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Floristic Diversity, Life-Form Composition, and Anthropogenic Pressures on The Vegetation of Wadi om-El-Amaym in Al-Jabal Al-Akhdar, Northeastern Libya

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Abstract
Al-Jabal Al-Akhdar in northeastern Libya is renowned for its distinctive Mediterranean mountain ecosystems, high biodiversity, and a significant proportion of endemic plant species. Yet, limited comprehensive ecological studies have focused on its wadi systems, particularly in the face of increasing anthropogenic pressures. This study examines the vegetation of Wadi Om-El-Amaym, a northern segment of Wadi Al-Agar, with the aim of assessing species composition, taxonomic diversity, life-form distribution, and the impact of human activities on local flora. Field surveys were conducted over a 12-month period, during which plant specimens were collected, identified, and categorized into major taxonomic groups and life forms using standard floristic and ecological methodologies. A total of 141 species spanning 43 families were recorded, including nine endemics and several taxa with medicinal properties. Dominant families included Fabaceae, Poaceae, and Geraniaceae, while Trifolium and Erodium emerged as particularly species-rich genera. Analysis of life-form spectra revealed a prevalence of annual therophytes, alongside the presence of woody phanerophytes and chamaephytes, reflecting adaptations to the region's varied topography and climatic conditions. However, the vegetation is increasingly threatened by overgrazing, woodcutting, agricultural expansion, and other human-driven disturbances. These pressures have led to habitat degradation, putting several species at risk. The findings highlight the urgent need for targeted conservation measures, sustainable land-use practices, and increased environmental awareness to preserve the ecological integrity and unique botanical heritage of Wadi Om-El-Amaym and the broader Al-Jabal Al-Akhdar region.

Keywords: Floristic diversity, Endemic species, Anthropogenic disturbances, Mediterranean mountain ecosystem, Biodiversity conservation, and Life-form spectrum.

Introduction
Al-Jabal Al-Akhdar, located in northeastern Libya, is a critical phytogeographical region characterized by its rich biodiversity and varied habitat types. The region's unique topography and climatic conditions

support a diverse array of plant species, many of which are endemic. Despite its ecological significance, comprehensive studies focusing on the vegetation and habitat distribution within Al-Jabal Al-Akhdar have been limited, emphasizing the need for detailed ecological investigations to inform conservation efforts and sustainable management practices.

Recent studies have begun to address this need. For instance, Hegazy et al. (2011) conducted a field study analyzing vegetation across different habitat types in Al-Jabal Al-Akhdar, revealing significant variations in species richness and composition along altitudinal gradients. Similarly, Elshatshat and Mansour (2014) assessed the impact of human activities on the flora of the coastal regions of Al-Jabal Al-Akhdar, identifying 104 plant species across 37 families and highlighting the adverse effects of land abuse, charcoal burning, and overgrazing on vegetation composition.

Building upon these foundational studies, recent research by Abd El-Ghani and Al Borki (2024) examined how elevation and soil properties influence plant distribution patterns and species diversity in the Mediterranean mountain ecosystem of Al-Jabal Al-Akhdar. Their findings underscore the complex interplay between environmental factors and vegetation dynamics in the region. Additionally, Dakeel et al. (2024) conducted a vegetation analysis of the Cyrene Campus Apollo in Shahat, Al-Jabal Al-Akhdar, utilizing the quadrat method to estimate species diversity and determine dominant plant species through the Importance Value Index.

The present study aims to extend this body of knowledge by focusing on Wadi Om-El-Amaym, a northern segment of Wadi Al-Agar located in the northwestern part of Al-Jabal Al-Akhdar. This research seeks to investigate the effects of human activities on the vegetation of Wadi Om-El-Amaym, thereby contributing to a more comprehensive understanding of the region's wadi ecosystems and informing strategies for their conservation and sustainable management.

By integrating recent data and building upon previous studies, this research endeavors to provide a detailed ecological assessment of Wadi Om-El-Amaym, offering insights into the current state of its vegetation and the anthropogenic pressures it faces. Such information is crucial for developing effective conservation strategies to preserve the unique biodiversity of Al-Jabal Al-Akhdar.

