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Taxonomic Analysis and Landscape Status of Some Selected Tree Species for Climate Change Mitigation

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ABSTRACT

The study investigated the taxonomic analysis and landscape status of some selected tree species at University of Ilorin botanical garden and environs by examining the relationship between taxonomic characters among thirty (30) tree species and determining their landscape status for climate change mitigation. The study area was divided into several plots using transect lines of 10m X 10m for tree species. Samples were collected from each plot for taxonomic analysis and landscape status was determined by using cluster and frequency analyses. The study revealed that; 30 tree species which belong to 18 families were represented in the study areas, landscape status showed species clusters and outliers in the Dendrogram, also species abundant (11) and rare (19) of 36.67% and 63.33% respectively. Tree species that consistently form clusters in dendrogram irrespective of the method used were identified as: *Plumera alba* (24), *Prosopis africana* (27); *Eucalyptus cinerea* (14), *Adansonia digitata* (2); *Blighia sapida* (7), *Bridelia ferruginea* (8); *Burkea africana* (9), *Citrus sinensis* (11); *Azadirachta indica* (6), *Parkia biglobosa* (23), *Gmelina arborea* (18), and *Lonchocarpus cyanenscens* (20). These patterns of relationships could be taken into consideration in selection of tree species as a good candidate for reduction in the carbon emission (outliers) or carbon storage (clusters). The study concluded that 11 families include; Apocynaceae, Bombacaceae, Meliaceae, Sapindaceae, Mimosaceae, Myrtaceae, Euphorbiaceae, Caesalpiniaceae, Rutaceae, Verbenaceae and Fabaceae out of 18 families were better candidates for climate change mitigation based on clusters formation for effective carbon sequestration practices.

Keywords: Dendrogram, landscape status, taxonomic characters, tree species

INTRODUCTION

It is now widely accepted that human activities are contributing to global climate change due to increased levels of greenhouse gases in the atmosphere (Thom *et al*., 2010). United Nations Framework Convention on Climate Change defines climate change as a change of climate that is attributed directly or indirectly to human activities that alter the composition of the global atmosphere in addition to natural climate variability observed over comparable time periods. Climate change mitigation is any attempt to reduce the rate at which greenhouse gases are accumulated in the atmosphere which could be through the reduction of carbon emissions, temperature and carbon sequestration.

According to Kuhns (2008), tree species can help to reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year, as part of the carbon cycle. The amount of carbon annually sequestered increases with the size and health of the trees. Over the lifetime of tree, several tons of atmospheric carbon-dioxide can be absorbed (McPherson and Sundquist, 2009).

The most significant factor affecting climate is solar radiation (Ammann *et al.*, 2007). Seasonal changes in radiation are due to the angle of the incidence of sunlight, and daily variances are due to absorption and scattering of the radiation by the atmosphere and reflection by clouds. The radiation that strikes the earth's surface is largely accountable for temperature of the ground and the air above it. The nature of the soil surface will greatly determine how much of the emission is absorbed and how much is reflected. This in turn determines the soil-surface temperature. The more radiation a surface absorbs the more it heats the surrounding air.

Climate change is a topical issue of global concern and interest. It is a human-induced change in the climate of the world, due to global warming or greenhouse effect, whereby increase of greenhouse gases in the atmosphere causes the temperature of the earth to rise. These gases allow light energy from the sun to enter the earth, but avert or prevent the heat energy arising from sun's rays to escape into the outer space. The heat trapped, builds up to cause the earth's temperature to rise (Ammann *et al.*, 2007). Over the past 100years, the earth has warmed by 0.74^{o}C, and about 0.4^{o}C of this warming has occurred within the last 40years. The United Nation Commissioned a global body of scientists called Intergovernmental Panel on Climate Change (IPCC) to examine the issue of climate change (Frederick and Rosenberg, 1994). The body confirmed in 1995 that human-induced global warming had begun. The global community now understood that the world is facing an unprecedented climate crisis caused by human activity.

