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ASSESSMENT OF ORNAMENTAL PLANTS SPECIES THAT SERVE SEQUESTRATION AND AESTHETIC ROLES IN MAITAMA, ABUJA MUNICIPAL AREA COUNCIL, OF THE FEDERAL CAPITAL TERRITORY OF NIGERIA

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Abstract

The study assessed the ornamental plants in Maitama District of the Abuja Municipal Area Council of the Federal Capital Territory of Nigeria with the view of establishing their sequestration and aesthetic roles. The study area was purposively selected based on its residential characteristics. The study used Simpson's Index (SI) to obtain and analyze data. The findings show that the plant species that were found in the study area; Artificial palm trees, Aloha, Blush Noisette, Antirrhinum majus, Alstroemeria, African Daisy, Aconitum and Masquerade trees. The first quadrant is heterogeneous with a low value of species composition, in the second quadrant, the dominant species is Blush Noisette with a value of 26. In third quadrant, there are four different species of plant totaling 81 with a Simpson's Index value of 0.2605. For the Biomass estimation for the samples, Antirrhinum majus and Aconitum have the highest mean DBH (47.3cm and 43.5cm), AGB (124kg and 95.8 kg), BGB (32.27 kg and 24.91 kg) and TB (156.37 kg and 120.71 kg). The rate of carbon stored in the ornamental plants within the study area differs among tree species and this could be associated with the different characteristics of the tree species such as leaf width, DBH and tree age. Antirrhinum majus has the highest rate of average carbon storage (78.18kg) and CO_2 *sequestered at the rate of 286.64kg, which is equivalent to 26.06kg annually per tree species and 1719.85kg for the 66 trees. The study concluded that, aside from the beautification function of the plant species in the study area, the volume of the ornamental plants can serve as carbon sink in the study area and are rich to help in the reduction of carbon (iv) oxide released by vehicles and other machines plighting around the study area. The strength of tree species to reduce the carbon content in and around the environment depends on its composition and dynamics. The study recommended that to offset carbon and related pollution associated with urban activities, trees with high carbon intake such as Masquerade tree should be planted along the streets and open space.*

Key Words: *Heterogeneous, Aesthetic plants, Biomass, Sequestration and Carbon sink*

Introduction

The environment and beautiful landscape as provided by nature has been extensively exploited by man for decades through over-exploitation of open spaces, geometric increase of automobiles and human population pressure due to rapid industrialization and random urbanization (Brown *et al*., 2003). Human influences on plants can further affect CO_2 source/sink dynamics of plants through such factors as fossil fuel emissions and utilization of biomass. A simple way to cushion the effect of this menace is the planting of trees and shrubs. Trees act as a sink for carbon dioxide (CO_2) by fixing carbon during photosynthesis and storing carbon as biomass, Trees in urban areas store carbon sequester as they grow and such is emitted back to the atmosphere after the tree's death (Areo, 2021a). The net long-term CO_2 source/sink dynamics of plants change through time as trees grow, die and decay (Zhenga, 2013).

The continuous increase in urban environmental pollution has made urban landscaping a very important approach to achieve dual effects i.e. bio-aesthetics and mitigation of pollution. This concept has enabled environmental horticulturists to have better means to solve the pollution problems related to urban landscape by creating a micro-climate (Ibironke *et al*., 2016).

More integrative studies have proven that urban trees, particularly low volatile organic compound emitting species, can be a viable strategy in reducing urban ozone levels (Nowak and Crane, 2002), particularly through the series of tree functions that reduce air temperature (transpiration), remove air pollutants (dry deposition to plant surfaces) (Akbari and Konopacki, 2005) and reduce building energy and power plant emissions (e.g. temperature reductions; tree shade).

However, a set of holistic therapies aimed at treating people as researched through surveys and randomised trials is so-called green care, or therapy. It is a systematic exposure of patients to plants and gardening. Several cases have revealed the progressive beneficial effects on mood and mental health of persons by simply observing nature, or even images of natural scenes. An aspect of environmental psychology explains how plants and trees from post-operative wards improved the mood of patients, and reduced analgesic use, surgical complications and length of stay. Similar beneficial results over time have been noted for patients undergoing dental treatment, and viewing natural scenes of vegetations together with natural sounds improved the experience of bronchoscopy (Prashant and Chaitra, 2017; Vogt *et al*., 2012).

