BULLETIN OF THE IRAQ NATURAL HISTORY MUSEUM
Iraq Natural History Research Center & Museum, University of Baghdad
https://jnhm.uobaghdad.edu.iq/index.php/BINHM/Home
Copyright © Bulletin of the Iraq Natural History Museum Online ISSN: 2311-9799, Print ISSN: 1017-8678

Bull. Iraq nat. Hist. Mus.
(2026) 19 (1): 29-58. https://doi.org/10.26842/binhm.7.2026.19.1.0029

ORIGINAL ARTICLE

INFLUENCE OF SOIL PROPERTIES ON PLANT SPECIES DISTRIBUTION AND DIVERSITY IN ANTHROPOGENIC HABITATS OF ARID NUBIAN DESERT CITIES, EGYPT

Ali Gaafar*♦, Monier M. Abd El-Ghani**, Marwa M. Ragaey*
and Salwa Abd El-Wahab*

*Department of Botany and Microbiology، Faculty of Science، New Valley University، EL-Kharga 71511, Egypt.
**Department of Botany and Microbiology, Faculty of Science, Cairo University, Giza 12613, Egypt.
♦Corresponding author: aligaafar2006@yahoo.com

Received: 2 Sep. 2025, Revised: 6 Jan. 2026, Accepted: 17 Jan. 2026, Published:20 June 2026

ABSTRACT

Home gardens (HG), public gardens (PG), road islands (RI), and vacant lots (VL) were the most common urban habitats in Kharga and Dakhla Oases that were analyzed in terms of species distribution patterns. In total, 39 geo-referenced sampling stands were surveyed and were distributed as follows among these habitats: 16 in home gardens (HG), 11 in public gardens (PG), 8 in road islands (RI), and 4 in vacant lots (VL). The total number of recorded species showed variation among habitats: 132 species in HG, followed by PG (112 species), RI (71 species), and VL (58 species). The vegetation structure of the home gardens was characterized by orchard trees, cultivated herbs and xerophytes, while that of public gardens was dominated by ornamentals and wetland plants. On the contrast, the road islands and vacant lots were largely composed of weeds and xerophytes. Eleven variables, including coarse sand (CS), fine sand (FS), clay, moisture content, electrical conductivity, soil reaction, organic matter, carbonates, sodium, sulphates, and phosphates, were used in the CCA analysis after soil variables with high inflation factors were eliminated. After applying cluster analysis to presence /absence dataset of 112 species × 39 sampling stands, 14 vegetation cluster groups were recognized, each was dominated by one or a number of species. Soil characteristics showed significant correlations with the separated cluster groups. The Shannon–Wiener index ranged from 1.93 to 3.27, and species richness ranged from 8 to 27.33 species per stand, with clear separation among vegetation groups along the DCA axes, indicating ecologically meaningful differences even without formal significance testing. Clearly, weeds and ruderal species were most abundant in disturbed habitats impacted by the effects of disturbances and the species invasion in urban habitats. Our results confirmed that managed habitats can act as biodiversity refuges in arid urban ecosystems, while disturbed sites require restoration to limit invasive spread and enhance native plant diversity.

Keywords**:** Human impacts, multivariate analysis, plant diversity, sustainability, urban habitats.

INTRODUCTION

Urban environments are characterized by a wide spectrum of plant species ranging from ornamental cultivated plants to naturally occurring flora (Sukopp and Werner, 1983). Therefore, urban vegetation is a mixture of intentionally planted species (cultivated) and spontaneous (wild) species. Among these, synanthropic plants, which are strongly shaped by human activity, flourish in cities, agricultural fields, and ruderal habitats such as waste grounds, railways, and road verges (Campos *et al*., 2004). Urban vegetation research has evolved over the last few decades, focusing on themes such as biodiversity (McKinney, 2002; Diamant *et al*., 2025). Floristic composition (Florgård, 2000; Pyšek *et al*., 2004), the spatial structuring of plant species across different habitats (Godefroid and Koedam, 2003a), and the spread of alien species (Pyšek, 1998; Bastin and Thomas 1999; Guirado *et al*., 2006; Godefroid and Koedam, 2003b; Khan, *et al*., 2023) are all examined here. Despite the progress, research on the ecological variables that control species distribution is still limited (Mucina, 1990; Sukopp, 2004). This lack of baseline ecological data hampers the integration of vegetation research into the analysis of species richness and human population size (Klotz, 1990; Pyšek, 1995), with land-use impacts examined in English cities such as Plymouth (Kent *et al*., 1999) and European capitals such as Berlin (Maurer *et al*., 2000).

Physical zonation within cities was frequently explored (Hejnỳ, 1971; Klotz, 1987), with extensive research work on the relationships between flora and vegetation (Chojnacki, 1991). Among the different challenges facing the protection of native flora are physical disturbances, pollution and habitat fragmentation (Good, 1977), and hence the prevailing species composition is strongly shaped by initial colonizing populations (Sukopp, 2002). Compared to Europe, a few research studies on urban vegetation have been initiated in other regions (Dana *et al*., 2002). Several countries of Central Europe assessed the proportion of alien plant species in the total floras which accounts for 20–60% of urban floras (Pyšek *et al*., 2004). The plant communities of urban habitats focused essentially on biodiversity patterns (Kühn *et al*., 2004; Abd El-Ghani *et al*., 2015), the distribution of species (Godefroid and Koedam, 2003a), and habitat fragmentation (Stenhouse, 2004). In addition, Abd El-Ghani *et al*., (2011), found that show that land use patterns significantly influence species distribution. The variances between urban-industrial ecosystems and surrounding non-urban landscapes are significant because of factors like shading, extensive paved surfaces, atmospheric pollution, and combustion-related heat (Zerbe *et al*., 2003; Abd El-Ghani and Hussein, 2024). The relatively high diversity of urban and industrial plant communities can be attributed to diverse land use practices, the influx of non-native species, human-mediated speciation and overall habitat heterogeneity (Zerbe *et al*., 2004). Indeed, studies consistently highlight species richness in cities as a product of habitat variety and the influx of alien plants (Gilbert, 1989).

In Egypt, establishing new cities is a national plan to redistribute population, alleviate urban congestion, and reduce agricultural land invasion. Some of these cities can be found close to major urban centers such as Cairo, Giza, and Alexandria, while others, like New

Safaga, are situated along the Red Sea. In the Sahara, oases are landscapes that have been altered by people since the third millennium BCE (Merlo, 2024), beyond their natural formation. Dakhla and Kharga southern oases are crucial areas for expansion, with rich soils and large groundwater reserves (Kato *et al*., 2014; Abdel Meguid, 2017). The lack of ecological studies that examine vegetation dynamics in these arid urban oases where habitat heterogeneity and human activities jointly shape species distribution, is a major problem. This research aims to identify existing knowledge limitations by providing baseline information on urban vegetation cover in two desert oases in the Western Desert of Egypt. The specific objectives are to identify the dominant urban habitats in the study regions, assess floristic composition and evaluate species diversity across habitats, determine the spatial distribution ranges of recorded species, study the environmental factors that affect plant community distribution and statistically assess the vegetation units (plant communities) that make up urban environments.

MATERIALS AND METHODS

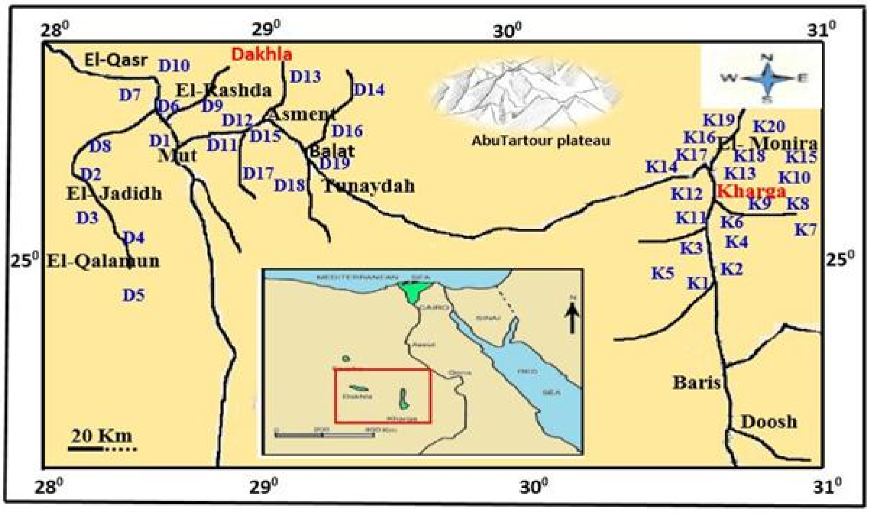
Identification of plants: At Cairo University Herbarium, the collected plant material was identified using Täckholm's (1974) taxonomic nomenclature, which was later updated by Boulos (2009). The major electronic sources and global online databases, included the Plants of the World Online (POWO) website, the International Index of Plant Names (IPNI), the World Flora Online (WFO) website, and the WFO Plant List. The species were then systematically classified into native and non-native species based on the POWO database.

Description of the research area: El Hadidi (2000) points out that the Dakhla and Kharga Oases, which are the largest oases in the New Valley, are located in the Western (Nubian) Desert. Kharga (24° 30´- 26°N and 30° 07´- 30° 47´E) spans around 7200 km2 and lies southwest of Assiut, while Dakhla (25° 28´- 25° 44´N and 28°- 29°E) is situated west of Kharga and the Nile Valley, covering around 2,000 km2. The depression floors of both oases are made of non-fossiliferous brown sandstone, and they lie below the surrounding plateau (Said, 1962). Water availability is the primary factor sustaining life in these arid environments. Irrigation relies on natural springs and wells, with a system of side channels optimizing limited water resources (Abd El-Ghani, 1992). Agriculture in both oases relies primarily on groundwater, which is believed to be replenished by rainwater in tropical Africa that percolates into deep aquifer systems (Bornkamm and Kehl, 1990). Kharga and Dakhla are distinguished by their abundant and high-quality water supply. Artesian wells, some dating back to Pharaonic and Roman times, are the sole source of agriculture in the region. However, many old wells have been abandoned due to sand encroachment or reduced artesian pressure. To improve water access, modern deep wells (250–850m) with higher discharge rates have been drilled (Abd El-Ghani *et al*., 1992). Agriculture plants, specifically clover, wheat, barley, and broad beans are among the most important winter crops, but maize dominates the summer crop. Alfalfa is a perennial crop also grown as a cash crop. Date palms and dom palms are the dominant plants in regions that are vastly cultivated. The region is located in a zone that is considered to be hyper-arid due to its low rainfall and extreme aridity (Ayyad and Ghabbour, 1986; Abd El-Ghani *et al*., 2017). Average temperature of the coldest month ranges between 10-20°C while the average temperature in the hottest month exceeds 30°C). Table (1) gives some climatic characteristics of the nearest meteorological station to the study areas. The most striking climatological feature is the precipitation gradient; which is almost negligible. Temperature below zero is not a frequent phenomenon, while the hottest months occur between May and August.