Greenhouse effects caused mainly by CO_2, ozone depletion mainly by CFCs and acid rain by SO_2 and NO_2 are threating the very existence of mankind. Even in non-urban areas, man's activities have led to climate change. Change of forests to pasture has often been followed by over-grazing, with increased soil erosion by water and wind being the end result. Likewise, change of grasslands to agricultural crop production has led to erosion as well (Satpathy and Usha, 2008). Urban microclimates are described by significantly higher temperatures, higher wind speeds and lower net rainfall inputs than rural and natural landscapes (Satpathy and Usha, 2008). The most important environmental benefit and landscape status of trees species in particular, is probably their ameliorating effect on urban climate and microclimate (McPherson, 1994). Similarly, according to O'Brien (1993), trees improve cities climatically; indeed this is probably the greatest benefit of tree planting in a developed area. The objective of this study was to examine the relationship between taxonomic characters among thirty (30) tree species and determine their landscape status for climate change mitigation.

MATERIALS AND METHODS

Study area and collection of plant specimens

The study was conducted at the botanical gardens of University of Ilorin and environs, located in Sudano-Guinea Savanna Region of Nigeria between the periods of 2012 and 2018. The area is characterized by various floras with flat land terrain, and it is located between latitude 8.486776^{0}N and longitude 4.675104^{0}E. The presence of derived savanna has been observed which is manmade, through the effects of grazing, farming and fire burning, which occurred at different time of the season. The leaf specimens were identified at the Herbarium for confirmation of their identity. Voucher specimens of all plants were deposited at the Herbarium of the Department Plant Biology, University of Ilorin, Nigeria.

Determination of frequency distribution of tree species

The frequency distribution of tree species was determined using the method described by Brower *et al*. (1998) and Shukla and Chandel (2008). Thirty (30) different transect lines of 10m by 10m were established for the garden, the occurrence of the selected tree species in each transect line was recorded numerically in ascending order. The frequency of each species was determined with this formula:

$$Frequency = \frac{Number\ of\ occurrence\ of\ each\ species}{\text{Total number of all occurrences}} \times 100$$

Landscape Status

Tree species was classified as abundant or rare based on its frequency count in all the assessed quadrat generated by 10m X 10m line transects laid out at the University of Ilorin botanical garden and environs. A tree species found in 40% and above of all the assessed laid out was considered abundant while a species present in less than 40% of all the assessed quadrants was regarded rare following the procedure of Olajide *et al*. (2006)

Taxonomic Studies of the Foliage Features

Codes (1, 2, 3, 4, 5, and 6) were assigned to the character states (qualitative and quantitative) in accordance to the observation, measurement and range of variation of these characters among the operational taxonomic unit (Tables 1 and 2). The formula of Hill (1980) was used to determine the character states for the quantitative features only.

K = 1.0+3.332 log n

Where K = Number of States

n = Number of species (OTU'S)

The formula helps in the determination of number of states, which could be in range of two or three states called character values which is the transformation of quantitative characters to qualitative characters for the generation of the dendrogram by cluster analysis. The converted numerical code is represented as 1- represent short, small or low value, 2- represent medium value and 3- represent large, long, tall, narrow or high value.

Cluster Analysis

The data obtained were subjected to cluster analysis using Paleontological Statistical Software Application Packages 3.14 (Hammer *et al*., 2001; Hammer and Harper, 2006). Cluster analysis was performed by agglomerative technique using the Un-weighted Pair Group Method with Arithmetic Mean (UPGMA) method. Relationships between the tree species were graphically represented and analysed taxonomically in form of dendogram, based on ward's method, neighbour joining and single linkage.

Information on tree species landscape status for climate change mitigation

Information on the selected tree species landscape status for climatic change mitigation was gathered through the frequency and taxonomic analysis of the tree species and their foliage features. Line transects was used and total enumeration of the tree species in the Botanical Garden and environs was recorded. Taxonomic studies of the foliage features were assessed (Olajide *et al*., 2006).

