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AN ASSESSMENT OF TREE SPECIES DIVERSITY AND THEIR POTENTIAL FOR CARBON SEQUESTRATION IN BORGU SECTOR OF KAINJI LAKE NATIONAL PARK

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ABSTRACT

Global warming is becoming a huge problem for the society due to carbon emission in the wake of modernization and urbanization. Forests biodiversity, soils, oceans and atmosphere are agents for storage of carbon. Rapid urban development around Borgu Park area has created large human concentration around the park with high demand for natural resources. Increased reliance on floral diversity services for human sustainability constitutes a growing threat to the physical integrity, richness, biodiversity productivity of woodland in the park. The study aimed at identifying the different trees within the park with the objective of identifying the sequestration capacity of the species identified. The point centered quarter (PCQ) method was adopted to determine the Important Value Index (IVI) of various species. The carbon sequestration computation involved: Determining the total (green) weight of the tree, the dry weight of tree; the weight of carbon in the tree; weight of carbon dioxide sequestered in the tree; and the weight of CO_2 sequestered in the tree per year. Sixteen (16) species were identified using the PCQ method with variation in their girth. The important value index gives the value for the most dominant species found in the study area. The most important tree species in the study area were found to be; Terminalia glauscens, Vitalaria paradoxa, with an IVI values of 28.16, 21.13, respectively. While the least important tree species with IVI values of 1.76, 1.77, were found to be Acacial seyal, crossopteryx ferbrifuga respectively. The sequestration performance for the different species identified were calculated and found to be for a tree of 10 to 15 years with an average DBH of 11cm would sequester between 26 to 29kg of carbon per year for the most important species and between 18kg and 25kg of carbon per year. Tree species identified in the study area has the ability to sequester certain amount of carbon dioxide which is one of the green house gasses that causes climate change. Efforts should be geared towards conserving the degraded areas with carbon sequestration activities been part of planning because this can be integrated as a management option and carbon credit project.

Key words; Flora, Carbondioxide, Sequestration, Diversity, park

INTRODUCTION

Urban development and transportation activities have increased the concentration of air pollutants as greenhouse gases, especially Carbon dioxide (CO_2) in the atmosphere. These have led to increase in temperature through the trapping of certain wavelengths of heat radiation in the atmosphere. The increasing carbon emission is of major concerns; it has been well addressed in Kyoto protocol (Ravindranath *et. al*., 1997). Tree and shrub have been known to play a crucial role in absorbing atmospheric carbon dioxide. The trees act as a major CO_2 sink which captures carbon from the atmosphere in a process known as sequestration and store the same in the form of fixed biomass during the growth process. Therefore trees in any area have the potential to contribute in reducing the concentration of CO_2 in atmosphere. As trees grow and their biomass increases, they absorb carbon from the atmosphere and store it the plant tissues (Mathews et. al., 2000) resulting in growth of different parts. Although it is known that both terrestrial and marine ecosystems constitute a significant carbon store, the exact figures are uncertain. Global estimates range from approximately 1500-2500 GtC (Cao and Woodward 1998; IPCC 2001). A recent study combining data for carbon stored in biomass (Ruesch and Gibbs,2008) with that of carbon stored in soil has estimated that over 2,000 GtC is stored in terrestrial ecosystems (Campbell *et al.* 2008). A large amount of terrestrial carbon pool is stored in forest ecosystems but there are also significant stores in other ecosystems such as grasslands and wetlands. Carbon stored in soil accounts for a high percentage of the total terrestrial store (Eliasch, 2008).

It has been estimated that terrestrial ecosystems sequester 2.1-3 GtC of atmospheric carbon annually (Canadell and Raupach, 2008), approximately 30 per cent of all anthropogenic CO_2 emissions. Much of this is realized by forest (Luyssaert *et al.*,2008); although over the past 10,000 years peat lands have sequestered an estimated 1.2 trillion tonnes of CO_2. The Luyssaert *et al.*,(2008) estimate for forest ecosystems is based on a global database of flux observations, updated since the Intergovernmental Panel on Climate Change Assessment Report 4(IPCCAR4). Marine ecosystems sequester large amounts of carbon through phytoplankton at the ocean surface, a process that accounts for approximately 50 per cent of the global biological uptake of CO2 (Arrigo 2007).

