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Original Research

Medicinal Plants Status, Habitat Degradation Factors and Rehabilitation Possibilities in Sra Ghurgai Protected Area Takatu Mountain Range Quetta Pakistan

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Abstract

Despite massive efforts to protect plant diversity around the world over the last few decades, it is becoming increasingly evident that present policies are insufficient to prevent the continued trends of decline in biodiversity. The encroachment of humans and their animals on protected areas is causing changes in its natural environment. This study was performed in the protected highlands of Sra Ghurgai, Quetta District, Balochistan from July to November 2020. The study used a survey approach that included a purposive location selection, a questionnaire to assess the effects of anthropogenic activities, analysis of random samples of soil and identification of medicinal plants. Soil properties were studied at three altitudes: site I (1660 m), site II (1700 m), and site III (1720 m) at 0-30 cm soil depths. A total of ten plant species belonging to eight different families were collected and identified. Our findings reveal that the primary cause of the reduction in organic contents was habitat destruction due to overgrazing and human activities. Implementation of government policies and their technical support can help in the restoration of the natural beauty of this protected region.

Keywords: anthropogenic activities, soil, conservation, medicinal plants, altitude

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Introduction

Recent climate changes in the world have made a great impact on the biodiversity of plants and their geographical distribution [1]. It has posed a grave threat to plant habitation. The growing human activities (i.e., anthropogenic activities) from rapidly emerging villages in protected areas, such as pasturing cattle, medicinal plant harvesting and deforestation cause environmental changes [2]. Anthropogenic activities have been categorized on the specific use of land such as industrialization, urban development, excessive overuse of agricultural fertilizers and pesticides, the release of untreated industrial wastes and interference in protected areas such as sanctuaries [3-5]. The exponential increase of the human population and their activities can also alter soil biodiversity in protected areas [6]. More than 15 categories affecting the biodiversity of plants due to anthropogenic activities have been identified such as, urban, residential rangeland and residential irrigation land etc. [7-9]. Most of the plant conservation programs are poorly addressed at national and global levels due to a lack of reliable and up-to-date data on plants in specified regions. As a result, medicinal plants are not given due share in plant preservation planning programs at the local, regional, and global levels [10]. Consequently, conservation strategies in such areas have become a challenge for policymakers that can be addressed through multidisciplinary approaches [11, 12].

Elevation of the cultivated area is considered the dominant factor of microsite conditions which can affect the distribution, physiology and growth of plants [13]. Environmental factors such as low temperature and decomposition of organic materials change the texture and physiology of the soil [11]. As we move up along the slope of the soil, a decrease in exchangeable potassium, base saturation, pH, and fine silt-sized particles is observed. On the other hand, soil aggregate stability, water repellency, sand-sized particles, and organic matter increase significantly [14]. Changes in any of the above parameters affect plant performance such as height, structure and physiology of the plant.

Cattle farming provides a source of income to a vast number of people around the world [15]. Cattle farming is a part of the culture and about one-quarter of all terrestrial land, mainly drylands, is reserved for this purpose. However, overgrazing can cause significant structural and functional damage to the ecosystem such as diminishing plant species, erosion of soil and depletion of nutrients in the soil such as carbon and nitrogen [16]. Another side effect of overgrazing is the decline in invertebrate populations and their species because of changes in plant communities in a specific area [17].

Balochistan province (Pakistan) has the largest area among all provinces and several attempts have been made to safeguard the regional natural mountainous areas and conservation of medicinal flora [18-20]. Most of these efforts are not successful due to poor local government planning and management issues in Sra Ghurgai located in the Koh-i-Takatu mountains of Balochistan. This has been identified as a significant wetland coverage biodiversity hotspot. The area is a popular tourist destination. Human activities are causing a non-recoverable loss of medicinal plant species in the area. Only one study has been reported for this area which excludes any anthropogenic implications and overgrazing effects on soil physiology or on the distribution of medicinal plant fauna [21]. Keeping in view all the above-mentioned facts, the present study was designed to (a) Assess the socioeconomic and demographic characteristics of people living in the vicinity of Sra Ghurgai Mountain (b) Identify the potential factors causing disturbance of this natural ecosystem (c) Examine the physical and chemical properties of soil, and (d) Identify the various medicinal plants in the region.