In another randomised experiment, some post-operative patients were at a time exposed to eight different ornamental species of indoor plants, both pain and length of stay were once again reduced and patients' satisfaction with their hospital rooms was greatly improved. Sometimes, presenting pictures of ornamental flowers in the dictator game, usually an economic game that questions whether individuals are solely driven by self-interest, have shown to have changed the decisions made by the players. Several studies, including putting plants in a computer room have shown to have improved productivity and lowered blood pressure. Indoor gardening has been used to treat patients with mental health problems. The appearance of ornamental plants is beneficial especially their leaves which remove toxins, dust and microorganisms from the air (Harun *et al*., 2010; Areo and Magaji, 2017; Hassan *et al*., 2010).

Green space has been linked with increased longevity in some studies and that is why there seems to be correlation between green space and higher income, better housing, and healthier lifestyles (such as less smoking), which can be difficult to disentangle. Interestingly, the benefit of green space may not be simply related to physical activity but might rely more on improved social interaction. Gardens around prisons have a long history of improving the lives of the prisoners and offering training towards employment in the horticulture industry (David *et al*., 2013; Wise, 2015; Maas *et al*., 2006).

Bada *et al*. (2018), reported carbon sequestration of urban trees along selected roads in Abeokuta, Ogun State. The study evaluated the carbon-dioxide concentration reduction from vehicular emission due to the sequestration processes of roadsides trees.

In Nigeria, it has been reported that carbon dioxide use by trees during photosynthesis varies from species to species (Piraino *et al.,* 2002). Notably, several scholars like Ibironke *et al*. (2016) carried out research on air pollution tolerance index and carbon sequestration of selected trees and shrubs for urban development in Akure Ondo State, Southwest Nigeria. In their study, the plant species identified in the sample area were *Ficus* spp*, Tabebuia rosea, Polyalthia longifolia, Delonix regia and Raphia farinifera.* The assessment of the ascorbic acid, pH, and relative water content and total chlorophyll content of the leaves of the identified plant species was done to determine the APTI. The APTI of the plant ranged from 5.11 to 9.31 with *Tabebuia rosea* having the highest value which indicates its high tolerance of air pollutants from the assessment and *Raffia farinifera* with the lowest value and least tolerant.

Several studies have examined the beneficial roles of ornamental plants in terms of health improvement (psychology of patients), ornamental plants roles in biodiversity, climate change mitigation and environmental benefits. Unfortunately, efforts have not been intensified to identify and assess species of plants that serve as carbon sequestration as well as aesthetic value. It is against this backdrop that, this study intends to assess the ornamental plants species that serves sequestration and aesthetic roles in Maitama, Abuja Municipal Area Council, of the Federal Capital Territory of Nigeria.

The study objectives are to: identify and take inventory of the flora species that are considered to be ornamental in the study area, take measurements of their characteristics, estimate their biomass using nondestructive method, and calculate the carbon sequestration of the dominant tree species in the study area.

Study Area

Maitama lies between Longitudes 7.463892° and 7.524349° east of the Greenwich Meridian and Latitudes 9.175699° and 9.113010° North of the Equator. It occupies a land area of 44.325 Ha. Mataima and other parts of the FCT is predominantly underlain by high grade metamorphic and igneous rocks of pre-Cambrian age. These rocks consist of gneiss, migmatites and granites. In general, the rocks are highly sheared and can be divided into four major groups, as follows: Metamorphosed Supracrustal

(Exogenetic) Rocks: Rocks in this group includes Mica Schist (sh), Marble (m), Amphibolite and Amphibole Schist (a), Fine Medium Grained Gnesis. Migmatitic Complex: This includes Migmatite (mi), Migmatitic Gneiss (mg), Granite Gneiss (gg), Porphyroblastic Granite-Gneiss (pg), Leucocratic Granite Gneiss (lg). Intrusive GraniteCoarse Grained. Minor Intrusions: Rhyolites (ry), Quartz Feldspar Porphyry (py), Dacatitea and Anddesites (an), Dolerites and Basalts (b) Granite (FCT Secretariat, 2012).

