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Sequestered Standing Carbon Stock in Selective Exploited Timbers Grown in Tropical Forest: a Case Study from the National Park of Lobeke (Cameroon)

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Research Article

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ABSTRACT

The study was carried out in the National Park of Lobeke (Cameroon). It aimed to assess diversity and sequestration potential of some commercialized timbers under industrialisation pressure. We took place 37 transects of 5 ha each. All selected timbers of at least 5 cm of DBH were surveyed. 8, 619 individuals divided into 6 families, 6 genera and 9 species were recorded. *Diospyros crassiflora* (Ebene) was the most diversified species (ISH= 8.09); followed *Terminalia superba* (Frake; ISH= 2.08). *Triplochyton scleroxylon* (Ayous), *Terminalia superba* (Frake) and *Entandrophragma cylindricum* (Sapelli) were the biggest species of the flora with 549.01; 370.22 and 334.8 m² of basal area respectively. With a stock of carbon evaluated at 107.5 t C/ha, the ecological service from the selected species was estimated at 23,419,305 t of CO2 incorporated in their biomass as from now. In the context of REDD+, the conservation of forests are welcome in mitigating climate change for the humanity welfare.

INTRODUCTION

Tropical rain forests provide many resources and services that contribute to the welfare of humanity [1-5]. However the global forest cover is dwindling fast in view of great biotic pressure, industrialization, urbanization, land use change for developmental activities and conversion of forests to agricultural land [6]. In the Congo basin, the annual rate of deforestation has been estimated at 0.13 % during 1990-2000; and this rate has increased for double during 2000-2005 [7]. Nowadays, the annual rate of deforestation in the Congo basin is not yet evaluated, but would be probably higher than the precedent rate.

Covering about 217,854 ha and located in the Congo basin, the national park of Lobeke is filled with a strong biological wealth [8]. This forest and surroundings provide important advantages to about 191,100 people. From the biological point of view, these forests are probably the most threatened of the world. More than 764 species of plants divided into 102 families and several others unidentified have been harvested [9]. Among timbers, exploited trees such as Ayous (*Triplochiton scleroxylon*), Iroko (*Millicia excelsa*), Sapeli (*Entandrophragma cylindricum*), Kossipo (*Entandrophragma candolei*), Sipo (*Entandrophragma utile*), Assamela (*Pericopsis elata*) and Azobé (*Lophira alata*) are well represented. Compared to mount Cameroon and Korup national park, the flora of the national park of Lobeke is different of about 55 %.

It was estimated that tropical forests stored more than 200 t C/ha in timbers [10,11]. Carbon management in forests is the global concern to mitigate the increased concentration of greenhouse gases in the atmosphere. Reviving forest cover and finding low cost methods to sequester carbon is emerging as a major international policy goal. As trees grow and their biomass increases, they absorb carbon from the atmosphere and store in the plant tissues resulting in growth of different parts. Active absorption of CO_2 from the atmosphere in photosynthetic process and its subsequent storage in the biomass of growing trees or plants is the carbon storage [12,13]. After a long discussion on the contribution of forest ecosystems to the global carbon cycle, it seems as if these will finally be recognized through a Reduced Emissions from Deforestation and Degradation (REDD) mechanism, not only for their ability to absorb anthropogenic carbon but its function as a carbon reservoir. However, carbon stocks vary following the type of wood; it has been demonstrated that DBH and basal area are important factors in carbon stock variation [3].

Several studies were carried out on the biomass and carbon stocks in ecosystems all over the world [12-27]. These studies have never demonstrated the role or the potential of an isolated group of plants in mitigating climate change. However, in many works, biomass was correlated to DBH and some proper factors of plants [3,5]. So, trees contribute differently in the process of sequestering CO_2 from the atmosphere. In this context, the present study was initiated to evaluate the quantity of carbon in exploited timber from African rain forests (Ayous: *Triplochiton scleroxylon*; Azobe: *Lophira alata*; Ebene: *Diospyros crassiflora*; Frake: *Terminalia superba*; Kosipo: *Entandrophragma candollei*; Sapelli: *Entandrophragma cylindricum*, Sipo: *Entandrophragma utile*; Tali: *Erythrophleum ivorense* and Tiama: *Entandrophragma angolense*) in order to determine the potential sequestration of CO_2 of these species in our forests.