Materials and Methods

Bibliographic Review

In the present work different research databases searches such as Web of Science, Thomson Reuters, Scopus, and PubMed were used with specific keywords; soil composition, plant conservation, protected areas and anthropogenic activities, etc. Published articles were searched in Google Scholar, PubMed, Science Direct and Mendeley. Publications such as commentary, conference papers, and letters to the editor were not included because these usually lack complete information. After screening the research papers, we found about 50 papers were relevant to our study.

Study Area Geography

The area for the study was Sra Ghurgai (GPS: 30º17′ 39ºN, 67º01′02ºE) included in Quetta District, Balochistan (Fig. 1). It is a part of the Koh-i-Takatu mountains range, which covers a total area of ~140 km^2. It is located at an altitude about 1,600-3,000 [21]. According to the agro-climatic classification system of Pakistan [22]. This area is characterized by a semi-arid climate with two distinct seasons; rainy season (December-April) and dry season (May-November). The area is extensively covered with a variety of shrubs, herbs and grasses including selected medicinal plants. These plants are used for medical purposes by local residents and as fodder for their domestic animals. The area receives an annual rainfall of 35-212 mm. The rainy season is between August and November while the season from December to July is mostly dry. The average temperature varies from -5º to 43ºC with relatively low humidity.

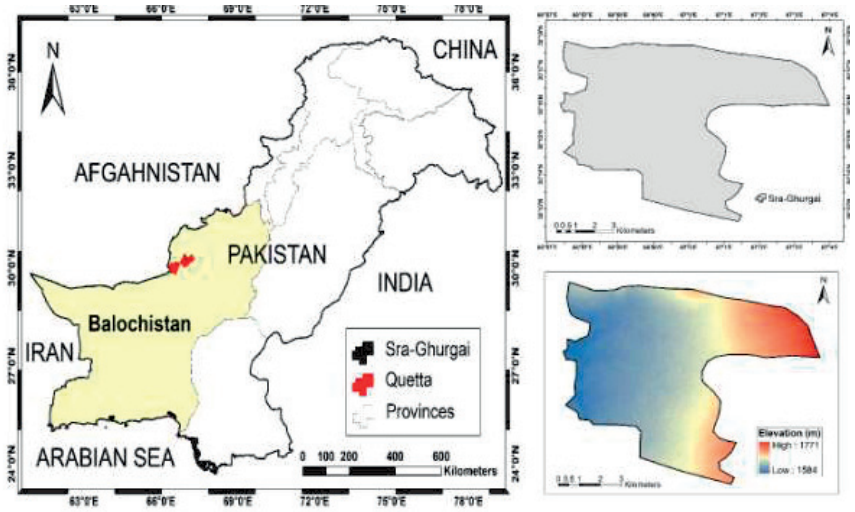

Fig. 1. The study area: (left) map of Pakistan showing the study area i.e., Quetta, (top right) map of Sra Ghurgai, Takatu mountain range, (bottom right) elevation map of Sra Ghurgai.

Questionnaire for Locals and Visitors

A small number of local people of these hill districts are nomads and they move their herds

from the plains to these mountain ranges during the early winter months. They stay here throughout the summer and with the onset of winter and then return to the plains (Fig. 2). This area is filled with tourists and local people, especially on the weekend. A small number of local people residing in the neighborhood are involved in summer tourism and work as rest house managers, tour guides, shopkeepers, restaurant workers and drivers.

Fieldwork was carried out from July to November 2020 (a total of five months) and standard methods previously described were used [23]. In this survey, a total 50 local residents and 50 visitors were randomly chosen for participation in the questionnaire. The questionnaires were separately designed for local people and visitors. Locals were asked about their socio-economic demography through direct interviews. Information regarding their age, level of

