# Trees outside forests: Species adopted by the HIMO approach as part of the Diméo-Walamaï road rehabilitation project inMokoloCouncil, Far North, Cameroon


## ABSTRACT

Biodiversity, a natural biological capital of the earth presents important opportunities for all societies, provides essential goods and services for human livelihoods and aspirations. This work assesses the potential of plant species adopted by the HIMO (High Labour Intensity) approach. More specifically, the aim is to: gauge farmers' perceptions of suitable species; characterize the plant population of the species encountered in Diméo to Moufou section and assess the carbon stock in this area. To do this, a participatory methodology based on survey of local population followed by interviews with relevant authorities was first adopted, followed by floristic inventories in 03 villages (Diméo, Moufou and Walamaï). *Azadirachta indica*were planted mainly on selected sites along the road, 9 km. The quadrat method, which consists of using a string to mark out a 50x50 m area within which an inventory of the vegetation is carried out by following 10m radius wide and 50 m long one after the other. Results showed that the diametric, vertical and horizontal distribution of trees on these sites has a "U" shape. This confirms the effect of the anthropization of these sites. Good regeneration of the species on the sites, whether reforested or notis indicated. The presence of large trees explained the fact that they are sometimes protected in fields, houses and roadsidesagainst intermediate trees, which are exploited for firewood. However, total carbon is estimated at 80.837 tC/ha. It is higher in Walamaï (22.24±7.05 tC/ha). Equivalent $CO_2$ varies significantly between villages and plant species. The total value of equivalent carbon dioxide was 296.402 $tCO_2$/ha. This carbon dioxide is most represented by *A. indica* in the Walamaï village (81.56±24.85 tCO2/ha) and least by the species *Acacia nilotica* (1.08±0.00) in Walamaï. The total monetary value of the total quantity of carbon is US$2,964,023.



**Key words:**Council, floristic Species, Forest, HIMO, Carbon stock.

# INTRODUCTION

Natural vegetation is a vital resource for humans and a capital that meets the multiple needs of a fast-growing population (Dodet and Collet, 2012). African continent is experiencing a booming population growth rate (UNDP, 2012). In Cameroon, the average annual growth rate is estimated at 2.7%, and the Far North Region is experiencing galloping demographic growth, with an annual growth rate of around 3%, giving a population density of 120 or even 240 inhabitants per $km^2$ (MINADT, 2010). This demographic explosion is leading to ever-increasing pressure on natural ecosystems (Bellefontaine *et al.,* 2001; Degrande *et al.,* 2007; Mapongmetsem *et al.,* 2011). Vegetation degradation may or may not be caused by human activity, resulting in a change in the nature of a biotope, causing it to lose its forest status (Tchotsoua, 2006; Tchobsala, 2011). It should also be noted that the Far North region is threatened by drought and desertification (GIZ, 2014). These phenomena, combined with demographic and climatic parameters, are increasing fragmentation of habitats. This is reflected in a change in floristic composition and vegetation structure, and in the low level of natural regeneration of some species (Diatta *et al.,* 2009). The sustainable use of trees or their planting thus remains a preventive or adaptive practice for safeguarding our environment. *Azadirachta indica* is a plant species imported from India (Cooke *et al.,* 2008). Since its introduction to this locality, this species, in homogeneous or heterogeneous plantations, occupies large areas in urban agglomerations and surroundings. The towns of Maroua, Kousseri, Mora, Yagoua, Kaélé and Guidiguis are real forests in the making, despite the lack of replanting of *Khaya senegalensis* and *Azadirachta indica*. In aerial view, they can be likened to gallery forests (GIZ, 2014). Indeed, the use of *A. indica* is playing an important role in people's daily lives, as native species are more often than not eliminated and replaced by *A. indica*. However, reforestation with exotic species can lead to ecological imbalance and does not encourage the reconstitution of forest formations based on native species (Parrotta, 2012). This type of reforestation contributes considerably to the reduction or loss of floristic and faunal diversity. The risk of having a single-species local plant cover (*A. indica* monospecific forest) would therefore be great. Aside from natural catalysts, human activities contribute considerably to the disappearance of plant cover in Sahelian zones, as Mokolo district is in a Sahelian zone. These are being destroyed to the detriment of residential areas, agricultural land and the actual exploitation of wood for various uses. This phenomenon contributes to pronounced climatic hazards experienced on a daily basis in Mokolo district. The aim of this work is to evaluate the species adopted by the labour-based approach of the Diméo, Marché-Moufou, Walamaï road rehabilitation project. Specifically, it is to gauge farmers' perceptions of suitable species; characterize the plant population of encountered species along the Diméo section as far as the Moufou market; and estimate the carbon stock in this area.

## MATERIAL AND METHODS

### Study area

The study area belongs to the Sudano-Sahelian zone in the Mokolo district, characterized by a long alternating dry season from October to June and a short rainy season between July and September. The site was chosen because of rapid deforestation, population explosion, the threat of desert encroachment, population's exposure to extreme poverty, uncontrolled and illegal exploitation of NTFPs and expansion of agriculture, which is considerably reducing vegetationareas (Figure 1). The studied area lies between the geographical coordinates, longitude 100 31'12" North latitude and 13058'48" East longitude (Fotsing, 2009).