Rapid urban development around Borgu Park area has created large human concentration around the park with high demand for natural resources. Increased reliance on floral diversity services for energy, food, and other product for human sustainability constitute a growing threat to the physical integrity, richness, biodiversity productivity of forestland in the park. Kainji Lake National Park (KLNP), despite its legal status, designation as protected area does not in itself guarantee protection of the ecosystem they contain. According to Clark *et al*. (2008), whilst protected areas generally reduce deforestation relative to unprotected areas, they do not entirely eliminate land use change within them. Currently the parks ecosystem, instead of maintaining and enhancing nature's carbon capture and storage, is getting depleted at an alarming rate. Global warming is becoming a huge problem for the society due to carbon emission in the wake of modernization and urbanization. Forests biodiversity, soils, oceans and atmosphere are agents for storage of carbon. They act as source or sink depending on the land use activities at different times. Carbon dioxide (CO_2) is the principal greenhouse gas contributing to climate change. One way to promote storage of CO_2 is by maintaining or enhancing natural processes such as the planting of tree or in general term afforestation, reforestation and forest management (which involve the management of existing forest to maximize growth).

The paper aims at identifying the different flora with the view of estimating the sequestration of the species identified.

MATERIALS AND METHODS

The study area

Kainji Lake is Nigeria's first experiment at establishing and managing a National park. The Park has a total area of 5340.82 km^2 out of which Borgu sector alone accounts for 3,970km^2 which is about 74.3% of the total land area. The park is located between latitudes 9°40'N to 10°30'N and longitudes 4°30'E to 5°50'E. It enjoys the savanna climate with distinct wet and dry seasons. The mean temperature during the wet season is about 30°C and drops to about 28° C during the dry season as a result of the north east harmatan winds. Rainfall is a major climatic element in the park being responsible for vegetal growth and the hydrology of the rivers. The mean annuals rainfall is about 1200mm (Ecological Survey of KLNP 2004).

Borgu sector is well drained by River Oli and Eri. River Oli, the main river of the Borgu sector takes its source from outside Nigeria and drains the western two-third of the park. While river Eri drains the remaining northern one –third of the sector. The topography consists of hills, extensive plains and river valleys. On the whole, the entire area is gently undulating with quartzite ridge in few places. Elevation in most parts of the park ranges between 250m and 300m above sea level. The highest point in the park is at the northwestern corner with an elevation of 350m, while the lowest elevation is along the River Niger where the maximum water mark is about 140m above sea level.

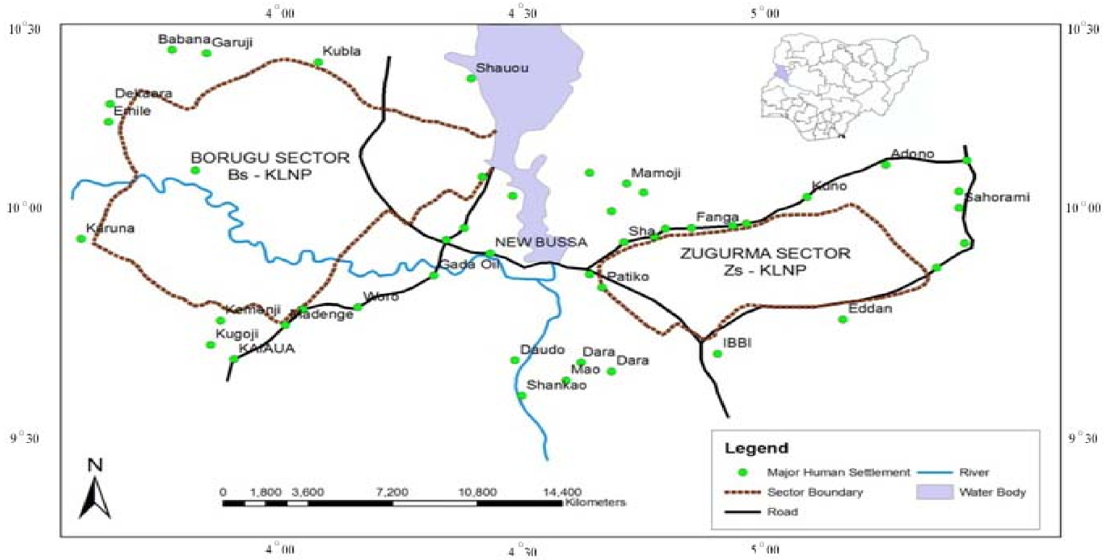

Figure 1: KLNP- two non contiguous sectors with surrounding Communities.

