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Phytodiversity and carbon stock in Sudanian savannahs zone of Tandjile-East of Chad

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Abstract
The Sudanian savannahs of the Tandjile - East are fragile and vulnerable. They face severe threats from land use change, unsustainable exploitation of natural resources, desertification and climate change. In this perspective, the objective of the study is to understand the plant diversity and epigeal carbon storage of the Sudanian savannahs of the Tandjile - East. It can be a good step towards their management for the delivery of diverse ecosystem services. A total of 90 plots of 2500 m^2 each in three types of vegetation were established and all trees and shrubs were recorded (>10 cm). Tree biomass was estimated in the basis of diameter at breast height (dbh) while the understorey biomass using destructive method.
A total of 2840 trees were measured belonging to 46 species, 28 genera and 21 families. The richest family is Fabaceae (Fiv, 46.35%) follow by Combretaceae (13.70%) and Moraceae (12.71%). The analysis of species diversity indexes shows a relative important biodiversity and the vegetation structure showed a high occurrence of average diameter of plant species. Shannon index varied from 3.68±0.206 bits to 3.80±0.24 bits whereas Simpson index oscillated between 0.961±0.008 and 0.977±0.01. The mean aboveground carbon stock varies from 13.28±1.32 tC/ha in shrubby savannah to 17.52 ± 2.76 tC/ha to dry forest. The total death aboveground carbon stock ranges from 5.25 ± 2.23 tC/ha in the shrubby savannah to 13.96 ± 2.31tC/ha in dried forest. These results will help in developing reliable REDD$^+$ mechanisms in Chad.

Keywords: Biodiversity, savannahs, biomass, carbon, Sudanian climate, Chad

Introduction
Natural African savannahs represent great biodiversity tanks [1]. Unfortunately this biodiversity is threatened during the last decades due to unfavorable socio-economic and pedoclimatic conditions [2, 3]. This degradation is characterized by an important reduction of plant species and particularly considerable woody resources. The high anthropic pressures on biodiversity are deforestation; shorten of the fallow duration and over grassing [4]. The phenomenon of biodiversity degradation constitutes a threat to humanity and was becoming since the United Nation Conference on the Environment and Development (CNUED) held in Rio in 1992, a world worry [5]. Due to its vulnerability to the modification of climatic conditions, Chad republic is interested to all the conventions of the United Nations (UN) on the environment notably: the Framework Convention on Climate Change (CCNUCC), Framework Convention on Biological Diversity (CBD) and Framework Convention on Desertification (CCD) [6]. These conventions are obligations with concrete objectives aiming at the integration of the environment protection and sustainable management of biodiversity on the socio-economic development of the populations. Biodiversity plays a role on main climatic equilibriums and provides substantial revenue to local populations [7, 8]. It protects soil against erosion and reduces greenhouse gas effects. Carbon dioxide (CO_2) is a green house gaze (GHG) that the increase of concentration induces climatic warm [9, 10]. Plant diversity is a potential atmospheric carbon tank via trees photosynthesis and can cause growth rate and biomass production [11]. Biomass estimate is essential for carbon stock determination [12, 13].

Despite the importance of biological diversity in ecological fragile country like in Chad, little scientific research is devoted to Biodiversity and carbon stock except those of [14-16] which assessed some aspects of biodiversity. Very few studies have examined this problematic using quantitative data. Current work is designed to characterize the Tandjile-East Sudanian vegetation from biodiversity and carbon storage perspective in order to gather useful information usable to launch reliable $REDD^+$ mechanisms in Chad.

Materials and methods

Study site

The work was undertaken in three localities of Tandjile-East situated in south of Chad named Guidari, Kimré and Ndam (Table 1). The ethnolinguistic groups involved are comprised of Gham, Gabri and Ndam. They are native most representative group of the region and present diversified cultures. This region is characterized by a Sudanian climate, with two seasons: a rainy season from April to October and a dry season from November to March. The average annual rainfall ranges between 700 and 1200 mm with important intra and interannual variations; the average annual temperature 27 and 44 °C [17]. The soils are essentially developed on lateritic sediments, sand, sand –clay and limoneous [18]. The area is covered by a diversity of woody species dominating bush frequently burned by fires [19].

Table 1: Sites characteristics: vegetation type and geographical position.

