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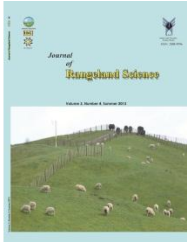

Full Length Article:

Modeling the Limitative Factors of Forage Production Suitability Using GIS (Case Study: Aliabad Rangelands, Lorestan, Iran)

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Abstract. This research was conducted to identify the limitative factors of forage production suitability in order to achieve the sustainable exploitation of natural ecosystems in Aliabad Watershed in Lorestan in 2013. The field measurements have been done through cutting and weighing method to estimate the forage amount, four-factor method to determine the range condition, trend scale to specify the orientation and appearance, the plant cover percent measurement to categorize the types and desert scroll to separate the land units followed by the classification. At last, all the digital maps of type, orientation, condition and forage production by the help of integration were changed into the final forage production suitability map using specific software ArcGIS 9.3. Results indicate that 6 separated vegetation types have been put in the suitability classes of S1, S2 and S3 for the areas of 972 ha (20.02%), 3478 ha (71.62%) and 406 ha (8.36%), respectively and no part of the given rangelands was placed in non-suitability class (N). Considering the results obtained from final suitability model of range production in this study, it has been found that high slope was the most restricting factor of range suitability. In addition, there were other decreasing factors such as low percentage of vegetation, overgrazing, early grazing, nonconformity of livestock and rangeland balance and changes of ranges into low-yielding dry lands' farming as well as forage production. It was concluded that the accuracy, simplicity and quickness can be considered as fundamental elements to determine the range suitability using Geographical Information System (GIS) which has been addressed in this study.

Key words: Available forage, Proper use factor, Production, Palatability, GIS, Aliabad

Introduction

Rangelands can constitute the widest area of mountainous regions in Zagros Mountains and a large portion of these ranges is not of appropriate quality and quantity of forage production and suitable access to water resources. It cannot meet all the water requirements and livestock forage and the erosion rate is high in this region which is hardly to be controlled to achieve a sustainable production. Certainly, it completely depends upon the exploitation history of these rangelands (Moghadam, 1998). Need to sustainable and balanced uses of land resources and information overload along with the increasing applications of them in a variety of systems related to the land such as natural resources and their dynamic nature and alterability have forced the human beings to apply modern techniques and sciences as well as electrical utilities and new methods (Makhdom, 2001). Since the exploitation of ranges has been done without regarding the capabilities of them and existing resources, many ranges have been intensely destructed due to their special-purpose applications. Considering the fact that each ecosystem has specific resources, recognizing these resources and planning in order to achieve the exploitation ratio to the existing range resources in every region decrease the rangeland destructions while protecting and reviving them. Thus, determination of range suitability has been one of the most difficult and significant issues for analyzing the range and knowing the elements affecting this task is of considerable importance (Mohtasham Nia, 2000). Determining the range suitability can introduce the existing resources and capabilities to realize the potentials of effective rangelands and according to the definition expressed by FAO[1], land use capability is defined as the range usage with regard to the sustainable usage of these lands (FAO, 1991 & 1993). Young (1987) expressed that the evaluation of range suitability might be the basic step for planning the land uses based on their capabilities. Zander and Kalcheh (1999) stated that for range Suitability, the explanation of current exploitation procedure is not important but the discussion of applying the range potentials for various types of applications has to be presented. Kakolarimi *et al.* (2009) have specified the suitability of Lasem Rangeland for grazing the sheep. Research results have shown that slope has been the most important factor for the reduction of range suitability. 3.7, 22.7, 41.8 and 31.8 percent of rangelands may be classified as suitability classes of S1 (good), S2 (normal), S3 (weak) and N (no suitability), respectively. Results of the study done by Gholinejad *et al.* (2012) concerning the evaluation and comparisons of different methods for estimating forage production in the desired rangelands in Kurdistan Showed that the composition of range plants was one of the factors affecting the accuracy of estimation methods and the important diversity of ecosystem is more likely to be a key to achieve an appropriate method to estimate the spectrum of production. The capability of GIS multi-criteria evaluation for rangeland suitability assessment was approved (Sour *et al*., 2013). Ariapour *et al.* (2013) have modeled the water resources' suitability of Sarab Sefid Rangeland in Boroujerd and stated that considering 16 separated types, all of them were put into the classes of S1 and S2 which are of no limitations with respect to the quality, quantity and distance to water resources. Integration of remote sensing and GIS techniques provides reliable, accurate and up-to-date information on land and water resources which may be a prerequisite for the purpose of multi-criteria decision-making for site suitability analysis of ground water recharge (Mehrabi *et al.*, 2012). Regarding the fact that 73 million livestock units out of 124 million livestock of the country involve sheep and goats and more than 70 percent of existing livestock may rely on the rangelands (Moghadam, 1998), it is necessary to investigate the limitations and

