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Community Forests of Rogho and Boala, Significant Carbon Sinks in the Center-West Region of Burkina Faso

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Abstract

This study aimed to evaluate the carbon stock potential of Community forests of Rogho and Boala. The indirect method was adopted to estimate the above and belowground woody biomass, while the integral collection method was chosen to estimate the herbaceous biomass. Data was collected from 77 circular plots with a radius of 18m, which included the diameter and height of plant species within these plots. The data analysis revealed that the Boala community forest produced 2,150.7 t/ha of biomass, which corresponded to 1,075.35 t/ha of carbon, while the Rogho community forest produced 402.81 t/ha of biomass, which corresponded to 201.41 t/ha of carbon. The G1 group had the highest amount of carbon sequestered with 2,327.61 t/ha of biomass, which corresponded to 1,163.80 tC/ha. The CCEN unit had the lowest amount with 262.49 t/ha of biomass, which corresponded to 131.24 tC/ha. The proportion of herbaceous biomass in the carbon stock in the Rogho and Boala sites was 4.49% and 0.8%, respectively. Therefore, there is a need to strengthen the management of these forest areas to further improve their carbon storage potential.

Keywords: Biomass, Carbon stock, Allometric equation, Integral collection, Burkina Faso

Introduction

The global forest cover regression is still relevant (FAO, 2020). This regression is largely linked to land degradation (FAO, 2018) and increased deforestation of forest cover, although this deforestation has decreased considerably during the period of 2015-2020 (FAO, 2020). Overall, there is a spatio-temporal dynamism of these forest ecosystems (Razakamarivo et al., 2011 ; Tiamiyu et al., 2023). This dynamism is likely to cause significant variations in carbon stocks by reducing emissions or increasing their carbon sequestration capacity, with obvious impacts on the climate. In fact, the crucial role of forest ecosystems in mitigating the process of climate warming is no longer in doubt and is unanimous within the scientific community. Forests and trees play a fundamental role in regulating the climate. They absorb the equivalent of about two billion tonnes of carbon dioxide each year (FAO, 2018). African forests in the intertropical zone have a huge share in this trapped carbon amount. But they also constitute a significant potential for high CO2 emissions associated with deforestation (Ndjomba et al., 2022). Enormous amounts of carbon emissions resulting from land degradation and deforestation unbalance the global carbon cycle balance by increasing greenhouse gases (Ganamé, 2021), thus contributing to accelerating climate warming. However, a 2°C increase in the average global temperature would threaten life on earth (Ganamé, 2021). To reverse the trend and decelerate climate warming, the United Nations Framework Convention on Climate Change (UNFCCC) through the implementation of the REDD+ mechanism encourages emerging countries to increase the potential for forest carbon sequestration and reduce emissions related to land use change. However, the implementation of this mechanism requires the availability of reliable and up-to-date data on forest carbon storage potential, among others (Chave et al., 2014 ; Dimobe et al., 2018c). Hence the urgent need to assess the potential carbon stock of forest ecosystems (Bocko et al., 2017). Significant efforts have therefore been made at both the global and regional levels to address the insufficient data on CO2 stocks and flows by mobilizing both direct and indirect methods (Bocko et al., 2017). However, it is worth noting a plethora of studies on the evaluation of carbon stock of forest ecosystems in Asian, American, and European countries (Bocko et al., 2017) and to a lesser extent in Central and Eastern African countries.

At the West African regional level, the assessment of carbon stocks in forest ecosystems is rarely addressed in scientific studies and is more commonly studied at the national level, in Burkina Faso. Nevertheless, the country enacted law number 027-2002/AN on October 9th, 2002 authorizing Burkina Faso's accession to the Kyoto Protocol on climate change through DECREE No. 2002-471/PRES, (JO No.47 2002), thereby officially joining the Kyoto Protocol. Consequently, the country must, in accordance with Article 2.1.a.iv of the Protocol, promote and enhance, among other things, carbon dioxide sequestration strategies. One of the most ecologically sound strategies in this field is community forestry. Promoting and enhancing this strategy requires an update of data on their carbon sequestration potential. Therefore, this study aims to contribute to knowledge of the carbon stock potential of national forest areas in general, and that of community forests in particular. Specifically, this study aims to :

- Evaluate the potential carbon stock of the Rogho and Boala community forests
- Spatialize the stock of the Rogho and Boala community forests.

Materials and methods

Study area

The research work of this study was carried out in two sites located respectively in the municipalities of Sourgou and Bieha in the Central-West region of Burkina Faso (Figure 1). The Sourgou site, which houses the Rogho community forest, is located between 12°00'05" and 12°10'01" north latitude and between 2°16'06" and 2°19'41" west longitude. It is bordered to the north and northwest by the Ramongo municipality; to the east and southeast by the Sabou municipality; to the west by the Tenado municipality and to the southwest by the Pouni municipality. The Bieha site, which houses the Boala community forest, is located between 1°25' and 2°03' west longitude and 10°58' and 11°23' north latitude. It shares its northern borders with the Cassou and Sapouy municipalities (Ziro province); east with the Guiaro and Po municipalities (Nahouri province); west with the Léo and To municipalities (Sissili province) and south with the Republic of Ghana.