Taxonomic Studies of the Foliage Features

Details of coded character states of the selected tree species in the study are summarized in Tables 1 and 2. Codes (1, 2, and 3) were assigned to the character states (qualitative and quantitative) in accordance to the observation, measurement and range of variation of these characters among the plant species.

RESULTS

Selected Tree Species at the Study Area

Tree species of 30 belonging to 18 families were represented in the study area known as University of Ilorin botanical garden and environs.

Cluster analysis

The commonly used approaches in multivariate analysis (hierarchical clustering) are the Ward's method, single linkage, UPGMA, and neighbourhood joining dendrogram (Fig. 1 - 4). Column dendrogram shows the distance (or similarity) between the variables (the selected cell value column). Dendrograms are made up of clades and leaves which is the terminal end of each clade, it also consists of trees species as either outliers or clusters in the Dendrogram generated

Table 1: Qualitative Characters of Plant species at the University of Ilorin Botanical Garden and Environs

Qualitative Characters	Coded Character State 1	2	3	4
Shape of crown	Globular	Conical	Cylindrical	Spreading
Shape of leaf	Linear	Lanceolate	Oblanceolate	Oval
Leaf type	Simple Compound	Pinnate compound	Bipinnate compound	None
Leaf texture	Thine	Thick	Leathery	
Leaf surface	Glaborous	Pubescent	Floccose	scabrid
Leaf apex	Acute	Acuminate	Obtuse	Truncate
Leaf margin	Smooth	Serrated	Cuneate	Entire
Leaf base	Cuneate	Obtuse	Cordate	Oblique
Petiole	Winged	Puberulus	Glaborous	Cylindrical
Fruit type	Berry	Drupe	Follicule	Legume
Flower type	Perfect	Imperfect	Bilateral symmetry	Radial symmetry
Leaf form	Narrow leaf	Fascicle	Conifer	Broadleaf
Leaf arrangement	Opposite	Alternate	Whorled	Linear
Twigs anatomy	Present	Absent	None	I don't know
Leaf colour	Parrot green	Lime peel	Deep mist	Alfalfa

Table 2: Quantitative Characters of Plant species at the University of Ilorin Botanical Garden and Environs

Quantitative Characters	Coded Character State 1	2	3	Instrument
Leaf length	Short	Medium	Long	Measurement tape
Leaf width	Small	Medium	Narrowwide	Measurement tape
Stem height	Short	Medium	Tall	Stem gauge
Plant height	Short	Medium	Tall	Altimeter
Freq. distribution	Small	Medium	Large	Quadrat
Blade length	Short	Medium	Long	Measurement tape
Petiole length	Short	Medium	Long	Measurement tape
Leaf area	Small	Medium	Large	Leaf area meter
Blade width	Small	Medium	Narrowwide	Measurement tape
Crown diameter	Short	Medium	Long	Spiegel Relaskope
Area of canopy	Small	Medium	Large	Densitometer
Trunk diameter	Short	Medium	Long	Diameter Caliper
Lichen frequency	Small	Medium	Large	Quadrant
Lichen density	Low	Medium	High	Quadrant
Leaf density	Low	Medium	High	Quadrant

Table 3: Information on Tree species at University of Ilorin Botanical Garden and Environs

