Ethnopharmacological study of native medicinal plants and the impact of pastoralism on their loss in arid to semiarid ecosystems of southeastern Iran

Mohsen Sharafatmandrad & Azam Khosravi Mashizi

The purpose of this study was to gather ethnopharmacological information on plants used by the pastorals of southeastern Iran. The relationships between ecological value of the plant species and ethnobotanical indices were investigated. The loss of medicinal plants and its effective factors were also determined under nomadism and sedentary pastoralism. Ethnopharmacological information of plants was collected through interviews with 85 local people including nomads (43%) and sedentary pastorals (57%). Ethnobotanical indices including relative frequency of citation (RFC), relative importance (RI), cultural value (CV), and use value (UV) were estimated. Canopy cover and density of plant species were measured at 60 sampling plots in the exclosure, nomadic rangelands and sedentary pastorals rangelands. The Importance Value Index (IVI) and Relative Loss Index (RL) were estimated for both nomadic and sedentary pastoral rangelands. Pearson correlation coefficient was used to investigate the relationship between ethnobotanical indices and IVI of plant species. The Bayesian networks was used to investigate the relationship between ethnobotanical indices and plant species loss. In total, 156 medicinal plant species of 50 families were identified in the region by locals. Positive correlation was observed between ethnobotanical indices (RFC and RI) and ecological index (IVI). The mean decline of the ecological importance of medicinal species in sedentary pastoral rangelands was approximately three times higher than in nomadic rangelands. Bayesian networks showed that cultural value, seed exploitation and aerial parts exploitation had direct relationships with species loss in both nomadic and sedentary pastoral rangelands. Bunium persicum, an ecologically and socially important species, had been extensively harvested (more than 60%) in the both nomadic and sedentary pastoral rangelands, making it a priority species in future conservation programs.

Medicinal plants had high ecological value and were severely exploited, threatening sustainability of arid and semiarid ecosystems. Local pastorals not only use medicinal plants as herbal remedies but also consider them as a source of income. Popular plants with multiple medicinal uses were more susceptible to loss. Higher medicinal knowledge of pastorals did not help to mitigate medicinal plant loss, requesting new plans to aware them to the circumstances that often leads to species removal from community. Given the importance, abundance and widespread use of medicinal plants, further studies can provide a basis for their conservation and for identifying new therapeutic effects of plants in the region.

Plants provide many uses for humans, the medicinal usage is one of their most important benefits traditionally1,2. According to the World Health Organization3, more than 80% of people depend on traditional use of medicinal plants for their health in developing countries. Botanical studies have considerably increased in recent years4,5. Today there are 20,000 plants used for medicinal purposes in the world6 and there are about 8000 plant species
in Iran, of which 2300 species are aromatic and medicinal. These medicinal plants are mostly distributed across arid and semiarid rangelands, which are historically used by local pastorals.

The history of pastoralism in Iran (Zagros Mountains) is traced back to 10,000 years ago. During this long time, local pastorals gained a lot of information on medicinal plants and their relation to nature, especially in rangelands. They transferred their experiences to later generations. This knowledge that is accumulated over generations of living in a particular environment, known as native or indigenous knowledge. Indigenous knowledge is based on the perceptions and various insights of local communities on the surrounding environment, land resources and their exploitation. Local communities earned it over the years with numerous trials and errors. Using this knowledge, pastorals have sustainedly managed their rangelands for a long time. Therefore, indigenous knowledge of different pastorals in the plans and adopted policies.

With the increase in human population and thus their demands, the intensive use of wild plants is increasing. With the increase in human population and thus their demands, the intensive use of wild plants is increasing. On the one hand, the knowledge of pastorals can vary based on environmental conditions, animal husbandry systems and social issues, requesting an investigation with different pastoralism types in the region (nomadism and sedentary pastoralism).

On the other hand, ethnobotanical information is of high cultural importance and of great socio-economic value to researchers, politicians, and the local populations. This knowledge is being eroded due to the decline of custodians of indigenous knowledge and the lack of interest of the younger generation to this knowledge. Therefore, researchers should look for approaches for applying and institutionalizing the indigenous knowledge of different pastorals in the plans and adopted policies.

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Data collection. Ethnopharmacology of medicinal plants. Ethnopharmacological interview was used as the basis for data gathering from 8 nomadic tribes and 10 villages in the study area. Nomadic and sedentary pastorals were surveyed using non-proportional quota sampling. A questionnaire was administered only to the basis for data gathering from 8 nomadic tribes and 10 villages in the study area. Nomadic and sedentary pastorals were surveyed using non-proportional quota sampling. A questionnaire was administered only to the

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Methods

Study area. Khabar National Park was selected for this study. Khabar National Park is located in the southeast of Iran (28° 25' to 28° 59' N and 56° 02' to 56° 38' E). The total area is 120,000 ha and the elevation ranges from 1000 to 3845 m a.s.l. Mean annual rainfall is 253.69 mm and mean annual temperature ranges from 13.7 to 25.3 °C. Soils are primarily sandy loam with different depth. About 55% of the area is surrounded by fences and ditches excluding grazing livestock for more than 25 years. The northern plains consist of pure stand of Artemisia aucheri, which is grazed mostly under sedentary pastoralism and nomadism. Of the nomad families, 81% use the region rangelands for livestock grazing in spring and summer and migrate to the provinces on the northern shore of the Persian gulf (Hormozgan) in autumn and winter.

Data collection. Ethnopharmacology of medicinal plants. Ethnopharmacological interview was used as the basis for data gathering from 8 nomadic tribes and 10 villages in the study area. Nomadic and sedentary pastorals were surveyed using non-proportional quota sampling. A questionnaire was administered only to people who had knowledge of medicinal plants, through face-to-face interviews. Various data such as ethnopharmacological information including local names, purpose of usage, preparation method, and the plant parts used were obtained through interviews and discussions. Furthermore, respondents age, gender, and educational status were also questioned. The voucher specimens were collected on site and were identified by specialist with the help of available florals. The species entries were complemented along with data on taxonomic position (family) and vernacular name.

Ethnobotanical indices. Some ethnobotanical indices were measured on the basis of collected ethnobotanical information. We have compared the importance of each species using the following four indices: Use-value (UV), relative frequency of citation (RFC), relative importance index (RI) and cultural value index (CV).

Use-value (UV). A quantitative index used to determine the relative importance of an indigenous plant species, which was calculated as follow:

\[ UV_i = \sum U_i / n \]

where \( U_i \) is the sum of the total number of use citations by all informants for a given species, \( n \) is the total number of informants. A high use value indicates the potential importance of the cited plant species.

Relative frequency of citation (RFC). This index shows the local importance of each species and it is given by the frequency of citation (FC, the number of informants mentioning the use of the species) divided by the total number of informants participating in the survey (N), without considering the use-categories as follow:

\[ RFC_i = FC_i / N \]
Cultural value index (CV). This index was measured with multiplying three factors using the following formula:

\[ CV_s = \frac{NU_s}{NC} \times \frac{FC_s}{N} \times \left( \frac{\sum_{u=u_i}^{u=N} UR_u}{N} \right) \]

where in the first factor, NUs the number of different uses cited for the species and NC is the total number of use-categories. FCs is the relative frequency of citation of the species in the second factor. Finally, the third factor is the sum of number of participants who mentioned each use of the species (URui) divided by N\(^2\).

