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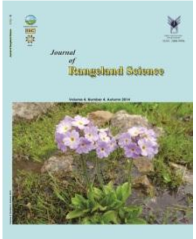

Research and Full Length Article:

Determining Rangeland Suitability for Sheep Grazing Using GIS (Case Study: Sadegh Abad Watershed, Kermanshah Province, Iran)

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Received on: 02/05/2014
Accepted on: 24/11/2014

Abstract. Rangelands are mainly used for grazing the livestock in Iran, it is essential to specify grazing suitability of rangelands in each region of country, so that it may improve the management policies and approaches for planning and designing current and future plans. The aim of this research was to determine the rangeland suitability for sheep grazing in the watershed of Sadegh Abad, Kermanshah Province, Iran. Three sub-models namely forage production model, water siutablity model (quantity, quality and distance of water resources) and erosion sensibility which formed the components of the final studied model. EPM procedure for erosion sensitivity and FAO method for land capability evaluation were employed. Furthermore, combining information layers was done by means of ArcGIS9.3 software. For forage production suitability, the effective factors as allowable limit of exploitation, having access to forage and physical conditions were considered. Our findings indicated two separate classes including low suitability (S3) and non-suitability (N) with the contributions of 68.65 and 31.34% rangeland area, respectively. Low suitability was due to soil erosion sensitivity and limited standard exploitation of forage. In some regions, distance to water resources and high slope of grazinig land caused the decrease of grazing suitability. Considering the grazing capacity and applying the correction programs in rangelands can affect the increase of range suitability for grazing sheep. Using GIS may lead to the increase in accuracy and speed of implementing plans.

Key words: Sheep grazing, Suitability, Geographical Information System (GIS), Slope, Soil erosion

Introduction

Rangelands are regarded as natural ecosystems that occupy the most areas of earth (Mesdaghi, 1998). It is managed as a natural ecosystem supporting indigenous vegetation, common grasses, shrubs and forbs (Havstada *et al.*, 2007). Rangelands constitute almost 52 percent of the country area computed as 164 million ha. The extent of rangelands has been estimated as 84 million ha in Iran and they have been classified as good, moderate to poor and poor to very poor ones ranged as almost 10, 42 and 48 percent, respectively (Khakpour, 2011). One of the fundamental problems concerning land uses of rangelands is that rangelands are not to be used on the basis of their potentials and suitability and the improper land use let to excessive degradation of range. Moghadam (1998) defined range suitability as a situation in which the range can be used for grazing by livestock and it may not restrict the range use in future years and it is able to be used for long periods without damaging the vegetation cover and soil of a specific area and its adjacent regions. On the other hand, the exploitation of rangelands is happening without attention to the suitability and capacity of them (Kakularimi and Yasar, 2013).

Many factors affect the rangeland suitability such as vegetation and abiotic factors such as land slope, hillside length, soil properties, erosion sensibility, water distribution and etc., (Amiri *et al.*, 2011). Water is a major determinant of livestock distributions and grazing.

Livestock grazes from a water point to another depending on the availability of forage and water (Schlecht *et al.*, 2004; Amiri, 2009b). Mainly grazing animals in rangelands of Iran are sheep and goat (Hosseininia *et al.*, 2013). It provides an environment where collected information and data can be used in a spatial framework to predict the behavior of animals over several periods of time (Ungar *et al.*, 2005; Miller, 2012). GIS application to analyze the grazing capability at a landscape scale is not a new concept. Amiri (2009a) utilized GIS to portray rangelands suitable for sheep grazing in the semi-arid landscapes of Iran. Roukos *et al.*, (2011) assessed the rain use efficiency factor and the grazing capacity of Preveza Prefecture rangelands in Greece by applying GIS techniques and field works. Their results showed that the usable forage in grasslands and phrygana range types is inadequate to meet the grazing animal requirements. Integration of remote sensing and GIS techniques provides reliable, accurate and up-to-date information on land and water resources which is a prerequisite for the purpose of multi-criteria decision-making for site suitability analysis of ground water recharge (Mehrabi *et al.*, 2012). In order to classification of goat grazing suitability using GIS, a study was conducted in middle Taleghan rangelands (Sour *et al*., 2013b). The findings indicated that no vegetation type was classified in S1 (High suitability) and N (Nonsuitability) class and most of the studied types were grouped into class S2 (Moderate suitability). The capability of GIS multi-criteria evaluation for rangeland suitability assessment was approved (Sour *et al.*, 2013b).

