



# Survey on threatened medicinal plants diversity of Northwestern Syria

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**Abstract:** Throughout history, many plant species have been used as natural medicines to prevent and treat human diseases. Due to its geographical location, climate, and history, Syria contains a remarkable diversity of medicinal plants. However, in recent years a prolonged period of conflict has resulted in widespread ecosystem destruction, human population displacement, and disruption of farming practices. Although poorly documented this is believed to have resulted in a significant decline in medicinal plant populations.

In this study, we used structured interviews with local agricultural experts to collect basic information on the current status and critical threats to medicinal plant species in northwest Syria. Our results show that many of these species have experienced genetic erosion and deterioration due to a combination of overuse (massive unmanaged gathering of medicinal plant material) and climatic changes, particularly those relating to more frequent droughts. To initiate *ex situ* conservation initiatives, the locations of medicinal plants exposed to deterioration were identified from the results of a questionnaire. Seeds from seven species: chamomile (*Matricaria chamomilla* L.), wild thyme (*Thymus capitatus* L.), sage (*Salvia officinalis* L.), hyssop (*Hyssopus officinalis* L.), caper (*Capparis spinosa* L.), basil (*Ocimum basilicum* L.), and watercress (*Nasturtium officinale* R. BR.) were collected for the establishment of *ex situ* collections in the future. We discuss the potential for recovery initiatives to protect and conserve these species and to support the sustainable use of medicinal plant genetic resources in Northern Syria. Such endeavours are vital for the continued well-being of the Syrian population and humanity as a whole.

**Keywords:** plant genetic resources, medicinal plants, genetic erosion, *in situ* conservation, *ex situ* conservation

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## Introduction

Medicinal and aromatic plants represent valuable global resources for the practice of traditional medicine as well as the development of novel pharmaceuticals (Nalawade *et al*, 2003; Hamilton, 2004; Chacko *et al*, 2010; Chen *et al*, 2010; Alachkar *et al*, 2011; Asiimwe *et al*, 2021; Pakdemirli *et al*, 2021). Several studies showed that there is a strong and continuing scientific and

commercial interest in documenting the traditional uses of medicinal plants collected from their natural habitats and in exploring new applications for them (Daily, 1997; Ecological Society of America, 1997; Nasrallah *et al*, 2020). The heightened demand for herbal medicines, natural health products and secondary compounds from medicinal plants is rapidly reshaping their use worldwide (Saxena *et al*, 2007; Khatib *et al*, 2021).

In many regions of the world, the medicinal plant market is intimately connected with the livelihoods of people and their primary healthcare (Saxena *et al*, 2007; Valderrabano *et al*, 2018). Collecting medicinal

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plants and plant materials from the wild contributes to the subsistence livelihoods of many Indigenous People. Even today, it is estimated that hundreds of millions of people, primarily in developing countries, derive a significant part of their sustenance and income from collecting plant and animal products. Furthermore, a remarkable 70% of the global human population relies in some way on medicinal plants for their healthcare needs, underscoring the pivotal role these plants play in the economies of biodiversity-rich countries, through export and import (Walter, 2001). In addition to the collection from wild populations, people cultivate various medicinal plants in their home gardens for everyday use, as their access to modern medicines and healthcare facilities is often limited (Al-Oudat and Laham, 1994; Agelet et al, 2000; Kandari et al, 2012)

The surge in demand for medicinal plants in urban areas and high unemployment rates in rural areas means a much wider range of people are now accessing wild medicinal plant resources beyond the restricted set of specialists who were previously dominant in this role (Nahashon, 2013).

As well as direct pressure from harvesting, many medicinal plants are also under pressure from bio-prospecting – collection in pursuit of sources of new biochemicals. Such unregulated commercialization may lead to these vital plant resources becoming inaccessible and unaffordable for populations that have relied on them for centuries, as well as denying them to people elsewhere in the world (Roberson, 2008). Furthermore, the profits from such commercial exploitation are rarely returned to the people who may have provided Indigenous knowledge, neglecting the access and benefit-sharing aspects of the Nagoya Protocol (Knight et al, 2023). Finally, medicinal plant species also face general threats from habitat loss and climate change. As wild areas are destroyed or degraded, unique and valuable species are lost along with the habitat. This loss of biodiversity may also result in the loss of essential remedies for current and future diseases. Due to all these pressures, medicinal plant populations are disappearing at an alarming rate, and conservation measures are urgently needed.

