16.0

About soil fertilization, people gave their opinion on the most useful species. Five species had citation frequencies higher than 40%. *Piliostigma reticulatum* had the highest value (59.7%), followed by *Acacia albida* (56.6%), *Guiera senegalensis* (46%), *Combretum glutinosum* (40.3%) and *Cordyla pinnata* (40.1%). This property could justify the reason of their preference in fields and fallows. The classification in lands of *Piliostigma reticulatum* and *Combretum glutinosum* was identical to the overall distribution, whereas in lands of *Guiera senegalensis*, *Acacia albida* (59.8%) was in the first rank followed by *Piliostigma reticulatum* (52.9%), *Guiera senegalensis* (43.6%), *Combretum glutinosum* (40.7%) and *Cordyla pinnata* (38.2%). *Cordyla pinnata* (45.7%) outperformed *Combretum glutinosum* (38.6%) in lands of *Combretum glutinosum*. Despite various tree virtues in the environment, inappropriate practices in their exploitation were noted and contribute significantly to the woodlands regression. There were coal exploitation (42.6%), service wood production (39.8%), bushfires (36.6%), intensive use of medicinal products (27.7%) and the transhumant actions on woods (cutting, pruning) during the pasture of their cattle. Two major solutions were recommended to stop these practices threatening woody species stands. It was about a vigilance committee implementation with 67.2% in lands of *Piliostigma reticulatum* and *Combretum glutinosum*, 63% in those of *Guiera senegalensis* and 68.7% in lands of *Combretum glutinosum*. It was followed by sensitization with frequencies of citation of 42.4%, 42.4% and 43.3% respectively in lands of *Piliostigma reticulatum* and *Combretum glutinosum*, lands of *Guiera senegalensis* and those of *Combretum glutinosum*. These results seemed proving people were aware that they were primarily responsible for the decline of woodlands by preconizing solutions to be implemented by them.

Natural regeneration of woody species: The species found in the lands were regenerated; this was the opinion of more than eight out of ten interviewed villagers (88.7%). Citation frequency was 85.9% in lands of *Piliostigma reticulatum* and *Combretum glutinosum*, 90.5% in lands of *Guiera senegalensis* and 93.3% in those of *Combretum glutinosum*. This people perception was confirmed by the floristic composition of woodlands, where were counted only three species (*Lannea acida*, *Euphorbia balsamifera*, *Crataeva religiosa*) which showed no seedlings out of the 75 species recorded. Besides this natural regeneration potential, the respondents knew the methods of seedling protection including surveillance which met 54.6% of the occurrences and monitoring / maintenance which recorded 47.2%. However less than

60% of respondents said they practiced managed natural regeneration. This was practiced mainly by protecting the shooting seedlings (80.7%), natural sowing in fields (50.2%) and the seed trees protection in fields and fallows (15.9%). In the lands of *Piliostigma reticulatum* and *Combretum glutinosum*, the shooting seedlings protection recorded 85.2%, natural seedlings totaling 49% followed by seed trees (20%). The lands of G*uiera senegalensis* had frequencies of 77.7%, 48.8% and 11.6% respectively for the shooting seedlings protection, natural seedlings and seed trees. As for lands of *Combretum glutinosum*, the shooting seedlings protection, natural seedlings and seed trees recorded respectively 74.5%, 56.9% and 13.7% (Figure 6).