Materials and Methods

Study Area

The study area comprises a section of Wadi Al-Agar, specifically Wadi Om El-Amaym, located on the eastern coast of Libya within the Al-Jabal Al-Akhdar region. It lies geographically between 20°45'00" and 20°01'42" E longitude and 32°35'00" and 32°01'15" N latitude. The wadi spans approximately 17 kilometers, extending in a north-south direction from its endpoint at the Mediterranean Sea to its southern limits, with Farzugha to the west and Al-Marj to the east (Figure 1). The elevation of the area reaches approximately 380 meters above sea level.

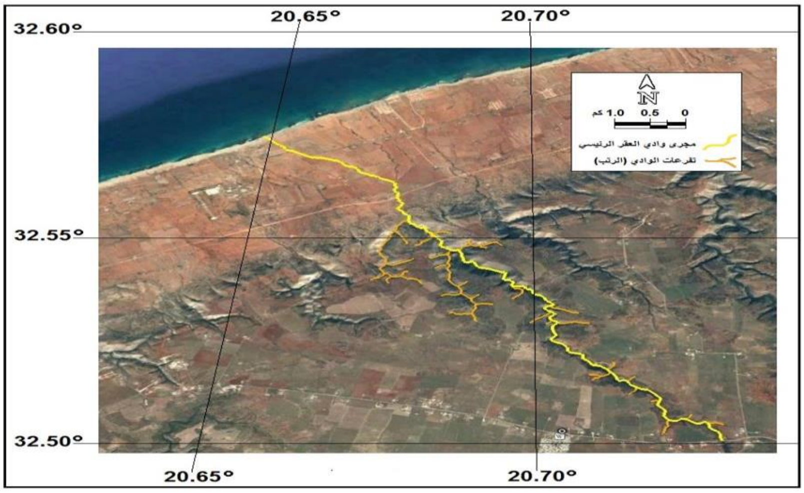

Figure 1: Geographic map of the study area showing the topographical features and the delineated boundaries, including the coastal region and the wadi system under investigation.

Collection and Identification of Specimens

Fieldwork was conducted over 12 months to ensure comprehensive specimen collection and vegetation observation across various parts of the study area. During this time, at least one field trip was carried out each month, with increased frequency during the rainy seasons and spring when the majority of plants were in flowering condition.

Plant specimens were collected during their flowering and/or fruiting stages. For herbaceous plants, specimens were collected with their underground parts wherever possible. In the case of woody plants, branches or twigs approximately 25 cm in length were sampled. A minimum of four specimens were collected for each species. Specimens collected repeatedly from the same location and time were assigned unique field numbers.

At the time of collection, relevant field information was meticulously recorded, including the collection date, locality, habitat type, flower color, abundance, vernacular names, and any known uses. Specimens were pressed either in the field immediately after collection or upon return to the herbarium. Each specimen was carefully arranged on blotters or newspaper sheets, with overlapping leaves or branches removed when necessary. Larger specimens were adjusted to fit the sheet using V- or N-shaped arrangements and were tightly bound in a plant press.

For drying, the plant presses containing the specimens were placed under sunlight or in an oven with hot air circulation. The specimens were periodically checked, rearranged, and transferred to fresh sheets every two to three days until completely dry. In damp environmental conditions, artificial heat was used to facilitate the drying process. Once dried, the specimens were mounted onto herbarium sheets for further analysis. Identification of the specimens was conducted using available taxonomic references, including the Flora of Libya (Ali & Jafri, 1976; Ali & El-Gadi, 1988). The collected specimens were deposited in the Herbarium of the Botany Department, Faculty of Arts and Science, Tukrah, University of Benghazi, Libya.

Results and Discussion

This study recorded a total of 141 species belonging to 43 families. Gymnosperms were represented by two families, each containing one species and one genus. Angiosperms were represented by 38 families, with Dicotyledons contributing 115 species across 64 genera and 37 families, while Monocotyledons contributed 24 species across 11 genera and four families, as indicated in Table 1. The diversity recorded in this study highlights the ecological significance of the region as a repository of both Gymnosperm and Angiosperm biodiversity, which requires further exploration for conservation purposes.

Table 1: Summary of taxonomic groups recorded in the study area.