There are well-established methods for the conservation and sustainable use of medicinal plant resources. Rajasekharan and Shabir (2020) assert that both conservation (*in situ* and *ex situ* conservation and cultivation practices) and resource management strategies (e.g. good agricultural practices and sustainable use solutions) should be developed in parallel and adhered to, in order to secure their long-term future. However, despite the availability of guidance, only a small fraction of medicinal plant species are being protected through traditional conservation methods in nature reserves or botanical gardens (Chen et al, 2016). Most collection practices for medicinal plants are unsustainable, with impacts including overharvesting, lack of replenishment in the wild, and poor cultivation practices. Consequently, many species are now endangered or at risk of extinction

and several have recently been included on the IUCN Red List (Walter, 2001; Baričević et al, 2002; Nahashon, 2013; Rajasekharan and Shabir, 2020)

Although extinction is the most serious impact on society, the loss of even a proportion of a species impacts diversity and translates into the loss of potential new medicinal discoveries (Kumar, 2006).

Syria, situated within a region characterized by substantial topographical and climatic diversity in the area known as the Fertile Crescent, possesses a remarkable abundance of agro-biodiversity. Of particular note, it has a rich diversity of plants used by local communities for medicinal purposes. The use of Indigenous plants is widespread at the community and end-user levels (Khatib et al, 2021). A study by Kywan (2016) highlighted that among the 394 cultivated plant species grown in Syria, 91 were classed as medicinal plants and were either collected from the wild or grown in home gardens. Medicinal, aromatic wild plants represent a large part of Syria's flora. Various plants, including *Matricaria* sp., *Thymus* sp., *Artemisia* sp. are gathered directly from the wild by rural communities for use in traditional medicine (FAO, 2001). Traditional medicine is a significant healthcare system in Syria, where people rely on various natural substances as sources of treatment (Alamholo et al, 2023). These plants are integral to traditional medicine, especially in impoverished regions. At present, documentation of Syria's agro-biodiversity is inadequate, but what little information is available indicates the presence of numerous globally significant species. Disturbingly, there have been documented declines in several species in Syria, especially wheat, along with both cultivated and wild barley, as well as various types of legumes and vegetables – whether domesticated or wild – are at risk of degradation and extinction (FAO & ITPGRFA, 2022). Also, Handa et al (2006) noted that Syria's mild climate is ideal for growing a variety of plants. Many of these plants are used in Syrian culture for aromatherapy, perfumes and medicine. Syria is home to approximately 3,459 plant species, spread across 865 genera and 131 families (FAO, 2001). A significant number of these species are valued for their medicinal and aromatic properties. Rural communities often gather these plants from the wild to prepare traditional medicines. However, Syria's medicinal and aromatic plants face threats from issues such as forest destruction due to fires, overgrazing, urban expansion, water scarcity, tree cutting for fuel and unsustainable harvesting (FAO & ITPGRFA, 2022). To safeguard these plants, there is a need for improved management, conservation, research into traditional knowledge and medicine, and the regulation of herbal medicine production and trade.

Within Syria, a range of pressures are threatening the medicinal flora, including a changing climate (drought, rising temperature), wildfires, overgrazing, uncontrolled urban expansion, internal displacement, and extensive overharvesting. In particular, the expansion of agricultural cultivation into new areas, and the

adoption of economically significant crops like cereals, forages and legumes, are driving substantial habitat loss (Syrian Government, UNDP, GEF, 2009; Aldarvish et al, 2022). Although the deterioration of plant genetic resources in Syria had begun before the ongoing political crisis started (FAO, 1996), it has amplified existing threats and it will be imperative to quantify the scale of this effect (Kywan, 2016; Gaafar, 2021; Geoglam Crop Monitor, 2021). Alongside direct effects, such as armed conflicts in mountainous regions involving landmines and explosives, the civil war has also severely impaired the research and regulatory infrastructure, with institutions formerly dedicated to conserving and propagating genetic resources for future generations now closed. There are currently no conservation activities for medicinal plants taking place, not least because Syrian botanists have been moved or diverted to other activities. The loss of competent authorities, along with any effective government oversight, has undermined a national process based on Key Biodiversity Areas (KBAs) and now management and conservation plans that address both ecological and social dimensions are urgently needed, to avoid extinction and promote restoration and sustainable use practices (Valderrabano et al, 2018).

