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Distribution study of tree diversity in Aswan Botanical Garden

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Abstract: To evaluate the diversity of tree species presented in Aswan Botanical Garden, Aswan, Egypt, by determining the numbers, morphological characteristics and some diversity indices, many visits to the garden were done from January up to November 2023 to collect the required data. Aswan Botanical Garden (17.0 fed) contained 209 tree species, 851 tree individuals and 43 plant families. The southern section with an area of 5.0 fed contained the highest number of individuals and density/fed compared to middle and northern sections (7.0 and 5.0 fed area, respectively). In the whole garden, the old trees recorded the highest number of trees. The highest number of young age tree species were observed in the middle section then the northern then the southern. Fabaceae family recorded the highest number of individuals and species for the whole garden followed by Moraceae, Myrtaceae, Malvaceae, Bignoniaceae then Meliaceae. There were no dominant species in the garden, while the biodiversity indices showed high diversity and equal abundance in the whole garden and its sections, the middle section recorded the highest indices. *Ficus microcarpa* recorded the highest number of individuals in the whole garden. *Khaya senegalensis*, *Alstonia scholaris*, *Bombax ceiba*, *Pterygota alata* and *Syzygium grande* recorded the tallest trees in the whole garden (22.0 m), while *Bombax ceiba*, *Ficus sycomorus* and *Ficus microcarpa* recorded the highest DBH (184.62, 182.07 and 171.89 cm, respectively). Aswan Botanical Garden contained 14 tree species and according to the IUCN website these tree species under these categories are classified as, endangered, vulnerable or near threatened. This study referred to the crucial role of Aswan Botanical Garden in Egypt in preserving several important tree species with economic value that provide high-quality timber used for a variety of uses in the wood industry i.e. *Swietenia macrophylla, Swietenia mahagoni, Khaya senegalensis, Tectona grandis, Eucalyptus* sp., *Corymbia citriodora, Acacia* sp., *Albizia* sp., *Tipuana tipu*, and *Dalbergia* sp.

Key words: Aswan Botanical Garden, Trees, Biodiversity.

1. Introduction

Botanic gardens are becoming more and more significant tools for studying and conserving plants. Since the middle of the 20th century, several botanic gardens have been founded all over the world to carry out novel socio-environmental goals. Others with centuries-long histories have also experienced significant change in light of the increased focus on sustainability issues **(Neves, 2024)**. Botanical gardens are not just gardens in the traditional sense of the word; rather, they are botanical scientific establishments where the garden is small part alongside the greenhouses, research laboratories, herbarium and the library**.** Botanical Garden is a living museum that reflects the scientific, cultural and educational concepts of the life of various plants, and it has a prominent position in conducting scientific research related to botany at the national and global levels in the areas.

As they are considered scientific institutions that reflect the extent of agricultural progress in any country and usually include the most important plant families that grow in the climatic zone in which the garden is located, with the possibility of bringing new species, acclimatizing them and displaying them to the public. Botanical gardens are necessary in universities to enable students to get to know plants closely and obtain complete information about them. Garden plants are grown for the purposes of scientific and educational research and to study plants from environmental, phenotypic and functional aspects. It also includes the largest collection of types and varieties of local and imported plants, distributed according to the families to which they belong **(Girmay, 2023)**. The goal of botanical gardens is to raise awareness of, interest in, and efforts to conserve the diversity of plant species **(Pautasso and Parmentier. 2007)**.

In recent time cultivation of trees in landscapes has aesthetic purposes and provide health benefits to all people visit it because their contact with nature. The result has led to, the urban green space and public education roles of botanical gardens have developed rapidly **(Ren and Blackmore, 2023)**. Humanity now understands the value of plant conservation and the necessity of creating and residing on a "garden earth" in light of climate change and ecosystem deterioration. This goal is supported by the live collections and knowledge skills of botanical gardens, which may contribute to the peaceful coexistence of humans and environment **(Blackmore, 2017)**. Green areas like parks, botanical gardens, and historic landscapes are becoming more and more valued in today's lives because they provide a much-needed break from the bustle of the city. A garden is an example of an organized natural area that may help individuals reconnect with their senses **(Meneses and Marrero, 2024)**. In order to preserve living plant collections for scientific study, conservation, and education, botanic gardens are essential. Additionally, botanic gardens are crucial for maintaining human health **(Moraleda, *et al.*, 2022)**. Green is associated with the garden's trees, plants, and grass, while flowers are associated with a variety of vivid hues **(Lee, 2020)**.

If the Botanic Garden is included into national conservation and urban development plans, it may protect biodiversity and play a vital role in conservation efforts **(Acheampong, *et al.*, 2021)**. Throughout history, botanic gardens have employed their collections of live plants for a multitude of objectives, which have changed throughout time to accommodate the ever-evolving demands of the society. Botanic gardens are in a better position than other types of institutions to interact with the public and mobilize support for the preservation of plant diversity by delivering compelling and uplifting messages that encourage people to take an active role in determining the course of the future. This is because botanic gardens are well-liked recreation areas. Natural environment and beautiful gardens are essential to everyone's emotional and physical health. People who can design, maintain, and appreciate gardens have happier and healthier lives. A botanic garden provides the perfect setting for contemplating and learning about global change, as well as raising awareness of the UN's 2030 **(Blackmore, 2017)**.

Sustainable development depends on the preservation of plant diversity, and botanic gardens are essential hubs for conservation efforts. The garden's endangered species must be the focus of conservation efforts. In many organizations and local communities, a major barrier to maintaining plant variety is a lack of the requisite skills and information. As a result, in order to adequately safeguard

plants and their habitats, conservation activities must be made more widely known **(Heneidy and Marzouk, 2008)**. Today's world, when natural habitats are vanishing at a rapid pace and the number of plants under threat is always rising, ex situ conservation is becoming more and more crucial **(Volis, 2017).** Botanic gardens must update their strategic objectives and their methods for achieving the new goals in order to face this challenge.

Known as Natroun island in reference to the Nuba tribe, Aswan Botanical Garden is the most well-known and historic island centre in the River Nile. Its name was originally changed by the British in Egypt during the 19th century AD to the island of radar in proportion to the English Lord Kitchener's headquarters. It was subsequently renamed Island of King in 1928 during the reign of King Fuad I st, and finally the Botanical Garden, or the plants of the island, was introduced by the Ministry of Agriculture during the administration of the late President Gamal Abdel Nasser **(Mohamed *et al*. 2014)**. The plants in the garden have come from three primary sources: plants that were brought from outside Egypt, plants that already in this area, and plants that exchanged with other Egyptian gardens. Aswan Botanical Garden has several rare tree species that are not present in Egypt's historical gardens, as well as many trees that yield high-quality timber that is used in numerous wood industries for various purposes.

This study aimed to quantify the diversity of forest tree species and predict the actions necessary to ensure tree preservation in line with Aswan Botanical Garden's goals for sustainable development and conservation. Additionally, Aswan Botanical Garden's dominant tree species can be employed for afforestation in the same area or another area with comparable environmental conditions.

2. Materials and Methods

This study was carried out to evaluate the diversity of tree species presented in Aswan Botanical Garden, Aswan, Egypt, by determining the numbers, morphological characteristics and some diversity indices. This may be beneficial in suggesting appropriate actions required for the optimal conservation of such tree species and recommending expanding the cultivation of dominant species characterized by good specifications in similar areas.

2.1 Garden location and weather

Aswan Botanical Garden is an island surrounded by water from all sides, situated in the middle of River Nile (24° 05' 32" N & 32° 53' 17" E) at Aswan City, Egypt and located on the other side of Elephantine Island (Fig., 1). Aswan Botanical Garden has a rectangular elliptical shape with an area of 17 feddans (71400 m^2).

According to the climatic data averaged from 1981 to 2022, the weather in Aswan varies from pleasant in the winter to quite hot in the summer. The average temperature ranged from 14.79 to 33.50 °C, the maximum temperature ranged from 35.13 to 48.84 °C, and the minimum temperature ranged from 0.37 to 20.13 °C within the year (Fig., 2). Average data of relative humidity (%) and wind speed (m/s) are shown in Table (1).

2.2. Methods

Many visits to the garden were done from January up to November 2023 to manually compile the trees required data. Taxonomic data (family, genus and species) and variation identifications, as well as age, for every tree species found in the garden were provided by the herbarium of the Aswan Botanical Garden.

To organize the data collection, the whole garden area (17 feddans) was virtually divided into three sections (Fig., 1) i.e. south, middle and north (5, 7 and 5 feddans, respectively). Also, the tree species were grouped depending on the age into old more than (50 years), medium (20 years) and young (12 years). According to the Aswan botanical garden records.

2.3. Data collected and calculations

1. General records

The number of families, species and individuals was recorded for the whole garden and per section. Based on these records, density (number of trees/feddan), the number of individuals/age and number of individuals/family for the whole garden and per section was registered. Also, the number of species/age/section and the number of species/family for the whole garden were counted.

2. Morphological characteristics

Total height (m) was measured using a clinometer device (Suunto PM-5/360PC). Also, diameter at breast height (DBH) was recorded by measuring the circumferences of all trunks and converted to diameters at breast height DBH (cm). These measures were calculated for all trees in the garden but only species with the 15 most numerous individuals and with the highest maximum height and DBH were tabulated.

3. Biodiversity indices

Biodiversity indices e.g. richness (No. species), number of individuals, dominance (D), Simpson (1-D), Shannon (H), evenness (eH/S), Brillouin, ... etc were calculated using the ComEcolPaC (Drozd, 2010).