Site	Savannah types	Latitude	Longitude	Altitude (m)
Ndam	Woody savannah	09° 46' 03,4'' N	017° 10' 57,8'' E	382,2
Guidari	Shrubby savannah	09° 18' 16,7'' N	016° 55' 47,6'' E	354,9
Kimré	Dry forest	09° 17' 48,5'' N	016° 55' 47,6'' E	355,8

Methodology

A preliminary prospection of the area permitted to identify three types of vegetation: shrubby savannah, woody savannah and dried forest. The nested plot method was used for the sampling of the above ground vegetation. It is one of the most commonly used for all kind of vegetation sampling. The method is applicable to baseline as well as project scenario. They were inspired from various floristic inventory methods used in Burundi [20] and Senegal [21]. Inside each plot, 30 nested plots of 2500 m^2 were established randomly. The diameter at the breast height (dbh) of woody plant species were measured at 1.30 cm in each plot. A total of 90 floristic records were realized. To estimate tree biomass and understorey biomass, non - destructive and destructive methods were respectively used. The understorey carbon pool includes the aboveground biomass of all trees less than 2.5 cm Dbh along with all non-tree vegetation [22]. The biomass of tree was estimated on the basis of Dbh. For understory biomass, fresh and dry weights were measured. Biomass values were then multiplied by an expansion factor to scale them to a one hectare area.

Data analysis

Species richness, Shannon-wiener index (H), Simpson index (D') and Hill index were used to calculate the species diversity (Shannon and Wiener, 1963). $H = - \sum Pi \log_2 Pi$, Where $Pi = ni /N$, ni is the number of individuals of the species and N is the total number of individuals of all species. $D' = 1-\sum Pi^2$. $Hill = (1/\lambda)/e^H$, where $1/\lambda$ is the reciprocal of the Simpson index; $e^{H'}$ is the exponential of the Shannon index. Rarity-weighted Richness Index (RWRI) was also calculated using equation formula of [23]. $RWRI = [1-(ni/N)] x100$. RWI index is high when the sample is composed only of rare species and low when there are few rare species in the sample. In this study, we assume that when RWRI is higher than 80 %, the species is considered as rare. The quantitative analysis of frequency, density and abundance was done by using the standard expressions. The importance value index of species (IVI) was determined as the sum of relative frequency, relative density and relative dominance [24]. IVI determines vegetation status and importance of component species in a stratum stand. To describe the ecological importance of species, morpho-species and families within each plot as well as for the total flora, the species Importance Value Index (IVI; [25]) and the Family Importance Value index (FIV; [26]) were also calculated: Relative abundance = (number of trees of the species or family/total number of trees) x 100.

Relative frequency = (frequency of a species=sum of all frequencies) x 100.

Family relative diversity = (number of species in a family=total number of species) x 100.

IVI = relative density + relative frequency + relative dominance.

FIV = family relative diversity + relative density + relative dominance. These indexes determine vegetation status and importance of component species in a stratum stand.

The above ground live biomass was calculated using several allometric equations: for dry forest [27], for Palmaceae [28] and others for the death biomass [29, 30].

Results and Discussion

Taxonomic composition

A total of 2840 woody plants were recorded, belonging to 46 species, 28 genera and 21 families. The density was 28.40 stems/ha. The richest families include the Fabaceae with 7 species, followed by Combretaceae (6 species), Moraceae and Anacardiaceae with 3 species each. In the semi-arid zone of Cameroon, Combretaceae was recorded as the most diversified family [22]. The richest genera are *Combretum, Ficus and Terminalia* with 3 species each (Table 2). The number of tree species (46) assessed in this vegetation is lower than 298 species recorded in Massenya vegetation of the Centre Chad [16]. The previous studies included both trees and herbaceous contrary to ours.

Table 2: Recorded families, genera and the number of species

Families	Species richness
Fabaceae	7
Combretaceae	6
Moraceae	3
Anacardiaceae	3
Rubiaceae	2
Total	**21**
Genera	
Ficus	3
Combretum	3
Terminalia	3
Gardenia	2
Piliostigma	2
Grewia	2
Total	15

Species richness, diversity and abundance

Forest communities are considered rich, characterized by a Shannon diversity value of about 3.5 or higher [31]. The vegetation type of Tandjile-East, which all have high values of Shannon diversity (Table 3), can accordingly be considered diversify. The Shannon Weiner diversity index varied from 3.68±0.206bits in the woody savannah to 3.80±0.24 in the shrubby one. The high value of Simpson diversity index (D'= 0.977±0.01) showed a relatively high species diversity in the dry forest in term of plant species.