1- Food and Agricultural Organization

effective elements of range suitability determination such as forage production for the livestock grazing to improve the use of range potentials. Thus, Aliabad region in Aleshtar city has been investigated with respect to high number of sheep.

This paper aims to suggest a suitability model of forage production using the capabilities of GIS and identify the most significant elements influencing the selection of suitable zones in the studied rangeland for grazing the livestock.

Materials and Methods

Study area

The study area is located in Aliabad, Aleshtar in Lorestan Province in the center of Iran. Aliabad Watershed with the area of 8289 ha has been located in the longitude of $48^{\circ}16'48''$ to $48^{\circ}28'45''$ E and latitude of $33^{\circ}46'27''$ to $33^{\circ}52'06''$ N (Fig. 1). Maximum and minimum height rates of the region are 3577 and 1619 m above sea level, respectively. Its mean annual precipitation and mean annual temperature are 582 mm and 8.5°C.

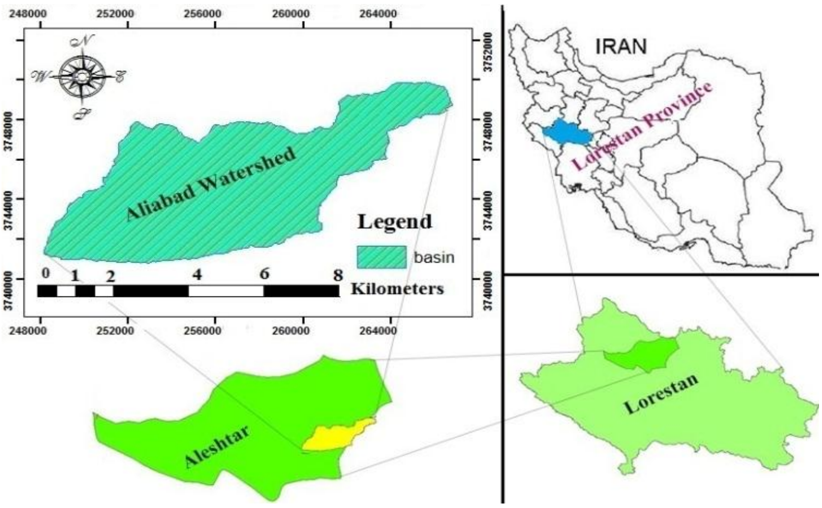

Fig. 1. Location of the study area, Aliabad Watershed

Methods

After drawing topographic maps of case study regarding 1:25000, a topographic map with the scale of 1:50000 was provided using Landsat ETM images and sampling. In this paper, softwares of ArcGIS and Gps were implemented. First, the region was completely explored by the field inspections and the case study has been digitally marked on the desired maps. Considering the fact that vegetation is always changing because of environmental conditions and management variables, vegetation studies have classified the plants according to the plant types. Plant types were specified and then, distinguished through studying the dominant species and conducting field inspections by the use of flouristic method and in addition, field harvests have been done. Vegetation sampling of plant types has been performed using a randomized systematic sampling method in May, 2013 (before the beginning of grazing season).

To collect vegetation data in order to present a forage production suitability model, four-factor method, trend scale and range classification have been utilized through cutting and weighing method to determine the range conditions, specify the tendency and appearance, estimate the forage production and measure the plant cover percentage.