4. Some growth parameters

Some parameters based on height and diameter at breast height for each section and age were calculated for all tree species in the garden, but the species with the highest the Importance Value Index (IVI %)were tabulated. The following parameters were calculated:

a. Basal area per tree and species (m^2)

The basal area per tree (BA/tree) at 130 cm above ground level was calculated based on DBH (m^2/tree). By multiplying BA/tree by the number of individuals/species, the BA/species was calculated (m^2/tree) **(Brashears *et al.*, 2004)**.

b. Relative density (RDi)

The following formula was used to calculate species' relative density, which is an index for evaluating species relative distribution **(Brashears *et al.*, 2004)**:

$$RDi = (n_i / N) x 100$$

Where: ni is the number of individuals per species, and N is the total number of individual trees of all species in the whole community.

c. Relative Dominance (RD_o)

According to **(Aidar *et al.*, 2001)**, species relative dominance (RD_o %), which is used to determine the relative space occupancy of a tree, was calculated as follows:

$$RD_o = (\sum Ba_i \times 100) / \sum Ba_n$$

Where: Ba_i is the basal area of all trees in a certain species, Ba_n is the basal area of all trees in the garden.

d. Value Index (IVI)

According to the connection in the equation below, each species' importance value index (IVI) was calculated **(Brashears *et al.*, 2004)**:

$$IVI = (RD + RD_o)/2$$

5. Threatened status

Threatened status for all tree species in Aswan Botanical Garden was determined according to the International Union for Conservation of Nature's (IUCN) Red List website (https://www.iucnredlist.org). The tree species were classified into different levels assigned by IUCN i.e. least concern, vulnerable, near threatened, … etc.

2.4. Statistical analysis

Microsoft Excel software was used to average and calculate the most morphological and growth parameters including standard deviation (SD). All biodiversity indices were calculated and analysed by using Past software ver. 4.15 **(Hammer *et al.*, 2001)**.

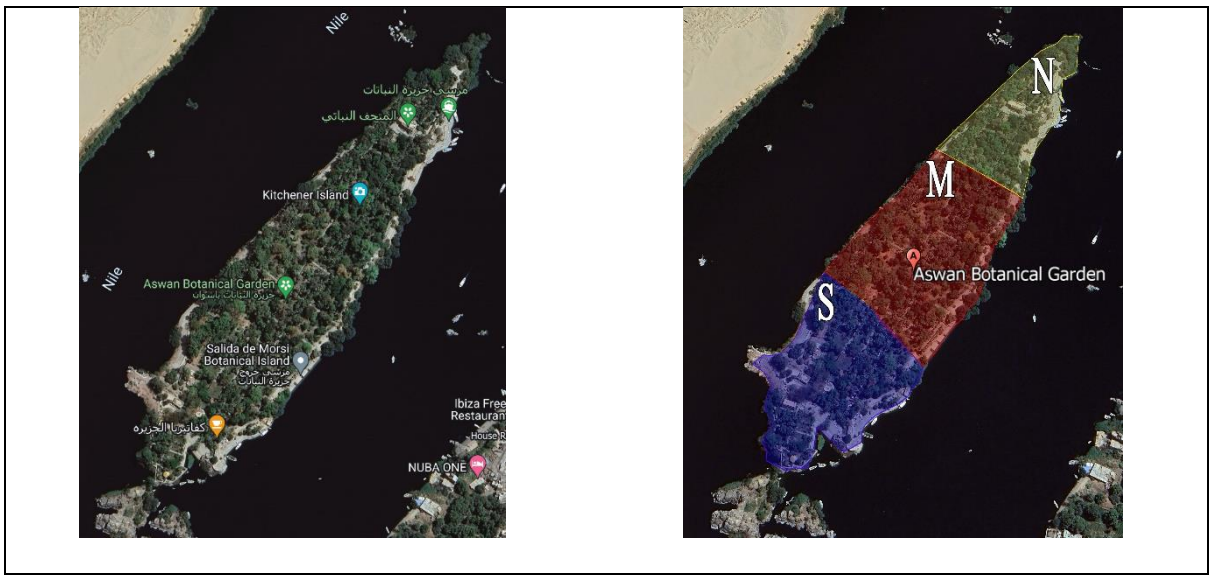

Fig. (1). Aswan Botanical Garden and its sections (N; north, M; middle and S; south)

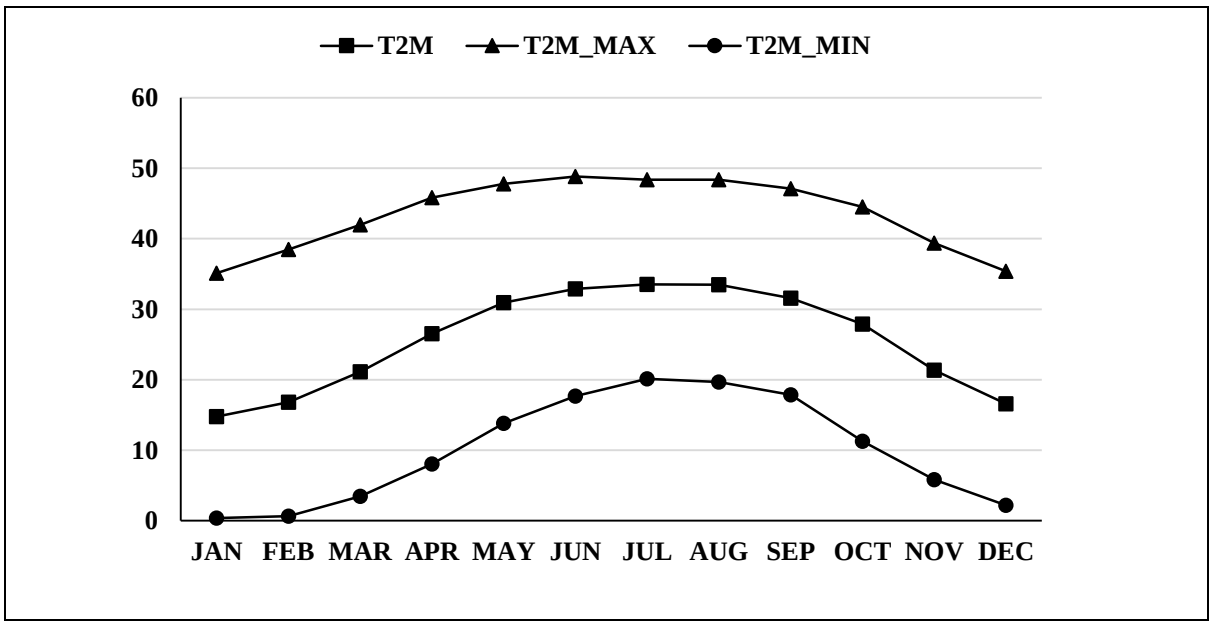

Fig. (2). Average temperature data (mean, maximum and minimum) from 1981 to 2022 of Aswan Botanical Garden Area

Table (1). Average relative humidity (%) and wind speed (m/s) data from 1981 to 2022 of Aswan Botanical Garden area

Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
RH	42.56	33.63	24.53	18.02	15.73	14.68	16.64	18.03	20.24	26.66	36.81	43.76	25.92
WS	2.70	2.86	3.07	3.15	3.26	3.59	3.40	3.54	3.45	2.90	2.67	2.63	3.10

3. Results

3.1. Some general parameters of Aswan Botanical Garden

Table (2) presents some general parameters of Aswan Botanical Garden and its three sections. In this regard, the total area of the whole garden is 17.0 feddans, while the South, Middle and North sections recorded 5.0, 7.0 and 5.0 feddans, respectively, with an average of 5.7 feddans for each. The total number of individuals presented in the whole garden was 851 trees with a density of 50.1 tree/feddan, these included 209 species and 43 families. The highest number of individuals was recorded in the South section (367 trees with 73.4 tree/feddan), then the Middle section (253 trees with 36.1 tree/feedan) and finally North section (231 trees with 46.2 tree/feddan). It could be noticed that, although the middle section included a higher number of individuals than the north one, its density was lower because the area of this section (middle) was higher than the North section.

Table (2). Some general parameters represent the whole garden and per section identified in this study for Aswan Botanical Garden

parameters	For the whole garden	Per section			
		South	Middle	North	Average (SD*)
Area (feddan)	17.0	5.0	7.0	5.0	5.7 (±1.2)
Density (tree/feddan)	50.1	73.4	36.1	46.2	51.9 (±19.3)
No. of individuals	851.0	367.0	253.0	231.0	-
No. of families	43.0	-	-	-	-
No. of species	209.0	-	-	-	-
* Standard deviation					

3.2. Number of individuals classified by age for the whole garden and per section

To describe the structure of Aswan Botanical Garden regarding the distribution of individuals classified by age either in the whole garden or its three sections. Fig. (3) showed that, 608 trees represented old individuals, 224 trees for young and 19 trees only for medium trees. Nearly the same trend was recorded for the three sections. For the South section 289, 71 and 7 trees for old, young and medium were recorded, respectively. While for the middle section 163, 83 and 7 trees for old, young and medium were recorded, respectively. Finally, 156, 70 and 5 trees for old, young and medium ages were recorded in the North section, respectively.

3.3. Number of species classified by age per section

The distribution of species classified by age for each section were shown in Fig. (4). The highest number of old species was recorded in the south section (94 species), this was followed by the middle section (75 species) then north section (61 species). On the other hand, the highest number of young tree species were recorded in the middle section then north and south (66, 59 and 45 species, respectively). In this regard, both south and middle sections recorded the highest number of medium species (6 species for each), then the north section (5 species only).

The above-mentioned records related to the number of individuals and species classified by age showed the extent of Aswan Botanical Garden renovation activities, these were done by cultivate new species from endemic and naturalized species. It could be observed that the number of young trees was higher than medium ones this indicated that the renovation activities in the garden have been intensive in the recent period compared to previous periods, despite the majority of trees being old in age.