Table (1): Contains monthly records from (2019-2023) of some climatic features at the nearest meteorological station to the study areas (courtesy of the Kharga Oasis Meteorological Station).

Months	**Temperature (°C)**		**Rainfall (mm)**	**Relative Humidity (%)**	**Wind Velocity (km /H^{-1})**
	Max.	Min.			
Jan.	18	5	0.25	39	9.88
Feb.	19	6	0.12	30	10.37
Mar.	20	7	0.07	22	12.06
Apr.	25	8	0.02	19	13.94
May.	30	9	0	15	15.06
Jun.	32	11	0	16	11.76
Jul.	34	12	0	19	10.72
Aug.	35	13	0	20	8.81
Sep.	30	6	0	21	11.09
Oct.	25	5	0	26	11.69
Nov.	20	4.5	0	38	8.31
Dec.	18	3	0.05	40	9

Vegetation sampling: Vegetation specimens were taken from thirty-nine sites distributed across both the Dakhla and Kharga oases during the winter and summer of 2023 (Map 1), selected to include physiognomic variation in habitats and geo-referenced using GPS with altitudes ranging from 98 to 168 m above sea level. The area of each specimen stand was approximately 20 m × 20 m, the minimal area for species associations in the study area (Saavedra *et al*., 1989). Four main habitats were recognized: PG, HG, RI, and VL. The distribution of specimen stands in the studied habitats was as follows: 16 in HG, 11 in PG, 8 in RI, and 4 in VL (abandoned stands). Permanent stands randomly positioned to reflect the floristic composition of the habitat were used to record the occurrence or absence of species. The number of specimens in which a species was recorded divided by the total number of stands representing the habitat was used to compute the occurrence percentages (f %) for each species in each habitat.



Map (1): Location map of Dakhla (D) and Kharga (K) Oases showing the studied specimen plots.

Soil sampling and analysis: To remove gravel and pebbles, a composite soil sample was taken from each sampled stand in three distinct locations (0–30 cm), dried naturally by exposure to air at room temperature, blended, and then run through a 2 mm mesh screen. Particles smaller than 2 mm were retained for chemical and physical examination (Jackson, 1967; Allen and Stainer, 1974). The hydrometer analysis was employed to determine soil texture (Bouyoucos, 1962), and the granular composition, including clay, silt, fine sand, and coarse sand was determined using the results. Moisture content was determined by drying the soil at 105°C, and the dry weight of the soil was used to compute the percentage of soil moisture (Kaupur and Govil, 2000). Soil pH and electrical conductivity were evaluated in (1:5 w/v) soil-water extract using a glass electrode pH-meter and an electrical conductivity meter (model 4310 JEN WAY), respectively. The percentage of organic matter content was determined in the soil samples by the dichromate oxidation method according to Walkley and Black (1934). The chloride ion concentrations in soil extract samples were determined by the silver nitrate titration method as described by Jackson (1967). CO_3 content was determined using 1N HCl with phenolphthalein indicator (Jackson, 1967). Calcium and magnesium were determined volumetrically by the versene titration method as described by Biedermann and Schwarzenbach (1948). Sodium and potassium were determined by the flame emission technique using a flame photometer (Carl-Zeiss DR LANGE M7D), which is considered a rapid and sensitive method for the determination of sodium and potassium (Williams and Twine, 1960). Phosphates (PO_4) were determined colorimetrically as phospho-molybdate according to Woods and Mellon (1941). Sulphates were determined by a turbidimetric technique as ($BaSO_4$) using barium chloride and acidic sodium chloride solution using a spectrophotometer (model 1200) according to Bardsley and Lancaster (1965).

Data processing and analysis of the vegetation: Vegetation data were analyzed and defined using multivariate methods of classification and ordination, and their interactions with the environmental variables under study were examined. The Community Analysis Package (CAP) version 1.2 for Windows was used to conduct the cluster analysis (Henderson and Seaby, 1999) and CANOCO version 4.5 for Windows was used for all ordinations (Ter Braak and Šmilauer, 2002). In the current study, three complementary analyses were used.

First, an agglomerative hierarchical clustering method was performed to identify the presence/absence species-by-plot dataset, which comprised 112 species and 39 sample stands (after removing species with occurrence rates below 5%). To evaluate the consistency of the results, several classification algorithms were employed, including single linkage, complete linkage, unweighted pair group method average (UPGMA) using Euclidean distance, and Ward (minimum variance) clustering method using squared Euclidean as a distance measure. Similar results were obtained using various classification methods; however, Ward's method of minimum variance was applied.

Second, ordination based on Detrended Correspondence Analysis (DCA; Hill and Gauch, 1980) was used to analyze the extent of variation in species composition along the first ordination axis in the data set. The gradient's length was estimated using the standard deviation (SD) units. In this study, the gradient's length along the first DCA axis was 3.11 SD. Accordingly, the Canonical Correspondence approach (CCA) was the appropriate method for demonstrating the connections between environmental variables and plant species (Ter-Braak and Prentice, 1988).

Third, a Monte Carlo permutation test (499 permutations); Ter Braak (1990) was employed to determine whether the eigenvalues of the first canonical axis were significant, and CCA was conducted to investigate the connections between vegetation gradients and the investigated soil variables. All soil parameters were examined for normality before analysis, and the appropriate transformations were implemented. Eleven variables, including coarse sand (CS), fine sand (FS), clay, moisture content, electrical conductivity, soil reaction, organic matter, carbonates, sodium, sulphates, and phosphates, were used in the CCA analysis after soil variables with high inflation factors were eliminated (Jongman *et al.*, 1987). Then, using SPSS version 16.0 for Windows, significant differences between clusters groups were tested using ANOVA (One-Way Analysis of Variance).

Measures of species diversity: The species richness (SR) for each cluster group was calculated based on the frequency (f%) of each species as the average number of species per sample plot. Additionally, the Shannon diversity index (H′) was used to assess relative species evenness, following the formula $H' = -\Sigma P_i \log P_i$, where $P_i = N_i/N$; N_i is the number of individuals of species i, and N is the total number of individuals across all species (Magurran, 2021). Ecological studies frequently use SR and H′, which indicate α-diversity of the vegetation relative to the sample plot size (400 m^2) (Mahdavi *et al.*, 2013; Zhang and Zhang, 2017). The quantity of Beta diversity was derived from the length of the first DCA axis, measured in standard deviations. A length of four standard deviations indicates a complete species turnover (Muenchow *et al*., 2013). Both α- and β-diversity are essential for understanding biogeographic forms and the ecological processes driving them, making their integration into research crucial (Mori *et al*., 2018).

RESULTS

Patterns of species distribution across habitats

Four main urban habitat types were distinguished: PG, HG, VL, and RI. Among these, home gardens supported the maximum species richness totaling 132 species, followed by PG (112 species), RI (71 species), and VL (58 species) (Tab. 2, Diag. 1). Perennials accounted for 90 species (52% of the total), making them the majority of the flora. With 70 species, or 40% of the flora, they were most prevalent in household gardens. Road islands had 30 species, or 17%; public gardens had 19 species, or 11%; and vacant lots had 17 species, or 10%. 83 species, or 47.9% of the total flora, were annuals. Additionally, they were most common in-home gardens (61 species, 35%), followed by road islands (40 species, 23%), vacant lots (22 species, 13%), and public gardens (54 species, 31%). The order of numbers vs habitats is inconsistent. Fabaceae, Poaceae, Asteraceae, Amaranthaceae, Brassicaceae, Convolvulaceae, Euphorbiaceae and Malvaceae were the most species-rich families in all habitats surveyed (Tab. 2; Diags. 1, 2).

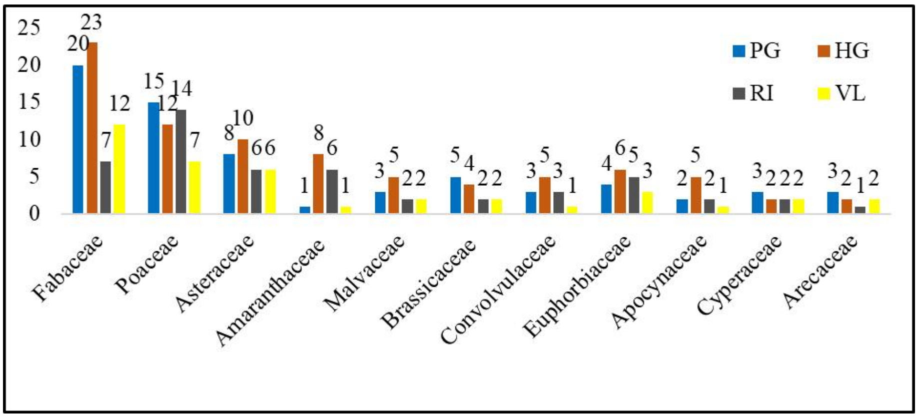


Diagram (1): The species-rich families in the four habitats (PG, HG, RI, and VL).