Production suitability criterion

In production Suitability criterion, total and usable production rates of every type were calculated. Every type's total production has been estimated in the 1 m^2 plots by the means of cutting and weighing method. This method is the most accurate one in order to compute the production rate. Therefore, in every plant type, number of plots was determined through the size of samples. Afterwards, plotting was performed on the basis of number of given plots. In each plot, all the existing species have been recorded and palatable species were recognized and regarding the views of experts working in Natural Resources Organization and local ranchers, they were classified into palatable classes I, II and III according to the livestock type (Moghadam, 1998). Then, species of classes I and II and few species of class III which were dominated and grazed in the region have been cutted by specific scissors and their weight was recorded. After being dried outdoors, their dry weight has been computed (Jung, 2006). By collecting all the species belonging to one type, total production rate of that type was given. Furthermore, by adding the plants of each class and determining their ratio to total production rate in every type, the production percentage of calsses I, II and III has been calculated. Concerning production suitability model, it is essential to specify the usable production in addition to the calculation of total production rate of each type. To determine the usable production of every type, being familiar with the production rate of classes I, II and III is required for the allowable exploitation limit of palatable species. If the rangelands are to be constantly grazed during the grazing seasons, allowable exploitation limit will be given as almost 50 percent (half of cultivation amount and half of harvest amount) but SRM[2] (1991) has proposed that the allowable exploitation limit should be considered as 60 percent when the ranges are periodically harvested or grazed under the specific grazing systems. It should be noticed that since palatability of plants depends on the type of grazing livestock in a variety of rangelands, palatability class of plant species has to be computed with respect to the local experts' views and range plant code booklet (Annanymus, 2011). Proper Use Factor (PUF) is defined as the degree of utilization of the current year's growth that if it is continued, it will lead to achieve management objectives and maintain the long-term productivity of the site. PUF varies within seasons and systems of grazing (Butler *et al.*, 1997). Seasons, rainfall, soil erosion, slope types, vegetation types, rangeland conditions and trend, palatability and management are all the factors that can be included as components for the available forage model. In order to calculate the usable forage production rate, there are various methods but due to their complexity, the mentioned method is to be utilized (Table 1 & Figs. 2 and 3).

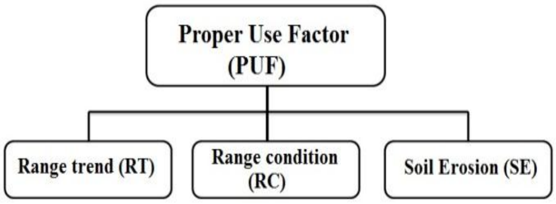

Fig. 2. Conceptual model of Proper Use Factor (PUF) based on Range Conditions (RC), Range Trend (RT) and Soil Erosion (SE) (Amiri *et al.*, 2011)

Calculation of usable forage production and forage production suitability

Grazing season is almost constant in the region and because of low level, climate changes are trivial and negligible in the studied area. Thus, these two factors are omitted from the model. With regard to the results of soil sensivity to the erosion (MPSIAC[3] model), erosion conditions of each type are to be given. Then, Table 1 was used for specifying the allowable exploitation limit of every plant type. As table 1 has already shown, the allowable exploitation limit of each plant type has been calculated on the basis of suitability class, soil sensivity to the erosion and range types' conditions and orientation. Through field studies and interviews with the experts of Natural Resources Organization of Aleshtar city as well as range plant code booklet, every plant species was classified into palatability classes I, II and III and

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3- Modified Pacific South West International Agency Committee palatability coefficients for these classes might be regarded as 50%, 30-35% and 20-25% and lower than 20%, respectively. Suitability classes will be S1 (good), S2 (normal), S3 (weak) and N (no suitability) concerning the forage production (Arzani, 2006). It has been found what percentages of production are related to the classes I, II and III.

