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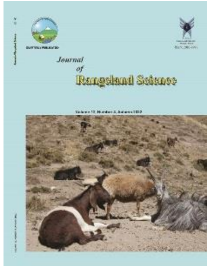

Research and Full Length Article:

Effect of Environmental and Managerial Factors on Range Condition in Semi-Arid Mountainous Area of Chahar Bagh in Northeastern Iran

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Received on: 11/06/2021
Accepted on: 19/10/2021
DOI: 10.30495/RS.2022.685840

Abstract. Semi-arid mountainous areas are of special importance in terms of ecological function i.e. vegetation dynamics and its evaluation under environmental- managerial factors is a necessity for their sustainable use. Due to the highly variable environmental characteristics in these areas, proper land management and utilization can severely affect the Range Condition (RC). Here, the relationship between topography, soil characteristics and management (RC) under grazing] was investigated through multivariate analysis in mountain areas of Golestan's Chahar Bagh, northeastern Iran in 2019. The RCs were assessed by scoring vegetation and soil characteristics in areas under livestock grazing areas. The preliminary findings of this research showed that environmental factors i.e. clay, P, EC, slope, aspect, Soil Moisture (SM) and K had the most effect on the formation of five different vegetation types (Cum.% of Var.=80.4%). The results showed that RC changes had more significant relationships with managerial factor/grazing than environmental factors. In general, the effect of environmental and management factors and their common effect in changing RC were equal to 1.84%, 74.1 and 21.04%, respectively. The change of soil physical properties was more than soil chemical properties under RC changes. Factors of Organic Matter (OM), Bulk Density (BD), porosity and SM showed significant changes under excellent, good, fair, poor and very poor conditions ($P<0.05$). In general, excellent and good rangelands were related to more OM and porosity and less slope and K. Moreover, poor/very poor rangelands were related to more SM, BD, P and slope. Overall, managing grazing can significantly decline/improve RC in mountainous area.

Key words: Plant composition, Rangeland assessment, Soil condition, Sustainable use

Introduction

Under semi-arid conditions, the increased human effects tend to over-stress land and vegetation resources leading to degradation in rangelands (Al-Bukhari *et al*., 2018; Oñatibia *et al*., 2020; Vanderpost *et al*., 2011; Van der Westhuizen *et al.*, 2005). Therefore, Range Condition (RC) assessment is discussed as a matter of principle for the management of such factors and land management as well (Khaleghi and Aeinebeygi, 2016; Trollope *et al.,* 2014). Similarly, semi-arid mountainous areas are of special importance in terms of forage production and ecological functions (Mahmoudi *et al.*, 2021; Farsi *et al.,* 2021), in which understanding the relationship between environmental- managerial factors and their conditions play a significant role in the sustainable use of these ecosystems. Therefore, given the importance of soil and vegetation in natural ecosystems, understanding the ecological factors affecting these elements seems necessary (Funk *et al.*, 2018; Mir *et al*., 2006).

In Iran, rangelands are located mainly in mountainous areas (Mahmoudi *et al.*, 2021) where sustainable land management requires reliable information on the land condition (soil/plant properties) affecting both landscape process and services (Bhunia *et al.,* 2017; Kumar, 2018). In order to achieve sustainable development and also to protect natural ecosystems and their function, it is necessary to study the role of ecological factors and their impact on ecosystem elements (Kilaneh and Vahabi, 2012; Sheikhzadeh *et al.,* 2019).

Naturally, vegetation/soil characteristics changes are influenced by environmental factors i.e. climatic conditions and physiographic features (Dashti *et al.,* 2021). On one hand, there is a closed relationship between living organisms and their environmental and non-living conditions (Martínez-Antúnez *et al.,* 2013; Wang *et al.,* 2016). In rangeland areas, the relationships between environmental and managerial factors are complex and ecologists have reported the certain relationships between RCs and some environmental gradients around the world (Plieninger and Huntsinger, 2018). However, these effects were unique in each region due to the combination of environmental (i.e. climate and soil) and management factors.

The study of the relationship between land conditions and environmental factors has a special complexity because environmental variables have many changes and there are complex interactions between environmental variables (Vahabinia *et al.*, 2019; Veen *et al.*, 2015). However, investigation of RC and factors with more attention to some factors can be commented. Therefore, awareness of RC changes in relation to ecological conditions i.e. soil-climatic characteristics and management in each habitat has an effective role in sustainable land use (Jafari *et al.,* 2002; Wang *et al.,* 2019).

Moreover, major ecological studies have been conducted in flat areas with arid and semi-arid climates and very limited studies have been conducted in areas with severe topographic features. In this regard, various methods i.e. multivariate regression, PCA and DCA have been used to study the environmental or managerial factors affecting the vegetation and their results have been reported (Mir *et al*., 2006; Sheikhzadeh *et al.,* 2019; Wang *et al.,* 2019).

