sustainability

MDPI

Article

Anthropic Effects on the Biodiversity of the Habitats of *Ferula gummosa*

Parviz Moradi [1,*], Farhad Aghajanloo [1], Ahmad Moosavi [1], Hossein Hosseini Monfared [1], Jafar Khalafi [1], Mehdi Taghiloo [2], Tooraj Khoshzaman [2], Mohammad Shojaee [2] and Andrea Mastinu [3,*]

[1] Zanjan Agricultural and Natural Resources Research & Education Centre, AREEO, Zanjan 45195, Iran; faghajanloo@yahoo.com (F.A.); a_mousavi1379@yahoo.com (A.M.); hhmonfared@gmail.com (H.H.M.); jkhalafi.2012@gmail.com (J.K.)
[2] Department of Education Zanjan, University of Zanjan, Zanjan 45195, Iran; taghiloo.mehdi@gmail.com (M.T.); t_khoshzaman@yahoo.com (T.K.); shojaie1300@yahoo.com (M.S.)
[3] Department of Molecular and Translational Medicine, University of Brescia, 25123 Brescia, Italy
* Correspondence: p_moradi@areeo.ac.ir (P.M.); andrea.mastinu@unibs.it (A.M.)

Abstract: The uncontrolled exploitation of soil and plants by people has generated important ecological imbalances all over the world. This manuscript focuses its attention on the ecosystem of *Ferula gummosa (FG)*. *FG* belongs to the Apiaceae family and has a vast distribution from central Asia to South Africa, as well as northwest Iran, including the Zanjan Province. This plant has diverse applications across industrial, forage and medicinal fields. To investigate the effective factors on the *FG* distribution, four main natural habitats were selected based on field visits and a literature review. Then, environmental factors, such as climate features, topography conditions, and soil characteristics, were collected and analysed. According to the results, the slope is mainly north-northeast with a slope of 55 to 70 degrees, and an elevation range above 2200 m is suitable for the growth of *FG* in the Zanjan Province. The main companion plants were *Silene bupleuroides* L. and *Thymus kotschyanus*. The results show that in the habitats where *FG* grew, the soil was mostly shallow, sometimes semi-deep and consisting mainly of loam, loamy sand, loamy clay and mostly clay loam with very low salinity (less than 0.7 dS/m), and was in the neutral range of soil acidity (6.9 to 7.33). Soil organic carbon was relatively high, but the amount of nutrients, such as phosphorus and potassium, was less than optimal in these soils. Next, using a Geographic Information System (GIS), maps of homogeneous areas for possible *FG* establishment across the province were created. In conclusion, the main factors affecting the *FG* distribution in the Zanjan Province were land use conversion, harvesting fodder and grazing livestock, improper exploitation of rangelands, pests and diseases of *Ferula gummosa* in the region. The ecological data collected on *FG* may be useful to understand how human action can affect the existence and extinction of many plant species.

Keywords: *Ferula gummosa*; eco-distribution; rangeland; ecology; Zanjan

check for updates

Citation: Moradi, P.; Aghajanloo, F.; Moosavi, A.; Monfared, H.H.; Khalafi, J.; Taghiloo, M.; Khoshzaman, T.; Shojaee, M.; Mastinu, A. Anthropic Effects on the Biodiversity of the Habitats of *Ferula gummosa*. *Sustainability* **2021**, *13*, 7874. https://doi.org/10.3390/su13147874

Academic Editors: Marianthi Tsakaldimi and Vladan Ivetic

Received: 31 May 2021
Accepted: 11 July 2021
Published: 14 July 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Ferula gummosa (*FG*) is named Barijeh, Balijeh, Ghasni and Barzard in Persian [1,2]. It belongs to the *Ferula* genus in the family Apiaceae. This family with at least 112 genera contains aromatic plants with hollow stems and umbrella inflorescences [3]. The genus *Ferula* contains 170 species and is extensively distributed from Central Asia to South Africa [4]. *FG* is one of the industrial, medicinal and forage valuable assets in Iran. As a dominant or associated species, it forms a wide range of plant types in mountainous areas [5]. The phenological stages of the *FG* plant are as follows: seed germination starts from late March to early April, and vegetative growth begins from the second half of April and continues until the first half of July. According to the monocarpic nature of *FG*, its phenology continues in two ways: plants that go through the prematurity stage have only basal leaves, and from mid to late June, their vegetative growth stops, and the leaves begin to dry out. These leaves are easily separated from the roots by the wind. However, the roots remain in the soil and grow again the following year. In plants that are in the last year of their life, flowering begins from the middle to the end of May. The sowing date is from the end of June to the middle of July and the ripening of the seeds happens at the end of July. November and December are the best times to plant *FG* seeds. The seeds of this plant begin to germinate and grow at 3 to 5 °C. In order to break the dormancy period of the seed and its stratification, it needs to pass a cold period between 3 to −15 °C for 15 to 45 days.

FG shows important applications in cosmetics, pharmaceuticals and animal breeding [6]. In particular, the cosmetic industry requires increasingly greater quantities of *FG* for its perfume [7]. Indeed, the resin is used for incense, and, above all, as a base for many known fragrances [8]. In the pharmaceutical field, *FG*-based products are considered energizers, mucolytics and pain relievers for the stomach and joints. The resin of *FG* is used as a cosmetic in skin care creams. In addition, other authors report an anti-parasitic effect for humans and farmed animals [6]. Finally, in the zootechnical field, some varieties of *FG* are dried and used to enrich the food of farm animals with nutrients. Some anecdotal observations on livestock report warming effects and an increase in fertility [9]. Like other plant species that are exploited for their therapeutic potential [10–14], *FG* is among the main plants exploited for its resin [6,15].

Environmental factors such as climate features, topography conditions and soil characteristics affect the establishment of habitats in any region considerably [16]. The distribution of plant species in rangeland ecosystems is not accidental; rather, environmental factors such as climate, soil, topography and human activities play an important role in the expansion of plants [17,18]. Some authors have shown that the establishment of plant communities in mountainous areas is mainly affected by climate factors, and in low-lying areas and rolling hills by soil factors [19–23]. Therefore, it seems that regarding the establishment of *FG* in the highlands, climatic factors have the greatest role in the distribution and establishment of this plant. This plant is highly resistant to severe cold and frost in mainly semi-arid areas, and it usually grows well in cold and ultra-cold Mediterranean regions with an average annual temperature between 3.5 and 12 °C, the minimum absolute temperature being less than −30 °C and the maximum absolute temperature 40 °C. Areas with an average annual rainfall of 300–450 mm, in which most of the precipitation is snow, are suitable for this plant. Shallow soils, sometimes semi-deep, medium to heavy texture (loam, loamy sand, loamy clay and mostly clay loam), calcareous, sometimes up to about 30% lime and without salinity and alkalinity, are desirable for this plant [24].