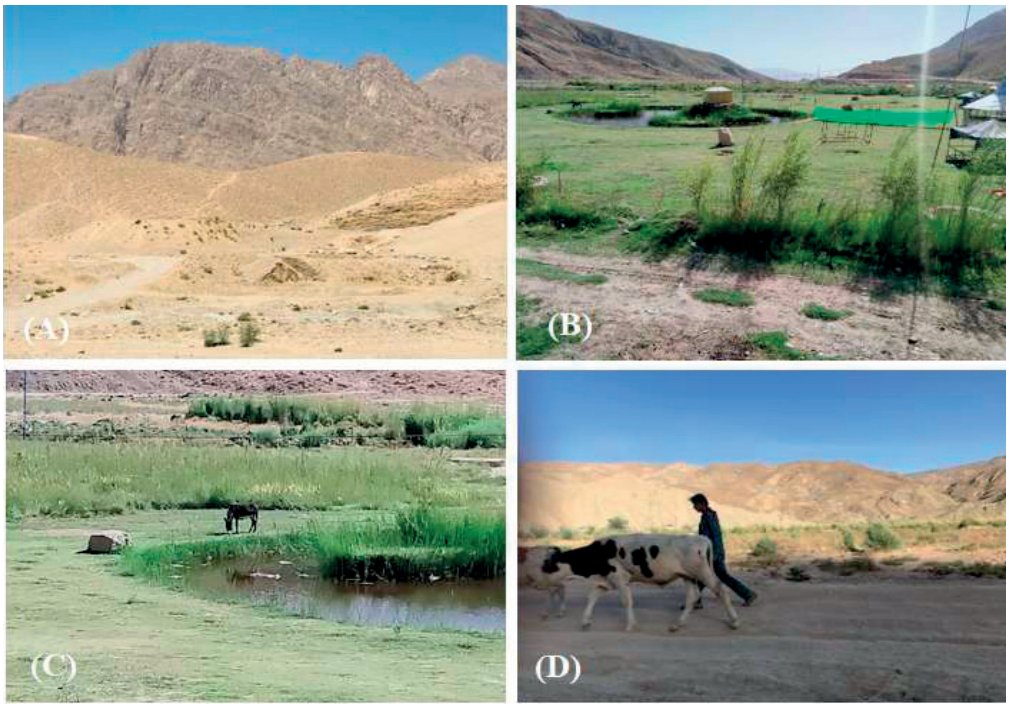

Fig. 2. Example of land use activities a) location of the study area, b) picnic spot for visitors, c) grazing land, d) nomadic pastoralist system.

Table 1. Questions of the survey questionnaire for visitors.

Question 1. Have you observed any land being cultivated by local residents?
Question 2. Do people throw the garbage in open area?
Question 3. Are you aware of any non-government organization (NGO) working on the conservation of plants?
Question 4. Availability of signboards/maps to guide visitors about the area.
Question 5. State whether camping is allowed.
Question 6. Are you aware of any research/efforts on the conservation of biodiversity being carried out by the government?
Question 7. Have you seen grazing of cattle?
Question 8. Have you observed any roads, fences, or any physical structures?
Question 9. Availability of facilities for disabled people.
Question 10. What should be the role of stakeholders? [a]
Question 11. State whether hiking, climbing and caving, etc. is allowed.
Question 12. Did you observe any guided tours?

[a] Environmental protection agency (EPA) Pakistan, local conservation board, advisory council members, municipalities and park managers.

education, professional career and the total number of domestic animals was collected. Each visitor was given a questionnaire in Urdu (the national language of Pakistan) having 12 questions (Table 1). The English translation of the questionnaire is as under.

Experimental Design and Sampling

Two key parameters (a) Plant biodiversity status and (b) physical and chemical properties of the soil were investigated in this study. The distribution of plants was observed at three different altitudes (1660 m, 1700 m, and 1720 m). The biodiversity indices for the plant species were calculated at each altitude using the formula [24].

$$Biodiversity\ Index = \frac{the\ number\ of\ speices\ in\ the\ area}{the\ number\ of\ individual\ in\ the\ area}$$

Soil Analysis and Data Calculation

Collected plants were left for 24-48 hours at 50ºC in an oven to get their dried form and then their organic contents (OC) were measured using the Loss-on-Ignition method [25]. Total calcium carbonate contents were estimated by adopting the Back-titration method [26]. Bulk density was calculated by the Core method [27]. Soil samples were initially oven-dried at 40ºC for 15 min, then oven-dried at 105ºC for 4-5 h in order to obtain completely dry samples. The final samples have rock fragments larger than 2 mm. About 100-150 g of this dry soil was mixed with distilled water to make a soil-saturated paste. The electrical conductivity and pH of the paste were measured by pH/EC meter (Model number: 21821 Spectrum Technologies, USA). The soil organic carbon stock (SOCS) was studied because it was suspected that the carbon content in the top profile of the soil has been chemically decomposed due to anthropogenic activities and overgrazing. The SOCS was estimated by following the method developed by Walkley and Black [28] and using the following formula [29].

