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Biomass and Carbon of Trees and Shrubs in the Commune of Mbunya in the City of Bunia, Ituri Province, DRC

Yannick Ngoy[a*], Hippolyte Nshimba[b], Prince Kaleme[c], Julien Kpane[d], Lafleur Musalizi Muharabu[e]

[a] *Shalom University of Bunia, Faculty of Sciences, Environmental Management, DRC*
[b] *University of Kisangani, Faculty of sciences, DRC*
[c] *Center for Research in Natural Sciences, DRC*
[d] *Shalom University of Bunia, Faculty of Sciences, Environmental Management, DRC*
[e] *University of Kisangani, Faculty of Management of Renewable Natural Resources, DRC*
[a] *Email: yannickngoy058@gmail.com*
[b] *Email: hippolytenshimba@gmail.com*
[c] *Email: pkaleme@gmail.com*
[d] *Email:julienkpne@gmail.com*
[e] *Email: lafleur.musalizi@unikis.ac.cd*

Abstract

The aim of this study of trees in the MBUNYA commune is to assess the diversity of trees and their role in improving the urban environment. The itinerant survey method was used to identify trees along 19 avenues. During the survey, the DBH and height of trees with DBH ≥ 10 cm were recorded. We then assessed the biomass of the individuals using generic allometric equations for urban trees. The analyses revealed 1,689 individuals, divided into 36 species and 21 families. The average above-ground biomass for the neighbourhoods studied was 1366.14±710.106 (CV: 51.98%), corresponding to an average of 683.075 ± 355.053 kg of sequestered carbon. The total above-ground biomass of the areas surveyed amounts to 5464.6 kg of dry matter, which corresponds to a sequestered carbon stock of 2732.3 kg, with a CO2 equivalent of 10119.63 kg. The values of these parameters vary from one neighbourhood to another and from one avenue to another.

Keywords: biomass; carbon; deforestation; degradation and climate change.

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* Corresponding author.

1. Introduction

The balance between man and nature is being disturbed by climate change and the loss of biodiversity at an unprecedented rate. Cities, with their growing populations, often focus on developing commercial complexes rather than green spaces. This has inevitable consequences for the environment, including a reduction in vegetation [1].The evaluation of natural and semi-natural ecosystems stems from the philosophical debate on environmental ethics and the value of the relationship between man and nature. According to an ecocentric approach, this value is based on the existence of ecosystems and their ecological functioning, which is crucial to their survival, independently of human needs and profits [7]. However, human activities such as the conversion of forests to agricultural land, overgrazing, unsustainable management, the introduction of invasive alien species, infrastructure development, mining and oil extraction, human-induced fires and pollution are having negative impacts on forest biodiversity on a global scale. These forest losses and degradations make landscapes more vulnerable and reduce ecosystem services that are essential for humans [3]. The Democratic Republic of Congo (DRC), once considered a country with high forest cover and low deforestation, has seen a transition to a high rate of deforestation since 2010. With an absolute deforestation rate of 0.31%, the DRC is one of the ten most deforested countries in the world. Between 2000 and 2010, the country lost an average of 350,000 hectares of forest each year, for a total loss of 3,500,000 hectares over the period [4]. Population growth, infrastructure development and urbanisation are among the main causes of deforestation in the DRC. Despite this, many towns are home to plant formations, both natural and planted, which are also subject to anthropogenic pressures [5]. These plant formations, ranging from small isolated plants to larger formations, play a crucial role in thermal regulation by sequestering carbon dioxide and providing a specific microclimate. It is important to stress the complex link between the term "function" and the term "service", considering the former from an ecological point of view (composition, structure, genetic processes, etc.) and attributing to the latter a societal dimension [6]. Studies have been carried out worldwide to assess biomass and above-ground carbon stocks in different forest stands. However, in the Democratic Republic of Congo, most of these studies have focused on forest stands, and no survey has been carried out in Bunia to quantify the biomass and carbon stored by trees in this urban area. In order to assess the diversity of urban trees and quantify the carbon stock they sequester in the commune of Mbunya, one of the three communes of the city of Bunia, this study was undertaken.