Table 3: Diversity indexes of different vegetation type in Tandjile-East

indices	Vegetation types		
	Shrubby savannahs	**Woody savannahs**	**Dry forest**
Indice de Shannon	3.80±0.24	3.68±0.21	3.72±0.02
Indice de Simpson	0.961±0.01	0.967±0.01	0.98±0.01

The relative density of the top seven species ranged from 1.25 % (*Khaya senegalensis*) to 2.97 % (*Mangifera indica*). The average relative density of woody plants is 2.32%. The top seven with high density include *Vitellaria paradoxa*, *Mangifera indica*, *Parkia biglobosa*, *Faidherbia albida*, *Cordia senensis*, *Khaya senegalensis* and *Daniellia oliveri* (Table 4). *Vitellaria paradoxa* is the most frequent species (5.60%) with a high basal area (5.43%).

The most important ecological tree species based on IVI score are *Vitellaria paradoxa* (12.63), *Mangifera indica* (12.06), *Parkia biglobosa* (11.38), *Acacia albida* (10.36), *Cordia senensis* (10.09), *Khaya senegalensis* (10.03) and *Daniellia oliveri* (10.02) (Table 4). Among these species *Vitellaria paradoxa*, *Mangifera indica* and *Parkia biglobosa* are species with a great socio-economic importance for the populations. The fruits of these species are consumed and commercialized in local and regional markets of the zone. Similar results are reported in natural ecosystems of Benin [32, 33] and Cameroon [34].

Table 4: Quantitative vegetation analysis (Relative density, Relative frequency, Basal area and IVI) of Tandjile-East

Espèces	Relative density (%)	Relative frequency (%)	Basal area (%)	IVI
Vitellaria paradoxa	1.60	5.60	5.43	12.63
Mangifera indica	2.97	5.41	3.68	12.06
Parkia biglobosa	2.65	3.30	5.43	11.38
Faidherbia albida	2.56	4.97	2.83	10.36
Cordia senensis	2.42	4.47	3.20	10.09
Khaya senegalensis	1.25	4.38	4.40	10.03
Daniellia oliveri	2.78	2.74	4.68	10.02

Ecological importance of plant species

Concerning the most important ecological families, the top five families based on the Family Importance Value index (FIV>10) are Fabaceae (46.35), Combretaceae (13.70), Moraceae (12.71), Anacardiaceae (11.45) and Mimosaceae (10.23) (Table 5). The most diversified families are equally the most dominant. Species belonging to these families, benefited from their protection due to the fact that the majority of them are useful for the populations. Analogous observations were reported in Senegal [35]. Nevertheless, the importance of Combretaceae has been reported in the humid lowlands of Cameroon [36].

For the relative diversity, the Fabaceae (12 %) is the most diversified family, confirming the previous result (Table 5). This results is also in line with the findings of the Gowayang forest of Cameroon [37].

Table 5: Quantitative family analysis (Relative density, Basal area, Relative diversity) and Important ecological families in Tandjile-East

Family	Relative density (%)	Basal area (%)	Relative diversity (%)	FIV (%)
Fabaceae	30.08	4.26	12	46.35
Combretaceae	6.90	4.79	2	13.70
Moraceae	6.24	2.47	4	12.71
Anacardiaceae	7.20	2.25	2	11.45
Mimosaceae	3.84	3.39	3	10.23
Rutaceae	4.28	3.21	2	9.49
Polygalaceae	2.81	2.82	3	8.63
Tiliaceae	3.51	1.89	3	8.40
Meliaceae	5.76	0.48	2	8.24
Verbenaceae	2.14	3.06	3	8.20
Sapotaceae	5.72	0.65	1	7.37
Sterculiaceae	2.44	3.21	1	6.65
Boraginaceae	0.74	4.79	1	6.53
Loganiaceae	3.17	2.08	1	6.26
Rutaceae	1.96	1.05	3	6.00
Arecaceae	2.40	0.59	3	5.99
Hymenocardiaceae	1.96	2.98	1	5.94
Moringaceae	2.81	2.03	1	5.84
Ebenaceae	1.37	2.82	1	5.19
Olacaceae	3.17	0.34	1	4.52
Bombacaceae	1.51	0.41	1	2.92