Despite these considerable applications, even today it is difficult to cultivate *FG* due to its particular conditions of growth and development [25]. Furthermore, the lesions induced on the surface of the stem of *FG* to produce the resin are deep and often lead to the death of the plant [26]. Therefore, the growing demand of the cosmetic and pharmaceutical industry for these species and the alterations of natural habitats, as reported by many authors [6], could lead to its extinction in the wild.

In this manuscript, various ecological analyses are reported on some areas of spread of *FG* in Iran in order to identify the physical, chemical and biological parameters of four defined areas where the spread of *FG* seems to be most in crisis. In this way, the natural resources department of the government could plan a long-term strategy to decline the amendment that would likely lead to extinction.

2. Materials and Methods

The main objective of this work was to identify the factors affecting the distribution of FG. For this reason, initially, a review of the scientific literature on *FG* habitats was performed. Next, climatic information as well as other characteristics were analyzed in a GIS environment (Figure 1). All the meteorological data were provided by the Zanjan Province meteorological organization from 1955 to 2014 initially. To investigate the anthropic effect on the distribution and biodiversity of FG in northwest Iran, four main habitats were selected, and edaphic, climatic and ecological parameters were recorded. In particular, four natural *FG* habitats were subsequently identified, as shown in Figure 2. According to the *FG* distribution, the representative area was identified inside each natural habitat, and three points were randomly selected in each area. Then, the information from nearby meteorological stations was collected. In particular, data relating to average temperatures and rainfall (monthly and yearly) from 1955 to 2014 were collected and processed.

Figure 1. Experimental design followed for the analysis of the ecology of *FG* in Zanjan Province. Collection of climatic, topography and habitat information and the Geographic Information System (GIS) contributed to identify the factors affecting the distribution of FG.

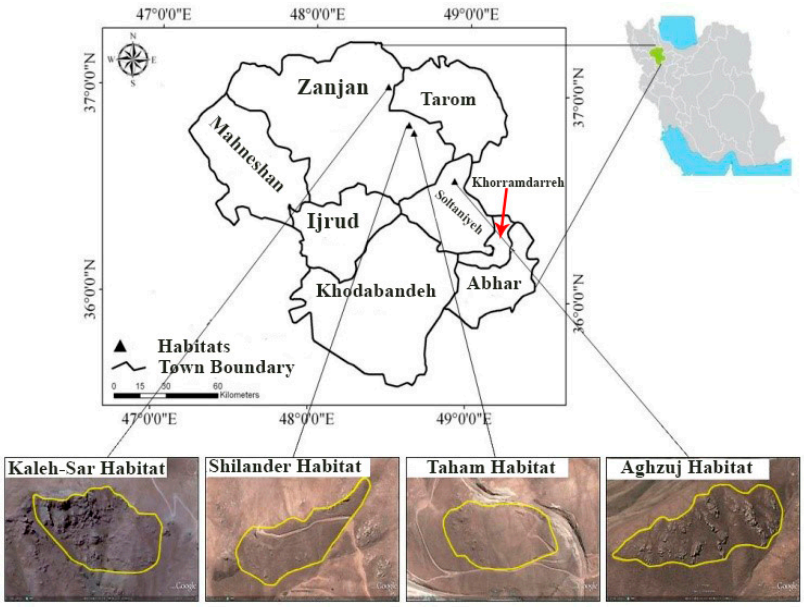

Figure 2. The location of the studied areas in Zanjan Province.

In the next step, the ecological traits of *FG* were recorded from habitats selected (Table 1). To do this, three linear transects of 150 m were placed in each habitat and 10 plots (2 m^2) on each transect were sampled and studied. In each plot, coverage and density of *FG* and associated species were measured and recorded.

Table 1. Estimation of climatic parameters by location altitude.

Climate Parameter	Aghzavaj	Kaleh-Sar	Shilander	Taham	Used Formula
Precipitation	408	423	408	415	Pre = 0.116 Alt + 125.25
Average Temperature	8/6	8	8/4	8/3	Tmean = 20.816 − 0.005 Alt

Soil sampling was performed along each transect at three points (beginning, middle and end of the transect) by digging profiles to the depth of rooting. Soil properties, such as texture by the hydrometer method [27], salinity by the saturated mud extract method [28], acidity by the saturation mud method using pH meter [29], organic carbon by the Walkley Black method [30], phosphorus content by the colorimetric method [31], nitrogen content by the Kjeldahl method [32], potassium content by flame photometer [33] and the amount of neutralizing materials by the reverse titration method [34], were determined in the laboratory. In addition, elevation was determined using an altimeter, geographical directions were determined using a compass and slope percentage was determined using a slope gauge for each habitat to estimate the climatic parameters (Table 1).

The project database was prepared with collected information about climate, the soil of specific habitats and topographic conditions. Climatic parameters such as precipitation, average and absolute minimum and maximum temperature were predicted using the Inverse Distance Weighted (IDW) interpolation method by prebuilt procedures in the ArcGIS software. IDW is an easy technique, which uses linear combinations of weights at known points to estimate unknown location values. In interpolation models, $Z(s_o)$ equals the values at unknown locations and is determined by the weighting value (λ_i) and values at known locations $Z(s_i)$.

$$Z(s_o) = \sum_{i=1}^{n} \lambda_i Z(s_i)$$

$$\lambda_i = \frac{[d(s_i, s_o)]^P}{\sum_{i=1}^{n} [d(s_i, s_o)]^P}$$

In the IDW equation, $d(s_i,s_o)$ is the Euclidean distance between s_i and s_o. P is a power value that controls how fast the weights tend to zero as the distance from the location increases. The higher the exponent, the more influence nearby data will have on the predicted values [35]. After basic layers preparation, other auxiliary layers such as slope layer, slope direction and topographic elevation were prepared using ArcGIS procedures with scale 1:25,000 and fabrication of TIN and DEM models. Then, the factors affecting *FG* distribution in the rangelands were combined. Therefore, homogeneous and similar areas of natural habitats were extracted, and thus an *FG* distribution map of the Zanjan Province was obtained and validated with existing documents. Finally, the obtained data was analysed, and the reasons for *FG* distribution reduction in the natural habitats of the Zanjan Province were concluded.