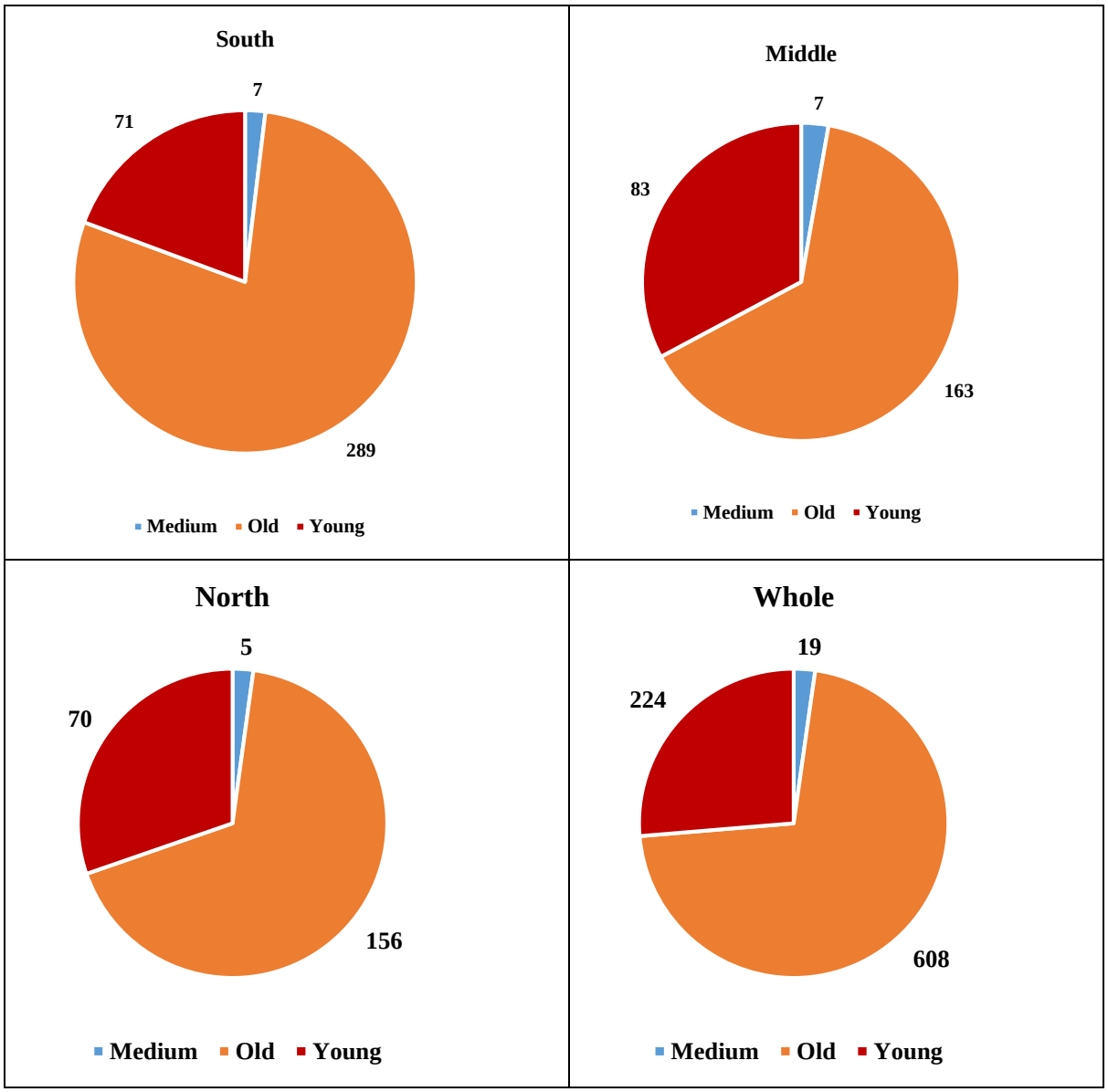

Fig. (3). Number of individuals classified by age for the whole garden and per section

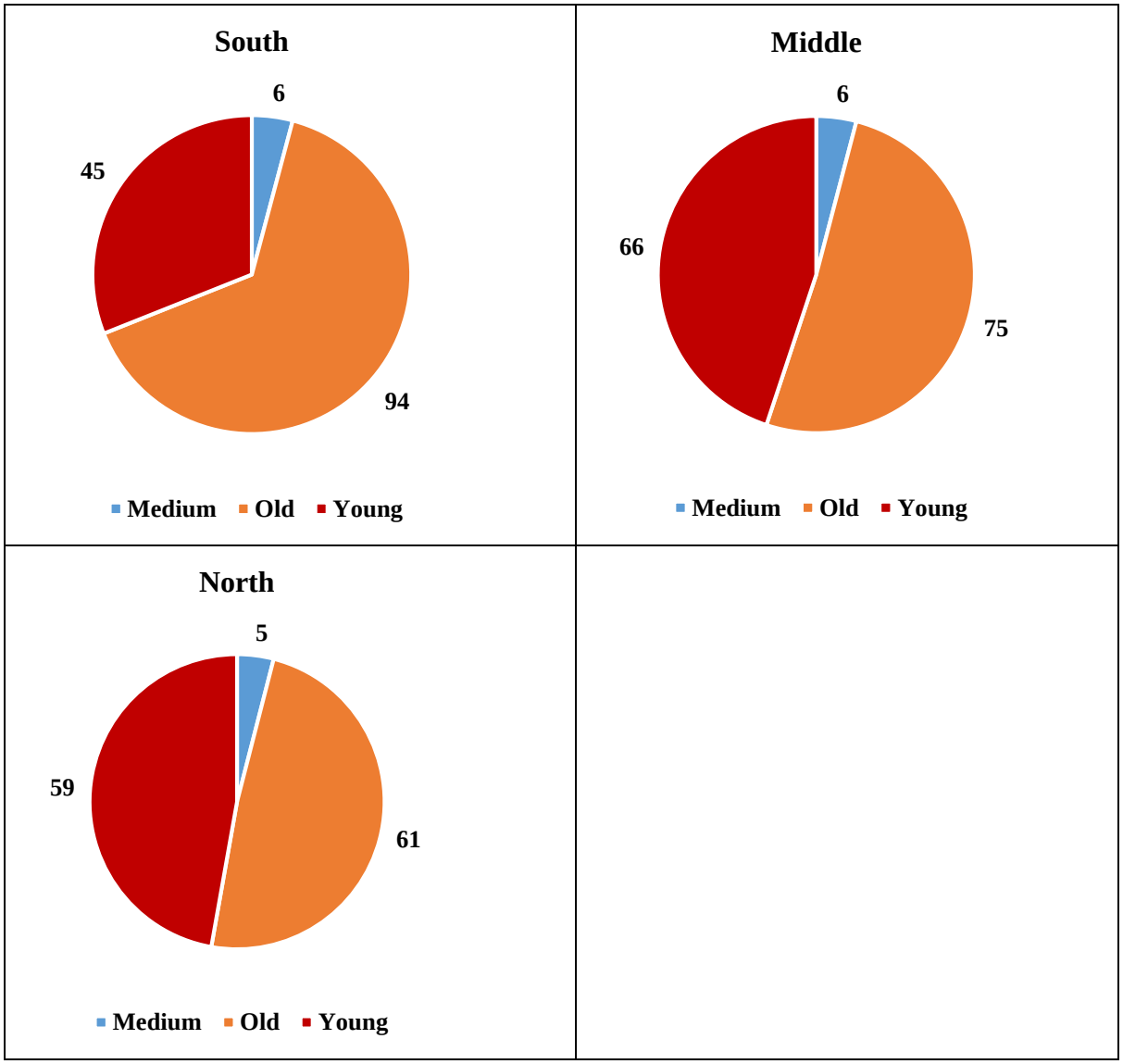

Fig. (4). Number of species classified by age per section

3.4. Number of individuals and species classified by plant families

Furthermore, Table (3) and Fig. (5) presented the number of individuals and species classified by plant families. Fabaceae recorded the highest number of individuals in the whole garden (163) and in the middle section (63). This was followed by Moraceae (159 in the whole garden and 100 in the south section), Myrateacea (64 in the whole garden and 26 in the north section), Malvaceae (52 in the whole garden and 25 in the south section), Bignoniaceae (49 in the whole garden and 24 in the south section), Meliaceae (48 in the whole garden and 21 in the north section), Apocynaceae (37 in the whole garden and 21 in the south section), Sapotaceae (27 in the whole garden and 15 in the middle section), Rutaceae (25 in the whole garden and 14 in the south section), Combertaceae (23 in the whole garden and 9 in the south section), Anacardaceae (22 in the whole garden and 9 in the south section) and Boraginaceae (20 in the whole garden and 10 in the middle section).

Among the 43 families recorded in the garden, Fabaceae were represented by the highest number of species as recorded 53 species in the whole garden. This was followed by Moraceae, Malvaceae, Myrateacea, Bignoniaceae, Sapotaceae, Combertaceae, Meliaceae, Rutaceae, Boraginaceae, Anacardaceae, Apocynaceae (24, 14, 12, 12, 8, 7, 6, 5, 5, 4 and 3 species, respectively). The remaining 43 families were represented by 56 species (Fig., 3).