As a first step, there is an urgent need to assess the current status of medicinal plant populations and identify cost-effective strategies for conserving those most at risk of genetic erosion and degradation (Valderrabano et al, 2018). The research reported here was designed in accordance with the Syrian National Strategy for Conservation and Management of Plant Genetic Resources for Food and Agriculture 2015–2035 (FAO, 2015), and aimed to:

- Collect information about the current status and most pressing threats to medicinal plants in Northern Syria, using a questionnaire
- Characterize and map the distributions of medicinal plant species facing deterioration
- Collect seeds from multiple genotypes of each of the seven medicinal plant species for the future establishment of an *in situ* and *ex situ* collection.

## Materials and methods

The study was conducted from January to September 2023 across specific subdistricts in the Idlib Governorate (Harim, Mhambal, and Darkosh) and the Aleppo Governorate (Jebel Saman and Atareb) of Northern Syria (Figure 1). These locations were identified after a series of focus group discussions (FGDs) with local communities and stakeholders in Northern Syria, including agricultural experts, community leaders and senior farmers. Representatives in each subdistrict nominated key informants (KIs), allowing for the targeted selection of knowledgeable individuals with local expertise. The FGDs revealed that these subdistricts were particularly exposed to ecosystem deterioration and disruption due to prolonged conflict, making them

priority sites for assessing the status and threats facing medicinal plant species.

Data collection aimed to evaluate the current status and conservation needs of locally valuable medicinal plant species in these ecologically vulnerable areas. A questionnaire (Supplemental Data) was developed and administered to 50 KIs between 1 April 2023 and 1 August 2023. The questionnaire was designed with diverse question types to gather detailed information. Participants mainly chose answers from a predefined list, ensuring consistency across responses, but also had the option to add any additional answers not included in the predefined list. KIs, nominated by subdistrict representatives, included senior farmers, agricultural engineers and researchers, chosen for their expertise and involvement with local agricultural practices. The participant composition consisted of 76% male and 24% female respondents aged 24–85, with 36% agricultural researchers, 34% agricultural engineers and 30% senior farmers, offering a comprehensive perspective on the perceived threats to the selected species and potential conservation interventions.

## Survey and data analysis

The survey aimed to capture respondents' perceptions of critical threats to medicinal plant species – chamomile (*Matricaria chamomilla* L.), wild thyme (*Thymus capitatus* L.), sage (*Salvia officinalis* L.), hyssop (*Hyssopus officinalis* L.) and caper (*Capparis spinosa* L.), which were considered by local experts to be the species most vulnerable to deterioration due to diverse factors such as overharvesting, unmanaged collection, and climate-driven droughts. Collected data were analyzed in MS Excel (Microsoft Office 2020) to assess the prevalence and distribution of responses for each question. The analysis included calculating percentages, frequency counts, and averages, providing a comprehensive view of response patterns, and highlighting key trends across participants' answers.

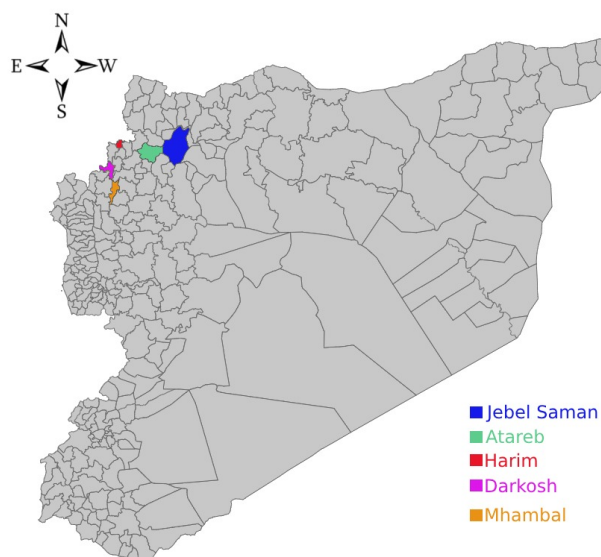
## *Ex situ* conservation methodology

For *ex situ* conservation, seeds from five mature individual plant genotypes (1,000 seeds of each genotype) of each identified species were collected within each subdistrict, ensuring representation across ecological variations in Northern Syria. The seeds were harvested, dried and disinfected using a thiram fungicide.

For proper tracking and future use, each seed sample was labelled with essential 'passport' information, including the species name, original collection location, and collection date, which includes the date the seeds were placed in storage. The seeds were then stored in paper bags, which were placed within airtight plastic containers along with dry silica gel to maintain optimal humidity levels at ambient room temperature (approximately 20–25°C). Seed samples have been temporarily stored in a designated room at the field staff's home.