In a rangeland ecosystem, a common effect of environmental and managerial factors can influence RC and this expresses the need to pay attention to managerial factors under human influence and intervention (Mohsennezhad *et al.,* 2010; Zhang and Dong, 2010). However, there is limited research on the relation between RC and environmental/managerial factors in mountainous areas. Rangeland ecosystems in semi-arid mountainous areas have potential in terms of water/forage production, medicinal plant, and recreational uses and the recognition of these relationships will lead to sustainable use and sustainable development of these areas. Moreover, reflectance data can be used to derive information about vegetation attributes, which are common metrics for RC (Kong *et al.*, 2015).

Accordingly, no detailed information is available about the relationship between environmental factors and RC with respect to the grazing as a managerial factor in semi-arid mountainous areas. Therefore, the aim of this study was to determine the contribution of soil, and topography factors under grazing in changing the RCs in semi-arid mountainous areas of Chahar Bagh in northeastern Iran.

Materials and Methods

Study area

This study was conducted in the semi-arid mountainous areas of Chahar Bagh in northeast Iran, between Golestan and Semnan provinces (latitude of 36º 37′ 76″ to 36º 40′ 49″ N in the north and a longitude of 54º 30′ 00″ to 54º 35′ 20″ E). The minimum height of the area is 2330 m and the maximum height is 3330 m a.s.l. This area is approximately 2957.6 ha which is used as a summer pasture (Fig. 1).

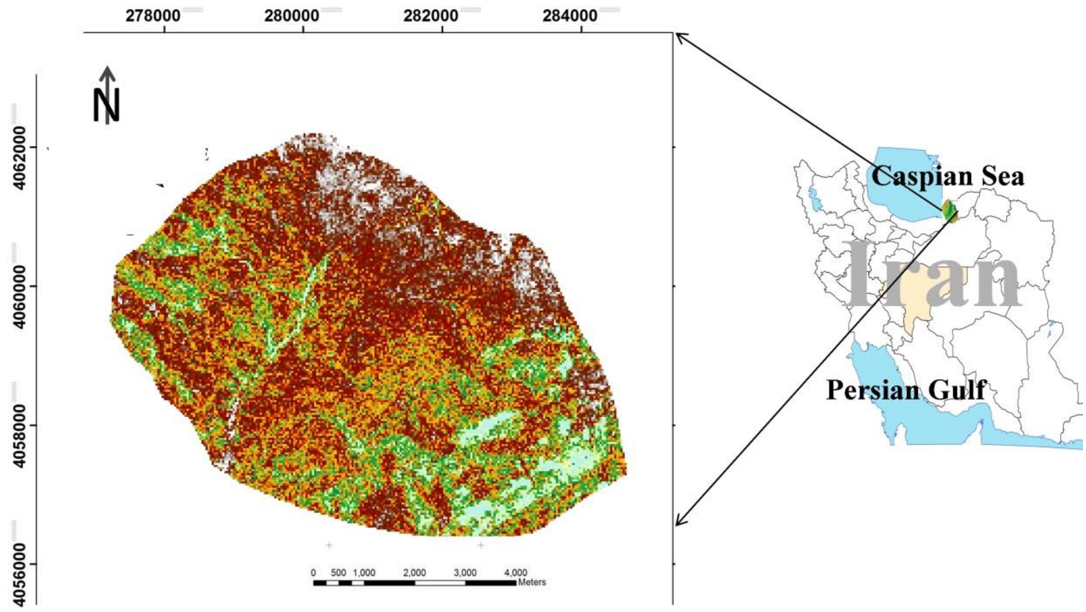

Fig. 1. Geographical location of the study area in northern Iran

The study area is located in Iran-Turan vegetation zone and the average annual rainfall is 348.5 mm, with the highest rainfall in March equal to 47.5 mm and the lowest rainfall in July equal to 11.8 mm. The lowest average monthly temperature is -4.5 ºC in February and the highest average monthly temperature is 17.2 ºC in July. This region has cold and wet winters and hot and dry summers and the climate of the region is estimated semi-arid by Domarten method. At present, the exploitation of the area is done in the form of livestock grazing without pasture fragmentation. Despite being mountainous, this area has been continuously grazed by livestock over the years and has been severely grazed and destroyed in different areas. Moreover, the limited water resources also caused severe grazing in some parts of the area so that high and steep points are severely grazed.

Data collection

Vegetation measurement

Random sampling method was used to study the vegetation cover in spring 2019. The study area was stratified based on environmental characteristics, vegetation type, and then, management factors (grazing intensity). Random sampling was performed inside each of the mentioned layers. The type of management was determined based on the four-factor method for RC. For this purpose, four transects perpendicular to each other with a length of approximately 500 m were placed along the peripheral gradient in each vegetation type.

For measurement of species, canopy cover and its density, plot-based method was used along the transects. The plot size was determined based on the largest canopy diameter of the species (1×1.5 m). The number of plots was determined statistically and due to the intense topography of the area, 15 plots were placed in different directions on the slope along each transect. In each plot, scientific name of the existing species, the percentage of canopy cover (by species) and density (by counting the number of plant stands) were recorded. Also, physiographic parameters such as slope, geographical direction and altitude were recorded using GPS.