Table (3). Number of individuals/family for whole garden and per section

Fam. (43 families)	Whole garden	South	Middle	North
Fabaceae	163	50	63	50
Moraceae	159	100	26	33
Myrateacea	64	19	19	26
Malvaceae	52	25	18	9
Bignoniaceae	49	24	12	13
Meliaceae	48	17	10	21
Apocynaceae	37	21	9	7
Sapotaceae	27	8	15	4
Rutaceae	25	14	4	7
Combertaceae	23	9	6	8
Anacardaceae	22	9	6	7
Boraginaceae	20	1	10	9
Other families in garden	162	70	55	37
Total	**851**	**367**	**253**	**231**

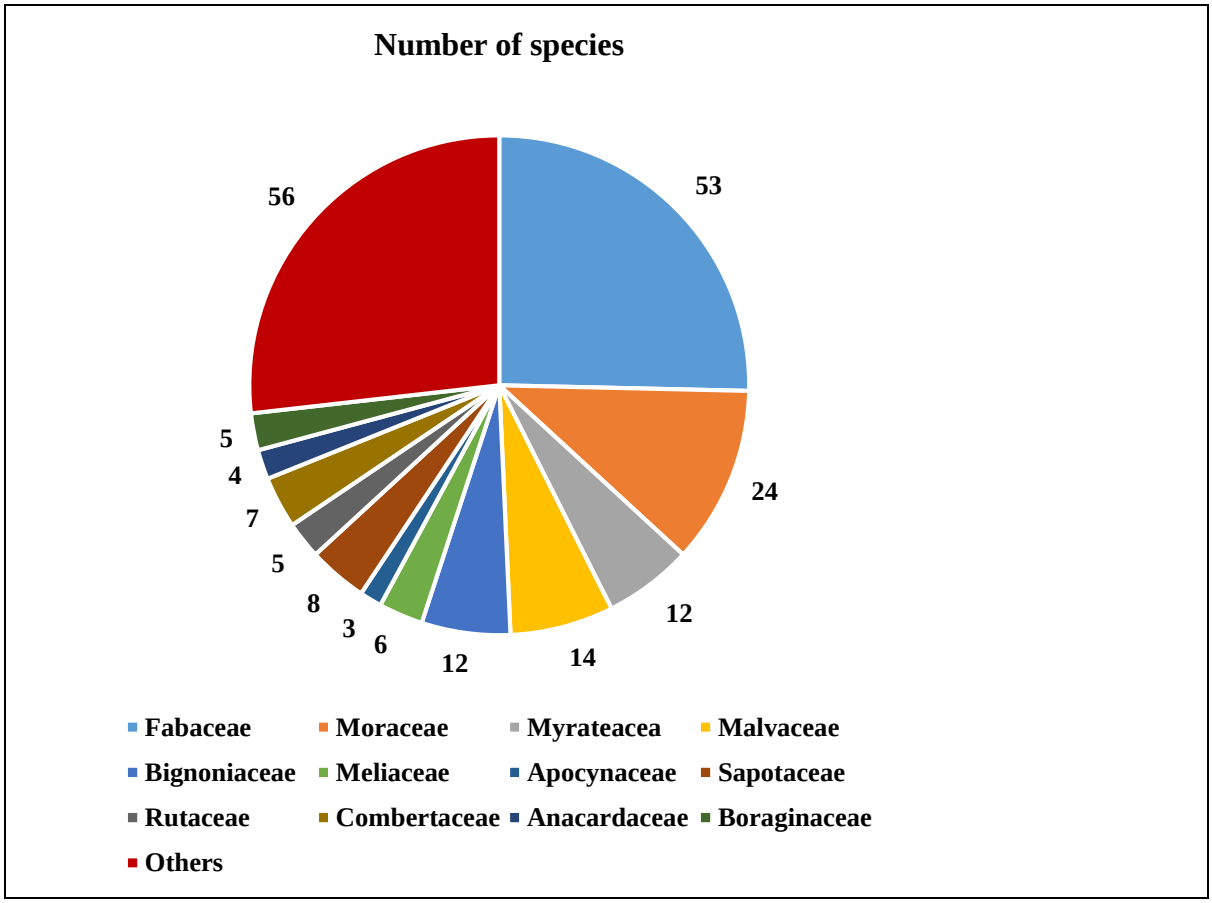

Fig. (5). Number of species classified by plant families for the whole garden

3.5. Number of species regarding dominant % and number of individuals

To investigate the number of dominant species for the whole garden or each section, two measurements (number of species regarding dominant and number of individuals) were calculated and presented in Table (4). As for the number of species with different dominant % categories, subrecedent species with less than 1% dominant counted the highest values in the whole garden and the south, middle and north sections (194.0, 102.0, 109.0 and 92.0 species, respectively), Followed by recedent species which recorded 10.0, 16.0, 18.0 and 11.0 species for the whole garden and south, middle and north sections, respectively. Only one eudominant species was observed in the south section only with more than 10% dominant. The number of species regarding the number of individuals showed the same trend as the mastery was to singleton and doubleton species with 1 and 2 individuals, respectively in the whole garden and each section. The highest number of species with 1 individual was obtained in the middle section (83), then north (68) and south (61), while for the whole garden there were 68.0 species. It is worth also to mention that, there were 40 species in the whole garden and 14 species in the south section with more than 5 individuals. All these results indicated a low number of dominant species in the garden and its sections.

Table (4). Number of species regarding dominant % and number of individuals

Indicies	Number of species regarding dominant %*			
	South	Middle	North	Whole Garden
Subrecedent (less than 1%)	102.0	109.0	92.0	194.0
Recedent (1% to less than 2%)	16.0	18.0	11.0	10.0
Subdominant (2% to less than 5%)	6.0	9.0	9.0	4.0
Dominant (5% to less than 10%)	0.0	0.0	1.0	1.0
Eudominant (more than 10%)	1.0	0.0	0.0	0.0
	Number of species regarding number of individuals			
1 individual (singleton)	61	83	68	68
2 individuals (doubleton)	30	26	24	41
3 individuals (triplet)	11	13	8	22
4 individuals (quadruplet)	6	5	3	27
5 individuals (quintuplet)	3	3	3	11
> 5 individuals	14	6	7	40

* Calculated according to Tischler's scale for species dominance

3.6. Some biodiversity indices

Table (5) showed some biodiversity indices. In this regard, richness (number of species) recorded 209 tree species in the whole garden. The highest richness was observed in the middle section, then the south and north sections (136, 125 and 113 tree species). No more dominant species were observed in the whole garden or the south, middle and north sections (0.02, 0.04, 0.01 and 0.02 respectively). These low values of dominance measurement indicate lower dominance with even species distribution. The rest of the indices recorded in Table (4) showed higher diversity, equal abundance and no dominant tree

species in Aswan Botanical Garden or its sections. According to the diversity indices of Simpson, Shannon, Brillouin, Menhinick, Margalef and Fisher_alpha, the middle section showed higher diversity than other sections as the highest values were obtained (0.99, 4.94, 4.05, 8.55, 24.40 and 119.80 for these indices, respectively). Evenness (e^H/S), Equitability_J and Berger-Parker indices proved equal abundance of tree species as the highest values (near to 1) were obtained for the first two indices and lower values (near to 0) were obtained for the third one. Also, the middle section distinguished with the highest abundance than other sections, as recorded 1.02, 1.01, and 0.04 for the three last-mentioned indices, respectively. Chao-1, iChao-1, ACE, and Squares indices estimate the richness of species in the community that take into account the possibility of rare species that were not counted. As shown in Table (4), the values were higher than the counted number of species (209), these indicate the possibility of the presence of rare species that were not counted.

Table (5). Some biodiversity indices of tree species in Aswan Botanical Garden

Indices	All Garden	South	Middle	North
Richness (No. species)	209.00	125.00	136.00	113.00
Number of individuals	851.00	367.00	253.00	231.00
Dominance (D)	0.02	0.04	0.01	0.02
Simpson (1-D)	0.98	0.96	0.99	0.98
Shannon (H)	4.91	4.32	4.94	4.61
Evenness (e^H/S)	0.65	0.60	1.02	0.89
Brillouin	4.44	3.73	4.05	3.80
Menhinick	7.16	6.53	8.55	7.44
Margalef	30.83	21.00	24.40	20.58
Equitability_J	0.92	0.89	1.01	0.98
Fisher_alpha	88.45	66.82	119.80	87.41
Berger-Parker	0.08	0.17	0.04	0.08
Chao-1	263.20	183.90	261.50	203.70
iChao-1	275.70	202.10	299.70	232.80
ACE	263.20	206.20	289.10	235.90
Squares	287.20	289.70	239.10	222.00

3.7. Some trees parameters

Data in Table (6) presented the count, height (m) and diameter at breast height; cm (DBH) per tree in the whole Aswan Botanical Garden regardless of the section location or age, only species with the highest number were included. While data recorded in Table (7) presented the tree species with the highest maximum height and DBH. Tables (8, 9 and 10) showed some tree parameters i.e. count, height (m), diameter at breast height; cm (DBH), basal area per tree; cm^2 (BA/tree), basal area per species; cm^2 (BA/species), species relative density; % (RDi), species relative dominance; % (RDo) and the importance value index; % (IVA) in Aswan Botanical Garden which were divided based on location (southern, middle and northern sections of the garden) and age (medium, old and young trees). Not all

tree species were integrated into the Tables but only 12 (if possible) species with the highest importance value index (IVI) were selected.

3.8. Whole garden

It is clear from Table (6) that *Ficus microcarpa* was the most numerous tree presented in the whole garden (72.00), the height varied between 4.00 and 15.00 m with an average of 10.67 m, while the DBH varied between 22.28 and 171.89 cm with an average of 79.80 cm. *Syzygium cuminii* came in the second position regarding the number of individuals (36.00), the height varied between 6.00 and 14.00 m with an average of 9.62 m, while the DBH varied between 22.92 and 73.25 cm with an average of 52.39 cm. Although *Khaya senegalensis* counted a smaller number of individuals (17) than *Ficus microcarpa*, it recorded higher values of height and DBH. In this connection, the height varied between 9.00 and 22.00 m with an average of 16.64 m, while the DBH varied between 22.92 and 138.50 cm with an average of 86.56 cm.

The highest maximum height trees (22.00 m) were recorded for *Khaya senegalensis*, *Alstonia scholaris*, *Bombax ceiba*, *Pterygota alata*, *Syzygium grande* followed by *Tamarindus indica*, *Mangifera indica*, *Casuarina equisetifolia*, *Artocarpus altilis*, *Couroupita guianensis*, *Sterculia urens* as recorded 20.00 m then *Swietenia mahagoni*, *Azadirachta indica*, *Albizia lucidior* as recorded 18.00 m (Table, 7). In the same concern, the highest DBH can be ranked descendingly as *Bombax ceiba* > *Ficus sycomorus* > *Ficus microcarpa* > *Ficus sp.* > *Chorisia speciose* > *Khaya senegalensis* as recorded 184.62, 182.07, 171.89, 146.50, 144.83 and 138.50 cm, respectively (Table, 7).