Relative importance index (RI). This index was calculated using the following formula.

\[ RI_s = \frac{RFC_s(max) + RNU_s(max)}{2} \]

\[ RFC_s(max) = \frac{FC_s}{maxFC} \]

\[ RNU_s(max) = \frac{NU_s}{maxNU} \]

\[ NUs = \sum_{u=u_i}^{u=N} UR_u \]

where RFC\(_{(s(max)}\) is the relative frequency of citation over the maximum, i.e., and was measured with FCs divided by the maximum value in all the species of the survey. RNU\(_s\) is the relative number of use-categories over the maximum and it was calculated with the number of uses of the species (NU\(_s\)) divided by the maximum value in survey\(^24\).

Ecological data of medicinal plants. Ecological data were collected in three adjacent sites (inside the park, outside the park including both nomad and sedentary pastoral rangelands). Sites were selected in homogeneous areas with similar topography and ecological properties. The vegetation survey was carried out using 180 nested quadrats, which randomly located in the sites to show the loss of plant species under different pastoralism types. As a constant quadrat size may not be appropriate or all plant species with different sizes, sixty 10 × 10 m quadrats were used to sample trees and shrubs and 1 × 1 m sub-quadrats were used to sample semi-shrubs and herbaceous plants in each site. Canopy cover and individual numbers of plant species were recorded in each plot.

Importance value index (IVI) provides information about the ecological importance of a species in plant communities\(^25\). IVI was used to determine ecological value of medicinal plant in our study. Since species density, frequency and dominance comprised IVI are sensitive indicators to anthropogenic actives\(^26,27\). Reaction of species to human exploitation can be revealed with comparing IVI with and without exploiting\(^28,29\). Relative loss (RL) index was measured to assess ecological situation of medicinal plants under both nomadic and sedentary pastoral system using changes IVI.

Index of RL of species s was calculated using the following formula:

\[ RL_s = \frac{IVI_s_{in} - IVI_s_{out}}{IVI_s_{in}} \]

where IVI is the importance value index. Vegetation composition was evaluated by analyzing the frequency, density, dominance and IVI, using the following formula\(^30,31\).

\[ IVI = \frac{\text{Relative frequency} + \text{Relative density} + \text{Relative dominance}}{3} \]

Relative frequency = Frequency of a species/frequency of all species * 100, Density = Total no. of individuals of a species/total no. of quadrats studied, Relative density = Number of individuals of a species/number of individuals of all species * 100, and Relative Dominance = Canopy cover of a species/Canopy cover of all the species * 100.

Data analysis. Bayesian networks (BNs) were used to investigate the relationship between ethnobotanical indices and relative loss of species for both pastoralism rangelands. The variations of the probability of species loss was estimated under different scenarios.

BNs are a general way to find important paths in a network that are usually not easily estimated by mathematical equations. The calculations in the BNs are estimated using Bayes’ theorem\(^32\). According to Bayes’ theorem, a prior probability represents information about the initial uncertainty of a parameter. However, the posterior probability is estimated using the observed data and its likelihood function to update the uncertainty distribution of the parameters. Bayes’ theorem updates probability of each factor in the network as follow:\(^32\).
Sensitivity analyses in BNs was used to determine factors effective on relative loss of medicinal plants under nomadism and sedentary pastoralism\textsuperscript{34} and then, scenarios were defined based on the most effective factors to predict changes in relative loss with altering effective factors.

Pearson correlation coefficient was used to investigate the relationship between ethnobotanical indices and IVI. A t-test was applied to compare relative loss of plant species under nomadism and sedentary pastoralism.

Ethics approval and consent to participate. All experimental protocols were approved by Review Board of Faculty of Natural Resources, University of Jiroft, Iran. All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all participants.

Results
Respondents’ socio-demographics. All of the 85 participants who randomly selected in the study (55 men and 30 women) were locals. The participants were belonged to two pastoralism types i.e. nomadism (43%) and sedentary pastoralism (57%). The focus was on older generations as the holders of traditional knowledge. Therefore, 98% of the participants were more than 45 years old and 60% were over 60 years old (Table 1).

Medicinal plants. In total, 156 medicinal species of 50 families with medicinal uses were identified by pastorals (Table 2). The families Asteraceae, Lamiaceae, Apiaceae, and Fabaceae were the most abundant families in terms of medicinal species in the region (Fig. 1).

Plant parts used. The plant parts used by pastorals for treatment include stems, flowers, seeds, fruits, roots, gums, leaves, and whole aerial parts, of which aerial parts (25%), leaves (24%), and fruits (24%), were the most abundant parts used (Table 3). Medicinal uses of the species were divided into 16 different categories, of which the uses for digestive system (50% species), immune system (23% species), sedative (20% species) had the most frequencies (Table 3).

Ethnopharmacological indices. Descurainia sophia (RFC = 0.70), B. persicum (RFC = 0.70) and G. glabra (RFC = 0.70) had the highest RFC values. UV changed from 0.96 to 0.06 and Z. multiflora (UV = 0.96), D. sophia (UV = 0.90) and M. sativa (UV = 0.90) had the highest UVs. The highest IR index belonged to C. intybus (IR = 0.89), F. carica (IR = 0.85) and B. persicum (IR = 0.84). CV changed from 0.35 to 0.004 and B. persicum (0.35), Z. multiflora (0.35), and C. intybus (0.33) had the highest CVs (Fig. 2).

The relationships between ecological and ethnopharmacological indices. In terms of importance value index, A. sieberi (IVI = 0.55), B. persicum (IVI = 0.54) and R. pallasii (IVI = 0.54) had the highest values in the study area (Fig. 2). Importance value index was significantly correlated with RFC and RI indices (Fig. 3, \( p < 0.01 \)).

The values of relative loss index in the rural area varied between 0.01 and 0.84, and Z. tenuir (RL = 0.84), B. persicum (RL = 0.83), and Z. clinopodioides (RL = 0.76) had the highest values (Fig. 2). However, the values of RL index in the nomadic rangelands varied from 0.03 to 0.75, which T. fedtschenkoi (RL = 0.75), M. sativa (RL = 0.73) and Z. tenuir (RL = 0.68) had the most relative loss index. (Fig. 2). There were significant differences between pastoralism types (sedentary pastoralism and nomadism) in the relative loss of medicinal plant species (Fig. 4). The relative loss indices of medicinal species were 0.648 ± 0.222 and 0.223 ± 0.212 in sedentary pastoral and nomadic rangelands respectively, indicating more species are removed under the sedentary pastoralism.

| Characteristics | Class   | Frequency | Percentage |
|-----------------|---------|-----------|------------|
| Gender          | Female  | 30        | 35         |
|                 | Male    | 55        | 65         |
| Age (year)      | <45     | 2         | 2          |
|                 | 45–55   | 8         | 9          |
|                 | 55–65   | 25        | 30         |
|                 | 65<     | 50        | 59         |
| Pastoralism type| Nomadism| 37        | 43         |
|                 | Sedentary pastoralism | 48 | 57 |
| Education       | Less than high school | 33 | 39 |
|                 | High school | 25 | 30 |
|                 | Bachelor’s degree | 24 | 28 |
|                 | Higher degrees | 3  | 3  |