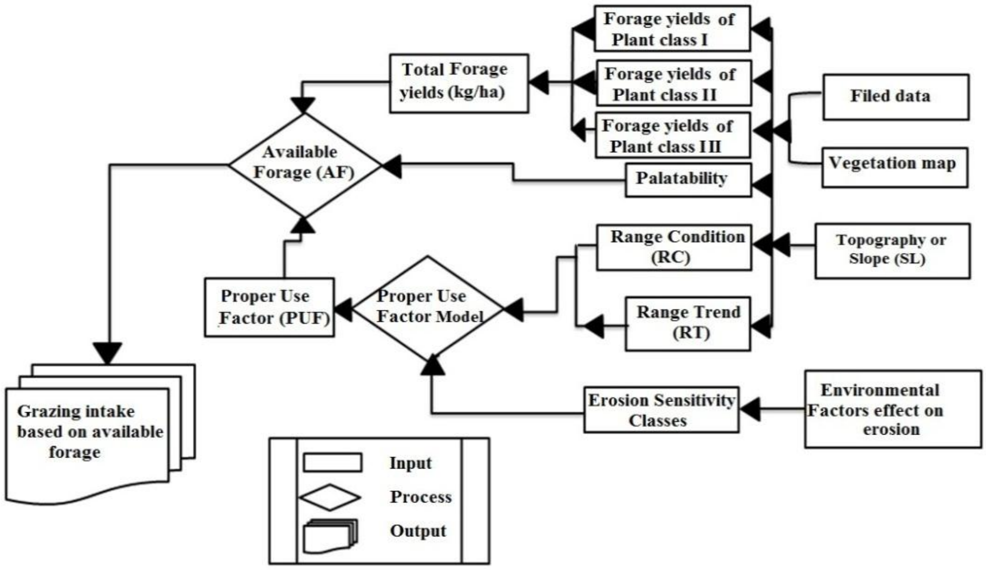

Fig. 3. Components of forage production suitability model (Amiri *et al.*, 2011)

Table 1. Coefficients of palatability and proper use factor for calculating available forage (Arzani, 2006)

Soil Erosion Sensitivity (SE)	Range Condition (RC)	Range Trend (RT)	Proper Use Factor (PUF)
Low and Medium	Good or Excellent	Positive or constant	50
Low and Medium	Good or Excellent	Negative	40
Low	Fair	Positive or constant	40
Medium	Fair	Positive or constant	35
Medium	Fair	Negative	30
High	Fair	Positive or constant	30
High	Fair	Negative	25
Medium	Poor	Positive or constant	30
Medium	Poor	Negative	25
High	Poor	Positive or constant	25
High	Poor	Negative	20

Finally, total forge production of those types that may be lower than 100 kg/ha is to be omitted from the model based on the proposed model in order to determine the forage production suitability and the suitability of that type is considered as N for the forage production. According to the utilized model, usable forage production rate of each plant type for the livestock (by adding usable production rates of classes I, II and III) is computed and class suitability concerning the forage production is expressed as usable forage rate.

Soil erosion conditions

MPSIAC model was first presented by the committee of water management for estimating the erosion and deposition of dry and semi-dry regions in USA for the zones with no stations for measuring the deposition (PSIAC, 1968). It is based upon the evaluation of nine geological elements including soil, climate, water, vegetation, land use, current erosion and gully erosion and roughness that are scored according to their strength and weakness. Johnsen and Gembhart (1982) have corrected this model in a manner that nine factors of this method were expressed as numerical equations and the model was changed from the qualitative model into a quantitative one. Then, it has been called the corrected formula of MPSIAC (Tueller, 1982; Johnsen and Gembhart, 1982). (Table 2) represents the suggested factors of this model and their scoring procedure. After scoring each factor, sum of these scores is called the erosion intensity (R). At last, R is added to the model of forage production Suitability as a sub-model based upon the class of soil erosion (Table 3) and Suitability class map of soil sensitivity to erosion for estimating the allowable exploitation limit.

Table 2. Effective factors and their points' calculation equation in MPSIAC model (PSIAC, 1968)

Effective Factors	Points Calculation Equation	Explanation Parameter
Geology	Y1=X1	X1: Stone Sensitivity Point
Soil	Y2=16.67K	K: Erodibility Factor in USLE
Climate	Y3=0.3X3	X3: Six hour Precipitation Intensity with 2 Year Interval Return
Water runoff	Y4=0.006R+10QP	R: Annual Runoff Depth (mm), QP: Annual Specific Discharge (cm/s/km2)
Topography	Y5=0.33S	S: Average Watershed Slop (%)
Ground cover	Y6=0.2X6	X6: Bare Soil (%)
Land use	Y7=20-0.2X7	X7: Canopy Cover (%)
Upland erosion	Y8=0.25X8	X8: Points' Summation in BLM Model
Channel erosion	Y9=1.67X9	X9: Points of Gully Development in Model

Table 3. Soil erosion class of MPSIAC model (Ilanloo, 2012)

Erosion Class	Qualitative Erosion Classification	Sum of Given Numbers and Nine Effective Factors
V	Very high	100<
IV	high	75-100
III	average	50-75
II	low	25-50
I	Very low	<25

Results

Due to the mountainous aspect of the studied region, agricultural lands have only covered 1869 ha (22.60%) and much of this area is the mountainous ranges as 4832 ha (58.35%) and residential lands are 24.2 ha (0.29%). Thus, current land uses of the region consist of the rangeland and agricultural lands including irritated agriculture and gardens, normal vegetation and good vegetation ranges (Fig. 4).