Data and Methods

Specie Data Collection (Point Centered Quarter Method)

The point centered quarter (PCQ) method is distance methods used to sample plant communities. The adoption of PCQ method was to determine the Important Value Index (IVI) of various species in a community. According to (Bonham, 1989; Elzinga *et al.*, 2001), the three factors used to determine the importance value of a species are density per hactare, size (basal area/ha) and frequency (distribution). After a random point has been located the area around each point was split into four quadrants of 90˚. At each sampled point, four quadrant were identified using the transect line as one line and imposing an imaginary line perpendicular to the transect line to establish four quadrants. The quadrants were then numbered from one to four with quadrant one being the first quadrant in a clockwise direction from the North. The nearest tree species were then identified and the distance from the point to the tree identified was recorded. For each tree selected, the Diameter at Breast Height (DBH) (greater than or equal to 10 cm) was recorded.

Point Centered Data Analysis

Data collected were analyzed to obtain information on the composition of each sampled quadrants. The Point Centered Quarter Method (PCQM) data was obtained by calculating

a. The mean point to plant distance for the entire sample, regardless of the type of species, and the value recorded. For each species, density and relative density were calculated,
b. The Basal area, relative basal area, and mean basal area (BA) for each species was calculated as well as frequency, and relative frequency
c. Important value (IV) and relative important value index (RIV) were also calculated.
d. Importance value (IV) (sum of relative density, relative basal area and relative frequency) and (RIV) were calculated using the equations 1 and 2;

$$IV = RELDEN + RELFREQ + RELBA \qquad (1)$$

$$RIV = \frac{IV}{3} \qquad (2)$$

These were done to get the most abundant species and the least abundant species as well.

Tree carbon Sequestered Analysis (Methodology for Calculating Amount of Carbon Sequestered in a Tree)

The rate of carbon sequestration or the amount of carbon stored in trees depends on the growth characteristics of the tree species, the condition for growth, where the tree is planted or growing, and the density of the tree wood as well as the age of the tree. For the purpose of this research, formula (3.3a) was used to obtain an average estimate over the life span of a sampled tree species. This was based on a combined generalization that 35% of the green weight of a tree is water after drying (Ximenes *et al.*, 2008) compared with an average tree which is 72.5% dry matter and 27.5% moisture (Scott *et al.*,2005). 50 % of the dry weight of a tree is carbon and since 20% of the tree biomass is below ground level in root, a multiplying factor of 120% was used to determine the equivalent amount of carbon dioxide by multiplying with a factor of 3.67. An estimate of the amount of CO_2 sequestered in a given tree was calculated, and divided by the tree's age, to get a yearly sequestration rate.

The process involved: Determining the total (green) weight of the tree; the dry weight of the tree; weight of carbon in the tree; weight of carbon dioxide sequestered in the tree; and the weight of CO_2 sequestered in the tree per year;

The general algorithm used was adopted from Ximenes *et al.* (2008); as shown in equations 3a and 3b.

For trees with D< 11: $W = 0.25D^2H$ (3a)

For trees with D >= 11: $W = 0.15D^2H$ (3b)

Where; W = Weight of tree, D = Diameter, H = Height

Depending on the species, the coefficient 0.25 could change, and the variables D^2 and H could be raised to exponents just above or below 1. However these two equations were used because they are seen as an "average" of all the species' equation. The height of the tree was determined by getting the angle of elevation to the top of the tree from the ground and measuring the distance of the researcher to the tree and the height of the eye above the ground. The following equation was the used to get the height of the tree. (Tan angle of elevation X distance to the tree) + Height of the eye above the ground.