Considering the fact that 73 million livestock out of 124 million ones existing in the country consist of sheep and goats and given that more than 70 percent of country cattle rely on the rangelands (Arzani, 2003), it is essential that limitations and lack of limitations should be addressed and investigated in order to use the range potentials appropriately and determine the range suitability for grazing the livestock. The aim of this study was to determine the rangeland suitability for sheep grazing using GIS in the watershed of Sadegh Abad, Kermanshah Province, Iran.

Materials and Methods

Study area

Research location in this study was Sadegh Abad watershed, Kermanshah Province, Iran (latitude: 34˚ 43' 02"- 34˚ 46' 04"; longitude: 46˚ 36' 19" 46˚ 36' 21"; altitude: 1410-1660 m). The surface of this area is 1613 ha with 508 ha of rangeland in south of Ravansar, Iran (Fig. 1).

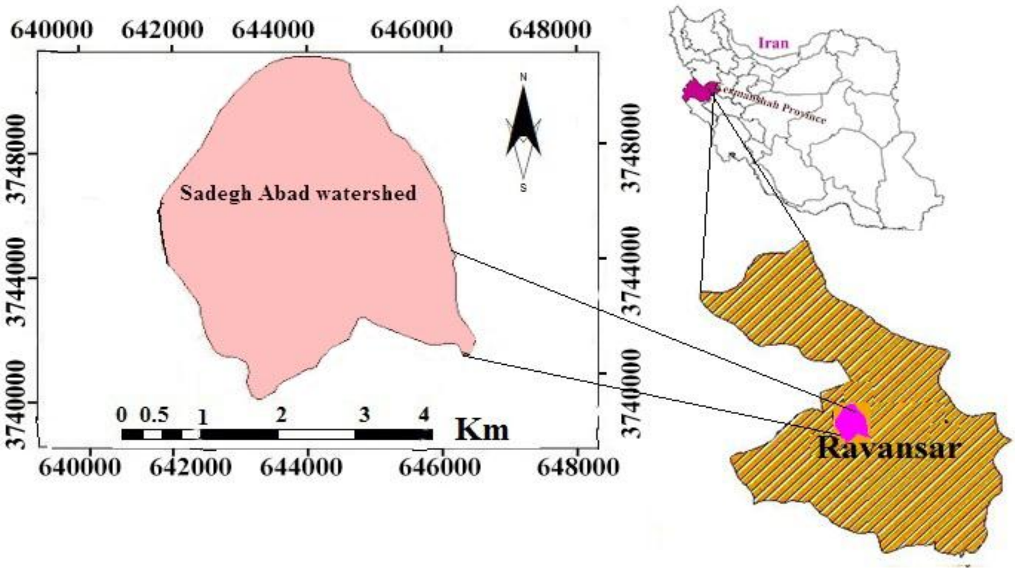

Fig. 1. Location map of Sadegh Abad, Ravansar, Iran (1:50000 scale)

Research method

The study was carried out using FAO method and GIS in 1:50000 scale. FAO method was applied to investigate and determine the capacity of the land (FAO, 1981). Assessment and grading of various factors performed using common standard procedures. Topographic maps (1:50000 scale) and aerial photographs (1:20000 scale) were used for primary classification. After determining the primary types, field operations were conducted and all regions were gauged. Sampling of the vegetation types was done in a random-systematic form by locating fourteen 1m^2 plots according to the designed map and density, composition, size and homogeneity of the vegetation. For determination of the plot location, stand area of types was determined, then plot locations were selected and the data collected in each type (based on Sour *et al*., 2013a).

ILWIS4 software was used for data analysis, design vector map (with 100 m distance between vector lines) and Digital Elevation Model (DEM mapping) preparation. Then slope direction (Fig. 2) and slope points prepared (Fig. 3). Slope map was classified into arbitrary classes based on the aim of the study. Position of water resources was determined using a topographic map for mapping of the points with the same distance from water resources (Fig. 4). Using the available data, points with the same distance from water resources were mapped for each customary order. Then the overall map of the points with the same distance from water resources was created for the whole region. Finally the latest model of rangeland suitability for grazing was prepared based on three sub-models, namely forage production model, water model (quantity, quality and distance of water resources) and erosion sensibility (Arzani, 2006).