Also, using digital maps, balance lines and contours with the pixel dimensions of 10 m were applied by the help of GIS in relation with digital height model to provide the slope map, slope direction and three-dimensional landscape of the desired area. Kakolarimi *et al.* (2009) have stated that slope is one of highly influential factors on range suitability . Therefore, it has been indicated that most of the zones have the height as 1600 m above sea level.

According to the results obtained from primary classification of vegetation, six dominant vegetations were identified in the region (Table 4 & Fig. 5).

Table 4. Vegetation communities in Aliabad, Lorestan rangeland

Type Code	Vegetation Communities Scientific Name	Abreviation Symbol	Area /ha	Area to Total Area Ratio (%)	Area to Rangeland Ratio (%)
1	*Astragalus adscendens - Daphne mucronata-Agropyrom imbricatum*	As.ad- Da.mu -Ag.im	1771	21.37	36.46
2	*Daphne mucronata-Astragalus gossypinus*	As.go-Da.mu	754	9.09	15.53
3	*Poa bulbosa - Bromus dantoniae*	Br.da-Po.bo	953	11.50	19.63
4	*Bromus tomentellus-Astragalus gossypinus*	Br.to- As.go	194	2.34	4.00
5	*Poa bulbosa - Ferula behboudiana*	Po.bo -Fr.be	778	9.38	16.02
6	*Boissiera squarrosa- Astragalus gossypinus*	Bo.sq-As.go	406	4.90	8.360
7	Other land use	-	3433	41.42	-
	Total rangeland area		8289	100	100

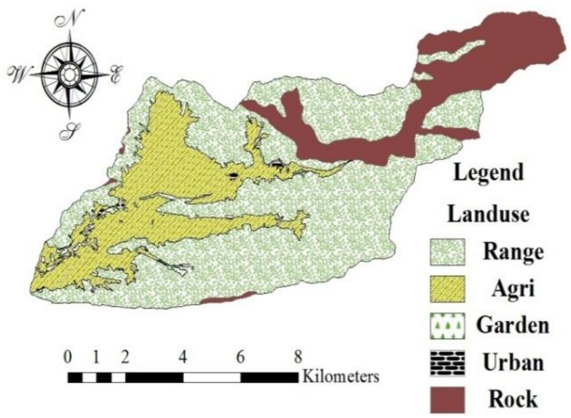

Fig. 4. Current land use of Aliabad watershed

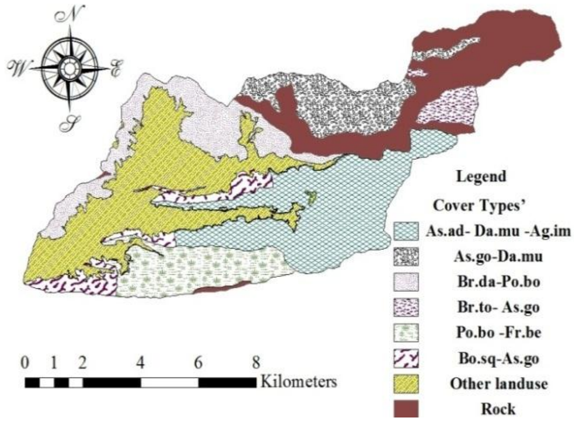

Fig. 5. Rangeland types

Results of evaluating the effective factors of erosion using MPSIAC method for the regional plant types have shown that types 1, 2, 3, 4 and 5 cover a portion of heights of the case study involving the mountains and hills from the geomorphologic perspective. Plant litter amount is estimated as a normal one at the levels of these types. Regarding the material uniformity of hillsides for these types near the water flows, some signs of more uniform erosion are appeared and are more severe with respect to the vegetation conditions, moderate gully and stream erosions and severe surface one. Soil elements, topography, moderate slope and soil sensitivity to erosion have resulted in the fact that these types having the area of 3696 ha or 76.11% were put in the normal suitability class of erosion. Also, types 4 and 5 are of good and perfect conditions with positive orientation.