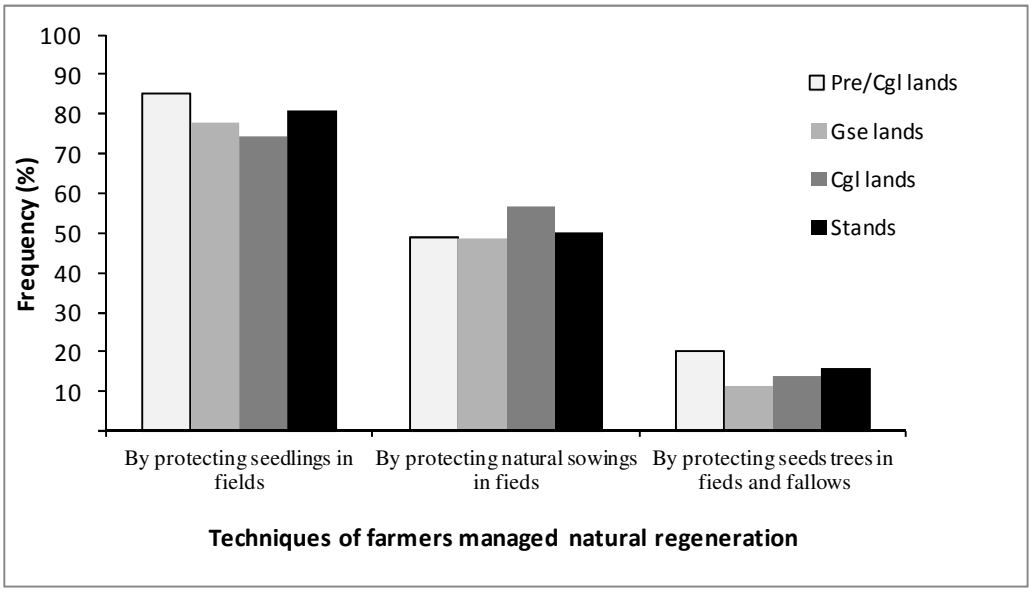


Figure 6: Techniques of farmers managed natural regeneration. Pre = *Piliostigma reticulatum*, Cgl = *Combretum glutinosum*, Gse = *Guiera senegalensis*

The practice of farmers managed natural regeneration had several constraints, the most cited were the monitoring / protection (49.2%), the transhumant action (cutting of young seedlings) (47.3%) and maintenance (29.6%). In lands of *Piliostigma reticulatum* and *Combretum glutinosum*, the transhumant action got the first rank with 53.6%, while in lands of *Guiera senegalensis* and those of *Combretum glutinosum*, monitoring / protection got the first rank with respectively 51.7% and 52.3% of the citations. Three main alternatives were suggested by people to overcome these constraints. Information / awareness obtained 47.6% of the citations, followed by the sanction / fine (33.9%) and the support of Water and Forests Service (31.2%) for monitoring and sanction applications. In lands of *Guiera senegalensis*, the support of Water and Forests Service got the second rank (32.4%) before sanctions / fines (25.4%). Farmers who practiced managed natural regeneration mainly justify it by unknown benefits (47.3%) and lack of information (20.5%).

DISCUSSION

One hundred and forty wood species were identified by households, while the floristic composition indicated 75 species including 71 in the lands of *Piliostigma reticulatum* and *Combretum glutinosum*, 58 in the lands of *Guiera senegalensis* and 46 in those of *Combretum glutinosum* (Bakhoum et *al*., 2012). According to local people perception, the land of *Piliostigma reticulatum* and *Combretum glutinosum* contained more species followed by lands of *Guiera senegalensis* and *Combretum glutinosum*. However, the floristic composition from the species inventory indicated that lands of *Guiera senegalensis* had more species than those of *Piliostigma reticulatum* and *Combretum glutinosum* (Bakhoum *et al*., 2012). These differences

could be explained by people appreciation which was individual and the target composed by people of different ages. People perception showed the dominance of Combretaceae (*Combretum glutinosum*, *Guiera senegalensis*) and Caesalpiniaceae (*Cordyla pinnata*, *Piliostigma reticulatum*). This appreciation was confirmed by the woodlands inventories carried out in the Groundnut basin (Bakhoum *et al*., 2012).However the Mimosaceae family highly represented in the woodlands through *Acacia macrostachya* was lower cited by the people. Its presence in the protected area of Mousdalifa seemed to justify it. People appreciation on the woodlands evolution was consistent with previous studies. The climax was a raised savanna colonized by the dominant species such as *Khaya senegalensis*, *Anogeissus leiocarpus*, *Pterocarpus erinaceus* and *Cordyla pinnata*. Today this raised savanna is degrading and progressively leaving place to shrub savanna characterized by the dominance of Combretaceae (*Combretum glutinosum*, *Guiera senegalensis*), *Acacia macrostachya* and *Piliostigma reticulatum* (Ndao, 2001; Bakhoum *et al*., 2012). The main causes of species threat such as abusive exploitation, bushfires, drought and inappropriate farming practices demonstrate that the stands regression is influenced by two factors: climate change and human activities (Albergel *et al*., 1985). Climate change is remarkable on a century scale and by drought conditions affecting significantly the Sahelian ecosystem and vegetation change (Hulme, 2001; Darkoh, 2003). Successive droughts of 1970 and 1980 have caused in Africa particularly in the Sahel, mortality of woody species in fragile ecosystems (Kossi *et al*., 2009). The anthropic action influences the modifications of plant succession and environmental degradation (Khresat *et al*., 1998). Larwanou *et al.* (2012) showed that excessive wood cutting is a determinant factor in the regressive dynamics of woodlands and bushfires.