MATERIAL AND METHODS

Study Site

Lobeke Park is located between latitudes 2° 05' to 2° 30' N and longitudes 15° 33' to 16° 11' E **(Figure 1)**. Its area is approximately 217,854 ha. The climate is typically equatorial with four seasons. Rainfall spread throughout the year with two peaks in April and October [28]. The maximum height of precipitation is approximately 1,500 mm/year. The Lobeke region is located in the Northwest of the Congolese basin slope, and is a part of the Congo basin with typical metamorphic formations composed of limes stones and dolerites. On the phytogeographic point of view, Lobeke park is a transitional forest between the evergreen forest of Dja and semi deciduous forest of Sterculiaceae and Ulmaceae [29].

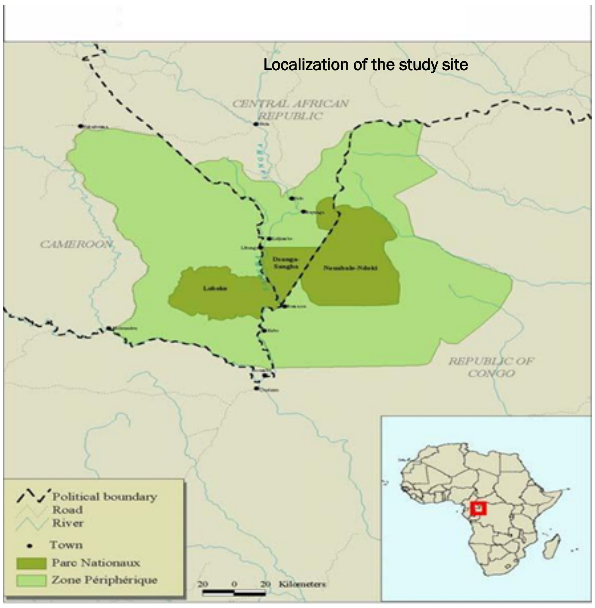

Figure 1. Localization of site in the « TNS » (Source : MINFOF, 2005).

Data collection

Floristic inventory

Data were collected in thirty seven transects of 5 ha each. The total area of investigation was 185 ha for a survey rate of about 0.085 %. Compass and GPS were used to establish transects of 2.5 km in length over 20 m in width. All selected trees with a diameter at breast height (dbh) ≥ 5 cm were assessed and measured throughout each transect using standard forestry methods [30-33].

Above ground biomass (agb)

AGB concerns trees of Diameter of Breast Height of at least 5 cm (DBH, at 1.3 m), litter and herbs of understory. Trees were collected along transects of 2.5 km in length over 20 m in width; herbs at each 500 m along transects in plots of 1 x 1 m² and litter in sub-plots of 0.5 x 0.5 m². In each survey of 2500 m over 20 m, 5 plots were demarcated **(Figure 2)**.

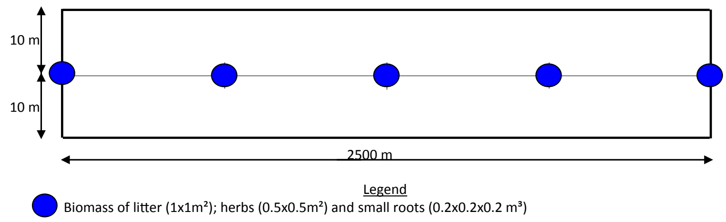

Figure 2. Detail of a sampling

Below ground biomass (bgb)

Small roots and rootlets of soil were concerned. These roots were extracted from soil in sub-plots of 0.2 x 0.2 m^2 at 0.2 m of depth **(Figure 2)**. In each survey of 2500 m over 20 m, 5 sub-plots of 0.2 x 0.2 m^2 were demarcated.