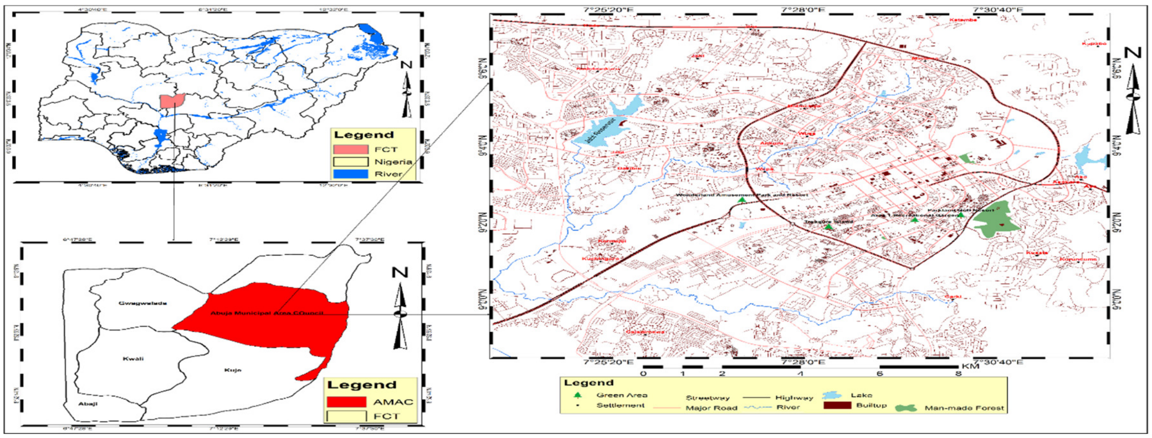

Fig. 1: Map of Federal Capital City

The soils of the study area are the tropical zonal type known as tropical ferruginous soils characterized by reddish to brownish colour due to the relative accumulation of iron. The high sand content particularly makes the soil to be highly erodible (Areo, 2023). The tree species found there include shrub savannah: *Terminalia macroptera*, *Terminalia laxiflora*, *Afromosis laxiflora*, *Anonas senegalesis*, and *Pilioostigma thonningii* (Areo, 2021). According to Ishaya *et al*. (2016), it contains African locust bean (*Parkia biglobosia*), *Albizia* sp. *Daniela oliveri*, *Butyrospermus paradoxum*, and *Danielia oliveri* are among the tree species identified. In this setting, the most common tree is the shea butter tree (*Butyrospermus paradoxium*) (Areo, 2023).

Materials and Methods

The data were purely quantitative (numerical) in nature. Suitable sites for species investigation and delineation of sample plots for the study were derived through quadrant. The plant diary and plant identifier software were also used to identify individual tree stands and their respective species. Data on the characteristics on flora species generated on the field included: tree trunk diameter, tree height, tree species, the healthiness of the tree, and estimated tree age. All these data play a significant role in investigating the ornamental plants species and their roles in carbon sequestration in Maitama.

Maitama district is the sample frame for this research. The area was purposively chosen for the study, due to its richness in ornamental plants. The study area was purposively selected. A total of eight urban tree species community structures were selected for tree inventory examination. The tree inventory was aimed at analyzing the characteristics of the current tree species, which include the tree trunk diameter, tree height, tree species, and estimated age. The geographical coordinates (latitude and longitude) and altitude of each site were recorded with a GPS. In all, eleven dominant urban tree species were selected and the physical characteristics of the tree stands (diameter at breast height, tree height and age) were assessed.

The quadrant sampling technique for assessing vegetation density was used. The term quadrant used in this study refers to a sample area of given shape and size used for analysis of plant communities. Four quadrants of twenty square metres ($20m^2$l) each were mapped out in four different streets in the study area. The study adopted instruments and software packages (Table 1).