Table (6). Some growth parameters for species with the most numerous individuals of whole garden

Species	Total No	Height (m)				DBH (cm)			
		Min.	Max.	Average	SD	Min.	Max.	Average	SD
Ficus microcarpa	72	4.00	15.00	10.67	3.16	22.28	171.89	79.80	45.03
Syzygium cuminii	36	6.00	14.00	9.62	2.12	22.92	73.25	52.39	13.01
Plumeria rubra	29	5.00	9.00	6.81	1.28	14.33	27.06	20.63	3.23
Artocarpus heterophyllus	20	6.00	11.00	8.20	1.48	25.15	64.94	37.12	13.28
Tamarindus indica	19	10.00	20.00	13.93	2.74	37.88	90.76	64.89	18.71
Khaya senegalensis	17	9.00	22.00	16.64	3.35	22.92	138.50	86.56	30.79
Balanites aegyptiaca	15	4.00	8.00	5.50	2.18	10.82	44.90	22.71	19.23
Citrus sinensis	15	5.00	8.00	5.70	0.95	10.19	26.11	18.18	5.40
Swietenia mahagoni	13	10.00	18.00	13.82	2.14	20.69	111.41	57.48	33.54
Bauhinia variegata	11	6.00	10.00	7.11	1.54	9.55	50.93	25.58	14.42
Mangifera indica	11	7.00	20.00	11.40	3.86	31.21	78.30	51.32	18.83
Spathodea campanulata	11	6.00	15.00	8.20	2.74	17.83	38.83	26.77	6.06
Cordia myxa	10	6.00	15.00	9.29	3.68	19.10	105.10	50.64	29.16
Delonix regia	10	8.00	16.00	11.33	3.12	42.67	74.17	60.17	11.09
Psidium guajava	10	5.00	7.00	6.29	0.76	8.60	24.52	17.78	5.65

3.9. Southern section

As for the middle age trees, data in Table (8), *Ficus lutea* recorded the highest number (2), the highest values of BA/species (0.13 m^2), RDi (28.57%), RDo (27.43%) and IVI (28.00%). While *Alstonia scholaris* recorded the highest height (13 m) and *Pterocarpus dalbergioides* recorded the highest DBH (38.83 cm) and BA/tree (0.12 m^2).

Ficus microcarpa in the old age group was superior in all evaluated characters except height, the recorded values were 64, 114.91 cm, 1.04 m^2, 66.37 m^2, 22.15%, 57.32% and 39.73% for count, DBH, BA/tree, BA/species, RDi, RDo and IVI, respectively. on the other hand, Bombax ceiba revealed the tallest trees (17.20 m).

In the case of the young age group, the highest number of individuals was observed (11.00) with *Balanites aegyptiacus* which also recorded the highest RDi (15.49%) and IVI (11.13%) values. Albizia procera was superior in terms of DBH (31.51 cm), BA/tree (0.08 m^2), BA/species (0.23 m^2) and RDo (15.65%). The tallest tree was recorded for *Gmelina arborea* (12.00 m) which was associated with high DBH (31.51 cm) and BA/trees (0.08 m^2).

Table (7). Species with the highest maximum height (m) and DBH (cm)

Species	Max. height (m)	Species	Max. DBH (cm)
Khaya senegalensis, Alstonia scholaris, Bombax ceiba, Pterygota alata, Syzygium grande	22.00	*Bombax ceiba*	184.62
Tamarindus indica, Mangifera indica, Casuarina equisetifolia, Artocarpus altilis, Couroupita guianensis, Sterculia urens	20.00	*Ficus sycomorus*	182.07
Swietenia mahagoni, Azadirachta indica, Albizia lucidior	18.00	*Ficus microcarpa*	171.89
Cassia javanica, Ficus sp., Corymbia citriodora	17.00	*Ficus sp.*	146.50
Delonix regia, Ficus sycomorus, Mimusops elengi, Ficus benjamina, Albizia lebbeck, Tipuana tipu, Acacia modesta, Adenanthera pavonina, Millettia brandisiana, Sterculia foetida, Manilkara hexandra	16.00	*Chorisia speciosa*	144.83
Ficus microcarpa, Spathodea campanulata, Cordia myxa, Chorisia speciosa, Strychnos nux-vomica, Tectona grandis, Madhuca longifolia, Terminalia catappa, Conocarpus erectus, Enterolobium contortisiliquum, Kigelia pinnata (*K. Africana*), *Chrysophyllum oliviforme, Dalbergia sissoo, Pterocarpus indicus, Albizia procera, Ficus elastica, Ficus platyphylla, Tabebuia rosea, Adansonia digitata , Eucalyptus camaldulensis, Ailanthus altissima, Ficus sp.*	15.00	*Khaya senegalensis*	138.50

3.10. Middle section

In the case of middle age trees, data in Table (9) showed that, *Premna odorata* recorded the highest DBH (32.80 cm), the highest values of BA/tree (0.08 m^2), BA/species (0.08 m^2), RDo (33.60%) and IVI (23.94%). Meanwhile *Pterospermum acerifolium* recorded the highest number (2.00) and RDi (28.57%). On the other hand, *Pithecellobium dulce* was the tallest tree (12.00 m).

As for the old age group, *Tamarindus indica* recorded the highest count (9.00), BA/species (3.85 m^2), RDi (5.52%), RDo (8.88%) and IVI (7.20%). On the other side, *Alstonia scholaris* was the tallest tree (18.67 m), *Ficus microcarpa* presented the highest DBH (59.08 cm) and *Khaya senegalensis* recorded the highest BA/tree (0.73 m^2).

Tipuana tipu in the young age group recorded the highest DBH (31.05 cm), BA/tree (0.08 m^2), BA/species (0.15 m^2), RDo (9.58%) and IVI (6.00%). In this regard both *Pterocarpus dalbergioides* and *Gmelina arborea* were the tallest trees as recorded 13.00 m. meanwhile *Ficus hispida*, *Celtis sinensis* and *Bauhinia variegata* recorded the same highest values in case of count (3.00) and RDi (3.61%).

Table (8). Some trees parameter of Aswan Botanical Garden south section

Species	Count	Height (m)	DBH (cm)	BA/tree (m^2)	BA/ species (m^2)	RDi (%)	RDo (%)	IVI (%)
	Medium							
Ficus lutea	2.00	8.50	28.65	0.06	0.13	28.57	27.43	28.00
Pterocarpus dalbergioides	1.00	10.00	38.83	0.12	0.12	14.29	25.20	19.75
Kigelia pinnata (K. Africana)	1.00	10.00	35.01	0.10	0.10	14.29	20.49	17.39
Swietenia mahagoni	1.00	12.00	25.46	0.05	0.05	14.29	10.84	12.56
Alstonia scholaris	1.00	13.00	23.87	0.04	0.04	14.29	9.53	11.91
Morus macroura	1.00	7.00	19.74	0.03	0.03	14.29	6.51	10.40
	Old							
Ficus microcarpa	64.00	11.75	114.91	1.04	66.37	22.15	57.32	39.73
Khaya senegalensis	12.00	16.67	90.56	0.64	7.73	4.15	6.67	5.41
Plumeria rubra	18.00	7.29	22.24	0.04	0.70	6.23	0.60	3.42
Ficus sycomorus	6.00	13.80	79.70	0.50	2.99	2.08	2.59	2.33
Bombax ceiba	5.00	17.20	91.04	0.65	3.25	1.73	2.81	2.27
Syzygium cuminii	9.00	9.00	44.95	0.16	1.43	3.11	1.23	2.17
Ficus amplissima	7.00	10.00	57.93	0.26	1.85	2.42	1.59	2.01
Chorisia speciosa	6.00	9.83	69.23	0.38	2.26	2.08	1.95	2.01
Paulownia tomentosa	8.00	8.00	26.10	0.05	0.43	2.77	0.37	1.57
Pleiogynum timoriense	6.00	10.33	48.70	0.19	1.12	2.08	0.97	1.52
Enterolobium contortisiliquum	4.00	12.75	77.51	0.47	1.89	1.38	1.63	1.51
Citrus sinensis	8.00	5.50	16.55	0.02	0.17	2.77	0.15	1.46
	Young							
Balanites aegyptiacus	11.00	4.50	10.82	0.01	0.10	15.49	6.77	11.13
Albizia procera	3.00	8.00	31.51	0.08	0.23	4.23	15.65	9.94
Pterocarpus indicus	2.00	9.50	27.85	0.06	0.12	2.82	8.15	5.48
Brachychiton rupestris	2.00	8.50	23.24	0.04	0.08	2.82	5.67	4.25
Millingtonia hortensis	2.00	10.50	19.42	0.03	0.06	2.82	3.96	3.39
Gmelina arborea	1.00	12.00	31.51	0.08	0.08	1.41	5.22	3.31
Alstonia scholaris	2.00	9.00	18.94	0.03	0.06	2.82	3.77	3.29
Robinia pseudoacacia	2.00	7.00	17.51	0.02	0.05	2.82	3.22	3.02
Citrus aurantium	3.00	4.33	10.19	0.01	0.02	4.23	1.64	2.93
Oroxylum indicum	3.00	4.83	8.81	0.01	0.02	4.23	1.22	2.72
Hibiscus tiliaceus	2.00	6.00	14.48	0.02	0.03	2.82	2.20	2.51
Tectona grandis	1.00	9.00	25.46	0.05	0.05	1.41	3.41	2.41