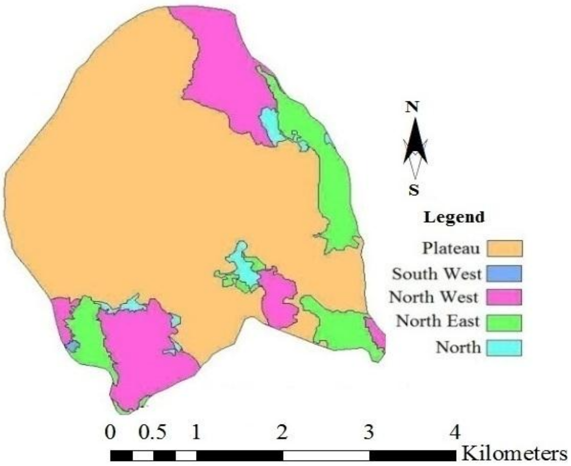

Fig. 2. Map of slope direction of Sadegh Adab watershed

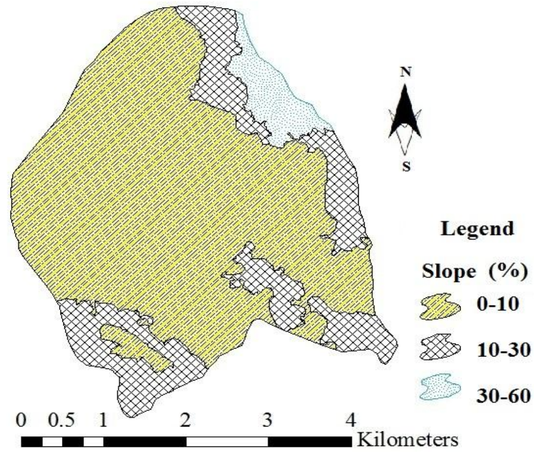

Fig. 3. Slope % map of Sadegh Abad watershed

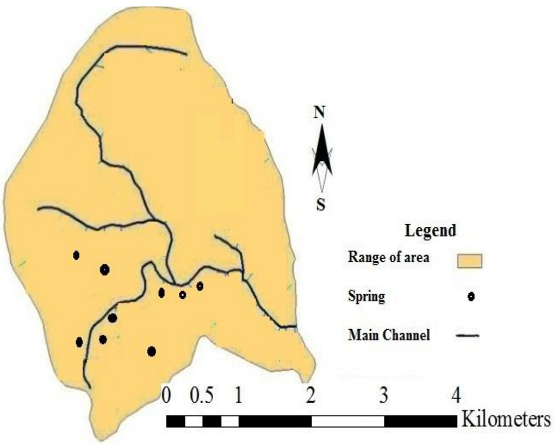

Fig. 4. Map of water resources of Sadegh Abad watershed

Forage production suitability

Production of palatable species for grazing sheep was estimated through cutting and weighing sampling method since this method is the most accurate one in order to calculate the production. Accordingly, plants were placed in the separated packages for each plant type in order to estimate the plant production and harvest of every plot considering the plant species and afterwards, they were dried and weighed. Finally, forage production of palatable species for sheep has been specified for each plant type and forage production of plant types has been estimated through collecting every species production in the studied area.

Then, the regions that have the rate of production less than 150 kg/ha may be considered as unusable rangelands. Forage production suitability classes were S1, S2, S3 and N for 50%, 30-50%, 20-30% and less than 20% forage production, respectively.

To calculate the usable forage rate of the cattle, it is necessary to estimate the allowable exploitation limit. Effective factors on the allowable exploitation limit involve soil sensitivity to erosion and range condition and orientation. For determining the range conditions, orientation and soil sensitivity to erosion, the corrected four-factor method, orientation scale and Erosion Potential Method (EPM) were utilized. At last, the allowable exploitation limit suggested for each plant type was estimated (Arzani, 2006).

Suitability model of soil erosion

In suitability model of soil-erosion, EPM model was used. It was based upon scoring four factors including topographic status, lithology, soil, land use and climatic elements. Finally, erosion status in the watershed was qualitatively classified using method of Ahmadi (1999), in Table 1.