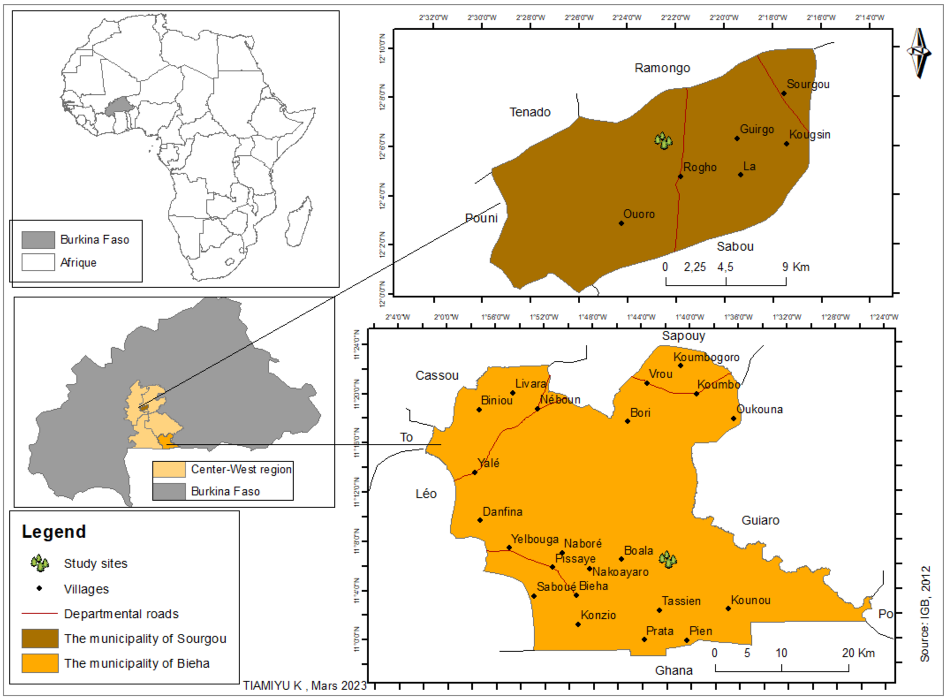

Figure 1. Map of the stady area

Sampling

Circular plots with a radius of 18 m were installed according to the vegetation units present in the Rogho forest, including the savannah formation and the natural field-space complex, and according to the discriminated plant communities in the Boala forest, including community G1 with Vitellaria paradoxa and Pteleopsis suberosa and community G2 with Vitellaria paradoxa - Detarium microcarpum - Burkea africana. The collected data included the names of the individuals, as well as their diameter and height. The individuals included in the study were those with a diameter greater than or equal to 5cm.

Estimation of woody biomass

The non-destructive method using allometric equations was adopted to estimate woody biomass (Ouédraogo et al., 2019). This estimation took into account both aboveground and belowground woody biomass. To estimate aboveground woody biomass (AGB), four allometric equations were first selected to estimate the biomass of the woody stands in the studied forests, using three pantropical equations (FAO1, FAO4, and Chave et al., 2014) and two local equations (Dimobe et al., 2018a and Mbow et al., 2013) as part of the comparative test of allometric models (Table 1).

Table 1. Allometric models selected for the estimation of woody biomass

Allometric model	Formula	Domain of validity		Predictors	Application site
		Climate	D(cm)		
Dimobe et al. 2018a	$AGB=e^{-1,38}(DBH)^{1,06}+e^{-2,9}(DBH)^{2,47}+e^{-2,23}(DBH)^{1,73}(Ht)^{0,8}$	Sudanese	5-35cm and more	D ; H	Both
Mbow et al., (2013)	$AGB=1,929\times D+0,116\times D^2+0,013\times D^3$	Soudanese and Soudano-Guinean	5-41,5cm	D	Both
FAO1	$Y = expo[-1,996+2,32\ln(D)]$ $Y=10^{(-0,535+\log_{10}(D))}$	Pmm<900mm Pmm >900mm	5-40cm 3-30cm	D	FCmR FCmB
Chave et al. (2014)	$AGB = 0,0673 \times (\rho D^2 H)^{0,976}$	Tropical zone	5 – 212	D ; ρ ; H	Both

Source : Literature review

Table 1 summarizes the allometric models used in the study, providing for each model its formula, validity range, predictor, and corresponding application site.

The qualitative analysis of each preselected allometric equation led to the selection of the allometric model proposed by C. Mbow et al., 2013 for evaluating the carbon stock of woody populations in the study area.
The root biomass (BGB) was deduced by applying the conversion factor of aboveground biomass to belowground biomass. This factor is 0.24 (Mokany et al., 2006).

Estimation of Herbaceous Biomass (Bh)

To estimate herbaceous biomass, the total harvest method used by some authors (Ouédraogo et al., 2019 ; Yé et al., 2016 ; Santi, 2011) in Burkina Faso was adopted. This method consists of harvesting all the herbaceous plants found in the delimited quadrats. For this study, three 1.2m diameter disks were delimited inside each plot. The herbaceous plants collected in each plot were weighed on site to determine their weight. The size of the disk, which is 1.13 m2, is roughly equal to that of the quadrats used by Ouédraogo et al. (2019) in their study. After weighing, the herbaceous sample was packed for drying to determine its dry weight. Valentini (2007) used two equations to estimate herbaceous biomass in agroforestry plantations and fallow lands resulting from shifting cultivation in the autochthonous territories of Talamanca, Costa Rica. These equations were taken up by Ouédraogo et al. (2019) and are as follows :
MS = (DWE / FWE) x 100 (1)

Where : MS = percentage of dry matter (%) DWE = dry weight of sample after drying (g) FWE = fresh weight of sample in the field (g)

$$Bh = (TWF \times MS) / 100 \quad (2)$$

Where : Bh = biomass (g) TWF = total wet weight in the field (g) MS = percentage of dry matter (%)

Carbon Stock Assessment

The assessment of carbon stock is based on the estimated total biomass (herbaceous and woody) multiplied by the wood carbon content. This content is 50% of the biomass considered according to the IPCC (2003) recommendations cited by Valentini (2007). For Ouédraogo et al. (2019) this content varies between 0.47 and 0.51. However, the conventionally used coefficient is 0.5 (Mille & Louppe, 2015). This gives :

$$SC = Bt \times 0.5 \quad (3)$$

Where: SC = stored carbon (t C) Bt = total biomass = Bh + AGB + BGB

Results and discussion

Woody biomass (aboveground and belowground) according to pantropical equations

The average biomass production (aboveground and belowground) of woody stands in the different vegetation units of the study sites differs according to the vegetation units and equations used. The allometric equation FAO1 expresses the highest amount of biomass produced for all vegetation units. The highest biomass production is recorded in vegetation group G1 with an average of 2,038.67 t/ha while the lowest is observed in the fields and natural spaces complex with an average of 197.81 t/ha. The least amount of biomass is provided by the allometric model of Chave et al. (2014). These amounts vary from 27.24 t/ha (fields and natural spaces complex) to 325.78 t/ha (vegetation group G1).

Table 2. Woody biomass of vegetation units according to pantropical equations

Allometric equations applied		FAO1			Chave et al. (2014)		
Vegetation units		AGB (t/ha)	BGB (t/ha)	Blt (t/ha)	AGB (t/ha)	BGB (t/ha)	Blt (t/ha)
FCmR	FS	477,39	114,57	591,96	48,13	11,55	59,68
	CCEN	159,52	38,29	197,81	21,97	5,27	27,24
FCmB	G1	1 644,09	394,58	2 038,67	262,73	63,05	325,78
	G2	1 370,03	328,81	1 698,84	233,41	56,02	289,42

Source : Field data processing AGB : Aboveground biomass ; BGB : Belowground biomass; Blt : Total woody biomass ; FS : Savanna formation ; CCEN : Fields and natural spaces complex ; G1 : Vegetation group G1; G2 : Vegetation group G2 ; FCmR: Rogho community forest ; FCmB : Boala community forest.