3. Results and Discussion

Collected data analysis revealed that the main factors affecting *FG* diversity include misuse of FG-distributed areas for forage cultivation, grazing livestock and improper harvest by local farmers. Meanwhile, pests have been observed on *FG* stems from Curculionidae species, damaging the stem and leading to lower seed production.

3.1. The Main Habitats of FG Characteristics in the Zanjan Province

The results show that *FG* constituted more than about 15% of the total abundance of species present in the habitats considered. Furthermore, given the ecological diversity of the habitats studied, these data highlight the ability of *FG* to distribute itself in multiple ecosystems compared to the other considered species (Table 2). Furthermore, given the distribution of *FG*, its exploitation would lead to a strong decrease in biodiversity in the areas considered. Likewise, it is observed that the amount of stone and gravel in the studied habitats is significant, and it seems that this factor is effective in the early stages of growth and establishment of the *FG*. Considering the range of species distribution in the studied habitats, it is observed that the elevation factor is one of the most influential factors in the distribution of *FG*. In this regard, Egyptian researchers have also considered the various environmental factors on plant communities as a crucial element and have described the characteristics of elevation, slope and direction as the most important factors [36]. On the other hand, it seems that the destruction of these habitats for many years due to improper and unscrupulous human exploitation has forced *FG* to take refuge in mountainous areas with scattered rocks to allow its growth and survival.

Table 2. Characteristics and vegetation status of *FG* habitats in the studied areas.

Plant Species	Elevation	Density	Stone and Gravel	Bare Soil	Litter	Vegetation Cover	
	m	Plant/ha	%				Habitat
- *Ferula gummosa* Boiss., 15.6% - *Pimpinella tragium* Vill., 8% - *Silene bupleuroides* L., 9% - *Thymus kotschyanus* Boiss. & Hohen., 10.7% - Others, 56.7%	2430	12,000	43	13	3	41	Aghzavaj
- *Ferula gummosa* Boiss., 15% - *Festuca ovina* L., 7% - *Onobrychis cornuta* (L.) Desv., 9% - *Silene bupleuroides* L., 9% - *Tanacetum polycephalum* Sch. Bip., 9% - Others, 51%	2530	16,800	32	14	3	51	Shilander
- *Ferula gummosa* Boiss., 18% - *Alopecurus textilis* Boiss., 8% - *Centaurea aucheri* (DC.) Wagenitz, 6% - *Prangos ferulacea* (L.) Lindl., 6% - *Thymus kotschynus* Boiss. & Hohen., 8% - Others, 54%	2577	17,200	35	16	4	45	Kalasar
- *Ferula gummosa* Boiss., 16% - *Acantholimon festucaceum* (Jaub. & Spach) Boiss., 12% - *Elymus transhyrcanus* (Nevski) Tzvelev, 16% - *Onobrychis cornuta* (L.) Desv., 16% - *Silene bupleuroides* L., 9% - Others, 31%	2490	8800	32	10	3	55	Taham

3.2. Climatic Characteristics of the Studied Areas

3.2.1. Total Annual Rainfall and Average Temperature

We referred to the rainfall and annual temperature data of synoptic stations adjacent to the study area, in order to obtain the amount of rainfall and temperature in the region. The results are presented in Figure 3.

According to the calculations, rainfall and the average temperature of all habitat areas were in the range of 423–408 mm and 7.8–8.8 °C, respectively, so that both parameters were among the ideal characteristics for the growth of *FG* [24].

In order to evaluate the water required by the plant in the different phenological stages, the monthly distribution of rainfall was considered (Figure 4). Figure 5 shows the monthly distribution pattern of the necessary rainfall in the different stages of germination, vegetative growth and reproductive growth of *FG*.

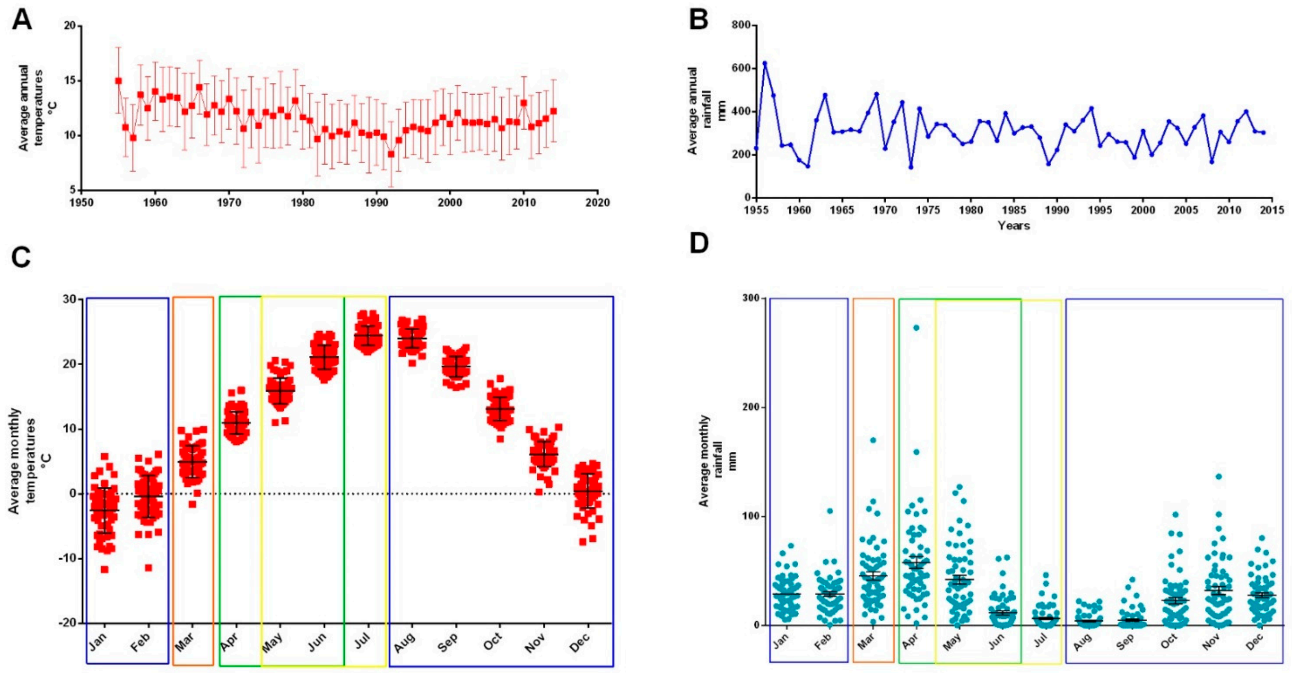

Figure 3. Climatic characteristics of the Zanjan Province. Average temperatures (**A**) and average annual rainfall (**B**) recorded from 1955 to 2014. Average temperatures (**C**) and average rainfall (**D**) monthly. Graphs C and D show the growth and development phases of *FG*: germination (orange), vegetative growth (green), reproductive growth (yellow), winter dormancy (blue).