	Tree Species	Common Names	Local Names	Families
1.	*Acacia moniliformis* Griseb	Acacia	Kasia eleti	Mimosaceae
2.	*Adansonia digitata* A.L	Baobab	Ku'uka	Bombacaceae
3.	*Albizza lebbeck* (Linn) Benth	Silk flower	Igbagbo	Fabaceae
4.	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardiaceae
5.	*Annona senegalensis* Pers.	Curstard apple	Abo	Annonaceae
6.	*Azadirachta indica* A Juss	Neem	Dongo yaro	Meliaceae
7.	*Blighia sapida* K. Koenig	Akee apple	Ishin	Sapindaceae
8.	*Bridelia ferruginea* Benth	Pyrexia	Ira	Euphorbiaceae
9.	*Burkea africana* Hook	Wild seriga	Apasa	Caesalpiniaceae
10.	*Casuarina equisetifolia* L	Whisthing pine	Iu Jeki	Casuarinaceae
11.	*Citrus sinensis* Osbeck	Sweet Orange	Orombo didun	Rutaceae
12.	*Daniellia olieveri* (Rolfe) Hutch and Dalz	Balsam tree	Iya	Caesalpiniaceae
13.	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinaceae
14.	*Eucalyptus cinerea* F.Muell. ex Benth	Eucalyptus	Igi-Rosia	Myrtaceae
15.	*Eucalyptus citrodora* Labii	Lemon scented	Igi-Rosia	Myrtaceae
16.	*Ficus diversifolia* L	Fig	Odan	Moraceae
17.	*Gliricidium sepium* (Jacq) Kunth	Quick stick	Agunmaniye	Fabaceae
18.	*Gmelina arborea* Roxb	Melina	Igi-melina	Verbenaceae
19.	*Hildagardia barterii* Roxb	Hildagadia	Okurugbedu	Malvaceae
20.	*Lonchocarpus cyanenscens* Perkin	WestAfrica indigo	Elu	Fabaceae
21.	*Lophira lanceolata* Tiegh.ex Keay	Chewstick	Ipawhaw	Ochnaceae
22.	*Mangifera indica* L	Mango	Mangoro	Anacardiaceae
23.	*Parkia biglobosa* (Jacq) R. Br. Ex Don	Locust bean tree	Igbaa	Mimosaceae
24.	*Plumera alba* L	Frangipani	Usibaka	Apocynaceae
25.	*Plumera rubra* L	Frangipani	Usibaka	Apocynaceae
26.	*Polyalthia longifolia* Sonn	Azoka tree	Igunnu	Annonaceae
27.	*Prosopis africana* (Guill and Perr.)	Iron wood	Kirya	Mimosaceae
28.	*Tectonia grandis* L	Teak	Tikii	Verbenaceae
29.	*Terminalia catappa* L	Almond tree	Igi furutu	Combretaceae
30.	*Vitellaria paradoxa* Gaertn. F.	Shea butter	Emi	Sapotaceae

Accordingly, the landscape status of the tree species gave 13 clusters namely: 26, 24, 27; 2, 14; 13, 28; 7, 8; 25, 16; 3, 19, 29; 17, 15; 9, 11; 22, 10; 6, 23; 31, 21; 18, 20; 12, 4, 30 and 1 outlier namely: 5. Tree species 26 occurred as an outliers but with some affinity or relationship with the cluster 26, 24, 27. Likewise tree species 3 and 12 occurred as outliers with some affinity or relationship with clusters 3, 19, 29 and 12, 4, 30 respectively and were fair representation of these interrelationship (Fig. 1)