Table 1. Socio-demographics of the respondents.
| Scientific name                          | Family                | Local name         | Life form | IVI | Plant part used       | Medicinal uses                                                                 | Preparation               | Mode of application |
|-----------------------------------------|-----------------------|--------------------|-----------|----|-----------------------|-------------------------------------------------------------------------------|---------------------------|---------------------|
| Acantholimon scorpius (Jaub.&Spach)Boiss| Plumbaginaceae        | Khar poshtou       | Geophyte  | 0.001 | Flower, Fruit          | Sore throat, Dry cough, Removing phlegm throat                                | Decoction                 | Oral                |
| Achillea wilhelmsii K.Koch              | Asteraceae            | Bomadaran           | Geophyte  | 0.015 | Aerial parts           | Sore throat, Dry cough, Removing Phlegm Throat                                | Decoction, Moisturized with water | Oral                |
| Actinos graveolens (M.Bieb.) Link        | Lamiaceae             | Malango            | Therophyte| 0.001 | Aerial parts           | Sore throat, Dry cough, Removing Phlegm Throat                                | Decoction                 | Oral                |
| Aerva javanica (Burm.f.) Juss. ex Schult| Amaranthaceae         | Pashmouk           | Phanerophyte| 0.002 | Leaves, Flowers        | Diuretic, Kidney stone                                                         | Decoction                 | Oral                |
| Allagi marorum Medik                    | Fabaceae              | Adour              | Hemicryptophyte| 0.001 | Aerial parts           | Hemorrhoids, Leaf for rheumatism                                              | Cataplasm, Decoction      | Oral, Topical       |
| Allagi pseudalhagi (M. Bieb.) Desv. ex B. Keller & Shap | Fabaceae              | Adour              | Hemicryptophyte| 0.001 | Aerial parts           | Diuretic, Cathartic, Leaf for rheumatism                                      | Decoction, Lini-         | Oral, Topical       |
| Alyssum dasyar- pum Stephan ex Wild      | Brassicaceae          | Qodoumeh           | Therophyte| 0.002 | Fruits, Aerial parts   | Sore throat, Dry cough, Removing Phlegm Throat                                | Decoction                 | Oral                |
| Amaranthus hybri- dus L                 | Amaranthaceae         | Taj-e Khooroos     | Therophyte| 0.021 | Seeds, Flowers, Leaves | Immune System, Brain and nervous system, Headache                             | Decoction                 | Oral                |
| Animi majus L                          | Apiaceae              | Golsefid           | Therophyte| 0.003 | Fruits                | Nausea, Diuretic                                                              | Decoction                 | Oral                |
| Amygdalus elae- agnifolia Spach        | Rosaceae              | Archen             | Phanerophyte| 0.008 | Fruits                | Swollen Gums, Convulsant, Anemia, menstruation, roots for intestinal worm     | Liniment, Deco-          | Oral, Topical       |
| Artemisia sieberi Besser               | Asteraceae            | Dormoun            | Chamophyte| 0.023 | Current year twigs    | Anti-angel, abdominal parasites, disinfectant                                | Decoction, Moist-        | Oral                |
| Asphodelus tenuifollius Care            | Xanthorrhoeaceae      | Peymaouk           | Geophyte  | 0.005 | Seeds, Leaves         | Diuretic, Swollen Gums, Intestinal worm, rheumatism                           | Decoction                 | Oral                |
| Astragalus crenatus Schult              | Fabaceae              | Nakhonak           | Therophyte| 0.012 | Fruits                | Colds, Analgesic                                                             | Decoction                 | Oral                |
| Astragalus gossypi- nus Fasch           | Fabaceae              | Gavan              | Chamophyte| 0.018 | Gum                   | Heir                                                                           | Moisturized with water   | Oral                |
| Berberis integerrima Bunge              | Berberidaceae         | Zarch              | Phanerophyte| 0.013 | Fruits, Roots         | Blood purifier, heat regulation, Edible fruit                                | Decoction                 | Oral                |
| Blepharis edulis (Forsk.), Pers         | Acanthaceae           | Khar sonbol        | Hemicryptophyte| 0.002 | Leaves, Seeds         | Blood coagulant                                                              | Liniment                  | Topical             |
| Bursium persicum (Boiss.) Jr.Fedtsch    | Apiaceae              | Zireh-e Siyah      | Geophyte  | 0.022 | Fruits                | Flatulence, Spasm, Antimicrobial, Menstrual pains, Spice                     | Decoction                 | Oral                |
| Calotropis procera (Aiton) Dryand       | Apocynaceae           | Kharak             | Phanerophyte| 0.001 | Leaves, roots, Gum    | Leaf for sedative after snake, scorpion and insect bite; roots for gastric discomfort and migraine | Decoction, Dress-        | Oral, Topical       |
| Capparis spinosa L                      | Capparidaceae         | Kavar              | Chamophyte| 0.004 | Fruits, Roots         | Diuretic, cathartic, Antimicrobial, Oickled flower buds                      | Decoction                 | Oral                |
| Capsella bursa- pastoris (L.) Medik     | Brassicaceae          | Kiseh-e Keshish    | Therophyte| 0.002 | Aerial prts           | Blood coagulant                                                              | Decoction                 | Oral                |
| Chenopodium album L                     | Amaranthaceae         | Salmak             | Therophyte| 0.007 | Aerial parts           | Laxative, Febrifuge                                                          | Decoction                 | Oral                |
| Chrysopogon australi (Boiss.) Staaf     | Poaceae               | Rish Zard          | Hemicryptophyte| 0.005 | Roots                | antiseptic, repellent and treatment of stomach ache, colds and fever          | Decoction                 | Oral                |
| Cichorium intybus L                     | Asteraceae            | Kasir              | Hemicryptophyte| 0.008 | Roots                | Diuretic, Trans-qualizer, febrifuge, diaphoretic, Stom-ach strengthening, jaundice | Decoction                 | Oral                |