No	Plant groups		No. of Species	No. of Genera	No. Of Families
1	**Gymnosperms**		**2**	**2**	**2**
3	**Angiosperms**	Dicotyledones	115	64	37
4		Monocotyledons	24	11	4
	Total		**141**	**77**	**43**

The distribution of species across families in the study area suggests a flora that is relatively modest in diversity. The most prominent families in terms of species richness were Fabaceae, with 28 species, and Poaceae, with 11 species. These were followed by Geraniaceae, comprising ten species, and Lamiaceae, with seven species. Asteraceae and Ranunculaceae were each represented by six species, while Alliaceae accounted for five. Five families—Asparagaceae, Caryophyllaceae, Euphorbiaceae, Linaceae, and Malvaceae—each contributed four species. Families such as Apiaceae, Cistaceae, Oleaceae, Convolvulaceae, and Resedaceae each included three species.

Additionally, families such as Araceae, Anacardiaceae, Boraginaceae, Caprifoliaceae, Plantaginaceae, Papaveraceae, Primulaceae, and Rhamnaceae were represented by two species each. The remaining families, including Amaranthaceae, Apocynaceae, Caesalpinaceae, Capparaceae, Cucurbitaceae, Ephedraceae, Fagaceae, Ericaceae, Liliaceae, Adoxaceae, Smilaceae, Solanaceae, Rosaceae, Oxalidaceae, Polygonaceae, and Rubiaceae, were each represented by a single species (Table 2). This indicates a predominance of certain families, particularly Fabaceae, suggesting their ecological adaptability and potential utility in environmental restoration programs.

Table 2: Major families and their respective number of species recorded in the flora of the study area.

No	Family	No. of Species
1	Fabaceae	27
2	Poaceae	11
3	Geraniaceae	10
4	Lamiaceae	7
5	Asteraceae	6
6	Ranunculaceae	6
7	Alliaceae	5
8	Caryophyllaceae	4
9	Euphorbiaceae	4
10	Linaceae	4

11	Malvaceae	4
12	Asparagaceae	4
13	Apiaceae	3
14	Cistaceae	3
15	Oleaceae	3
16	Resedaceae	3
17	Convolvulaceae	3
18	Araceae	2
19	Anacardiaceae	2
20	Boraginaceae	2
21	Caprifoliaceae	2
22	Plantaginaceae	2
23	Papaveraceae	2
24	Primulaceae	2
25	Rhamnaceae	2
26	Amaranthaceae	1
27	Apocynaceae	1
28	Caesalpinaceae	1
29	Capparaceae	1
30	Cucurbitaceae	1
31	Cupressaceae	1
32	Ephedraceae	1
33	Fagaceae	1
34	Ericaceae	1
35	Liliaceae	1
36	Adoxaceae	1
37	Smilaceae	1
38	Solanaceae	1
39	Rosaceae	1
40	Lauraceae	1
41	Oxalidaceae	1
42	Polygonaceae	1
43	Rubiaceae	1

Regarding genus representation, Trifolium emerged as the most species-rich genus, with seven species forming the largest genus in the area. Erodium followed this with six species, and Allium with five species. Genera such as Avena, Bromus, Euphorbia, Geranium, Linum, Malva, Medicago, and Silene were each represented by four species. Seven other genera, including Cistus, Convolvulus, Lotus, Ononis, Teucrium, Ranunculus, and Reseda, contributed three species each. Thirteen genera, such as Ammi, Calicotome, Echium, Vicia, Globularia, Asparagus, Phillyrea, Hordeum, Papaver, Clematis, and Rhamnus, were represented by two species each. The remaining genera were each represented by a single species (Table 3). The dominance of genera such as Trifolium and Erodium points to their significant role in the ecological stability of the region, possibly linked to soil enrichment through nitrogen fixation and other environmental processes.

Table 3: Species recorded in the study area, organized by family.