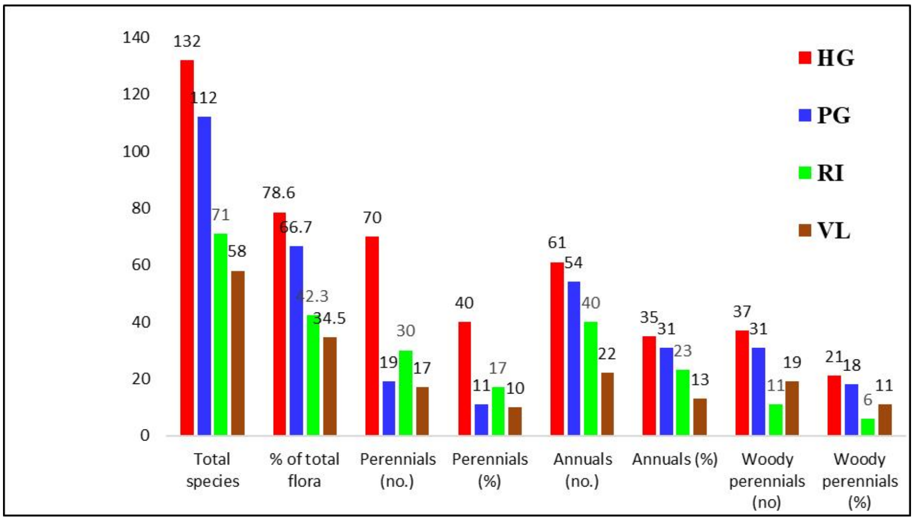


Diagram (2): The floristic diversity found in four different habitats: RI stands for road islands, VL for vacant lots, HG for home gardens, and PG for public gardens. Each family's documented number of species is displayed in the figure, along with the proportional percentages of each habitat for each species.

There were also a number of domesticated plants found. *Anethum graveolens* L., *Coriandrum sativum* L., *Petroselinum crispum* (Mill.) Fuss, *Abelmoschus esculentus* (L.) Moench and *Solanum lycopersicum* L. were among the vegetable herbs; fruit trees like *Mangifera indica* L., *Morus alba* L., *Morus nigra* L., *Musa nana* Swangpol & Traiperm, and *Psidium guajava* L.; hedge plants like *Bougainvillea glabra* Choisy, *Lantana camara* L., *Jasminum grandiflorum* L., and *Dodonaea viscosa* Jacq.; Woody trees including *Allocasuarina distyla* (Vent.) L. A. S. Johnson, *Ziziphus spina-christi* (L.) Desf., *Sesbania sesban* (L.) Merr., *Melia azedarach* L., and *Eucalyptus globulus* Labill. are utilized for roofing and other domestic tasks. Most significantly, weed species accounted for 40% of the flora on road islands. Ornamental plants, on the other hand, showed a more uniform distribution across habitats, with 16.2% in public gardens and 8.9% in vacant lots. Fruit trees and domestically used herbs, such as *Morus alba*, *Olea europaea* L., *Musa nana*, *Citrus limon* (L.) Osbeck., *Cucurbita pepo* L., *Hibiscus sabdariffa* L., and *Anethum graveolens*, were common in both home and public gardens. Xerophytic (35.5%) and salt-tolerant (9.0%) species predominated on vacant lots, which mostly consisted of desert-like ecosystems. The most prominent species in this ecosystem included *Tamarix nilotica* (Ehrenb.) Bunge, *Prosopis farcta* (Banks & Sol.) J. F. Macbr., *Imperata cylindrical* (L.) Raeusch., *Alhagi graecorum* Boiss., *Phragmites australis* (Cav.) Trin. ex Steud., and *Pulicaria undulata* (L.) C. A. Mey.

Classification of the vegetation

The dominant species with the highest frequencies (f%) were used to designate the resulting vegetation clusters. The total number of species composition and distribution across the various habitats are shown in the figure. In addition, the distribution of growth forms within each habitat was indicated by their numbers.

Fourteen vegetation groups were found in the designated habitats after cluster analysis was applied (Diag. 3, Tab. 2). Each group was named after the dominant and most prevalent species and referred to as a cluster vegetation group.

The classification of 11 sample stands from public gardens habitats resulted in 3 groups in the public gardens: Group (A): dominated by *Cynodon dactylon*, *Melilotus siculus*, *Alhagi graecorum* and *Erigeron bonariensis*; Group (B): dominated by *Dicanthium annulatum*, *Phoenix dactylifera* and Group (C): dominated by *Ziziphus spina-christi* and *Imperata cylinderica*. Five vegetation categories were identified from the classification of the 16 home garden stands, each of which was named after the main and most prevalent species.

The five stand groups in the home gardens were group (A) dominated by *Chenopodiastrum murale*, *Cynodon dactylon* and *Melilotus siculus*; Group (B) dominated by *Sonchus oleraceus*, *Cynodon dactylon*, *Sorghum halepense* and *Trifolium alexandrinum*; Group (C)) dominated by *Chenopodiastrum murale*, *Imperata cylindrical* and *Eruca sativa*; Group (D) dominated by *Ziziphus spina-christi*, *Sesbania sesban*, *Boerhavia diffusa* and *Echinochloa colonum* and Group (E) dominated by *Cynodon dactylon*, *Olea europaea* and *Coincya tournefortii*.

The classification of eight stands from road the islands in studied sample stands from Kharga and Dakhla Oases resulted in 4 cluster groups, Group (A): dominated by *Sonchus oleraceus*, *Portulaca oleracea*, *Medicago sativa* and *Tribulus pentandrus*; Group (B): dominated by *Chenopodiastrum murale*, *Amaranthus viridis* and *Dicanthium annulatum*; Group (C): dominated by *Tamarix nilotica*, *Cenchrus ciliaris*, *Ziziphus spina-christi*, *Phragmites australis* and Group (D): dominated by *Lysimachia arvensis* var. *caerulea* and *Lysimachia arvensis* subsp. *arvensis*.

The classification of the five stands from vacant lots resulted in two groups; Group (A) dominated by *Tamarix nilotica*, *Imperata cylindrica* and *Malva parviflora* and Group (B) dominated by *Alhagi graecorum*, *Phragmites australis*, and *Prosopis farcta*.

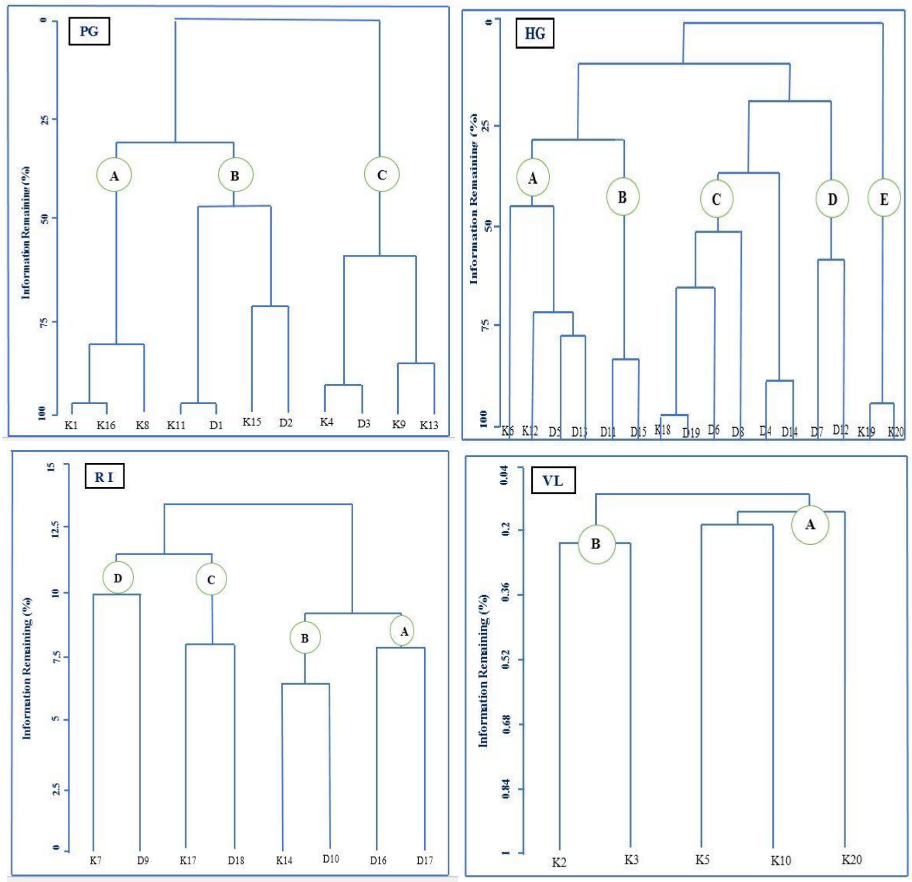


Diagram (3): The vegetation categories that resulted from classifying the vegetation in the four habitats using cluster analysis: RI stands for Road Island, VL for vacant lots, PG for public gardens, and HG for home gardens.

Table (2) Floristic composition of the four habitats. Figures are the frequency percentages (f%) of each species.

Habitats	**PG**	**HG**	**RI**	**VL**
Total vegetation stands	11	16	8	4
Total number of cluster groups	3	5	4	2
Species recorded in all habitats				
Cynodon dactylon (L.) Pers.	91	94	88	40
Melilotus siculus (Turra) Steud.	82	50	88	40
Malva parviflora L. var. *parviflora*	27	38	75	60
Tamarix nilotica (Ehrenb.) Bunge	45	25	50	80
Dicanthium annulatum (Forssk.) Stapf. var. *annulatum*	64	31	63	40
Alhagi graecorum Boiss.	55	25	13	100
Sonchus oleraceus L.	55	56	50	20
Ziziphus spina-christi (L.) Desf.	55	44	38	40
Phragmites australis (Cav.) Trin. ex Steud.	36	31	25	60