Soil measurement

In order to sample the soil, out of 120 plots located in the area, in 40 plots (30% of total plots), soil sampling was performed randomly along the four transects in all geographical directions. The samples were taken (from 0-23 cm depths) exactly from the middle of the plot. Due to the mountainous nature of the area and the changes in the depth of the soil profile, this depth was considered for sampling. The samples were transferred to a soil laboratory to measure physical and chemical properties. After drying, the samples were sieved with a 2 mm sieve to determine the percentage of gravel. Hydrometric method was used to determine the soil texture and the percentage of clay, silt and sand. Soil pH was measured using a pH meter and Electrical Conductivity (EC) by the electrical conductivity meter. Also, Sodium Absorption Ratio (SAR), lime (titration with NaOH), Organic Matter (OM) [Walkey-black method], concentration of sodium (Na), calcium (Ca) and magnesium (Mg) ions in saturated and potassium extracts absorbed (K) [flame photometry method], Saturation Percent (SP), Soil Moisture (SM) and Bulk Density (BD) [weight method], absorbable phosphorus (P) [Olson method], cation exchange capacity (ESP) [sodium and ammonium acetate method] were measured.

Assessing the RC

The RC was assessed based on scoring according to soil characteristics and cover in plant types (Baars *et al.*, 1997). In fact, according to 1) floristic composition, 2) basal cover and litter cover, 3 (soil condition, and 4) number of seedlings and age of grasses, the scoring ranges from 3 to 50 points with respect to values of 41-50 for excellent rangeland, 31-40 for good rangeland, 21-30 for fair rangeland, 11-20 for poor rangeland and 3-10 for very poor rangeland (Angassa, 2014). For this purpose, the plant composition and their condition and soil cover characteristics were also studied so that the composition of grasses and forbes in terms of **a:** decreaser (desirable specieslikely to decrease under heavy grazing intensity), **b:** increasers (intermediate species likely to increase under heavy grazing intensity; and **c:** invaders (undesirable species likely to increase under heavy grazing intensity) were examined. Also, basal cover and litter cover were assessed in plots and all scores were recorded. Basal cover was considered very poor at <3 percent cover and excellent at 12.5<percent cover. The rating for litter cover within the plots was considered excellent when it exceeded 40% and poor at <10%. A score of 1–5 points was used for both the number of seedlings and age distribution of dominant grasses (maximum score was given when all age categories of grasses were present in the plots). For the soil condition, a score of 0–10 points were used). In fact, the status of soil erosion (0–5 points) and soil compaction (1–5 points) was investigated and all scores were combined.

Data analysis

The data were analysed through multivariate analysis of Principal Component Analysis (PCA) and Canonical Component Analysis (CCA) using PC-ORD software. Analysis of variance (ANOVA) was also carried out to compare soil factors under different RCs using SPSS software.

Results

Preliminary results of this study showed the relationship between environmental characteristics and plant types in the area. Then, the relationship between RC and environmental characteristics is shown below.

Vegetation types and environmental factors

Preliminary study of vegetation in this area led to the identification of 5 vegetation types including *1) Acanthophyllum glandulosum- Poa bulbosa*, 2) *Juniperus exelsa-Juniperus commonis*, 3) *Juniperus exelsa- Festuca ovina- Onobrychis cornuta*, 4) *Juniperus exelsa- Juniperus commonis- Bromus tomentellus* and 5) *Festuca ovina- Cousinia nekarmanica*. The PCA results showed that 80.43% of the changes in vegetation types are justified by the characteristics of the first and second axes, which the variance of each component being 52.71 and 27.71 %, respectively (Table 1).

Table 1. Eigenvalue values and percentage of variance justified by environmental variables in the PCA

Axis	Eigenvalue	% of Variance	Cum.% of Var.	Broken-stick Eigenvalue
1	12.65	52.71	52.71	3.77
2	6.65	27.71	80.43	2.77
3	3.34	13.94	94.37	2.27
4	1.35	5.62	100	1.94

By observing the contribution of each component in justifying the vegetation changes, it can be said that environmental factors of Cl, P, EC, slope, aspect, SM and K had the most effect on the distribution of ecological sites/vegetation types. The results showed that the most ecologically difference is due to the characteristics of the first axes (including OM, Cl and sand%, K, P, lime, EC, aspect and slope), and the second axes including SM, SP, porosity and Mg (Table 2).

Table 2. Correlation between vegetation and environmental-managerial factors in principal component analysis

Variable	Axis			
	PC1	PC 2	PC 3	PC 4
pH	-0.774	0.102	-0.569	0.576
Electrical conductivity (EC)	0.915	-0.317	0.308	-0.123
Saturation percent (SP)	0.465	0.852	-0.148	0.274
Soil moisture (SM)	0.129	0.930	-0.230	0.266
Bulk density (BD)	-0.520	-0.823	-0.169	-0.229
Lime	-0.997	0.125	-0.022	-0.135
Gravel	-0.767	-0.073	-0.387	0.373
Sand	-0.856	-0.274	-0.397	0.002
Clay	0.977	0.074	0.084	-0.024
Silt	-0.307	0.520	-0.774	-0.062
Porosity	0.520	0.823	0.161	0.229
Organic matter (OM)	0.946	0.250	0.138	-0.034
Sodium (Na)	0.341	-0.169	-0.609	0.695
Potassium (K)	0.949	-0.043	0.291	-0.040
Calcium (Ca)	-0.408	0.781	-0.24	-0.053
Magnesium (Mg)	-0.157	0.908	-0.290	-0.286
Phosphorus (P)	0.891	-0.061	0.400	-0.132
Sodium adsorption ratio (SAR)	0.502	-0.457	-0.723	0.547
Exchangeable sodium percentage (ESP)	0.557	-0.612	-0.441	0.359
Aspect	-0.939	0.326	-0.230	0.053
Slope	0.129	0.930	-0.230	0.266
Elevation	0.556	0.038	-0.792	-0.033