Table 1: Adopted Instrument

S/No	Instrument	Model	Purpose
1	Global Positioning System	GPSmap 60Cx	To obtain sampling points
2	Cutlass	-	Clearing site and cutting thorns
3	Notepad/Pen	40 leaves/bic	For writing
4	Line	Plastic/ 100m	For delineating sampling points and preparing plot
5	Tape rule	Fibre 100ft	For measuring sampled plot
6	Wooden Peg	1ft	To delineate plot
7	Plant Diary	Photo book	To identify plants
8	Plant Identifier	Mobile Software	To identify plants
9	ArcGIS	ArcGIS 10.1	To produce study map
10	Clinometers	SUUNTO	To measure tree height
11	DBH tape		To measure diameter of trees
12	Leaf area index	LAI-2000	To measure leaf area index which the total surface of leaf for each tree

For quantitative analysis of the plants species, the following vegetation species measuring parameters were used; Simpton's Index (SI), Basal Area, Volume of individual plant, Species Relative Density (RD), Species Relative Dominance (RD*o*) and Species Evenness were used.

The Simpton's Index was used for the analysis of data from each quadrant selected for the study. In analyzing the results obtained, the logic of Simpson's Index is that, if a quadrant has a value that is above 1, that indicates an index of dominance of one plant species in such quadrant, hence the quadrant is less diversified because it is dominated by a particular tree species. Thus, a maximum value of 1 is obtained if all individuals in the community belong to the same species of equal important value.

The Simpton's Index is expressed as:

S.I. = $\Sigma\ ({}^{n}/N)^2$--------------------Equation 1

Where:

S.I. = Simpson's Index

Σ = Summation of values

n = Squared value of the number of each tree species in a quadrant

N = Sum total of all the number of plant species (n).

The basal area of all trees in this study area was calculated using

$$BA = \frac{\pi D2}{24} \text{ ---------------------- Equation 2}$$

Where; BA is basal area (m^2), D is diameter at breast height (cm), π is pie (3.142). The total BA for the study was obtained by adding all trees BA in the study area.

Volume of individual trees was estimated using tree volume equation developed Newton's formula as follows:

$$V = \frac{\pi h \;^2 + 4\,(Dm^2) + Dt^2}{24} \text{ ---- Equation 3}$$

Where: V is tree volume (m^3), Db, Dm, and Dt are diameters (m) at the base, middle, and top of each tree, and h is total tree height (m).

Species relative density, which is an index for assessing species relative distribution, was computed with

$$RD = \frac{n_i \times 100}{N} \text{ --------------- Equation 4}$$

Where: RD (%) is species relative density; ni is the number of individuals of species i; and N is the total number of all individual plants of all species in the entire quadrants.

Species Relative Dominance (RDo (%)), used in assessing relative space occupancy of a tree, was estimated using

$$RDo = \frac{(\sum Bai \times 100)}{Ba_n} \text{ --------- Equation 5}$$

Where: Bai is basal area of all trees belonging to a particular species i and Ba_n is basal area of all trees in the study area.

Species evenness in each city was determined using Shannon's equitability (EH), which was obtained using

$$E_H = \frac{H'}{H_{max}} = \frac{-\sum si{=}1\; Pi\ln(Pi)}{\ln(S)} \text{--Equation 6}$$

Diameter at breast height which is 1.3 m above basal level for the trees (cm), Db - Diameter at the base (cm), Dm - Diameter at middle (cm), Dt - Diameter at the top (cm), and the Height (m) will all be the parameters taken for volume estimation (m^3).

The measurement of diameter at breast height of the tree will be taken with the diameter tape, also measurement of diameter at the middle-dm and top-dt will be taken with and the measurement of the base will be done with the Girth tape for the entire trees. In measuring the total height, ranging pole and measuring tape will be used.

The height was determined by Davies (2011) formula:

$$Ht = D * Rt - Rb/100 \text{ ----- Equation 7}$$

Where:
Ht = Total Height
D = Distance
Rt = Reading at the top
Rb = Reading the base

The volume of tree was determined using the formula formulated by Hall *et al.* (2001).

The formula is given thus:

$$V = \pi * Ht * ((Db2 + 4(Dm2) + Dt2)/24$$

Where:
π = 3.142
Ht = Height of the tree
Db = Diameter at the base
Dm = Diameter at the middle
Dt = Diameter at the top

There are two major methods used in the carbon biomass estimation: the Destructive process and the Nondestructive process, but for the sake of this study the non-destructive method volumetric process (formula for a truncated cone and a cylinder) were used.