Type 2 covers a part of heights of the region including a mountainous unit with rocky protrusions. This type's lands are covered with shallow soil, pebbles and gravels as well as range tree species. Surface pebbles and gravels related to the fragmentation of rocks resulting from the temperature differences of day and night or seasons can be evidently seen. Plant litter amount at the type levels is very low. High slope, surface erosion and soil sensitivity to erosion have led to the fact that this type having the area of 754 ha or 15.53% is ranged as severe erosion category. Furthermore, it has moderate conditions. Type 6 covers some parts of hillsides, plains between the mountains and watershed terrace and may have half deep soil cover. In fact, it consists of rain-fed agricultural lands and soil structure is considerably weakened and becomes susceptible to erosion because of lots of irregular plowing operations. Often, these lands are more likely to be plowed and planted so that they play influential roles in the sedimentation. Concerning this type, severe surface, slight gully and moderate stream erosions can be observed. Thus, such parameters as slope, land use, soil and severe surface erosion led to the classification of this type as the one with severe erosion while having the area of 405 ha or 8.360%. It has poor conditions and negative orientation. Current research findings are in conformity with those reported by Wallace *et al*. (2003) based upon the vegetation variations and the accuracy accepted by GIS to estimate the vegetation rate of rangelands. (Table 5 and Figs. 6, 7 and 8) show the Conditions, trend and soil erosion of case study.

Table 5. Conditions, trend and allowable exploitation limit of plant types

Type Code	Vegetation Type	Area to Rangelands Ratio	Range Trend (RT)	Range Conditions (RC)	Soil Erosion Sensitivity (SE)	Proper Use Factor (PUF)	Palatability	Available Forage (%)
1	As.ad- Da.mu -Ag.im	36.46	positive	Moderate	S2	35	50	35
2	As.go-Da.mu	15.53	positive	Moderate	S3	30	40	30
3	Br.da-Po.bo	19.63	constant	Moderate	S2	35	40	35
4	Br.to- As.go	4.00	positive	Perfect	S2	50	60	50
5	Po.bo -Fr.be	16.02	positive	Good	S2	50	60	50
6	Bo.sq-As.go	8.360	negative	Poor	S3	20	30	20