Table 1. Erosion intensity classification using EPM model (Ahmadi, 1999)

Erosion Classification	Limit Rate of Z	Erosion Intensity	Suitability to Erosion
1	Z >1	Very high	N
2	1> Z >0.71	High	S3
3	0.71> Z >0.2	Moderate	S2
4	0.4> Z >0.2	Low	S1

Suitability model of water resources

Suggested model has been combined of three sub-models involving quantity, quality and distance from water resources.

a) Sub-model of distance from water resources

Regarding the fact that when several water resources exist for one specific plant species or range allotments, distances between water resources may be twice as the maximum distance which must be covered by the cattle to reach the water resource. Distance to water resources can be adjusted as follows (Table 2).

Table 2. Adjusted distances (m) from water resources for sheep in the slope classes of 0-60% (Ariapour *et al*., 2013)

Slope Class	Suitability Class			
	0-10%	10-30%	30-60%	>60%
S1	0-3400	0-3000	0-1000	N
S2	3400-5000	3000-4800	1000-3600	N
S3	5000-6400	4800-6000	3600-4100	N
N	> 6400 m	> 6000 m	> 4100 m	N

b) Water quantity sub-model

In this step, the location and discharge of water resources were determined and summed up within each type of plant boundary for calculating water availability. Comparing animal water demand with available water, indicates the results in the water quantity suitability sub-model. According to climatic conditions, vegetation characteristics, grazing season and animal type, animal water demand were estimated for sheep. The suitability categories were then determined by comparison of the available water with the needed water by the livestock (Karami *et al*., 2014) (Table 3).

Table 3. Water resource suitability classes (Ariapour *et al*., 2013)

Available Water in Pasture Ration to Livestock Need (%)	>76	51-75	26-50	<25
Suitability classes	S1	S2	S3	N

c) Water quality sub-model

In this study, water quality data of water resources [pH, EC, Total Dissolved Salts (TDS), Na, Cl, Co_3, Mg, SO_4, Ca, Total Hardness (TH), S.A.R, K^+, Mg^{2+} and NO_3] were provided from local offices, Sadegh Abad watershed, Kermanshah Province, water management and other researches and compared with standards to determine water quality suitability.

Finally these three sub-models were integrated to make the final water resources suitability model for extensive grazing (Ariapour *et al*., 2013).

Final model of range suitability

In this stage, through combining final maps resulting from three sub-models including forage production, water resources and soil sensitivity to erosion and based on the restrictive conditions presented by FAO (1991), final map of range suitability along with its classes was achieved based on FAO (1993). Since this paper aims to study and determine the range suitability for grazing sheep, it is essential to separate rangelands and non-range lands from each other and range suitability has to be specified only for rangelands. Also suitability classes for all the models in this study were: S1 (good), S2 (normal), S3 (weak) and N (no suitability).

Results

Regional rangelands' area has been recorded as 508.13 ha. Two dominant plant types of *Astragalus gossypinus* Fisch- *Hordeum bulbosum* L. and *Astragalus gossypinus* Fisch-*Gundelia tournefortii* L. with the areas of 75.31 and 532.82 ha were recognized (Fig. 5).

Suitability forage production model

As findings indicated, type of *As.go-Ho.bu* with a total production of 2290 (kg/ha) had positive position with average trend ranked as class of S2 suitability. According to the results of soil sensitivity to erosion model, it classified in S3. The ratio of available forage to the total forage in the plant type was 40.61%. Therefore, this type according to model of feed suitability was in class S2. Type *As.go-Gu.to* with a total production of 1790 kg/ha had negative position and weak trend so it was ranged as suitability class of S3 concerning production suitability. The ratio of available forage to the total forage in this plant type was 39.27%. Therefore, this type according to model of feed suitability and soil sensitivity to erosion model was classified in class S2 and S3 respectively (Fig. 6 and Table 4).