## Results

Data collected from 50 key informants, including farmers, agricultural engineers and researchers in five target regions within the Aleppo and Idlib Governorates in Northwestern Syria are detailed in [Supplemental Table](#). The results indicated that seven species mentioned in this study showed signs of deterioration across the locations surveyed ([Figure 1](#)); the seven species showing this deterioration are given in [Table 1](#).



**Figure 1.** Map of Syria showing the study area (Subdistricts within the Aleppo and Idlib Governorates) in the north of the country. Source: Humanitarian Data Exchange

Across the study area, most (98%) of participants stated that wild thyme was susceptible to degradation, followed by chamomile (94%), hyssop (76%), sage (76%), basil (42%), watercress (38%) and caper (14%) ([Figure 2](#)).

Responses to the questionnaire ([Supplemental Table](#)) indicated that the species considered to be most in decline varied across the five subdistricts. Most of the respondents in Mhambal (86%) mentioned that Caper was in decline, whereas those who mentioned the decline of chamomile (17–21%) and wild thyme (18–20%) were more evenly distributed across the five subdistricts ([Figure 3](#)). Although seven species were listed as being in decline in the study region, they were not in decline across all subdistricts. For example, none of the respondents from Harim listed sage or hyssop as being in decline and none of the responders from Jebel Saman mentioned that caper and watercress were in decline.

For all species except wild thyme, all respondents considered each species to be 'rarely available'. For wild thyme, 98% of respondents considered it to be 'rarely available', and 2% considered it to be 'not available'.

There was complete agreement among respondents regarding the natural habitat of the seven species. Wild thyme, sage and hyssop were considered to

grow in natural public spaces and forested areas. In contrast, caper and chamomile were considered to occur along agricultural roadsides, while watercress grew near freshwater streams. Basil, on the other hand, is typically cultivated at home.

Respondents were asked to assess the importance of a list of reasons for the decline of medicinal plant species in Northern Syria. The results show that respondents considered the primary factor contributing to the deterioration of these species to be excessive use, characterized by unmanaged gathering of plant material, with 47% of respondents considering this to be a contributory factor. In addition, frequent droughts, climatic changes, desertification and the loss of forested areas to urban expansion were also identified as significant factors by a large number of respondents. To a lesser extent, respondents considered neglect by local authorities, lack of awareness regarding the importance and value of these species, and the repercussions of the Syrian crisis, notably the lack of law enforcement, to play a role. The lack of interest and understanding in the use of medicinal plants among the younger generation and overgrazing were also noted by some as contributory factors but were only mentioned by 5% of the respondents. Interestingly, deforestation and floods were not considered by any of the respondents to have a discernible impact on the deterioration of these species.

When asked specifically about the effects of the Syrian crisis in exacerbating the deterioration of these medicinal plant species, 60% of respondents indicated that the crisis had a substantial role. This was primarily attributed to the absence of both interest and legal measures aimed at safeguarding and preserving these botanical species. In contrast, 40% of participants expressed uncertainty regarding the impact of the crisis.

It was notable that all participants stated that they continue to be interested in cultivating some of these species, with 66.7% stating that these species are for family use and 33.3% stating that these species are of economic use.