2. Materials and Methods

This study focused on the commune of Mbunya, located north of the equator, between 1° and 2° north latitude and 30° and 31° east longitude, in the Democratic Republic of Congo. It lies close to the Mont Bleu mountain range, with an average altitude of 1,230 metres and an average temperature of 19°C. The commune is bordered to the north by the commune of Shari, to the south by the Basili chiefdom, to the east by the commune of Nyakasanza and to the west by the Tsere group of the Irumu Bahema chiefdom. Its climate is divided into two seasons, a dry season and a rainy season, with temperatures ranging from 14°C to 28°C. The commune's hydrographic network is made up of three rivers: Shari, Ngezi and Nyamukau, the last two flowing into the Shari River, a tributary of the Ituri River. [5]. Several tools and equipment were used to carry out the study of urban tree diversity and carbon stock quantification in the commune of Mbunya. A machete was used to facilitate access and lighting during the measurement of diameter at breast height (dbh). A diameter tape was used to measure the DBH of the trees. A

1.30-metre pole was used to indicate the Dhp level. The VERTEX-IV device was used to measure tree heights. An Android phone was used to take photos of unidentified trees in the field and to access the internet to use applications such as PlantSnap and PlantNet to identify unknown trees. A notebook and pen were used to take notes in the field, while a laptop was used to enter and analyse the data later. These tools and equipment were essential for collecting valuable information for assessing the diversity of urban trees and quantifying the carbon stock in the commune of Mbunya. To collect floristic data in the commune of Mbunya, the itinerant survey method was used. This method consisted of inventorying all the tree species encountered along the various avenues over a width of 50 metres, with the length varying according to the avenue. All the trees along the targeted avenues were identified, and for each tree, information such as scientific and vernacular names, diameter at breast height (DBH) and total height (TH) was collected. Photographic images of species not identified in the field were taken and taken to the faculty for identification by botanists. Two allometric equations were used to estimate biomass and carbon stock. The first equation, based on the equation in [2], takes into account Dhp, height and wood density to calculate above-ground biomass. The second equation, a general allometric equation for urban trees [7]. It uses only Dhp to estimate total biomass. The carbon stock was obtained by multiplying the total biomass by 0.5, in accordance with previous references.Categorical variables included municipality, neighbourhoods and sampling avenues. To determine the wood density of the species inventoried, a global wood density database was used. R software was used to calculate the Shannon_H, Simpson_1-D and equitability indices. These analyses were used to quantify plant diversity and assess the distribution of species in the Mbunya commune.

3. Results and discussions

Notices: EVA: Assessing the richness of flora in landscaped green spaces, CV: Coefficient of Variation, kg: Kilogram, T/ha: tonne per hectare, *E. spp*: *Eucalyptus spp, Ps. Americana: Perceae americana ,M. indica: Mangifera indica, P. guajava: Psidium guajava*

Table 1: Abundant species by neighbourhood

YAMBI YAYA		HOHO	
species	**A (%)**	***species***	**A (%)**
Mangifera indica	34, 42	*Mangifera indica*	30,67
Eucalyptus spp.	24,64	*Eucalyptus spp.*	27,33
Perceae americana	17,75	*Perceae americana*	17,78
Jacaranda mimosifolia	5,07	*Psidium guajava*	3,11
Grevillea robusta	2,90	*Spondias mombin*	2,44
Les autres espèces	15,22	*Les autres espèces*	18,67
BANKOKO		**OPASI**	
species	**A (%)**	***species***	**A (%)**
E. spp.	29,49	*E.spp.*	45,32
M. indica	29,49	*Ps. americana*	24,63
P. americana	18,10	*M. indica*	15,76
Ficus spp.	4,06	*Casia spectabilis*	3,45
P. guajava	2,96	*Ficus spp.*	3,45
Les autres espèces	15,90	*Les autres espèces*	7,39

Analysis of Table 1 reveals that three species, namely Eucalyptus spp, Mangifera indica and Persea americana, are abundant in all the neighbourhoods studied. However, their order of abundance varied from one neighbourhood to another. In Yambi Yaya and Hoho, the order of abundance is M. indica - E. spp - P. americana, while in Bankoko, it is E. spp - M. indica - P. americana, and in Opasi, it is E. spp - P. americana - M. indica. Moreover, these species are among the five most abundant in each district.