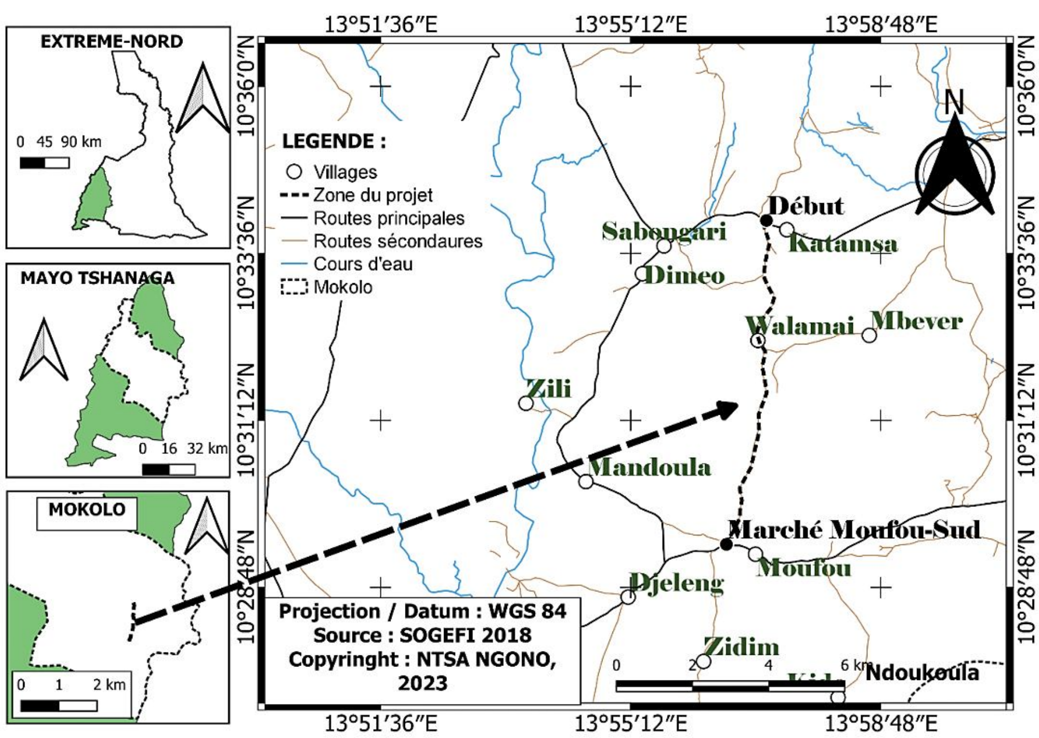


**Figure 1 :** Map of the study area

**Ethnobotanical surveys**

Ethnobotanical surveys were carried out in the 3 surrounding villages with 300 people (100 people/village), completed by direct field observations. These surveys were carried out in the form of semi-structured interviews based on a questionnaire drawn up beforehand. The main headings of the questionnaire included variables for identifying the respondents, the activities practiced and the farmers' perception of the environment.

**Floristic survey**

The quadrat method was used to carry out the floristic survey. This method was successfully applied by Tchobsala (2011) to suburban savannah vegetation in Adamaoua (Cameroon). It consists of using a string to delimit an area measuring 50x50 m, within which an inventory of the vegetation is carried out by following 10m radius wide and 50 m long one after the other (Figure 2). Experimental survey was a factorial design with the 3 villages as main treatments. The 3 plant formations as secondary treatments and 3 plots of 50x50 m plots in each plant formation as replicates. In each 50x50 m plot, all woody plants were inventoried. The dendrometric parameters measured were height, diameter at breast height (DBH) for woody plants with a height ≥1.30 m and the diameter of the pourbier; the number of woody plants was also counted and enumerated in terms of the number of living plants. To identify anthropization on vegetation (abrasion, burning, cutting), the method of Haiwa (2017) was used. It consists of observing the tracks and counting the number of feet of diseased individuals out of the total number of individuals in a plot.

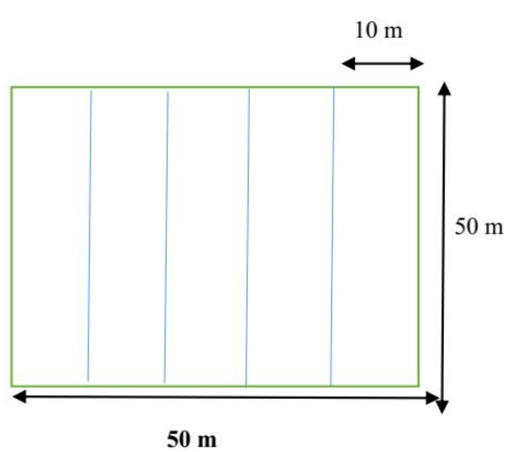


**Figure 2:**Plant survey plan

**Assessment of carbon stock potential**

Data from the floristic inventory were used in this section to assess sequestered carbon. This method uses statistics based on diameter at breast height (DBH). It is easier to implement and low cost. It was recommended by Tchobsala *et al.* 2014, unlike the direct method.

**Aerial tree phytomass (Carbon)**

The Aerial tree phytomass for each woody individual surveyed was calculated using the allometric equation developed by Chave *et al.* (2005) for dry tropical climates. AGB = expo (-1.996 + 2.32*ln(dbh)) or AGB: above-ground biomass in kilograms (kg), dbh: diameter at breast height in centimeters (cm).