In the Sudanese zone (Groundnut basin) in Senegal, Diatta *et al.* (1998) indicated that the woody vegetation distribution can be explained by human actions. The clearing of natural formations for crop extension, the bushfires and the high grazing induce pressure on the environment. Indeed, the continued growth of the rural population results in the increase of cultivation land needs, the reduction even the abandonment of fallow. Other studies in semiarid area showed that gradual soil occupation by crops is a major cause of vegetation change. During land clearing for farming, trees are removed. Despite the conservation of some useful trees, the destruction of others and the frequency of fires do not allow recovering the vegetation (Diallo *et al.,* 2011). In this context, only shrubs can quickly regenerate causing a profound change in the structure and composition of vegetation (Fournier *et al*., 2001). The multipurpose species are most threatened (*Pterocarpus erinaceus*, *Cordyla pinnata*, *Detarium microcarpum, Sterculia setigera.* The importance of co-products provided by some species is a major cause of their destruction because of intense exploitation (Ouedraogo *et al*., 2006). Therefore, *Sterculia setigera* is a species which plays a very important economic, food and pastoral role for rural populations in the Groundnut basin (Bakhoum *et al*., 2001).

Cordyla pinnata occupies both the second rank among the most represented and the most threatened species due to the fact that it is carefully protected in the fields by people but its regeneration is low. Increasingly, non-timber forest products even with their limited availability contribute to the livelihoods and sometimes generate more net income than agriculture and animal husbandry. The fruits of dimb (*Cordyla pinnata*) are valorized out of the rural family economy and in recent years, it was noted very rapid growth of urban demand for forest products. This increase reflecting a change in food habits, has contributed significantly to the regression of many woody species often overused. People appreciation shows that a species preference does not depend on its abundance in the area but his roles as food, as fertilizer, fodder, traditional medicines, firewood and wood service. In short, preferences are linked to ecological, agronomic and socio-economic benefits. *Guiera senegalensis* and *Piliostigma reticulatum* which are among the four most represented species in the woodlands were outclassed by *Adansonia digitata* and *Zizyphus mauritiana* in preferences. This could be related to the respondents ignorance of some roles played by *Guiera senegalensis* and *Piliostigma reticulatum* in the medium. Dossa *et al*. (2009) indicated that these two species protect crops against wind and water erosion. In addition to this protection, they can release nutrients into the soil (N, C, P). Kizito *et al*. (2007) have demonstrated the impact of *Guiera senegalensis* and *Piliostigma reticulatum*, native species in Groundnut basin on the components of water balance in the fields. These authors suggest that up to 1.10 m depth, these two trees do not compete with annual crops for water. In the previous studies, Kamara and Haque (1992) showed that *A. albida* has a positive effect on annual crops. Samba (1997) demonstrated that the impact of all factors having a

depressive effect on crops under *Cordyla pinnata* is more important than the improvement of chemical properties of the soil. *Combretum glutinosum* plays a protected role against wind, water evaporation and soil transpiration (ENSA – AGROCONSULT, 1998).

The main mode of propagation of species remains natural regeneration. Farmers have noted species regenerative capacity. Among those regenerating spontaneously, some are preserved and their growth is favored (Bakhoum *et al*., In press; Brown *et al*., 2011). The enhancement of natural regeneration done primarily through the protection of natural shooting seedlings and natural seedlings confirms Reij *et al.* (2009) and Gijsbers *et al.* (1994) studies. This asexual regeneration in the woodlands seems to reveal a means of survival or a state of going beyond of the capacities of sexual reproduction. It is question almost always of economic value of the species. The asexual reproduction is not able to ensure a spatial propagation of the species at the same scale as the seeds uses. It does not promote the plant genetics conservation (Ouédrago *et al*., 2006). Monitoring / protection, transhumant actions by cutting preserved young seedlings and maintenance are the main constraints to the development of natural regeneration given by the farmers.