Continued
| Scientific name | Family | Local name | Life form | IVI | Plant part used | Medicinal uses | Preparation | Mode of application |
|-----------------|--------|------------|-----------|-----|-----------------|----------------|-------------|---------------------|
| Cirsium arvense (L.) Scop | Asteraceae | Kangar saharaei | Hemicryptophyte | 0.008 | Roots | Gastric discomfort, appetizing | Decoction | Oral |
| Citrullus colocynthis (L.) Schrad | Cucurbitaceae | Hanzal | Therophyte | 0.003 | Fruits, Aerial parts | Adult squat, liver cysts, hypertension antipyretic | Decoction, Distillation | Oral |
| Cleome coluteides Boiss | Cleomaceae | Alaf-e Mar | Therophyte | 0.001 | Leaves, Flowers, Fruits | vomiting, Diuretic, cathartic, antiseptic | Decoction | Oral |
| Colchicum schimperi Janka ex Stef | Colchicaceae | Soranjan, Gol-e Hasrat | Geophyte | 0.001 | Roots | Inflammation and Local pain, gout pains | Decoction, Dressing | Oral, Topical |
| Cotula maculatum L | Apiaceae | Shawkaran | Geophyte | 0.007 | Aerial parts | Pertussis, respiratory ailments | Decoction | Oral |
| Convolvulus arvensis L | Convolvulaceae | Pichak | Therophyte | 0.014 | Aerial parts | Abdominal pains, diarrhea, jaundice, gynecological problem, wound healing, | Decoction, linctus | Oral, Topical |
| Convolvulus sericeus L | Convolvulaceae | Gombeko | Chamophyte | 0.015 | Current year twigs | Blood purifier, cathartic | Decoction | Oral |
| Cotoneaster kotschyi (C.K.Schneid.) G.Klotz | Rosaceae | Siahchou | Phanerophyte | 0.008 | Gum | Child squirt, Jaundice | Infusion | Oral |
| Cotoneaster persicus Pojark | Rosaceae | Siahchou | Phanerophyte | 0.004 | Fruits | Heat regulation | Decoction | Oral |
| Coccusia stockii C.Winkl | Asteraceae | Syah Bej | Phanerophyte | 0.006 | Flowers | milk production in a woman | Decoction | Oral |
| Crambe orientalis L | Brassicaceae | Sepideh | Hemicryptophyte | 0.003 | Leaves, Flowers | Cytotoxic, antioxidant, antimicrobial and phytotoxic | Decoction | Oral |
| Cressa cretica L | Convolvulaceae | Alaf mourcheh | Chamophyte | 0.001 | Aerial parts | Anti-fungal, anti-bacterial | Liniment | Topical |
| Cynus depressus (M.Bieb.) Sojak | Asteraceae | Gol-e Gandom | Therophyte | 0.012 | Flowers | cough, Digestive | Decoction | Oral |
| Cymbopogon olivieri (Boiss.) Bor | Poaceae | Nagard | Hemicryptophyte | 0.011 | Roots | treatment of leprosy, bronchitis and heart disease | Decoction | Oral |
| Descurainia sophia (L.) Webb ex Prantl | Brassicaceae | Khakshi | Therophyte | 0.009 | Seeds | Anti diarrhoea, Heat regulation | Decoction | Oral |
| Dionanthus orientalis Adams | Caryophyllaceae | Gharanphel | Hemicryptophyte | 0.008 | Flowers | Toothache, nerve tonic, hiccups | Liniment, decocation | Oral, Topical |
| Diplopataxis harra (Forsk.) Boiss | Brassicaceae | Gol Zard | Therophyte | 0.007 | Aerial parts | anti-inflammatory, anti-bacterial, anti-fungal and anti-tumor | Decoction | Oral |
| Dorema ammania-cum D.Don | Apiaceae | Vosha, Oshtork | Geophyte | 0.003 | Gum | Infectious wounds, Infection, abscess, | Cataplasm | Topical |
| Dorema ascheri Boiss | Apiaceae | Bile-har, Vosha | Geophyte | 0.004 | Gum, Leaves | Infectious wounds, Infection, Stomachache | Cataplasm, Linctus | Oral, Topical |
| Drucecephalium polychaetum Bornm | Lamiaceae | Badranj boye | Chamophyte | 0.003 | Aerial parts | Rheumatism | Decoction, Dressing | Oral, Topical |
| Duccrosia anethifolia (DC.) Boiss | Apiaceae | Meshgak | Hemicryptophyte | 0.011 | Aerial parts | Stomachache, backache, childbirth pain | Decoction | Oral |
| Eberis stellata Boiss | Fabaceae | Jou sikhak | Chamophyte | 0.011 | Flowers | anti-fungal | Decoction | Oral |
| Echinops ritrodes Bunge | Asteraceae | Shekar tigal | Hemicryptophyte | 0.004 | Fruits | Treatment of digestive disorders, Dry cough | Decoction | Oral |
| Ephedra major Host | Ephedraceae | Ormalk | Phanerophyte | 0.004 | Aerial parts | Analgesic, cold | Decoction | Oral |
| Ephedra major subsp. procer a (C.A.Mey.) Bornm | Ephedraceae | Ormalk, Rishe Boz | Phanerophyte | 0.001 | Aerial parts | Treatment of respiratory diseases | Decoction | Oral |
| Epilobium angustifolium C.Winkl | Onagraceae | Poneh-e Gav | Hemicryptophyte | 0.011 | Aerial parts | Elimination of oral mucositis | Cataplasm | Topical |

Continued
| Scientific name                | Family            | Local name | Life form   | IVI  | Plant part used                  | Medicinal uses                                      | Preparation                  | Mode of application |
|-------------------------------|-------------------|------------|-------------|------|----------------------------------|-----------------------------------------------------|-----------------------------|----------------------|
| Eryngium billardieri Delile   | Apiaceae          | Jaz        | Hemicryptophyte | 0.012 | Aerial parts                     | Removing Phlegm                                    | Decoction                 | Oral                |
| Euphorbia helioscopia L       | Euphorbiaceae     | Shirbeng   | Geophyte    | 0.003 | Fruits, Roots                    | Abdominal pains; diarrhoea, root for parasite repellent, rheumatism | Decoction                   | Oral                |
| Fagonia bruguieri DC          | Zygophyllaceae    | Esfand     | Therophyte  | 0.002 | Aerial parts                     | Appetizing, vermicide, carminative                 | Decoction, infusion         | Oral                |
| Ferula assa-foetida L         | Apiaceae          | Anghozeh   | Hemicryptophyte | 0.003 | Gum                              | Removing Phlegm                                     | Direct use                 | Oral                |
| Ferula oopoda (Boiss. & Buhse) Boiss | Apiaceae          | Koma      | Hemicryptophyte | 0.002 | Gum                              | Tooth infection, toothache                          | Cataplasm                 | Topical             |
| Fitzzia suffruticosa (Vent.) Sweet | Brassicaceae      | Seki      | Therophyte  | 0.005 | Seeds                            | Headache, sinus infection                          | Decoction, Powder          | Oral                |
| Ficus carica L                | Moraceae          | Hanzir     | Phanerophyte | 0.004 | Leaves, Roots, Fruits, Gum       | Leaves for skin diseases; Roots for Disposal of intestinal parasites; Fruits as cathartic, skin burns, Analgesic, Edible fruits | Cataplasm, Powder, Drying  | Oral, Topical       |
| Fortunymia garcinii (Burm.) Shuttlew | Brassicaceae      | Makhleseh | Phanerophyte | 0.013 | Current year twigs               | Migraine, sedative, menstruation additive, spasms | Decoction, infusion        | Oral                |
| Fumaria parviflora Lam        | Papaveraceae      | Shahtareh  | Therophyte  | 0.011 | Current year twig                | Treatment for eczema and Cutaneous itching, Diuretic, diaphoretic | Decoction, Dressing       | Oral, Topical       |
| Glycyrrhiza glabra L          | Fabaceae          | Motki      | Geophyte    | 0.003 | Roots                            | Removing Phlegm                                     | Decoction                 | Oral                |
| Helianthemum lippii (L.) Dum.Corze | Cistaceae         | Gol Aftabi | Chamophyte  | 0.001 | Current year twigs               | analgesic and anti-inflammatory                     | Decoction                 | Oral                |
| Hernia intermedia (Boiss.) Kuntze | Asteraceae        | Kar Qich   | Chamophyte  | 0.003 | Leaves                           | Epilepsy, anti-tumult                               | Decoction                 | Oral                |
| Hypecymus reticulatus L       | Solanaceae        | Bang Daneh | Hemicryptophyte | 0.005 | Seeds                            | Analgesic                                           | Decoction                 | Oral                |
| Iris songarica Schrenk        | Iridaceae         | Zanbaq     | Geophyte    | 0.005 | Roots                            | Analgesic, Anti-inflammatory                        | Decoction                 | Oral                |
| Ixolirion tataricum (Pall.) Schul. & Schult.f | Ixiriaceae       | Gol Baanafsh | Geophyte  | 0.003 | Aerial parts                     | Stomach Strengthening                               | Direct use                 | Oral                |
| Juncus fontanensis J.Gay ex Laharpe | Juncaceae        | Sazou      | Hemicryptophyte | 0.013 | Roots                            | Infections                                          | Decoction                 | Oral                |
| Juniperus communis L          | Cupressaceae      | Overs      | Phanerophyte | 0.006 | Fruits                           | Stomach Strengthening, Anti-flatulence, appetizing, blood purifier, rheumatism | Powder, Liniment          | Oral, Topical       |
| Keukenhostovia ceratoideis (L.) Gueldenst | Amaryanthaceae   | Barg Noghree | Chamophyte  | 0.004 | Roots                            | skin burns                                          | Cataplasm                 | Topical             |
| Lactuca serriola L            | Asteraceae        | Kahou khardar | Therophyte  | 0.013 | Leaves                           | Bone and joint pains; Jaundice, lossing weight, Liniment | Oral                      | Oral                |
| Lalemanita royanae (Benth.) Benth | Lamiaceae        | Melango    | Therophyte  | 0.003 | Seeds                            | Cold, cough and Removing Phlegm Throat             | Decoction, moisturized with water | Oral                |
| Lamium album L                | Lamiaceae         | Gazzaneh   | Therophyte  | 0.013 | Leaves                           | Asthma, cough, antipyretic, osteoporosis, lactiferous | Infusion                   | Oral                |
| Lysimachia camothea (Boiss.) Kuntze | Asteraceae       | Charkheh   | Hemicryptophyte | 0.002 | Aerial parts, Gum                | Anticonvulsant, sasthma, hemorhoids, wound healing | Liniment                 | Topical             |
| Leonurus cardica L            | Lamiaceae         | Dom Shir   | Hemicryptophyte | 0.008 | Leaves                           | Cardiac distress                                    | Decoction                 | Oral                |
| Lepidium draba L              | Brassicaceae      | Mokou      | Therophyte  | 0.003 | Leaves, Seeds                    | Diuretic, Edible leaves                             | Decoction                 | Oral                |