**Tree root phytomass**

Hypogeous carbon was deduced from Aerial tree phytomass according to the allometric equation used by Cairns *et al.* (1997): BGB = expo (- 1.0587 + 0.8836*ln(AGB)) where AGB is the biomass removed in kilograms (kg).

**Estimation of the amount of carbon in the aerial phytomass**

To assess carbon in the various components, biomass present in the plots was evaluated. Following the recommendations of the IPCC (2000), many studies used an average carbon concentration value of 50% for vegetation when more precise data are not available. This involves assessing the quantity of carbon from the biomass present in several components (above and below ground).

**Estimation of the amount of carbon in the root phytomass**

The amount of carbon was obtained using Ibrahima *et al.* (2002) and Saïdou (2012) approach.

$$\mathbf{Q_{Cr} = Br \times Cv}$$

Where $Q_{Cr}$ = root carbon (tC/ha); Br = root biomass (t/ha) and Cv = vegetation carbon concentration (0.5).

**Estimation of the total amount of carbon**

It was obtained by summing the quantities of carbon from all the components (aerial, root). In other words, it is the sum of Aerial tree phytomasscarbon and root carbon.total

$$C_Q = \text{Aerial tree phytomass CQ} + \text{Root CQ}$$

**Estimation of the ecological service**

Ecological service is estimated using the 44/12 ratio corresponding to the $CO_2$/C ratio representing molecular weight used to convert carbon stocks into the quantity of

$CO_2$sequestered by the forest. This quantity of $CO_2$ is then assessed in monetary terms using the value of the ecological service estimated at 10 USD/t $CO_2$ (Ecosystems Marketplace, 2016). However, a recent survey of the voluntary market by Ecosystems Marketplace shows that the transaction price per ton of $CO_2$ is as follows: Afforestation and Reforestation (A/R): US$10 per ton.

## RESULTS

### Distribution according to age

It was observed that 71% of the people living in the locality are men and 29% are women. This is due to the many activities they carry out in relation to the siteFigure 3 shows the interviewedrespondents, grouped by age. These range from [20-30], [30-40], [40-50] and >50 years old. This shows that the main respondents are young people in the 20 to 30 age range. This active population represents 50.85% spread across the various activities. However, 3.75% are not fully active because they no longer have sufficient energy to carry out the activities that lead to deforestation and forest degradation.

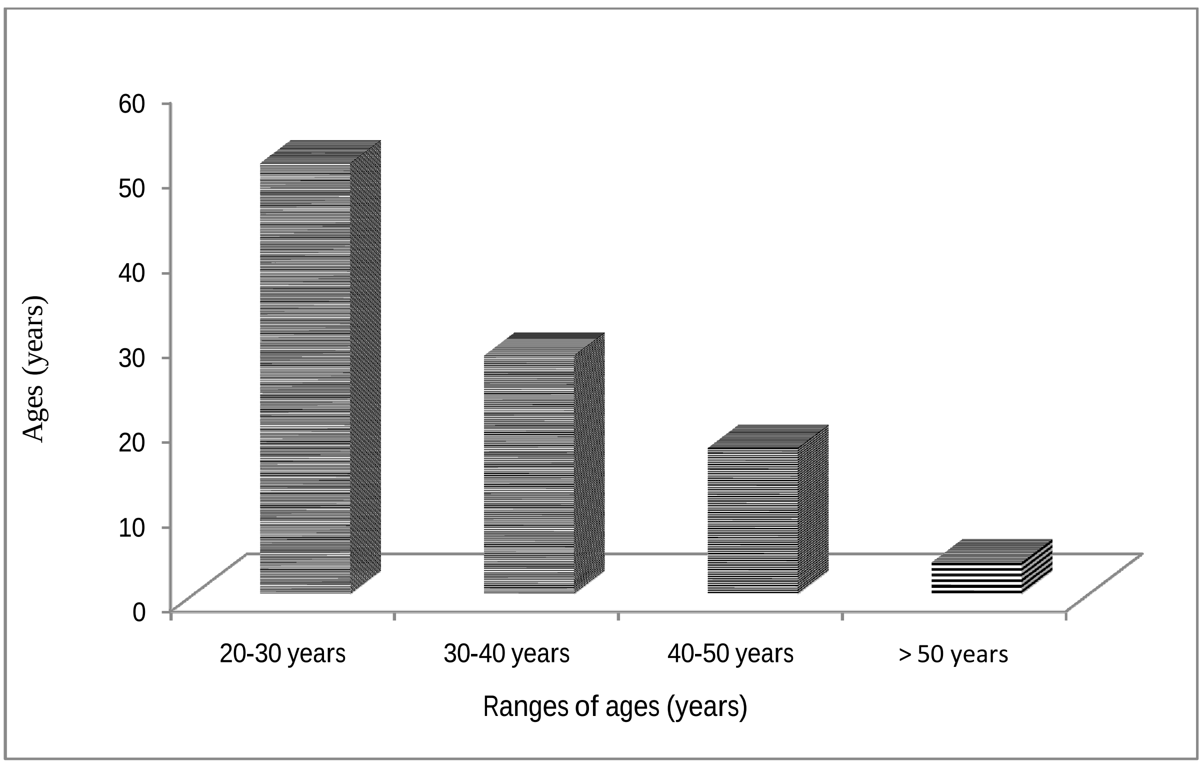


**Figure 3:** Distribution of respondents by age group

**Perception of the local population on environment**

The people sampled said that the local vegetation before 1965 at Diméo was dense, bushy and diverse(Figure 4). It was a veritable scrubland with hardy, deciduous, thorny species entangled by creeping species. It was almost impossible to see more than 50 m away. The genera *Acacia,Balanites, Ficus, Anogeissus, Sclerocaya, Combretum, Piliostigma, Ziziphus* etc. were the most dominant. Mammals, reptiles, insects, birds etc. were found in this wild vegetation. According to the populations, the climate was not too severe. Although dry, it was pleasant and conducive to human activity. To date, the majority of people interviewed say that the reforestation with *A. indica* has greatly improved Diméo's environment.