However other major obstacles to the regeneration are about the pressure from human and animals, mechanization, the rainfall constraints, the early fruits picking and the old aging subjects (Samba *et al.*, 2000). The wandering livestock, drought, pests (termites, grasshoppers.) and abusive cuts were identified by Diouf (2001). The main solutions proposed by respondents to remove these constraints to the practice of assisted natural regeneration (information / awareness, sanction / fine and the support of Water and Forests Service in the monitoring, sanctions enforcement) confirm the farmers perceptions in previous studies including those of Diouf (2001) in Groundnut basin for natural assisted regeneration revival.

CONCLUSION

People's perceptions on the woodlands characteristics especially the dominant species (*Combretum glutinosum*, *Guiera senegalensis* and *Piliostigma reticulatum*) and most threatened such as *Pterocarpus erinaceus, Cordyla pinnata, Detarium microcarpum* and *Sterculia setigera* in the Groundnut basin corroborate the results on the wood composition. If people are aware of the main causes of species loss (abusive exploitation, bushfires, drought and inappropriate farming practices) and know the appropriate solutions, the implementation of these solutions has not really reversed the trend of the woodlands regression. The preference of a species is more related to its multiple uses that are socio-economic, agronomic and ecological. Between the lands, both the spatial distribution, evolution, and the species preference, variations are noted essentially on the rank. From the results of the present study, many challenges remain to be overcome through the scientific research. The scientific reasons must be found to justify some positive judgments on the tree and its regeneration and finally, to refute the negative apprehensions related to the practice of assisted natural regeneration.

ACKNOWLEDGMENTS

This work is a part of the research project: 'Management of natural regeneration by farmers'of World Vision Senegal. It was financially and technically supported by the Australian Government (AUSAID)

REFERENCES

Akpo L. E., & Grouzis, M., 1996 - Influence du couvert sur la régénération de quelques espèces ligneuses sahéliennes (Nord-Sénégal, Afrique occidentale). Webbia 50 (2) : pp. 247-263.

Albergel J., Carbonnel J.P., Grouzis M., 1985. Sécheresse au Sahel : incidences sur les ressources en eau et les productions végétales. Cash. ORSTOM, sér. Hydrol., vol. XXI, 1 : 3-19.

ANSD, 2005 - Enquête Démographique et de Santé IV (EDS IV), Sénégal.

Bakhoum C., Samba A.N.S., Ndour B., 2001 - *Stercula setigera* Del. : Effet sur les cultures. Ann. For. Sci. 58: 207–215

Bakhoum C., Ndour B., Akpo L.E., 2012 - Typology of woodlands 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., 1995– Influence du *Sterculia setigera* del « Mbepp » sur les rendements des cultures annuelles (arachide, mil, sorgho) au sud-est du bassin arachidier du Sénégal, ISE, Faculté des Sciences et Techniques, UCAD, Sénégal, pp. 10-61

Bakhoum C., Ndour B., Akpo L.E., sous presse - Régénération naturelle du peuplement ligneux des terroirs du bassin arachidier en zone soudano-sahélienne (Région de Kaffrine, Sénégal). IJAEBS.

Belsky A. l, Mwonga S.M. &Duxbury IM., 1993 - Effects of widely spaced treesand livestock grazi.ng on under storey environnements in tropical savannas. *Agroforestry System,* 24: 1-20.

Bonkoungou, E.G., 1985. *Acacia albida Del.,* a multipurpose tree for arid and semi-arid zone.

Brown D.R., Dettmann P., Rinaudo T., Tefera H., Tofu A. 2011 - Poverty Alleviation and Environmental Restoration Using the Clean Development Mechanism: A Case Study from Humbo, Ethiopia. Environmental Management, 48(02): 322-333

Dancette C. et Poulain J.P. 1968. Influence of *Acacia albida* on pedoclimatic factors and crop yields. *African Soils* 14: 143-184.

Darkoh MBK. 2003. Regional perspectives on agriculture and biodiversity in drylands of Africa. Journal of Arid Environments 54 : 261-79.

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 n° 3, avril-juin, pp. 97-107

Diatta M., Grouzis M., Faye E., 1998. Typologie de la végétation ligneuse en zone soudanienne. Bois et forets des tropiques, N° 257 (3), pp. 23-36.

Diouf B., 2001. Étude de la Régénération Naturelle Assistée des espèces associées aux cultures annuelles dans les parcelles agroforestières du projet GERT (Gestion de l'Espace et des Ressources Naturelles du Terroir). Mémoire de fin d'étude pour l'obtention du diplôme d'ingénieur des travaux agricoles, Département des Productions Végétales, Ecole Nationales des Cadres Ruraux de Bambey (ENCR), Sénégal, pp. 27-31.