Sesbania sesban(L.) Merr. var. *nubica* Chiov.	45	25	38	40
Cenchrus ciliaris L.	55	19	38	20
Sorghum halepens (L.) Pers.	27	31	25	40
Erigeron bonariensis L.	64	25	13	20
Eruca sativa Mill.	18	50	13	40
Medicago sativa L. subsp. *Sativa*	27	19	50	20
Lactuca serriola L.	36	13	25	40
Calotropis procera (Aiton)W.T. Aiton	27	19	25	40
Coincya tournefortii (Gouan) Alcaraz, T. E. Díaz, Rivas Mart. & Sánchez-Gómez	18	31	25	40
Launaea mucronata (Forssk.) Muschl.	27	19	25	40
Olea europaea L.	9	50	25	20
Convolvulus arvensis L.	27	31	25	20
Euphorbia prostrata Aiton .	27	6	50	20
Euphorbia hirta L.	36	19	25	20
Lysimachia arvensis (L.) U. Manns & Anderb. var. caerulea (L.) Turland & Bergmeier.	36	19	25	20
Lysimachia arvensis (L.) U.Manns & Anderb. spp. *Arvensis*.	36	19	25	20
Hyphaene thebaica (L.) Mart.	18	19	13	20
Bougainvillea glabra Choisy	18	25	13	40
Cyperus longus L. subsp. *Longus*.	9	6	13	20
Ricinus communis L.	9	6	13	20
Species recorded in three habitats				
Trifolium resupinatum L. var. *resupinatum*.	55	13	38	-
Chenopodiastrum murale (L.) S. Fuentes, Uotila & Borsch	64	69	63	-
Phoenix dactylifera L.	73	81	-	40
Imperata cylindrica (L.) Raeusch.	55	50	-	60
Portulaca oleracea L.	45	19	63	-
Tribulus pentandrus Forssk. var. *pentandrus*	27	13	50	-
Amaranthus viridis L.	27	19	38	-
Hyoscyamus muticus L.	-	19	25	40
Pluchea dioscoridis (L.) DC.	36	6	-	40
Moringa oleifera Lam.	18	31	-	20
Corchorus trilocularis L.	18	25	-	20
Prosopis farcta (Banks & Sol.) J. F. Macbr.	9	13	-	40
Boerhavia diffusa L.	9	25	25	-
Echinochloa colonum (L.) Link	9	25	25	-
Cordia myxa L.	18	19	-	20
Astragalus vogelii (Webb.) Bornm subsp. *fatimensis* Maire	18	19	-	20
Chenopodium album L.	9	19	25	-
Plantago lagopus L. subsp. *lagopus*	9	19	25	-
Trichodesma africanum (L.) Sm.	18	13	-	20
Dalbergia sisso Roxb.ex DC.	18	13	-	20
Morus alba L.	18	13	-	20
Cuscuta campestris Yunck.	9	13	25	-
Trigonella glabra Thunb. subsp. *glabra*	18	6	-	20
Hibiscus sabdariffa L.	9	13	-	20
Dodonaea viscosa Jacq.	9	-	13	20
Vicia monantha Retz. subsp. *monantha*	9	6	25	-
Euphorbia peplus L. var. *minima* DC.	18	6	13	-
Sorghum *varigatum* (Hack.) Stapf	18	6	13	-
Cassia fistula L.	9	6	-	20
Ficus nitidifolia Bureau.	9	13	13	-

Lantana camara L.	9	6	-	20
Tecoma stans (L.) Juss. ex Kunth	9	6	13	-
Lawsonia inermis L.	9	6	13	-
Species recorded in two habitats				
Lolium rigidum Gaudin.	-	19	50	-
Pulicaria undulata (L.) C.A.Mey.	-	13	-	40
Opuntia ficus-indica (L.) Mill.	-	31	-	20
Psidium guajava L.	-	25	-	20
Beta vulgaris L.	-	6	38	-
Leptochloa fusca (L.) Kunth	18	-	25	-
Nerium oleander L.	36	6	-	-
Oxalis corniculata L.	36	6	-	-
Vicia faba L.	-	19	-	20
Zygophyllum coccineum L.	-	19	-	20
Bassia indica (wight) A. J. Scott	-	25	13	-
Citrullus colocynthis (L.) Schrad.	-	13	25	-
Ocimum basilicum L.	18	19	-	-
Lathyrus oleraceus Lam.	-	13	-	20
Mangifera indica L.	18	13	-	-
Bidens pilosa L.	18	13	-	-
Bolboschoenus maritimus (L.) Palla subsp. *maritimus*	18	-	13	-
Poa annua L.	18	-	13	-
Cenchrus divisus (J. F. Gmel.) Verloove, Govaerts & Buttler	9	-	-	20
Vigna unguiculata (L.)Walp. subsp. *unguiculata*	9	19	-	-
Morus nigra L.	9	19	-	-
Solanum nigrum L.	9	19	-	-
Caroxylon imbricatum (Forssk.) Moq.	-	6	-	20
Conocarpus lancifolius Engl.	-	13	13	-
Cyperus difformis L.	-	6		20
Digitaria sanguinalis (L.) Scop.	-	13	13	-
Citrus limon (L.) Osbeck.	-	6	-	20
Catharanthus roseus (L.) G.Don	18	6	-	-
Mutarda nigra (L.) Bernh.	18	6	-	-
Vachellia nilotica (L.) P.J.H.Hurter &Mabb.	18	6	-	-
Cascabela thevetia (L.) Lippold	-	6	13	-
Euphorbia heterophylla L.	-	6	13	-
Dactyloctenium aegyptium (L.) Willd.	-	6	13	-
Polygonum equisetiforme Sm.	-	6	13	-
Suaeda aegyptiaca (Hasselq.) Zohary	9	6	-	-
Cynanchum acutum L.	9	6	-	-
Carthamus tinctorius L.	9	6	-	-
Tagetes tenuifolia Cav.	9	6	-	-
Stellaria apetala Ucria	9	6	-	-
Cressa cretica L.	9	6	-	-
Bauhinia varigata L. var. *variegata*	9	6	-	-
Mimosa pudica L. var. *pudica*	9	6	-	-
Abutilon pannosum (G.Forst.) Schltdl	9	6	-	-
Jasminum grandiflorum L.	9	6	-	-
Species recorded in one habitat				
Ammi majus L.	18	-	-	-
Glycine max (L.) Merr. subsp. *max*	18	-	-	-
Setaria viridis (L.) P. Beauv.	18	-	-	-
Anethum graveolens L.	9	-	-	-

Bombax ceiba L.	9	-	-	-
Coriandrum sativum L.	9	-	-	-
Petrosilinum crispum (Mill.) Fuss	9	-	-	-
Washingtonia filifera (T.Moore & Mast.) H.Wendl. ex de Bary	9	-	-	-
Lepidium didymum L.	9	-	-	-
Lepidium sativum L.	9	-	-	-
Cassia javanica subsp.*nodosa* (Buch.-Ham ex Roxb.)K. Larsen & S.S Larsen.	9	-	-	-
Cyperus laevigatus L.	9	-	-	-
Lathyrus hirsutus L.	9	-	-	-
Medicago laciniata (L.) Mill.	9	-	-	-
Vachellia farnesiana (L.) Wight & Arn.	9	-	-	-
Juncus rigidus Desf.	9	-	-	-
Volkameria inermis L.	9	-	-	-
Melia azedarach L.	9	-	-	-
Plantago major L. subsp. *major*	9	-	-	-
Eragrostis tef (Zuccagni)Trotter.	9	-	-	-
Panicum repens L.	9	-	-	-
Phalaris minor Retz.	9	-	-	-
Rumex spinosus L.	9	-	-	-
Rosa chinensis Jacq.	9	-	-	-
Leucophyllum frutescens (Berland.) I.M.Johnst.	9	-	-	-
Brassica rapa L.	-	6	-	-
Allocasuarina distyla (Vent.) L. A. S. Johnson	-	6	-	-
Boerhavia repens (L.) subsp. *viscosa* (Choisy) Maire.	-	6	-	-
Ipomoea carnea Jacq.	-	6	-	-
Cucurbita pepo L.	-	6	-	-
Euphorbia helioscopia L. subsp. *helioscopia*	-	6	-	-
Rhynecosia minima (L.) DC. var. *minima*	-	6	-	-
Senna italica Mill.	-	6	-	-
Senna didymobotrya (Fresen.) H.S.Irwin & Barneby	-	6	-	-
Mentha longifolia (L.) L.	-	6	-	-
Gossypium barbadense L.	-	6	-	-
Musa nanensis Swangpol & Traiperm	-	6	-	-
Eucalyptus globulus Labill.	-	6	-	-
Tritcum aestivum L.	-	6	-	-
Rumex dentatus L.	-	6	-	-
Polygonum bellardii All.	-	6	-	-
Tamarix tetragyna Ehrenb.	-	6	-	-
Urtica urens L.	-	6	-	-
Zygophyllum arabicum (L.) Christenh. & Byng.	-	6	-	-
Balanites aegyptiaca (L.) Delile	-	19	-	-
Ipomoea pes-caprae (L.) R.Br.	-	19	-	-
Luffa aegyptiaca Mill.	-	19	-	-
Trifolium alexandrinum L.	-	19	-	-
Solanum lycopersicum L.	-	19	-	-
Cichorium endivia L. subsp. *divaricatum* (Schousb) P.Dsell	-	19	-	-
Casuarina equisetifolia L.	-	13	-	-
Senna alexandrina Mill. var. *alexandrina*	-	13	-	-
Abelmoschus esculentus (L.) Moench	-	13	-	-
Vitis vinifera L.	-	13	-	-
Suaeda fruticosa Forssk. ex J. F. Gmel.	-	13	-	-
Senecio glaucus L.	-	-	25	-

Avena fatua L.	-	-	25	-
Convolvulus fatmensis Kunze	-	-	25	-
Trianthema portulacastrum L.	-	-	13	-
Amaranthus graecizans L.	-	-	13	-
Urospermum picroides (L.) Scop. ex F.W.Schmidt	-	-	13	-
Spergularia marina (L.) Besser.	-	-	13	-
Trigonella laciniata L.	-	-	13	-
Hibiscus rosa-sinensis L.	-	-	13	-
Polypogon viridis (Gouan) Breistr.	-	-	13	-
Cordia sinensis Lam.	-	-	-	20
Senna occidentalis (L.) Link	-	-	-	20

Description of cluster groups and ordination of stands

The Public gardens:

Group A: *Cynodon dactylon* - *Melilotus siculus* - *Alhagi graecorum*- *Erigeron bonariensis* comprised 3 stands mainly from Kharga oases with soil analysis of these stands was characterized by the lowest content of the majority of the studied soil variables, and the highest content of clay, pH, Na, CO_3, SO_4, PO_4, and organic matter (Tab. 3). It comprised 53 species, 9 woody perennials (trees or shrubs), 31 annuals, and 22 perennial species. Group A showed the highest species richness (27.33 ± 7.64 species stand^{-1}), and Shannon's index (3.27 ± 0.30).

Group B: *Dicanthium annulatum* - *Phoenix dactylifera* included 4 stands with soils that exhibiting intermediate characteristics of most of the studied soil variables. It comprised 52 species, of which 16 were woody perennials (trees and shrubs), 30 perennial herbs and 22 annuals. It showed the lowest species richness (19.50 ± 6.56) and Shannon's index (2.91 ± 0.41 species stand^{-1}).