No	Species	Family
1	Viburnum tinus L.	Adoxaceae
2	Amaranthus viridis L.	Amaranthaceae
3	Pistacia lentiscus L.	Anacardiaceae
4	Rhus tripartita (Ucria) Grande	Anacardiaceae
5	Allium ampeloprasum L.	Alliaceae
6	Allium erdelii Zuec.	Alliaceae
7	Allium longanum Pamp.	Alliaceae
8	Allium orientale Boiss.	Alliaceae
9	Allium ruhmerianum Asch.	Alliaceae
10	Ammi majus L.	Apiaceae
11	Ammi visnaga (L.)Lam.	Apiaceae
12	Pimpinella peregrine L.	Apiaceae
13	Arum cyrenaicum Hruby	Araceae
14	Arisarum vulgare Targ. & Tozz .	Araceae
15	Periploca angustifolia Labill.	Apocynaceae
16	Asparagus acutifoilus L.	Asparagaceae
17	Asparagus albus L.	Asparagaceae
18	Ornithogalum tenuifolium Guss	Asparagaceae
19	Urginea maritima (L.) Baker.	Asparagaceae
20	Bellis sylvestris Cyr. Var cyrenaica Begu	Asteraceae
21	Centaurea cyrenaica. Beguinot & Vacc.	Asteraceae
22	Cichorium spinosum L	Asteraceae
23	Crepis senecioides Delile.	Asteraceae
24	Helichrysum stoechas (L) Moench.	Asteraceae
25	Pallenis spinosa (L.) Cass.	Asteraceae
26	Echium angustifolium Mill.	Boraginaceae
27	Echium sabulicola DC.	Boraginaceae
28	Fedia caput-bovis Pomel.	Caprifoliaceae
29	Lonicera etrusca Santi.	Caprifoliaceae
30	Ceratonia siliqua L.	Caesalpinaceae
31	Capparis spinosa L.	Capparaceae
32	Silene apetala Willd.	Caryophyllaceae
33	Silene behen L.	Caryophyllaceae
34	Silene cyrenaica Maire & Weiller.	Caryophyllaceae
35	Silene gallica L.	Caryophyllaceae
36	Cistus incanus L. subsp. creticus (L.) Heywood.	Cistaceae
37	Cistus parviflorus Lam.	Cistaceae

38	Cistus salvifolius L.	Cistaceae
39	Convolvulus maireanus Pamp	Convolvulaceae
40	Convolvulus siculus L.	Convolvulaceae
41	Convolvulus tricolor L.	Convolvulaceae
42	Bryonia cretica L.	Cucurbitaceae
43	Juniperus phoenicea L.	Cupressaceae
44	Arbutus pavarii Pamp.	Ericaceae
45	Ephedra altissima Desf.	Ephedraceae
46	Euphorbia biovnae Steud.	Euphorbiaceae
47	Euphorbia chamaesyce L	Euphorbiaceae
48	Euphorbia falcata L.	Euphorbiaceae
49	Euphorbia helioscopia L.	Euphorbiaceae
50	Quercus coccifera L.	Fagaceae
51	Anagyris foetida L	Fabaceae
52	Calicotome villosa (Poiret) Link	Fabaceae
53	Calicotome spinosa (L) Link	Fabaceae
54	Coronilla valantia L.	Fabaceae
55	Genista acanthoclada DC.	Fabaceae
56	Lotus edulis L.	Fabaceae
57	Lotus halophilus Boiss. Et. Sprun.	Fabaceae
58	Lotus ornithopodioides L.	Fabaceae
59	Medicago littoralis Rohde ex Lois.	Fabaceae
60	Medicago orbicularis (L.) Bart.	Fabaceae
61	Medicago polymorpha L.	Fabaceae
62	Medicago turbinata (L.) All.	Fabaceae
63	Melilotus sulcatus Desf	Fabaceae
64	Ononis pendula Desf.	Fabaceae
65	Ononis reclinata L.	Fabaceae
66	Ononis viscosa L.	Fabaceae
67	Tetragonolobus purpureus Moench	Fabaceae
68	Trifolium angustifolium L.	Fabaceae
69	Trifolium arvense L.	Fabaceae
70	Trifolium campestre Schreb.	Fabaceae
71	Trifolium purpureum Lois.	Fabaceae
72	Trifolium scabrum L.	Fabaceae
73	Trifolium stellatum L.	Fabaceae
74	Trifolium tomentosum L.	Fabaceae
75	Spartium junceum L	Fabaceae
76	Vicia monantha Retz.	Fabaceae
77	Vicia sativa L	Fabaceae
78	Erodium hirtum (Forsk.) Willd.	Geraniaceae
79	Erodium gruinum (L.) L' Herit.	Geraniaceae