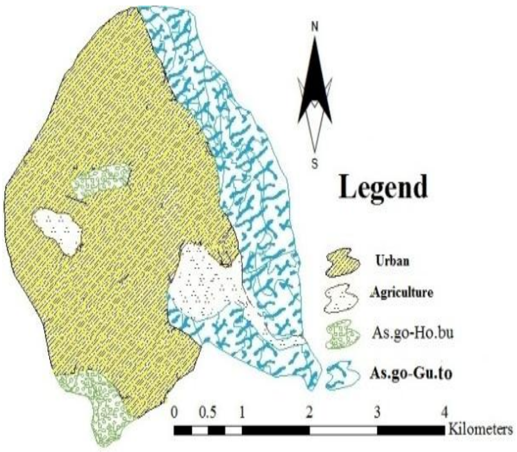

Fig. 5. Map of vegetation types of Sadegh Abad watershed

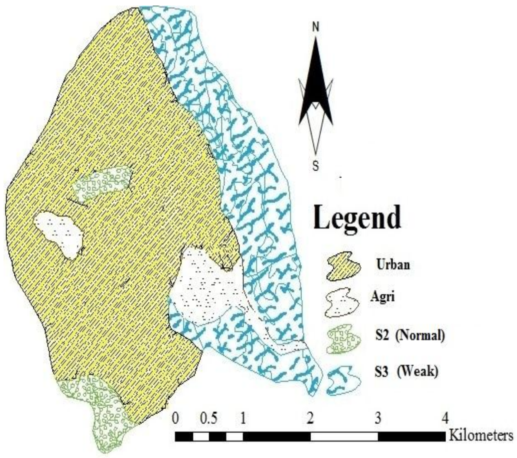

Fig. 6. Forage production suitability model (Sadegh Abad watershed)

Table 4. Forage production suitability classes of plant types of case study

Type Code	Dominant Species	Area (ha)	Trend	Condition	Useable Forage (kg/ha)	Capacity of Grazing Period (month)	Suitability
1	*As.go-Ho.bu*	75.31	Positive	Average	930	233.4	S2
2	*As.go-Gu.tu*	432.8	Negative	Weak	703	1014.2	S3
Total	-	508.13	-	-	-	1247.6	-

Soil sensitivity to erosion model

Obtained results by evaluating effective factors on the erosion using EPM for studied plant species indicated (Table 6) that 4.6 ha (0.92%), 58.24 (11.46%), 351.1 (69.11%) and 94.06 ha (18.51%) of rangelands have been classified as S1, S2, S3 and N (non-suitability), respectively (Fig. 7 and Table 6).

Regarding *As.go-Ho.bu*, rain fed cultivation was applied due to proximity to the village but then, the lands were abandoned. It can be introduced as the most important element of soil erosion and some parts of the lands were used for grazing the livestock because they were near the village and they were regarded as a part of private rangelands. In fact, the grazing periods are very long in these lands. Erosion of *As.go-Gu.to* and proper use factor of land caused that the mentioned type having the erosion intensity coefficient of 0.64 was put in the suitability class of S2 and erosion class of III (moderate erosion) concerning the soil sensitivity to erosion and erosion intensity by the help of EPM, respectively. Surface erosion leads to the lack of vegetation establishment and reduction of suitability class with respect to soil sensitivity to erosion in these two plant types. Reductive elements of range suitability degree in the studied area can be mentioned as soil and rock sensitivity to erosion, existing erosions in the region and proper use factor of lands (land use-range conditions) and they have direct relationship with the distance from the villages.

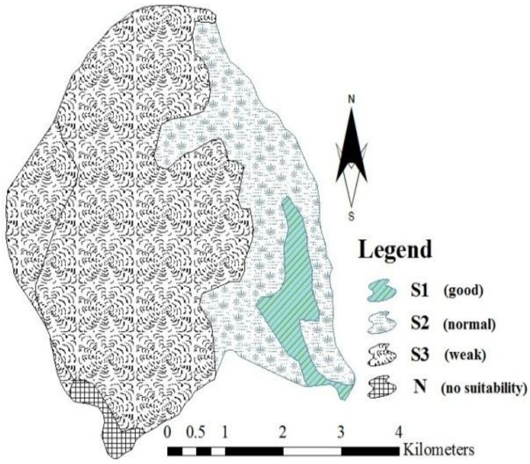

Fig. 7. Map of soil suitability to erosion (Sadegh Abad watershed)

Table 6. Area and area percent of suitability classes of soil sensitivity to erosion in rangelands of case study