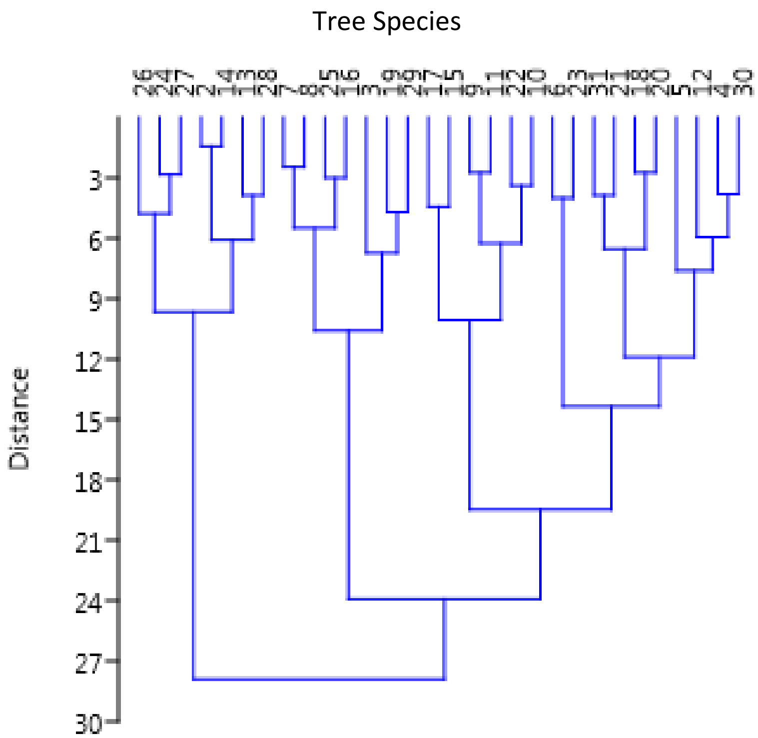

Fig.1: Ward's Linkage Dendrogram Hierarchical Clustering of Trees Species at University of Ilorin Botanical Garden and Environs

Accordingly, the landscape status of the tree species gave 9 clusters namely: 4, 30; 7, 8, 25; 18, 20; 20, 13, 14, 2; 24, 27, 26; 9, 11, 22; 6, 23; 23, 12 and 6 outliers namely: 21, 29, 5, 15, 17, 3. Tree species 25, 16, 28, 19 occurred as outliers but with some affinity or relationship with cluster 7, 8, 25, also tree species 13, 26, 22 and 10 occurred as outliers but with some affinity or relationship with clusters 13, 14, 2; 24, 27, 26 and 9, 11, 22 respectively and were fair representation of these points interrelationships (Fig. 2)

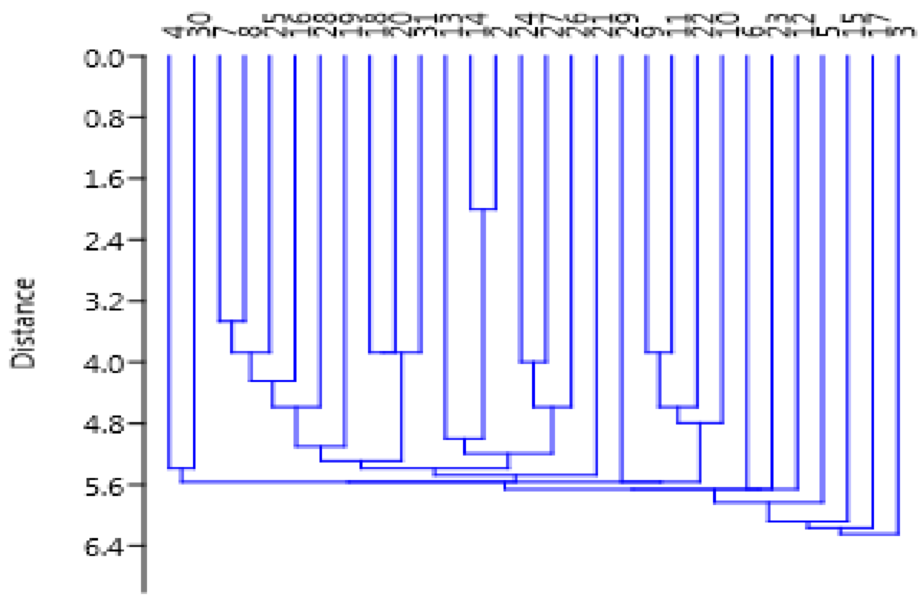

Fig.2: Single Linkage Dendrogram Hierarchical Clustering of Trees Species at University of Ilorin Botanical Garden and Environs