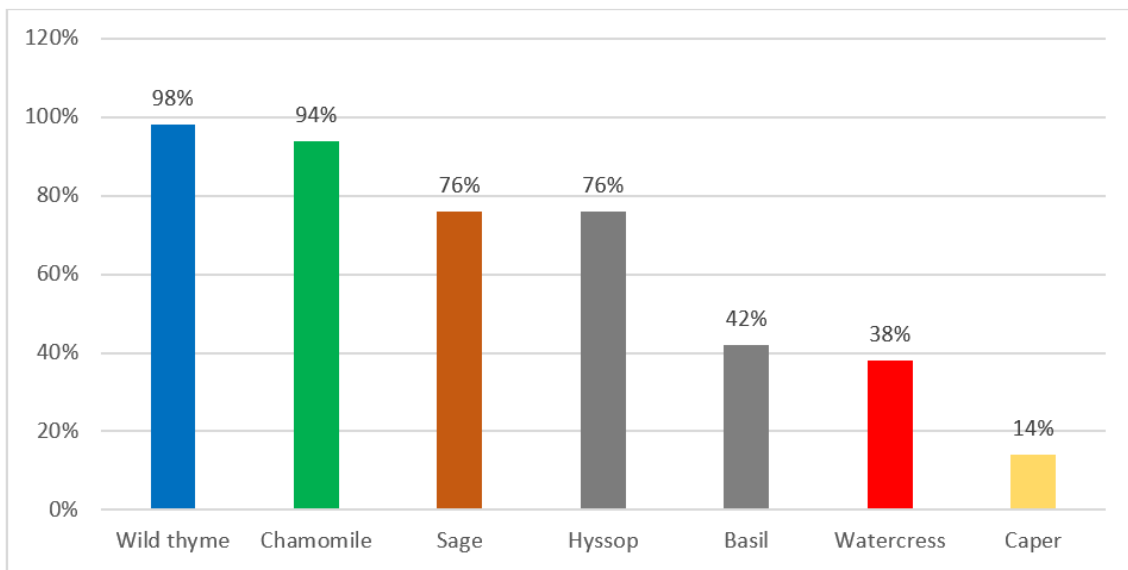
According to respondents, the local population in Northern Syria uses these medicinal plant species to treat a range of complaints and diseases ([Table 2](#)), with some complaints being treated by several species. For example, respiratory diseases were treated by chamomile, wild thyme, hyssop and basil. Others were only treated by one species. For example, blood pressure is only treated with basil, and anorexia is only treated with sage. Consequently, the loss of a certain species might mean that there is no other medicinal plant available to replace it as a treatment.

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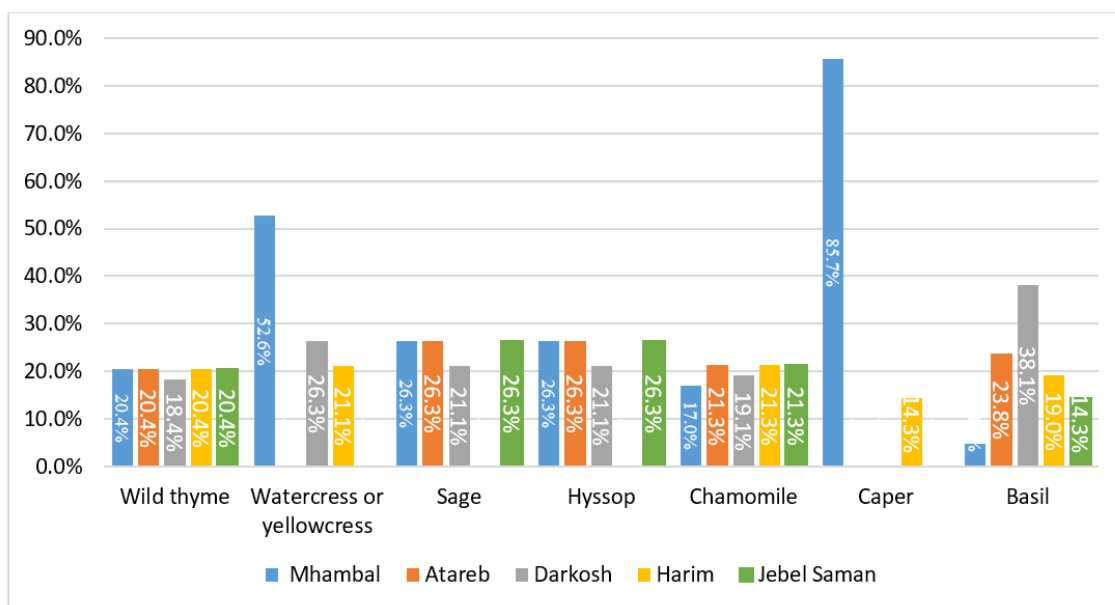


**Table 1.** Medicinal plant species identified by the key informants as most vulnerable to genetic erosion and deterioration.

| English name | Family       | Scientific name                     | Life cycle |
|--------------|--------------|-------------------------------------|------------|
| Basil        | Lamiaceae    | <i>Ocimum basilicum</i> L.          | Annual     |
| Caper        | Capparaceae  | <i>Capparis spinosa</i> L.          | Perennial  |
| Chamomile    | Asteraceae   | <i>Matricaria chamomilla</i> L.     | Annual     |
| Hyssop       | Lamiaceae    | <i>Hyssopus officinalis</i> L.      | Perennial  |
| Sage         | Lamiaceae    | <i>Salvia officinalis</i> L.        | Perennial  |
| Watercress   | Brassicaceae | <i>Nasturtium officinale</i> R. Br. | Annual     |
| Wild thyme   | Lamiaceae    | <i>Thymus capitatus</i> L.          | Perennial  |



**Figure 2.** The percentage of respondents who listed each medicinal plant species as being in decline in Northern Syria (N=50).



