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RESEARCH PAPER

First Checklist of Traditional Wild Plants and Their Uses in The Nineveh Plains, Northern Iraq

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Abstract

In the Nineveh Plains region of Northern Iraq, wild plants are important elements of ecological and social systems. To identify and document the knowledge, vernacular names, and ethnobotanical practices related to wild plants in this area, we conducted 421 in-person surveys across 40 villages, representing five ethnoreligious groups living in the Nineveh Plains (Christians, Yezidis, Shabaks, Turkmen, and Kaka'i). Thirty semi-structured interviews were conducted with individuals who were knowledgeable about wild plants. Overall, 69 wild plant species belonging to 68 genera and 35 families were identified in the study area. Asteraceae and Papilionaceae were the dominant families, with nine species each. Wild plant use has significant socio-economic importance for communities that reside in the Nineveh Plains, as people report using wild plants for food, medicine, cosmetics, animal husbandry, and income generation. *Gundelia tournefortii*, *Malva neglecta*, *Matricaria chamomilla*, and *Silybum marianum* achieved the highest rankings in both the Relative Frequency of Citation (RFC) and the Cultural Importance Index (CI). According to the Informant Agreement Factor and Informant Consensus Index for the categories of wild plant use, there was significant consensus among individuals regarding the species employed for food, as opposed to those used for decoration, medicine, and religious rituals. People have identified the greatest threats to local wild plant habitats, such as drought, herbicide use, overgrazing, expansion of large-scale agriculture, urbanization, and fires. Elderly community members also reported a lack of wild plant knowledge transfer between generations. The findings of this study have significant implications for developing a local biocultural conservation strategy to preserve the remarkable wild plants and natural heritage of the multi-ethnic and multi-cultural communities in Nineveh Plains.

Keywords

Ethnobotany; Wild plants; Natural heritage; Biocultural conservation; Traditional knowledge

1. Introduction

Edible wild plants have long played an important role in human settlements, as people have traditionally used these species for food, fodder, crafts, clothing, medicine, and fuel (Michael, 2008; Schulp et al., 2014). Currently, people worldwide continue to rely on wild plant collections to supplement their diets and meet health and nutritional needs (Pardo-de-Santayana et al., 2007), including essential vitamins and minerals, or "nutraceuticals" (Tardío et al.,

2006; Łuczaj, 2012). Harvesting wild edible plants can also generate household income and strengthen rural economies (Lead et al., 2010). Researchers have increasingly pointed to the potential of wild plants to play a role in more sustainable and resilient social and ecological systems (Addis et al., 2005; Pieroni et al., 2021).

Despite this potential, wild plant populations face significant challenges in terms of their continued social importance and ecological health. For example, recent evaluations of European wild food plants indicate that a significant proportion of plants previously used as food are rarely or never used (Tardío et al., 2006; Łuczaj et al., 2012). Other scholars point to factors that hinder people from using wild plants as a traditional food as a result of changing ecological and socioeconomic conditions (Bonet et al., 2002; Pieroni et al., 2005). Wild plant knowledge can also be negatively affected by widespread human migration and displacement. Such situations disconnect individuals from areas where they have developed local ecological knowledge (Vlková et al., 2015). Climate change, increased industrial agricultural practices, invasive species, and growing urbanization can also limit wild plant habitats, which in turn limits the opportunities for people to collect potentially useful plants.

In this study, we recorded the use of wild plants by communities living in the Nineveh Plains region of Northern Iraq, a region with thousands of years of practice and knowledge of wild plants (Pieroni et al., 2018). Northern Iraq is a part of the Irano-Anatolian biodiversity hotspot, which is home to over 6,000 plant species, approximately 2,500 of which are indigenous (Mittermeier et al., 2004). Situated at the crossing point of the Mediterranean, temperate, arid, and semi-arid biogeographical areas, this region is known to be a site of plant hybridization, colonization, and speciation (Mittermeier et al., 2004). The area's range of elevations and topographical features (from Mesopotamia plains to high mountain peaks to cliffs and gorges) results in variable precipitation and temperature zones, fostering significant plant species diversity. As a result, many uncommon, unique, endangered, and extraordinary plants are found in this area (Youssef et al., 2019). In addition to its botanical diversity, the Nineveh Plains is home to cultural diversity that includes many ethnic and religious minority communities. Local cultural and religious practices often include a broad knowledge of wild plants, which are widely incorporated into traditional diets, medicine, and ceremonies (Kawarty et al., 2020; Osterhoudt et al., 2024; Pieroni et al., 2018).

Below, we draw on surveys and semi-structured interviews with Christians, Yezidis, Shabaks, Turkmen, and Kaka'i individuals to consider the important role of wild plants in the cultural, social, and economic systems of Northern Iraq. Wild plants have been classified as vegetation found in urban, semi-natural, and natural areas, capable of surviving and growing as a population independent of human intervention (Heywood, 1999). The majority of respondents we surveyed used wild plants in their everyday lives, most notably for food and medicine. Individuals across groups also share the concern that their access to wild plants is decreasing due to both social and environmental threats. Elderly community members report a lack of knowledge of and overall interest in wild plants by many people in younger generations. Rather than focusing only on the unique ways each group uses local wild plant resources, we emphasize the ways in which wild plant use and knowledge are shared among different socio-religious groups in the Nineveh Plains. The findings of this study have significant implications for developing a local biocultural conservation strategy to preserve the remarkable wild plants and natural heritage of the diverse ethnic and religious communities of the Nineveh Plains.

2. Materials and methods

2.1. Study area

The Nineveh Plains of northern Iraq cover an area of approximately 2500 square kilometers. The Tigris River borders them to the west, and the Great Zab River to the south (Townsend & Guest, 1966). The region's landscape is primarily flat in the central and southern areas with minor hills and valleys in the northeast (Al-Ozeer et al., 2021). The northern region is considered a mountainous bioclimate with a high elevation and longer and more severe winters. In contrast, the southern area is considered a Saharian bioclimate with low rainfall and high summer temperatures, reaching 40°C (Youssef et al., 2019). In this region of the Nineveh Plains, frost is rare and occurs only at night. In general, the Nineveh Plains can be considered a "Xero-thermo-Mediterranean" bioclimate, dominated by annual plant species, strongly steppic Irano-Turanian and/or Saharo-Sindian, and entirely dry in the summer (Youssef et al., 2019). Steppic grasslands, developed alluvial plains, and foothill zones make up the habitat of the Nineveh Plains in general (Youssef et al., 2019). Nineveh's diversity of topographic features and bioclimatic zones contribute to the region's abundance of biological diversity, including many local and regional endemic species. The Nineveh Plains likely served as a significant habitat and climate refugia during Quaternary oscillations and the Neolithic transition (Youssef et al., 2019). Within the Nineveh Plains, our study area was concentrated in the Tilkaif and Hamdaniya districts and Bashiqa sub-district (Figure 1).