80	Erodium keithii Guitt .et Le Houerou.	Geraniaceae
81	Erodium laciniatum (Cav.) Willd.	Geraniaceae
82	Erodium malacoides (L.) L' Herit.	Geraniaceae
83	Erodium neuradifolium Delile.	Geraniaceae
84	Geranium rotundifolium L.	Geraniaceae
85	Geranium molle L.	Geraniaceae
86	Geranium brutium Gasp.	Geraniaceae
87	Geranium robertianum L.	Geraniaceae
88	Marrubium vulgare L.	Lamiaceae
89	Phlomis floccosa D. Don.	Lamiaceae
90	Prasium majus L.	Lamiaceae
91	Rosmarinus officinalis L.	Lamiaceae
92	Teucrium barbeyanum Aschers.	Lamiaceae
93	Teucrium brevifolium Schreber.	Lamiaceae
94	Teucrium fruticans L.	Lamiaceae
95	Linum bienne Miller.	Linaceae
96	Linum decumbens Desf.	Linaceae
97	Linum nodiflorum L.	Linaceae
98	Linum strictum L.	Linaceae
99	Laurus nobilis L.	Lauraceae
100	Asphodelus microcarpus Salzm & Viv	Liliaceae
101	Malva aegyptia L.	Malvaceae
102	Malva nicaeensis All.	Malvaceae
103	Malva parviflora L.	Malvaceae
104	Malva sylvestris L	Malvaceae
105	Olea europaea (Wall. ex G.Don) Cif.	Oleaceae
106	Phillyrea angustifolia L.	Oleaceae
107	Phillyrea latifolia L.	Oleaceae
108	Oxalis pes-caprae L.	Oxalidaceae
109	Globularia alypum L.	Plantaginaceae
110	Globularia arabica Jaub. & Spach.	Plantaginaceae
111	Avena barbata Pott. ex Link.	Poaceae
112	Avena fatua L.	Poaceae
113	Avena sativa L.	Poaceae
114	Avena sterilis L.	Poaceae
115	Bromus alopecuros Poir.	Poaceae
116	Bromus diandrus Roth.	Poaceae
117	Bromus madritensis L.	Poaceae
118	Bromus rubens L.	Poaceae
119	Cynodon dactylon (L.) Pers.	Poaceae
120	Hordeum murinum L. ssp. leporinum (Link.) Arcang.	Poaceae
121	Hordeum vulgare L.	Poaceae

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122	Papaver hybridum L.	Papaveraceae
123	Papaver rhoeas L.	Papaveraceae
124	Polygonum maritimum L.	Polygonaceae
125	Anagalis arvensis L. var. caerulea (L.) Gouan.	Primulaceae
126	Cyclamen rohlfsianum Asch.	Primulaceae
157	Adonis dentata Delile	Ranunculaceae
128	Clematis cirrhosa L.	Ranunculaceae
129	Clematis flammula L.	Ranunculaceae
130	Ranunculus asiaticus L.	Ranunculaceae
131	Ranunculus bullatus L.	Ranunculaceae
132	Ranunculus paludosus Poiret.	Ranunculaceae
133	Rhamnus alaternus L.	Rhamnaceae
134	Rhamnus lycioides L.	Rhamnaceae
135	Reseda alba L. subsp. alba.	Resedaceae
136	Reseda alba L. subsp. decursiva (Forsk.) Maire.	Resedaceae
137	Reseda lutea L.	Resedaceae
138	Sarcopoterium spinosum (L.) Spach.	Rosaceae
139	Smilax aspera L.	Smilaceae
140	Galium mollugo L.	Rubiaceae
141	Lycium europaeum L.	Solanaceae

Among the collected specimens, nine species were identified as endemic to the Libyan flora, including Allium longanum Pamp, Allium ruhmerianum Asch, Arbutus pavarii Pamp, Arum cyrenaicum Hruby, Arisarum vulgare Targ & Tozz, Centaurea cyrenaica Beguinot & Vacc, Convolvulus maireanus Pamp, Cyclamen rohlfsianum Asch, and Teucrium barbeyanum Asch & Taube ex E. J. as shown in Table 4. These endemic species are crucial for biodiversity conservation strategies and highlight the need for habitat protection to prevent their extinction.