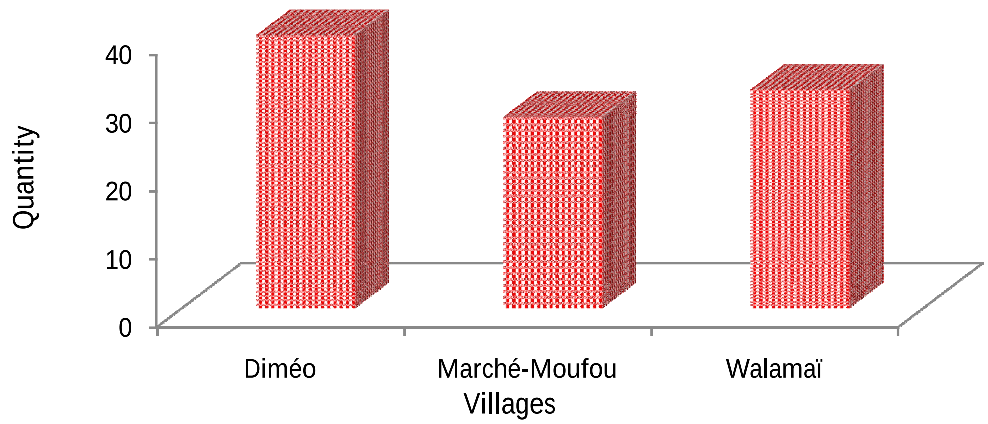


**Figure 4:** People's perception of the environment

**Choice of tree species**

Figure 5 shows that 47% of people chose *Azadirachta indica*; 31% chose *Faidherbia albidada*; 9% chose *Anacardium occidentale* and 8% chose *citrus limon*. The spread of *Azadirachta indica*(neem) in the villages has been encouraged by the local population thanks to the various reforestation projects that have taken place.

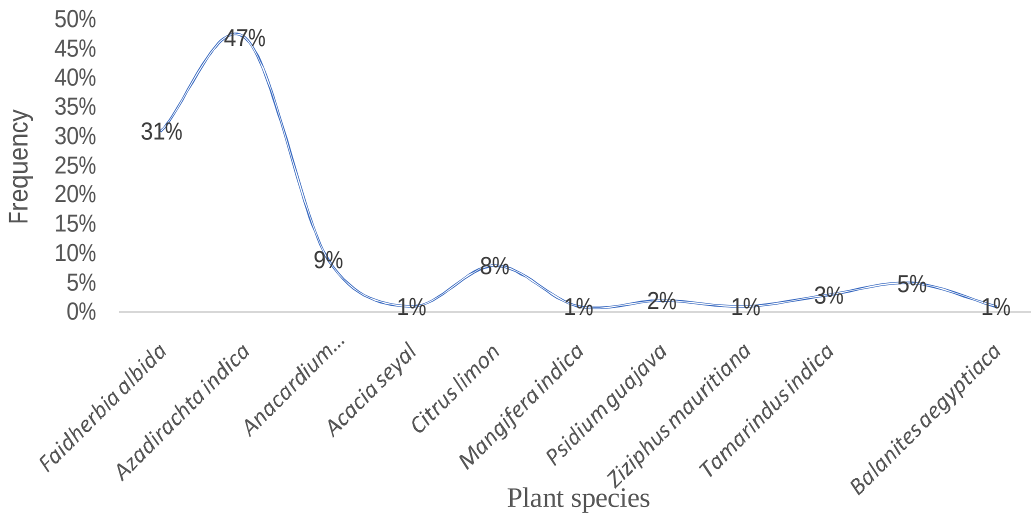


**Figure 6:** The perception of populationof the choice of tree species

**Characterization plant species encountered in Diméo, Moufou marketandat Walamaï**

***Vertical structure of the trees***

Generally, trees on reforested site grow taller than those on the natural ones, uncontrolled savannahs. This difference can be explained by the fact that, during the dry season, trees on reforested savannahs are watered and protected from fire and domestic animals, compared with those on control sites. The vertical distribution of individuals is U-shaped(Figure 7). Trees concentrated at an interval [<1 m] are young trees. They are subject to many stresses caused by human activities (felling, exposure to animals, bush fires, etc.). Trees between [1-1.30] were considered to be rejects. Those whose height is between [1.30-3] are considered to be intermediate plants. They are exposed to phenomena such as cutting for firewood, peeling for pharmacopoeia and burning. Those that are taller than 3m are considered to be old trees; they already provide shade for the population and are not subject to the same attacks as intermediate plants.