Data analysis

Abundance, diversity

Abundance was estimated for each harvested species using the following relation: A= (ni/N)*100; where ni is the number of individuals of species i and N the total of the flora.

All types of land uses (TLU) were identified throughout each transect; the diversity of each TLU was determined using Shannon index to compare data: ISH =-Σ pi $\log_2$ (pi); where pi is the frequency of species i (ni/N), ni the number of individuals of species i and N the number of individuals of all species.

Basal area and species density

The following formula was used to calculate basal area of each species: BA = π (Di^2/4); where BA is the basal area, Di is the diameter of the individual of species i and π = 3.14.

The following formula was used to evaluate density: D= ni/BA; where D is the density, ni is the number of individual of species i and BA is the basal area.

Aboveground biomass (agb)

Biomass was estimated using allometric regression model; DBH were used to assess the mass of the carbon. We used the following allometric model (Chave *et al*., 2005) to evaluate carbon sequestered by each individual and infer carbon of all timbers:

AGB= αExp [-1,499 + 2,148*ln(DBH)+0,207*$(\ln(DBH)^2$-0,0281*$(\ln(DBH))^3$] ; where α is the density of wood and DBH the diameter of breast height at 1.3 m. We used the mean density of 0.6 as recommended in the literature. This model was used for two reasons: the work was carried out in tropical humid forest and individuals of a DBH ≥ 5 cm were harvested.

Ecological service

We used ratio CO_2/C (44/12) molecular weight to convert carbon stocks (t C/ha) into t CO_2/ha and thus, the total CO_2 sequestered in the forest. According to Ecosystems Marketplace (Ecosystems marketplace, 2009), the transaction price for conservation was estimated at 4.8 USD/t CO_2; we used this ratio to estimate the ecological service value.

RESULTS

Abundance, Diversity

A total of 8, 619 individuals divided into 6 families, 6 genera and 9 species were recorded. Ebenaceae was the most diversified family; followed *Combretaceae* **Table 1**. *Entandrophragma* was the most diversified genus with 4 species. *Diospyros crassiflora* was the most abundant (61.9 %) and diversified (ISH= 8.09) species; followed *Terminalia superba* (15.9 %; ISH= 2.08) **Table 2**.

Table 1. Families summarize data

Families	ni	A	ISH	BA (m²)	D (ind./ha)	AGB(t/ha)
Caesalpiniaceae	333	3.86	0.51	147.02	1.8	9.95
Combretaceae	1373	15.92	2.08	370.22	7.42	22.86
Ebenaceae	5339	61.94	8.09	92.32	28.85	3.41
Meliaceae	631	7.32	0.95	350.13	3.41	24.91
Ochnaceae	296	3.43	0.45	103.40	1.6	7.05
Sterculiaceae	647	7.50	0.98	549.01	3.49	39.31

ni: number of individual of species i; A: abundance ; ISH: index of Shannon ; BA: basal area ; D: density; AGB: above ground biomass.

Species Density and Basal Area

The most important basal areas were those of *Sterculiaceae*, *Combretaceae* and *Meliaceae* with 549.01; 370.22and

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350.13 m² respectively. With a high basal area, these families were not too dense; the densest family was Ebenaceae with 28.85 ind./ha **Table 1**. *Triplochyton scleroxylon*, *Terminalia superba* and *Entandrophragma cylindricum* were the biggest species of the flora with 549.01; 370.22 and 334.8 m² of basal area respectively **Table 2**. however, the densest species was *Diospyros crassiflora* (28.8 ind./ha).