Table 4: List of endemic species recorded in the study area.

No.	Name of species	Family
1	Allium longanum Pamp.	Alliaceae
2	Allium ruhmerianum Asch.	Alliaceae
3	Arbutus pavarii Pamp.	Ericaceae
4	Arum cyrenaicum Hruby	Araceae
5	Arisarum vulgare Targ. & Tozz.	Araceae
6	Centaurea cyrenaica. Beguinot & Vacc.	Asteraceae
7	Convolvulus maireanus Pamp	Convolvulaceae
8	Cyclamen rohlfsianum Asch.	Primulaceae
9	um barbeyanum Asch&Taube ex E.J .	Lamiaceae

Life Form Spectrum

The 141 species recorded in the study area were categorized into life forms according to Raunkiar's classification, based on the height of the perennating bud from the ground (Raunkiar, 1934). The biological spectrum of the study area is summarized as follows: Phanerophytes: 25 species, accounting for 17.73% of the total flora. This category represents the taller woody plants and trees, indicating their adaptation to the region's climatic conditions; Chamaephytes: 23 species, constituting 16.31%. These low-growing shrubs are well-suited for arid and semi-arid regions, reflecting the local environmental conditions; Hemicryptophytes: The smallest category, represented by only one species (0.70%). This suggests a limited representation of herbaceous perennials adapted to temperate climates; Cryptophytes: 18 species, making up 12.76%. These plants, often bulbous or rhizomatous, reflect an adaptation to seasonal climatic variations; and Therophytes: The largest category, comprising 74 species (52.48%). The dominance of annuals highlights the prevalence of seasonal vegetation adapted to the arid environment.

The life form classification provides insight into the floristic structure of the community. When the proportion of species in each life form is converted into percentages, these percentages create a life-form spectrum, reflecting species' ecological adaptation in each area (Whittaker, 1975), as indicated in Figure 2. Such data are valuable for environmental planning and management, especially in regions susceptible to desertification and climate change.