Continued
| Scientific name                      | Family                  | Local name   | Life form     | IVI | Plant part used | Medicinal uses                                      | Preparation          | Mode of application |
|--------------------------------------|-------------------------|--------------|---------------|----|-----------------|--------------------------------------------------|-----------------------|---------------------|
| Levisticum officinale                | W.D.J. Koch             | Apiaceae     | Geophyte      | 0.007 | Leaves, Roots | Stomachache, Diuretic, tranquilizer, Bad breath eliminator | Powder, Liniment      | Oral, Topical       |
| Loranthus grewing-kii Boiss. & Buhe  | Loranthaceae            | Doongi       | Epiphyte      | 0.001 | Leaves, Fruits | wounds Healing, heart Strengthening, tranquilizer, | Decoction, Catal-plasm | Oral, Topical       |
| Lycium depression Stocks             | Solanaceae              | Zil          | Phanerophyte  | 0.002 | Leaves, Fruits | Epilepsy, spurt, Persussis                         | Decoction             | Oral                |
| Lycium shawii Roem. & Schult         | Solanaceae              | Div Khar     | Phanerophyte  | 0.003 | Fruits         | blood Strengthening, Cutaneous itching, toothache, Leaf juice increases visual acuity | Moisturized with water | Oral                |
| Malva microcarpa Pers                | Malvaceae               | Khatmi       | Therophyte    | 0.004 | Flowers        | Throat protuberance, heat regulation, tooth mass   | Moisturized with water, Infusion | Oral                |
| Malva sylvestris                     | Malvaceae               | Khatmi, Panirak | Hemicryptophyte | 0.022 | Flowers        | diaphoretic, heat regulation, oral mucositis, Anti cough | Moisturized with water, Infusion | Oral                |
| Marrubium vulgare                    | Lamiaceae               | Farasien     | Chamophyte    | 0.002 | Aerial parts   | Diuretic, Anti-flatulence, appetizing, Anti cough, Anti-venom | Powder, Decoction      | Oral                |
| Medicago sativa                      | Fabaceae                | Yonjeh       | Chamophyte    | 0.016 | Leaves         | nyctalopia, Anemia, cathartic, tranquilizer, Edible leaves | Decoction             | Oral                |
| Melilotus officinalis (L.) Pall      | Fabaceae                | Yonjeh-e Zard | Therophyte    | 0.003 | Leaves, Flowers | Diuretic, tranquilizer, Anticonvulsants             | Decoction, Infusion   | Oral                |
| Mentha longifolia (L.) L.            | Lamiaceae               | Pooaneh, pooneh | Geophyte      | 0.004 | Leaves, Flowers | Stomachache, Anti-flatulence, Spice                | Powder, Distillation  | Oral                |
| Myrtus communis                      | Myrtaceae               | Moord        | Phanerophyte  | 0.004 | Leaves, Fruits | Neuralgia, colds, deodorant, Herpes treatment, Seed as abdominal parasites | Decoction, Powder | Oral                |
| Nasturtium officinale R.Br           | Brassicaceae            | Alaf-e Cheshmeh | Hemicryptophyte | 0.005 | Aerial parts   | Diuretic, tranquilizer, Removing Phlegm Throat, Blood purifier, Neuralgia, Digestive | Direct use             | Oral                |
| Nepeta assurgens Hausskn. & Bornm    | Lamiaceae               | Poone say    | Chamophyte    | 0.002 | Aerial parts   | Diuretic, Anticonvulsants, Anti cough, Disinfectants | Decoction             | Oral                |
| Nepeta bornmuelleri Hausskn. ex Bornm | Lamiaceae               | Badranj boye | Chamophyte    | 0.005 | Aerial parts   | tranquilizer, cardtieric, rheumatism               | Decoction             | Oral                |
| Nepeta glomerulosa Boiss             | Lamiaceae               | Chagmal      | Chamophyte    | 0.005 | Current year twigs | arthritis | Liniment | Topical |
| Nerium olexander                     | Apocynaceae             | Ghish        | Phanerophyte  | 0.003 | Roots          | arthritis, Stomachache                             | Decoction, Lini-ment | Oral, Topical       |
| Nonea carpa (Willd.) G.Don           | Boraginaceae            | Sezkouei     | Therophyte    | 0.004 | Leaves         | Cardiac distress, nerve tonic, sedative             | Decoction             | Oral                |
| Nonea persica Boiss                  | Boraginaceae            | Chezkouei    | Therophyte    | 0.006 | Leaves         | Sedative                                           | Decoction             | Oral                |
| Ochradenus ochradeni (Boiss.) Abdallak | Resedaceae             | Sham         | Chamophyte    | 0.008 | Leaves         | wound healing, skin parasites                      | Liniment              | Topical             |
| Olea ferruginea Wall. ex Aitch       | Oleaceae                | Zeytoun-e Koobi | Phanerophyte  | 0.003 | Leaves         | Anti allergic, asthma treatment, diaphoretic, Removing Phlegm Throat | Decoction             | Oral                |
| Onopordum leptolepis DC              | Asteraceae              | Kangar       | Hemicryptophyte | 0.002 | Aerial parts   | Urinary stone, abdominal pains, diarrhea            | Decoction             | Oral                |
| Onesma stenosiphon Boiss             | Boraginaceae            | Hoochereh    | Therophyte    | 0.008 | Roots          | arthritis, headache                                | Decoction, Dressing   | Oral, Topical       |