Accordingly, the landscape status of the tree species gave 11 clusters namely: 4, 30, 12; 5, 21; 7, 8; 16, 25; 18, 20, 31; 9, 11; 10, 22; 6, 23; 13, 14, 2; 24, 27, 26; 15, 17 and 3 outliers namely: 29, 19, 3. Tree species 12, 13 and 28, 26 occurred as outliers but with some affinity or relationship with the clusters 4, 30, 12; 18, 20, 13, 14, 2 and 24, 27, 26 respectively and were fair representation of these points interrelationships (Fig.3)

Accordingly, the landscape status of the tree species gave 11 clusters namely: 2, 14; 13, 28; 7, 8; 24, 27, 26; 15, 17; 16, 25, 19; 3, 29; 18, 20, 15, 21; 11, 22, 9, 10; 4, 30, 12; 6, 23. Tree species 13, 28, 26, 19, 9, 10, 12 occurred as outliers but with some affinity or relationship with the clusters 2, 14, 13, 28; 24, 27, 26; 16, 25, 19; 18, 20, 11, 22, 9, 10 and 4, 30, 12 respectively and were fair representation of these points interrelationships (Fig. 4)

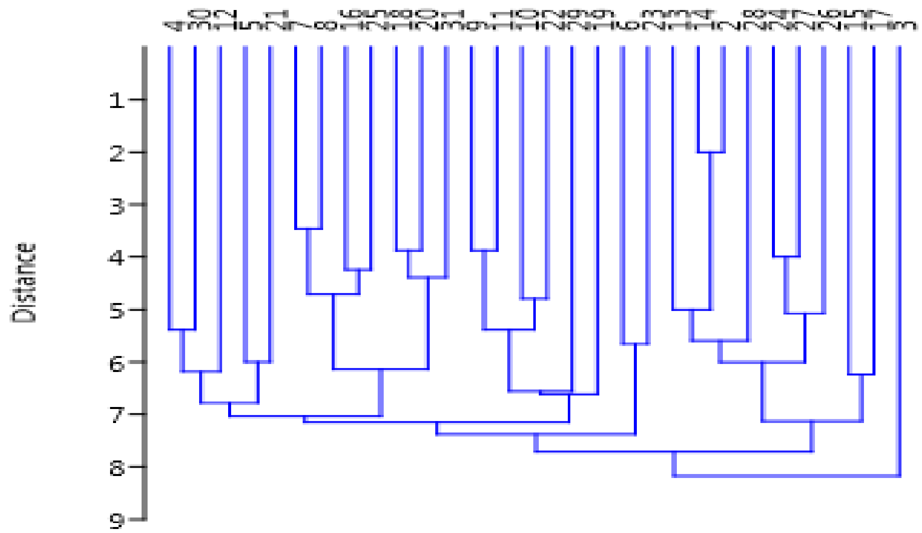

Fig.3: UPGMA Linkage Dendrogram Hierarchical Clustering of Trees Species at University of Ilorin Botanical Garden and Environs

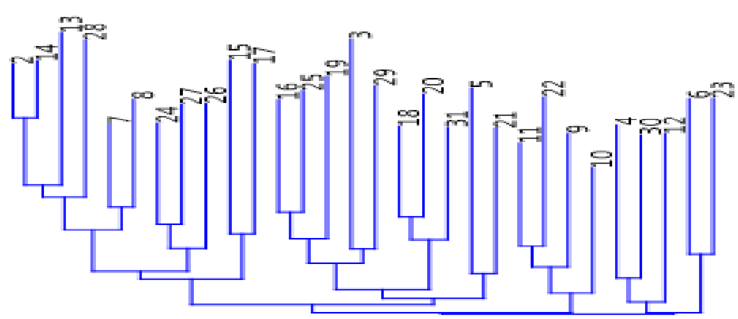

Fig.4: Neighbour Joining Clustering Linkage Dendrogram Hierarchical Clustering of Trees Species at University of Ilorin Botanical Garden and Environs

Information on trees species landscape status for climate change mitigation

Information on the selected trees species landscape status for climatic change mitigation in the study area is presented in Table 4. Landscape status showed 11 abundant (A) and 19 rare (R) of 36.67% and 63.33% landscape status respectively.