The underline coefficients have significant correlation with the relevant axes

According to Fig. 2, it is possible to justify the vegetation distribution based on the position of environmental factors and their distance/proximity to the axes. Vegetation type *Ac. gl-Po.bu* (*Acanthophyllum glandulosum- Poa bulbosa*) in the first quarter of the diagram is directly related to the properties of Cl, OM, SM, K, Mg and soil EC while this type is inversely related to the soil lime and geographical direction. *Ju.ex- Ju. Co* (*Juniperus exelsa-Juniperus commonis*) is located in the second quarter of the graph, and is directly related to SM, lime, Mg and geographical direction. Vegetation types of *Ju. ex- Fe. ov- On. co* (*Juniperus exelsa- Festuca ovina- Onobrychis cornuta*) and *Ju. ex- Ju. co- Br. to* (*Juniperus exelsa- Juniperus commonis- Bromus tomentellus*) in the third quarter of the diagram are inversely related to the properties of Ca, OM, K, SM, Mg and EC while it is directly related to the properties of lime and geographical direction. Moreover, the vegetation type *Ju. ex- Fe. ov- On co* had a significant direct relationship with soil lime and geographical direction and vegetation type *Ju. ex- Ju. co- Br.* to is related to the decrease of Mg and SM. Also, *Fe. ov- Co. ne* had a direct relation with Cl, OM, K and EC of soil and indirect relation to the amount of lime, geographical direction, SM and Mg.

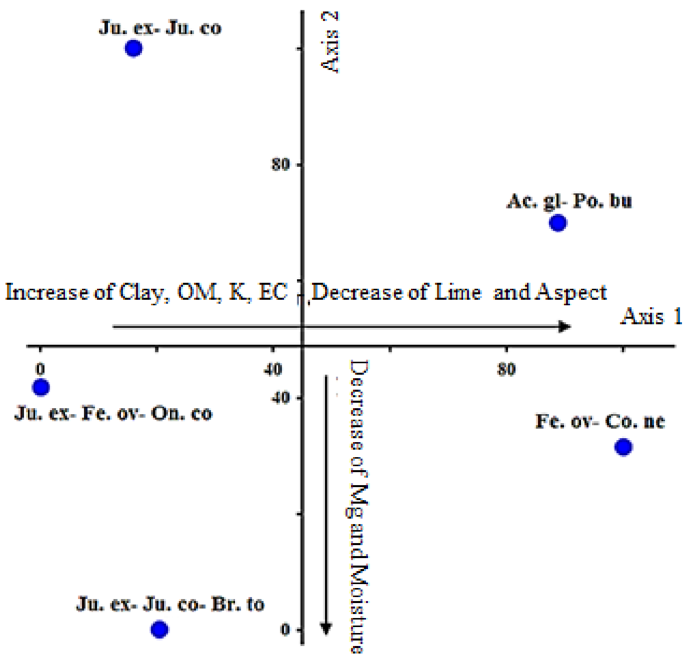

Fig. 2. Diagram of distribution of vegetation types in relation to environmental and managerial factors through principal component analysis

Moreover, when SM and Mg decreased, species of *Onobrychis cornuta* and *Bromus tomentelus* increased in *Ju. ex- Ju. Co* type where the vegetation type changed to a new types called *Ju. ex- Fe. ov- On. co* and *Ju. ex- Ju. co- Br. to*. According to the results, in points with higher amount of clay, OM, K and EC, the presence of *Acanthophyllum glandulosum*, *Poa bulbosa*, *Festuca ovina* and *Cousinia nekarmanica* species increased and formed two separate vegetation types. *Acanthophyllum glandulosum*, *Poa bulbosa*, *Festuca ovina* and *Cousinia nekarmanica* are mainly representative of areas with an average salinity of 0.53 ds/m and high OM (2.3%) which represent low lands and relatively saline clay soils with high OM and K located on the northern slopes.

Environmental/managerial factors and RC relationship

Ttopographic and edaphic factors

The results of the variance classification method showed that a total of 94.70% of RCs changes was related to topographic and soil factors (Table 3). With all these changes, the highest percentage (53.33%) was related to soil factor. Topographic factors alone have a lower effect than soil factors (27.88%) while the common effect was less (13.49%) (Fig. 3A).

Edaphic and managemeral factors

The results of the variance classification method showed that in total, 98.43% of RCs changes were related to managerial factors and soil (Table 3). Of these changes, the highest percentage (89.06%) was related to managerial factors. The soil factors had poor relation with RCs changes (0.04%) and their common effect was 9.36% (Fig. 3B).