Woody biomass (aboveground and belowground) according to local equations

Local equations provide quantities of biomass that are both higher and lower than those provided by pantropical equations. These amounts of biomass produced are even higher when it comes to the equation of Mbow et al. (2013) and vary from 244.56 t/ha (fields and natural spaces complex) to 2,309.75 t/ha (vegetation group G1). The lowest amount of biomass produced is observed in the fields and natural spaces complex with a value of 104.20 t/ha provided by the equation Dimobe et al. (2018a).

Table 3. Woody biomass of vegetation units according to local equations

	Community forest of Boala					
Vegetation units	Vegetation group G1			Vegetation group G2		
	AGB (t/ha)	BGB (t/ha)	Blt (t/ha)	AGB (t/ha)	BGB (t/ha)	Blt (t/ha)
Mbow et al., (2013)	1 862,7	447,05	2 309,75	1 604,97	385,19	1990,16
Dimobe et al. 2018a	866,89	208,05	1074,94	743,16	178,36	921,52
	Community forest of Rogho					
Vegetation units	Savana			Complexe_ChampEsN		
	AGB (t/ha)	BGB (t/ha)	Blt (t/ha)	AGB (t/ha)	BGB (t/ha)	Blt (t/ha)
Mbow et al., (2013)	584,59	140,3	724,89	222,46	47,33	244,56
Dimobe et al. 2018a	245,42	58,90	304,32	84,04	20,17	104,20

Source : Field data processing

3.3. Herbaceous biomass per vegetation unit

The herbaceous biomass produced by the vegetation units is roughly identical in both sites. The highest quantity is recorded in the savanna formation of the Rogho community forest, valued at 18.97 t/ha. The vegetation group G2 of the Boala community forest records the lowest value of 16.76 t/ha.

Table 4. Herbaceous biomass produced by vegetation unit

Vegetation units	FS	CCEN	Vegetation group G1	Vegetation group G2
Bh (t/ha) Ch (t/ha)	18,97 9,49	17,92 8,96	17,84 8,92	16,76 8,38

Source : Field data processing

Estimation of woody biomass between pantropical and local equations, which one to prioritize for carbon stock evaluation ?

Each equation used to estimate woody biomass presents different results as indicated in tables 2&3. Although each of the four equations used has valid scientific arguments to be used to evaluate the carbon stock of the study forests, there is a need to prioritize one. The pantropical equation FAO1 used to estimate woody biomass is designed to be applied to populations in dry areas with annual precipitation below 1500 mm, which is consistent with our study area. However, it only takes into account individuals with diameters between 3 and 40 cm, which is not the case for individuals considered in this study, which have diameters ranging from 5 to over 100 cm. This will therefore bias the estimation of woody biomass.

The Chave et al. (2014) equation takes into account the specific density of species as a predictor in estimating woody biomass. This specific density, which is unique to each species and varies from one biotope to another, is a key factor in this equation (Chave et al., 2014). In the absence of availability of specific densities of species included in this study, the standard value provided by the IPCC (2006) for tropical forests in Africa was used, which significantly compromises the results (Ilboudo, 2018). Some authors (Ngomanda et al., 2014) even think that pantropical equations do not guarantee an optimal estimate of woody biomass.

The equation of Dimobe et al. (2018a), designed and applied in climate domains perfectly similar to ours, could be preferred for the evaluation of carbon stock of woody stands in our study sites. However, its application to other sites requires knowledge of the tree structures of that community (Dimobe et al., 2018a), which should resemble those used in its development for the most optimal estimation of biomass. Taking into account the DHP parameter, which is an essential predictor of this model, there is a non-conformity between the individuals used in the development of this equation and the individuals inventoried in the present study. Only three of these have a DHP greater than 35 cm. The rest have DHPs between 5 and 35 cm, which is far from the reality of our study sites where over 50% of individuals have DHPs ranging from 35 to over 100 cm. Furthermore, this model was developed based on populations of a single species. Using it to estimate the woody biomass of our study sites will significantly compromise the results.

Therefore, the equation of Mbow et al. (2013) (0.934) is the only option left. This equation was developed from 101 individuals from dry savanna populations in the Sudanian and Sudanian-Guinean zones in southern Senegal. These individuals belong to 13 different species distributed in semi-arid areas with annual rainfall ranging from 600 to over 1000 mm. Although the range of DHP of individuals used to develop this model differs from that of individuals in the present study, its application in our context provides results that are less biased compared to the equations mentioned above. These equations indeed underestimate the woody biomass in dry savanna zones (Kuyah et al., 2012a ; Mbow et al., 2013). Arguing that the development of the allometric equation took place in a natural savanna formation, Mbow et al. (2013) consider it inappropriate to apply it to areas of cultivation and plantation, and therefore suggest the application of the allometric model of Kuyah et al. (2012a). This model, in fact, was designed based on woody populations in forest reserves converted into cultivation spaces in western Kenya. Three aspects related to the development of this single-predictor equation (AGB=0.09xDHP2.472) invalidate its application for a less biased estimation of the biomass of the complex vegetation unit of fields and natural spaces: the climatic characteristics of this zone (average precipitation ranging from 1028 to 1950 mm per year); the range of diameters considered (DBH € >2.5 cm- >60 cm) taking into account individuals with small diameters; and the low diversity of the species considered (three species) in the development of the equation (Kuyah et al., 2012a). Therefore, the model of Mbow et al. (2013) was used for all present vegetation units.

This study adopted the non-destructive method for estimating forest biomass and assessing carbon stock through allometric equations. This method has been widely advocated by numerous researchers for quantifying forest biomass and carbon stock (Bakayoko et al. (2012) ; Moumouni et al. (2017) ; Adamou et al. (2020) ; Adjéran et al. (2020) ; Djaouga et al. (2021)). Although it offers the advantage of being quickly operational in terms of time and cost estimation, the use of these allometric equations outside of the sites for which they were developed could result in biased estimates, according to several authors (Chave et al. (2004) ; Molto et al. (2013) ; Loubota et al., (2016)).