Table (9). Some trees parameter of Aswan Botanical Garden middle section

Species	Count	Height (m)	DBH (cm)	BA/tree (m^2)	BA/ species (m^2)	RDi (%)	RDo (%)	IVI (%)
	Medium							
Premna odorata	1.00	6.00	32.80	0.08	0.08	14.29	33.60	23.94
Pterospermum acerifolium	2.00	6.00	14.33	0.02	0.03	28.57	12.83	20.70
Pithecellobium dulce	1.00	12.00	28.34	0.06	0.06	14.29	25.08	19.68
Terminalia arjuna	1.00	7.00	20.10	0.03	0.03	14.29	12.62	13.45
Cassia javanica subsp. nodosa	1.00	7.00	19.42	0.03	0.03	14.29	11.78	13.03
Sterculia foetida	1.00	7.00	11.46	0.01	0.01	14.29	4.10	9.19
	Old							
Tamarindus indica	9.00	15.71	73.84	0.43	3.85	5.52	8.88	7.20
Cordia myxa	8.00	10.40	60.72	0.29	2.32	4.91	5.34	5.12
Syzygium cuminii	8.00	9.50	56.37	0.25	2.00	4.91	4.60	4.75
Khaya senegalensis	4.00	18.50	96.49	0.73	2.92	2.45	6.74	4.60
Ficus microcarpa	6.00	11.25	59.08	0.27	1.64	3.68	3.79	3.74
Strychnos nux-vomica	6.00	12.00	55.52	0.24	1.45	3.68	3.35	3.51
Swietenia mahagoni	4.00	14.33	78.02	0.48	1.91	2.45	4.41	3.43
Madhuca longifolia	7.00	11.17	41.12	0.13	0.93	4.29	2.14	3.22
Alstonia scholaris	3.00	18.67	85.88	0.58	1.74	1.84	4.00	2.92
Adansonia digitata	3.00	12.67	80.57	0.51	1.53	1.84	3.52	2.68
Dalbergia sissoo	4.00	11.75	57.24	0.26	1.03	2.45	2.37	2.41
Ficus platyphylla	3.00	14.33	73.78	0.43	1.28	1.84	2.96	2.40
	Young							
Tipuana tipu	2.00	9.50	31.05	0.08	0.15	2.41	9.58	6.00
Pterocarpus dalbergioides	2.00	13.00	29.93	0.07	0.14	2.41	8.91	5.66
Gmelina arborea	2.00	13.00	28.50	0.06	0.13	2.41	8.08	5.24
Ficus hispida	3.00	5.50	19.75	0.03	0.09	3.61	5.82	4.71
Celtis sinensis	3.00	5.67	17.51	0.02	0.07	3.61	4.57	4.09
Bauhinia variegata	3.00	6.00	16.08	0.02	0.06	3.61	3.86	3.74
Ceiba pentandra	2.00	9.00	19.74	0.03	0.06	2.41	3.87	3.14
Acacia laeta(senegalia-)	1.00	9.00	27.70	0.06	0.06	1.20	3.81	2.51
Putranjiva roxburghii	2.00	5.00	15.60	0.02	0.04	2.41	2.42	2.41
Pterocarpus indicus	1.00	9.00	26.75	0.06	0.06	1.20	3.56	2.38
Koelreuteria henryi	2.00	7.00	13.85	0.02	0.03	2.41	1.91	2.16
Cordia dichotoma	1.00	7.00	24.52	0.05	0.05	1.20	2.99	2.10

3.11. Northern section

In the middle age group data in Table (10) cleared that, *Swietenia mahagoni* recorded the tallest tree (14.00 m) and *Ficus benjamina* recorded the highest DBH (32.47 cm), BA/tree (0.08 m^2),

BA/species (0.08 m^2), RDo (29.64%) and IVI (24.82%). All tree species were equal in count (only one) and Rdi (20.00%).

It is clear in the old age group that *Syzygium cuminii* presented the highest number of individuals (19.00), BA/species (4.93 m^2), Rdi (12.18%), Rdo (12.22%) and IVI (12.20%). On the other hand, *Swietenia mahagoni* and *Corymbia citriodora* were the tallest trees (16.00 m for each), while *Ficus sycomorus* produced the highest DBH (137.99 cm) and BA/tree (1.50 m^2).

In the case of young group trees *Bauhinia variegate* recorded the highest number (3.00) and the highest Rdi value (4.29%), while *Ceiba pentandra* was the tallest tree (13.00 m), produced the highest BA/species (0.18), Rdo (8.15%) and IVI (5.50%). *Enterolobium contortisiliquum* registered the highest DBH value (40.11 cm) and BA/tree (0.13 m^2).

Table (10). Some trees parameter of Aswan Botanical Garden North section

Species	No	F Height	F DBH	BA (m2)/tree	BA (m2)/species	Rdi%	Rdo%	IVI%
	Medium							
Ficus benjamina	1.00	10.00	32.47	0.08	0.08	20.00	29.64	24.82
Terminalia catappa	1.00	12.00	28.65	0.06	0.06	20.00	23.07	21.54
Swietenia macrophylla	1.00	9.00	27.06	0.06	0.06	20.00	20.58	20.29
Swietenia mahagoni	1.00	14.00	25.15	0.05	0.05	20.00	17.78	18.89
Spathodea campanulata	1.00	8.00	17.83	0.02	0.02	20.00	8.93	14.47
	Old							
Syzygium cuminii	19.00	10.30	57.45	0.26	4.93	12.18	12.22	12.20
Artocarpus heterophyllus	11.00	9.00	59.52	0.28	3.06	7.05	7.59	7.32
Azadirachta indica	8.00	11.20	59.27	0.28	2.21	5.13	5.47	5.30
Tamarindus indica	8.00	11.50	49.02	0.19	1.51	5.13	3.74	4.44
Ficus sycomorus	2.00	13.50	137.99	1.50	2.99	1.28	7.42	4.35
Swietenia mahagoni	4.00	16.00	85.52	0.57	2.30	2.56	5.70	4.13
Mangifera indica	6.00	10.00	55.13	0.24	1.43	3.85	3.55	3.70
Chorisia speciose	2.00	15.00	124.14	1.21	2.42	1.28	6.00	3.64
Delonix regia	5.00	9.00	61.67	0.30	1.49	3.21	3.70	3.45
Tectona grandis	4.00	13.00	67.06	0.35	1.41	2.56	3.50	3.03
Cassia javanica	3.00	13.33	69.50	0.38	1.14	1.92	2.82	2.37
Corymbia citriodora	3.00	16.00	64.94	0.33	0.99	1.92	2.46	2.19
	Young							
Ceiba pentandra	2.00	13.00	34.06	0.09	0.18	2.86	8.15	5.50
Conocarpus erectus	2.00	10.00	31.83	0.08	0.16	2.86	7.12	4.99
Enterolobium contortisiliquum	1.00	9.00	40.11	0.13	0.13	1.43	5.65	3.54
Cordia Africana	2.00	9.00	23.55	0.04	0.09	2.86	3.90	3.38
Ficus microcarpa	2.00	4.00	22.28	0.04	0.08	2.86	3.49	3.17
Dalbergia lanceolaris subsp. Paniculata = D. Paniculata	1.00	10.00	35.01	0.10	0.10	1.43	4.31	2.87
Bauhinia variegata	3.00	7.00	10.19	0.01	0.02	4.29	1.09	2.69
Moringa stenopetala	1.00	6.00	33.42	0.09	0.09	1.43	3.92	2.68
Acacia laeta	2.00	5.50	18.78	0.03	0.06	2.86	2.48	2.67
Moringa oleifera	2.00	7.00	18.14	0.03	0.05	2.86	2.31	2.59
Pterocarpus dalbergioides	1.00	11.00	31.83	0.08	0.08	1.43	3.56	2.49
Pithecellobium dulce	1.00	6.00	29.92	0.07	0.07	1.43	3.15	2.29

BA (basal area), Rdi% (relative species density), Rdo% (relative species dominance), IVI% (importance value index)

3.12. Threatened status of tree species

Most tree species in Aswan Botanical Garden were categorized according to the IUCN website, Red List as Least Concern, Data Deficient, or Not Evaluated. Fourteen tree species are categorized as Endangered (*Pterocarpus indicus, Swietenia macrophylla,* and *Tectona grandis*), Vulnerable (*Jacaranda mimosifolia, Khaya senegalensis, Pterocarpus dalbergioides, Araucaria heterophylla, Eucalyptus gomphocephala, Macadamia integrifolia* and *Sequoia sempervirens*), or Near Threatened (*Eucalyptus camaldulensis*, *Swietenia mahagoni*, *Aegle marmelos* and *Platycladus orientalis*). According to the IUCN website, Endangered and Vulnerable species are considered to be at a very high risk of extinction in the wild, so the species under these categories were classified as threatened. Near Threatened species were close to qualifying for or were likely to qualify for, a threatened category in the near future.

Table (11). Threatened status of Aswan Botanical Garden tree species

Species	Count				Threatened status	Reference
	Medium	Old	Young	Total		
Aegle marmelos	-	-	3	3	Near Threatened (NT)	Plummer 2020
Araucaria heterophylla	-	-	1	1	Vulnerable (VU)	Thomas (2024).
Eucalyptus camaldulensis	-	1	1	2	Near Threatened (NT)	Fensham *et al.* (2019)
Eucalyptus gomphocephala	-	-	1	1	Vulnerable (VU)	Fensham *et al.* (2019)
Jacaranda mimosifolia	-	5	-	5	Vulnerable (VU)	Hills (2020)
Khaya senegalensis	-	17	-	17	Vulnerable (VU)	W.C.M.C. (1998)
Macadamia integrifolia	-	-	1	1	Vulnerable (VU)	Forster *et al.* (2020)
Platycladus orientalis	1	7	1	9	Near Threatened (NT)	Farjon (2013)
Pterocarpus dalbergioides	1	-	3	4	Vulnerable (VU)	Barstow (2018a)
Pterocarpus indicus	-	1	4	5	Endangered (EN)	Barstow (2018b)
Sequoia sempervirens	1	-	-	1	Vulnerable (VU)	Farjon and Schmid (2013)
Swietenia macrophylla	1	1	-	2	Endangered (EN)	Barstow and Negrão (2023)
Swietenia mahagoni	2	9	2	13	Near Threatened (NT)	Barstow (2020)
Tectona grandis	-	7	1	8	Endangered (EN)	Gua *et al.* (2022)

4. Discussion

Since ancient times Botanical Garden play a major role in the science of plant division. of conservation and protection of endangered species. Botanic gardens are essential for education the public about climate change and involving them in the subject. Drawing on decades of historical evolution, botanic gardens have emerged as preeminent worldwide establishments specializing in conservation, research, teaching, and recreation. Botanical gardens are becoming more and more important in offering a scientific foundation for the protection and sustainable utilization of plant variety. As public awareness of biodiversity grows, they play a significant role as public windows **(Borsch and Lohne, 2014)**. In a world where the planet's flora resources are being threatened at a rate never seen before, the botanical garden is more than just a pretty place to have a picnic; it's also a significant space that displays plant diversity and allows researchers to come up with novel ideas and suggest fresh approaches to preserve and increase biodiversity. Additionally, botanical gardens are

crucial to the preservation of tree species, but they also suggest ways to improve biodiversity conservation in the future **(Khamis and Bahnasy, 2023)**.