Structure of woody vegetation

The minimum dbh was 13.01 cm, found in *Gardenia erubescens* while the maximum one was 216.95 cm in *Bombax costatum*. However, the distribution of dbh classes was in conformity to 'bell' shape curve, with 4.35 % of individuals having Dbh lower than 30 cm (Fig. 1). Diameter structure of the vegetation in Tandjile - East presents a high tree density (0.08 individuals / ha) within the average diameter classes (60.1-70 cm) which decreases with increasing diameter. The high proportion of young individuals within 60.1-70 cm could suggest a dominance of average diameter trees in Tandjile-East land use systems. This population structure of the woody species in the area suggested that regeneration and maintenance of mature trees are difficult in the zone due to anthropic pressures. As these savannahs are under degradation, should agro-ecosystems be able to provide the same ecological services to local populations after their conversion? It is important to think about how to develop appropriate management systems which protect the environment without forbidding the populations from executing their daily activities.

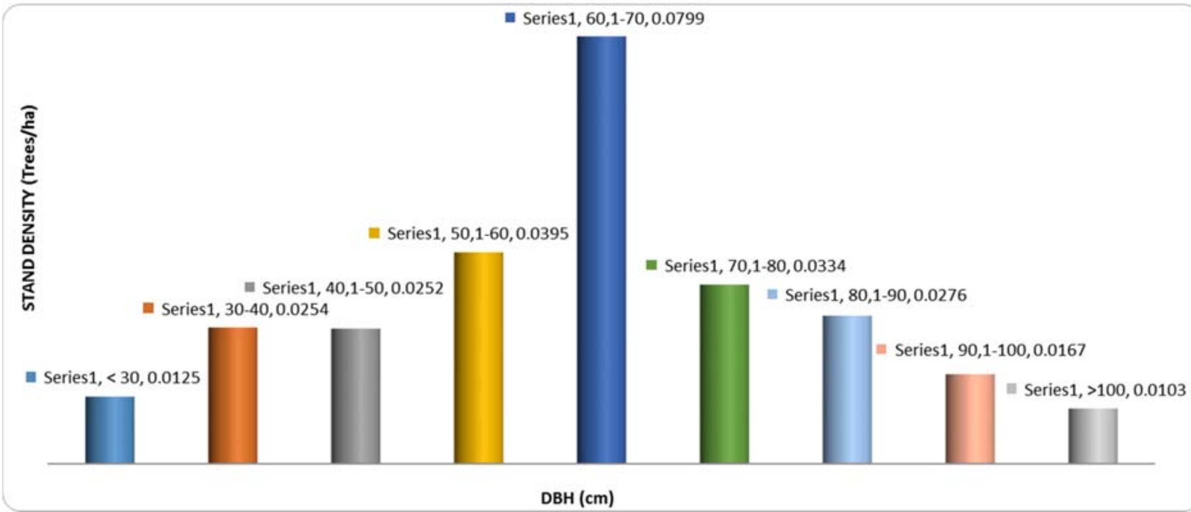

Fig 1: Stand structure of trees based on diameter classes in Tandjile – East

Carbon distribution

The overall aboveground carbon stock obtained in the study area was 72.01 tC/ha including 47.47 ± 7.57 tC/ha for life carbon and 24.54 ± 6.79 tC/ha for the death one.

Standing live carbon stock

The total standing live carbon stock ranged from 0.97 ± 0.13 tC/ha from stump to 42.22 ± 6.96 tC/ha in woody. The woody savannah showed the greatest carbon stock (42.22 ± 6.96 tC/ha) followed by the herbaceous (4.28 ± 0.46 tC/ha). Concerning the vegetation type, the standing live plant carbon stock varied from 13.28±1.32 tC/ha in woody savannah to 17.52 ± 2.76 tC/ha in dried forest. The dry forest and the woody savannah were the most important tanks of carbon in the zone. The total quantity of carbon stored by the biological types among which woody and herbaceous species was 47.47 ± 7.57tC/ha (Table 6). There is no significant difference between vegetation types (*p*>0.05). However this result falls within the interval of 10-60tC/ha obtained in Costa Rica [38]. In humid forest of Cameroon, similar conclusions were drew [39]. Nevertheless, the amount of carbon recorded in Sudanian area is lower than that obtained in the humid lowlands of Cameroon [35, 40].