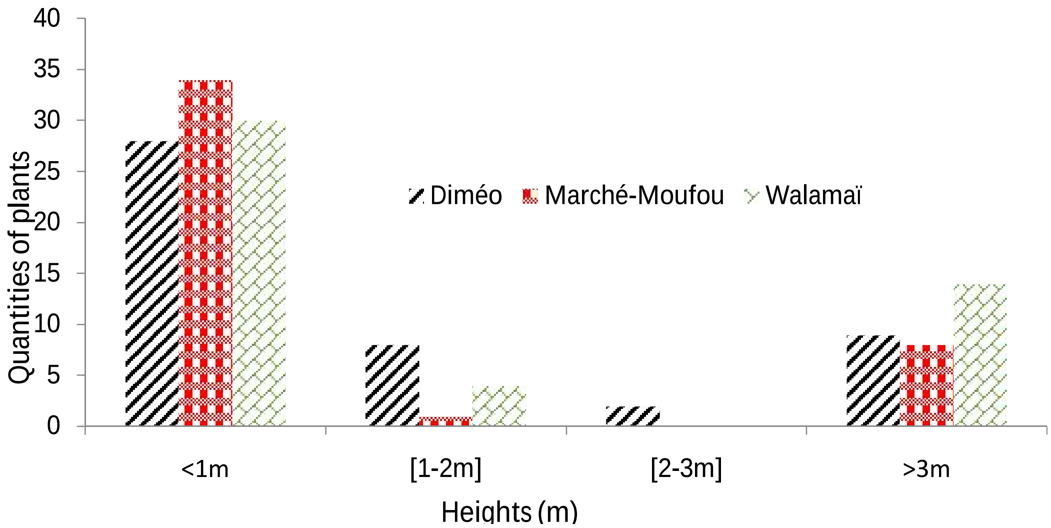


**Figure 7:** Distribution of trees by height class

***Horizontal structure of the trees***

Generally, the distribution of the diameter of the tree mire is bell-shaped. The maximum number of trees has a mire diameter concentrated between 13 and 10 m in diameter. Below 10 m, the diameter decreases in site 3 (Figure8).

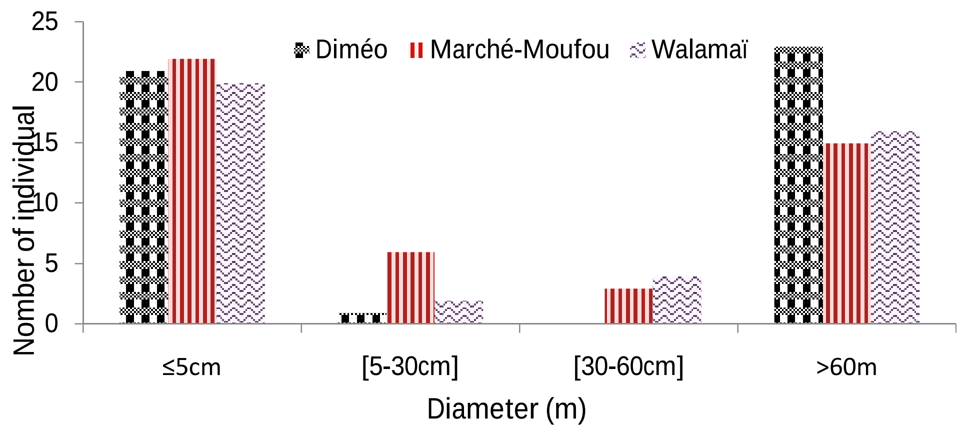


**Figure 8:** Distribution of trees according to the diameter of the mire

**Diametric structure of the trees**

The diametric structure of the trees is generally U-shaped. The distribution of trees on the reforested site (200 individuals of young plants) following the example of *Azadirachta indica* shows that individuals with dbh less than 0.01 m are the most numerous. Above 50 cm, trees become scare (Figure 9).

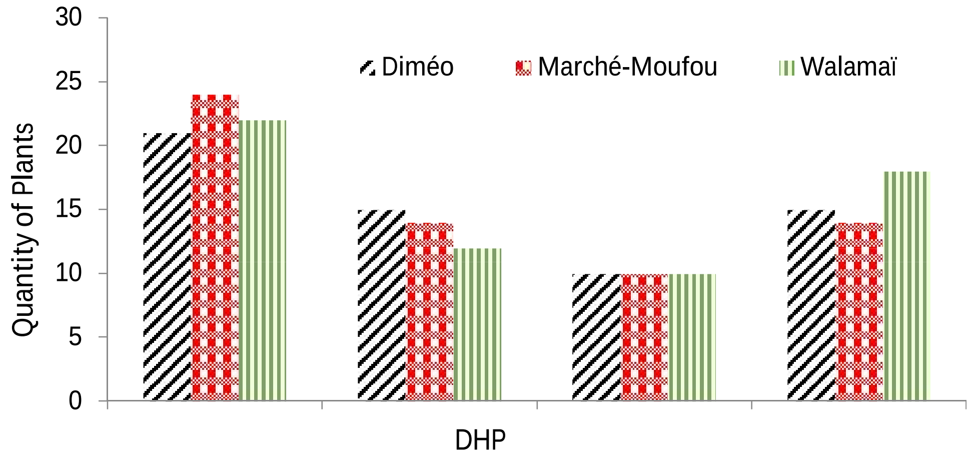


**Figure 8:** Distribution of trees according to diameter

**Assessment of biomass, carbon stock and carbon credit in this zone**

***Aerial biomass***

Table 1 shows the aerial biomass in the three study sites according to species. Aerialphytomass varied significantly between villages and species (p< 0.001). *Azadirachta indica* in Walamaï village (36.22±12.65 t/ha), followed by *Balanites aegyptiaca* (17.032±7.55 t/ha) in the same village. The smallest quantity was found in *Acacia niloica* (0.432±0.00 t/ha).