**Figure 3.** Proportions of all respondents who listed a particular species as exposed to deterioration (100%) according to subdistrict (N=50).

**Table 2.** List of diseases and complaints for which the seven medicinal species are used as treatment locally in Northern Syria, according to survey respondents.

| Species                   | Use in traditional medicine  |
|---------------------------|--|
| Chamomile                 | Infections of mouth and gums, respiratory diseases, colds, headaches; calming the nerves; protecting skin; regulating blood sugar; strengthening immune system   |
| Wild thyme                | Infections and inflammations of the digestive system, respiratory problems, coughs, worms; antispasmodic   |
| Sage                      | Anorexia, flatulence, stomach pain or inflammation, diarrhoea, colic, stomach ulcers, indigestion  |
| Hyssop                    | Respiratory diseases   |
| Caper                     | Diabetes, skin diseases, anaemia, strengthening immunity, promoting weight loss  |
| Basil                     | Enhance the functioning of the digestive system, cleanse the intestines, prevent constipation, relieve pain, enhance the health of the heart and arteries, treat colds and asthma, treat respiratory infections, and treat anaemia |
| Watercress or yellowcress | High blood pressure, increases sexual energy in men, diuretics, anaemia, expectorant   |

with sage. Consequently, the loss of a certain species might mean that there is no other medicinal plant available to replace it as a treatment. To guarantee the availability of seeds from these varieties, *ex situ* conservation was employed in this study. Seeds from five plant genotypes were collected, dried, disinfected, and placed in paper bags within airtight containers at ambient temperature. This approach allowed for accurate tracking of the samples, with vital passport information documented for future reference. The seeds are currently stored temporarily to preserve their viability until more sustainable long-term storage solutions can be adopted.

The data from the questionnaire revealed that every respondent displayed a strong commitment to safeguarding medicinal plant species. The results highlighted that the most popular method for protecting these seeds was seed collection and conservation of these species in the local gene bank. Followed by raising awareness about the need to safeguard these species, as well as the implementation of practical protective measures in the areas where these species are found to counteract the factors leading to their decline. The idea of the establishment of local collections received significant support. In contrast, seed exchange was the least favoured method among respondents (Figure 4).

## Discussion

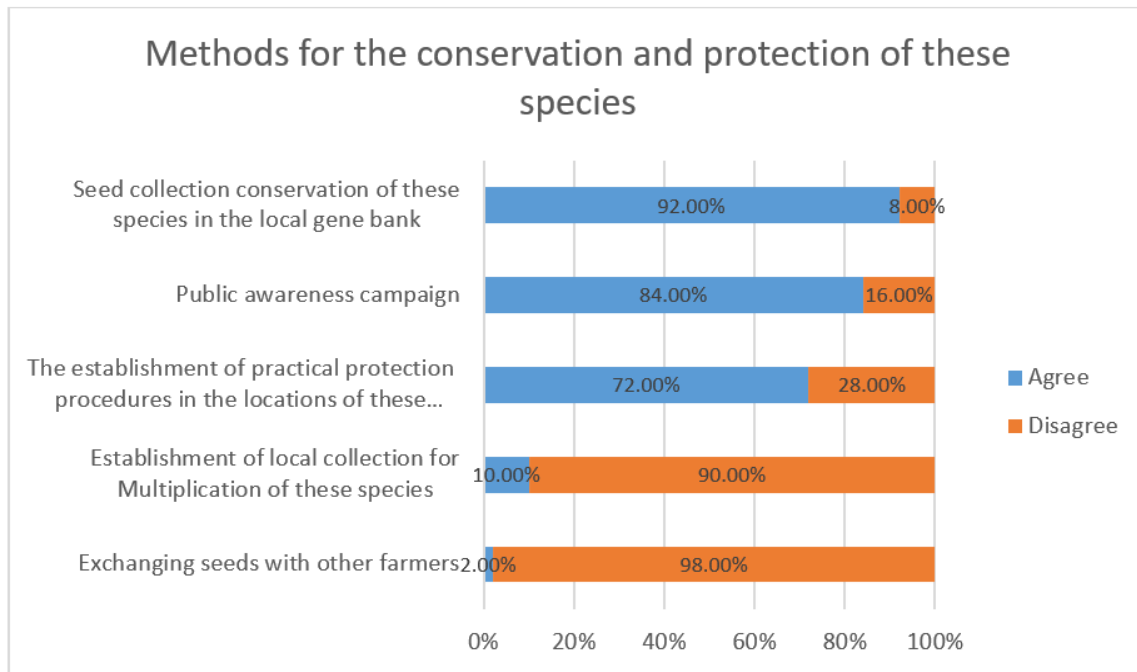
Syria, located in the Fertile Crescent, a region known for its significant topographical and climatic variety, boasts a rich diversity of plants used by local communities for medicinal purposes. These plants play a crucial role in plant diversity and contribute to global genetic resources, as highlighted by various studies (Chacko *et al*, 2010; Chen *et al*, 2010; Alachkar *et al*, 2011; Asimwe *et al*, 2021; Pakdemirli *et al*, 2021). However, the ongoing armed conflict has led to the overexploitation of local resources, including the excessive harvesting of medicinal plants. The absence of regulatory entities, protective laws and sustainable management practices leaves these resources unprotected, threatening their survival and regeneration. On top of this, forest