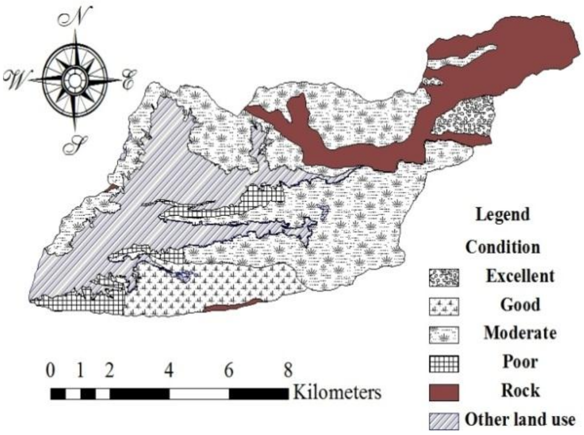

Fig. 6. Conditions of plant type in the case study

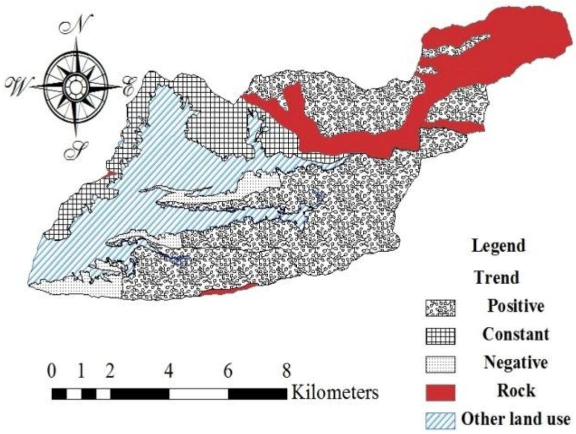

Fig. 7. Trend of plant types in the case study

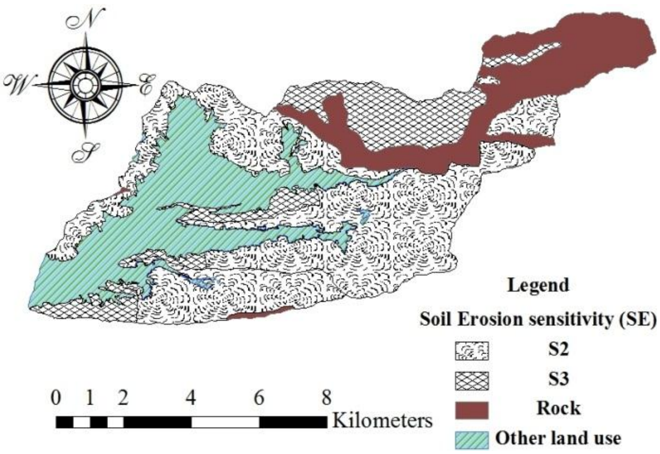

Fig. 8. Results of suitability classes of soil sensitivity to erosion using MPSIAC method

After determining the erosion rate, conditions and trend of every plant type, allowable exploitation limit and finally, the usable forage production rate will be calculated for every type.

Results of evaluation and measurement of some vegetation parameters like plant cover percentage, species composition percentage of classes I, II and III, plant litter percentage, stone and pebbles, bare soil, conditions, trend and area of every plant type existing in the region have indicated that types of *Daphne mucronata, Agropyrom imbricatum* and *Astragalus adscendens* having the code 1, the area of 36.46% and production rate of 198 (kg/ha) are observed as the largest regional types as compared to the whole type. In the case, Moghadam (1998) reported that to specify the exploitation suitability of the range, forage production rate must be given. Concerning these types, most of regional Nomads may dwell near these types. Also, types of *Bromus tomentellus* and *Astragalus gossypinus* having the code 4, the area of 4% and production rate of 407 (kg/ha) are likely to be the smallest ones in the region (Table 6). It should be expressed that in few parts of mentioned types, shallot is illegally harvested in a manner that it leads to the endangerment of the species along with the intensified soil erosion in the desired area. Existing regional types are of the area of 30-60% and in the studied region, various soil types are categorized into two groups of Anti- and inspty soil. Stone structures consist of Marny limestone, old alluvium, hard coral limestone and dolomite. Table 5 presents the results obtained by the forage production model in order to give the forage production suitability class for all the plant types existing in this region and compute the allowable exploitation limit of them. Figure 9 demonstrates the forage amount of each type before calculating the allowable exploitation limit. Figure 10 shows the map of forage production suitability classes while computing every type's allowable exploitation limit.

Table 6. Usable forage production and forage production suitability classes of plant types in case study while computing the allowable exploitation limit for Aliabad watershed

Type Code	Type Name	Area	Production rate (kg/ha): Total production (kg/ha)	Production rate (kg/ha): Production of Usable (kg/ha)	Forage (kg)	Usable Forage/ kg	Production Suitability
1	As.ad- Da.mu -Ag.im	1771	198	69.3	350658	122730	S2
2	As.go-Da.mu	754	270	81.0	203580	61074	S2
3	Br.da-Po.bo	953	287	100.4	273618	95766	S2
4	Br.to- As.go	194	407	203.9	79160	39578	S1
5	Po.bo -Fr.be	778	305	152.5	239624	118465	S1
6	Bo.sq-As.go	405	115	23.0	46684	9336	S3
7	Other land use	3433	-	-	-	-	-
	Total	8289	1582		1193324	447130	-