In Bankoko, M. indica and Eucalyptus spp are the most abundant species, with an abundance of 20.49% each, followed by Persea americana (18.10%), Ficus spp (4.06%) and Psidium guajava (2.96%). Other species accounted for 15.91% of total abundance. In Hoho, M. indica is in first place with 30.67%, followed by E. spp with 27.33%, P. americana (17.78%), Ps. guajava (3.11%), Spondias mombin (2.44%) and the other species represent 18.67%. In Opasi, Eucalyptus spp is the most abundant species with 45.32%, followed by P. americana (24.63%), M. indica (15.76%), Casia spectabilis and Ficus spp with 3.4% each. The other species together account for 7.39% of total abundance. Finally, at Yambi Yaya, M. indica is the most abundant species with 34.42%, followed by E. spp (24.64%), P. americana (17.75%), Jacaranda mimosifolia (5.07%), Grevillea robusta (2.90%) and the other species together account for 15.22% of total abundance.

In the commune studied, three species showed high numbers in terms of numbers, but their distribution varied from one district to another. These were Eucalyptus spp (498 individuals in total, including 175 in Bankoko, 95 in Hoho, 92 in Opasi and 136 in Yambi Yaya), Mangifera indica (471 individuals in total, including 226 in Bankoko, 57 in Hoho, 32 in Opasi and 156 in Yambi Yaya) and Persea americana (327 individuals in total, including 93 in Bankoko, 83 in Hoho, 50 in Opasi and 101 in Yambi Yaya).

Table 1 confirms these results in percentage terms. The abundance of these species can be explained by the fact that Mangifera indica and Persea americana are fruit trees that contribute to the urban population's diet and subsistence economy. They are also medicinal species and play a role in supporting the household microclimate. As for Eucalyptus spp, it is widely used locally for house building. It is interesting to note that according to [11]. The most common species are Azadirachta indica, Cocos nucifera and Ficus polita. Cocos nucifera is found mainly along lakeshores, and these species are chosen as line trees because of their rapid growth, their roots that grow deep to avoid damaging asphalt roads, and the shade they provide.

Table 2: Diversity indices in : BANKOKO, HOHO, OPASI and YAMBI YAYA

Indices de diversité	Bankoko	Hoho	Opasi	YAmbi Yaya
Simpson_1-D	0,97	0,95	0,92	0,96
Shannon_H	3,37	3,09	2,49	3,30
Equitability_J	1,00	1,00	1,00	1,00

Table 2 shows that the study environment is highly diverse, as indicated by the Simpson diversity index (Simpsom_1-D index), which tends towards 1. The values are 0.97 at Bankoko, 0.95 at Hoho, 0.92 at Opasi and 0.96 at Yambi Yaya. This indicates a balanced distribution of species in the neighbourhoods studied, with equitability close to 1.

In addition, the Shannon index, which measures species diversity, varies according to the neighbourhoods considered individually. It is higher in Bankoko (3.37) and Yambi Yaya (3.30), and has a lower value in Opasi (2.49). This indicates that Bankoko and Yambi Yaya have greater species diversity than Opasi.

The total of 3168 individuals in the entire study area [11]. in the districts of Assabou and Dioulakro in Abidjan, Côte d'Ivoire, is higher than our result of 1689 individuals. It should be noted that our study focused only on individuals with a diameter at breast height (DBH) greater than or equal to 10 cm, whereas their study took into account even individuals with a DBH less than or equal to 10 cm. In addition, our study identified 36 species in 21 families, while [10]. Found 29 species in 17 families in Cocody and Plateau in Abidjan. The inventory [8]. Identified 742 individuals with a Dhp ≥ 10 cm divided into 127 species and 39 families in the botanical garden of Bingerville. The high number of individuals (1689) in our study, compared with the work mentioned above, and the high Simpson diversity indices (Simpsom_1-D index) (0.97 at Bankoko, 0.95 at Hoho, 0.92 at Opasi and 0.96 at Yambi Yaya), as shown in Table 2, confirm our first hypothesis that the commune of Mbunya is diverse in terms of tree species.