Dry Weight Determination

A D-tape was used for measuring the diameter at breast height (DBH) and clinometers an instrument for measuring total tree height was used to measure the height. Including height in the measurement increases the accuracy of the estimated weight, the total weight was then calculated using a tree factor of 4 to 6 depending on the species. Based on Scott *et al.* (2005), an average tree is 72.5% dry matter and 27.5% moisture. In determining the dry weight of tree species, the weight of the tree was multiplied by 72.5%.

Carbon Weight Determination

The average carbon content is generally 50% of the tree's total volume according to (Robinson and Kile, 2007). Therefore the weight of carbon in the tree was determined, by multiplying the dry weight of the tree by 50%.

Weight of Sequestered Carbon Determination

Carbon dioxide (CO_2) is known to be composed of one molecule of carbon and two molecules of oxygen, given that;

a. The atomic weight of carbon is 12.001115.
b. The atomic weight of oxygen is 15.9994.
c. The weight of CO_2 is given by C+2*O=43.999915
d. Therefore, the ratio of CO_2 to C is 43.99915/12.001115 = 3.6663

The weight of carbon dioxide sequestered in any tree species sampled, was determined by multiplying the weight of carbon in the tree by 3.6663.The weight of carbon dioxide sequestered in a tree per year was then calculated by dividing the weight of carbon dioxide sequestered in the tree by the age of the tree as determined in the field. The age of the tree was determined measuring the diameter of the tree and multiplied by a growth factor of between 4 and 6 depending on the type of species. The amount of carbon dioxide sequestered per hectare of land was estimated by multiplying the value of yearly average sequestration rate per species by the total number of tree species on specified land area.

RESULTS AND DISCUSSION

Identified tree species and their Diameters at Breast Height (DBH) class intervals

Table 1 shows the sixteen (16) standing trees identified with variation in their girth. From the measurement taken in the field, the tree species have a DBH greater than 10 cm, but most of the tree species DBH falls between 21 and 50 cm e.g *Acacia laeta, Detarium microcarpum* and *Isoberlinia doka*. Few has DBH of between 51 and 100 e.g is *Vitalaria paradoxa* and about 8 standing tree species with DBH between 11 and 20 this includes *Terminalia glaucescens,*and *Acacia seyal.* The girth of the tree species were used in the calculation of carbon sequestration.

Table 1 Diameter at Breast Height (DBH) class intervals

	DBH CLASS INTERVAL					
Species Name	**1-10**	**11-20**	**21-50**	**51-100**	**TOTAL**	**Average height (feet)**
Acacia laeta			4		4	14
Acacia seyal		1			1	12
Afzelia africana			5	1	6	20
Anogeissus leiocarpus			4		4	17
Boswellia spp		1	3		4	21
Combretum molle			4		4	21
Crossopteryx ferbrifuga			1		1	15
Detarium microcarpum		1	9	1	11	23
Ficus capensis			1		1	15
Gardenia aqualla			1		1	16
Isoberlinia doka		1	6		7	23
Maytenus senegalensis		1	5		6	21
Prosopis africana			1		1	20
Strychnos spinosa			1		1	16
Terminalia glaucescens		3	13		16	22
Vitalaria paradoxa			11	1	12	21
TOTAL		**8**	**69**	**3**	**80**	

The table 1 shows species having the least average height with *Acacia seyal* to be 12ft while the highest average height recorded was 23ft for *Detarium mocrocarpon and Isoberlinia doka* and these species are the most abundant tree species found within the study area.

Important value index (IVI) for species identified in PCQ

The result for the PCQM data used for the computation of the important value index is presented in figure 2.