Group C: *Imperata cylindrica* -*Ziziphus spina-christi* comprised 4 stands (2 stands from Kharga and 2 stands from Dakhla Oases) with soils that had maximum content of most of the studied soil variables e.g., gravels, coarse sand and silt, carbonates, organic matter, but the lowest in fine sand, total soluble salts, electrical conductivity, water content and chlorides. It comprised 20 woody perennials, 37 perennial herbs and 32 annuals. Table (3) gives the eigenvalues of the first two axes 0.553 and 0.409, respectively. The three cluster groups of public gardens (Diag. 3) were spread out over 4.478 S.D. units along the first DCA axis, indicating high floristic variations among vegetation groups. The first two DCA axes explained 15.6 % and 27.1% of the total variation in species data, respectively.

The home gardens habitat:

Group A: *Cynodon dactylon* - *Chenopodiastrum murale*- *Melilotus siculus* comprised 4 stands; 2 from Kharga and 2 from Dakhla Oases, with soils characterized by the lowest content of pH, moisture, organic matter, Ca, Mg, Na, K, fine sand, coarse sand and clay, but the highest in silt (Tab. 3). It comprised 61 species: 16 woody perennials, 16 perennial herbs and 29 annuals.

Group B: *Cynodon dactylon* - *Sonchus oleraceus* - *Sorghum halepense* - *Trifolium alexandrinum* comprised 2 stands from Dakhla Oasis with soils that had high contents of gravels, fine and coarse sand, silt, clay, total soluble salts, pH, Ca, Mg, Na and CO_3, but instead low contents of SO_4, PO_4, Cl, K and organic matter. It comprised 22 species: 4 woody perennials, 5 perennial herbs and 13 annuals. It showed the highest species richness (25.67 ± 3.22 species stand^{-1}) and Shannon's index (3.24 ± 0.13).

Group C: *Imperata cylindrica* - *Eruca sativa* - *Chenopodiastrum murale* included 4 stands, three from Dakhla and one from Kharga, with soils that had the maximum contents of gravels, coarse sand, silt, total soluble salts, water content, pH, Ca, Na and K and the minimum in fine sand, clay, Mg, CO_3 and organic matter. It comprised 53 species; 15 woody perennials, 13 perennial herbs and 25 annuals.

Group D: *Ziziphus spina-christi*, *Sesbania sesban*, *Boerhavia diffusa* and *Echinochloa colona* included 4 stands from Dakhla Oasis, with soils that had high contents of gravels, coarse sand, silt, total soluble salts, water content, pH, Ca, Na and K the lowest contents of moisture, soluble salt content, silt and clay.

It included 71 species, of which 34 were annuals, 17 were perennial herbs, and 20 were identified as woody perennials. It had the lowest Shannon's index (2.71 ± 0.29) and species richness (15.67 ± 4.53 species stand-1). Group E consisted of two stands from Kharga and featured *Olea europaea*, *Cynodon dactylon* and *Coincya tournefortii*. The soils in the oasis showed low levels of moisture, organic matter, SO_4, PO_4, Cl, K and high levels of gravels, fine and coarse sand, silt, clay, total soluble salts, pH, Ca, Mg, Na, and CO_3. It included 42 species, of which 16 were annuals, 11 were perennial herbs, and 15 were identified as woody perennials. The eigenvalues of the first two axes (0.531 and 0.376, respectively) were provided in Table (4). The large floristic variability across plant groups was expressed by the five cluster groups of home gardens (Figure 4), which were distributed at 3.744 S.D. units along the first DCA axis. 11.2% and 19.1% of the overall variation in the species data, respectively, were explained by the first two DCA axes.

Influence of soil properties

Table (3): Shows the ANOVA P values for species richness (SR), soil variables, and Shannon's index (H') in the stands that correspond to the groups that were found by cluster analysis across all habitats. Soil response (pH), total soluble salts (TSS), chloride (Cl), total carbonate (CO3), bicarbonate (HCO3), sulphate (SO4), organic matter (OM), phosphate (PO4), coarse sand (CS), fine sand (FS) and Water content (WC), are all listed. * = $P \leq 0.05$ and ** = $P \leq 0.01$.

Soil variables		PG	HG	RI	VL
OM		0.35	0.71	0.23	0.57
Gravels		0.46	0.79	0. 000**	0.02*
CS		0.11	0.82	0.03*	0.75
FS	(%)	0.87	0.75	0.39	0.45
Silt		0.35	0.69	0.04*	0.16
Clay		0.23	0.39	0.01**	0.45
WC		0.45	0.76	0.001**	0.32
EC	(meq l^{-1})	0.51	0.63	0.59	0.001**
TSS		0.22	0.63	0.67	0.001**
pH		0.49	0.22	0.03*	0.63
Ca		0.36	0.68	0.49	0.17
K		0.55	0.11	0.17	0.26
Na		0.19	0.83	0.47	0.28
Mg		0.59	0.69	0.44	0.49
Cl	(meq l^{-1})	0.39	0.64	0.67	0.21
CO_3		0.31	0.15	0.02*	0.84
SO_4		0.48	0.31	0.21	0.09
PO_4		0.32	0.35	0.39	0.05*
SR		0.34	0. 01**	0.66	0.04*
H'		0.39	0.03*	0.68	0.07

The road islands habitat

Group A: *Sonchus oleraceus* - *Portulaca oleracea* - *Medicago sativa* - *Tribulus pentandrus* comprised 2 stands from Dakhla Oasis with soils that had the maximum contents of gravels, coarse sand, water content, pH, carbonates but the minimum in fine sand, silt, clay, EC, TSS, Ca, Mg and SO_4 (Table 3). It comprised 35 species: 3 woody perennials, 8 perennial herbs and 24 annuals. This group showed the maximum species richness (19 ± 2.83 species stand^{-1}) and Shannon's index (2.94 ± 0.15).

Group B: *Chenopodiastrum murale* - *Amaranthus viridis* - *Dicanthium annulatum* included 2 stands from the two oases with soils rich in contents of gravels, silt, Na, EC and water content, but the lowest contents of fine and coarse sand, Ca, Mg, K and CO_3. It comprised 24 species: 2 woody perennials, 4 perennial herbs and 18 annual species.

Group C: *Tamarix nilotica*, *Cenchrus ciliaris*, Ziziphus *spina-christi* and *Phragmites australis* comprised 2 stands, one from Kharga and the other from Dakhla oases with soils exhibiting intermediate features of most of the studied soil variables. It comprised 25 species; 6 woody perennials, 6 perennial herbs and 13 annuals. Group C showed the lowest species richness (13.0 ± 7.07 species stand^{-1}) and Shannon's index (2.48 ± 0.58).

Group D: *Lysimachia arvensis* var. *caerulea* and *Lysimachia arvensis* subsp. *arvensis*; *Lysimachia arvensis* included 2 stands from two oases with soils that had the lowest contents of gravels, fine and coarse sand, pH, Ca, Mg, K, but rich in contents of silt, clay, Na and organic matter. It comprised 39 species; 7 woody perennials, 10 perennial herbs and 22 annuals. The eigenvalues of the first two axes (0.431 and 0.258, respectively) are provided in Table (4). The relatively large floristic variability among vegetation groups was expressed by the two cluster groups of road islands (Diag. 3), which were dispersed at 2.956 S.D. units along the first DCA axis. Of the total variation in species data, the first two DCA axes accounted for 40.9% and 25.6% percent, respectively.

The vacant lots habitat

Group A: *Imperata cylindrica* - *Tamarix nilotica* - *Malva parviflora* comprised 3 stands from Kharga Oasis with soils rich in contents of clay, fine sand, silt, pH, CO_3 and PO_4, but the lowest contents of gravels, coarse sand, electrical conductivity, organic matter and TSS, K, Ca, Mg, Na, Cl, SO_4 (Tab. 3). It comprised 54 species: 18 woody perennials, 17 perennial herbs and 20 annuals. This group showed the maximum species richness (24 ± 4.36 species stand $^{-1}$) and Shannon's index (3.17 ± 0.19).

Group B: *Phragmites australis* - *Alhagi graecorum* - *Prosopis farcta* included 2 stands from Kharga Oasis with soils rich in contents of gravels, coarse sand, electric conductivity, organic matter and TSS, K, Ca, Mg, Na, Cl, SO_4, but the lowest contents of fine sand, silt, clay, pH, CO_3 and PO_4. It comprised 13 species: 4 woody perennials, 4 perennial herbs and 5 annuals. Group B showed the minimum species richness (8.0 ± 5.66 species stand $^{-1}$) and Shannon's index (1.93 ± 0.78). The eigenvalues of the first two axes (0.645 and 0.330, respectively) are provided in Table (5). The comparatively significant floristic variability across vegetation groups was expressed by the two cluster groups of road islands (Diag. 3), which were dispersed at 3.104 S. D. units along the first DCA axis. 32.8 % and 49.7% of the overall variation in the species data, respectively, were explained by the first two DCA axes.

Table (4): Summary of DCA results for the 4 studied habitats along the first two axes.

Habitats	PG		HG		RI		VL	
DCA axes	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Eigenvalue	0.553	0.409	0.531	0.376	0.431	0.258	0.645	0.330
Length of gradient	4.478	4.422	3.744	3.195	2.956	2.153	3.104	3.097
% Cumulative variance of species data	15.6	27.1	11.2	19.1	25.6	40.9	32.8	49.7

Soil-vegetation relationships of the habitats

The relationship between vegetation pattern and soil characteristics were examined using Canonical Correspondence Analysis (CCA). The CCA ordination biplots for the investigated habitats, along with their cluster vegetation assemblages and the soil properties under investigation, were displayed in Diagram (4). Table (5) shows the inter-set correlations derived from Canonical Correspondence Analysis (CCA) of the soil variables across the studied habitats. Species distribution showed an inverse correlation with Na and a strong positive correlation with K along the first CCA axis of public gardens. Consequently, a K–Na gradient can be used to define this axis. The second axis showed a negative relationship with

Ca and a positive association with Na. This axis can be described as the gradient between Na and Ca (Diag. 4, Tab. 5).