The qualitative analysis of each preselected allometric equation led to the selection of the allometric model proposed by Mbow et al. (2013) for assessing the carbon stock of woody stands in the study area. This method used for the final selection of the allometric model differs from that used by Ndjomba et al. (2022) to choose the best-fitted allometric model for their study area. These authors used quantitative analysis to select three of the six initially chosen equations: a two-predictor equation (D, ϱ) from Fayolle et al. (2013) and two three-predictor equations (D, ϱ, H) from Ngomanda et al. (2014) and Chave et al. (2014). The difference in the choice of equations can be explained by a number of factors: (i) divergent climatic characteristics of the two study areas. Our study area is located in the dry tropical domain with annual precipitation ranging from 600 to 1200 mm, while Ndjomba et al.'s study area is in a humid equatorial climate zone with an average annual rainfall of 3000mm ; (ii) divergent nature of the study object. Our study object, which is a dry forest with shrubby to arboreal savannah appearance, contrasts with that of Ndjomba et al. (2022), which is a dense humid forest; (iii) availability of specific density values for species in the humid forest. These values are missing for our study area. Other authors (Ouédraogo et al., 2019 ; Ganamé 2021 ; Ngoufo et al., 2019) used qualitative analysis to choose allometric models. These authors used several allometric models to estimate the amount of biomass of the studied woody stands according to the typology of forest formations. Ouédraogo et al. (2019) used four models: Mbow (2009), Mbow et al. (2013), and two Brown (1997) equations, also known as FAO (1997) ; Ngoufo et al., 2019 used three : the pantropical equation of Chave et al. (2014), that of Mokany et al. (2006) and Cummings et al. (2002). For our specific case, only one equation was used. The difference in the number of equations used by the authors takes into account the types and characteristics of the vegetation layers present. And the choice of equations is guided by these aspects

Total biomass (Bt) and carbon stock per vegetation unit

The quantity of biomass provided by the single-predictor equation of Mbow et al. (2013) was used to estimate the total biomass and carbon stock of the vegetation units. This quantity varies from one site to another and from one vegetation unit to another (Figure 2). The Boala site records the highest amount of biomass with an average of 2,150.7 t/ha, which is equivalent to a significant stock of 1,075.35 t/ha of carbon. The biomass produced by the Rogho site is estimated at 402.81 t/ha, which is equivalent to 201.41 t/ha of carbon. At the level of occupation units, group G1 produces the highest amount of biomass with 2,327.61 t/ha, which corresponds to 1,163.80 tC/ha sequestered. The CCEN unit records the lowest quantity with 262.49 t/ha of biomass, which is worth 131.24 tC/ha (Table 5). The share of herbaceous vegetation in the carbon stock in the Rogho and Boala sites is 4.49% and 0.8%, respectively.

Table 5. Total biomass and carbon stock per vegetation unit

Vegetation units	Bt	B (t/ha)	C (t)	C (t/ha)
FS	832,379	743,86	416,19	371,93
CCEN	694,276	262,49	347,14	131,24
G1	4 261,85	2 327,61	2 130,93	1 163,80
G2	4 491,50	2 006,93	2 245,75	1 003,46

Source : Field data processing

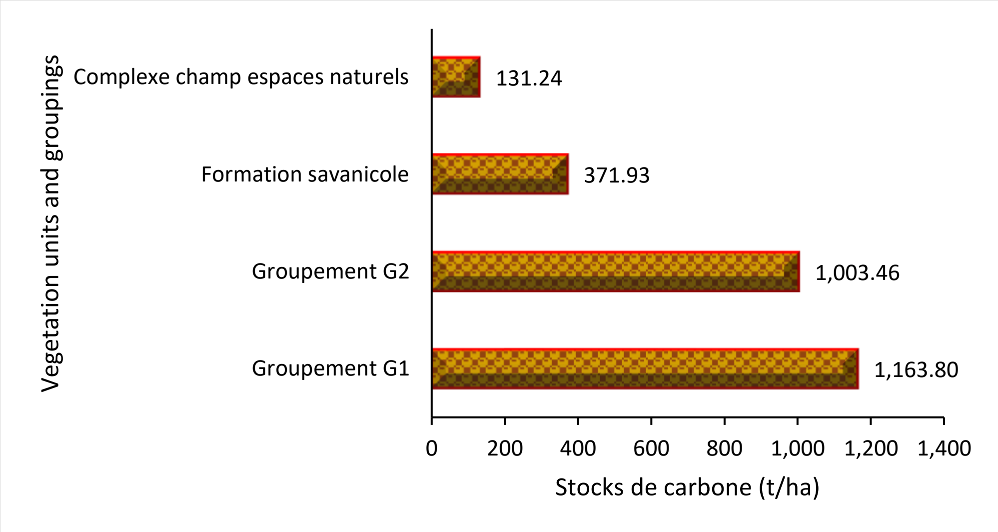

Figure 2. Spatial distribution of carbon stock by vegetation units and groups

At the scale of the study area, the community forests studied store significant amounts of carbon ranging from 131.24 t/ha for the natural spaces and fields complex to 1,163.80 t/ha for the G1 group. These results reveal a variation in carbon stocks depending on the plant units and groups present. The carbon stock of the savanna formation and the G2 plant group is 371.93 t/ha and 1,003.46 t/ha, respectively. This difference in carbon stock follows the same order, taking into account the woody density of these different plant units and groups. Thus, the G1 group with higher density (834.97 trees/ha) stores the largest amount of carbon. While this logic is respected at the scale of plant units and groups, it is also respected at the scale of sites. The community forest of Boala with higher density (742.01 trees/ha) sequesters the most carbon, with a quantity of 1,075.35 t/ha of carbon compared to that of Rogho, which is less dense (330.34 trees/ha) with a less important carbon stock of 201.41 t/ha. However, density cannot be the sole explanatory factor for this variation in carbon stock per site and per plant units and groups. The work of Ngoufo et al. (2019) has indeed revealed vegetation units with high woody population density but storing low amounts of carbon compared to units with reduced population density. The characteristics of woody species must therefore be taken into account to explain this variation in carbon stock, notably the diameter at breast height. This variation would thus be more related to the fact that the G1 group contains more individuals with large diameters than the other plant units and groups. Individuals with small diameters contribute less to aboveground biomass (Mbow et al., 2013). By limiting the stock to the natural spaces and fields complex (131.24 t/ha), this result is similar to those found by Bocko et al., 2017 in the flooded forest

(147.7 t/ha) in the North of Congo ; by Tedou et al. (2015) in the old cocoa plantation (137.53 t/ha) in an itinerant agricultural landscape in the Ayos commune in Cameroon. It diverges widely from those found respectively by Ganamé (2021) "in the field unit" (0.41 t/ha) of the TP pastoral reserve in Burkina Faso ; Ngoufo et al., 2019 and Tedou et al. (2015) respectively "in the cultivation area" (12.84 t/ha) of the Ngog-Mapubi forest massif and "in the mixed field" in an itinerant agricultural landscape in the Ayos commune in Cameroon.