Data for this study were collected from measurements made on the identified tree species at the roadside (not more than 5m to the side of the road), and shrubs planted at the middle of the lanes (not less than 0.5 m in height) with a girth tape, and measuring tape.

The botanical name or common name of every living tree and shrubs encountered at the study sites were identified and recorded. Each plant was recorded individually in the field and possible efforts were made not to omit any eligible plant in a sample area. This is because any species omitted will indicate the absence of such species in the area.

The following formulas were adopted:

Tree Biomass Estimation

Above Ground Biomass (AGB) = 2.2014 (DBH) – 1.0615

Where: DBH = diameter at breast height

2.2014 and 1.0615 = Constant

Below Ground Biomass (BGB) = AGB x 0.26

Total Biomass (TB) = AGB + BGB

Estimating Tree Carbon Content

Following the assumption by (Mckinley *et al*. (2011) that, 50% of biomass of any plant species is considered as carbon, the weight of carbon in the tree was estimated by multiplying the biomass of the tree by 50%.

Carbon Storage = Biomass x 50%

CO_2 Sequestration = Carbon storage x 3.6663 (which is ratio of CO_2 to C)

Annual CO_2 sequestration = CO_2 Sequestration ÷ Tree Age

Results and Discussion

Table 2: Names of Tree Species in Maitama

S/N	English Name	Botanical Name
1	Masquerade tree	*Polyalthia longiflora*
2	Aconitum	*Ranunculus* sp.
3	African Daisy	*Gazania* sp.
4	Alstroemeria	Peruvian Lilly
5	Antirrhinum majus	Snapdragon
6	Blush Noisette	Old Noisette Rose
7	Aloha	Hybrid
8	Artificial palm tree	*Elaeis guineensis*

Table 2 shows the common English and botanical names of tree species found in Maitama during data collection 2021. As at the time of data collection in 2021, the plant species that were found in the study area are enumerated in table 2. The results obtained from this study show a similar pattern and that obtain by Addo-Fordjour *et al*. (2009) who studied the flourish composition, structure and natural regeneration in a moist deciduous forest in Ashanti Region, Ghana. Their finding concluded that there is a significant correlation between DBH and height of the forest and carbon sequestration.

Table 3 Biodiversity Indices and Growth Variables

S/N	Biodiversity Indices and Growth Parameters	Quadrants Plants
1	Number of individual plants	337
2	Number of species	8
3	Number of families	8
4	Mean Dbh (cm)	22.6
5	Basal area (m^2)	46.3
6	Maximum Dbh (cm)	82.8
7	Volume (m^3)	98.6
8	Diversity index	0.782
9	Species evenness (E_H)	0.512

In table 3, a cumulative total of three hundred and thirty-seven (337) numbers of individual plants, with eight (8) number of species and eight families were encountered within the four quadrants considered for the study. Based on the results of tree growth parameters, the plants in the study area were significantly larger and higher than each other, implying that the species in the study area were uneven. The mean Dbh (22.6 cm), Basal area (46.3 m^2), Volume (98.6 m^3) and Maximum Dbh (82.8 cm) are the measurements of plant species in the study area. This result also corroborated the finding of (Areo, 2021b; Muhammad and Aqeela, 2013; Makinde, Womiloju, & Ogundeko, 2017) who argued that the tree height varies significantly among fallow classes.

Table 4 Simpson's Index for Quadrant A at Maitama

S/N	Plant Species	No. of Species	$^n/N$	$(^n/N)^2$
1	Masquerade tree	25	0.2315	0.0536
2	Aconitum	20	0.1852	0.0343
3	African Daisy	24	0.2222	0.0494
4	Alstroemeria	21	0.1944	0.0378
5	Antirrhinum majus	18	0.1667	0.0278
		$\Sigma n = 108$		$\Sigma (^n/N)^2 = 0.1535$

SI = 0.1535

Table 4 shows the Simpson's Index for quadrant A at Maitama. The table shows that the dominant specie is masquerade tree with a value of 25, follow by African daisy which is 24, alstroemeria is 21, aconitum is 20, while antirrhinum majus is 18. In quadrant A there are five different species of plant totaling 108 with a Simpson's Index value of 0.1535. Based on the result in table 4, it can be concluded that the quadrant is heterogeneous with a low value of species composition. The findings in this present study are also consistent with the findings of (Chavan and Rasal, 2011; Chavan and Rasal, 2012; Areo, 2021b) who argued that tree height and Basal Cover classes influence carbon emission.