Table 4: Information on trees species landscape status

	Tree Species	Frequency Value (%)	Landscape Status
1.	*Acacia moniliformis*	1.94	R
2.	*Adansonia digitata*	0.97	R
3.	*Albizzia lebbeck*	0.97	R
4.	*Anacardium occidentale*	4.85	A
5.	*Annona senegalensis*	0.97	R
6.	*Azadirachta indica*	9.71	A
7.	*Blighia sapida*	2.91	R
8.	*Bridelia ferruginea*	0.97	R
9.	*Burkea africana*	1.46	R
10.	*Casuarina equisetifolia*	2.43	R
11.	*Citrus sinensis*	6.31	A
12.	*Daniela olivieri*	5.83	A
13.	*Delonix regia*	4.37	A
14.	*Eucalyptus cinerea*	2.91	R
15.	*Eucalyptus citrodora*	3.40	R
16.	*Ficus diversifolia*	1.94	R
17.	*Gliricidium sepium*	4.37	A
18.	*Gmelina arborea*	4.37	A
19.	*Hildagardia barterii*	0.97	R
20.	*Lonchocarpus cyanenscens*	1.94	R
21.	*Lophira lanceolata*	0.97	R
22.	*Mangifera indica*	4.85	A
23.	*Parkia biglobosa*	2.91	R
24.	*Plumera alba*	1.94	R
25.	*Plumera rubra*	2.91	R
26.	*Polyalthia longifolia*	7.28	A
27.	*Prosopis africana*	2.91	R
28.	*Tectonia grandis*	2.91	R
29.	*Terminalia catappa*	5.34	A
30.	*Vitellaria paradoxa*	4.37	A

DISCUSSION

Trees can help mitigate climate change by contributing to net reduction in atmospheric carbon-dioxide through carbon sequestration and storage (Abdollahi *et al*., 2000). Tree species that consistently form clusters irrespective of the method used are namely: (a) *Polyalthia longifolia* , *Plumera alba* , *Prosopis Africana* ; (b) *Eucalyptus cinerea* , *Adansonia digitata* ; (c) *Blighia sapida* , *Bridelia ferruginea* ; (d) *Blighia sapida* , *Bridelia ferruginea* ; (e) *Burkea Africana* , *Citrus sinensis* ; (f) *Azadirachta indica* , *Parkia biglobosa* and (g) *Gmelina arborea*, *Lonchocarpus cyanenscens* while the outliers tree species include the following: *Annona senegalensis* , *Albizza lebbeck* , *Eucalypytus citrodora* , *Gliricidium sepium* , *Lophira lanceolata and Terminalia catappa*. These patterns of affinity or relationships can be taken into consideration when involved in the selection of tree species that can be used in the landscape as either for reduction in the carbon emission (outliers) or carbon storage (clusters) based on the taxonomic characters of the foliage features for climate change mitigation in our society. The term carbon sequestration is used to describe both natural and deliberate processes by which CO_2 is either removed from the atmosphere or diverted from emission sources and stored in the terrestrial environment such as vegetation areas like botanical gardens. In the study some tree species such as *Casuarina equisetifolia, Daniellia olieveri, Delonix regia, mangifera indica, Polyalthia longifolia and Tectonia gradis* occurs as outliers but with some affinity or relationship with the clusters tree species. These patterns of affinity or relationships can be taken into consideration when involved in the selection of tree species that can be used as a good candidate for carbon sequestration.