Continued
| Scientific name       | Family              | Local name | Life form | IVI | Plant part used | Medicinal uses                                           | Preparation       | Mode of application |
|-----------------------|---------------------|------------|-----------|-----|-----------------|---------------------------------------------------------|-------------------|---------------------|
| *Origanum vulgare* L  | Lamiaceae           | Mirzangou  | Chamophyte | 0.019 | Aerial parts    | Diuretic, Anti-flatusion, disinfectant, Analgesic, appetizing, Spice | Powder            | Oral                |
| *Papaver dubium* L    | Papaveraeae         | Khashkhash | Therophyte | 0.007 | Flowers, Fruits | Analgesic, anti-inflammatory, anti-absecas               | Drying, Liniment  | Oral, Topical       |
| *Parietaria jasaitica* L | Urticaceae         | Goush Mooshi | Chamophyte | 0.008 | Leaves | Diuretic, Heat, Blood purifier, cathartic, Removing Phlegm Throat | Decoction         | Oral                |
| *Peganum harkama* I   | Zygophyllaceae      | Esfand, Dashi | Therophyte | 0.002 | Seeds | disinfectant, tranquilizer, abdominal parasites            | Drying            | Oral                |
| *Perovskia divissum* (Forsk. ex J.F.Gmel.) Henriard | Poaceae | Berschenk | Hemicyrpyophyte | 0.008 | Roots | heart Strengthening, appetizing                            | Decoction         | Oral                |
| *Periplaca aphylla Dcne* | Apocynaceae       | Gerisheh | Phanerophyte | 0.006 | Gum | anti-inflammatory, cathartic, wound healing                | Liniment          | Topical             |
| *Phagnalon rupestr* (L.) DC | Asteraceae        | Gol-e Aftabi | Chamophyte | 0.004 | Aerial parts | Toothache                                                | Liniment          | Topical             |
| *Pistacia atlantica* Desf | Anacardiaceae     | Baneh     | Phanerophyte | 0.001 | Leaves, Fruits | Diuretic, Menstruation regulation, anti-diarrhea, Thirst Quenching, Edible fruits | Direct use, Liniment, Oil | Oral, Topical       |
| *Pistacia khibnuk Stocks* | Anacardiaceae     | Kasour    | Phanerophyte | 0.014 | Fruits | Hemorrhoids, stomachache, Anti cough, Jaundice, Backache, Edible fruits | Direct use, Decoction, liniment | Oral, Topical       |
| *Plantago lancedolata* L | Plantaginaceae    | Barhang   | Hemicyrpyophyte | 0.009 | Leaves, Roots, Seeds | Blood diluent, Diuretic, diaphoretic, colds, wound healing | Decoction, Liniment | Oral, Topical       |
| *Plantago major* L    | Plantaginaceae      | Barhang   | Hemicyrpyophyte | 0.001 | Seeds | Removing Phlegm Throat, Anti cough,                        | Decoction         | Oral                |
| *Platanus orientalis* L | Platanaceae       | Chenar    | Phanerophyte | 0.001 | Leaves | Removing skin patches, hoarseness, sedative after snake bite | Decoction, Dressing, Liniment | Oral, Topical       |
| *Placuna ascheri* (Guill.) M.Backlund & Thulin | Rubiaceae | Karpous  | Phanerophyte | 0.001 | Leaves, Flowers | Facilitating milk digestion in infants                     | Decoction         | Oral                |
| *Pogostemon cras‑song* (Benth.) Press | Lamiaceae | Zopha | Therophyte | 0.008 | Aerial parts | Colds, Anti cough, Removing Phlegm Throat                 | Decoction         | Oral                |
| *Populus nigra* L     | Salicaceae          | Sepidar   | Phanerophyte | 0.001 | Leaves, Current year twigs | Diuretic, Disinfectants, Digestive, Hemorrhagic, Rheumatism, Sciatica, Gout | Decoction, Dressing, Liniment | Oral, Topical       |
| *Portulaca oleracea* L | Portulaceae        | Khorfeh   | Therophyte | 0.006 | Aerial parts | Antiseptic, Anti Scurvy, Blood purifier, Thirst Quenching, Intestinal parasites, diaphoretic, muscle relaxant | Direct use         | Oral                |
| *Prunus ebunara* (Spach) Aitch. & Hemsl | Rosaceae | Qousk, Arjan | Phanerophyte | 0.012 | Fruits, Roots | Root for burn treatments, Fruits for neurological pains, Liver colic, Migraine, Rheumatic pains | Decoction, Liniment | Oral, Topical       |
| *Prunus sco‑paria* (Spach) C.K.Schneid | Rosaceae | Badam-e Koohi | Phanerophyte | 0.011 | Fruits, Roots | Eczema treatment, wound healing, Edible fruit | Decoction, Cataplasm | Oral, Topical       |
| *Pulsatia garnzial‑odes* (Vent.) Boiss | Asteraceae | Kak Kooshi | Chamophyte | 0.008 | Aerial parts | Anti-bacterial, antifungal                               | Decoction         | Oral                |
| *Pyrocutia modifloro* Decne. ex Boiss | Asteraceae | Sag Dandan | Chamophyte | 0.001 | Aerial parts | Stomachache                                               | Decoction         | Oral                |
| *Rhamsus papilisi* Fisch. & C.A. Mey | Rhamnaceae | Tangkas | Phanerophyte | 0.022 | Skin, Current year twigs, Fruits | Diuretic, cathartic                                       | Decoction         | Oral                |

Continued
| Scientific name | Family | Local name | Life form | IVI | Plant part used | Medicinal uses | Preparation | Mode of application |
|-----------------|--------|------------|-----------|-----|-----------------|----------------|-------------|---------------------|
| *Rhamnus persica* F. Lawson | Rhamnaceae | Tangras | Phanerophyte | 0.003 | Skin, Current year twigs, Fruits | Stomachache, cathartic | Decoction | Oral |
| *Bhaya stricta* Decne | Apocynaceae | Gish | Phanerophyte | 0.002 | Fruits, Gum | Toothache, Eye problems | Liniment | Topical |
| *Rheum ribes* L | Polygonaceae | Rivas | Geophyte | 0.005 | Stems, Fruits | Stomach Strengthening, blood purifier, Intestinal parasites, | Decoction, Powder | Oral |
| *Ribes orientale* Desf | Grossulariaceae | Tot-e Roobah | Phanerophyte | 0.004 | Fruits | Diuretic, cathartic, blood pressure Adjust, Gastrointestinal infection | Decoction, Powder | Oral |
| *Ricinus communis* L | Euphorbiaceae | Kenton | Phanerophyte | 0.005 | Seeds | Abdominal pains, diarrhea, emetic | Decoction, Oil | Oral, Topical |
| *Rosa beggeriana* Schrenk et Fisch. & C.A.Mey | Rosaceae | Nastaran | Phanerophyte | 0.007 | Fruits | Colds | Moisturized with water | Oral |
| *Rumex vesicatorius* L | Polygonaceae | Torshak | Therophyte | 0.008 | Leaves | Appetizing, remove bur from skin, Edible leaves | Direct use, Decoction, liniment | Oral, Topical |
| *Rhydonia persica* (Burm.f.) Scheen & V.A.Albert | Lamiaceae | Goldar | Phanerophyte | 0.004 | Flowers, Fruits | Toothache, Antimicrobial | Decoction, Cataplasm | Oral, Topical |
| *Saccarum ravennae* (L.) L | Poaceae | Kash | Geophyte | 0.0004 | Roots | Diuretic, tranquilizer, | Decoction | Oral |
| *Sageretia thea* (Osbeck) M.C. Johnst | Rhamnaceae | Toutlangou | Phanerophyte | 0.001 | Fruits | Blood purifier | Decoction | Oral |
| *Salix alba* L | Salicaceae | Bid | Phanerophyte | 0.004 | Leaves, Current year twigs | Burn healing, Wound healing, diaphoretic, Analgesic, Headache, oral mucositis | Distillation, liniment | Oral, Topical |
| *Salix carmanica* Bornm | Salicaceae | Bid | Phanerophyte | 0.003 | Leaves, Current year twigs | Burn healing, Wound healing, diaphoretic, Analgesic, Headache, oral mucositis | Distillation, liniment | Oral, Topical |
| *Salvia macrosiphon* Boiss | Lamiaceae | Moureshk | Hemicryptophyte | 0.006 | Seeds, Roots | Menstruation additive, Wound healing | Decoction, liniment | Oral, Topical |
| *Salvia mirzayanii* Rech.f.&Esfand | Lamiaceae | Maryam Goli | Chamophyte | 0.003 | Aerial parts | Stomachache, | Decoction | Oral |
| *Sanguisorba minor* Scop | Rosaceae | Toot-e Roobah | Therophyte | 0.013 | Leaves, Roots | Blood coagulant, Antihomorrhoids, tranquilizer, | Decoction | Oral |
| *Scabiosa candollei* DC | Dipsacaceae | Toosak, Sar banafsh | Therophyte | 0.001 | Flowers | anti diarrhea, arthritis | Decoction | Oral |
| *Scrophularia striata* Boiss | Scrophulariaceae | Mokhalaseh | Chamophyte | 0.013 | Fruits | Gastrointestinal Disorders | Powder | Oral |
| *Senecio glaucus* L | Asteraceae | Qasedak | Chamophyte | 0.011 | Roots | wound healing | liniment | Topical |
| *Setaria italic* (L.) P. Beauv | Poaceae | Garch | Therophyte | 0.013 | Seeds | Flatulence, prevention of hair loss | Decoction, liniment | Oral, Topical |
| *Solidago alatun* Moench | Poaceae | Ropask | Chamophyte | 0.002 | Fruits | Blood coagulant, diaphoretic, Analgesic | Moisturized with water | Oral |
| *Sonchus asper* (L.) Hill | Asteraceae | Shirtighak | Therophyte | 0.005 | Leaves | Skin rash | Liniment | Topical |
| *Sonchus oleraceus* (L.) L | Asteraceae | Shirtighak | Therophyte | 0.004 | Leaves | Skin ailments | Liniment | Topical |
| *Sophora mollis* (Royle) Baker | Fabaceae | Zard Gol | Chamophyte | 0.006 | Leaves, Roots, Seeds | roots for heat regulation and as a diuretic. Leaves and seeds are used for gastrointestinal disorders, urinary tract infections, eczema, abdominal parasites | Decoction | Oral |