Table 5 Simpson's Index for Quadrant B at Maitama

S/N	Plant Species	No. of Species	$^n/N$	$(^n/N)^2$
1	Antirrhinum majus	22	0.2716	0.0738
2	Blush Noisette	26	0.3210	0.1030
3	Aloha	15	0.1852	0.0343
4	Antificial palm tree	18	0.2222	0.0494
		$\Sigma n = 81$		$\Sigma (^n/N)^2 = 0.2605$

SI = 0.2605

Table 5 shows the Simpson's Index for quadrant B at Maitama. The table shows that the dominant specie is Blush Noisette with a value of 26, follow by Antirrhinum majus which is 22, Artificial palm tree is 23, while Aloha is 18. In quadrant B there are four different species of plant totaling 81 with a Simpson's Index value of 0.2605. Based on the result in table 5, it can be concluded that the quadrant is heterogeneous with a high value of species composition.

Table 6 Simpson's Index for Quadrant C at Maitama

S/N	Plant Species	No. of Species	$^n/N$	$(^n/N)^2$
1	African Daisy	12	0.1333	0.0178
2	Alstroemeria	18	0.2000	0.0400
3	Antirrhinum majus	22	0.2444	0.0597
4	Blush Noisette	24	0.2667	0.0711
5	Aloha	14	0.1556	0.0242
		$\Sigma n = 90$		$\Sigma (^n/N)^2 = 0.1531$

SI = 0.1531

Table 6 shows the Simpson's Index for quadrant C at Maitama. The table shows that the dominant specie is Blush Noisette with a value of 24, follow by Antirrhinum majus which is 22, Alstroemeria is 18, Aloha is 14, while African daisy is 12. In quadrant C there are five different species of plant totaling 90 with a Simpson's Index value of 0.1531. Based on the result in table 6, it can be concluded that the quadrant is heterogeneous with a low value of species composition. This result conforms to the assertion of Sani *et al.* (2016) and Areo, (2021a) that ornamental trees play a vital role in our environment, they adorn our streets, parks and garden, making the landscape much more interesting.

Table 7 Simpson's Index for Quadrant D at Maitama

S/N	Plant Species	No. of Species	$^n/N$	$(^n/N)^2$
1	Masquerade tree	28	0.3011	0.0907
2	Aconitum	16	0.1720	0.0296
3	Alstroemeria	20	0.2151	0.0463
4	Antirrhinum majus	14	0.1505	0.0227
5	Blush Noisette	15	0.1613	0.0260
		$\Sigma n = 93$		$\Sigma (^n/N)^2 = 0.2153$

SI = 0.2153

Table 7 shows the Simpson's Index for quadrant D at Maitama. The table shows that the dominant specie is Masquerade tree with a value of 28, follow by Alstroemeria which is 20, Aconitum is 16, Blush Noisette is 15, while Antirrhinum majus is 14. In quadrant D there are five different species of plant totaling 93 with a Simpson's Index value of 0.2153. Based on the result in table 7, it can be concluded that the quadrant is heterogeneous with a low value of species composition. The biomass of the tree stands of the respective species identified in the study area are presented in Table 8.