Suitability class	Erosion intensity	Area (ha)	Area percent (%)
S1(good)	Low	4.6	0.92
S2 (normal)	Moderate	58.24	11.46
S3 (weak)	High	351.1	69.11
N (no suitability)	Very high	94.06	18.51
Total		508	100

Suitability water resources model

Research results showed that water resources in the studied area are of appropriate distribution and all the water resources constitute natural springs. The most important reason of it, is sufficient rainfall, especially snow in winter, as well as the melting of snow in spring. Regarding to quality and quantity of water resources, there is no limitation for the case study and all the plant types have been ranked in the class of S1. According to the suitability model of distance from water resources, 242 ha of rangelands in the studied area might be classified as S1 suitability. Also, 190 and 74 ha of rangelands in case study were classified as S2 and S3 suitability (Fig. 8 and Table 7).

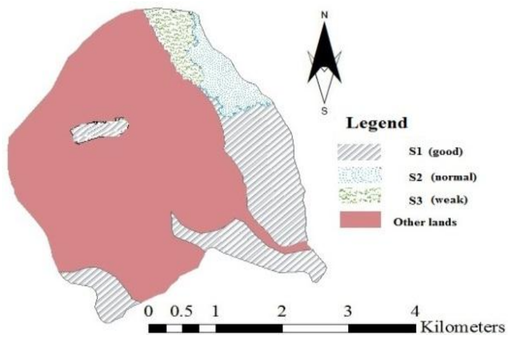

Fig. 8. Map of water resources suitability (Sadegh Abad watershed)

Table 7. Suitability classes' area and percent of distance from water resources in case study and regional rangelands

Suitability Class	Regional Rangelands (ha)	Area (%)
S1 (good)	242.4	47.73
S2 (normal)	190.9	37.59
S3 (weak)	74.5	14.68
Total	508	100

Final rangeland suitability model

The results of the final model of suitability for sheep grazing which is obtained from mentioned three sub-models indicated that 348 ha (68.65%) dropde in class S3. 159 ha (31.34%) of the area classified in N (non-suitaible for livestock grazing) (Fig. 9 and Table 8).

Also this final model of suitability showed that the most important reducing factors of the rangeland suitability were soil erosion, water resources, low amount of available forage for livestock as compare total forage production, rangeland condition and land slope. High land slope more than 60% decreased the suitability of 14.68% of the area (Table 7). In addition to these factors, other decreasing factors which can also be noted, were the low prevalence of vegetation, soil susceptibility to erosion, early grazing and overgrazing, lack of grazing systems from farmers, fundamental ignoring of custodians to economical and social issues of farmers, drought stress in the past few years, and the conversion of pastures to low yielding rain-fed farms.

Table 8. Classification of the studied total area and rangeland

Suitability Classes	Rangelands	
	Area (ha)	Area %
S_3 = low suitability	348.78	68.65
N= non-suitaible for grazing	159.22	31.34
Sum	508.00	100.00

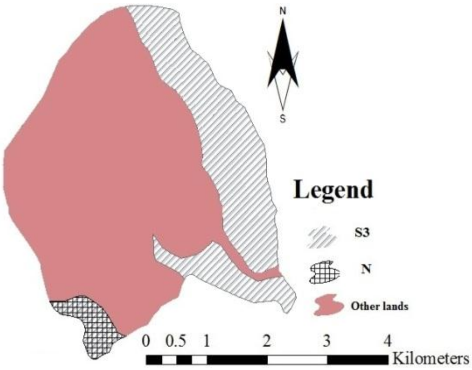

Fig. 9. Final rangeland suitability map (Sadegh Abad watershed)

Discussion

Our findings illustrated that most of rangeland in the evaluated area weren't homogenous because of the variable classification. Land slope was an important problem to decrease suiatability and increase soil erosion. The slope of pastures specially in mountain rangeland is a serious problem in Iran which has been followed by other researchers (Abolhassani, 2011; Hosseini, 2013) as was found in this study. Water resource distance was a second challenge for about half of studied rangelands. This problem decreases rangeland suitability and sheep yield as reported in some projects (Ansari-Renani *et al.*, 2013). According to these findings, no shortcomings (regarding the quantity and the quality of available water), except for the distance to water resources was reported; which is the main factor for determining the suitability of rangeland regions with respect to water resources (Kakularimi and Yasar, 2013).