This study's objectives to evaluate the diversity of tree species presented in Aswan Botanical Garden by determining the numbers, morphological characteristics and some diversity indices.

It can be concluded from aforementioned results that, Aswan Botanical Garden contained 209 tree species, 851 tree individuals and 43 plant families. Fabaceae family recorded the highest number of individuals and species for the whole garden then Moraceae, Myrtaceae, Malvaceae, Bignoniaceae then Meliaceae, respectively.

The biodiversity indices showed high diversity and equal abundance in the whole garden. *Ficus microcarpa* recorded the highest number of individuals in the whole garden.

Khaya senegalensis, Alstonia scholaris, Bombax ceiba, Pterygota alata and *Syzygium grande* recorded the tallest tree in the whole garden, respectively, while recorded the highest DBH, respectively. Also the Garden contained 8 tree species classified by IUCN as endangered, vulnerable or near threatened.

These results are agreement with those reported by **Abd El Migid *et al.* (2014)**. Also **Mohamed *et al.* (2014)** study the inventory, assess, and record the perennial plants that were grown at Egypt's Aswan Botanical Garden. The results show that a total of 361 species from 263 genera and 88 families were gathered and identified using existing checklists and regional floras. Leguminosae, Palmae, Moraceae, and Bignoniaceae were the most prevalent families. Ten species each for the Apocynaceae and Labiatae, and sixteen and fourteen species each for the Myrtaceae and Euphorbiaceae were found. Additionally, three species represented six families, two species represented eleven families, and one species represented forty-two families. There were 192 (53.19%), 75 (20.78%), and 29 (8.03%) species of trees, shrubs, and perennial plants, respectively. The floristic composition diversity and tree density at the Orman Botanical Garden in Giza, Egypt, were clarified by **Bahnasy and Khamis (2019)**. According to the assessment, there are 576 individual trees in the garden, which represent 58 families and 247 species. The most prevalent family in the garden is Fabaceae, which is followed by Bignoniaceae, Meliaceae, Pinaceae, Moraceae, Cupressaceae, and Malvaceae. The angiosperm clade produced 228 tree species from 158 genera and 53 families out of the 247 species identified in the garden. This is much more than the gymnosperm clade. The garden's tallest trees were *Terminalia arjuna* (one specimen), *Eucalyptus camaldulensis* (four specimens), and *Dalbergia sisso* (one specimen). *Tabernaemontana divaricate* was the tree that suppressed. *Ficus benghalensis, F. palmata,* and *F. religiosa* were the three enormous trees, measuring 250, 222.3, and 213.7 cm at dbh, respectively. The garden's relative species dominance (RDo) was higher in *Taxodium distichum* than in *Ficus nitida* and *Ficus religiosa*, whereas the greatest RDi was found in *Ficus nitida and Taxodium distichum. Ficus nitida* and *Taxodium distichum* received the greatest Importance Value Index (IVI). The Shannon-Weaver and Simpson indices of species richness, evenness, and diversity as well as the Jaccard and Sorensen indices of similarity were examined. With an emphasis on endangered species, Ahmed *et al.* (2020) study attempts to assess the contribution of Egyptian gardens to the protection of wild plants in the Nile Region. An overview of their life types, geographic ranges, economic applications, environmental advantages, conservation classifications, and local dangers in their natural habitats is provided for this assessment. also found that there were 96 species identified representing 43 families and 76 genera. Acacia was the most represented genus and Fabaceae the most documented family. The most prevalent living type (39.6%) was phagerophytes. Of these, 20 species were limited to the Nile area, which had the highest representation (75 species, 78.1%). In addition, 21 species from different phytogeographical zones, including the Sinai, Mediterranean, Gebal Elba, and deserts, were preserved in garden. The most prevalent commercial applications were medicinal plants (58 species), whereas the most prevalent environmental advantages were nitrogen fixers trees (37.9%). At least one hazard affects 87 species in their native habitats, with over-collecting species accounting for the majority of risks (70.1%). Twenty-three foreign species and seventy-three native species were identified. Five least worried, one endangered, and one vulnerable species were among the seven listed as IUCN threatened. The findings demonstrate the endless potential of public and botanic gardens in the Egyptian Nile Region for the preservation of plant variety, since they assist to preserve not only the endangered species

within the research area but also wild plant species from other geographic areas. Also **Aderounmu *et al*. (2017)** studied, the growth traits and variety of tree species at the University of Ibadan Botanical Gardens in order to gather information for better garden management. The following growth parameters were assessed: diameters at breast height (DBH), middle, base, and top, as well as total and merchantable height. According to the findings, *Terminalia cattapa* had the smallest tree volume, while *Afzelia africana* had the largest, followed by *Vitex doniana*. Twelve species each possessed a single tree, with *Cedrela odorata* having the highest frequency of solitary trees, followed by *Delonix regia*. The majority of the garden's tree species are resistant to wind-induced damage, according to the Slenderness Coefficient (SLC). Despite some kind of resistance, only *Enterolobium cyclocarpum* had considerable SLC, making it susceptible to wind velocity. For better botanical garden management, more studies focused on tree shape and growth characteristics must be supported. **Khamis and Bahnasy (2023)**. Studied the measure of the diversity of woody species in Giza Zoo garden. Indices of species richness, Shannon, and Simpson's diversity were calculated. The conservation potential of the trees in the garden was also assessed using the conservation status and the species significance value index, which measures a species' dominance in a particular population. According to the IUCN Red List, the garden is essential to the conservation of 145 individuals of threatened trees from 18 species that are classified as endangered, near threatened, or vulnerable.

Thus, based on the findings of this research, showed that Aswan Botanical Garden in Egypt is essential to the preservation of numerous important tree species that yield high-quality timber used in various wood industries for various purposes. It is home to numerous economic species, including *Swietenia macrophylla, Swietenia mahagoni, Khaya senegalensis, Tectona grandis, Eucalyptus* sp., *Corymbia citriodora, Acacia* sp., *Albizia* sp., *Tipuana tipu* and *Dalbergia* sp. Additionally, Aswan Botanical Garden play a crucial role in protecting endangered tree species. Since the tree species that were discovered in the garden are significant and some of them fall under the category of "endangered" or another threatened species, they ought to be saved and propagate it.

5. Conclusion

With a remarkable high number of woody species that are unique to Egypt, particularly tropical species, Aswan Botanical Garden is a hotspot of diversity. Across the three garden parts, 851 individual trees representing 209 species from 43 families were found.

Although the middle section occupied the biggest area than the other two sections, the southern section contained the highest number of individuals and density/fed compared to the middle and north sections. For the whole garden, the medium age trees recorded the lowest number than the young and the old trees which recorded the highest number of trees. The highest number of young age tree species were observed in the middle section then the northern then the southern.

Fabaceae family recorded the highest number of individuals and species for whole garden then Moraceae, Myrtaceae, Malvaceae, Bignoniaceae then Meliaceae, respectively. There were no dominant species in the garden as there were no eudominant species with more than 10% dominant. The majority was for subrecedent species with less than 1% dominant (194 species from 209 in the garden). Also, there were 68 species that contained only one tree, 40 species that contained more than 5 trees, while the majority were for the tree species contained between 2 – 5 trees/species.

The highest species richness was recorded in the middle section (136), then southern then northern. Also, there were no dominant species in the whole garden or its sections. Biodiversity indices showed high diversity and equal abundance in the whole garden and its sections, the middle section recorded the highest indices.

Ficus microcarpa, *Syzygium cuminii*, *Plumeria rubra* and *Artocarpus heterophyllus* recorded the highest number of individuals in the whole garden (72, 36, 29 and 20, respectively).

Khaya senegalensis, *Alstonia scholaris*, *Bombax ceiba*, *Pterygota alata* and *Syzygium grande* recorded the tallest tree in the whole garden (22.0 m), while

Bombax ceiba, *Ficus sycomorus* and *Ficus microcarpa* recorded the highest DBH (184.62, 182.07 and 171.89 cm, respectively).

Aswan Botanical Garden contained 14 species classified by IUCN as endangered, vulnerable or near threatened, most of these species are old age trees, followed by young, while a few were medium age. Aswan Botanical Garden in Egypt is crucial to the preservation of several significant tree species that provide high-quality timber used for a variety of uses in the wood industry. *Swietenia macrophylla, Swietenia mahagoni, Khaya senegalensis, Tectona grandis, Eucalyptus* sp., *Corymbia citriodora, Acacia* sp., *Albizia* sp., *Tipuana tipu,* and *Dalbergia* sp. are among the many economically significant species that call it home.