Table 6: Amount of aboveground biomass in categories of plants in different types of vegetation

Categories of plants	Shrubby savannah	Woody savannah	Dry forest	Total
Woody (tC/ha)	15. 24 ± 3.31	11.78 ± 1.13	15. 20 ± 2.52	42.22 ± 6.96
Stumps (tC/ha)	0.27 ± 0.039	0.33 ± 0.0 42	0.37 ± 0.053	0.97 ± 0.13
Herbaceous(tC/ha)	1.16 ± 0.12	1.17 ± 0.15	1.95 ± 0.19	4.28 ± 0.46
Total	16.67±3.34 a	13.28±1.32 b	17.52 ± 2.76 b	47.47 ± 7.57

Death aboveground carbon

In savannahs, the stock of death aboveground carbon varied from 7.11 ± 0.87 tC/ha from felt tree in the tree savannah to 17.43 ± 5.92 tC/ha in the standing one. The death epigeal carbon stored by biological type constituted by death stumps is evaluated at 24.54 ± 6.79 tC/ha (Tableau 7). This result is in line with those obtained in Tropical ecosystems (13 - 25 tC/ha) [41]. However our results are against those reported in Amazonia (10 - 60 tC/ha) [42]. There was a significant difference between sites (*p*<0.05). This was due to the fact that farmers harvested firewood on dead trees or stumps. Concerning the ethnical group, the amount of carbon varied from 5.25 ± 2.23 in the Kimre group to 13.96 ± 2.31 in Ndam group. This result indicated that Ndam group has good knowledge on sustainable management of the environment because they harvest death wood preferentially for fuel.

Table 7: Amount of aboveground biomass of death plants in different tribes

Categories of death plants	Guidari	Kimre	Ndam	Total
Death trees laid down (tC/ha)	3.12 ± 1.94 a	3.12 ± 1.94 a	11.19 ± 2.04 b	17.43 ± 5.92
Death stumps (tC/ha)	2.21 ± 0.27	2.13 ± 0.29	2.77 ± 0.31	7.11 ± 0.87
Total	5.33 ± 2.21	5.25 ± 2.23	13. 96 ± 2.31	24.54 ± 6.79

Human generated disturbances such as uncontrolled logging, hunting or transient farming may rapidly reduce the biodiversity value of the Sudanian vegetation in the near future, by exerting severe negative impacts on its rich but poorly known fauna and flora. There is an urgent need to consider this area within the national strategy for conservation and sustainable development, fostering actions to preserve this region and its potential for providing ecosystem services both to local populations and to the nation and the region. This study begins to fill in an important gap in the floristic knowledge of the Tandjile – East.

Conclusion

The savannahs of the Sudanian area of Chad showed an important role in mitigating climate change. Their carbon sink potential represents important biomass fraction stored in the natural vegetation. The main results obtained include relative high value of diversity indexes and carbon stock. These results suggest that the Sudanian savannah of Tandjile-East of Chad dry lands need to be taken into account in national environment protection policies as an alternative to respond to international agreements related to biodiversity conservation, combating desertification and climate change.