$$\text{SOC stock } (Mg/ha^{-1}) = \text{soil depth (cm)} \times \text{SBD } (g\ cm^{-3}) \times \text{C content of OM (\%)} \times (1 - F)$$

where F is the volume of the coarse fraction of fragments >2 mm.

Index Calculation

The available satellite-based remotely sensed data were used to determine various indices for our sites [30]. *S*atellite images data used in the study were retrieved for the two-growing season from July 2020 to November 2020. The following four indices (i) Normalized difference water index (NDWI), (ii) Moisture stress index (MSI), (iii) Soil salinity index (SSI) and (iv) Soil-adjusted vegetation index (SAVI) were mapped for the selected sites.

Spatial and Statistical Analysis

A study map linking plant distribution and climate conditions was drawn using ArcGIS (version 20.15). The data obtained for the questionnaire was first entered into an MS Excel spreadsheet (2019) and the same was graded using the Z-score statistics. The Kruskal-Wallis test was used to examine soil properties using the SPSS® 26.0 Faculty Pack (released on October 1st, 2018, IBM Inc., Chicago, Illinois, USA)

(https://www.ibm.com/). If $p<0.05$, then the results were considered statistically significant.

Results

Questionnaire Output

The following eight parameters were selected i.e., age, gender, education, occupation, number of family members, monthly income, number of domestic animals, land for cultivation and damage to medicinal plants due to human activities for analysis of the socioeconomic and demographic characteristics of the local residents (Table 2). Our results revealed that the ages of persons in the sample ranged from 18 to 80 years, with a mean age of 28 years. The mean family size was eight person per house. Most of the respondents had secondary education (n = 29, 58%) followed by primary education (n = 12, 24%), tertiary education (n = 6, 12%) and quaternary education (n = 3, 6%). It was noted that 80% (40 families) of the respondents had their own livestock. On the other hand, 20% (10 families) had no livestock and one person of such family was employed either in the government or private sector. Seventy-five percent (30 families) used livestock for their own use while twenty-five percent (10 families) used them for generating income. The average monthly income of a family was about Rs 28,500. The distribution of domestic animals kept by the respondents is sheep (38.50%) followed by goats (35.50%), cows (15.21%) and buffaloes (10.79%). The majority of respondents (n = 47, 94%) answered that very little harm was caused to medicinal plants by their livestock.

Conclusions based on the second questionnaire were drawn that can alter the distributions of medicinal plants and the composition of the soil (Table 3). More than half of the respondents did not know about the cultivated land of the local people (n = 28, $P>0.92$). Referring to the second question of the questionnaire i.e., "do people throw the garbage in open area", the apparent response of most respondents was in "Yes" (n = 32, 97.89%, $P<0.001$). Most respondents (n = 42, 84%, $P<0.02$) were not aware about any NGO working on the conservation of plants. In the same way, most of the respondents (n = 35, 70%, $P<0.04$) were also not aware about any research sponsored by the government or private sector. Our study indicated that the signboards or maps were not available for visitors. The camping in our selected site was not allowed by relevant authorities (n = 26, 52%, $P<0.01$). However, few farmers did carry their animals for grazing in the protected area (n = 31, 62%, $P<0.03$). It is suspected that these farmers are either using their personal influence or paying off some money for the entrance of their domestic animals. It was observed that facilities for disabled persons (n = 29, 58%, $P<0.001$) were not available. Most respondents (n = 41, 82%, $P<0.002$) pointed out that the role of the stakeholder is absent. It was further reported by respondents that sports activities are not allowed (n = 39, 78%, $P<0.004$) and there is a lack of guided tour facilities (n = 43, 86%, $P<0.0001$).