Topographic and managemeral factors

The results of the variance classification method showed that in total, 64.48% of RCs changes were related to management and topographic factors (Table 3). Of these changes, the highest percentage (32.97%) was due to managemeral factors. The soil factor alone has been almost ineffective (2.60%) while their common effect on RC changes was 0.33% (Fig. 3 C).

Table 3. The common effect of environmental factors and management in describing vegetation changes through CCA

		Variance	Total variance	CV (%)
Edaphic-management	Management	6.34	7.12	89.06
	Edaphic	0.003	7.12	0.04
	Common effect	0.667	7.12	9.36
	Total effect	7.019	7.12	98.43
Topography-management	Management	1.153	3.50	32.97
	Topography	0.910	3.50	2.60
	Common effect	0.012	3.50	0.33
	Total effect	2.257	3.50	64.48
Topography-Edaphic	Edaphic	2.09	7.5	27.88
	Topography	4.00	7.5	53.33
	Common effect	1.012	7.5	13.49
	Total effect	7.103	7.5	94.7
Management-environmental (Edaphic-Topography)	Environmental	0.149	8.088	1.84
	Management	5.996	8.088	74.13
	Common effect	1.702	8.88	21.04
	Total effect	7.847	8.88	97.02

Environmental and managerial factors

The results of the analysis of variance showed that in total, 97.02% of the changes RCs were caused by managerial and environmental factors (Table 3). Of these changes, 74.13% was related to managerial factor. The environmental factors alone (1.84%) had less effect on changes of the RC than their common effect (21.04%) (Fig. 3 D).

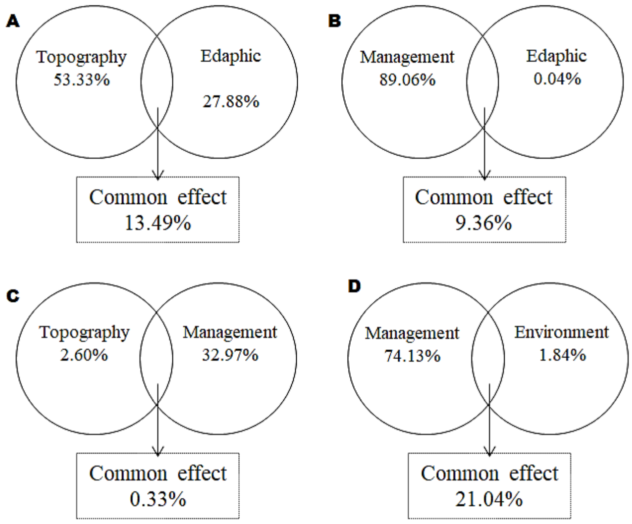

Fig. 3. The contribution of environmental (Soil and topography) and managerial factors in describing vegetation changes

Table 4 shows the first 4 eigenvectors, each scaled to its standard deviation according to a correlation matrix. Properties of Mg and pH, clay, slope, porosity, BD and lime had the highest specific coefficient values that showed a direct relationship with RCs.

Table 4. Eigenvectors of environmental variables in relation to RCs in PCA

Variables	Eigenvector Axis			
	PC1	PC2	PC3	PC4
Gravel	0.311	0.680	-0.196	-0.633
pH	0.915	-0.203	-0.083	0.338
Clay	-0.895	0.4107	0.069	0.156
Silt	-0.136	0.009	-0.955	-0.262
Sand	-0.873	0.217	0.189	-0.392
Electrical conductivity (EC)	0.880	0.205	0.014	-0.427
Exchangeable sodium percentage (ESP)	0.056	-0.040	0.996	-0.036
Calcium (Ca)	0.161	0.953	0.178	0.181
Magnesium (Mg)	0.963	0.133	0.232	-0.024
Organic matter (OM)	-0.660	0.740	0.049	-0.115
Saturation percent (SP)	-0.852	0.452	0.253	-0.065
Soil moisture (SM)	0.911	0.092	0.297	-0.267
Phosphorus (P)	-0.768	-0.605	-0.177	-0.107
Potassium (K)	0.273	-0.917	0.223	-0.182
Lime	-0.931	-0.338	-0.113	0.068
Aspect	-0.18	-0.801	0.245	-0.514
Slope	0.987	-0.150	0.027	0.047
Elevetion	-0.663	-0.26	0.062	0.016
Porosity	-0.966	0.088	0.194	-0.142
Bulk density (BD)	0.967	0.176	-0.153	-0.101

The underline coefficients have significant correlation with the relevant axes

The gradients of different RCs are shown in Table 5 for the first four axes. This table is related to Fig. 4, which shows the spatial distribution of the measured environmental properties and RCs.

Table 5. Coordinates (scores) of RCs in the study area

Range condition	Axis			
	PC 1	PC 2	PC 3	PC 4
Excellent (RC-Ex)	-4.033	3.210	0.860	0.198
Very poor (RC-VP)	4.803	0.000	2.119	-0.504
Fair (RC-F)	-0.378	-1.964	-0.110	2.108
Poor (RC-P)	2.834	1.351	-2.641	-0.297
Good (RC-G)	-3.226	-2.597	-0.228	-1.505

The following diagram shows the relationship/spatial distribution of soil-topography properties with RCs. For instance, poor (RC-P) and very poor (RC-VP) conditions have shown a direct and significant relationship with soil bulk density (BD), EC, slope and higher SM.