The carbon stocks of the plant groups G1 (1,163.80 t/ha) and G2 (1,003.46 t/ha) are significantly higher than those revealed by the work of Ganamé (2021) in the wooded savannas (71.48 t/ha) and gallery forests (49.60 t/ha) of the BK classified forest. The carbon stock of the savanna formation (371.93 t/ha) also far exceeds those of the grassy savanna (0.9 Mg/ha) and wooded savanna (1.6 Mg/ha) units of the Sudanian Basin of Burkina Faso, the savanna unit (50.93 t/ha) in the shifting agricultural landscape in the commune of Ayos, and the secondary forests (118.60 t/ha) on the periphery of the Lobéké National Park in Cameroon found respectively by Dimobe et al. (2018c) ; Tedou et al. (2015) and Zapfack et al., (2013).

These variations in carbon stocks can also be explained by the sampling methodology and the type of allometric equation used. For example, Chave et al. (2004) ; Clark and Oswald (2002) ; Molto (2012) admit that these two factors explain variations in carbon stocks obtained in tropical zones. Most authors generally use the allometric equations of Chave et al. (2005) ; Chave et al. (2014) or those of Brown (1997), whereas in our specific case, the equation of Mbow et al. (2013) was used. This latter equation, unlike those mentioned earlier, is developed from data from the dry savannas of West Africa.

At the specific scale, Lannea microcarpa sequesters the largest amount of biomass with a total biomass of 280.15 t/ha in the savanna vegetation formation unit. It is followed far behind by Mitragyna inermis and Vitellaria paradoxa with 98.05 t/ha and 52 t/ha of biomass, respectively. The biomass of the complex natural fields system is mainly provided by *Vitellaria paradoxa*, *Lannea microcarpa*, and *Mitragyna inermis* with respective biomass quantities of 88.36 t/ha, 57.67 t/ha, and 20.96 t/ha (Figure 3). As for group G1, the largest amount of biomass produced within it is provided by *Vitellaria paradoxa* and amounts to 630.16 t/ha. This quantity is well above that provided by *Terminalia laxiflora* (152.84 t/ha) and *Pterocarpus erinaceus Poir* (141.53 t/ha). *Vitellaria paradoxa* and *Burkea africana* provide the most significant amounts of biomass produced within group G2, with respective quantities of 334.21 t/ha and 333.42 t/ha. They are followed far behind by *Detarium microcarpum* with 93 t/ha of biomass

(Figure 4). At the scale of the *two sites, Lannea microcarpa with 122.96 t/ha of biomass and Vitellaria paradoxa* with 467.27 t/ha of biomass are the species with the highest biomass production, respectively in Rogho and Boala (Figure 5).

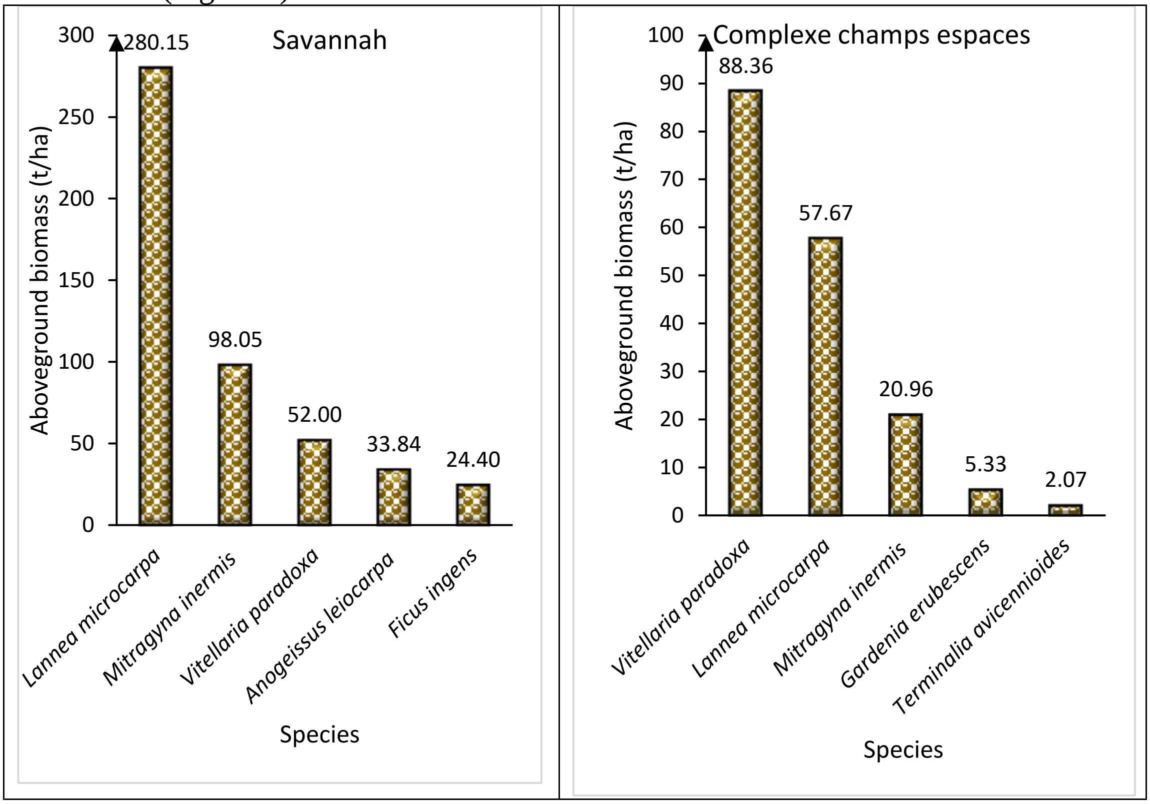

Figure 3. The five species with high biomass quantity per vegetation unit in the Rogho site