**Table 1:**Aerial biomass

| Species | Diméo | Marché-Moufou | Walamaï |
|---|---|---|---|
| *Azadirachta indica* | $27{,}14\pm9{,}5^{A}_{b}$ | $7{,}38\pm1{,}85^{A}_{c}$ | $36{,}22\pm12{,}65^{A}_{a}$ |
| *Acacia nilotica* | $7{,}36\pm1{,}82^{B}_{a}$ | $1{,}48\pm0{,}08^{B}_{b}$ | $0{,}432\pm0{,}00^{D}_{b}$ |
| *Balanites aegyptiaca* | $6{,}12\pm1{,}25^{B}_{b}$ | $3{,}14\pm1{,}15^{B}_{c}$ | $17{,}032\pm7{,}55^{B}_{a}$ |
| *Ziziphus mauritiana* | $6{,}22\pm1{,}33^{B}_{b}$ | $3{,}74\pm1{,}32^{B}_{b}$ | $12{,}96\pm3{,}51^{C}_{a}$ |

Numbers with the same lower case letters in the same column are not significantly different at the 5 % level
Numbers with the same upper case letters in the same row are not significantly different at the 5 % level

***Subterranean biomass***

Table 2 shows that root phytomass varies from one species to another and from one village to another (p < 0.001). The total amount of root phytomass is 32.45 t/ha. The *Azadirachta indica* species in the Walamaï village had a very high root phytomass (8.27±1.85 t/ha) compared with the other villages. The lowest amount was found for *Acacia niloica* in Walamaï (0.16±0.00 t/ha).

**Table 2:** Root biomass

| Species | Diméo | Marché-Moufou | Walamaï |
|---|---|---|---|
| *Azadirachta indica* | 6,41±0,98 $^{A}_{a}$ | 2,02±0,5 $^{A}_{b}$ | 8,27±1,85 $^{A}_{a}$ |
| *Acacia nilotica* | 2,02±0,5 $^{AB}_{a}$ | 0,49±0,00 $^{A}_{a}$ | 0,16±0,00 $^{BC}_{a}$ |
| *Balanites aegyptiaca* | 1,71±0,00 $^{B}_{b}$ | 0,95±0,00 $^{A}_{b}$ | 4,24±0,87 $^{B}_{a}$ |
| *Ziziphus mauritiana* | 1,74±0,00 $^{B}_{b}$ | 1,11±0,00 $^{A}_{b}$ | 3,33±0,72 $^{B}_{a}$ |

Numbers with the same lower case letters in the same column are not significantly different at the 5 % level
Numbers with the same upper case letters in the same row are not significantly different at the 5 % level

***Carbon in the aerial phytomass***

There was a significant difference between species and villages (Table 3). The total value of carbon in the aerial phytomass was (6.612 tC/ha). Carbon in the aerial phytomass found in the study area ranged from (0.216±0.00 tC/ha) for *Acacia niloica* to (18.11±6.35 tC/ha) for *Azadirachta indica* in Walamaï.

**Table 3:** Carbon in epigeous phytomass

| Species | Dimeo | Marché-Moufou | Walamaï |
|---|---|---|---|
| *Azadirachta indica* | 13,57±4,25 $^{A}_{b}$ | 3,69±0,06 $^{A}_{c}$ | 18,11±6,35 $^{A}_{a}$ |
| *Acacia nilotica* | 3,68±0,06 $^{B}_{a}$ | 0,74±0,00 $^{AB}_{b}$ | 0,216±0,00 $^{C}_{b}$ |
| *Balanites aegyptiaca* | 3,06±0,02 $^{B}_{b}$ | 1,57±0,00 $^{A}_{bc}$ | 8,516±3,65 $^{B}_{a}$ |
| *Ziziphus mauritiana* | 3,11±0,01 $^{B}_{b}$ | 1,87±0,00 $^{A}_{bc}$ | 6,48±1,15 $^{B}_{a}$ |

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**Carbon in root phytomass**

Carbon in root phytomass varied significantly between villages and species ($p < 0.05$). differences are appreciated in table 4. The total value of carbon in the hypogeous phytomass was (16.225tC/ha). The amount of carbon in the root phytomass ranged from (0.08±0.00 tC/ha) for *Acacia niloica* in the Walamaï village to (4.13±0.05 tC/ha) t/ha) for *Azadirachta indica* in Walamaï.