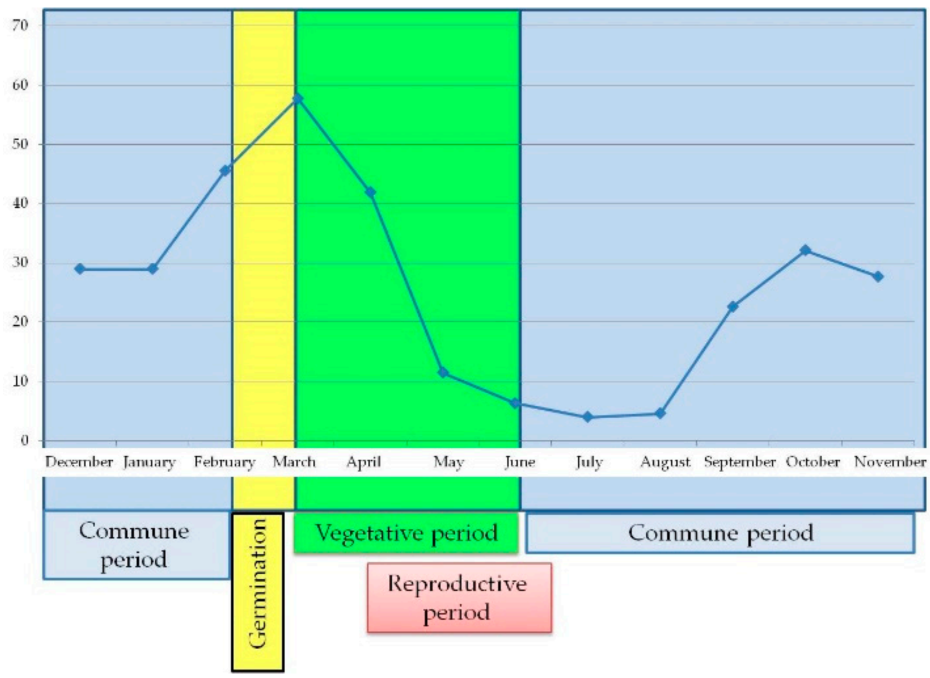

Figure 4. Relationship between monthly precipitation and physiological stage of FG.

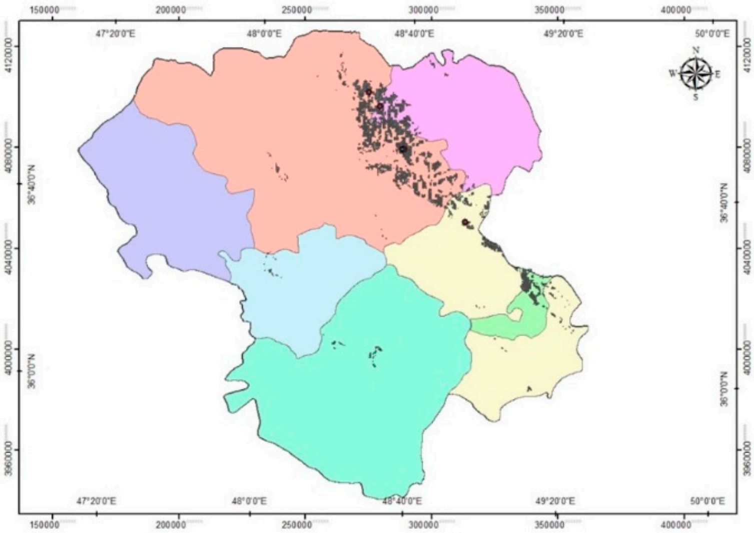

Figure 5. Homogenous distribution map of *FG* in Zanjan Province.

Several studies have shown that the *FG* plant is highly resistant to cold and frost, and grows mainly in semi-arid and sometimes cold and ultra-cold Mediterranean regions, with an average annual temperature between 3.5 and 12 °C [37–39]. This plant grows well at an absolute minimum temperature below −30 and absolute maximum temperature below 40 °C [40]. Our study showed that the absolute minimum temperature of *FG* vegetative growth period (from the second half of March to July) is equal to −15 °C and the absolute maximum temperature in the hottest month of the year (July) is equal to 34.5 °C. Therefore, these environmental factors cannot be a limiting factor for the distribution and establishment of *FG* in the region.

3.2.2. Topography

Topography is one of the factors affecting the growth and distribution of plants. Important and effective topographic parameters include habitat height, type of elevation (plains, foothills, rolling hills and mountains), amount and direction of the slope. Accordingly, the slope is mainly north and northeast with a slope of 55 to 70 degrees, and an elevation range above 2200 m is suitable for the growth of *FG* in the Zanjan Province (Table 3).

Table 3. Sampling sites characteristics in the main habitats of *FG* in Zanjan Province.

Geographical Direction	Height (Meters above Sea Level)	Percentage Slope	Latitude	Longitude	Area Name
N	2511	60	365,001	483,750	Shilander
NE	2577	70	370,209	482,818.5	Kalesar
NE	2430	55	363,451.2	485,442.2	Aghzavaj
NW	2490	65	365,011.6	483,735.9	Taham

3.2.3. Soil

The results show that in the habitats where *FG* grows, the soil was mostly shallow, sometimes semi-deep and consisting mainly of loam, loamy sand, loamy clay and mostly clay loam. Climatic factors, along with soil properties, change the vegetation by determining soil moisture (Noy-Meir, 1973). As indicated in Table 4, soil salinity was very low (less than 0.7 dS/m) and soil acidity was in the neutral range (6.9 to 7.33). Soil organic carbon was relatively high, but the amount of nutrients such as phosphorus and potassium was less than optimal in these soils. The results of soil samples analysis of the natural habitats of *FG* in the Zanjan Province are presented in Table 4.

Table 4. Soil characteristics of four FG natural habitats in the Zanjan Province.