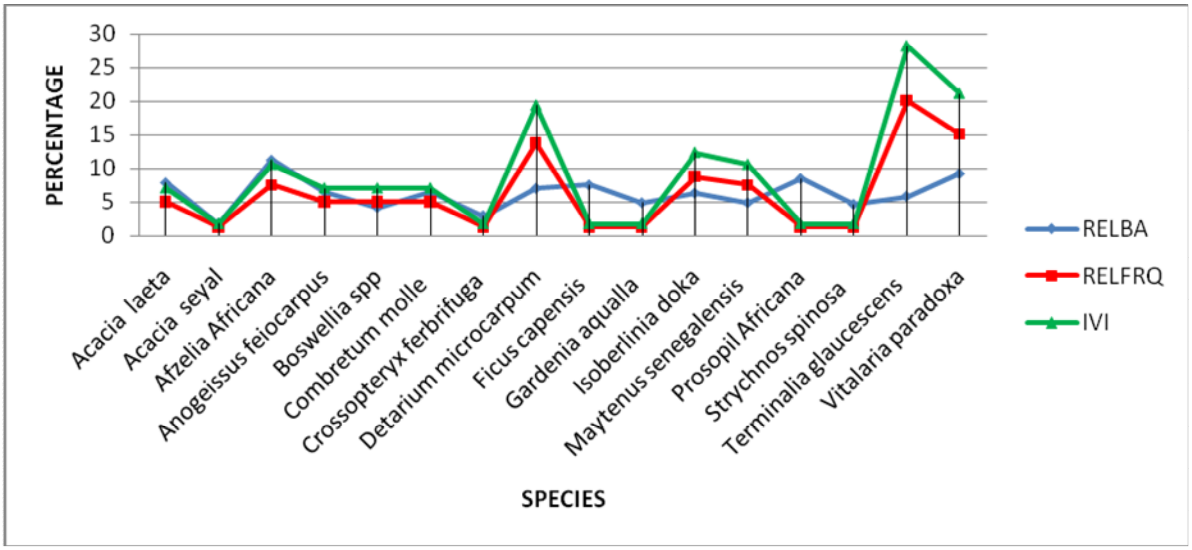

Figure 2; Importance value index (IVI) for all species identified in PCQ

The important value index gives the value for the most dominant species found in the study area. The six most important tree species in the study area were found to be; *Terminalia glauscens*, *Vitalaria paradoxa*, *Detarium microcarpum*, *Isoberlinia doka*, *Afzelia africana* and *Mayternu senegalensis* with an IVI values of 28.16, 21.13, 19.37, 12.33, 1058 and 10.57 respectively. This also shows the most dominant species as arranged in descending order. The six least important tree species with the least IVI values of 1.76, 1.77, 1.77, 1.78.and 1.79 in the study area were found to be; *Acacial seyal*, *crossopteryx ferbrifuga*, *ficuss capensis*, *Prosopis africana*, *Strichnos spinosa*, and *Gardenia aqualla* respectively. These also represent the least dominant specie within the park as presented in figure 2.

Carbon Sequestration Amount per Species

The results obtained for estimating the amount of carbon sequestered by the different flora presented in figure 3 based on their Diameter at Breast Height (DBH).