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APPENDIX

1. List of tree species in the northern section:

Acacia albida = Faidherbia albida
Acacia auriculiformis
Acacia farnesiana= Vachellia farnesiana
Acacia galpinii= Senegalia galpinii
Acacia laeta = Senegalia laeta
Acacia modesta = Senegalia modesta
Acacia nilotica= Vachellia nilotica
Acacia seyal
Nephelium tomentosum= Alectryon tomentosus
Alstonia scholaris
Antidesma bunius Amoora rohituca=
Aphanamixis polystachya
Artocarpus heterophyllus
Azadirachta indica
Balanites aegyptiaca
Bauhinia monandra
Bauhinia purpurea
Bauhinia retusa
Bauhinia tomentosa
Bauhinia variegata
Bixa orellana
Callistemon viminalis= Melaleuca viminalis
Cassia javanica
Casuarina equisetifolia
Catalpa speciosa
Ceiba pentandra
Celtis sinensis
Ceratonia siliqua
Chorisia speciosa
Chrysophyllum oliviforme
Citrus aurantium
Citrus sinensis
Conocarpus erectus
Cordia africana
Cordia myxa *Eucalyptus citriodora = Corymbia citriodora*

Dalbergia paniculata = Dalbergia lanceolaris subsp. *Paniculata*
Delonix regia = Poinciana regia
Dimocarpus longan
Diospyros discolor
Diospyros malabarica = D. embryopteris
Ehretia anacua
Ehretia wallichiana
Enterolobium contortisiliquum
Eriobotrya japonica
Erythrina variegata = E. indica
Eugenia edulis =Hexachlamys edulis
Eugenia supra-axillaris
Eugenia uniflora
Ficus benghalensis
Ficus benjamina
Ficus cyathistipula
Ficus drupacea = F. drupacea var. pubescens
Ficus decora= F. elastica
Ficus hispida
Ficus lutea
Ficus microcarpa= F. nitida
Ficus platypoda
Ficus sycomorus
Ficus thonningii = F. spragueana
Ficus trigonata
Flacourtia sepiaria = F. indica
Flacourtia rukam
Garcinia livingstonei
Gmelina arborea
Grewia asiatica
Harpullia pendula
Hibiscus tiliaceus
Jacaranda mimosifolia
Khaya senegalensis
Kigelia pinnata = Kigelia africana
Koelreuteria henryi
Lagerstroemia indica
Mangifera indica
Markhamia lutea Pongamia pinnata=
Millettia pinnata
Millingtonia hortensis
Mimusops caffra
Mimusops elengi
Moringa oleifera
Moringa stenopetala
Morus alba
Morus macroura
Olea europaea
Parkinsonia aculeata
Parmentiera aculeata
Persea americana
Pimenta racemosa
Pistacia terebinthus
Inga dulcis = Pithecellobium dulce
Pittosporum tobira
Plumeria rubra
Podocarpus neriifolius
Polyalthia longifolia

Premna odorata
Psidium guajava
Pterocarpus dalbergioides
Pterocarpus indicus
Pterospermum acerifolium
Sterculia alata = Pterygota alata
Putranjiva roxburghii
Radermachera ignea = Mayodendron igneum
Salix tetrasperma
Sapindus saponaria
Sapium aucuparium
Saraca indica
Schotia brachypetala *Cassia occidentalis = Senna occidentalis*
Cassia spectabilis= Senna spectabilis
Sophora secundiflora = Dermatophyllum secundiflorum
Spathodea campanulata = S. nilotica
Strychnos nux-vomica
Swietenia macrophylla
Swietenia mahagoni
Eugenia jambolana= Syzygium cuminii
Tabebuia pentaphylla = T. rosea
Tamarindus indica
Tectona grandis
Terminalia arjuna
Terminalia catappa
Terminalia muelleri
Terminalia myriocarpa
Thespesia populnea
Thevetia peruviana= Cascabela thevetia *Machaerium tipu= Tipuana tipu*
Cedrela toona= Toona ciliate
Vitex agnus-castus

2. List of tree species in the middle section:

Acacia galpinii= Senegalia galpinii
Acacia laeta =Vachellia nilotica
Acacia modesta= Senegalia modesta
Acacia nilotica= Vachellia nilotica
Acacia robusta = Vachellia robusta
Acacia seyal
Adansonia digitata
Adenanthera pavonina
Ailanthus altissima
Nephelium tomentosum= Alectryon tomentosus
Alstonia scholaris
Anacardium occidentale
Annona glabra
Amoora rohituca= Aphanamixis polystachya
Artocarpus heterophyllus
Bauhinia retusa
Bauhinia variegata
Lonchocarpus speciosus = Bolusanthus speciosus
Bombax ceiba
Caesalpinia sappan =Biancaea sappan
Cassia javanica
Cassia javanica subsp. *nodosa = C. nodosa*
Ceiba pentandra
Celtis sinensis
Cinnamomum camphora
Citrus aurantiifolia
Citrus sinensis

Cordia dichotoma
Cordia myxa
Dalbergia sissoo Poinciana regia =
Delonix regia
Diospyros chloroxylon
Diospyros ebenum
Diospyros malabarica
Enterolobium contortisiliquum
Erythrina indica= E. variegata
Eugenia supra-axillaris
Euphorbia royleana
Ficus benjamina
Ficus carica
Ficus hirta
Ficus hispida
Ficus nitida = F. microcarpa.
Ficus pseudosycomorus = F. palmata
Ficus platyphylla
Ficus religiosa
Flacourtia rukam
Garcinia livingstonei
Gardenia latifolia
Gliricidia sepium
Gmelina arborea
Grevillea robusta
Grewia asiatica
Hibiscus tiliaceus
Hymenaea courbaril
Khaya senegalensis
Kigelia pinnata= Kigelia africana
Koelreuteria henryi
Koelreuteria paniculata
Lagerstroemia indica
Leucaena leucocephala
Madhuca longifolia
Mangifera indica
Melaleuca leucadendra
Millettia brandisiana
Pongamia pinnata= Millettia pinnata
Millingtonia hortensis
Mimusops caffra
Mimusops elengi
Moringa stenopetala
Morus macroura
Muntingia calabura
Parkinsonia aculeata
Persea americana
Phoenix dactylifera
Phyllanthus emblica
Pistacia terebinthus
Inga dulcis = Pithecellobium dulce
Thuja orientalis =Platycladus orientalis
Pleiogynum timoriense
Plumeria rubra
Polyalthia longifolia
Polyalthia suberosa
Pouteria campechiana
Premna odorata
Psidium guajava
Pterocarpus dalbergioides
Pterocarpus indicus
Pterospermum acerifolium
Sterculia alata= Pterygota alata

Saraca indica
Senna candolleana
Cassia spectabilis= Senna spectabilis
Cassia glauca=Senna surattensis subsp. *sulfurea = Senna sulfurea*
Spathodea nilotica = S. campanulata
Strychnos nux-vomica
Swietenia mahagoni Eugenia jambolana=
Syzygium cuminii
Eugenia grandis= Syzygium grande

Eugenia javanica= Syzygium samarangense
Tabebuia pallida T. pentaphylla=Tabebuia rosea
Tamarindus indica
Tectona grandis
Terminalia arjuna
Terminalia catappa
Terminalia myriocarpa
Thevetia peruviana
Tipuana tipu = Machaerium tipu
Vitex agnus-castus
Ziziphus sp.
Ziziphus spina- christi

3. List of tree species in the southern section:

Acacia farnesiana= Vachellia farnesiana
Acacia laeta =Senegalia laeta
Acacia nilotica= Vachellia nilotica
Adenanthera pavonina
Albizia lebbeck
Albizia lucida =A.lucidior
Albizia procera Nephelium tomentosum= Alectryon tomentosus
Alstonia scholaris
Annona squamosa
Antidesma bunius
Amoora rohituca= Aphanamixis polystachya
Artocarpus altilis
Artocarpus heterophyllus
Averrhoa carambola
Bauhinia forficata
Bauhinia hookeri=Lysiphyllum hookeri
Bauhinia retusa= Bauhinia roxburghiana
Bauhinia variegata var. candida

Bombax ceiba
Brachychiton rupestris
Caesalpinia sappan
Casimiroa edulis
Cassia fistula
Casuarina equisetifolia
Catalpa speciosa
Ceiba pentandra
Ceratonia siliqua
Chorisia speciose=Ceiba speciosa
Chrysophyllum oliviforme
Cinnamomum verum
Citharexylon spinosum
Citrus aurantiifolia
Citrus aurantium
Citrus limetta
Citrus sinensis
Conocarpus erectus
Cordia africana
Couroupita guianensis
Dalbergia paniculata= D. lanceolaris subsp. *Paniculata*
Dalbergia sissoo
Poinciana regia =Delonix regia
Euphoria longan =Dimocarpus longan
Diospyros ebenum
Diospyros montana
Elaeis guineensis
Enterolobium contortisiliquum
Eriobotrya japonica
Erythrina indica= E. variegata
Eucalyptus camaldulensis
Ficus amplissima
Ficus benjamina
F. decora=Ficus elastica
Ficus hispida
Ficus lutea
Ficus nitida= F. microcarpa
Ficus pseudosycomorus =F. palmata
Ficus platyphylla
Ficus sycomorus
Ficus sprague ana =F. thonningii
Flacourtia jangomas
Flacourtia rukam
Garcinia dulcis
Garcinia livingstonei
Gardenia thunbergia
Gmelina arborea
Grevillea robusta
Grewia asiatica
Guazuma ulmifolia
Haematoxylum campechianum
Hardwickia binata
Hibiscus tiliaceus
Hura crepitans
Ixora sp.
Jacaranda mimosifolia
Khaya senegalensis
Kigelia africana=K. pinnata
Koelreuteria henryi
Lagerstroemia indica
Latania lontaroides
Magnolia grandiflora
Mangifera indica
Manilkara hexandra
Manilkara zapota
Millettia brandisiana
Millingtonia hortensis
Mimusops caffra
Mimusops elengi
Moringa stenopetala
Morus alba
Morus macroura
Nyctanthes arbor-tristis
Pachira aquatica
Paulownia tomentosa
Persea americana
Phoenix dactylifera
Pimenta racemosa
Pistacia terebinthus
Thuja orientalis =Platycladus orientalis
Pleiogynium timoriense
Plumeria rubra
Podocarpus macrophyllus
Premna odorata
Prunus persica
Psidium guajava
Pterocarpus dalbergioides
Pterocarpus indicus
Putranjiva roxburghii
Quercus robur
Robinia pseudoacacia
Samanea saman
Sapium aucuparium
Schotia brachypetala
Cassia siamea =Senna siamea
Cassia spectabilis =Senna spectabilis
Sophora secundiflora
Spathodea nilotica
S.campanulata
Sterculia foetida
Sterculia urens
Swietenia macrophylla
Swietenia mahagoni
Eugenia aquea =Syzygium aqueum
Eugenia jambolana =Syzygium cuminii
Eugenia javanica =Syzygium samarangense
Tabebuia argentea
Tabebuia pulcherrima
Tamarindus indica
Taxodium distichum
Tectona grandis
Terminalia bellirica
Terminalia catappa
Thevetia peruviana
Vitex agnus-castus
Ziziphus spina-christi