	Ec	pH	TNV %	Oc %	K (ppm)	P (ppm)	N %	Sand %	Silt %	Clay %
Aghzavaj	0.46	6.9	1	2.68	6.26	9.26	0.26	56.0	35.6	8.3
Shilander	0.69	7.8	3	1.46	245.6	11.7	0.14	41.3	44.0	14.6
Kalasar	0.63	6.9	2.13	2.14	219.3	6.33	0.12	56.6	33.6	10.6
Taham	0.29	7.3	4.7	2.47	384.6	12.5	0.14	31.3	54.0	18.0

Soil texture characteristics (amount of clay, sand and silt) and elements concentration in the soil (amount of potassium and nitrogen) are important and influential factors on *FG* distribution as observed by other authors [22,24,26]. The structure of the soil with its vegetation influences the amount of humidity and plant elements available, the water retention capacity and permeability of the soil, the organic matter present, the nutrient cycle of the soil and the depth of rooting of the plants.

3.2.4. Combined Data Analysis

In order to define the climatic, topographical, demographic and pedological areas of the natural habitats of *FG* studied through the Geographic Information System, a map of these habitats was drawn up with the ArcGIS software (Figure 5). This map shows homogeneous areas with the ability to support the establishment of *FG*. Several factors have been identified as main elements making changes in vegetation in *FG* habitats. These elements include land use conversion, harvesting fodder, grazing livestock, improper operation, pests and diseases of *FG* in the region.

3.3. Factors Affecting Vegetation Change

3.3.1. Land Use Conversion

The increasing rate of rangeland plants' population growth, followed by the increasing human need for food, have led farmers in different countries to exploit poor land with high erosion and low production potential [41,42]. Changes in land management and use, as well as tillage functions, have an abundant impact on organic matter and their physical, chemical and biological properties [42,43]. Reduction in organic matter due to the lands' management change has been reported by researchers [44,45]. In other words, tillage operations erode the soil, severely degrading it and greatly reducing its fertility. The conversion of land use to drylands was observed several times during the field visits to the habitats of *FG*. Figure 6A is an example of land turned into *Medicago sativa* L. in the Shilander area.

3.3.2. Harvesting Fodder and Grazing Livestock

Based on the available documents and reports, the condition of most rangelands is poor or very poor, and the percentage of undesirable species is very high compared to desirable rangeland species in Iran [18]. This condition can lead to a decrease in grazing production per unit area. Indeed, due to the lack of good forage, livestock is forced to feed on poor species from a nutritional point of view. For this reason, breeders are forced to enrich the nourishment of livestock with other plant species that grow in the areas intended for grazing. As previously mentioned, *FG* is a source of forage, especially during the winter (Figure 6B). Jamsranjav and colleagues argued that as long as the livestock population is in equilibrium with the ecosystem, precious resources such as water, soil and plants will not be harmed [46]. Therefore, proper use of land for grazing will lead to preserving the plant species of the habitat. It follows that in itself, the use of land for grazing does not damage the ecosystems where *FG* develops. Unfortunately, field observations of the areas studied showed that *FG* is being collected indiscriminately and intensively together with other species to provide winter forage. Undoubtedly, this type of exploitation can be considered a serious problem for the growth, development, diffusion and reproduction of *FG* in the coming years.

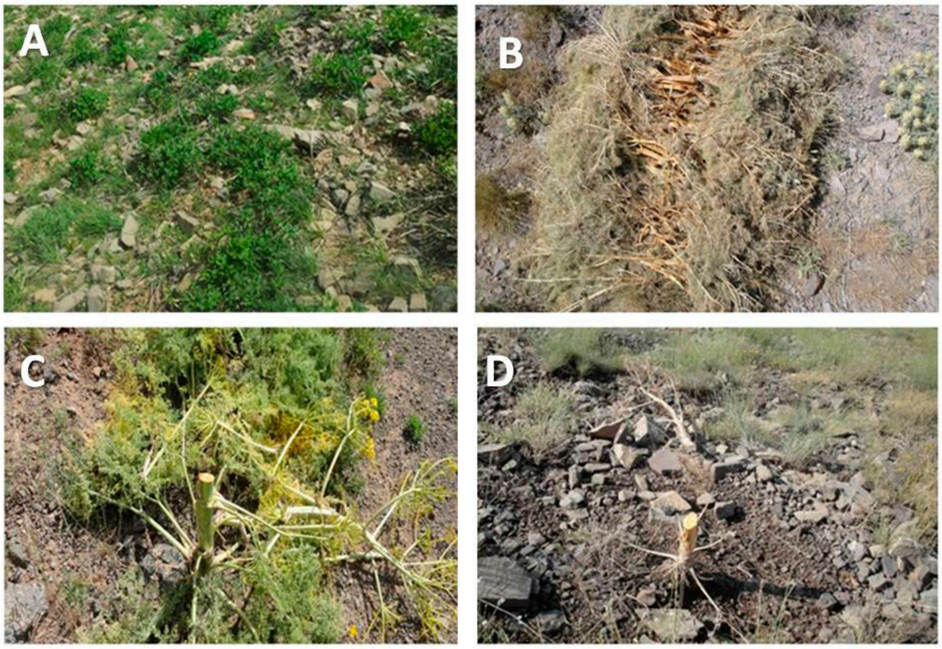

Figure 6. Some examples of factors affecting vegetation change in natural habitat. (**A**) shows land turned into alfalfa in the Shilander area. (**B**) FG as a source of forage in the area, especially during the winter. (**C**,**D**) FG's flowering stems are completely cut off due to inappropriate usage.

3.3.3. Improper Operation

Individuals' improper exploitation methods have resulted in the destruction of a large part of the natural habitats of *Ferula* species in Iran [47]. In the several visits of its natural habitats, *FG*'s flowering stems were seen to have been completely cut off (Figure 6C,D). In our opinion, if the improper operating process continues in the same way, the regeneration of the *FG* plant may be difficult after several years. Because of the monocarpic nature of this plant, it blooms once every 8–12 years.

3.3.4. Pests and Diseases of FG in the Region

Based on field evaluations, some Curculionidae species pierce the stem of the *FG* and lay their eggs inside, where their larvae subsequently grow (Figure 7A,B). However, the larvae rarely settle in the flower stems, as this allows the plant to pass the stages of pollination and seed production before the damage of this parasite spreads. Furthermore, *FG* is a latex content plant, meaning it responds to wounds, cuts and cracks by secreting latex. The limited number of holes is spawned successfully by female weevils. Most of these holes are filled quickly by latex during drilling due to this inherent property of the *FG* plant. A species of aphid is the second sub-parasite of *FG*. These aphids feed on the flower stem of *FG*. They are protected against their natural enemies (especially ladybugs) by cooperating with some species of ants (Figure 7C,D). However, thanks to the short life of the *FG* flower stem and the presence of natural enemies of the aphids, the damage of these parasites is almost never lethal for the life of *FG*.