fires and overgrazing have caused increased deterioration of plant populations in the region (Handa *et al*, 2006; Valderrabano *et al*, 2018; Gaafar, 2021; Khatib *et al*, 2021; Al-Darvish *et al*, 2022, 2023). This is a worldwide phenomenon, with loss of wild genotypes having been reported by several studies (Walter, 2001; Baričević *et al*, 2002; Kumar, 2006; Roberson, 2008; Nahashon, 2013; Chen *et al*, 2016; Rajasekharan and Shabir, 2020; Geoglam Crop Monitor, 2021) but the issue is particularly acute in Syria.

Medicinal plant species, which have been used by humans for thousands of years, are a key component of traditional medicine practices worldwide. In Syria, rural communities gather medicinal plants from the wild for use in traditional healing (FAO, 2001; Alamholo *et al*, 2023). These plants have gained increasing significance with the rise of folk healers who offer treatments with fewer side effects compared to synthetic drugs. Medicinal plants also have economic value, as they can serve as a source of raw materials for the pharmaceutical industry. However, in Northern Syria, medicinal plant species are facing a decline. Our questionnaire results have provided valuable insights into the current status of these plants and the perceived causes of their deterioration.

According to data collected from a sample of 50 expert respondents, seven medicinal plant species in Northern Syria were identified as experiencing deterioration. These species are used to treat at least 24 different medical conditions, meaning their loss would significantly impact the local population, who often rely on these plants as their primary form of medical treatment. Some conditions can be addressed by multiple species, while others depend on a single species for treatment. The loss of plants with unique medicinal properties would be especially detrimental to public health, particularly if no alternative plant species with similar properties are available.

Chamomile stands out among these species due to its broad medicinal applications for various complaints. It was one of the seven species identified as deteriorating across all five subdistricts. Given its wide usage and the decline it is facing, chamomile warrants priority



**Figure 4.** The proportion of respondents supporting each proposed method for the protection of medicinal species (N=50).

conservation efforts. In contrast, some of the other six species were reported as deteriorating in only one or two subdistricts, though the responses do not clarify the reasons for this. It could be due to more intense overharvesting in specific districts, but further investigation is needed to identify other potential causes.

The data might also suggest that certain species are naturally absent from areas where they were not mentioned, indicating a restricted distribution that also calls for conservation attention. Alternatively, uneven distribution could reflect increasingly unsuitable conditions in particular subdistricts for specific species. For instance, watercress, which requires freshwater streams, may be especially vulnerable to droughts in certain districts. A more comprehensive understanding of these patterns will help target conservation actions more effectively, ensuring that future plans are tailored to meet the specific needs of each subdistrict.

The questionnaire also examined the conservation actions that respondents considered most appropriate. It was encouraging to find that nearly all respondents agreed on the importance of seed collection for the establishment of genebanks. This indicates broad support for the seed collection activities conducted as part of this study. However, there was less enthusiasm for practical *in situ* conservation methods, which may be due to perceptions that such actions are difficult or unfeasible in a conflict zone. For proper tracking and future use, each seed sample was labelled with essential 'passport' information, including the species name, original collection location, and collection date, which includes the date the seeds were placed in storage. The seeds were then stored in paper bags,

which were placed within airtight plastic containers along with dry silica gel to maintain optimal humidity levels at ambient room temperature (approximately 20–25°C). Seed samples have been temporarily stored in a designated room at the field staff's home