2.2. Community collaboration and participation

Mindful of critiques of social science research for its history of unjustly appropriating knowledge and resources from the people whom they work with (Bruchac, 2018; Smith, 2013), we approached our project from a participatory and anti-colonial perspective (Richard & Ratsirarson, 2013). We aimed to include community members throughout the research process, including the survey design, data collection, and dissemination of results. We also worked to provide transparent and open channels for communication and questioning. The University of Duhok's research team made several visits to each community before beginning the research to discuss the aims and scope of the

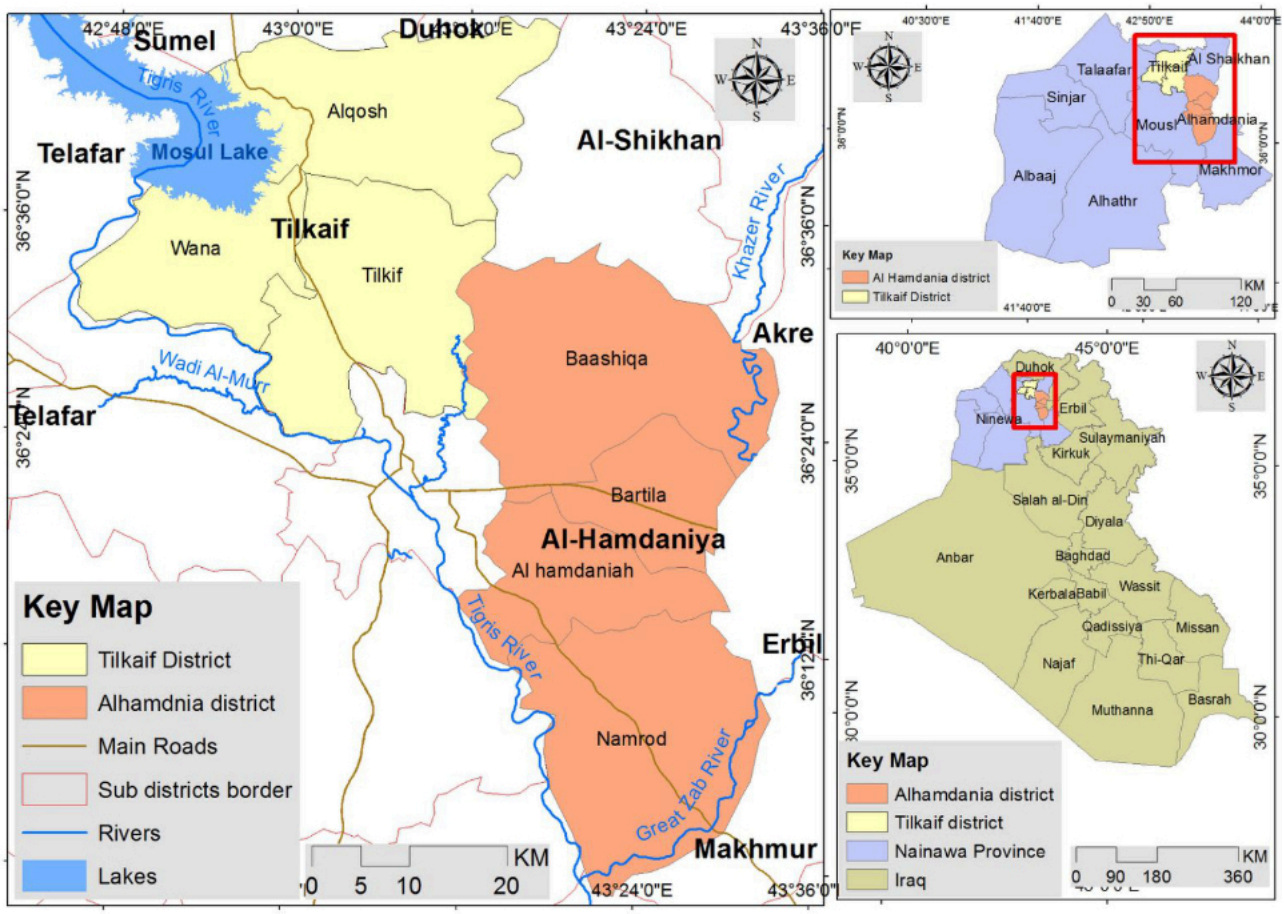

Figure 1 Maps of Nineveh Plains study area.

project, as well as paying courtesy visits to community leaders, including local Mokhtars (a position analogous to a mayor). Throughout, we remained aware of certain groups not included in the project discussions and worked to include a broad representation of ages, political views, and other identities. All research protocols were approved by the Human Subjects Review at the University of Notre Dame, and included statements of informed consent before beginning the surveys and interviews. Additionally, a key aim of our ongoing research collaboration is to produce materials of interest for non-academic audiences, especially for members of the participating communities. These products include short videos on the uses and traditions of wild plants, a wild plant cookbook, a local handbook on useful wild plant species, and educational materials on conservation approaches for local wild plant species. We also hosted workshops in several communities on topics including eco-printing with wild plants and herbal medicine.

2.3. Survey methodologies

This study aimed to identify and document wild plants in the Nineveh Plains, including their vernacular names, uses, and cultural importance (Table S1). To gather this information, we used a mixed methodology approach that included household surveys, semi-structured interviews, participant observations, and plant collection and identification. In all data collection, we included men and women from five main ethnoreligious communities in the region: Christians (Ch), Yazidis (Ye), Turkmens (Tu), Shabaks (Sh), and Kaka'is (Ka).

Survey data were collected between September 2022 and July 2023 from 421 individuals across 40 villages located in Nineveh Plains. Surveys were conducted in person using tablets programmed with the KoboToolbox Mobile Application, with Arabic, Syriac, and Kurdish language options. The interview team consisted of five researchers from the University of Duhok, three men and two women, representing both the Arabic and Kurdish languages. Our survey sample mirrored the overall ethno-religious, gender, and age-class demographics of the study region (Table 1). Of the respondents, 215 self-identified as men and 207 as women. Survey data was analyzed using MaxQDA software.

2.4. Semi-structured interviews, participant observation, and plant collection

In addition to the surveys, we conducted 30 semi-structured key informant interviews with men and women knowledgeable about wild plants from each participating socioreligious group, identified from the initial 421 survey

Table 1 Number and percentage of survey and semi-structured interview respondents by gender and ethno-religious affiliation.

	Surveys, n=421		Interviews, n=30	
Gender				
Women	193	46%	14	47%
Men	228	54%	16	53%
Ethno-religious affiliation				
Christian	103	25%	7	23%
Kaka'i	77	18%	6	20%
Shabak	78	19%	5	17%
Turkmen	72	17%	5	17%
Yazidi	88	21%	7	23%

informants (Table 1). Often, these key informants were older men and women with significant experience and deep knowledge about the use of wild plants, who could confirm and provide more details on the survey responses. Members of the research team visited these individuals several times throughout the field research to document the information and develop a more consistent relationship over time. These semi-structured interviews gathered more precise information on wild plant collection and use as well as changes in access to wild plants over time. In general, each interview lasted between 30 and 60 minutes. The interviews were recorded with permission, transcribed, and translated for data coding and analysis.

During the field visits, we integrated the participant-observation elements of ethnographic research into our project design. These methodologies included going out with people to visit their gardens and fields, speaking with them in their homes and kitchens, sharing food and drinks made from wild plants, and spending time getting to know individuals through repeated visits and conversations. Such observations provide a more intimate knowledge of the connections between meaning, knowledge, and ethnobotanical practices. These interactions also created connections between community members and the University of Duhok field researchers, providing opportunities for informal interactions and conversations related to wild plants.

During the project period, the research team collected approximately 69 plant species belonging to 35 families. The authors identified these species with the support of published botanical resources and deposited voucher specimens in the University of Duhok Forestry Herbarium. Plant collection and identification are ongoing as part of a broader initiative on traditional cultural practices in northern Iraq, supported by USAID. The USAID project was part of the Long-term Assistance and Services for Research (LASER) Partners for University-Led Solutions Engine (PULSE) project. The LASER-PULSE project in Northern Iraq included partner institutions of the University of Duhok, Purdue University, Indiana University, University of Notre Dame, and the Stockholm International Peace Research Institute.