CCA axis 1 in the home gardens (HG) demonstrated a strong negative correlation with silt and a positive correlation with PO4. This axis was therefore deduced to be the PO4–silt gradient. Fine sand displayed a strong positive connection along axis 2, whereas pH displayed a negative correlation. Thus, this axis can be described as a pH-fine sand gradient (Diag. 4, Tab. 5).

The inter-set correlations (Tab. 5) for the vacant lots revealed that clay had the highest negative correlation (r=-0.94) along CCA axis 1, while soil texture, particularly gravels, had a strong positive connection (r=0.96). Therefore, this axis might be described as gravels – clay gradient (Diag. 5). Meanwhile, CCA axis 2 showed a negative association with K and a large positive correlation with silt. Consequently, silt -K gradient can be deduced from this axis.

The inter-set correlations for road islands' CCA axes (Tab. 5) showed that the first CCA axis had a pronounced negative correlation (r=-0.87) with Na and a high positive correlation (r=0.79) with pH. Thus, the pH-Na gradient can be used to establish this axis. The distribution of species was influenced by soil texture along axis 2, with gravels showing the largest negative correlation (r=-0.81) and fine sand showing a significant positive correlation (r=0.65). Accordingly, this axis reflects variation in fine sand gradient.

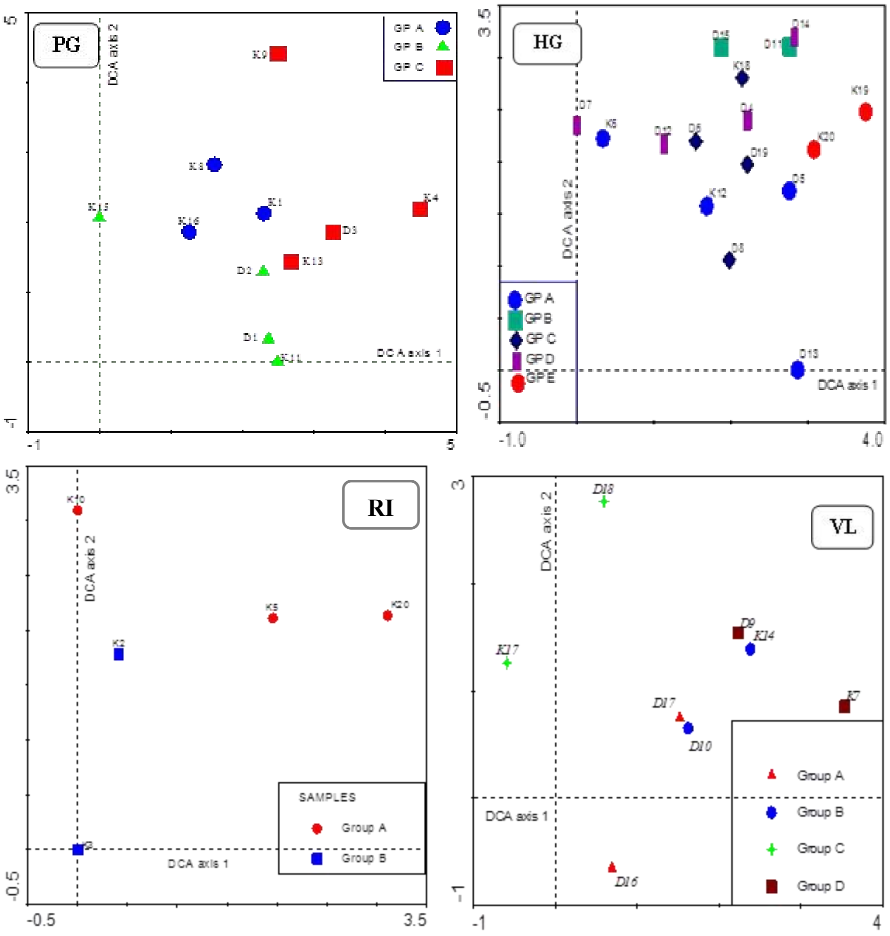


Diagram (4): Detrended Correspondence Analysis (DCA) ordination diagram for the stands of the 4 habitats: PG, HG, RI and VL on the first pair of axes, with their cluster groups superimposed.

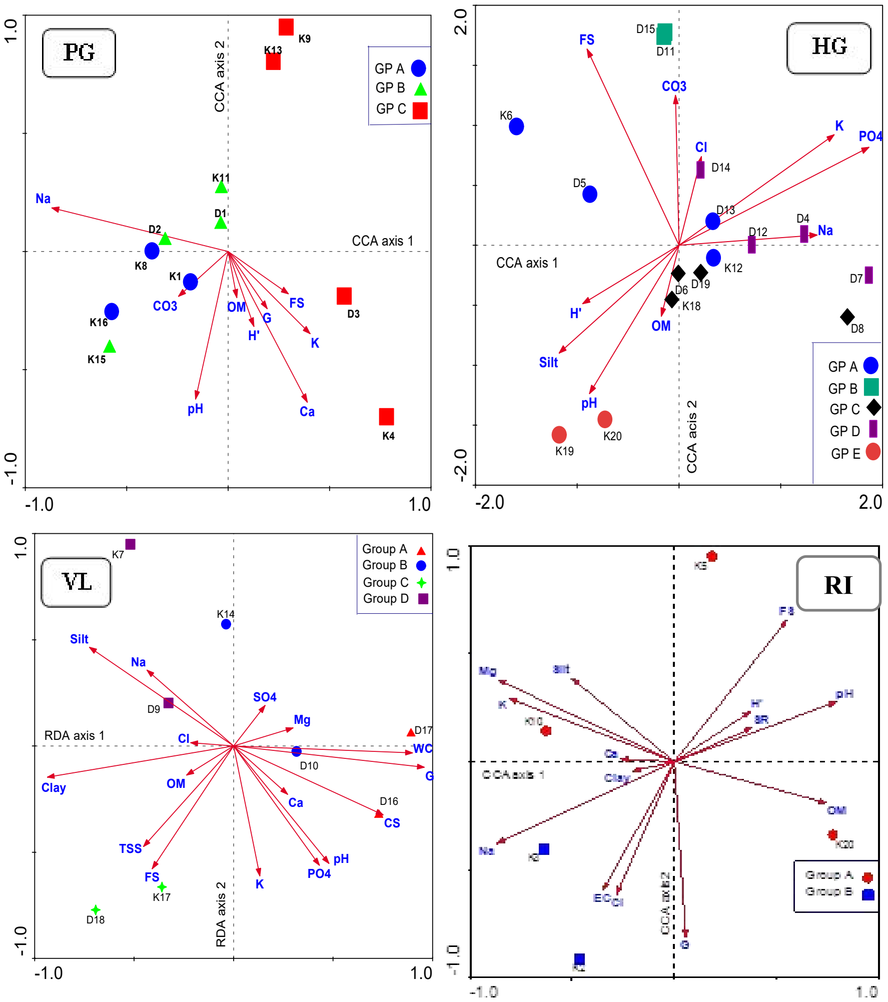


Diagram (5): CCA biplots along axes 1 and 2 visualizing the distribution of the stands across the four habitats, together with their cluster groups and soil variables. PG, HG, RI and VL=Vacant lots.

Table (5): Results of the inter-set correlation among soil variables along the first two axes of CCA, combined with eigenvalues and species-environment relationship coefficients in the four habitats of Kharga and Dakhla Oases. CS=Coarse sand and FS= Fine sand, WC=Water content, OM=Organic matter, EC= Electric conductivity, TSS=Total soluble salts, SR= Species richness, H'= Shannon-Wiener index, NI= Not included (high inflation factor).

Habitats	**PG**		**HG**		**VL**		**RI**	
Axes	**Ax_1**	**Ax_2**	**Ax_1**	**Ax_2**	**Ax_1**	**Ax_2**	**Ax_1**	**Ax_2**
Eigenvalues	0.55	0.45	0.48	0.44	0.65	0.58	0.23	0.19
Species environment correlations	0.98	0.99	0.99	0.99	0.98	0.96	0.98	0.97
Gravels	0.19	-0.24	NI	NI	0.96	-0.10	0.05	-0.81
CS	NI	NI	NI	NI	0.75	-0.32	NI	NI
FS	0.30	-0.18	-0.32	0.58	-0.41	-0.58	0.55	0.65
Silt	NI	NI	-0.42	-0.32	-0.72	0.46	-0.50	0.39
Clay (%)	NI	NI	NI	NI	-0.94	-0.15	-0.20	-0.04
WC	NI	NI	NI	NI	0.89	-0.03	NI	NI
OM	0.04	-0.20	-0.06	-0.21	-0.24	-0.14	0.75	-0.19
EC	NI	NI	NI	NI	NI	NI	-0.35	-0.59
TSS	NI	NI	NI	NI	-0.45	-0.47	NI	NI
pH	-0.16	-0.62	-0.32	-0.45	0.48	-0.55	0.79	0.28
Ca	0.38	-0.64	NI	NI	0.27	-0.23	-0.26	0.01
Mg	NI	NI	NI	NI	0.29	0.08	-0.86	0.38
Na (meq l^{-1})	-0.87	0.18	0.49	0.03	-0.44	0.36	-0.87	-0.38
K	0.40	-0.35	0.55	0.33	0.13	-0.61	-0.80	0.29
Cl	NI	NI	0.08	0.27	-0.22	0.02	-0.28	-0.61
SO_4	NI	NI	NI	NI	0.16	0.19	NI	NI
PO_4	NI	NI	0.67	0.29	0.43	-0.56	NI	NI
CO_3	-0.24	-0.19	-0.01	0.45	NI	NI	NI	NI
H'	0.13	-0.32	-0.34	-0.18	NI	NI	0.37	0.23

DISCUSSION

Clear insights into vegetation dynamics in arid environments can be gained from studying plant distribution in urban ecosystem types in the Dakhla and Kharga oases of Egypt.

Urbanization and plant diversity

The flora and vegetation in four major habitats were explored: road islands (RI), vacant lots (VL), public gardens (PG), and home gardens (HG); each with its own characteristic floristic features, soil properties and human impacts on plant life. In terms of species richness, the highest number of species was recorded in the managed habitats (public and home gardens) where the latter inhabited 132 species mainly composed of fruit trees, desert species and cultivated herbs, while the former was composed of 112 species mainly of wetland and ornamental. McKinney (2002) and Zerbe *et al.* (2003) reported similar results indicating that plant species diversity was increased in controlled ecosystems where more species are introduced. In contrast, altered habitats, such as road islands and vacant lots were suitable habitats for weeds and xerophytic species as shown by the presence of 71 species in RI and 58 in VL.