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

Fournier A., Floret C., Gnahoua GM, 2001. Végétation des jachères et succession post-culturale en Afrique tropicale. In : Ch.Floret Ch, Pontanier R. Jachère en Afrique tropicale. Montrouge (France) : éditions John Libbey Eurotext.

Gijsbers H.J.M., Kessler J.J., Knevel M.K., 1994. Dynamic and natural regeneration of woody species in farmed parklands in the Sahelian region (Province of Passore, Burkina Faso). For Ecol Manage, 64: 1-12.

Houmey V.K., 2012 - Drageonnage et caractéristiques nutritionnelles d'un ligneux fourrager, sahélien, *Maerua crassifolia* Forsk., pour le développement de l'élevage. Thèse de Doctorat en Ecologie et Agroforesterie, EDSEV, UCAD, Dakar (Sénégal), pp. 62 – 66.

Hulme, M., 2001- Climatic perspectives on Sahelian desiccation : 1973 - 1998. Global Environmental Change 11: 19 - 29. Pergamon, Elsevier.

Kamara C. S. & Haque L., 1992 -*Faidherbia albida* and its effects on Ethiopian highland vertisols. *Agroforestry Systems* 18: pp. 20-28.

Khresat SA., Rawajfih Z., Maohammad M., 1998. Land degradation in north-wester Jordan : causes and processes. Journal of Arid Environments 39 : 623-9

Kizito F., Sene M., Dragila M.I., Lufafa A., Diedhiou I., Dossa E., Cuenca R., J. Selker 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 90 : 137 – 148

Kossi A., Bellefontaine R., Kokou K., 2009 . Les forets claires du Parc national Oti-Kéran au Nord-Togo : structure, dynamique et impacts des modifications climatiques récentes. Sécheresse 20 : 394-6. doi : 10.1684/sec.2009.0211.

Larwanou M., Moustapha A.M., Rabe M.L., Iro D., 2012. Contribution de la Régénération Naturelle Assistée des ligneux dans l'approvisionnement en bois des ménages dans le département de Magaria (Niger). Int. J. Biol. Chem. Sci., Volume 6, Number 1. *Pages 24-36.*

Moussa H. 1997. Germination du palmier Doum (*Hyphaene thebaica* Mart.) et analyse de son interaction avec le mil (*Pennisetum glaucum* L.) en zone semi-aride du Niger. *Thèse de PhD*, Faculté des sciences de l'Agriculture et de l'Alimentation, Université Laval, Québec, Canada.

Ndao, M. 2001. Étude d'une zone test du département de Kaffrine (SENEGAL). Caractérisation du sol et de son occupation - Spatialisation des résultats. Travail de diplôme du Cycle Postgrade en Sciences de l'Environnement: EPFL, Lausanne.

Ouédraogo A., Thiombiano A., Hahn-Hadjali K., Guinko S., 2006 – Diagnostic de l'état de dégradation des peuplements de quatre espèces ligneuses en zone soudanienne du Burkina Faso. Sécheresse ; 17 (4) : 485-91

UICN, 2008. Évaluation de la biodiversité et des forêts tropicales au Sénégal. 74 p.

UICN, 2000 - Catégories et Critères de l'UICN pour la Liste Rouge. Version 3.1

Reij C., Tappan G., Smale M., 2009. Agro environmental Transformation in the Sahel. Another Kind of "Green Revolution". The International Food Policy Research Institute (IFPRI), pp. 1-38.

Samba A.N.S., Sène A., Thomas I., 2000 - Régénération des ligneux dans la parc à Acacia albida, CNRF, ISRA, Sénégal, 4p.

Samba A.N.S., 1997. Influence de *Cordyla pinnata* sur la fertilité d'un sol ferrugineux tropical et sur le mil et sur l'arachide dans un système agroforestier traditionnel au Sénégal, Thèse du grade de Philosophiae doctor (Ph.D.), Département des Sciences du bois et de la forêt, Faculté de foresterie et de géomatique, Université Laval, Québec, Canada, pp. 140-146.

World Vision International, 2003 - Indicateurs de Développement Transformationnel (TDI), Guide sur le Terrain; Volume 7, Washington, USA.