Continued
| Scientific name          | Family        | Local name | Life form | IVI  | Plant part used | Medicinal uses                                                                 | Preparation                          | Mode of application |
|--------------------------|---------------|------------|-----------|------|----------------|--------------------------------------------------------------------------------|--------------------------------------|---------------------|
| Stachys inflata Benth    | Lamiaceae     | Sonboleee  | Chamophyte | 0.007| Flowers, Fruits | Treatment of infectious diseases, rheumatoid arthritis and other inflammatory diseases | Decoction, Powder                    | Oral                |
| Stocksis brahuica Benth  | Sapindaceae   | Ketour     | Phanerophyte | 0.001| Seeds           | Bone pain, stomachache                                                           | Decoction                            | Oral                |
| Tanacetum parthenium (L.) Sch.Bip | Asteraceae | Babouneh | Therophyte | 0.007| Aerial parts    | Parasite repellent, migraine, anti-inflammation                                  | Infusion                             | Oral                |
| Teucrium polium L.       | Lamiaceae     | Kalpooreh  | Chamophyte | 0.009| Aerial parts    | Stomachache, Anti-flatulence, diaphoretic, Moisturized with water, Distillation   | Oral, Topical                        |                     |
| Thymus fechtschenkai Ronniger | Lamiaceae | Ezgen      | Chamophyte | 0.007| Aerial parts    | Stomachache, Anti-flatulence, colds, antiseptic                                  | Decoction, Distillation              | Oral                |
| Tragopogon crocifolius L | Asteraceae    | Sheng      | Geophyte  | 0.009| Gum, Aerial parts, Roots | Gastrintestinal Disorders, Blood coagulant, Wound healing                        | Direct use, Linctment                | Oral, Topical       |
| Tribulus terrestris L    | Zygophyllaceae| Kharkhasak | Chamophyte | 0.012| Fruits          | Diuretic, Blood purifier, Kidney stone                                           | Decoction                            | Oral                |
| Trifolium pratense L     | Fabaceae      | Shabdar    | Hemicryptophyte | 0.009| Aerial parts    | Blood purifier, asthma, bone and joint pains                                     | Decoction, Linctment                 | Oral, Topical       |
| Urtica urens L           | Urticaceae    | Gazaneh    | Chamophyte | 0.002| Leaves, Stems   | arthritis                                                                        | Liniment                             | Topical             |
| Verbena officinalis L    | Verbenaceae   | Shahbasand | Therophyte | 0.007| Aerial parts    | Fever, Nerve tonic                                                               | Liniment                             | Topical             |
| Veronica anagallis L     | Scrophulariaceae | Sizab    | Therophyte | 0.011| Aerial parts    | Diuretic, stomach strengthening                                                   | Decoction                            | Oral                |
| Zataria multiflora Boiss | Lamiaceae     | Avishan    | Chamophyte | 0.005| Aerial parts    | Bachache, Gastrintestinal Disorders, Colds, Spice                                | Decoction, Distillation              | Oral                |
| Ziziphus spinachristi (L.) Desf | Rhamnaceae | Konar      | Phanerophyte | 0.007| Leaves, Fruits | Colds, Intestinal infections, Heir, Edible fruits                               | Decoction, Cataplasm                 | Oral, Topical       |

Table 2. Indigenous medicinal knowledge of plants species in Khabr National Park, Iran.

![Figure 1](https://example.com/figure1.png)

Figure 1. Number of cited plants in each plant family.
The Bayesian networks show the relationship between the relative loss index and ethnopharmacological indices of medicinal plants in sedentary pastoralism (LS₁) and nomadism (LS₂) (Fig. 5). There are 15 nodes in the network. The probabilities that relative loss of species being high and low were 87.2% and 12.8% in sedentary pastoralism, respectively. The probabilities that relative loss of species being high and low were 71.9% and 28.1% in nomadism, respectively.

Sensitivity analysis revealed the most important variables affecting the relative loss index (Table 4). The CV, seed, aerial part and RI were the most important variables affecting the relative loss index whose effects on probabilities related to the relative loss were investigated under five different scenarios.

Under scenario 1, by changing the probability of CV index, the effect of increasing this variable on probability of relative loss index was investigated. The results showed that the probability of relative loss was increased to 97.86 and 88.45 for sedentary pastoralism and nomadism respectively, indicating a direct relationship between the relative loss and CV indices. Therefore, harvesting plant organs is one of the main causes of plant loss in both pastoralism types (Table 5). By changing the probability of seed, aerial part, and RI index, the effects of these variables increase on probability of relative loss index was investigated under the scenarios 2 to 4. The probabilities of relative loss index were respectively increased 95.23%, 90.04% and 89.03% in sedentary pastoralism and 83.03%, 78.12% and 75.82% in nomadism under scenarios 2 to 4 (Table 5), indicating a direct relationship between the relative loss index and seed, aerial part, and RI index.

Discussion
The region had a rich medicinal flora, which mostly belonged to Lamiaceae and Asteraceae families. The rich flora can be related to the diverse topo-climatic zones in the region from warm low elevation plains in the south to snow capped mountains and cold high elevation plains in the north, providing habitat for different plant species. Lamiaceae and Asteraceae are two main medicinal families in Iran.35,36 The dominance of these two families can be attributed to their widespread distribution in the area and their diverse traditional medicinal uses for the pastorals.

Decoction was the most common method of preparation in the region. Decoction is a powerful method for extracting the active ingredients of medicinal plants37, making it a pluralistic approach to faster and better treatment between local families38,39.

The medicinal plants were mostly used for digestive system between pastorals. Given the high incidence of gastrointestinal diseases among the population, there is more interest in treating it by locals40.

Local people mostly used leave of medicinal plants for health care. The leaves are usually easier to harvest than other plant organs and can be usually eaten directly as medicines. Leaves are rich in phytochemicals41, resulting in wide medicinal values42,43.