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Références

1. Faye E, Diatta M, Samba ANS, Lejoly J. Usages et dynamique de la flore ligneuse dans le terroir villageois de Latmingué (Sénégal). Journal des sciences et technologies, 2008; 7:43-58.
2. Sambou B, BÂA T, Mbow C, Goudiaby A. Studies of the woody vegetation of the welor forest reserve (Senegal) for sustainable use. West African journal of applied Ecology, 2008; 13(1) 10.
3. Anonyme. Variation de la biodiversité végétale en fonction de l'altitude dans le chainon montagneux de Ngovayang (sud-Cameroun). Rapport scientifique détaillé, 2009; 374:10.
4. Sounon B, Sinsin B, Goura S. Effet de la dynamique d'occupation du sol sur la structure et la diversité floristique des forêts claires et savanes au Benin. Tropicultura, 2007; 25(4):221-227.
5. Arranz L, Pfeffer P, Poilecot P. Zakouma vingt ans après. Le courrier de la Nature, 2007; 234:26-32.
6. United Nation Framework Convention on Climate Change (UNFCCC), 2007. Report of the conference of the parties, its thirteenth session, Addenduim, Part 2. Document FCCC/07/2007/6/Add.1.UNFCCC, Bonn, Germany. 2007.
7. Nouvellet Y, Kassambara A, Besse F. Le parc à karité au Mali : inventaire volume, houppier et production fruitière. Bois et Forêts des Tropiques, 2006; 287:5-20.
8. Gwali S, Okullo JBL, EILUG, Nakabonge G, Nyeko P, Vuzi P. Traditional management and conservation of shea trees (*Vitellaria paradoxa nilotica*) in Uganda. Environment, Developpement and Sustainability. 2012; 14(3):347-363.
9. Alamgi M, Al-Amin M. Allometric model to estimate biomass organic carbon stock in forest vegetation. Journal of forestry Research, 2008; 19:101-106.
10. Clark DA. Litter biomass and nutrient Determinants of and Density, Nest Size and Growth in a Costa Rican Tropical West Forest. Biotropical, 2009; 41:234-240.
11. Culmee H, Leuschner C, Moser G, Pitropang R. Forest aboveground biomass along an elevational transect in sulawesi in sulawesi, Indonesia and the role of Fagaceae in tropical montane rain forests. Journal of Biogeography, 2010; 37:960-974.
12. Ebuy Alipade J, Lokombé Diamandja JP, Ponette Q, Sonwa D, Picard U. Biomass equation for predicting tree above ground biomass at Yangambi, DRC. Journal of tropical forest science. 2011; 23(2):125-132.
13. Thangata PH, Hildebrand P. Carbon stock and sequestration potential of agroforestry systems of sub-sahara Africa: machinisms for reducing emissions from deforestation and forest degradation (REDD+). Agriculture, Ecosystems and Environment. 2012; (158):172-183.
14. Dona A, Mapongmetsem PM, et Fawa G. Traditional agroforestry systems and biodiversity conservation in Tandjile East, Chad. Annals of Experimental Biology, 2016; 4(1):25-34.
15. Béchir AB, Mopaté LY. Analyse de la dynamique des pâturages autour des ouvrages hydrauliques des zones pastorales du Batha ouest au Tchad, Afrique Science, 2015; 11(1):212-226.
16. Melom S, Mbaygone E, Ratnan Ngadoum, Bechir Ali Brahim, et Mapongmetsem PM. Caractéristiques floristique et écologique formations végétales de Massenya (Afrique centrale). Journal of Animal and Plant Sciences. 2015; 25(1):3799-3813.
17. Poilecot P, Boulanodji E, Taloua N, Djimet B, Ngui T, Singa J. Parc national de Zakouma : structure des peuplements ligneux dans les savanes exploitées par les éléphants. Bois et Forêts des Tropiques, 2006; 290:45-59.
18. Jamin JY, Gounel C, Bois C. (éd.), Atlas. Agriculture et développement rural des savanes d'Afrique Centrale. N'djamena, Tchad, Montpellier, France, Prasac/Cirad, 2004, 100.
19. Sougnabé P. Pastoralisme en quête d'espace en savane tchadienne : des Peuls autour de la forêt classée de Yamba Berté. Thèse de Doctorat, EHESS-Paris, 2010, 419.
20. Hakizimana P, Bigendako MJ, Habonimana B, Lejoly J, Bogaert J. Inventaire floristique et identification de quelques éléments d'un plan d'aménagement de la forêt ombrophile de Mpotsa au Burundi. In Xander Vander Burgt. Vander Maesen & Jean-Michel Onana (Eds), systématique et conservation des plantes Africaines, 2010, 653-661.
21. Ngom D. Diversité végétale et quantification des services écosystémiques de biosphère du Ferlo (Nord-Sénégal). Thèse, ED-SEV/UCAD, Dakar, 2013, 167.
22. Kemeuze VA, Mapongmetsem PM, Sonwa DJ, Fongnzossie E, Nkongmeneck BA. Plant diversity and carbon stock in sacred groves of semi-arid areas of Cameroon: case study of Mandara mountains.

International Journal of Environment, 2015; 4(2):308-318.