2.5. Data analysis

In keeping with previously published ethnobotanical surveys (Osterhoudt et al., 2024), we calculated quantitative indices of plant uses among the survey respondents, including the Relative Frequency of Citation (RFC) (Smith, 2013). We approached our project from a participatory and anti-colonial perspective (Trotter & Logan, 1986; Collins et al., 2006), Informant Agreement Ratio (IAR) (Trotter & Logan, 1986; Collins et al., 2006), and Cultural Importance Index (CI) (Tardío & Pardo-de-Santayana, 2008). Each of these indices considers the number of respondents (called "*informants*" in these indices) and the different uses reported for a species. Frequency of Citation (FC) is simply the number of informants who mention a species. A Use Report (UR) is each report of the use of a species by an informant. The Number of Uses (NU) is a count of the different types of use for a species. For example, one informant (i) may report using *Matricaria chamomilla* for three uses (u): medicine, cosmetics, and decoration. In this case, the FC is 1 (only one informant), the number of UR is three (one use report for medicine, one for cosmetics, and one for decoration), and the Number of Uses is three (medicine, cosmetics, decoration). If you add an additional informant reporting that they use *Matricaria chamomilla* but only as medicine, *Matricaria chamomilla* has an FC of 2, with four URs and three NU.

The relative Frequency of Citation was calculated by dividing the number of informants who mentioned a species (FC) by the total number of informants in the sample (N): RFC = FC/N. The Informant Agreement Ratio (IAR) or Factor (IAF), and Informant Consensus Index (Fic) refer to the degree of agreement between informants on what species are used for each use category. The formula for IAR/IAF/Fic is as follows:

$$IAF = \frac{n_{ur} - n_t}{n_{ur} - 1}$$

where n_{ur} is the number of use reports in a particular use category and n_t is the number of taxa reported for that use category. The number of taxa in a particular use category is subtracted from the number of use reports in that use

category and divided by the number of use reports minus one (Trotter & Logan, 1986). The IAF ranged from 0 to 1, with 1 indicating that all informants agreed on the use of one species in one use category, for example, if everyone who reported using *Matricaria chamomilla* reported using it as medicine and nothing else, the IAF for *Matricaria chamomilla* use as medicine would be 1.

The Cultural Importance Index (CI) is a measure of the importance of a species to a group by considering the number of people who use the species and the number of uses of the species among those people. It is the sum of the proportion of informants who report each use of a species or the URs divided by the number of informants for a species (Trotter & Logan, 1986).

$$\mathrm{CI} = \sum_{ui=ui1}^{uiNC} \times \sum_{i=i1}^{i} \times \frac{URui}{N}$$

We conducted descriptive data analyses using Microsoft Corporation (2018) and SAS Software (version 9.4; Copyright © 2002–2012 SAS Institute Inc.). Visualizations were produced using R Statistical Software (v4.3.2; R Core Team 2023), including the R MetaCoder package for visualization and manipulation of community taxonomic diversity data (Foster et al., 2017).

3. Results

3.1. Diversity and species richness of Nineveh Plains wild plants

Collectively, the survey and interview responses reflect the rich diversity of culturally useful wild plants in Nineveh Plains. These plants represented 36 families, 68 genera, and 69 species, frequency of citation for all FC, frequency of citation current FC, use reports UR, and number of uses NU, and the quotation index (QI; stated as the proportion of all interviewees who mentioned using a certain vegetable in their daily meals) (Table S2). The Asteraceae and Fabaceae families had the highest representation of nine and seven species, respectively. The next most abundant were species from the Brassicaceae and Apiaceae families, which were each represented by five plant species. The Lamiaceae family had four plant species, and Rosaceae and Boraginaceae each had three plant species on the list. The majority of plant species in the study were herbs (61 species), followed by shrubs (three species), trees (three species), and mushrooms (two species). Significant dominance of herbs is expected, as species tend to be more adaptive to harsh environments, as found in many plains (Al-Ozeer et al., 2021). The distribution of wild plant species by family is shown in (Figure 2). Each plant family has its own node. The size and color of the nodes represent the number of species identified in that family.

3.2. Wild Edible Plants in The Nineveh Plains

Most of the wild plant species named by respondents were described as edible plants. Overall, 41 taxa (59% of the reported plant species) were consumed as food sources. Thirty-four of these species were consumed in their fresh state, either before ripening or without any processing. The remaining species were consumed in prepared dishes, with recipes often depending on the traditions and tastes of the specific community (Table S2). Such recipes include preparing barbin (*Portulaca oleracea*) with rice and chopped lamb or mixing dried ku'uub plants (*Gundelia tournefortii*) with mint, thyme, and yogurt. Some of the identified edible wild plant species have value beyond their role as subsistence food sources; they also hold commercial significance, providing an opportunity to enhance household income. In the study areas, we observed that a variety of wild edible plants are available for purchase at local markets, although some of these species are considered locally threatened, such as *Gundelia tournefortii.*

Of the 41 taxa of wild plants reported as edible, six were noted for both food and medicinal properties (Figure 3 and Table S2). One such plant is the common species *Malva neglecta,* which is known for its anti-inflammatory, antimicrobial, antioxidant, and other beneficial properties (Al-Snafi, 2019). *Gundelia tournefortii,* a popular component of many traditional dishes, is also recognized as a medicinal herb and is used for its laxative, antiparasitic, and anti-inflammatory properties (Asadi-Samani et al., 2013). In general, people across different ethno-religious communities and between different geographical locations were consistent in which wild plants they used in their diets, although individuals did not have preferences for certain food plants over others depending on factors such as ease of preparation, nutritional value, and taste.

3.3. Wild plants with medicinal uses

The participants identified 24 species of medicinal plants (35% of the total species recorded in this project). These species represent 18 families and 23 genera. Shoots and leaves were the most frequently used parts of the plant, followed by the flowers, roots, seeds, and fruits (Figure 3). Twenty-two species were used for human treatment and two species were utilized in cattle medicine. For example, Harmal (*Peganum harmala*) has a distinct usage among the Kakai and Shabak communities, who burn the plant and utilize smoke as a sexual stimulant for female sheep (see Table S2). In Jordan, *Peganum harmala* has traditionally been used to enhance fertility and as an aphrodisiac (El-Dwairi, 2007).

The most common medicinal plant species used by all communities in the Nineveh Plains is chamomile, which includes *Matricaria chamomilla*, *Matricaria discoidea*, and *Anthemis spp*. This plant is widely reported to contain beneficial antioxidants, congestive neuralgia, anti-inflammatory, and mild astringent properties (Weiss 1988; Srivastava et al. 2010). Another commonly used medicinal plant is licorice (*Glycyrrhiza glabra*), an anti-inflammatory agent (Shahbaz, 2013). Licorice possesses various beneficial properties, including antiviral, anti-inflammatory, antioxidative, cardioprotective, anticancer, antimicrobial, hepatoprotective, and immunomodulatory functions (Anilkumar et al., 2012). Other examples of wild medicinal plants