Only ten plant species of medicinal value were reported and eight of these belong to dicot families. (Table 4). Four species of herbs belong to Asteraceae and Zygophyllaceae families while six remaining herbs belong to Ephedraceae, Solanaceae, Lamiaceae, Malvaceae, Nitrariaceae and Plantaginaceae. Highest biodiversity of medicinal plants reported are presented in descending order *Peganum hermala* > *Achilli whilhemsii* > *Tribulus terrestris* > *Peganum hermala* > *Ephedra intermedia* > *Perovskia abrotanoides* > *Zygophyllum fabago* > *Malva neglecta* > *Seriphidium*

Table 2. Socio-economic and demographic characteristics of local people (n = 50).

Variable	Range
Age	18-80
Gender	Male (n = 42), female (n = 8)
Level of education	(i) Primary (Grade 5) (ii) Secondary (Grade 10) (iii) Tertiary (College) (iv) Quaternary (University)
Primary occupation	Self-employed or government or private job
Number of family members	1-30
Monthly income of the family (Rs) [a]	20,000-100,000
Number of domestic animals	1-150
land for cultivation	0-10 acres
Land for cultivation and damage to medicinal plants due to human activities	Low, medium, high

[a] Conversion Rate (1 US dollar = Rs 185 on April 10, 2022).

Table 3. Use of univariable category method to determine the potential risk factors (n = 50).

Q. Number	Number of participants with responses			Z-score
	Yes	No	Do not know	
1	6	16	28	0.92
2	32	18	-	0.001
3	2	6	42	0.02
4	3	12	35	0.04
5	35	15	-	0.01
6	2	26	22	0.01
7	31	19	-	0.03
8	32	18	-	0.002
9	4	29	17	0.01
10	3	6	41	0.002
11	11	39	-	0.004
12	7	43	-	0.0001

Table 4. Medicinal plants, their local name and the season of occurrence (i.e., phenology).

Plant	Family	Local name	Habit	Phenology	Biological diversity
Achilli whilhemsii	Asteraceae	Zawal	Herb	June - Sep	0.08
Seriphidium quettense	Asteraceae	Tarkha	Herb	May - Nov	0.03
Ephedra intermedia	Ephedraceae	Oman	Shrub	Aug - Sep	0.05
Saphora mollis	Fabaceae	Ghuzera	Herb	July - Dec	0.01
Perovskia abrotanoides	Lamiaceae	Shinshobai	Herb	July - Sep	0.04
Malva neglecta	Malvaceae	Takali	Herb	June - Sep	0.03
**Peganum hermala*	Nitrariaceae	Spalani/Spanda	Herb	Apr - Oct	0.06
Plantago major	Plantaginaceae	Baartang	Herb	May - Sep	0.02
Tribulus terrestris	Zygophyllaceae	Gokhru	Herb	April - Oct	0.06
Zygophyllum fabago	Zygophyllaceae	Caper	Herb	May - Sep	0.04

quettense > *Plantago major* > *Saphora mollis* in the above table.

Soil Properties

Soil properties were not uniform for the entire site. Sand contents were significantly ($p<0.05$) increased with an increase in altitude while there was a significant decrease ($p<0.05$) in clay contents with an increase in altitude (Table 5). Soil texture was sandy loam at site I and clay loam at site II and III respectively. There was a slight but definite decrease in values of pH, EC and SBD with altitude. A significant decrease in $CaCO_3$, OM, SOC and SOCS values was recorded for each altitude.

Satellite-Derived Studies

The growing season for satellite data was from July to November. Fig. 3 clearly shows a higher MSI and SAVI distribution for our selected site. Other indices including NDWI and SSI show a decrease in spital pattern for the same period.

Discussion

The main objective of this research was to evaluate the physical and chemical qualitative properties of soil. It has been reported that altitude plays a dominant role in the determination of soil properties [30]. As we move upwards along altitude, there is significant decreases

Table 5. Physical and chemical properties of the soil (Mean±SD) elevated at the study area.