Soil–vegetation relationships

The distribution of species was controlled by soil characteristics, which differed significantly between environments. While organic matter and clay concentration were significant in controlled habitats, electrical conductivity, soluble salts, and chloride content were crucial in saline environments. Our findings were in line with research work indicating the role of soil features in shaping vegetation in dry regions (Abd El-Ghani *et al*., 2017).

In public gardens, stands dominated by *Alhagi graecorum*, *Cynodon dactylon*, *Melilotus siculus* and *Erigeron bonariensis* (Group A) had low values for most soil variables but higher organic matter, clay, pH, sodium, carbonates, sulfates and phosphates. This group showed the highest Shannon's index and species richness. Conversely, *Dicanthium annulatum* and *Phoenix dactylifera* stands (Group B) exhibited intermediate soil properties and lower richness, indicating the role of soil in diversity patterns. Similarly, in home gardens, soil conditions differed among groups. *Olea europaea*, *Cynodon dactylon* and *Coincya tournefortii* (Group E) soils were rich in gravel, sand, silt, clay, soluble salts, pH, carbonates, calcium, magnesium and sodium, but poor in organic matter, sulfates, phosphates, chlorides, potassium and moisture. This group displayed moderate richness, demonstrating the effect of soil heterogeneity even in managed sites.

Synanthropic vegetation and human impacts

Synanthropic species, largely driven by human activity, were abundant in disturbed habitats. Weeds and ruderal species dominated road islands and vacant lots, thriving under disturbance (Pyšek *et al*., 2004; Lososová and Simonová, 2008). Weed contribution reached 40% in road islands, while ornamentals were evenly distributed across habitats (8.9% in vacant lots to 16.2% in public gardens). The occurrence of synanthropic vegetation demonstrated the impact of urbanization, which often causes fragmentation, disturbance, and pollution, favoring invasive and ruderal species at the expense of native flora (Good, 1977; McKinney, 2002). In Kharga and Dakhla Oases, urban expansion and agriculture likely facilitated the spread of synanthropic species in disturbed habitats.

Re-evaluation of managed habitats as refuges

Despite the considerable diversity of managed habitats, much of it is attributed to deliberate human intervention rather than natural ecological processes. Therefore, they are not true preserves for native species. Native species in these habitats were underrepresented compared to degraded sites, which serve as important reservoirs for local xerophytic and ruderal vegetation.

Effects of alien species on local diversity

The dominance of introduced species in managed habitats was associated with lower Shannon diversity in certain groups as well as reduced functional diversity. This suggests that these species are capable of altering plant community structure, leading to the homogenization of plant populations. These findings are consistent with global evidence showing that urbanization and the introduction of such species can lead to a reduction in local biodiversity.

CONCLUSIONS

The results of this study assessed the significant role of soil parameters in the distribution of species across the four urban habitats in an arid region. This study also confirmed that managed habitats (e.g., home and public gardens) had the highest species diversity, which magnified their role in the plant diversity of urban environments. On the other hand, the urban habitats were fragmented, a state of affairs and this can be explained by the presence of tolerated species to both salinization and invasions by introduced species. Restoration efforts for fragmented habitats should include the reinstatement of native species, improvement of soil structure and nutrient status and implement long-term monitoring programs to confirm the sustainability and resilience of plant assemblages.

CONFLICT OF INTEREST STATEMENT

"The authors have no conflicts of interest to declare."

LITERATURE CITED

Abd El-Ghani, M. M., Barakat, H. N. and Shamloul, A. M. 1992. Vegetation pattern and habitat types around old wells in Kharga Oasis, Egypt. *Journal of Faculty of Education*, *Ain Shams University*, 17: 161-172.

Abd El-Ghani, M. M., El-Kheir, M. A., Abdel-Dayem, M. and Abd El-Hamid, M. 2011. Vegetation analysis and soil characteristics of five common desert climbing plants in Egypt. *Turkish Journal of Botany*, 35(5): 561-580. [CrossRef]

Abd El-Ghani, M., Bornkamm, R., Nadia, E. S. and Turky, H. 2015. Heterogeneity of soil and vegetation in the urban habitats of new industrial cities in the desert landscape of Egypt. *Notulae Scientia Biologicae*, 7(1): 26-36. [CrossRef]

Abd El-Ghani, M. M., Huerta-Martínez, F. M., Hongyan, L. and Qureshi, R. 2017. Plant responses to hyperarid desert environments. First edition, Springer, International Publishing, 598pp. [CrossRef]

Abd El-Ghani, M. M. and Hussein, E. A. 2024. Exploring Ruderal Vegetation Dynamics and Site Factors in Managed Habitats of North East Cairo, Egypt. Catrina: The International Journal of Environmental Sciences. *Catrina*, 29(1): 25-38. [CrossRef]

Abdel Meguid, M. 2017. Key features of Egypt's water and agricultural resources. *In*: Conventional water resources and agriculture in Egypt, p. 39-99. Cham: Springer International. [CrossRef]

Allen, M. M. and Stainer, S. T. 1974. Chemical analysis of ecological materials. Blackwell Scientific Publications, Oxford, London, 565 pp.

Ayyad, M. A. and Ghabbour, S. I. 1986. Hot deserts of Egypt and the Sudan. *In*: Evenari, M., Noy-Meir, L. and Goodall, D. W. (Eds.), Ecosystems of the world, 12B: Hot deserts and arid shrublands (pp. 149-202). Amsterdam.

Bardsley, C. and Lancaster, J. 1965. Sulfur. In: Methods of Soil Analysis: Part 2. *Chemical and Microbiological Properties*, 9: 1102-1116.

Bastin, L. and Thomas, C. D. 1999. The distribution of plant species in urban vegetation fragments. Landscape Ecology, 14: 493-507. [Click here]

Biedermann, W. and Schwarzenbach, G. 1948. Die komplexometrische Titration der Erdalkalien und einiger anderer Metalle mit Eriochromschwarz T. *Chimia*, 2(3): 56. [CrossRef]

Bornkamm, R. and Kehl, H. 1990. The plant communities of the western desert of Egypt. *Phytocoenologia*, 19(2): 149-231. [CrossRef]

Boulos, L. 2009. Flora of Egypt checklist (Revised annotated edition). Al-Hadara Publishing, Cairo, Egypt, 410 pp.

Bouyoucos, G. J. 1962. Hydrometer method improved for making particle size analyses of soils. *Agronomy Journal*, 54(5): 464-465. [CrossRef]

Campos, J. A., Herrera, M., Biurrun, I. and Loidi, J. 2004. The role of alien plants in the natural coastal vegetation in central-northern Spain. *Biodiversity and Conservation*, 13(12): 2275–2293. [CrossRef]

Chojnacki, J. 1991. Zróżnicowanie przestrzenne roślinności Warszawy. Warszawa: Wydawnictwo Uniwersytetu Warszawskiego, 227 pp. [Click here]

Dana, E. D., Vivas, S. and Mota, J. F. 2002. Urban vegetation of Almería City: a contribution to urban ecology in Spain. *Landscape and Urban Planning*, 59: 203-216. [CrossRef]

Diamant, E. S., Oswald, K. N., Awoyem, A. G., Gaston, K. J., MacGregor-Fors, I., Berger-Tal, O. and Roll, U. 2025. The importance of biome in shaping urban biodiversity. *Trends in Ecology and Evolution*, 40(6): 601-612. [CrossRef]

El-Hadidi, M. N. 2000. The main features of the natural vegetation. *In*: El Hadidi, M. N. and Hosni, H. A. (Eds.), Flora Aegyptiaca, Vol. 1 (p. 27-105). Cairo University Herbarium and The Palm Press.

Florgård, C. 2000. Long-term changes in indigenous vegetation preserved in urban areas. *Landscape and Urban Planning*, 52: 101-116. [CrossRef]

Gilbert, O. L. 1989. The ecology of urban habitats. Springer Dordrecht, 370pp. [CrossRef]

Godefroid, S. and Koedam, N. 2003a. Distribution pattern of the flora in a peri-urban forest: an effect of the city-forest ecotone. *Landscape and Urban Planning*, 65(4): 169-185. [CrossRef]

Godefroid, S. and Koedam, N. 2003b. Identifying indicator plant species of habitat quality and invasibility as a guide for peri-urban forest management. *Biodiversity and Conservation*, 12: 1699-1713. [CrossRef]

Good, J. E. G. 1977. Urban trees: some problems and proposals. 139th Annual Meeting, British Association for the Advancement of Science.

Guirado, M., Pino, J. and Rodà, F. 2006. Understorey plant species richness and composition in metropolitan forest archipelagos: effects of forest size, adjacent land use and distance to the edge. Global Ecology and Biogeography, 15(1): 50-62. [CrossRef]

Hejnỳ, S. 1971. Metodologickỳ příspěvek k výzkumu synantropní květeny a vegetace velkoměsta (na příkladu Prahy). *Zborník prednášok zo zjazdu Slovenskej botanickej spoločnosti, Tisovec*, 2: 545-567. (In Slovak).

Henderson, P. and Seaby, R. 1999. Community Analysis Package (CAP), version 1.2. Pisces Conservation Ltd., UK.

Hill, M. O. and Gauch, H. G. 1980. Detrended correspondence analysis: an improved ordination technique. *Vegetatio* 42: 47-58. [CrossRef]

Jackson, M. 1967. Soil chemical analysis. Prentice-Hall of India Private Limited, New Delhi, 498 pp.

Jongman, R., ter Braak, C. and van Tongeren, O. 1987. Data analysis in community and landscape ecology. Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen, Netherlands, 299 pp.