Table 3: Above-ground biomass and carbon mass in different avenues and neighbourhoods

QUARTIER/AVENUE	BA(kg)	COS (kg)
BANKONKO		
KAKWA DEUX	263,758	131,879
KAKWA UN BIS	333,202	166,601
LOGO UN	229,734	114,867
MANIEMA UN	266,618	133,309
MBANDAKA UN	584,888	292,444
MBUNYA	170,348	85,174
ZELANGA NA POKWA DEUX	257,558	128,779
Total	**2106,106**	**1053,053**
HOHO		
LE BON BERGER	250,621	125,3105
LEOPOLD VILLE	163,844	81,922
MUHIMBO	297,794	148,897
SADJABO	212,054	106,027
Total	**924,313**	**462,1565**
OPASI		
KIDJOGOLI	240,965	120,4825
MAYOLA UN	373,813	186,9065
Total	**614,778**	**307,389**
YAMBI YAYA		
NYARAMBE	617,661	308,8305
COMANDA	245,745	122,8725
DJALASIGA	376,572	188,286
KASOZA	215,58	107,79
KIVU	274,782	137,391
MARABO	89,063	44,5315
Total	**1819,403**	**909,7015**
Moy. quatrier	**1366,15±710,106**	**683,075±355,053**
CV(%)	**51,98**	**51,98**

Table 3 shows that the average above-ground biomass for the neighbourhoods studied in the commune of Mbunya is 1366.14 ± 710.106 kg of dry matter, which corresponds to an average of 683.075 ± 355.053 kg of sequestered carbon. The total above-ground biomass of the areas surveyed is 5464.6 kg of dry matter, which is equivalent to a sequestered carbon stock of 2732.3 kg. The CO2 equivalent is 10119.63 kg.

The breakdown of this total biomass is as follows: Bankoko (2106.106 kg), Yambi Yaya (1819.403 kg), Hoho (924.313 kg) and Opasi (614.778 kg), corresponding respectively to 1053.053 kg, 909.7015 kg, 462.1565 kg and 307.389 kg of sequestered carbon.

Looking at the avenues separately, Avenue Nyarambe has the highest carbon stock at 308.8305 kg, followed by Avenue Mbandaka UN at 292.444 kg. Avenue Marabo has the lowest stock at 44.5315 kg. It should be noted that these values are 122 times lower than the results obtained by [12]. For the Plateau commune in Abidjan, who observed 671204.3 kg of dry matter, corresponding to a sequestered carbon stock of 335602.2 kg and a CO2 equivalent of 90612.6 kg for all the areas inventoried. This difference can be explained by the fact that most of the trees surveyed in Mbunya have a diameter of between 10 and 20 cm. However, these results confirm our second hypothesis, according to which the quantity of biomass and aerial carbon sequestered by trees and shrubs in the commune of Mbunya is considerable.

4. Conclusion

The aim of this study was to assess the diversity of urban trees and quantify the carbon stock they sequester in the commune of Mbunya, one of the three communes of the city of Bunia. An exhaustive inventory of shrubs and trees was carried out in the Bankoko, Hoho, Opasi and Yambi Yaya neighbourhoods, with the diameter at breast height measured for each tree. Above-ground biomass and sequestered organic carbon were calculated using a specific allometric equation [2].

After analysis, the results obtained indicate that the various areas surveyed are home to 36 plant species divided into 21 families. The average above-ground biomass for the neighbourhoods studied was 1366.14 ± 710.106 (CV: 51.98%), corresponding to an average of 683.075 ± 355.053 kg of sequestered carbon. The total above-ground biomass of the areas surveyed was 5464.6 kg of dry matter, corresponding to a sequestered carbon stock of 2732.3 kg. The CO2 equivalent is 10119.63 kg, demonstrating the compensatory role of tree species in the commune of Mbunya in reducing carbon dioxide emissions from human activities. These results confirm the hypotheses formulated, namely that the commune of Mbunya is diverse in terms of tree species and that the quantity of biomass and above-ground carbon sequestered by trees and shrubs in the commune of Mbunya is considerable.

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