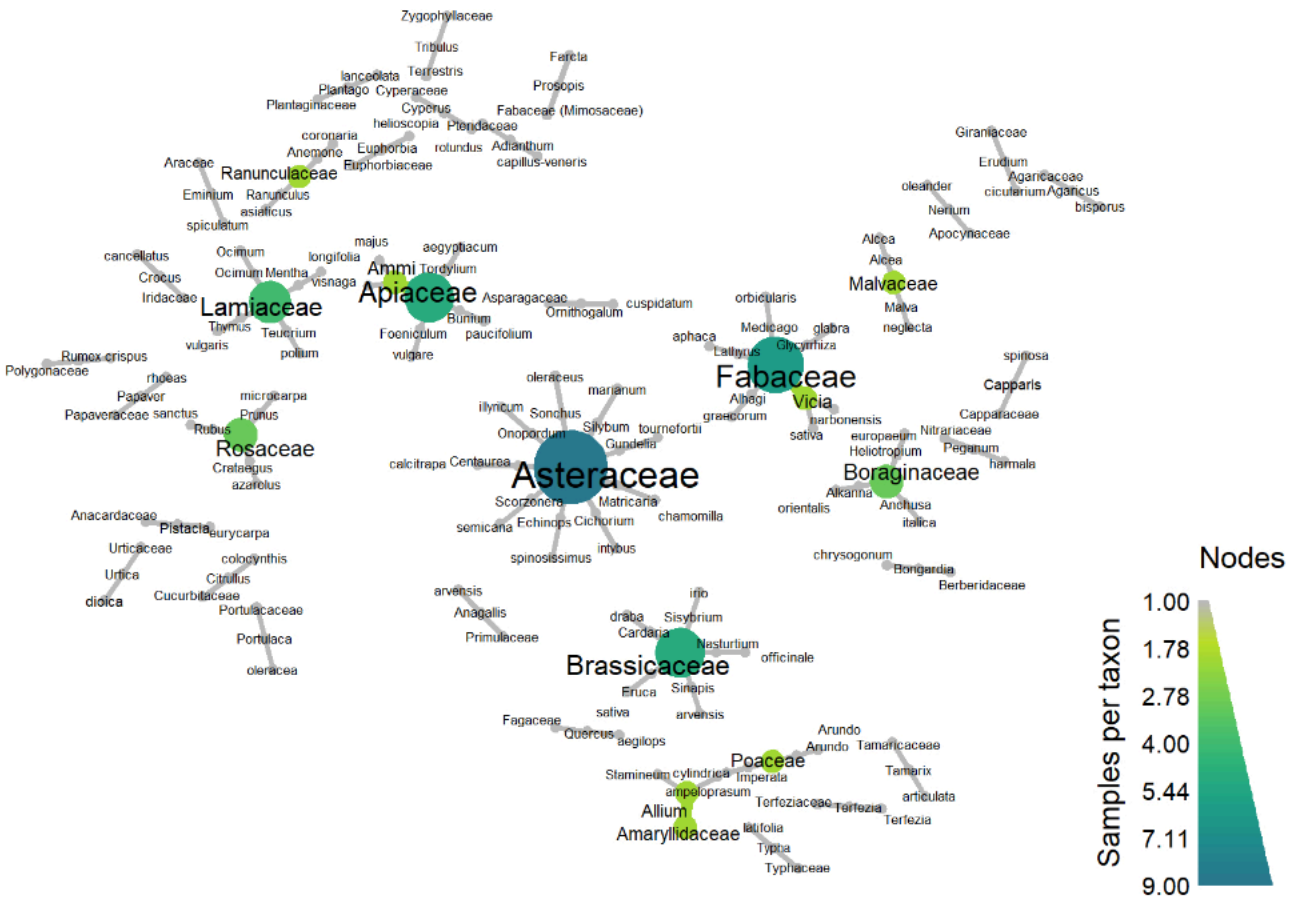

Figure 2 Plant families and wild edible plant species recorded in the Nineveh Plains. Each plant family has its own node. The size and color of the nodes represent the number of species identified for each family.

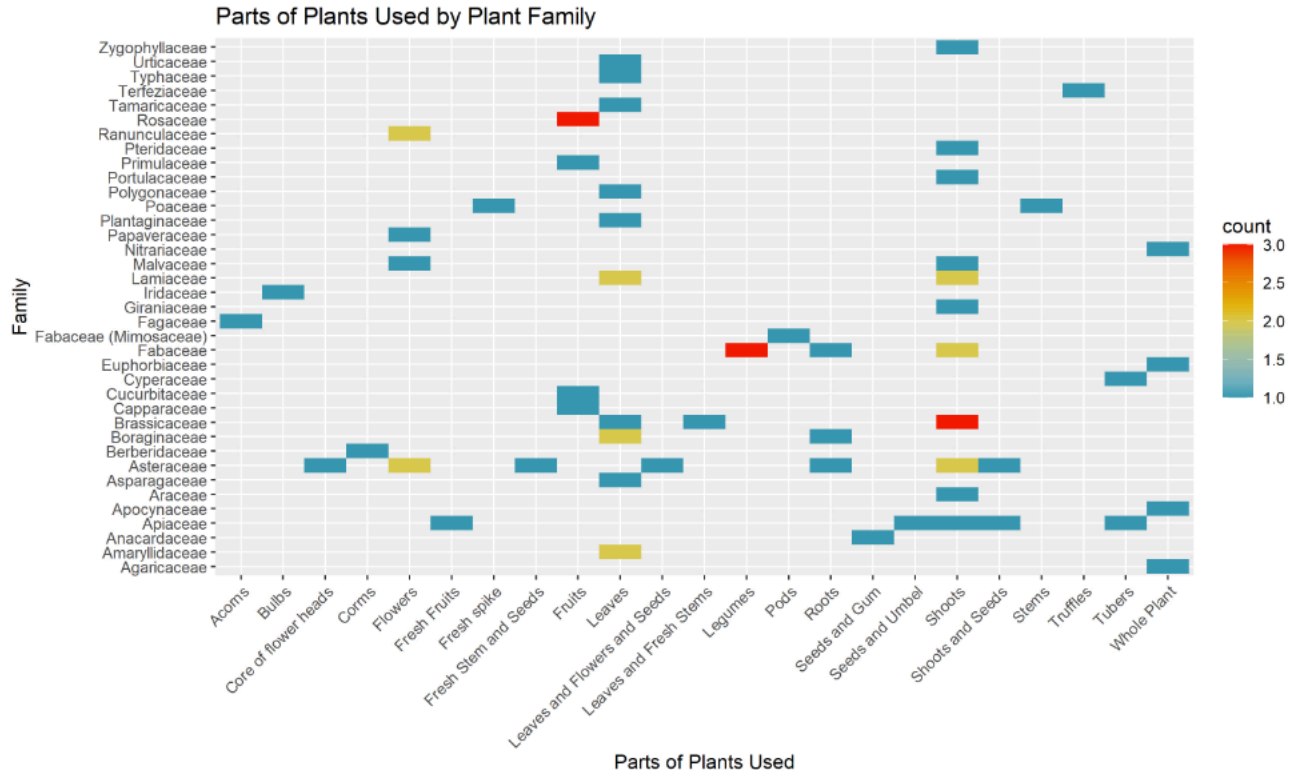

Figure 3 Parts of plants used traditionally in the Nineveh Plains by the plant family.

include *Matricaria chamomilla*, *Glycyrrhiza glabra*, *Prosopis farcta*, *Adiantum capillus-veneris*, and *Tribulus terrestris*. For instance, *Prosopis farcta* has been traditionally used in folk medicine to treat conditions such as heartburn and diarrhea (Shahbaz, 2013; Dheeb, 2020). Furthermore, some people use the whole plant of *Adiantum capillus-veneris* to promote kidney health and kidney stone removal (Wu et al., 1990).

In interviews, respondents explained the important role that traditional medicine plays to many people in the region, particularly in rural areas, who often have limited access to modern medical facilities. Some people said that they favored traditional medicines derived from wild plants because they are more affordable and have fewer side effects than modern medicine. However, due to factors such as over-harvesting and decreased access to collection sites, people noted that the abundance of therapeutic wild plants is decreasing in the Nineveh region.

3.4. Comparison of use indices

The frequency of citations (FC), number of use reports (UR), and number of uses (NU) for each species are shown in (Table S2). Based on the relative frequency of citation (RFC), *Gundelia tournefortii*, *Malva neglecta*, *Matricaria chamomilla*, *Silybum marianum,* and *Terfezia spp.* were the five most frequently cited plants in the Nineveh Plains.