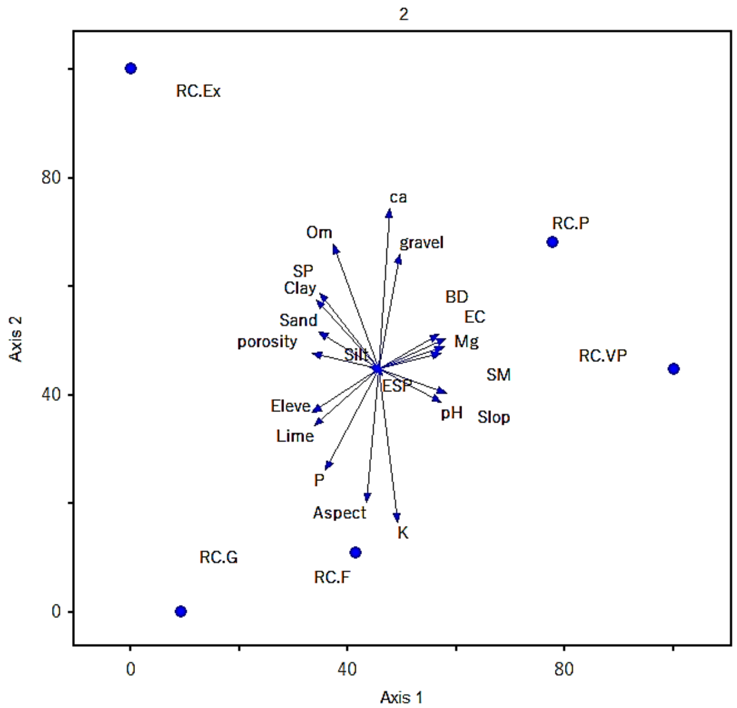

Fig. 4. Bioplote diagram for the environmental factor and RCs. RC= Range condition, Ex= Excellent, VP= Very poor, F= Fair, P=Poor, G=good, The full name of variables are presented in Table 4.

In study area, the changes in cover characteristics (i.e. height, coverage percent, freshness, regeneration, etc.) under changing RCs were significantly more pronounced and each RC had different cover characteristics. Therefore, the results of soil properties evaluation are presented here. The following diagram shows the values of the most important physical and chemical properties of soil under different RCs. Based on the results, some properties such as OM, P and porosity were significantly different ($p<0.05$). Moreover, despite the differences for some other factors i.e. EC, the difference was not significant under different RCs (Table. 6).

Table 6. Changing the soil factors under different RCs in the study area

Range Condition	OM (%)	pH	EC (mμ/cm)	Soil moisture (%)	Porosity (%)	K (%)	P (%)
Excellent (RC-Ex)	2.6^{a}	7.0^{b}	2.7^{a}	9.0^{b}	35.0^{a}	18.0	18.0^{c}
Very poor (RC-VP)	0.6^{b}	7.8^{a}	3.2^{a}	14.0^{ab}	12.0^{c}	17.0	30.0^{b}
Fair (RC-F)	2.1^{ab}	7.4^{ab}	2.8^{a}	15.0^{ab}	21.0^{b}	25.0	56.0^{a}
Poor (RC-P)	1.1^{b}	7.6^{a}	2.9^{a}	18.0^{a}	18.0^{bc}	24.0	21.0^{c}
Good (RC-G)	2.6^{a}	7.0^{b}	2.6^{a}	14.0^{ab}	34.0^{a}	21.0	20.0^{c}

Means of column followed by the same letters has no significant difference ($P<0.05$).

Discussion

Preliminary results of this study showed that environmental factors are significantly effective in separating vegetation types in the region. Edaphic factors i.e. lime, clay, K, OM, EC and geographical fators i.e. aspect/slope played an important role in the establishment and expansion of vegetation types. It seems that there is a direct relationship between the geographical direction and plant communities, especially in mountain areas (Goldin, 2001). In fact, in mountainous areas, geographical direction plays an important role in soil fators i.e. moisture and vegetation formation and development (Fu *et al.,* 2006; Jafari *et al.,* 2002).

In the study area, vegetation types of *Ju. ex- Fe. ov- On co, Ju. ex- Ju. co- Br. to* and *Ju. ex- Ju. co*. showed a direct relation to soil lime content, geographical direction and slope while other vegetation types were inversely related to these parameters and were directly related to soil properties such as clay, OM, K and EC. It seems that geographical direction is the most effective factor in distinguishing these vegetation types so that the above-mentioned types are more distributed in the northern direction and other types in the geographical direction to the south. Similarly, Liu *et al*. (2018) investigated the relationships between vegetation and soil properties in China and reported that although factors such as K, P, and lime were influential in shaping vegetation, OM has been the most important. Wang *et al.* (2016) also studied the relation between environmental factors and vegetation, and mentioned that a combination of the factors, especially soil properties influenced vegetation characteristics in loess plateau of China.