Based on ethnopharmacological indices, Z. multiflora, D. sophia, C. intybus, and B. persicum were the most important medicinal plant species for the pastorals. These species are completely known as herbs (Z. multiflora, D. sophia, C. intybus, and B. persicum) or spices (Z. multiflora and B. persicum) across the country44,45. Therefore, it is obvious they attract locals’ attraction.

Ecological value of medicinal plants. Our result showed that popular medicinal plants had higher dominance and abundance in ecosystem. Past studies also found a positive relationship between ecological value and traditional medicinal use of plant species46,47. Common species are more mostly used as medicines than rare species48. A number of studies suggested a negative relationship between ecological important of species and its medicinal use49.

| Use category      | Frequency | Percentage | Part used | Frequency | Percentage |
|-------------------|-----------|------------|-----------|-----------|------------|
| Digestive system  | 81        | 50         | Aerial part| 39        | 25         |
| Nervous system    | 23        | 14         | Leaf      | 38        | 24         |
| Skin-hair         | 33        | 20         | Gum       | 7         | 4          |
| Cold-flu-fever    | 29        | 18         | Root      | 26        | 17         |
| Respiratory system| 10        | 6          | Fruit     | 37        | 24         |
| Flavor-Appetizing | 7         | 4          | Seed      | 16        | 10         |
| Eye problems      | 2         | 1          | Flower    | 19        | 12         |
| Sedative          | 34        | 21         | Stem      | 12        | 8          |
| Gynecology        | 9         | 4          |           |           |            |
| Cardiac system    | 4         | 2          |           |           |            |
| Musculoskeletal   | 16        | 10         |           |           |            |
| Disorders         | 15        | 9          |           |           |            |
| Blood-wound       | 32        | 20         |           |           |            |
| Liver problems    | 2         | 1          |           |           |            |
| Immune system     | 38        | 24         |           |           |            |
| Food              | 18        | 11         |           |           |            |

Table 3. The percentage of plant species citation in each use category and the plant parts used.

Ethnobotanical indices and plant species loss. The Bayesian networks shows the relationship between the relative loss index and ethnopharmacological indices of medicinal plants in sedentary pastoralism (LS₁) and nomadism (LS₂) (Fig. 5). There are 15 nodes in the network. The probabilities that relative loss of species being high and low were 87.2% and 12.8% in sedentary pastoralism, respectively. The probabilities that relative loss of species being high and low were 71.9% and 28.1% in nomadism, respectively.
Medicinal plants A. sieberi, B. persicum and R. pallasii play important role in ecosystem sustainability due to having the highest ecological value. Overexploitation of these species may endanger supplying other medicinal plants, because loss of important ecological species can consecutively destruct the ecosystem balances and influence the dynamics and structure of populations or even drive other species to extinction. Therefore, conservation of such species is more important in ecosystem management than other species.

**Medicinal plants loss and effective factors.** Medicinal plants were strongly threatened in arid and semi-arid ecosystems of the region. About 15% of medicinal plants lost more than 50% of their ecological importance in pastoral rangelands due to overexploitation. Locals are mostly poor people whom their livelihood strongly
depends on natural resources in our study area. Selling of medicinal plants has become an alternative and additive income source for pastoralists, especially whom with forage deficiency resulted from recent droughts.

We found medicinal plants with high social value are particularly vulnerable to overexploitation. The harvest of species with high use popularity may encounter sustainability problems. The plant part used and exploitation method can effect on medicinal species loss. Harvesting of plant seed and whole of aerial parts endangered sustainable use of medicinal plants. The ecological importance of *B. persicum* as one of the medicinal plants with the highest CV, has declined 80% and 60% in the both pastoral rangelands, due to over-collecting of its seeds. Over-exploitation of aerial parts of *Z. tenuir*, *T. fedtschenkoi*, *M. sativa* and *Z. clinopodioides* has caused depletion of these plants in the both pastoral rangelands. These species were popular medicinal plants with relative importance more than 60% for social system. Reduction of photosynthetic ability linked with the loss of leaf area of plants can restrict plant growth in ecosystems.

Sever loss of medicinal plants has revealed the necessity of serious efforts to create public awareness about value of medicinal plants in aid and semiarid ecosystems of Iran. Gradual loss of traditional knowledge has intensified harvesting of medicinal plants. In our study, medicinal plants were conserved more in rangelands under nomadism compared to sedentary pastoralism. Nomadism has less destructive effects on the rangelands.
Figure 5. Bayesian networks for assessment of relationships between Relative Loss index of medicinal plants and ethnopharmacological indices in sedentary pastoralism (RL1) and nomadism (RL2) and parts of plant used with prior probabilities.

Table 4. Effective degree of factors of BNs on Relative Loss Index in sedentary pastoralism (RL1) and nomadism (RL2).

| Relative Loss Index in sedentary pastoralism | Relative Loss Index in nomadism |
|---------------------------------------------|---------------------------------|
| Factor       | Variance reduction | Factor       | Variance reduction |
| CV           | 28.31               | CV           | 19.24              |
| Seed         | 25.04               | Seed         | 17.89              |
| RI           | 23.65               | Aerial part  | 16.13              |
| Aerial part  | 21.18               | RI           | 14.01              |
| UV           | 1.53                | Flower       | 1.61               |
| RFC          | 1.13                | RFC          | 1.21               |
| Stem         | 1.01                | Root         | 0.004              |
| Root         | 7.05 e−5            | Gum          | 9.24 e−6           |
| Gum          | 4.17e−5             | Leaf         | 6.62e−6            |
| Leaf         | 6.83e−6             | Stem         | 3.06e−6            |
| Flower       | 3.12e−6             | UV           | 6.23e−7            |

Table 5. Prior probability and posterior probability of two classes (low and high) for Relative Loss Index in sedentary pastoralism (RL1) and nomadism (RL2) under 4 scenarios.

|                   | Prior probability | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|-------------------|-------------------|------------|------------|------------|------------|
| RL1 Low           | 12.8              | 2.14       | 4.77       | 9.96       | 10.97      |
| High              | 87.2              | 97.86      | 95.23      | 90.04      | 89.03      |
| RL2 Low           | 28.1              | 11.55      | 16.97      | 21.88      | 24.18      |
| High              | 71.9              | 88.45      | 83.03      | 78.12      | 75.82      |
due to limited exploitation compared to sedentary pastoralism in which all year round the rangelands are exploited. Nomads are in fact the real rangelands dwellers who have historically adapted to the rangelands and have more experiences and information about the medicinal properties on plants.

Conclusions
This study highlights the presence of ethnobotanical knowledge in southeastern Iran and the occurrence of native medicinal species as a key factor in their potential use and locals’ attention. Given the abundance and widespread use of medicinal plants, further studies can provide a basis for identifying new therapeutic effects of plants in the region. Popular plants with multiple medicinal uses were more susceptible to loss. Higher medicinal knowledge of pastoralists did not help to mitigate medicinal plant loss, requesting new plans to aware them to the circumstances that often leads to species removal from community. Given the abundance and widespread use of medicinal plants, further studies can provide a basis for identifying new therapeutic effects of plants in the region.

Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions
M.S. involved in the study design, laboratory work, fieldwork, filling questionnaires and general data collection and writing the manuscript. A.K.M. involved in conducting of interview and preparing questionnaires, fieldwork, filling questionnaires, general data collection and writing the manuscript. All authors wrote, read and approved the final manuscript.

Competing interests
The authors declare no competing interests.

Additional information
Correspondence and requests for materials should be addressed to M.S.

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