Kato, H., Elbeih, S., Iwasaki, E., Sefelnasr, A., Shalaby, A., Zaghloul, E. and Semedi, P. 2014. The relationship between groundwater, land use, and demography in Dakhla Oasis, Egypt. *Journal of Asian Network for GIS-based Historical Studies*, 2: 3-10. [Google Scholar]

Kaupur, P. and Govil, S. R. 2000. Experimental plant ecology (1st ed.). CBS Publishers & Distributors Pvt Ltd, India, 156pp. [Google Scholar]

Kent, M., Stevens, R. A. and Zhang, L. 1999. Urban plant ecology patterns and processes: a case study of the flora of the city of Plymouth, Devon, U.K. *Journal of Biogeography*, 26(6): 1281-1298. [CrossRef]

Khan, N., Ullah, R., Okla, M., Abdel-Maksoud, M. A., Ibrahim, A. Saleh, Abu-Harirah, A., Airamadneh and AbdElgawad, H. 2023. Spatial distribution of the four invasive plants and their impact on natural communities' dynamics across the arid and semi-arid environments in northwest Pakistan. *Frontiers in Plant Science*, 14:1-17. [CrossRef]

Klotz, S. 1987. Floristische und vegetationskundliche Untersuchungen in Städten der DDR. *Geobotanische Kolloquien*, 4: 61-69.

Klotz, S. 1990. Species area and species inhabitant's relations in European cities. *In*: Sukopp, H., Hejný, S. and Kowarik, I. (Eds.), Urban ecology: Plants and plant communities in urban environments (pp. 99-104). SPB Publishing, The Hague.

Kühn, I., Brandi, R. and Klotz, S. 2004. The flora of German cities is naturally species rich. *Evolutionary Ecology Research*, 6: 749-764.

Lososová, Z. and Simonová, D. 2008. Changes during the 20th century in species composition of synanthropic vegetation in Moravia (Czech Republic). *Preslia*, 80(3): 291-305.

Magurran, A. E. 2021. Measuring biological diversity. *Current Biology*, 31(19): R1174-R1177. [CrossRef]

Mahdavi, P., Akhani, H. and Van der Maarel, E. 2013. Species diversity and life-form patterns in steppe vegetation along a 3000 m altitudinal gradient in the Alborz Mountains, Iran. *Folia Geobotanica*, 48: 7-22. [CrossRef]

McKinney, M. L. 2002. Urbanization, biodiversity, and conservation: The impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. *BioScience*, 52(10): 883-890. [CrossRef]

Mucina, L. 1990. Urban vegetation research in European Comecon-countries and Yugoslavia: a review. *In*: Sukopp, H., Hejný, S. & Kowarik, I. (Eds.), Urban ecology. Plants and Plant Communities in Urban Environments. SPB Academic Publishing, SPB Academic Publishing, The Haguc, p. 23-43.

Maurer, U., Peschel, T. and Schmitz, S. 2000. The flora of selected urban land-use types in Berlin and Potsdam with regard to nature conservation in cities. *Landscape and Urban Planning*, 46(4): 209-215. [CrossRef]

Merlo, S. 2024. Oases occupation. *In*: Knight, J., Merlo, S. and Zerboni, A. (Eds), Landscapes and Landforms of the Central Sahara. Springer International Publishing. Cham, p. 173-184. [Click here]

Mori, A. S., Isbell, F. and Seidl, R. 2018. β-diversity, community assembly, and ecosystem functioning. *Trends Ecology Evolution*, 33(7): 549-564. [CrossRef]

Muenchow, J., Hauenstein, S., Bräuning, A., Bäumler, R., Rodríguez, E. F. and Wehrden, H. 2013. Soil texture and altitude, respectively, largely determine the floristic gradient of the most diverse fog oasis in the Peruvian desert. *Journal of Tropical Ecology*, 29(5): 427-438. [CrossRef]

Pyšek, P. 1995. Approaches to studying spontaneous settlement flora and vegetation in central Europe: a review. *In*: Sukopp, H., Numata, M. and et Huber, A. (ed.), Urban ecology as the basis of urban planning, p. 23-39, SPB Academic Publ., Amsterdam.

Pyšek, P. 1998. Alien and native species in Central European urban flora: a quantitative comparison. Journal of Biogeography, 25(1): 155-163. [CrossRef]

Pyšek, P., Chocholouškova, Z., Pyšek, A., Jarošik, V., Chytrý, M. and Tichý, L. 2004. Trends in species diversity and composition of urban vegetation over three decades. Journal of Vegetation Science, 15(6): 781-788. [CrossRef]

Saavedra, M., Garcia-Torres, L., Hernandez-Bermjo, E., and Hidlago, B. 1989. Weed flora of the Middle Valley of the Guadalquivir, Spain. Weed Research, 29(3): 167-179. [CrossRef]

Said, R. 1962. Geology of Egypt. Elsevier, Amsterdam, 377 pp.

Stenhouse, R. N. 2004. Fragmentation and internal disturbance of native vegetation reserves in the Perth metropolitan area, Western Australia. *Landscape and Urban Planning*, 68: 389-401.

Sukopp, H. 2002. On the early history of urban ecology in Europe. Preslia, 74: 373-393.

Sukopp, H. 2004. Human-caused impact on preserved vegetation. *Landscape and Urban Planning*, 68(4): 347-355. [CrossRef]

Sukopp, H. and Werner, P. 1983. Urban environments and vegetation. In Holzner, W., Werger, M. J. A. and Ikusima, I. (Eds.), Man's impact on vegetation, p. 247-260. [CrossRef]

Täckholm, V. 1974. Students' flora of Egypt (2nd ed.). Cairo University, Beirut, 888 pp.

Ter Braak, C. J. F. 1990. Update notes: CANOCO version 3.1. Wageningen: Agricultural Mathematics Group.

Ter Braak, C. J. F. and Prentice, I. C. 1988. A theory of gradient analysis. Advances in Ecological Research, 18: 271-317. [CrossRef]

Ter Braak, C. J. F. and Šmilauer, P. 2002. CANOCO reference manual and CanoDraw for Windows user's guide (Version 4.5).

Walkley, A. and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1): 29-38. [CrossRef]

Williams, V. and Twine, S. 1960. Flame photometric method for sodium, potassium and calcium. *Modern Methods of Plant Analysis*, 5: 3-5.

Woods, J. and Mellon, M. 1941. Molybdenum blue reaction: A spectrophotometric study. Industrial & Engineering Chemistry Analytical Edition, 13(11): 760-764. [CrossRef]

Zerbe, S., Maurer, U., Schmitz, S. and Sukopp, H. 2003. Biodiversity in Berlin and its potential for nature conservation. Landscape and Urban Planning, 62(3): 139-148. [CrossRef]

Zerbe, S., Maurer, U., Peschel, T., Schmitz, S. and Sukopp, H. 2004. Diversity of flora and vegetation in European cities as a potential for nature conservation in urban industrial areas: Examples from Berlin and Potsdam (Germany). *In*: Shaw *et al.* (Eds.), Proceedings of the 4th International Urban Wildlife Symposium.

Zhang, H. X. and Zhang, M. L. 2017. Spatial patterns of species diversity and phylogenetic structure of plant communities in the Tianshan Mountains, arid Central Asia. *Frontiers in Plant Science*, 8: 2134. [CrossRef]

Bull. Iraq nat. Hist. Mus.
(2026) 19 (1): 29-58.

تأثير خصائص التربة على توزيع وتنوع الأنواع النباتية في المواائل الناتجة عن الأنشطة البشرية في مدن الصحراء النوبية الجافة، مصر

علي جعفر*•، منير م. عبد الغني**، مروة م. رجائي* و سلوى عبد الوهاب*
*قسم علم النبات والأحياء الدقيقة، كلية العلوم، جامعة الوادي الجديد، الخارجة ٧١٥١١، مصر.
**قسم علم النبات والأحياء الدقيقة، كلية العلوم، جامعة القاهرة، الجيزة ١٢٦١٣، مصر.

الاستلام: 2025/9/2، المراجعة: 2026/1/6، القبول: 2026/1/17، النشر: 2026/6/20

الخلاصة

تم تحليل أنماط توزيع النباتات في أربعة موائل حضرية هي: الحدائق المنزلية والحدائق العامة وجزر الطرق والأراضي البور أو المهملة في واحتي الخارجة والداخلة بصحراء مصر الغربية. أخذت عينات من 39 موقعًا من مختلف الموائل الأربعة. احتوت الحدائق المنزلية على 132 نوعًا من النباتات، تميزت بأشجار البساتين والأعشاب المزروعة والنباتات الصحراوية، بينما احتوت الحدائق العامة 112 نوعًا، سادت فيها نباتات الزينة ونباتات الأراضي الرطبة. أما الموائل المضطربة فكانت أقل ثراءً بالأنواع، حيث وُجد 71 نوعًا في جزر الطرق 58 نوعًا في الأراضي الخالية البور او المهملة، معظمها من الأعشاب الضارة والنباتات الصحراوية. ارتبطت خصائص التربة ارتباطًا وثيقًا بأنماط الغطاء النباتي، إذ كان ثراء الأنواع وتنوع شانون أعلى في المواقع التي تحتوي على نسب مرتفعة من الطين والمادة العضوية ودرجة الحموضة، في حين أن الترب الرملية الفقيرة بالعناصر الغذائية حدّت من التنوع النباتي وقد تراوح مؤشر شانون–وينر بين 1,93 و 3,27 ، بينما تراوح الغنى النوعي بين 8 و 27,33 نوعًا لكل موقع، مع وجود تمايز واضح بين مجموعات الغطاء النباتي على

محاور تحليل التطابق المتري(DCA) ، مما يشير إلى فروق بيئية ذات دلالة حتى دون إجراء اختبارات دلالة رسمية. وكانت النباتات المصاحبة للنشاط البشري، وخاصة الأعشاب والنباتات الروديرالية (نباتات الأراضي المتدهورة)، الأكثر وفرة في المواقع المتأثرة بالاضطرابات، مما يعكس تأثير الأنشطة الحضرية وانتشار الأنواع الغازية. وتؤكد النتائج أن الموائل المُدارة يمكن أن تكون بمثابة ملاذات للتنوع الحيوي في النظم البيئية الحضرية القاحلة، بينما تتطلب المواقع المتدهورة اعادة تأهيل للحد من انتشار الأنواع الغازية وتعزيز تنوع النباتات المحلية. كما ينبغي أن يدمج التخطيط الحضري الفعّال في الواحات الصحراوية العلاقة بين التربة والنبات، ويُعطي الأولوية للأنواع المحلية المقاومة للجفاف، ويعمل على استصلاح وتأهيل المواقع المتدهورة لضمان الاستدامة البيئية.