**Table41: Carbon in hypogeous phytomass**

| Species | Dimeo | Marché-Moufou | Walamaï |
|---|---|---|---|
| *Azadirachta indica* | 3,20±0,04 $^{A}_{a}$ | 1,01±0,00 $^{A}_{ab}$ | 4,13±0,05 $^{A}_{a}$ |
| *Acacia nilotica* | 1,01±0,00 $^{A}_{a}$ | 0,24±0,00 $^{A}_{a}$ | 0,08±0,00 $^{BC}_{a}$ |
| *Balanites aegyptiaca* | 0,85±0,00 $^{B}_{b}$ | 0,47±0,00 $^{A}_{b}$ | 2,12±0,01 $^{A}_{a}$ |
| *Ziziphus mauritiana* | 0,87±0,00 $^{B}_{a}$ | 0,55±0,00 $^{A}_{a}$ | 1,66±0,00 $^{AB}_{a}$ |

Numbers with the same lower case letters in the same column are not significantly different at the 5 % level
Numbers with the same upper case letters in the same row are not significantly different at the 5 % level

### Estimated total carbon

Table 5 shows that the total carbon value differs according to village and species. However, total carbon is estimated at (80.837 tC/ha). It is highest in the village of Walamaï (22.24±7.05 tC/ha) for the species *Azadirachta indica*, followed by the species *Balanites aegyptiaca* (10.63±3.33 tC/ha).

**Table 5:** Total carbon

| Species | Dimeo | Marché-Moufou | Walamaï |
|---|---|---|---|
| *Azadirachta indica* | 16,77±5,05 $^{A}_{b}$ | 4,7±1,03 $^{A}_{c}$ | 22,24±7,05 $^{A}_{a}$ |
| *Acacia nilotica* | 4,69±1,02 $^{B}_{a}$ | 0,98±0,00 $^{AB}_{b}$ | 0,29±0,00 $^{C}_{b}$ |
| *Balanites aegyptiaca* | 3,91±0,1 $^{B}_{b}$ | 2,04±0,02 $^{A}_{b}$ | 10,63±3,33 $^{B}_{a}$ |
| *Ziziphus mauritiana* | 3,98±1,01 $^{B}_{b}$ | 2,42±0,03 $^{A}_{b}$ | 8,14±3,01 $^{B}_{a}$ |

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### Equivalent Carbon dioxide

Environmental degradation in terms of greenhouse gases, carbon dioxide emissions, thinning of the ozone layer, land degradation, water scarcity, deforestation and other calamities are considered a threat to the well-being of the population. $CO_2$ is a gas that allows the earth to benefit from a natural greenhouse effect that is essential for life, as it maintains the earth's average temperature at 15°C instead of -18°C (Alamgi and Al-Amin, 2008). Carbon dioxide fluctuates from one village to another and from one species to another (Table 6). Equivalent carbon dioxide ($CO_2$) varied significantly between villages and species ($p < 0.05$). The total value of equivalent carbon dioxide was (296.402 $tCO_2$/ha). This carbon dioxide is more represented in the Walamaï village (81.56±24.85 $tCO_2$/ha) with the species *Azadirachta indica*, followed by the species *Balanites aegyptiaca* (38.99±13.05 $tCO_2$/ha). This quantity is less represented for*Acacia nilotica* (1.08±0.00 $tCO_2$/ha).

**Table 6:** Quantity of $CO_2$

| Species | Dimeo | Marché-Moufou | Walamaï |
|---|---|---|---|
| *Azadirachta indica* | 61,5±21,15 $^{A}_{b}$ | 17,23±5,62 $^{A}_{c}$ | 81,56±24,85 $^{A}_{a}$ |
| *Acacia nilotica* | 17,19±5,56 $^{B}_{a}$ | 3,61±0,00 $^{C}_{b}$ | 1,08±0,00 $^{D}_{bc}$ |
| *Balanites aegyptiaca* | 14,35±4,25 $^{C}_{b}$ | 7,49±2,75 $^{B}_{c}$ | 38,99±13,05 $^{B}_{a}$ |
| *Ziziphus mauritiana* | 14,59±4,31 $^{C}_{b}$ | 8,89±3,66 $^{B}_{c}$ | 29,86±13,11 $^{C}_{a}$ |

Numbers with the same lower case letters in the same column are not significantly different at the 5 % level
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**Estimation of the monetary value of the total quantity of carbon**

The cost of the carbon credit varies according to department, year and species (Table 7). The total monetary value of the total quantity of carbon is (USD 2964.023) and (CFAF 1,763,593.88). The monetary value is highest in the Walamaï village (USD 815.6). *Azadirachta indica* (USD 815.6) and *Balanites aegyptiaca* (USD 389.9) were the most popular species.

**Table 7:** Monetary value

| Species | Dimeo | | Marché-Moufou | | Walamaï | |
|---|---|---|---|---|---|---|
| | $ USA | CFAF | $ USA | CFAF | $ USA | CFAF |
| *Azadirachta indica* | 615 | 365925 | 172,3 | 102518,5 | 815,6 | 485282 |
| *Acacia nilotica* | 171,9 | 102280,5 | 36,1 | 21479,5 | 10,8 | 6426 |
| *Balanites aegyptiaca* | 143,5 | 85382,5 | 74,9 | 44565,5 | 389,9 | 231990,5 |
| *Ziziphus mauritiana* | 145,9 | 86810,5 | 88,9 | 52895,5 | 298,6 | 177667 |