The Cultural Importance Index (CI) closely reflected the RFC for the species, although the rankings were not identical. The RFC, CI, and ranking of each species, based on these indices, are listed in Table 2. According to the results, *Gundelia tournefortii*, *Malva neglecta*, *Matricaria chamomilla*, and *Silybum marianum* were ranked (1, 2, 3, and 4) respectively, in both CI and RFC. Moreover, the study result showed that 13 out of 69 wild plants species have high CI and lower RFC such as *Ranunculus asiaticus*, *Rumex crispus*, *Thymus vulgaris*, and *Onopordum illyricum*. Furthermore, the study result showed that 49 out of 69 wild plant species, such as *Eminium spiculatum*, *Prosopis farcta*, *Adiantum capillus-veneris*, *Ammi majus*, and *Teucrium polium*, had higher RFC and lower CI. However, the rest of the wild edible plant species, such as *Sinapis arvensis*, *Portulaca oleracea*, and *Allium stamineum*, had the same ranking in both CI and RFC.

Respondents strongly agreed on the species used as food (IAR = 0.9607), followed by those used for decoration (IAR = 0.8871), medicine (0.8776), and religious rituals (0.8636). The number of reports, taxa, and IAF/Fic values for each category are shown in Table 3.

3.5. Threats to Wild Plants

During the interviews, many participants mentioned that wild plants were becoming increasingly difficult to find and that they had to go further to find plants that were once plentiful in the area. Some species, such as *Gundelia tournefortii*, *Nasturtium officinale*, *Adiantum capillus-veneris,* and *Imperata cylindrica*, seem to have disappeared from the region, with people noting that it has been more than ten years since they last observed them growing nearby. Informants from all ethnic minority groups explained that several factors influenced the availability of wild plants (Figure 5). The two most common factors affecting the continued availability of wild plants were drought (51%) and herbicide use (33%), which were calculated by dividing the number of times respondents mentioned a particular threat by the total number of respondents. Other factors included overgrazing, agricultural expansion, combined harvesting, deep plowing, urbanization, and fires (Figure 5). Collectively, these factors include environmental and climatic factors (such as drought) and more direct human or anthropogenic factors, especially those related to the expansion of large-scale industrial agriculture (Díaz et al., 2019). People also said that the expansion of housing and urban settlements in the region contributed to the decreased availability of wild plants, a growth due in part to significant population growth in the Nineveh Plains region between 2013 and 2023 (see also Hameed et al., 2016; Youssef et al., 2019; World Population Review, 2024).

4. Discussion

The relationship between people and wild plants has a long history in the Northern Iraq region (Mati and de Boer, 2011; Galalaey et al., 2021). This study investigated the traditional knowledge and use of wild plants in the Nineveh Plains area of Northern Iraq by the Christian, Yazidi, Turkman, Shabak, and Kaka'i groups. Wild plants are widespread in this region, especially for food and medicine, with over three-quarters of interviewed residents noting that they use wild plants in their practice (Tahir et al., 2023). We recorded 69 wild plant species across 36 families that were used by the local communities. These results show a slightly higher range of plant families compared to previous studies in the region, which documented useful plants from 30 (Ahmad & Askari, 2015) and 25 families (Galalaey et al., 2021). People use these wild plants in multifaceted ways, including culinary purposes, medicinal applications, cosmetics, beauty treatments, and other household uses. Wild plants also have cultural significance and are part of local aesthetic and religious practices with historical importance. For instance, many Yazidi individuals utilize *Ranunculus asiaticus* as a sacred symbol during their "Jajna Charshama Sor" red Wednesday feast. For ceremonial purposes, they collect *Ranunculus asiaticus* flowers to hang over the doorways of their homes and kitchens; they also use *Heliotropium europaeum* for tattooing on various parts of the body for cosmetic purposes, expressing love, and as a means of distinguishing individuals, especially during loss or martyrdom in battles; this plant has also been shown to slow bleeding and promote scar tissue formation (Moalla et al, 2023), and may help people heal from the tattooing process. Similarly, Christians collect wild plants to celebrate the Assyrian-Babylonian New Year, while Assyrians incorporate flowers into their religious symbols, including the flowers of *Ranunculus asiaticus* and *Anemone coronaria* (Osterhoudt et al., 2024). For household use, the corms of *Bongardia chrysogonum* were used as soap by Yazidi, Shabak, and Kaka'i communities.

Table 2 Comparison and ranking of plants by Relative Frequency of Citation (RFC) and Cultural Importance Index (CI).

Family Name	Scientific Name	RFC	CI	RFC ranking	CI ranking
1	2	3	4	5	6
Pteridaceae	*Adiantum capillus-veneris* L.	0.00475	0.00238	49	54
Agaricaceae	*Agaricus bisporus* J.E. Lange.	0.08789	0.06888	13	15
Malvaceae	*Alcea arbelensis* Boiss. & Hausskn. *Alcea chrysantha* (Sam.) Zohary. *Alcea kurdica* (Schltdl.) Alef. *Alcea peduncularis* Boiss. & Hausskn. *Alcea sulphurea* (Boiss. & Hohen.) Alef.	0.00475	0.00238	50	55
Fabaceae	*Alhagi graecorum* Boiss.	0.00475	0.00475	42	44
Boraginaceae	*Alkanna orientalis* (L.) Boiss.	0.00713	0.00475	43	45
Amaryllidaceae	*Allium ampeloprasum* L.	0.02613	0.02138	23	25
Amaryllidaceae	*Allium stamineum* Boiss	0.07363	0.06176	17	17
Apiaceae	*Ammi majus* L.	0.00950	0.00238	51	56
Apiaceae	*Ammi visnaga* (L.) Lam.	0.00238	0.00238	52	57
Primulaceae	*Anagallis arvensis* L.	0.00950	0.00950	33	34
Boraginaceae	*Anchusa italica* Retz.	0.03088	0.02850	21	22
Ranunculaceae	*Anemone coronaria* L.	0.01900	0.02613	24	23
Poaceae	*Arundo donax* L.	0.00238	0.00238	53	58
Berberidaceae	*Bongardia chrysogonum* L. Spach	0.00950	0.00238	54	59
Apiaceae	*Bunium paucifolium* DC	0.11401	0.06888	15	16
Capparaceae	*Capparis spinosa* L.	0.02138	0.01663	27	28
Brassicaceae	*Cardaria draba* (L.) Desv.	0.04038	0.03800	18	19
Asteraceae	*Centaurea calcitrapa* L.	0.04513	0.03800	19	20
Asteraceae	*Cichorium intybus* L.	0.00238	0.00238	55	60
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	0.02850	0.01663	28	29
Rosaceae	*Crataegus azarolus* L.	0.00713	0.00475	44	46
Iridaceae	*Crocus cancellatus* Herb.	0.04513	0.01900	25	26
Cyperaceae	*Cyperus rotundus* L.	0.01663	0.01663	29	30
Asteraceae	*Echinops spinosissimus* Turra	0.00950	0.00950	38	39
Araceae	*Eminium spiculatum* (Blume) Schott	0.19240	0.16627	6	7
Brassicaceae	*Eruca sativa* Mill.	0.01900	0.01900	26	27
Geraniaceae	*Erodium cicutarium* L.	0.00713	0.00238	56	61
Euphorbiaceae	*Euphorbia helioscopia* L.	0.00238	0.00238	57	62
Apiaceae	*Foeniculum vulgare* Mill.	0.00950	0.00475	45	47
Fabaceae	*Glycyrrhiza glabra* L.	0.03563	0.03563	22	21
Asteraceae	*Gundelia tournefortii* L.	0.79335	0.68646	1	1
Boraginaceae	*Heliotropium europaeum* L.	0.01188	0.01663	30	31
Poaceae	*Imperata cylindrica* (L.) P. Beauv.	0.01425	0.00713	39	40
Fabaceae	*Lathyrus aphaca* L.	0.01188	0.00238	58	63

Table 2 Comparison and ranking of plants by Relative Frequency of Citation (RFC) and Cultural Importance Index (CI) (cont.).