Biological carbon sequestration transfers carbon from CO_2 in the atmosphere to biomass through photosynthesis and ultimately stores it in plants taxonomic features such as the foliage parameters in the preserved areas such as botanical gardens. Changing climate is likely to have profound effect on Nigeria. CSIRO predicts that by 2030, annual average temperature over most of the continents will be 0.4 to 2.0^{o}C higher compared to 1990 (CSIRO, 2001). As a carbon sequestration activity, botanical garden establishment will primarily affect atmospheric carbon-dioxide. Climate change mitigation previous works focused mostly on the reduction of carbon-dioxide emission and greenhouse gases. This experiment advanced further by focusing more on the potential storing significant carbon in the tree species foliage features as an alternative means of offsetting the effect of future carbon emission in the atmosphere. The result of the taxonomic analysis of the landscape status of some tree species selected in this experiment at the University of Ilorin botanical garden and environs for climate change mitigation using cluster analysis of different methods such as ward's method, single linkage method, unpaired UPGMA method and neighborhood joining method revealed that selected trees species are grouped into two namely: clusters tree species for carbon storage and outliers tree species for carbon-dioxide emission reductions as a measure of climatic change mitigation based on the taxonomic description of their foliage features characteristics of both qualitative characters such as: shape of leaves, shape of crown and quantitative characters such as leaf length, leaf width, stem length, stem width.

Confirmation for this observation was found in this study with a significant effect of plant species according to cluster analysis in the botanical garden. This technique does not combine the two most similar trees successively. Instead, those trees whose merger increases the overall within cluster variance to the smallest possible degree are combined. It gives cluster with equal distance of measurement and very sensitive to outliers. Observation also makes it possible from the taxonomic characters of the tree species that occurred within the line transects in the garden. The results of the study serve as indices for selecting each of the tree species as either clusters or outliers' purposes, which could be of help to mitigate harsh weather condition and climate change. According to Oladele and AbdulRahaman (2008) on the establishment of hedge plants and ornamental trees around houses and buildings in schools, campuses and work environment for climate change mitigation. In this study the outlier trees species could be taken into consideration as well based on the different method of analysis used. Also the results showed that the landscape status of tree species was significantly determined based on cluster analysis of the taxonomic characters of both the qualitative and quantitative which served as the indices of tree species selection into either clusters such as fast-growing and wide-crowned shape of leaves of plant species families such as Myrtaceae, Sapindaceae, Euphorbiaceae and Fabaceae or outliers such as slow – growing narrow-crowned leaves shape plant species families of Annonaceae. Over the lifetime of tree, several tons of atmospheric carbon-dioxide can be absorbed (McPherson and Sundquist, 2009). Evidence of this observation was found in this study with a significant relationship between landscape status of qualitative and quantitative taxonomic characters using neighbourhood joining method of cluster analysis, in which both the tree species families clusters of Bombacaceae, Myrtaceae, Caesalpinaceae Verbenaceae Apocynaceae Mimosaceae and tree species families outliers Malvaceae, Casuarinaceae can be used for carbon-dioxide removal, which in turn lead to carbon sequestration and carbon storage (Abdollahi *et al*., 2000).

Conclusion:

The foregoing discussion on the taxonomic analysis and landscape status of some selected tree species for climate change mitigation in sudano-guinea savannah vegetational zones of Nigeria studied under different locations, inside and outside University of Ilorin botanical garden and environs during the dry and rainy seasons could be used as indicators to evaluate the environmental and socio-cultural benefits of botanical garden structure in climate change mitigation. The study concluded that, clusters tree species families of Apocynaceae, Bombacaceae, Meliaceae, Sapindaceae, Mimosaceae, Myrtaceae, Euphorbiaceae, Caesalpiniaceae, Rutaceae, Verbenaceae and Fabaceae out of 18 families were considered in this experiment as the best candidates' families for climate change mitigation based on clusters formation for effective carbon sequestration practices in the landscape and further studies can determine each of tree species carbon sequestration per year.

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