Table 8: Biomass Estimation of Ornamental Trees in the Study Area

Plant Name	Frequency	Mean DBH Cm	Constant 1	Constant 2	Constant 3	AGB kg	BGB Kg	TB kg
Antirrhinum majus	66	47.3	2.2014	1.0615	0.26	124.1	32.27	156.37
Masquerade tree	53	32.8	2.2014	1.0615	0.26	82.2	21.37	103.57
Blush Noisette	50	30.1	2.2014	1.0615	0.26	60.3	15.68	75.98
Alstroemeria	49	26.2	2.2014	1.0615	0.26	53.7	13.96	67.66
African Daisy	36	16.3	2.2014	1.0615	0.26	35.9	9.33	45.23
Aconitum	36	43.5	2.2014	1.0615	0.26	95.8	24.91	120.71
Aloha	29	26.4	2.2014	1.0615	0.26	55.1	14.33	69.43
Antificial palm tree	18	19.4	2.2014	1.0615	0.26	45.7	11.88	57.58
Total						**552.8**	**143.73**	**696.53**

DBH= diameter at breast height; AGB = above ground biomass, BGB = below ground biomass; TB = total biomass

Based on the field estimation as shown in Table 4.7, the total AGB, BGB and TB of the tree stands in the study area are 552.8kg, 143.73kg and 696.53kg respectively. *Antirrhinum majus* and *Aconitum* have the highest mean DBH (47.3cm and 43.5cm), AGB (124kg and 95.8 kg), BGB (32.27 kg and 24.91 kg) and TB (156.37 kg and 120.71 kg). African Daisy and Artificial palm tree have the least DBH (16.3cm and 19.4cm), AGB (35.9 kg and 45.7 kg), BGB (9.33 kg and 11.88 kg) and TB (45.23 kg and 57.58 kg). The result indicates that the total biomass of tree species depends on the number of stands of that particular species in a given area. The result presented in Table 4.7 indicates that the biomass estimation of ornamental trees in the study area differs with respect to individual species. This can be attributed to the number of tree stands of the respective species as well as the DBH, which is the measure of tree composition. The strength of tree species to reduce the carbon content in and around the environment depends on its composition and dynamics. Therefore, when residents within the study area are encouraged to plant high carbon intake tree species with notable composition as *Antirrhinum majus* and *Aconitum* in the neighborhood, it will help in the reduction of carbons and shading to the neighborhoods as well as providing atmospheric ventilations. This result is in line with the observation of Jithila and Prasadan (2018) found similarly in Wayanad region of Western Ghats in India.

To estimate the carbon sequestered by the respective species of ornamental trees in the study area, the carbon storage capacity was determined as part of the variables for CO_2 estimation based on (Mckinley *et al.*, 2011). The result is presented in Table 9.

Table 9: Carbon Sequestration of Ornamental Trees in the Study Area

Plant Name	TB	Carbon Storage	Constant	Mean Total CO_2 Sequestered (kg)	Tree Age	Annual CO_2 Sequestered (kg)	Total Annual CO_2 Sequestered (kg)
Antirrhinum majus	156.366	78.183	3.6663	286.64233	11	26.06	1719.85
Masquerade tree	103.572	51.786	3.6663	189.86301	11	17.26	914.79
Blush Noisette	75.978	37.989	3.6663	139.27907	11	12.66	633.09
Alstroemeria	67.662	33.831	3.6663	124.0346	11	11.28	552.52
African Daisy	45.234	22.617	3.6663	82.920707	10	8.29	298.51
Aconitum	120.708	60.354	3.6663	221.27587	9	24.59	885.10
Aloha	69.426	34.713	3.6663	127.26827	9	14.14	410.09
Artificial palm tree	57.582	28.791	3.6663	105.55644	8	13.19	237.50
Total	**696.528**	**348.264**		**1276.8403**		**15.96**	**5378.69**

The age of the plants in the study area are not the same, some are 11 years, while African Daisy is 10 years old. *Aconitum and Aloha* were 9 years while Artificial palm tree was 8 years old. This indicates that the ornamental trees weren't planted within the same time period; as such, their differences in years of existence are not significant enough to alter the carbon intake of the tree species except for the individual tree carbon needs. Table 4.8 shows that *Antirrhinum majus* has the highest rate of average carbon storage (78.18kg) and CO_2 sequestered at the rate of 286.64kg, which is equivalent to 26.06kg annually per tree species and 1719.85kg for the 66 trees. This is followed by *Aconitum* with carbon storage of 60.35kg, and CO_2 sequestration rate of 221.28kg, which is equivalent to the annual CO_2 sequestration rate of 24.59kg per tree and 885.10kg for 36 trees. The least estimated carbon storage (22.62kg) and CO_2 sequestration (82.92kg) is associated with African Daisy tree, which have an equivalent of 8.29kg of annual CO_2 sequestration per tree and 298.51kg for the 36 trees per annum. The result shows that the rate of carbon stored in the ornamental plants within the study area differs among tree species and this could be associated with the different characteristics of the tree species such as leaf width, DBH and tree age. This component has become critical in evaluating carbon estimation of living trees (Jithila and Prasadan, 2018, Areo, 2021a).