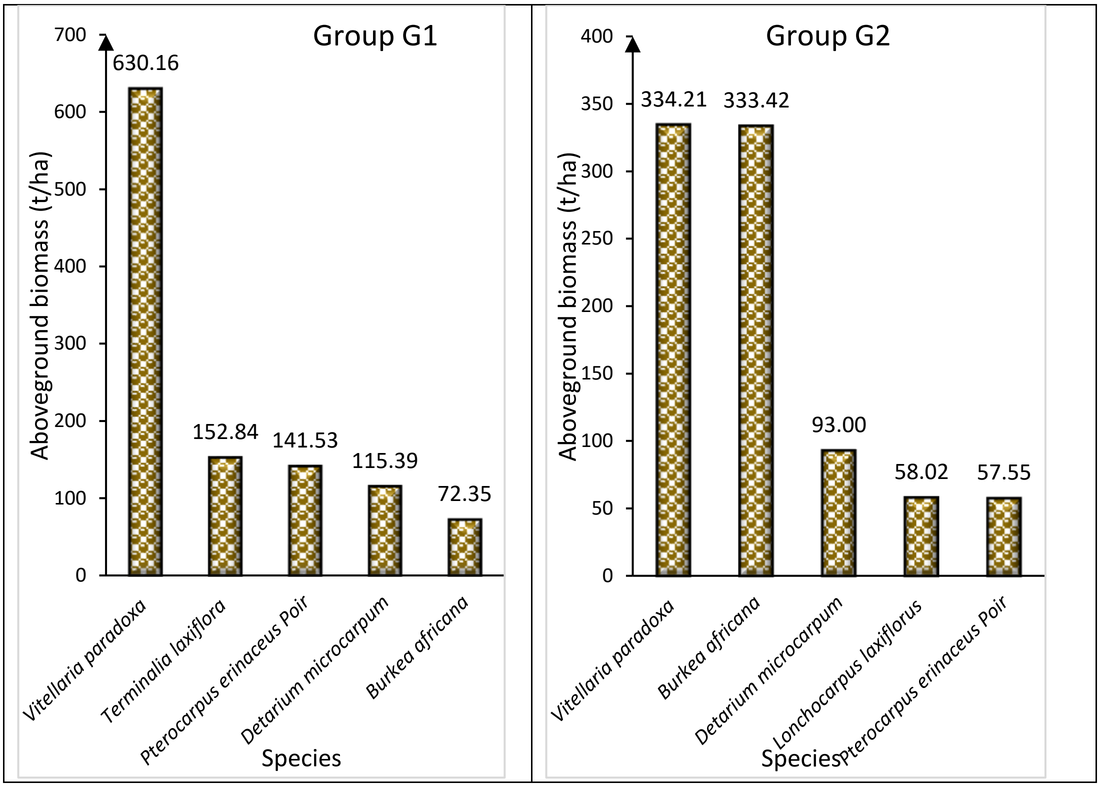

Figure 4. The five species with high biomass quantity per vegetation unit in the Boala site

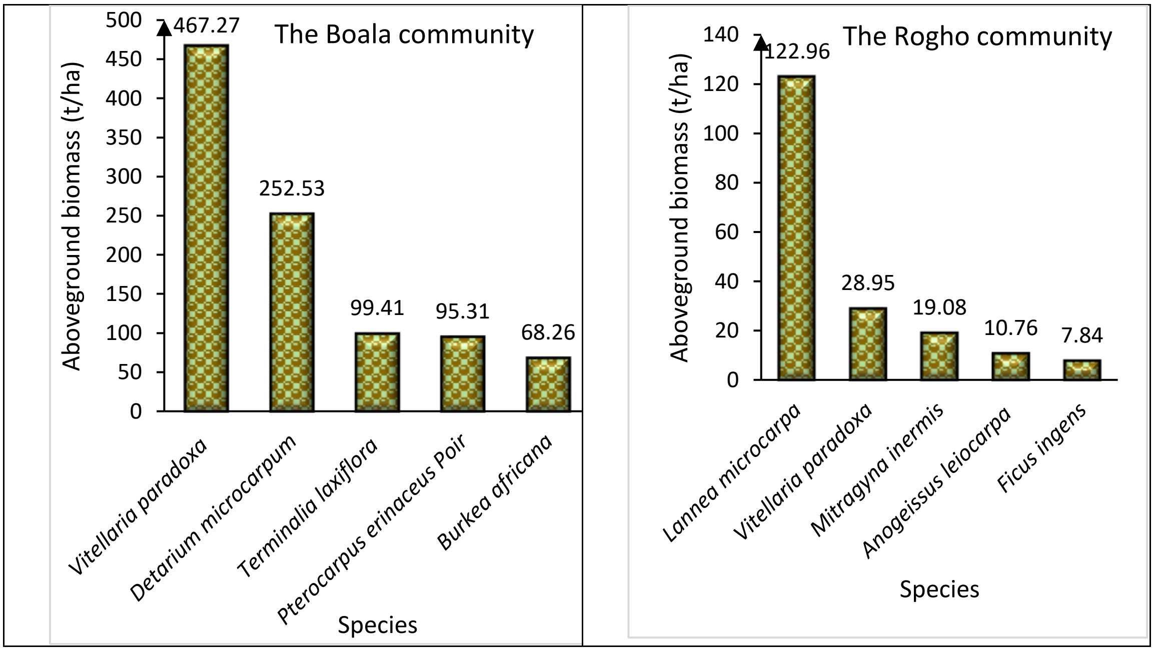

Figure 5. The five species with high biomass quantity per site

The strong contribution of these species to the carbon stock of the studied forests is related to their abundance, but also and especially to the importance of their diameter structure characterized by a dominance of medium to large diameter individuals. Since the diameter at breast height is a key predictor in the allometric equation used to estimate woody biomass, large diameter individuals therefore sequester enormous amounts of carbon (Bocko et al., 2017).

The potential stock of herbaceous flora is estimated at 4.86 t/ha in Rogho and 4.25 t/ha in Boala. This slight difference is due to the abundance of the herbaceous carpet in the Rogho forest compared to that of Boala. These values are higher than the one recorded (1.39 t/ha) by Ouédraogo et al. (2019) in the forested area of the National School of Water and Forestry of Dindéresso in the Houet province of Burkina Faso and slightly higher than the one observed (3.15 tC/ha) by Ibrahima & Fanta (2008) in the shrub savanna zone of the Ngaoundéré region in Cameroon. This variation is likely due to the divergent extent of the study sites and the abundance of the herbaceous layer in our study sites. In terms of area, the study site of Ibrahima & A. Fanta (2008) with 72,000 km2 is much smaller compared to ours. The same applies to that of W. Ouédraogo et al., 2019 which is 115.7 ha.

At the scale of plant units and groupings, there is a slight variation in the carbon stock of herbaceous plants in both sites. This stock varies between 8.48 t/ha (savanna formation) and 3.35 t/ha (complex of cultivated fields and natural spaces). This variation is also observed in the shrub savannah region of Ngaoundéré in Cameroon, where shrub savannah sequesters 1.32 tC/ha compared to 0.16 tC/ha sequestered by wooded savannah (Ibrahima & Fanta 2008). This variation is justified by the high density of woody plants in wooded savannah (3967 individuals/ha) compared to that of shrub savannah (2933 individuals/ha) (Ouédraogo et al., 2019).