23. Géhu JM, Géhu J, Essai d'objection de l'évaluation biologique des milieux naturels. Exemples littoraux. In Géhu J.M. (ed). Séminaire de Phytosociologie Appliquée. Amicale Francophone de Phytosociologie. Metz. 1980, 75-94.
24. Curtis JT. The vegetation of Wisconsin. An ordination of plant communities. University of Wisconsin Press. Madison. Wisconsin, 1959, 657.
25. Curtis JT, McIntosh RP. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology 1951; 32:476-496
26. Mori A, De Carvalino AM, Dos Santos TS. Southern Bahia moist forest. Bot. Rev, 1983; 49:155-232.
27. Chave J, Andalo C, Brown S, Cairns MA, Chambers JQ, Eamus D *et al*. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia, 2005; 145:87-99.
28. IPCC (Intergouvernemental Panel on Climat Change), Good Practice Guidance for land use, land-use change and forestry (LULUCF). Institute for Global Environmental Strategies, Hayama, Japon. 2003.
29. Segura M, et Kanninen M. Allometric models for tree volume and total aboveground biomass in tropical humid forest in Costa Rica. Biotropica, 2005; 37(1):2-8.
30. Simiane GV. Évaluation de la séquestration du carbone dans des plantations agroforestières et des jachères issues d'une agriculture migratoire dans les territoires autochtones de Talamanca, au Costa Rica. Mémoire de Maître ès Sciences (M. Sc), FSA, Université Laval, Québec, Canada, 2007, 128.
31. Kent M, Coker P. Vegetation description and analysis. Belhaven Press, London. 1992.
32. Akoégninou A. Recherches botaniques et écologiques sur les forêts naturelles du Bénin (Afrique de l'Ouest). Thèse d'État, Université de Cocody-Abidjan, 2004, 314.
33. Adjakpa BJ. Flore et végétation actuelle du Bas delta de l'Ouémé des zones humides du sud-Bénin. Thèse de Doctorat 3ème cycle en Biologie végétale, option Écologie. Faculté des Sciences et Techniques/UCAD, Dakar (Sénégal), 2006, 88.
34. Mapongmetsem PM, Nduryang B, et Fawa G. Contribution à la connaissance des produits forestiers non ligneux de la zone sudano-sahélienne du Cameroun. Kapseu C., Nzié W., Nso E., Silechi J. et Gomo (éds). Biodiversité et changements globaux du 21 au 23 juillet 2015 à Ngaoundéré, 2015, 139-147.
35. Gning ON. Caractéristiques2627- des ligneux fourragers dans les parcours communautaires de Khassanto (Kédougou, Sénégal oriental). Mémoire de DEA en Biologie végétale, UCAD, 2008, 78.
36. Noiha Noumi V, Zapfack L, Ngueguim JR, Tabue Mbobda R Br, Ibrahima A, Mapongmetsem PM. Sequestered Standing Carbon Stock in Selective Exploited timbers Grown in Tropical Forest: a Case Study from the Nation Park of Lobeke (Cameroon), Research & Reviews: Journal of Botanical Sciences, 2015; 4(2):19-24.
37. Gommadje CF, Doumenge C, Mckey D, Tchouto MGP, Sunderland TCH, Balinga MPB, Sonke B. Tree diversity and conservation value of Govayang's lowlands forests, Cameroon. Biodiversity Conservation, 2011; 20:2627-2648.
38. Valentini G. Évaluation de la séquestration du carbone dans les plantations agroforestières et des jachères issues d'une agriculture migratoire dans les territoires autochtone de Talamanca au Costa Rica. Mémoire de MSC en Biologie végétale, Université de Laval Québec, Canada, 2007, 128.
39. Kotto – Same J, Woomer PL, Appolinaire M, et Louis Z. Carbon dynamics in slash-and-brun agriculture and land use alternatives of the humid forest zone in Cameroun. Agriculture, Ecosystems & environment, 1997; 65:245-256.
40. Zapfack L, Noiha Noumi V, Dziedjou Kwouossu PJ, Zemagho L, Fomete Nembot T. Deforestation and Carbon Stocks in the Surroundings of Lobéké National Park (Cameroon) in the Congo Basin, Environment and Natural Resources Research. 2013; 3(2):78-86.
41. Albrecht A, et Kandji ST. Carbon sequestration in tropical agroforestry systems. Agriculture, Ecosystems and Environment. 2003; 99:15-27.
42. Schroth G, D'Angelo SA, Teixeira WG, Haag D, et Lieberei R. Conversion of secondary forest into agroforestry and monoculture plantations in Amazonia: consequences for biomass litter and soil carbon stocks after 7 years. Forest Ecology and Management. 2002; 163:131-150.