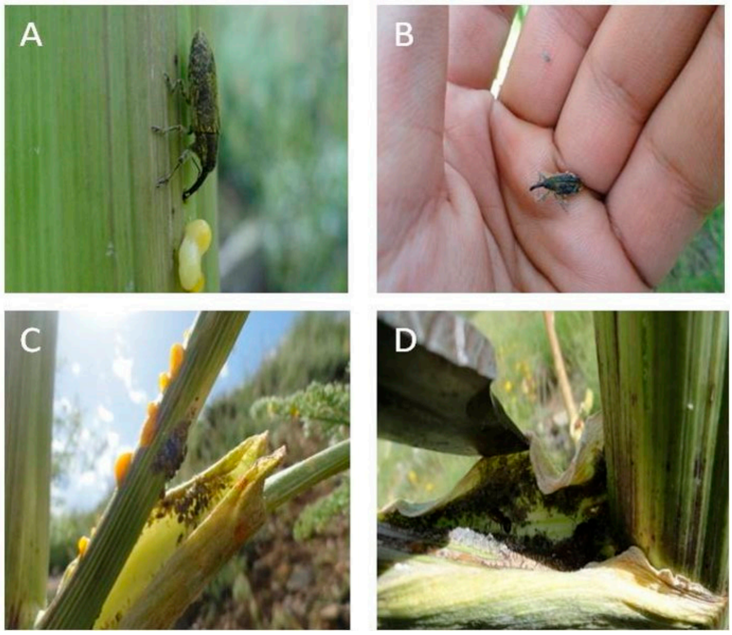

Figure 7. Pests and diseases of Galbanum in the region. (**A**,**B**) Curculionoidea species pierce the stem of the FG and lay their eggs. (**C**,**D**) Aphids inhabiting FG plants are protected against their natural enemies (especially ladybugs) by cooperating with some species of ants.

3.3.5. Proposed Solutions for FG Regeneration in Natural Habitats

The excessive density of livestock and the growth of the human population are at the root of the loss of precious species such as *FG* and the reduction in biodiversity. The strategies applied to stop this misuse of natural resources and restore the growth and spread of *FG* include its cultivation and the delimitation of areas intended for grazing [48]. Indeed, limiting grazing to well-defined areas (delimited by fences) allows the restoration of plant species in areas outside the fences. In these areas, the composition of vegetation changes as the duration of grazing restrictions increases [49]. Indeed, in areas excluded from grazing, there is an increase in forage species due to an increase in their ability to reproduce and expand. It follows that the protection of *FG* can also be implemented with attention to the breeding strategies of grazing livestock.

Cultivation and regeneration of plants in natural habitats is another effective management and conservation measure in degraded pastures. In general, this strategy can be applied to rebalance and restore the habitat of plant species such as *FG*, and to adopt a correct management of grassland ecosystems. In this strategy, ex situ germination with subsequent reintroductions to the wild, respecting the population's genetic diversity, would be implemented.

4. Conclusions

The results collected in this study on the ecology of *FG* have shown how the different ecosystems in which this species lives show physical-chemical characteristics suitable for the growth and spread of *FG*. At the same time, anthropic activities have a destructive effect on the ecological niches of *FG*. In particular, the indiscriminate exploitation of land aimed at grazing livestock reduces biodiversity and alters the habitat of *FG*. Population growth and the consequent increase in the human need for food is considered in many parts of the world to cause the disappearance of many wild plant and animal species [11]. Farmers and ranchers exploit poor and marginal lands, which mainly have a high erosion potential and a low production potential [50]. The soil of these areas has a natural yield and a specific organic matter for the endemic plant populations that live there. The indiscriminate exploitation of these soils reduces biodiversity and disrupts the balance of ecosystems, with a great impact on organic matter and other physical, chemical and biological properties of the land, leading to soil desertification. This anthropic action on the environment has also affected the habitats of the *FG*. Lack of attention in pruning, indiscriminate use as forage and the disappearance of plant biodiversity could lead to the reduction in and subsequent extinction of *FG*. This important problem observed for *FG* can be observed in many other plant species living in other ecological niches.

In conclusion, many plant species are at risk of extinction in the world due to mankind's improper lifestyle. *FG* has shown many adaptive capacities to different ecosystems and to attacks by insects. However, the excessive exploitation of the plant and the soil could reduce the spread of *FG* and lead it to extinction. Only greater awareness and sustainability of human societies towards the environment will be able to preserve biodiversity while avoiding the extinction of many plant species such as *FG*.