Parameter	Altitude (m.a.s.l)		
	Site-I (1660)	Site-II (1700)	Site-III (1720)
Slit (%)	38.22±0.54	55.43±0.75	59.25±0.50
Clay (%)	26.23±1.50	20.32±1.25	19.05±0.50
Sand (%)	35.77 ±2.19	24.43±1.00	21.70±1.92
$CaCO_{3\ (\%)}$	15.25±0.25	16.12±0.25	14.85±0.50
pH	8.22±0.54	8.10±0.24[a]	7.90±1.20
EC (µs/cm)	240.25±13.56	243.65±16.62[a]	241.00±19.76
SBD (g/cm^3)	1.5±0.13	1.3±0.00	1.3±0.02
OM (%)	4.52±1.85	3.21±2.80	2.75±1.75
SOC (%)	1.72±0.25	1.50±0.50	1.75±0.45
SOCS ($Mg\ ha^{-1}$)	46.44±11.32[a]	28.80±0.33	21.45±2.15
Texture class	Sandy loam	Clay loam [a]	Clay loam

[a] shows non-significant differences ($P<0.05$).

in the values of OH, SBD and $CaCO_3$ [21, 31] and the significant increase in the values of soil pH [32] and SOC values [21].

Remote sensing data is frequently used for spatial evaluation of different soil variables [22]. Images of satellite-derived NDWI and SSI show a narrow distribution pattern while MSI and SAVI images show vast distributed pattern between from July to November. The analysis of these images predicts that the area may experience low rainfall and severe drought in the future. It is also assumed that all these spatiotemporal changes can have far-reaching consequences on the survival and distribution of medicinal plants.

The use of plants as medicine varies from 4 to 20% in different countries [33]. Majority of the people in Balochistan rely on medicinal plants to find treatment for their minor children because the health care system and medicines are not in their reach owing to their low income [34]. We have identification of ten medicinal plant species belonging to eight families (Table 3). Among these species, *Ephedra* and *Peganum* are the most commonly found families [35, 36]. The species of medicinal plants mentioned in this study are used by the locals for various therapeutic purposes. For example, *Achilli whilhemsii, Peganum hermala, Ephedra intermedia*, *and Plantago major* are used for the treatment of digestive disorders [37-40], *Malva neglecta* is traditionally used to treat sunburns and insect bites [41], *Tribulus terrestris* has an anti-diuretic, anti-asthmatic, and anti-diuretic properties [42] and *Seriphidium quettense* used for geohelminth infections [43], *Perovskia abrotanoides* has the most dispersal in Iran with anti-oxidant, antibacterial and anti-fungal properties [44]. *Saphora mollis* is also used by local people for fodder and burning fuel [45].

The five major findings of our present study are as under: (i) Most of the study is based on data about visitors, local people and their domestic animals, (ii) The government has shown minimal interest in the conservation of this protected area, (iii) Overgrazing is responsible for decline in the soil productivity [46] and making soil habitat unsuitable to some rare species of arthropod for example, spiders and aphids [47, 48]. It has been reported that when level of grazing is reduced, it promotes the population of invertebrates associated with plants [49, 50]. (iv) Harvesting of medicinal plants is common practices because these plants are used to treat various ailments. The flower diversity is not included in the study site, which in term is continuously destroying the vegetation and habitat loss [51]. (v) Climate change is more frequent and it is predicted that there will be decline in annual rainfall in near future. Even in some cases where annual rainfall is low, feedback from the system regarding reduced biomass production can lead to greater sensitivity to soil erosion [52]. All of these factors equally are contributing to the loss of vegetation, soil erosion and habitat degradation of native medicinal plant species.

The Pakistan Environmental Protection Agency (EPA) is the department responsible for finding solutions to such problems in protected areas. It is recommended that the EPA form an advisory council to address all of these issues before implementing the following suggested reforms: (i) There is an urgent need to create and enhance the environmental awareness and sensitivity of problem among visitors and locals. This can be achieved by developing high-quality environmental training courses. Sustainable approaches to the problem can be improved by providing brochures, guidebooks and guided maps [53]. (ii) There is an urgent need to regulate the level of grazing by domestic