1	2	3	4	5	6
Malvaceae	*Malva neglecta* Wallr.	0.67221	0.68171	2	2
Asteraceae	*Matricaria chamomilla* L.	0.47506	0.51544	3	3
Fabaceae	*Medicago orbicularis* (L.) Bartal.	0.01188	0.00475	59	50
Lamiaceae	*Mentha longifolia* L.	0.04751	0.04276	20	18
Brassicaceae	*Nasturtium officinale* W. T. Aiton	0.08551	0.07601	10	12
Apocynaceae	*Nerium oleander* L.	0.00475	0.00475	46	48
Lamiaceae	*Ocimum basilicum* L.	0.00000	0.00475	67	52
Asteraceae	*Onopordum illyricum* L.	0.00000	0.02375	68	24
Asparagaceae	*Ornithogalum cuspidatum* Bertol.	0.01425	0.01188	31	33
Papaveraceae	*Papaver rhoeas* L.	0.00000	0.00475	69	53
Nitrariaceae	*Peganum harmala* L.	0.00238	0.00238	60	64
Anacardiaceae	*Pistacia eurycarpa* Yalt.	0.00238	0.00238	61	65
Plantaginaceae	*Plantago lanceolata* L.	0.00238	0.00238	62	66
Portulacaceae	*Portulaca oleracea* L.	0.07601	0.08314	11	11
Fabaceae	*Prosopis Farcta* (Banks & Sol.) J. F. Macbr.	0.11401	0.14252	7	8
Rosaceae	*Prunus microcarpa* C. A. Mey.	0.00475	0.00475	63	51
Fagaceae	*Quercus aegilops* L.	0.01188	0.00950	34	35
Ranunculaceae	*Ranunculus asiaticus* L.	0.10451	0.18527	8	5
Rosaceae	*Rubus sanctus* Schreb.	0.00475	0.00713	47	43
Polygonaceae	*Rumex crispus* L.	0.08076	0.07126	16	14
Asteraceae	*Scorzonera semicana* DC.	0.01188	0.00950	35	36
Asteraceae	*Silybum marianum* (L.) Gaertn.	0.18765	0.18765	4	4
Brassicaceae	*Sinapis arvensis* L.	0.11876	0.11164	9	9
Brassicaceae	*Sisymbrium irio* L.	0.00238	0.00238	64	67
Asteraceae	*Sonchus oleraceus* L.	0.00713	0.00713	40	41
Tamaricaceae	*Tamarix aphylla* (L.) H. Karst	0.00238	0.00238	65	68
Pezizaceae	*Terfezia hafizi* Chatin. *Terfezia metaxasi* Pantidou & Tzanoud. *Terfezia claveryi* Chatin.	0.23040	0.17102	5	6
Lamiaceae	*Teucrium polium* L.	0.00238	0.00238	66	69
Lamiaceae	*Thymus vulgaris* L.	0.08551	0.10214	12	10
Apiaceae	*Tordylium aegyptiacum* (L.) Poir.	0.13777	0.07126	14	13
Zygophyllaceae	*Tribulus terrestris* L.	0.00713	0.00713	41	42
Typhaceae	*Typha latifolia* L.	0.00475	0.00475	48	49
Urticaceae	*Urtica dioica* L.	0.01188	0.01425	32	32
Fabaceae	*Vicia narbonensis* L.	0.03088	0.00950	36	37
Fabaceae	*Vicia sativa* L.	0.01663	0.00950	37	38

RFC: Relative Frequency of Citation; CI: Cultural Importance Index

The *Nerium oleander* is used by Shabak to ward off feelings of envy. In addition, the Kaka'i community used *Arundo donax* to build livestock barns and fencing (Figure 4 and Table S2). Figure 4 illustrates the parts used and the traditional uses for each species. Religious and cultural ceremonies and celebrations often feature dishes prepared with wild plants, demonstrating the profound links between local plants and the region's unique cultural heritage.

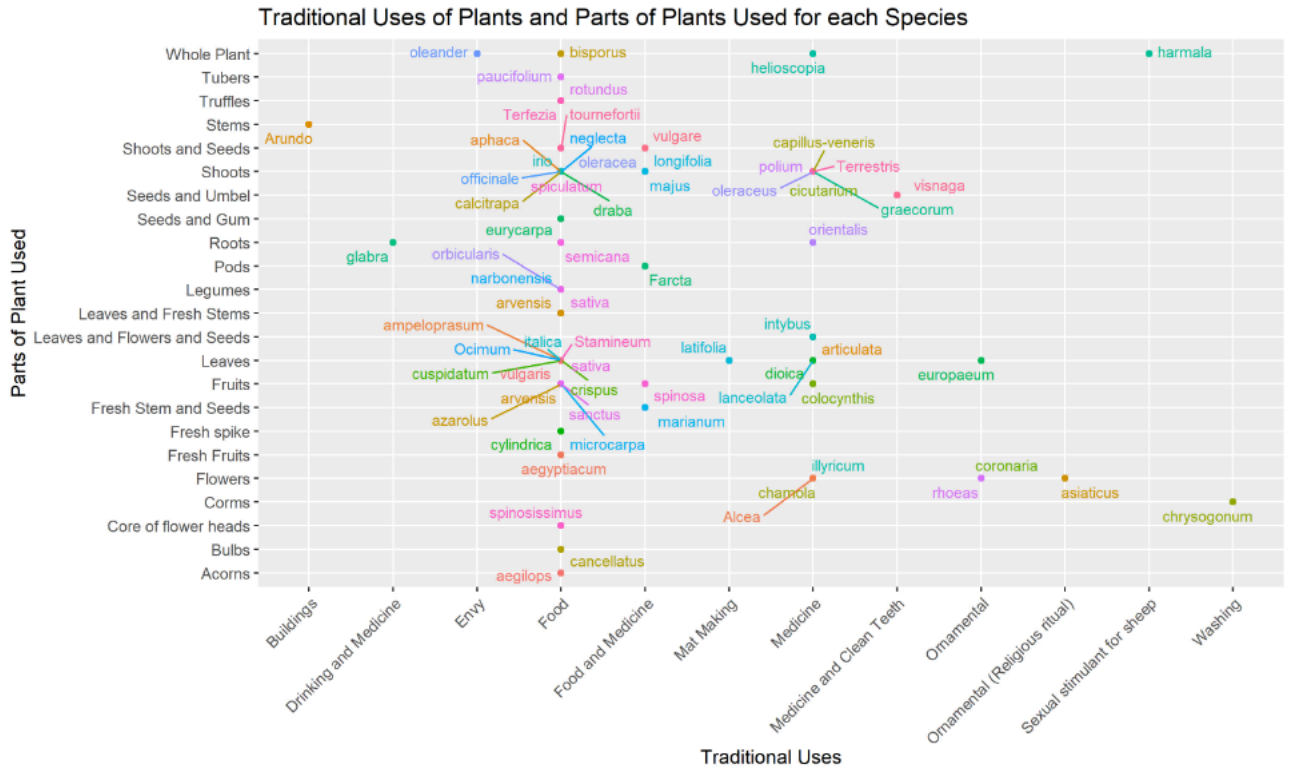

Figure 4 Traditional uses of wild plants in the Nineveh Plains and parts of the plant used by the species. Plot points may represent more than one species, and each species is labeled near its corresponding point.