Author Contributions: Conceptualization, P.M., F.A. and A.M. (Ahmad Moosavi); methodology, H.H.M., J.K., M.T., T.K. and M.S.; formal analysis, H.H.M., J.K., M.T., T.K. and M.S.; data curation, P.M., F.A. and A.M. (Ahmad Moosavi); writing—original draft preparation, P.M.; writing—review and editing, A.M. (Andrea Mastinu); supervision, A.M. (Andrea Mastinu). All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Muzaffarīyān, V.A.H. *Farhang-i nāMhā-yi giyāhān-i īrān: Lātīnī, Ingilīsī, Fārsī*; Farhang-i Mu'āṣir: Tihrān, Iran, 1996; pp. viii, 610, 669, 671.
2. Zargarī, A. *Giyāhān-i dārū'ī-i īrān*; Dānish: Tehran, Iran, 1329.
3. Affolter, J.M. *A Monograph of the Genus Lilaeopsis (Umbelliferae)*; American Society of Plant Taxonomists: Ann Arbor, MI, USA, 1985; p. 140.
4. Pimenov, M.G.; Leonov, M.V.; Ostroumova, T.A. Taxonomic and Phytogeographical Databases in Systematics of the Flowering Plant Family Umbelliferae/Apiaceae. In *Information Technologies in the Research of Biodiversity*; Springer: Cham, Switzerland, 2019; pp. 28–36. [CrossRef]
5. Khedrigharibvand, H.; Azadi, H.; Bahrami, H.; Tesfamariam, Z.; Bazzazi, A.; De Maeyer, P.; Witlox, F. Sustainable rangeland management in southwest Iran: Application of the AHP-TOPSIS approach in ranking livelihood alternatives. *Rangel. J.* **2018**, *40*, 603. [CrossRef]
6. Salehi, M.; Naghavi, M.R.; Bahmankar, M. A review of Ferula species: Biochemical characteristics, pharmaceutical and industrial applications, and suggestions for biotechnologists. *Ind. Crops Prod.* **2019**, *139*, 111511. [CrossRef]
7. Sani, A.M.; Arianmehr, A.; Najaf Najafi, M. Preparation of Barije (Ferula gummosa) Essential Oil–Loaded Liposomes and Evaluation of Physical and Antibacterial Effect on Escherichia coli O157:H7. *J. Food Prot.* **2020**, *83*, 511–517. [CrossRef]
8. Ali, B.; Al-Wabel, N.A.; Shams, S.; Ahamad, A.; Khan, S.A.; Anwar, F. Essential oils used in aromatherapy: A systemic review. *Asian Pac. J. Trop. Biomed.* **2015**, *5*, 601–611. [CrossRef]
9. Mahboubi, M. Ferula gummosa, a Traditional Medicine with Novel Applications. *J. Diet. Suppl.* **2016**, *13*, 700–718. [CrossRef]
10. Abate, G.; Zhang, L.; Pucci, M.; Morbini, G.; Mac Sweeney, E.; Maccarinelli, G.; Ribaudo, G.; Gianoncelli, A.; Uberti, D.; Memo, M.; et al. Phytochemical Analysis and Anti-Inflammatory Activity of Different Ethanolic Phyto-Extracts of *Artemisia annua* L. *Biomolecules* **2021**, *11*, 975. [CrossRef]
11. Gupta, A.K.; Rather, M.A.; Kumar Jha, A.; Shashank, A.; Singhal, S.; Sharma, M.; Pathak, U.; Sharma, D.; Mastinu, A. Artocarpus lakoocha Roxb. and Artocarpus heterophyllus Lam. Flowers: New Sources of Bioactive Compounds. *Plants* **2020**, *9*, 1329. [CrossRef]
12. Mastinu, A.; Bonini, S.A.; Premoli, M.; Maccarinelli, G.; Mac Sweeney, E.; Zhang, L.; Lucini, L.; Memo, M. Protective Effects of Gynostemma pentaphyllum (var. Ginpent) against Lipopolysaccharide-Induced Inflammation and Motor Alteration in Mice. *Molecules* **2021**, *26*, 570. [CrossRef] [PubMed]
13. Kumar, A.; Memo, M.; Mastinu, A. Plant behaviour: An evolutionary response to the environment? *Plant Biol.* **2020**, *22*, 961–970. [CrossRef] [PubMed]

14. Kumar, A.; Premoli, M.; Aria, F.; Bonini, S.A.; Maccarinelli, G.; Gianoncelli, A.; Memo, M.; Mastinu, A. Cannabimimetic plants: Are they new cannabinoidergic modulators? *Planta* **2019**, *249*, 1681–1694. [CrossRef]
15. Sonigra, P.; Meena, M. Metabolic Profile, Bioactivities, and Variations in the Chemical Constituents of Essential Oils of the Ferula Genus (Apiaceae). *Front. Pharmacol.* **2021**, *11*. [CrossRef]
16. Rodrigues, P.M.S.; Schaefer, C.E.G.R.; Silva, J.D.O.; Ferreira Júnior, W.G.; dos Santos, R.M.; Neri, A.V. The influence of soil on vegetation structure and plant diversity in different tropical savannic and forest habitats. *J. Plant Ecol.* **2016**, *11*, 226–236. [CrossRef]
17. Noy-Meir, I. Compensating Growth of Grazed Plants and Its Relevance to the Use of Rangelands. *Ecol. Appl.* **1993**, *3*, 32–34. [CrossRef]
18. Aghajanlou, F.; Mirdavoudi, H.; Shojaee, M.; Mac Sweeney, E.; Mastinu, A.; Moradi, P. Rangeland Management and Ecological Adaptation Analysis Model for Astragalus curvirostris Boiss. *Horticulturae* **2021**, *7*, 67. [CrossRef]
19. Tasser, E.; Tappeiner, U. Impact of land use changes on mountain vegetation. *Appl. Veg. Sci.* **2002**, *5*, 173–184. [CrossRef]
20. Rad, S.V.; Valadabadi, S.A.R.; Pouryousef, M.; Saifzadeh, S.; Zakrin, H.R.; Mastinu, A. Quantitative and Qualitative Evaluation of *Sorghum bicolor* L. under Intercropping with Legumes and Different Weed Control Methods. *Horticulturae* **2020**, *6*, 78. [CrossRef]
21. Reza Yousefi, A.; Rashidi, S.; Moradi, P.; Mastinu, A. Germination and Seedling Growth Responses of Zygophyllum fabago, *Salsola kali* L. and Atriplex canescens to PEG-Induced Drought Stress. *Environments* **2020**, *7*, 107. [CrossRef]
22. Zangani, E.; Afsahi, K.; Shekari, F.; Mac Sweeney, E.; Mastinu, A. Nitrogen and Phosphorus Addition to Soil Improves Seed Yield, Foliar Stomatal Conductance, and the Photosynthetic Response of Rapeseed (*Brassica napus* L.). *Agriculture* **2021**, *11*, 483. [CrossRef]
23. Khaleghnezhad, V.; Yousefi, A.R.; Tavakoli, A.; Farajmand, B.; Mastinu, A. Concentrations-dependent effect of exogenous abscisic acid on photosynthesis, growth and phenolic content of *Dracocephalum moldavica* L. under drought stress. *Planta* **2021**, *253*, 127. [CrossRef] [PubMed]
24. Karamzadeh, L.; Jafarian, V.; Vatankhah, E. Ecological and phytochemical attributes of endemic Ferula gummosa Boiss. at vegetative and generative stages. *Turk. J. Biochem.* **2018**, *43*, 393–402. [CrossRef]
25. Farhadi, F.; Iranshahi, M.; Mohtashami, L.; Shakeri Asil, S.; Iranshahy, M. Metabolic differences of two Ferula species as potential sources of galbanum: An NMR-based metabolomics study. *Phytochem. Anal. PCA* **2021**. Available online: https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/abs/10.1002/pca.3027?af=R (accessed on 31 May 2021). [CrossRef]
26. Bernard, F.; Bazarnov, H.S.; Khatab, L.J.; Darabi, A.S.; Sheidai, M. Ferula gummosa Boiss. Embryogenic Culture and Karyological Changes. *Pak. J. Biol. Sci.* **2007**, *10*, 1977–1983. [CrossRef]
27. Bouyoucos, G.J. A Recalibration of the Hydrometer Method for Making Mechanical Analysis of Soils 1. *Agron. J.* **1951**, *43*, 434–438. [CrossRef]
28. Ondrasek, G.; Rengel, Z. Environmental salinization processes: Detection, implications & solutions. *Sci. Total Environ.* **2021**, *754*, 142432. [CrossRef]
29. Thomas, G.W.; Haszler, G.R.; Blevins, R.L. The effects of organic matter and tillage on maximum compactability of soils using the proctor test. *Soil Sci.* **1996**, *161*, 502–508. [CrossRef]
30. Matus, F.J.; Escudey, M.; Förster, J.E.; Gutiérrez, M.; Chang, A.C. Is the Walkley–Black Method Suitable for Organic Carbon Determination in Chilean Volcanic Soils? *Commun. Soil Sci. Plant Anal.* **2009**, *40*, 1862–1872. [CrossRef]
31. Iatrou, M.; Papadopoulos, A.; Papadopoulos, F.; Dichala, O.; Psoma, P.; Bountla, A. Determination of Soil Available Phosphorus using the Olsen and Mehlich 3 Methods for Greek Soils Having Variable Amounts of Calcium Carbonate. *Commun. Soil Sci. Plant Anal.* **2014**, *45*, 2207–2214. [CrossRef]
32. Kirk, P.L. Kjeldahl Method for Total Nitrogen. *Anal. Chem.* **1950**, *22*, 354–358. [CrossRef]
33. Kemi Idowu, M.; Adote Aduayi, E. Sodium-potassium interaction on growth, yield and quality of tomato in ultisol. *J. Plant Interact.* **2007**, *2*, 263–271. [CrossRef]
34. Nelson, D.W.; Sommers, L.E. Total Carbon, Organic Carbon, and Organic Matter. **2015**, *9*, 539–579. Available online: https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/agronmonogr9.2.2ed.c29 (accessed on 31 May 2021). [CrossRef]
35. Roberts, E.A.; Sheley, R.L.; Lawrence, R.L. Using sampling and inverse distance weighted modeling for mapping invasive plants. *West. N. Am. Nat.* **2004**, *64*, 312–323.
36. Abd El-Ghani, M.; Soliman, A.; Abd Ei-Fattah, R. Spatial distribution and soil characteristics of the vegetation associated with common succulent plants in Egypt. *Turk. J. Bot.* **2014**, *38*, 550–565. [CrossRef]
37. Gholami, B.; Faravani, M. Effects of different cutting methods and times of cutting on growth performance and gum resin production of ferula assa-foetida. *J. Agric. Sci. Belgrade* **2014**, *59*, 35–44. [CrossRef]
38. Mahdavi, A.; Moradi, P.; Mastinu, A. Variation in Terpene Profiles of Thymus vulgaris in Water Deficit Stress Response. *Molecules* **2020**, *25*, 1091. [CrossRef] [PubMed]
39. Naservafaei, S.; Sohrabi, Y.; Moradi, P.; Mac Sweeney, E.; Mastinu, A. Biological Response of Lallemantia iberica to Brassinolide Treatment under Different Watering Conditions. *Plants* **2021**, *10*, 496. [CrossRef] [PubMed]
40. Zardari, S.; Ghaderi-Far, F.; Sadeghipour, H.R.; Zeinali, E.; Soltani, E.; Baskin, C.C. Deep and intermediate complex morphophysiological dormancy in seeds of Ferula gummosa (Apiaceae). *Plant Species Biol.* **2019**, *34*, 85–94. [CrossRef]