Conclusion

The estimation of biomass using different equations showed that the results vary from one equation to another and depend on the number of predictors in each equation. The qualitative analysis of the criteria for developing these equations with respect to the realities of our study sites allowed us to select the allometric model of Mbow et al. (2013) as the equation that best estimates the biomass of the woody plants in the studied stands. Using this equation and adding the biomass of herbaceous plants resulted in biomass quantities of 402.81 t/ha for the Rogho forest and 2,150.7 t/ha for the Boala forest. Converting these biomass quantities by applying the conversion factor recommended by the Intergovernmental Panel on Climate Change (IPCC) (2003) (50%) yields carbon stock equivalences of 201.41

t/ha and 1,075.35 t/ha, respectively, for Rogho and Boala. The respective share of herbaceous plants in these carbon stocks in Rogho and Boala is 4.49% and 0.8%. *Lannea microcarpa, Vitellaria paradoxa*, and *Mitragyna inermis* in the Rogho community forest and *Vitellaria paradoxa, Detarium microcarpum*, and *Terminalia laxiflora* in the Boala forest are the species with high potential for carbon storage revealed by this study. These findings indicate the strong potential for carbon sequestration that these community forests represent. This should enable authorities responsible for environmental and forestry issues to implement appropriate strategies for their sustainable management.

References:

1. Adamou, S., Amani A., Mahamadou H.M. and Yaye, A.D. (2020). « Modèle allométrique d'estimation du carbone aérien séquestré par Balanites aegyptiaca (L.) Del dans la partie Sud-Ouest du Niger ». *Afrique Science*, 16(6): 188-203.
2. Adjéran, R.W., Lougbegnon T.O., Djego G. J. (2020). « Estimation de la biomasse aérienne et du carbone des arbres de Lophira lanceolata dans la forêt classée de l'Ouémé supérieur au Bénin ». *Afrique Science*, 16(5): 17-31.
3. Bakayoko, O., Assa A, M., Coulibaly, B. and N'Guessan K.A. (2012). « Stockage de Carbone dans des peuplements de Cedrela Odorata et de Gmelina Arborea en Côte d'Ivoire ». *European Journal of Scientific Research*, 75(4): 490-501.
4. Bocko, Y.E., Ifo S.A. and Loumeto, J.J. (2017). Quantification Des Stocks De Carbone De Trois Pools Clés De Carbone En Afrique Centrale : Cas De La Forêt Marécageuse De La Likouala (Nord Congo). *European Scientific Journal* vol.13, No.5 ISSN 1857- 7431. doi: 10.19044/esj.2017.v13n5p438: 438-456
5. Chave, J., Andalo, C.S., Brown, M.A., Cairns, J.Q., Chambers, D.E., Fo¨lster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B.W., Ogawa, H., Puig, H., Rie´ra, B., and Yamakura, T. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Ecosystem Ecology*. 145: 87–99 DOI 10.1007/s00442-005-0100-x
6. Chave, J., Réjou, M.M., Burquez, A., Chidumayo, E., Matthew, S.C., Wellington C.B., Delitti, Á., Duque, T.A., Philip, M., Fearnside, R.C., Goodman, M.-H, Angelina Martínez-Yrízar, Wilson A. Mugasha, Hélène C. Muller-Landau, Maurizio Mencuccini, Bruce W. Nelson, Alfred Ngomanda, Euler M. Nogueira, Edgar Ortiz Malavassi, Raphaël Pélissier, Pierre Ploton, Casey M.Ryan, Juan G. Saldarriaga, Ghislain Vieilledent. (2014). Improved allometric

models to estimate the aboveground biomass of tropical trees. Global Change Biology, 20:3177-3190. https://doi.org/10.1111/gcb.12629

7. Dimobe, K., Goetze D., Ouédraogo, A., Mensah, S., Akpagana K., Porembski S., & Thiombiano, A. (2018a). Aboveground biomass allometric equations and carbon content of the shea butter tree (Vitellaria paradoxa C.F. Gaertn., Sapotaceae) components in Sudanian savannas (West Africa). *Agroforestry Systems*, 93:1119-1132. https://doi.org/10.1007/s10457-018-0213-y
8. Dimobe, K., Kouakou J.L. N. and Tondoh J.E., Zoungrana B. J.-B., Forkuor, G. and Ouédraogo, K. (2018c). Predicting the potential impact of climate change on carbon stock in semi-arid West African savannas. *Land*,7 :124.,21 p. https://doi.org/10.3390/land7040124
9. Djaouga, M., Karimou, S., Arouna O., Zakari S., Matilo. A.O., Imorou I.T., Yabi I., Djego J., Thomas, O., and et Houssou, C. (2021). Cartographie de la biomasse forestière et évaluation du carbone séquestré dans la forêt classée de l'Ouémé supérieur au Centre – Bénin. *Int. J. Biol. Chem. Sci*. 15(6): 2388-2401.
10. FAO. (2018). La situation des forets du monde (Résumé). p.28.
11. FAO. (2020). *Évaluation des ressources forestières mondiales 2020 (Principaux résultats).* p.14. En ligne : http://www.fao.org/3/CA8753FR/CA8753FR.pdf consulté le 05/05/2021.
12. Fayolle, A., Doucet, J.L., Gillet, J. F., Bourland, N. and Lejeune, P., (2013). Tree allometry in Central Africa: testing the validity of pantropical multi-species allometric equations for estimating biomass and carbon stocks. *Forest Ecology and Management* ,305, 29-37. https://doi.org/10.1016/j.foreco.2013.05.036 31/03/2023
13. Ganamé Moussa. (2021). *Dynamique spatio-temporelle et potentiel du stock de carbone des écosystèmes forestiers du Burkina Faso*. Thèse de doctorat en Sciences Biologiques Appliquées, Université Joseph KI-ZERBO. 167p.
14. brahima A, Fanta C.A. (2008). Estimation du stock de carbone dans les faciès arborés et arbustifs des savanes soudano guinéennes de Ngaoundéré, Cameroun. *Cameroon Journal of Experimental Biology*, 4(1): 1–11. DOI: http://dx.doi.org/10.4314/cajeb.v4i1.379
15. Ilboudo, D. (2018). Évaluation de la biomasse et du potentiel de séquestration de carbone par les petites formations forestières des savanes en zone soudanienne du Burkina Faso : Cas du site de l'École Nationale des Eaux et Forêts (ENEF) [mémoire de fin de cycle en vue de l'obtention du diplôme d'ingénieur du développement rural option : vulgarisation agricole]. Université Nazi Boni (UNB).