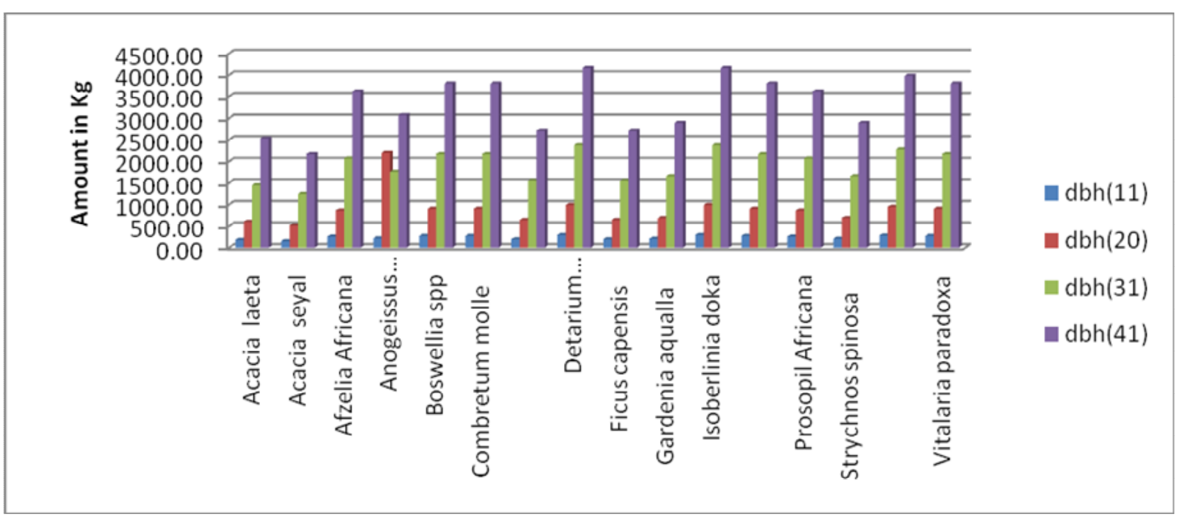

Figure 3: Carbon dioxide sequestration amounts per species

It was observed that the amount of carbon dioxide sequestered increases with increase in the girth with those having a diameter at breast height of 41cm having the highest amount of sequestration and those with 11cm of DBH having the least as presented in the figure 3.

This corroborate with findings by Dicson (2009) that as the tree utilizes the carbon dioxide captured from the atmosphere to produce its food, the carbon is stored within the tree trunk, stem, roots and soil while the Oxygen is released to the surrounding, as the amount of carbon stored increases the diameter of the tree also increases.

Sequestration performance by the most and least predominant Species

The sequestration performance of the most important species according to the important value index obtained is presented in figures 4 and 5. It shows *Isoberlinia doka* and *Detarium microcarpum* having the highest annual sequestration rate of 29.96kg each and *Afzelia africana* having the least sequestration rate of 26.05kg yearly. While figure 5 summarizes the annual Sequestration rate for the six least predominant species in the Borgu Sector of the Park, with *Prosops africana* having the highest annual sequestration rate of 26.05kg , *Strychnos spinosa* and *Gerdenia aqualla* having a sequestration rate of 20.84 each and *Acacia laeta* having the least sequestration rate of 18.24kg.

Variation in the girth and sequestration rate

The figure 6 presents a summary of the variation in the diameter at breast height (girth) and the rate of sequestration. Figure 6 presents the variation for tree species with diameter at breast height of eleven (11) and twenty (20). The figure shows that the rate of carbon dioxide sequestered increases with increase in the girth or DBH. Meaning that as the age of the tree species increases the DBH also increases. This conforms with findings by Dicsons (2009), as the tree is growing the DBH also increase in size.

Rate of annual Sequestration

The sequestration rate for each of the species per year obtained by dividing sequestration rate by the age of the tree and this is presented In Figure 7.

This also indicates that the sequestration rate for each species increases with the increase in the girth. The result obtained when compared with Dexter (2010) that the average tropical tree will sequester 22.6 kg or 50 lbs of carbon per year follows a pattern of the result obtained in figure 4 and figure 5. But stressed that the sequestration rate could be affected by location, soil type, rainfall and species. It implies that for a hectare of land with an estimated 600 trees of *Acacia* and *Crossopteryx ferbrifuga* which are among the least predominant species having a dbh of 11, they would be able to sequester an estimated amount of 10,944kg and 11,724 of Carbon dioxide from the atmosphere respectively while *Afzalia* and *Detarium* of the same dbh and number of trees per hectare should sequester 15,630kg and 17,976kg respectively.

According to a publication by United State Environmental Protection Agency (USEPA) on Carbon Sequestration in Agriculture and Forestry; mature forests will not sequester additional carbon after the trees have fully grown which implies that the mature trees will need to be sustained to maintain the level of accumulated carbon. Magnani *et al.*, (2007) on the other hand was of the view that the traditional assumption that carbon neutrality increases with age is incorrect, but suggested that mature forest protection may be a favoured policy choice for carbon sequestration strategies. While Skog and Nicholson (2000) argued that when wood from trees are used for construction, it gives carbon storage life for 100 years in homes, around 30 years in furniture, 30 years in rail road and 6 years in pallets and paper. In view of the above, carbon stored in trees can only be released into the atmosphere when the wood is burnt either for fuel, charcoal production or when it decays in soil. This implies that once the trees are fully matured, they would have to be protected from either been cut down, burnt or decayed so as to protect the stored carbon from being released into the atmosphere while at the same time a different land should be initiated for the purpose of nurturing younger trees to sequester more Carbon dioxide.