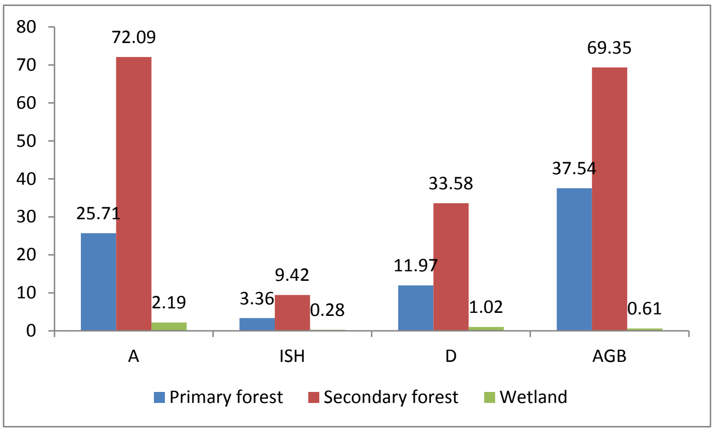
Table 2. Species summarize data.

Species	ni	A	ISH	BA (m²)	D (ind./ha)	AGB(t/ha)
Diospyros crassiflora	5339	61.9	8.09	92.32	28.8	3.41
Entandrophragma angolense	6	0.07	0.01	1.40	0.03	0.08
Entandrophragma candollei	38	0.44	0.05	12.85	0.2	0.89
Entandrophragma cylindricum	581	6.74	0.88	334.8	3.14	23.87
Entandrophragma utile	6	0.07	0.01	1.03	0.03	0.06
Erythrophloeum ivorense	333	3.86	0.50	147.02	1.8	9.94
Lophira alata	296	3.43	0.44	103.41	1.6	7.06
Terminalia superba	1373	15.92	2.08	370.22	7.42	22.86
Triplochyton scleroxylon	647	7.50	0.98	549.01	3.49	39.32

ni: number of individual of species i; A: abundance ; ISH: index of Shannon ; BA: basal area ; D: density; AGB: above ground biomass

Species Abundance Following the TLU

Three types of land use (TLU) were harvested **(Figure 3)** secondary forest was the most important with about 72 % of individuals. Wetland was the less important (2.19 %). AGB in secondary forest was the most important.



A: abundance; ISH: index of Shannon; D: density; AGB: above ground biomass.

Figure 3. Data summarize in TLU.

Aboveground Biomass (Agb)

Nine species were assessed in total. These species stored 107.5 t C/ha. *Sterculiaceae*, *Meliaceae* and *Combretaceae* were the most important families in term of biomass **Table 1**. The same, *Triplochyton scleroxylon, Terminalia superba* and *Entandrophragma cylindricum* were the most important species **Table 2**.

Total carbon stock in the selected trees throughout the park was estimated at is obtained by summing the values at the level of timbers, herbs, litters and roots. The total carbon throughout the Park (off set the carbon dissolved in the soil) is estimated at 23, 419, 305 t (107.5 x 217, 854) of carbon. The ecological service which should be paid to 4.8 US per ton of carbon is evaluated at 112, 412, and 364 US $.

DISCUSSION

For the entire work, the biomass is estimated at 107.5 t C/ha. This value represents more than ¼ of the biomass harvested in a homogeneous natural forest of *Gilbertiodendron dewevrei* in the Dja biosphere reserve in Cameroon and approximately comparable with many anterior results in the tropics [34,14,15,16]. These data were as important as the work carried out in Tanzania in some agroforestry practices such as parklands, homegardens and woodlot [35]. Carbon stocks were significant and much higher than those obtained in agro-ecosystems in the centre of the Himalayas in India, in tropical moist lowland forests in Costa Rica and in young stands of *Annona reticulata* and *Annona squamosa* in the Campus of Aurangabad University [6,24,26]. The total of CO_2 was very high explaining an important ecological service provided by the selected species in the park.

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CONCLUSION

The selected species showed an important role in mitigating climate change; their sequestration potential represents ¼ of the biomass stored in a homogenous natural stank of *Gilbertiodendron dewevrei* in the Dja biosphere reserve in Cameroon. It is important to precise that, nine surveyed species stored in their biomass a quantity of CO_2 comparable to the existent data from agro-ecosystems. As our natural forests are under degradation, should agro-ecosystems be able to provide the same ecological services? Several works are being carried out to assess and compare biomass in agro-ecosystems in Cameroon.

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