With increasing slope, decreasing EC and clay, species of *Juniperus* and astragalus had the most distrtibution. In this regard, it can be stated that due to light texture of soil and less sunlight, the amount of water available for the plant increases and evaporation from the soil surface and transpiration from the plant surface decreases. As a result, we can point to the effect of SM in this area on the distribution of the above species while it has been proven previously (Moles *et al.,* 2003; Taghipour *et al.,* 2011). It can also be found in the wide distribution of astragalus spp., *Juniperus polycarpus, Juniperus commonis* or *Onobrychis cornuta* in rough points indicating the lack of ecological conditions and the high tolerance of these species to harsh environmental conditions. It seems that the geographical direction and soil texture i.e. clay and sand percentage can be considered responsible for the sparse vegetation in this area. In fact, southern slope due to more salinity/EC and less moisture has less vegetation. Thus, by receiving more sunlight, and increasing evaporation from the soil surface, having soils with coarse texture and decreasing water availability for the plants, southern slope has less vegetation (Jane *et al.,* 2008). Therefore, the effects of environmental prpoertiese on vegetation varied according to scale and general characteristics of the region, i.e. direction, rainfall, etc. (Liu *et al*., 2018).

Moreover, by investigating the environmental (topographic and soil) and managerial effects on RC changes, the results of the variance classification showed that the most effect was related to managerial factor. Generally, knowing the RC in relation to environmental/managerial factors is pivotal for sustainable use of land (Haider *et al.,* 2011) and these changes will appear in soil and vegetation (Khaleghi and Aeinebeygi, 2016). At first, topographic factors, especially geographical direction and slope played an important role in the RCs in this mountain region under grazing, which corresponds to the results of previous studies (Khan *et al.,* 2017; Taghipour *et al.,* 2011). Other researchers also pointed to the non-uniformity effect of environmental variables on the land condition so that indicators such as topography, slope and maximum curvature had the highest correlation with soil properties changes (Babaeian *et al.,* 2019; Gholizadeh *et al.,* 2018).

Studying the common effect of environmental and managerial factors on RC showed that a high effect of managerial factor on RC changes and environmental factors of soil and topography had less effect. Among all soil factors, physical properties had a significant relationship with RC, which is consistent with the results of Sabahaddin *et al.* (2010); Tamartash *et al.* (2010); Shokrollahi *et al.* (2013). In fact, soil physical factors i.e. texture are related to the general performance of soil and play an important role in ecosystem productivity (Jensen *et al*., 2019; Ryals and Silver, 2013). Therefore, knowledge of these factors is essential to suitable land management and exploitation (Ladoni *et al.*, 2010; Wetterlind *et al.,* 2008) for the better rangeland conservation and improvement (Kohestani and Yeganeh, 2016).

Similarly, Angassa (2014) reported that grazing intensity significantly changed RC in terms of vegetation dynamics i.e. plants structures and composition. Khaleghi and Aeinebeygi (2016) also reported that managerial factor through grazing showed a significant relation with soil and vegetation characteristics in semi-arid rangelands of Shirvan in Iran. Howevere, RC, which is a combination of vegetation and soil conditions, was affected by livestock grazing programs (regular or irregular) in this mountainous area. In other words, there was a special relationship (and two-way interaction) between environmental characteristics (soil and topography) and RCs in this mountainous area. These findings are in accordance with the results of the Kohestani and Yeganeh (2016) over the 22-year range management plans (mainly grazing programs) in mountainous rangelands of Mazandaran Province, Iran.

The distribution of RCs in the two-dimensional space of multivariate analysis along with environmental and managerial variables showed that each RC is related to one or more environmental factors. So, RC influenced under management (grazing) in relation to both soil physical/chemical and topographic factors. This is found to be in accordance with previous findings in southern Ethiopia where grazing practices severely influenced RC (Angassa, 2014). Ruvuga *et al*. (2021) also reported that RCs are generally fair in miombo woodlands in eastern Tanzania and managerial practices through moderate livestock grazing are necessary to improve RC and avoid serious degradation.

In this study, SM, OM, K and P were the most important parameters in relation to RC changes. These properties are the most important and widely used elements of land that cause ecological differences (Shahriary *et al.,* 2012). The high amount of OM, Clay, BD and SM in the middle management situation (near the drinking water) increases through several mechanisms. First, as soil compaction and apparent specific gravity increase, soil oxygen storage decreases and vegetation will decrease through time (Lee et *al.,* 2011). The second mechanism is that severe grazing can affect the contribution of root biomass in the soil OM pool by changing plant composition and root-to-stem ratio. In fact, livestock grazing as a managerial factor increases the share of groundwater biomass/OM and SM will increase or maintains under less vegetation (Chaichi *et al.,* 2005). Moreover, the factors of slope, elevation, and SM are directly related to other factors i.e. OM in soil performance (Davy and Koen, 2013). It seems that soil factors, especially SM significantly changed under sever grazing and finally changed RC (Sheikhzadeh *et al.,* 2019). The results of the Lee *et al.* (2011) and Chaichi *et al.* (2005) also confirm these findings.