The research team acknowledges that ambient temperature storage is not a suitable long-term conservation method, as it may lead to degradation over time. This decision was made due to limited access to cooling systems in Northwestern Syria, as well as immediate access requirements and preliminary storage needs. However, the team fully recognizes the limitations of this approach for long-term preservation. To address this, the team is exploring alternative conservation strategies. These may include transferring the samples to optimal cold storage conditions and collaborating with official authorities, such as agricultural research centres or the Faculty of Agriculture in Idleb Governorate, to ensure the long-term viability and accessibility of these samples for future research

The findings of this study align with previous research on the deterioration of plant genetic resources and the conservation of medicinal plants. They reveal a consistent decline in biodiversity, particularly in regions like Syria, where climate change, habitat destruction, and socio-political instability – especially the ongoing conflict – accelerate the loss of valuable plant genetic resources. These results echo earlier studies documenting similar patterns of biodiversity loss due to environmental and socio-political challenges. The study underscores the urgent need to preserve medicinal plants, which are vital for both medicinal and cultural purposes. Environmental degradation, climate change, and conflict have significantly accelerated the decline of

plant biodiversity, emphasizing the necessity for targeted conservation efforts.

In Northern Syria, the ongoing crisis, coupled with the lack of effective conservation measures, has placed medicinal plants at significant risk of extinction. This poses a threat not only to the region but also to the global community. The conservation of these plants is essential for healthcare, biodiversity, sustainable ecosystems, and cultural heritage. Furthermore, the study highlights the critical need for immediate action to safeguard these plants, pointing to the absence of engagement from conservation organizations, which worsens their vulnerability.

Knowledge of the drivers behind the deterioration of these species is key to the development of appropriate conservation actions. The results of the questionnaire provide some useful pointers with the cause most frequently named by the respondents being ‘massive unmanaged gathering’ followed by ‘frequent droughts’. Whilst recognizing the difficulty of implementing any management of the level of collecting whilst in a war situation, the results of the questionnaire nevertheless highlight the need to develop and implement a policy that will control and sustainably manage these key genetic resources. Although the Syrian crisis was only listed by 5% of the respondents as a cause of the deterioration, when participants were directly asked whether the Syrian crisis contributed to the deterioration of medicinal plants, with options for ‘Yes’ or ‘No’, 60% of the respondents considered it to have been a contributory factor which is closely associated with excessive use, characterized by unmanaged gathering of plant material. It also seems likely that the crisis impacts medicinal plant populations indirectly: for example, the supply of pharmaceutical drugs has been compromised by the crisis and has probably led to increased unmanaged gathering of medicinal plants by vulnerable people in search of cost-effective treatments.

While the crisis is a significant factor, the decline of plant genetic resources in Syria began before the war that started in 2011 (FAO, 1996; Syrian Government, UNDP, GEF, 2009). Respondents noted that, although overuse is the primary cause of this decline, other contributing factors include frequent droughts, climate change, desertification and the expansion of urban development into forested areas. Moreover, neglect by local authorities, a lack of awareness about the importance and value of these species, and insufficient law enforcement further exacerbate the issue. Additionally, there is a noticeable disinterest among the younger generation in using plants for medicinal purposes, potentially due to the unavailability of certain species in their natural habitats.

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Our findings point to a substantial gap in policy regarding Syria’s indigenous genetic resources. While we have taken concrete steps to preserve what remains, there is an urgent need to develop a comprehensive national strategy to protect these species. Such a strategy should include both *in situ* and *ex situ* seed conservation. Also, awareness campaigns are essential to emphasize the importance of these plants, and the implementation of protective measures in the areas where they are found. These measures should be designed to specifically address the factors driving the decline of these species, with protocols tailored to reflect regional differences and local conditions. Only by adopting a comprehensive approach can we ensure the long-term survival and genetic diversity of these invaluable medicinal plants.

## Supplemental data

**Questionnaire** including responses received in the survey

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## Author contributions

Munzer Aldarvish coordinated the research and contributed to the research design and manuscript; Anas Al Kaddour, Akram Bourgol and Yasser Ramazan contributed to the research design and manuscript and undertook the data analyses; Yousef Hallak contributed to the research design and carried out the field data collection; Stephen Caversand Joan Cottrell provided academic guidance and support throughout the research process and contributed to the manuscript.



## Conflict of interest statement

The authors of this manuscript have no conflicts of interest to declare. All co-authors have seen and agreed with the manuscript's contents, and there is no financial interest in the report.

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