41. Coppock, D.L.; Fernández-Giménez, M.; Hiernaux, P.; Huber-Sannwald, E.; Schloeder, C.; Valdivia, C.; Arredondo, J.T.; Jacobs, M.; Turin, C.; Turner, M. Rangeland Systems in Developing Nations: Conceptual Advances and Societal Implications. *Rangel. Syst.* **2017**, *17*, 569–641. [CrossRef]
42. Di Falco, S.; Zoupanidou, E. Soil fertility, crop biodiversity, and farmers' revenues: Evidence from Italy. *Ambio* **2016**, *46*, 162–172. [CrossRef]
43. Willy, D.K.; Muyanga, M.; Mbuvi, J.; Jayne, T. The effect of land use change on soil fertility parameters in densely populated areas of Kenya. *Geoderma* **2019**, *343*, 254–262. [CrossRef]
44. Amelung, W.; Bossio, D.; de Vries, W.; Kögel-Knabner, I.; Lehmann, J.; Amundson, R.; Bol, R.; Collins, C.; Lal, R.; Leifeld, J.; et al. Towards a global-scale soil climate mitigation strategy. *Nat. Commun.* **2020**, *11*, 5427. [CrossRef]
45. Saljnikov, E.; Cakmak, D.; Rahimgaliev, S. Soil Organic Matter Stability as Affected by Land Management in Steppe Ecosystems. *Soil Process. Curr. Trends Qual. Assess.* **2013**, *7*, 57–72. [CrossRef]
46. Jamsranjav, C.; Reid, R.S.; Fernández-Giménez, M.E.; Tsevlee, A.; Yadamsuren, B.; Heiner, M. Applying a dryland degradation framework for rangelands: The case of Mongolia. *Ecol. Appl.* **2018**, *28*, 622–642. [CrossRef] [PubMed]
47. Noedoost, F.; Dehdari, S.; Razmjoei, D.; Ahmadpour, R.; Shoukat, P. Autecology of Ferula stenocarpa boiss. & Hausskn in Khuzestan Province, Iran. *Nova Biol. Reper.* **2018**, *4*, 337–352. [CrossRef]
48. Di Virgilio, A.; Lambertucci, S.A.; Morales, J.M. Sustainable grazing management in rangelands: Over a century searching for a silver bullet. *Agric. Ecosyst. Environ.* **2019**, *283*, 106561. [CrossRef]
49. Kelishadi, H.; Mosaddeghi, M.R.; Hajabbasi, M.A.; Ayoubi, S. Near-saturated soil hydraulic properties as influenced by land use management systems in Koohrang region of central Zagros, Iran. *Geoderma* **2014**, *213*, 426–434. [CrossRef]
50. Petersen-Rockney, M.; Baur, P.; Guzman, A.; Bender, S.F.; Calo, A.; Castillo, F.; De Master, K.; Dumont, A.; Esquivel, K.; Kremen, C.; et al. Narrow and Brittle or Broad and Nimble? Comparing Adaptive Capacity in Simplifying and Diversifying Farming Systems. *Front. Sustain. Food Syst.* **2021**, *5*, 564900. [CrossRef]