Ornamental tree species in the study area (Maitama, Abuja Municipal Area Council) contributes to carbon sink by absorbing considerable amount of CO_2 from the atmosphere. The total ornamental tree species in the area amounts to 348.26kg living biomass. The trees have the potential to absorb carbon at the rate of 1276.84kg, thereby sequestering approximately 5378.69kg of CO_2 annually in the environment (Table 4.8). The study reveals that, aside from the beautification function of the plant species in the study area, the volume of the ornamental plants can serve as carbon sink in the study area and are rich in helping in the reduction of carbon (iv) oxide released by vehicles and other machines plighting around the study area. This implied that urban green space would contribute to achieving the demand of Kyoto Protocol in reducing excess carbon from the environment.

Conclusion and Recommendations

This study assessed the potency of ornamental plants species that serves the roles of carbon sequestration and beautification in Maitama, FCT, Abuja. The study used measurements and Simpson's Index (SI) to obtain and analyze data. It also quantifies the rate of carbon storage and CO_2 sequestration associated with ornamental plants. Biomass and carbon storage of the identified tree species was estimated following the procedures of Udayakumar, *et al.* (2016) and Kiran and Kinnary (2011). The major findings of the study are:

A total of 337 individual plants were considered for this study; they all are part of 8 families and species.

Dominant species in Simpson's Index for quadrant A at Maitama is masquerade tree with a value of 25. And the quadrant is heterogeneous with a low value of species composition.

Dominant specie quadrant B is Blush Noisette with a value of 26, Simpson's Index value of 0.2605. The quadrant is heterogeneous with a high value of species composition.

From the Simpson's Index for quadrant C, the dominant species is Blush Noisette with a value of 24. The quadrant is heterogeneous with a low value of species composition.

The dominant species in quadrant D is masquerade tree with a value of 28, five different species of plant totaling 93 with a Simpson's Index value of 0.2153 was recorded. The quadrant is heterogeneous with a low value of species composition.

For the Biomass estimation for the samples, *Antirrhinum majus* and *Aconitum* have the highest mean DBH (47.3cm and 43.5cm), AGB (124kg and 95.8 kg), BGB (32.27 kg and 24.91 kg) and TB (156.37 kg and 120.71 kg). African Daisy and Artificial palm tree have the least DBH (16.3cm and 19.4cm), AGB (35.9 kg and 45.7 kg), BGB (9.33 kg and 11.88 kg) and TB (45.23 kg and 57.58 kg).

For carbon sequestration estimate, the rate of carbon stored in the ornamental plants within the study area differs among tree species and this could be associated with the different characteristics of the tree species such as leaf width, DBH and tree age. *Antirrhinum majus* has the highest rate of average carbon storage (78.18kg) and CO_2 sequestered at the rate of 286.64kg, which is equivalent to 26.06kg annually per tree species and 1719.85kg for the 66 trees.

The total ornamental tree species in the area amounts to 348.26kg living biomass. The trees have the potential to absorb carbon at the rate of 1276.84kg, thereby sequestering approximately 5378.69kg of CO_2 annually in the environment.

Based on the findings the study recommends that;

1. Urban green space should be protected at all cost within the Abuja city centers and its environs to serve as environmental beautification and relaxation centers.
2. To offset carbon and related pollution associated with urban activities, trees with high carbon intake such as *Antirrhinum majus* and *Aconitum* should be planted in urban green space.
3. Residents within the FCT should also be encouraged to plant high carbon intake tree species in the neighborhood. This will not only offset the carbon but serve as aesthetics and shading to the

neighborhoods as well as providing atmospheric ventilation.

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