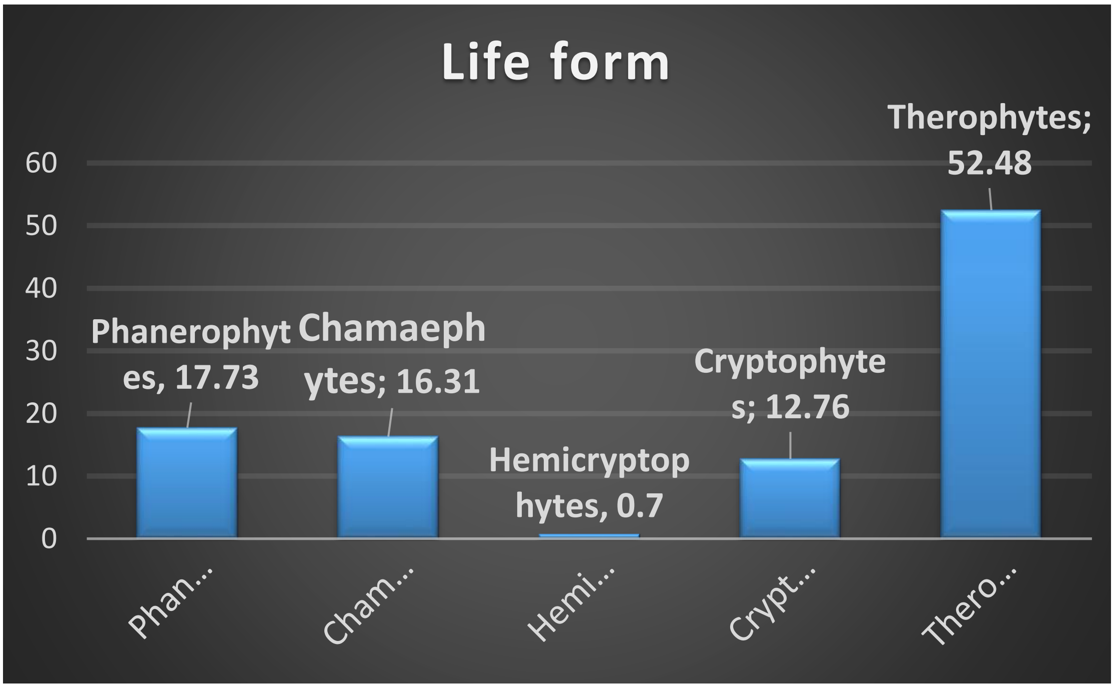

Figure 2: The biological spectrum of species in the study area, illustrating the distribution of life forms.

Medicinal Taxa

Among the species recorded in the wadi, 31 were identified as medicinal taxa. Examples include Asphodelus microcarpus Viv, Capparis spinosa L, Ceratonia siliqua L, Ephedra altissima Desf, Helichrysum stoechas (L.) Moench, Marrubium vulgare L, Olea europaea (Wall ex G. Don) Cif, Rosmarinus officinalis L, Teucrium barbeyanum Asch & Taube ex E. J., and Arbutus pavarii Pamp (Table

6). These medicinal plants underline the ethnobotanical importance of the region, presenting opportunities for pharmacological studies and the sustainable utilization of local flora.

Table 6: Medicinal Plants recorded in the study area.

No	Species	Family
1	Arbutus pavarii Pamp.	Ericaceae
2	Asphodelus microcarpus Salzm &Viv.	Liliaceae
3	Capparis spinosa L.	Capparaceae
4	Calicotome spinosa (L.) Link.	Fabaceae
5	Ceratonia siliqua L.	Caesalpiniaceae
6	Cichorium spinosum L.	Asteraceae
7	Cistus incanus L. subsp. Creticus (L.) Heywood.	Cistaceae
8	Cistus parviflorus Lam.	Cistaceae
9	Cistus salvifolius L.	Cistaceae
10	Cynodon dactylon (L.) Pers.	Poaceae
11	Ephedra altissima Desf.	Ephedraceae
12	Geranium molle L.	Geraniaceae
13	Geranium robertianum L.	Geraniaceae
14	Helichrysum stoechas (L.) Moench	Asteraceae
15	Laurus nobilis L.	Lauraceae
16	Lonicera etrusca Santi.	Caprifoliaceae
17	Lycium europaeum L.	Rosaceae
18	Malva aegyptia L.	Malvaceae
19	Malva sylvestris L	Malvaceae
20	Marrubium vulgare L.	Lamiaceae
21	Olea europaea (Wall. ex G.Don) Cif.	Oleaceae
22	Oxalis pes-caprae L.	Oxalidaceae
23	Papaver rhoeas L.	Papaveraceae
24	Phillyrea angustifolia L.	Oleaceae
25	Phlomis floccosa D. Don.	Lamiaceae
26	Polygonum maritimum L.	Polygonaceae
27	Rhamnus lyciodes L.	Rhamnaceae
28	Rosmarinus officinalis L.	Lamiaceae
29	Sarcopoterium spinosum (L.) Spach.	Rosaceae
30	Spartium junceum L.	Fabaceae
31	Teucrium barbeyanum Aschers.	Lamiaceae

Ecological Impacts of Anthropogenic Activities on Vegetation Dynamics in the Study Area

The vegetation in the study area is experiencing significant degradation due to various anthropogenic pressures, including overgrazing, woodcutting, agricultural expansion, plant collection, road construction, and increased human activity. Notably, visitors have further contributed to the depletion of vegetation by collecting wood for fire. As a result, several plant species are now at risk of extinction due to deforestation, habitat destruction, and overexploitation. Field observations and repeated visits to the wadi and its surroundings have identified several key factors contributing to vegetation degradation, specifically in the study area and the Al-Jabal Al-Akhdar region more broadly. These findings emphasize the urgent need to implement sustainable land-use practices, habitat restoration efforts, and community awareness programs to mitigate further loss of biodiversity and ensure the long-term ecological balance of the region.

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