## DISCUSSION

Biodiversity, a natural biological capital of the earth that presents significant opportunities for all societies, provides goods and services that are essential for human livelihoods and aspirations. The availability of tree species and their variety in the forest constitute an immense reservoir of plant proteins for women on limited incomes. This strong male dominance can be justified by the fact that these activities require a great deal of energy and in a socio-cultural context, women are called upon to remain in the household to carry out main domestic tasks. These results are similar to those obtained in the suburban savannahs of Ngaoundéré by Tchobsala (2011), who showed that men are most involved in wood resourcestransformation. People from different age groups are involved in production activities and therefore have the available land needed to set up their activities increasing the proportion of the working population, as observed by Haiwa(2017). He showed that the dynamic populations of the northern zone of Cameroon who practices an activity linked to deforestation are between 25 and 50 years old. Nevertheless, the discovery of the products and services that the species provides militated in favor of its adoption, encouraging its planting along roadsides and in marketplaces. Babou *et al.* (2004) report similar facts on the adoption of neem, which took place as populations discovered the goods and services that these species could provide, and as farmers gained experience of its domestication and management. However, similar observations are reported by Mapongmetsem *et al.* (2011) in the Guinean high savannas, where canopy trees over 20 m in diameter are scare. This result confirms the effect of anthropization of this site.

This reflects the good regeneration of species on the site, whether reforested or not. The incorporation of DHPin the regression model may therefore increase the potential applicability of equations to different sites. Furthermore, DHP is often used as an index for increasing site conditions. It also helps to explain many of the variations in trunk weight, and these explanations are in line with the ideas of Mbow *et al.* (2012) who showed that diameter considerably increases tree phytomass and that phytomass in ecosystems is linked to the presence of large trees whose contribution to phytomass is very dominant. Our values are significantly lower than those of Monssou *et al.* (2016) recorded in the Jardin Botanique de Bingerville in the Abidjan district of Côte d'Ivoire (236.2±155.1 tC/ha). However, this higher value compared with ours could be explained by the fact that, in addition to a few species with a high carbon storage capacity, the predominance of certain fast-growing species is a determining factor in carbon storage. Livestock pressure damages trees and shrubs, and regeneration of these trees takes time. The local population exploits natural resources illegally and abusively for firewood. Daily activities, such as driving machinery, using air conditioning and/or heating and lighting homes, consume energy and emit greenhouse gases that contribute to climate change. When greenhouse gas emissions rise, the climate is influenced, the overall weather pattern changes, and average temperatures rise, along with biodiversity. Yet vegetation is essential to human life on earth. It protects the soil from the sun's rays and the impact of rain. Leaves form humus and recycle mineral elements; leaf litter protects soil; roots improve water infiltration, increase soil's biological activity, retain soil and can pump mineral elements from the deep layers of the soil. These results are closed to those of Viana (2009) on the prospects for carbon financing for agriculture, forestry and other land-use projects on small farms. In today's context, the increase in $CO_2$ is one of the main concerns addressed by the Kyoto Protocol because it is the main factor responsible for global warming (Baishya *et al.*, 2009). Daily activities contribute strictly to climate change when land is converted to agricultural use and trees are destroyed. A new source of $CO_2$ emissions is created. The trend over the last twenty years is disconcerting, with an average annual increase of 4.1% for sheep and 5.9% for goats. This considerable increase in livestock numbers, combined with the fact that the area available to the herds was reduced during the long drought by simple aridification and by the conversion of pastures to arable land, has had dramatic effects on environment. $CO_2$ value varies according to the volume of plant and the number of individuals per hectare. Fluctuation in different types of plant formation is due to protected environments and others left to the pressures of the riparian population. It would therefore be wise to protect trees under human influence to reduce greenhouse gases emissions. These results are similar to those of Woods Hole Research Center (2011) on the field guide for estimating forest biomass and carbon. Economic value calculated from these species confirms the important role of trees in nature. It would be worth encouraging agroforestry to increase this economic value in agricultural systems too. Apply sustainable vegetation management in the Sudano-Sahelian zone would have enormous natural potential. But the way they are developed, combined with human factors, is leading to deforestation. Given their value to local populations and their role in mitigating and adapting to climate change, it is important to manage these natural resources sustainably. To this end, mankind is called upon to take these problems into account in order to mitigate the current trends as quickly as possible, and these problems must be taken into account by the relevant political authorities and donors so that action can be taken quickly to slow down or halt the processes underway. REDD+ is thus used as a means of mitigating climate change through reduced carbon emissions from deforestation and forest degradation (FAO, 2010) and is seen as a means of increasing support for forest stewardship activities by local communities (Springer and Larsen, 2012).

## CONCLUSION

The starting point for our research was the vertiginous deforestation pressure in recent decades on studied area. For this reason, a reforestation project was carried out using the HIMO approach. The aim of this work was to evaluate the species adopted by the HIMO approach; to gauge farmers' perceptions of suitable species; to characterize the plant population of the species encountered in the Diméo, Moufou, Walamaï villages and to evaluate the carbon stock. To achieve this, a participatory methodology was used, based on surveys of the local population, followed by interviews with the relevant authorities and, finally, floristic inventories were carried out in the 03 villages (Diméo, Moufou, Walamaï). Vertical and horizontal diameter distribution of trees at these sites is U-shaped. However, total carbon is estimated at 80.837 tC/ha. It is higher in the Walamaï village (22.24±7.05 tC/ha). Thus, the total value of equivalent carbon dioxide is (296.402 $tCO_2$/ha). The total monetary value of the total quantity of carbon is USD 2964.023 (1,763,593.88 CFA F). In the light of these results, a number of measures have been proposed, including a formal ban on cutting green wood and the regularization and exploitation of fruit trees.

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