16. Kuyaha, S., Dietzc, J., Muthuri, C., Jamnadass, R., Mwangi, P., Coea, R., Neufeldt, H. (2012). Allometric equations for estimating biomass in agricultural landscapes : I. Aboveground biomass. *Agriculture, Ecosystems & Environment*, 158, 216-224. https://doi.org/10.1016/j.agee.2012.05.011
17. Loubota, P.G.J., Doucet J-L., Loumeto, J-J., Biwole, A., Bauwens, S. and Fayolle, A. (2016). Biomasse et stocks de carbone des forêts tropicales africaines (synthèse bibliographique). *Biotechnologie, Agronomie, Société et Environnement*, 20(4): 508-522
18. Mbow C., Verstraete M.M., Sambou B., Diaw A.T., & Neufeldt H., 2013. Allometric models for aboveground biomass in dry savanna trees of the Sudan and Sudan-Guinean ecosystems of Southern. *Senegal. Journal of Forest Research*, 19: 340-347. https://doi.org/10.1007/s10310-013-0414-1
19. Mille, G. and Louppe D. (2015). Mémento du Forestier Tropical. Editions QUÆ. Versailles, France 33pages. https://www.researchgate.net/publication/301895341_Le_Memento_du_forestier_tropical/link/59771be80f7e9b4016c36631/download 31/03/2023
20. Mokany, K., Raison, R.J., and Prokushkin, A.S. (2006). Critical analysis of root : Shoot ratios in terrestrial biomes : root : shoot ratios in terrestrial biomes. Global Change Biology, 12(1), 84-96. https://doi.org/10.1111/j.1365-2486.2005.001043.x
21. Molto Q. (2012). « Estimation de Biomasse en forêt tropicale humide - Propagation des incertitudes dans la modélisation de la distribution spatiale de la biomasse en Guyane française ». Thèse de doct., p. 186.
22. Molto Q., Rossi V., and Blanc L. (2013). Error propagation in biomass estimation in tropical forests. Methods in Ecology and Evolution, 4(2): 175-183.
23. Moumouni Y.I., Arouna O., and Zakari S. (2017). Diversité floristique et structure des formations végétales dans le district phytogéographique du Borgou-nord au Benin (secteur de l'arrondissement de Bagou). *Notes Scientifiques, Homme et Société*, 2017, 7, pp.63-80 ISSN: 2409-9791 https://shs.hal.science/halshs-01703053/document 30/03/2023
24. Ndjomba, C.D., Koubouana F., Kimbatsa I.M.C.M., Mabaka, J.M. and Mbela, F. D. (2022). Diversité Floristique, Structure et Estimation du Stock de Carbone par les Peuplements Ligneux de la Forêt Naturelle de la Mondah. *European Scientific Journal, ESJ* Vol.18, No.33. ISSN: 1857-7881 (Print) e - ISSN 1857-7431: 75-100. Doi:10.19044/esj.2022.v18n33p75

25. Ngomanda A. and al. (2014). Site-specific versus pantropical allometric equations: Which option to estimate the biomass of a moist central African forest? *For. Ecol. Manage.*, 312, 1-9. https://doi.org/10.1016/j.foreco.2013.10.029 31/03/2023
26. Ngoufo, R., Louis, Z., Emmanuel, T.D., Louis, S.T.N., Cédric, A. M.G., Cédric A., Cédric, C.D., Armel, L., Flore, N. and Collins, E.K. (2019). « Évaluation et spatialisation du carbone stocké dans le massif forestier de Ngog-Mapubi (Cameroun). Conférence OSFACO : Des images satellites pour la gestion durable des territoires en Afrique, Mar 2019, Cotonou, Bénin. hal-02189496. 26p.
27. Ouédraogo, W.O., Gomgnimbou, A.P.K., Santi, S., Ilboudo, D. and Toguyeni, A. (2019). « Quantification de la Biomasse et stockage du carbone du massif forestier de l'Ecole Nationale des Eaux et Forêts de Dindéresso province du Houet au Burkina Faso. *International Journal of Biological and Chemical Sciences* 13(7): 3276-3288 , pp. 3276-388.
28. Razakamanarivo, R.H., Grinand, C., Razafindrakoto M.A., Bernoux M. and Albrecht A. (2011). Mapping organic carbon stocks in eucalyptus plantations of the central highlands of Madagascar : A multiple regression approach. Geoderma, 162: 335-346. doi:10.1016/j.geoderma.2011.03.006
29. Santi, S. (2011). Feu, pâture, climat et paramètres structurels et fonctionnels des écosystèmes savanicoles. Mémoire d'Ingénieur du Développement Rural, Option : Eaux et Forêts. IDR/UPB, Bobo, Burkina Faso, 124p.
30. Tedou, S.B.F., Yemefack, M. and Dameni H. (2015). Variabilité des stocks de carbone en zone forestière du Cameroun : Approche évaluative dans le paysage agricole itinérant de la commune d'Ayos. *Editions universitaires européennes*. ISBN: 978-3-8417-4911-6. 110pages https://www.researchgate.net/publication/273740247_Variabilite_des_stocks_de_carbone_en_zone_forestiere_du_Cameroun_Approche_evaluative_dans_le_paysage_agricole_itinerant_de_la_commune_d'Ayos/link/550b1df80cf285564096fc65/download 01/04/2023
31. Valentini, S.G. (2007). 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 présenté pour l'obtention du Grade de Maître ès Sciences (M.Sc.), Option : Biologie Végétale. Faculté des Sciences de l'agriculture et de l'alimentation, Université Laval, Québec, Canada, 140p.

32. Yé, L., Lata J-C., Masse D., Nacro H.B. et Barot, S. (2016). « Effets de pâturage sur la biomasse herbacée et sur des paramètres chimiques et biologiques des sols dans une savane arbustive au Burkina Faso. *International Journal of Biological and Chemical Sciences*, 10(6): 2539 – 2554. DOI: http://dx.doi.org/10.4314/ijbcs.v10i6.11
33. Zapfack, L., Noiha N.V., Dziedjou K.P.J., Zemagho, L. and Fomete Nembot T. (2013). Deforestation and carbon stocks in the surroundings of Lobéké National Park (Cameroon) in the Congo Basin. *Environment and Natural Resources Research* 3(2) : 78-86.