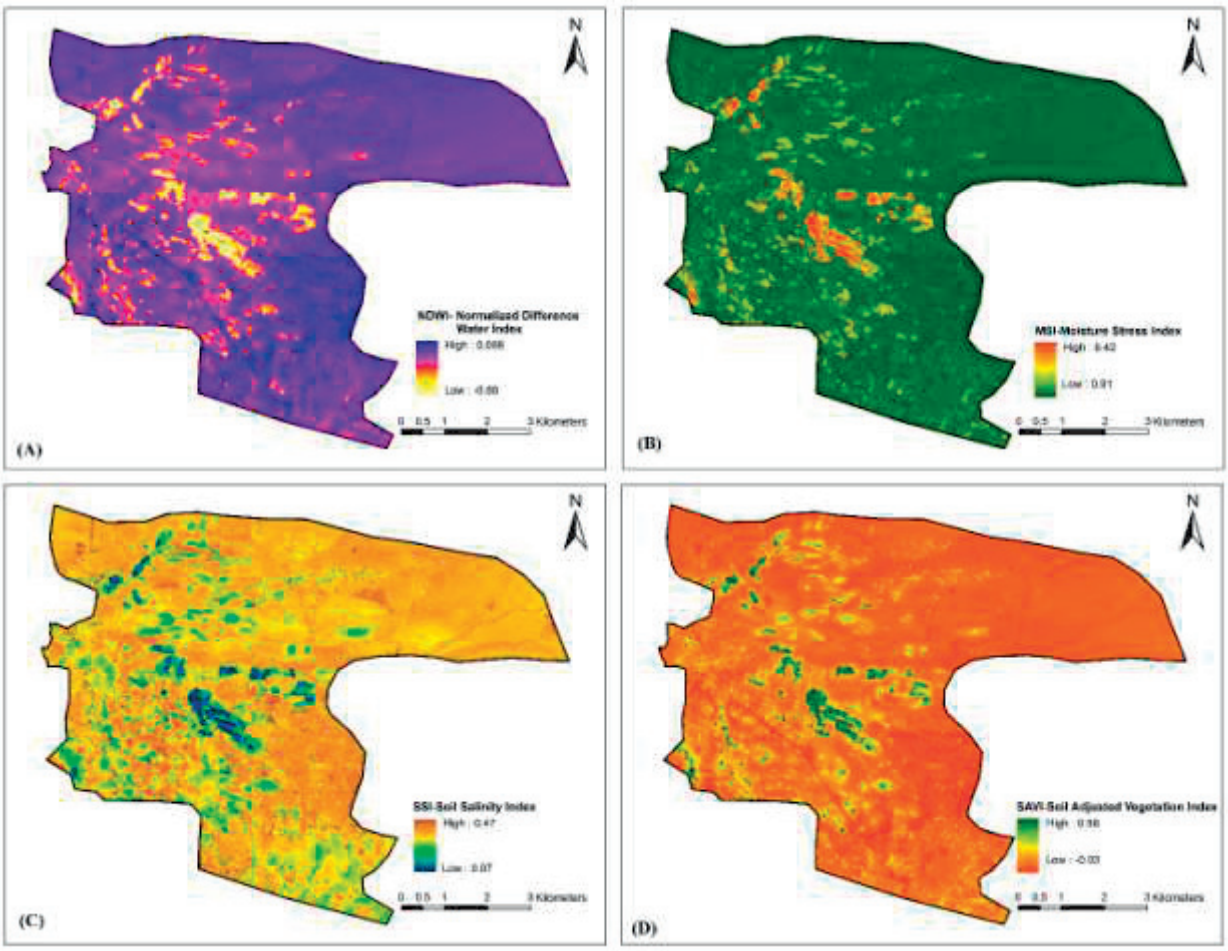

Fig. 3. a) Normalized difference water index (NDWI), b) Moisture Stress Index (MSI), c) Soil Salinity Index (SSI), d) Soil Adjusted Vegetation Index (SAVI) from July to November 2020.

animals grazing by quota allocation and implementation should be determined by the Local Government Protection Board [54]. (iii) No visitor fee is charged since it was declared a protected area. The amount collected as visitor fee can be used for the welfare and protection of the region [55]. All these suggestions can strengthen the long-term protection and sustainability of this protected region.

Conclusion

The entry of domestic animals is banned by government in this protected region but it is not implemented in its true spirit. However, overgrazing pressure is being felt directly on the medicinal plants and has also changed soil composition. These issues are interlinked with the lack of interest by government and private sectors. It was also noted that a communication gap is present between government and local people in order to protect this region. Therefore, several suggestions are proposed in this study for protection of medicinal plants and soil biodiversity.

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Conflict of Interest

The authors declare no conflict of interest.

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