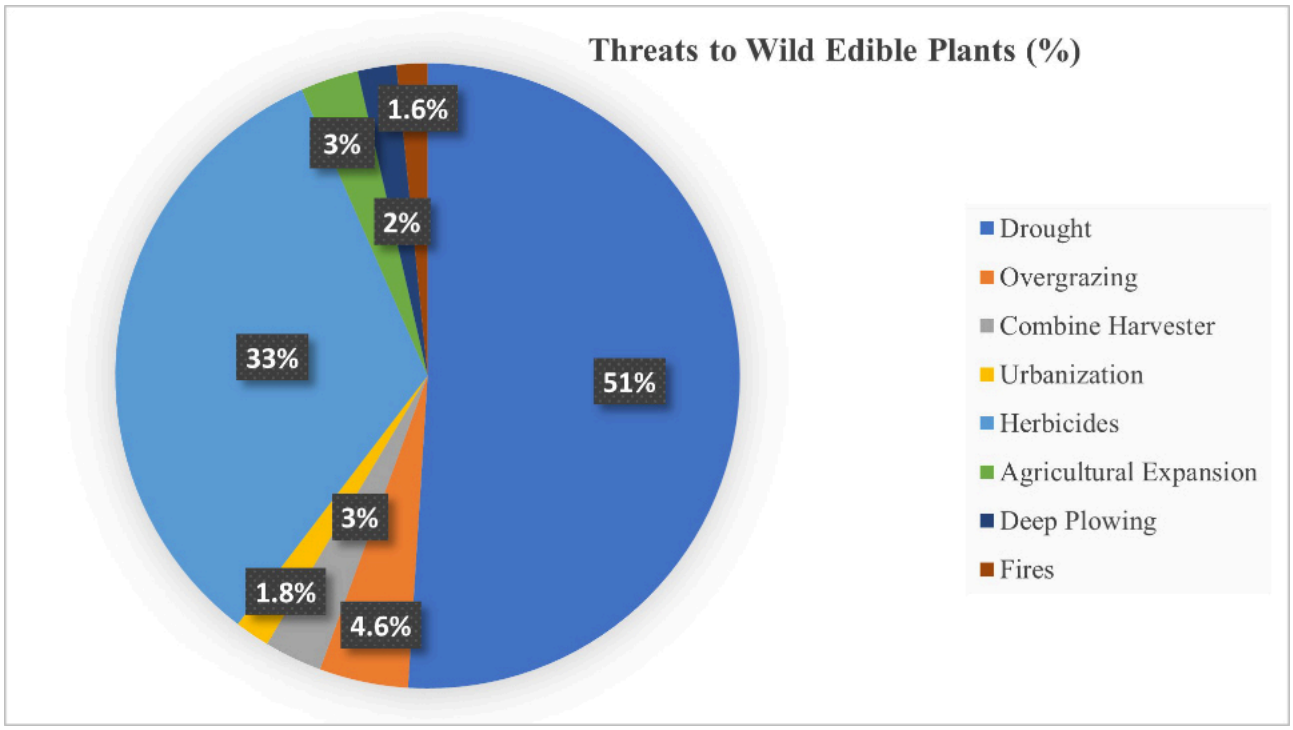

Figure 5 Threatening factors that decrease wild edible plants in the Nineveh Plains.

Table 3 Informant agreement factor (IAF) / Informant Consensus Index (*Fic*) for wild plant use categories.

Use category	n_t	n_{ur}	IAR / *Fic*
Food	48	1197	0.9607
Medicine	43	344	0.8776
Religious Ritual	7	45	0.8636
Decoration	8	63	0.8871
Cosmetics	6	22	0.7619
Building / Crafting	2	3	0.5000
Selling at the market	4	6	0.4000
Other	7	7	0
For animals / animal feed	4	4	0
Cleaning teeth	1	1	0
Leather tanning	1	1	0
Fragrance	1	1	0

n_t: *number of taxa*; n_{ur}: *number of use reports in each use category*;
IAR: Informant Agreement Ratio; *Fic*: Informant Consensus Index

The consistency of edible wild plant use across the Nineveh Plains suggests a shared ethnobotanical knowledge base among subsistence groups in the region. Local communities in the Nineveh Plains, particularly shepherds, are also knowledgeable about various wild toxic plants, and take care to avoid using them fresh or allowing their livestock to consume them. These communities are aware of the specific parts of each plant that are toxic and can vary from one plant to another. For example, some plants are toxic in all their parts, such as *Datura fastuosa* (Datora) (Dhaliwal et al., 2021), *Hypericum perforatum* (Alaran) (Hammerness et al., 2003), and *Nerium oleander* (Dafla) (Bai et al., 2022). Others, such as *Eminium spiculatum* (La'iah) (Fern, 2024) and *Urtica dioica* (Qurrais) (Cummings & Olsen, 2011), have toxic leaves.

Certain plants are hazardous when consumed as fruits, such as *Citrullus colocynthis* (Hanzal) (Li et al., 2022), and others are poisonous in their seeds, like *Ricinus communis* (Kharoa) (Lindahl & Shepherd, 2017).

Importantly, the people we interviewed explained how it is not only the wild plants themselves but also the processes of collecting and using them to reinforce cultural practices and social cohesion. Going together to collect wild plants strengthens social bonds between generations, particularly among women. Neighboring communities have also developed positive relationships with each other through the practice of collecting wild plants. For example, people from one village may travel together to neighboring communities in search of wild plant species, making friendships and social connections along the way. Similarly, preparing wild plants in traditional dishes brings people together through the act of preparing, cooking, eating, and sharing stories through food. In addition, wild plants can be a source of medicine, and sharing knowledge and resources related to them can create opportunities for social interactions and connections. The process of sharing plant knowledge and uses, especially across generations, is another way wild plants reinforce social connections and strengthen cultural heritage. Often, this knowledge is passed down through oral traditions (Cotton & Wilkie, 1996; Hamilton et al., 2003). Overall, a shared interest in wild plants has the potential to connect minority groups and other communities across the Nineveh Plains, preserving their unique cultural traditions and heritage.

There is a close relationship between people, plants, and geography; the natural environment is determined by the availability of wild plant species and how societies interact with them. For instance, people who live near the foothills and Maqlob Mountains, have long had an incredible amount of knowledge about the uses of wild plants. This is mostly because of the diversity of the topography of the region, where many plant species grow in mountainous terrain. This is mainly due to the diversity of the topography of the region where most of the plant species grow in mountainous terrain (Ertuğ, 2000; Hamilton, 2004). This traditional knowledge demonstrates the impact of biodiversity on human practices, as documented by ethnobotany and traditional knowledge system studies. As these wild plant environments are mostly unchanged, they have the ability to regrow. Ecological research confirms this assertion, with proof that relatively undisturbed habitats, such as specific mountainous or isolated areas, allow native plant species to reproduce and sustain their populations (Chazdon, 2008). More importantly, traditional ecological knowledge emphasizes that harvesting methods created by the local people themselves significantly contribute to the regeneration of wild plants in these stable ecosystems (Berkes, 2017). The rough terrain and microclimates in

these mountainous locales support the growth of plants that are not commonly found in plains or urban areas. High-altitude, cooler wild plants, shrubs, and berries are sometimes used as components in medicinal teas and salves, or as spices in traditional culinary styles. The ability to survive in mountainous areas is dependent upon these plants, especially in places with little access to modern markets or medical treatment. Rough microclimates and terrain in mountainous locales encourage plant growth, which is uncommon in urban or plain areas. Mountain environments are often characterized by high biological diversity, including unique species adapted to cooler temperatures, especially microclimates (Körner, 2007). Wild herbs, shrubs, and berries are among the various flora extensively employed in traditional methodologies for preparing medicinal teas, salves, and culinary spices, which is of great importance to local ethnobotanical knowledge (Hamilton, 2004). Furthermore, the dependence of inhabitants in mountainous areas on these plants is well-documented, especially in places with limited access to modern markets or health resources. These plant species are essential for maintaining the livelihood and health of individuals in these regions (Pardo-de-Santayana et al., 2007).