Domination of the mentioned *Astragalus* spp. indicated plant biodiversity loss, human intervention in nature, overgrazing and over capacity exploitation of evaluated rangelands. These species are inappropriate for sheep grazing (Pollock, 2006). Human is a part of the ecosystem and an instrument for ecological changes. Healthy natural ecosystems reflect the health of human systems (Amiri, 2009a). Therefore decline the human intervention in assessed rangeland leads to recovery and sustinabilty of them.

Conclusion

We concluded that the most important issues and problemes of the studied areas were overgrazing and overcapacity. These problemes increase plant biodiversity loss and decrease rangeland suitability for grazing. Therefore it is suggested to conduct a research project to find a solution for the problems. Because of the economic potentiality in the studied region, such as the presence of medicinal and industrial plants in rangeland vegetation, it is necessary to perform a research using a multi-purpose of the rangeland examination. Attention to some other aspects of rangeland is required such as genetic resource, environment and etc. Our findings showed two separate classes as low suitability (S3) and non-suitability (N) with the contributions of 68.65 and 31.34% rangeland area, respectively. Low suitability was due to soil erosion sensitivity and limited standard exploitation of forage. In some regions, distance to water resources and high slope of grazinig land caused the decrease of grazing suitability. Considering the grazing capacity and applying the correction programs in rangelands can affect the increase of range suitability for grazing sheep.

Acknowledgments

The authors are grateful to chief and staff of the Research Institute of Forests and Rangelands, Kermanshah, Branche, for their supporting in the preparation of this project.

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بررسی شایستگی مرتع حوزه آبخیز صادق آباد کرمانشاه برای چرای گوسفندان با استفاده از سامانه اطلاعات جغرافیایی (GIS)

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چکیده. با افزایش جمعیت، متنوع شدن نیازهای جوامع بشری و محدود شدن منابع طبیعی، مراتع به‌عنوان یک منبع طبیعی با ارزش، هر روز اهمیت خود را بیش از گذشته نمایان می‌سازند. از آنجا که استفاده عمده از مراتع ایران برای چرای دام بوده، لازم است برای مراتع هر منطقه شایستگی آن در این خصوص مشخص شود که به بهبود مدیریت جهت برنامه‌ریزی و طراحی برنامه‌های فعلی و آتی کمک کند. بنابراین در این پژوهش شایستگی مراتع حوضه آبریز صادق آباد در استان کرمانشاه برای چرای گوسفند در سال ۱۳۹۱، مورد بررسی قرار گرفت. در این تحقیق سه مدل فرعی تولید علوفه، مدل کمیت، کیفیت آب، فاصله از منابع آب و حساسیت به فرسایش خاک اجزای مدل نهایی مورد بررسی را تشکیل دادند. روش EPM برای ارزیابی حساسیت به فرسایش و روش FAO برای ارزیابی قابلیت زمین استفاده شد. همچنین تلفیق لایه‌های اطلاعاتی با استفاده از نرم افزار ArcGIS9.3 صورت گرفت. به منظور بررسی شایستگی از نظر تولید علوفه، عوامل موثر شامل حد بهره‌برداری مجاز، دسترسی به علوفه و شرایط فیزیکی در نظر گرفته شد. یافته‌ها ۲ کلاس شایستگی را نشان داد که شامل شایستگی کم (S۳) با سهم ۶۸/۶۵٪ و بدون شایستگی (N) با سهم ۳۱/۳۴٪ بود. حساسیت خاک به فرسایش و حد بهره‌برداری مجاز به عنوان عوامل کاهش‌دهنده شایستگی، تشخیص داده شدند. در برخی مناطق دوری از منابع آب و شیب زیاد زمین سبب کاهش شایستگی چرا گردید. رعایت ظرفیت چرا و به کار بردن برنامه‌های اصلاحی در مراتع می‌تواند در افزایش شایستگی مراتع برای چرای گوسفندان موثر باشد. همچنین نتایج این تحقیق استفاده از تکنیک GIS برای افزایش دقت و سرعت مورد تایید قرار داد.

کلمات کلیدی: چرای گوسفند، شایستگی، سیستم اطلاعات جغرافیایی، شیب، فرسایش خاک