Furthermore, the results showed a direct/indirect effect of the managerial factor (i.e. types of exploitation/livestock grazing intensity) on the physicochemical properties of soil and consequently vegetation (Khan *et al.,* 2017). As the results of analysis of variance showed, a total of 98.43% of RCs changes was influenced by soil and management factors. Among the two studied factors, about 90.48 and 0.18% of RCs changes were due to managerial and soil factors, respectively. Therefore, deponding on the land characteristics, management factor influences the RCs by changing vegetation and physicochemical properties of the soil (Paz-Kagan *et al.,* 2016). Similarly, Sangeda and Maleko (2018) reported that management factor (grazing practice) played an important role in vegetation condition change in terms of its composition and abundance in northern Tanzania.

Overal, in this mountainous region, due to the severe change in topographic characteristics, different soil and vegetation types, and a minimum change in management factor (grazing) will show significant effect on RC. Soil and vegetation are intricately interconnected with numerous ecosystem services for human well-being and nature conservation (Ghosh *et al.,* 2019) and suitable land management programs can maintain the their function/performance even at regional scales (Akpa *et al.,* 2016; Han *et al.,* 2017). Therefore, management practices i.e. prescribed grazing, can improve RC through soil/vegetation quality improvement and reduce the rate of land degradation (Schuman *et al.,* 2002).

Conclusion

This study highlights the importance of environmental and managerial factors on RC in semi-arid mountainous areas. Based on the result, RC changes had more significant relation with managerial factor (grazing) than environmental factors in this area. In general, the effect of environmental and management factors and their common effect on RC changes were equal to 1.84%, 74.1 and 21.04%, respectively. Moreover, the change of soil physical properties was more than chemical properties under RC changes. Factors of OM, BD, SM and porosity showed significant changes under excellent, good, fair, poor and very poor RC. Generally, excellent and good rangelands were related to more OM and porosity and less slope and K, and poor and very poor rangelands were related to more SM, BD, P and slope.

Acknowledgements

The present study was supported by Department of Natural Resources, Faculty of Agriculture and Natural Resources, Islamic Aza University of Tehran. The authors also, thank to Dr. Yazdanshena and Dr. Alizadeh for their help, guidance and providing facilities during research.

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تأثیر عوامل محیطی و مدیریتی بر وضعیت مرتع در منطقه نیمه‌خشک کوهستانی چهار باغ در شمال ایران

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چکیده. مناطق کوهستانی نیمه‌خشک از نظر عملکرد اکولوژیکی مانند پویایی پوشش گیاهی، از اهمیت ویژه‌ای برخوردار هستند، و ارزیابی آن‌ها تحت عوامل مدیریتی و محیطی برای استفاده پایدار از آن‌ها ضروری است. با توجه به خصوصیات محیطی بسیار متغیر در این مناطق، مدیریت و بهره‌برداری صحیح از زمین می‌تواند وضعیت مرتع را شدیداً تحت تأثیر قرار دهد. بدین منظور، رابطه بین خصوصیات توپوگرافی و خاک و وضعیت مرتع تحت چرای دام از طریق تجزیه و تحلیل چند متغیره در مناطق کوهستانی چهارباغ استان گلستان (ایران) در سال ۱۳۹۸ مورد بررسی قرار گرفت. وضعیت مرتع به روش نمره دهی به خصوصیات پوشش گیاهی و خاک در مناطق تحت چرای دام انجام شد. بر اساس یافته‌های اولیه، میزان رس خاک، فسفر، هدایت الکتریکی، شیب و جهت جغرافیایی، پتاسیم و رطوبت خاک بیش‌ترین تأثیر را در تشکیل ۵ تیپ مختلف پوشش گیاهی در این ناحیه داشتند (Cum.% of Var.=80.4%). نتایج نشان داد که تغییرات وضعیت مرتع با عامل چرای مدیریتی نسبت به عوامل محیطی در این منطقه رابطه معناداری دارند. به طور کلی، تأثیر عوامل محیطی و مدیریتی و تأثیر مشترک آن‌ها در تغییر وضعیت مرتع به ترتیب برابر با ۱/۸۴، ۷۴/۱ و ۲۱/۰۴ درصد بود. با توجه به تغییرات وضعیت مرتع، تغییر خصوصیات فیزیکی خاک بیش از خواص شیمیایی آن بود. ویژگی‌های ماده آلی، تراکم ظاهری خاک، تخلخل و رطوبت خاک به طور قابل‌توجهی تحت وضعیت‌های عالی، خوب، متوسط، فقیر و خیلی فقیر مرتع تغییر نشان داد($P < 0.05$). به طور کلی مراتع خوب و عالی با مقدار ماده آلی و تخلخل رابطه مستقیم و با شیب زمین و مقدار پتاسم خاک رابطه معکوس داشت. مراتع فقیر و خیلی فقیر نیز با مقدار فسفر، رطوبت خاک، تراکم ظاهری و شیب زمین رابطه مستقیم داشت. به طور کلی مدیریت چرای دام به طور چشمگیری می‌تواند موجب تغییر یا بهبود شرایط مرتع در مناطق کوهستانی شود.

کلمات کلیدی: ترکیب گیاهی، ارزیابی مرتع، وضعیت خاک، استفاده پایدار