Wild plants have long been used for various reasons, including traditional medicine, food, and cultural traditions, by the Yazidis and Christians, who comprise most of the population in these mountainous areas. These two groups cited most of the plant species found in the research region according to a questionnaire, demonstrating the close relationship between their way of existence and the biodiversity of the area. However, some ethnoreligious groups, such as the Turkmen, Kaka'I, and Shabaks, have vanished their traditional knowledge of wild plants due to agricultural expansion and urbanization. These changes have diminished the availability of wild plants and have replaced them with monoculture crops or artificial ecosystems. This shift not only reduced biological diversity but also eroded the practical and traditional knowledge related to endemic and native wild plants, especially in younger generations. Individuals residing in residential or urban areas are moving away from tradition. This expansion of agriculture often replaces the biodiversity of wild habitats with monoculture crops, thereby reducing plant diversity and access to native species (Tscharntke et al., 2005). Moreover, urbanization causes the fragmentation of natural habitats and the formation of artificial ecosystems, which are not hospitable to native flora (McKinney, 2002). In this respect, Gómez-Baggethun & Reyes-García (2013) noted that such changes have translated into younger generations experiencing much less exposure to natural settings and practices, thereby affecting the erosion of traditional ecological knowledge (Yeşil et al., 2019). Ethnobotanical research postulates that traditional knowledge systems relate directly to access to biodiverse environments, and that their disappearance is associated with a change in urban lifestyles and intensification of agriculture (Posey, 2000).

Currently, there are several challenges to the local wild plant populations of the Nineveh Plains, which have caused some species to become locally endangered. The first is climate change, as wild plants face increased periods of drought and rising temperatures. Second, social and economic factors cause declines in wild plant species. Some of these factors are related to the expansion of industrial agricultural models, including the use of pesticides, herbicides, and deep plowing practices. Other pressures on wild plants include the expansion of urban settlements and the potential overharvesting of certain wild plant species with economic value (Galalaey et al., 2021).

Finally, there is an indication that overharvesting of certain wild plant species may pose a threat to wild plant populations in this region (Hameed et al., 2016; Youssef et al., 2019). For instance, *Gundelia spp.* are facing a population decline, as indicated by inventory studies conducted in the northern region of Iraq (Galalaey et al., 2021). Despite the myriad threats, nearly all wild edible plants in the study areas lack adequate conservation measures, especially those utilized for food and medicinal purposes. Some farmers, however, are attempting to domesticate wild edible plant species with economic value. In terms of conservation, certain plant species possess economic value, prompting a few farmers to make attempts at domesticating some wild edible plants through a process known as "ethnodomestication."

As illustrated by our research, the decline of wild plant populations in the Nineveh Plains denotes not only an ecological loss but also a potential loss of social relationships, cultural heritage, a sense of belonging, and forms of indigenous environmental knowledge (Osterhoudt et al., 2024). A decline in wild plant availability could also negatively affect people who depend on these species for inexpensive and accessible nutrition and health options, especially those with limited economic resources (Osterhoudt et al., 2024). There are also likely negative ecological consequences of wild plant species decline, as wild plants are often important parts of functioning ecosystems, supporting the diversity of insects, bird life, and other wildlife species (Duffy, 2003).

Developing propagation protocols for the wild plants of the Nineveh Plains is one of the key conservation measures to prevent the rapid genetic depletion, which could result in these species becoming locally endangered or unavailable in adequate quantities for consumption and cultural-related use (Shibli et al., 2009; Yazdanshenas et al., 2016). In this regard, the authors conducted a germination experiment on *Gundelia tournefortii,* a widely used wild plant identified by ethno-religious groups in the Nineveh Plains (results not yet published).

The Cultural Importance Index (CI) of plant species often shows a close relationship with the RFC, as both indices reflect the importance of a species based on community knowledge and uses. *Gundelia tournefortii*, *Malva neglecta*, *Matricaria chamomilla*, and *Silybum marianum* were ranked (1, 2, 3, and 4) respectively, in both CI and RFC. However, when ranking species, divergences can occur between the CI and RFC methodologies because of the aspects emphasized in these indices. For example, the RFC measures the frequency of citation of the species among the participants, so it provides quantitative information

about the general recognition or utility of that species (Tardío & Pardo-de-Santayana, 2008). On the other hand, CI takes into consideration the diversity of uses attributed to the species and the cultural importance given to them, thus being capable of enhancing the rank of plants not as frequently mentioned but of central importance in the local culture (Martin, 2010). Therefore, species showing a lower RFC score may rank high in CI because of their complex cultural roles (Martin, 2010), whereas plants that achieve higher RFC scores would rank lower in CI when use is restricted across cultural contexts (Tardío & Pardo-de-Santayana, 2008). However, when plant species have the same rank for both Cultural Importance and Relative Frequency of Citation scores, this would usually be suggestive of a constant valuation and/or frequent mention within different cultural contexts. This may be so when plants have different uses (medical, nutritional, and material) and are frequently mentioned during ethnobotanical research studies by informants (Martin, 2010). Such a constant high rank would, in this case, point to plants having multifaceted relevance to culture (Tardío & Pardo-de-Santayana, 2008).

High informant consent levels for plant species use within different communities is a common finding in ethnobotanical studies. IAR is a robust quantitative measure of informant consensus regarding the use of plants. Other studies have reported high IAR values for food plants, which are usually well recognized and widely used in communities for nutrition (Phillips et al., 1994). Plants used for decoration, medicine, and rituals usually have high IAR values, although a little lower than that for food, due to the personal experiences and cultural diversity involved in their use. This finding was established by Heinrich et al. (2006). The Informant Agreement Factor, Fic, or Informant Agreement Ratio (IAR) is commonly used in ethnobotany, together with the number of use reports and taxa to calculate consensus and then categorize the uses of plants. Categories such as food and medicine usually have high Fic values, indicating collective knowledge and dependence on these plants (Trotter & Logan, 1986).

5. Conclusion

Given the broad cultural, economic, health, and environmental roles of wild plants in the region, an integrated conservation strategy is urgently required. Such a program should be interdisciplinary in scope, encompassing expertise in the natural and social sciences, including botany, ecology, genetics, sociology, anthropology, economics, and public health. This research prioritizes collecting baseline data on the habitat, distribution, ecological roles, and potential conservation status of the key wild plant species in the region. Additional research in ethnobotany and social sciences could examine the potential of wild plants to contribute to local livelihoods and health, including research on the nutritional and genetic properties of wild edible foods. There may also be the potential to cultivate wild edible plants, including *Gundelia tournefortii*, *Agaricus bisporus*, and *Malva neglecta*, leading to landscape restoration and local economic opportunities. Collectively, data from cultural and natural sciences can contribute to applied conservation and management plans to ensure the continued survival of the locally endangered wild plant species of the Nineveh Plains.

In addition to interdisciplinary research, successful wild plant conservation activities should include community members living in the region to prioritize, design, and implement conservation plans. People from various socio-religious groups in the Nineveh Plains share a connection to wild plant resources, and working together with diverse groups will enhance the success and impact of the project. Community conservation efforts will require a broad portfolio of activities as well as open lines of communication between researchers and community members. In our ongoing community-based research collaborations, for example, we are evaluating germination protocols for *Gundelia tournefortii* after hearing the concerns of many individuals regarding the declining populations available for collection. In the future, we plan to partner with community members to re-establish *Gundelia tournefortii* in selected areas of the region. Other collaborations included compiling a wild plant cookbook, organizing workshops on eco-printing with wild plants, and conducting local training on herbal medicines. Such activities draw from the rich environmental knowledge and cultural heritage of the region, while raising awareness of wild plant conservation. We hope that such research and outreach activities will contribute to preserving the valuable wild plants and natural heritage of the Nineveh Plains.

6. Supplementary material

The following supplementary material is available for this article:

- Table S1. LASER Support for Traditional Practices in Northern Iraq Wild Plants Main Survey Questionnaire and Deep Interview.
- Table S2. List of wild plant species recorded in …

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