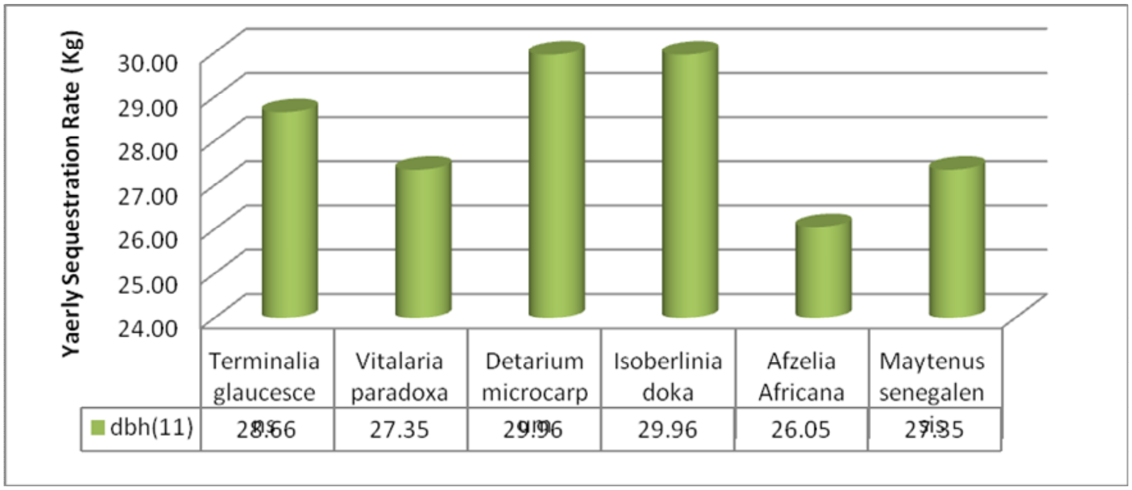

Figure 4; Yearly Sequestration Rate by the six most important Species

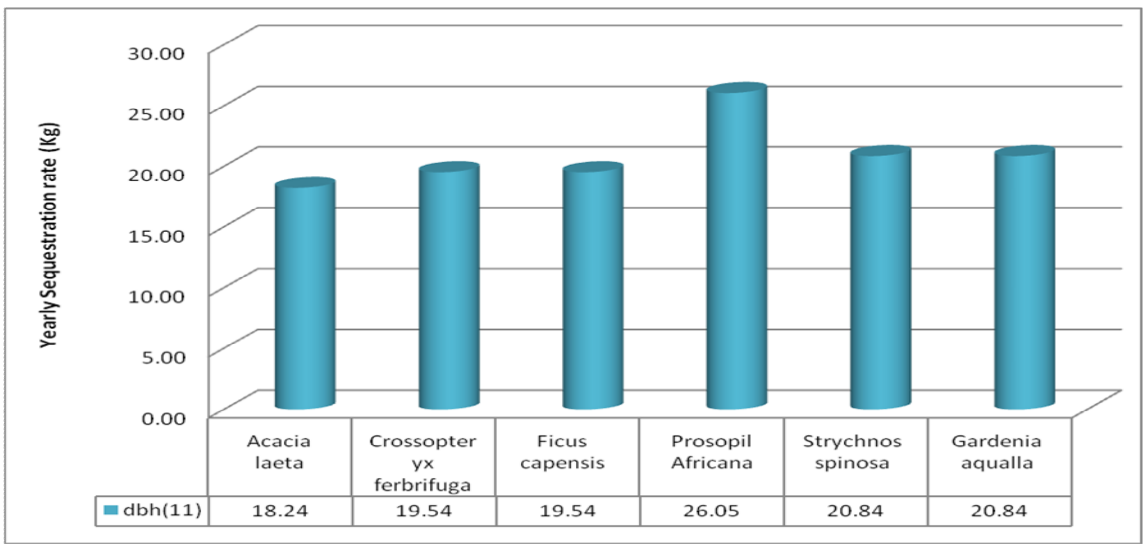

Figure 5; Yearly Sequestration Rate by the six least important Species

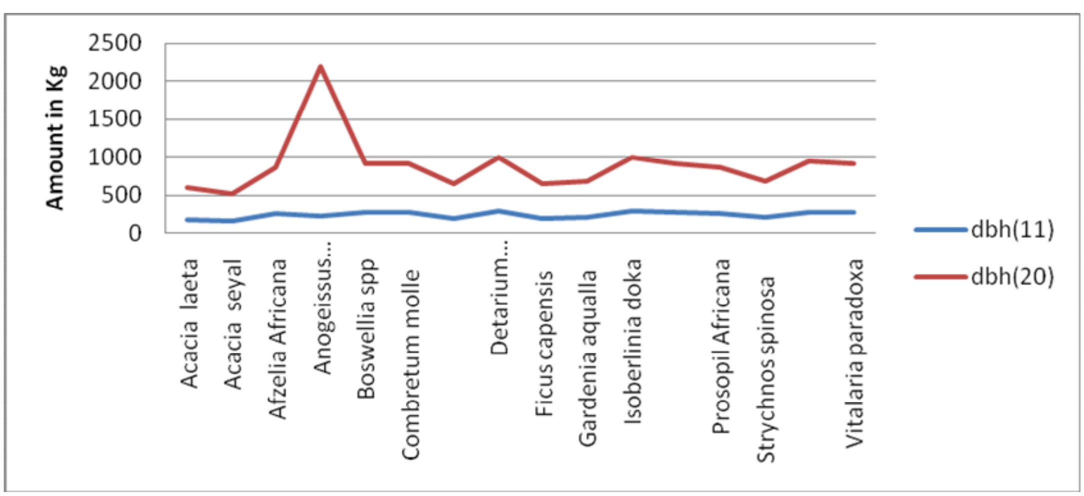

Figure 6: Variation in the girth and sequestration rate

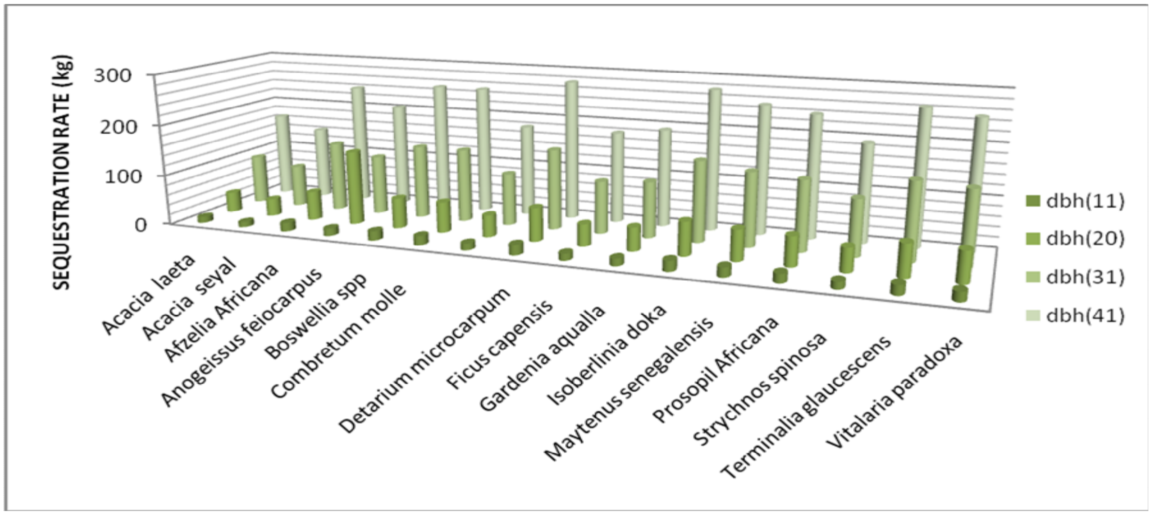

Figure 7: Rate of annual Sequestration

CONCLUSION

Having emphasized the role of vegetation/forest in sequestering carbon, it goes without saying that Nigeria must protect her National Park's floral diversity, through a well co-ordinate management strategy that will prevents loss of any species especially through activities such as deforestation, bush burning and resource harvesting etc. Since Land degradation is associated with floral diversity loss and this contributes to global climate change through the loss of carbon sequestration capacity and an increase in the land surface albedo, excessive exploitation or degradation of the diversity of flora would definitely lead to loss in the different available flora and a reduction in the amount of carbon dioxide been sequestered.

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