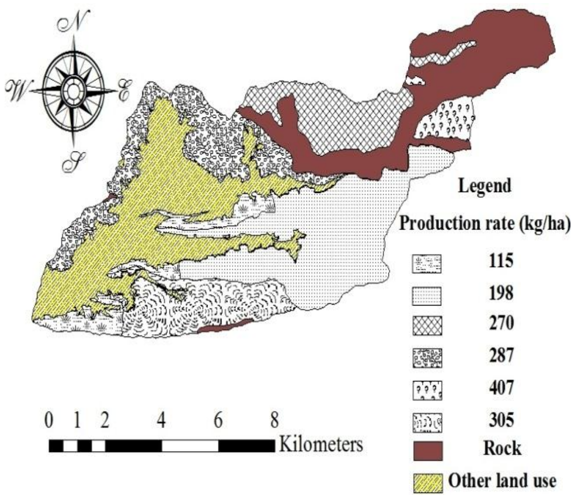

Fig. 9. Production rate of plant types in case study

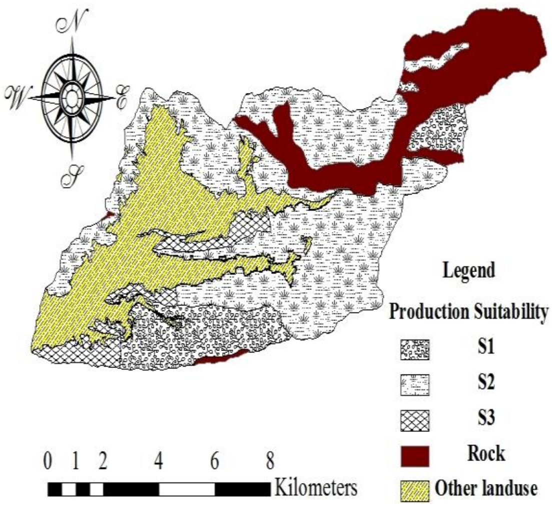

Fig. 10. Map of forage production suitability classes while computing the allowable exploitation limit

Discussion

Minor (2002) has applied RS and GIS to specify the grazing capacity of rangelands in California. He has utilized three sub-models of vegetation, slope and precipitation in order to determine final model of grazing capacity and stated that these results are of the acceptable precision and accuracy in a manner that they can be used by Range Management and may correspond to those suggested by Paul and Renu (2001) by the means of remote sensing technique for investigating the ranges' forage production. Therefore, the range suitability of the desired region for producing the forage was given as Young (1987) has emphasized that the evaluation of range suitability is the basic step to plan for exploiting the lands according to their capabilities. Since most of the lands are the mountains in the region and this area's population is increasing, the diversification of income sources of residents is essential to prevent from imposing more pressure on the rangeland which leads to the use of modern cost effective technologies with high speed and more accuracy. One of these sources is to provide the exploitation models for other income sources like apiculture in the region where there is a variety of nectar plants for the bees. Moreover, in order to avoid the pressure on the rangeland for enhancing the income level through increasing the number of livestock resulting in the soil erosion and water loss, ecosystem and tourism can be organized by these technologies regarding high water springs in a way that environment and natural resources are not damaged. This point has been confirmed and discussed by Zander and Kacheleh (1999) and Ariapour *et al.* (2013). Considering short periods of grazing in the regional rangeland due to cold weather, mountains and lots of water resources in the region, it can be proposed that fast-growing forage species with high production rates must be cultivated in the studied area and the livestock should be fed by the forage bought and stored in the hay loft for winter. In addition, number of livestock relying on the rangeland must be reduced and number of heavy livestock like cows that are kept in the folds or bred through industrial procedures can be increased.

Conclusion

Considering the results obtained from final suitability model of range production in this study, it has been found that the only limitative factor of range suitability is more likely to be high slope. In addition to the above-mentioned factor, other decreasing factors such as low percentage of vegetation, overgrazing, early grazing, nonconformity of livestock and range balance and range changes into low-yielding and dry lands as well as forage production may be mentioned.

Literature Cited

Ariapour, A., Hadidi. M, Karami, K., and Amiri, F., 2013. Water Resources Suitability Model by Using GIS (Case Study: Boroujerd Rangeland, Sarab Sefid). *Jour. Rangeland Science.* 3(2): 177-188. (In Persian).

Arzani, H., 2006. Some aspect of forage quality assessment. Eight International Conference on Development of Drylands (8 th ICDD, 25-28, FEB, 2006, Beijing, China).

Arzani, H., Jangjo, M., Mohtasham Nia, S., Agha Mohseni Fashami, M., Ahmadi, H., Jafari, M., Darvish Sefat, A., and Shahriari, V., 2006. Range suitability classification for grazing sheep in central Alborz region, Ardestan, Iran. *Agricultural Techniques and Sciences and Natural Resources Jour*. 1: 273-289. (In Persian).

Amiri, F., Rashid, A., and Shariff, M., 2011. An Approach for Analysis of Integrated Components on Available Forage in Semi-Arid Rangelands of Iran. *World Applied Sci. Jour,* 12(7): 951-961.

Anonymous, 2011. Effects of service: an introduction to Forest Organization, Range Management and Watershed Organization's performance, Fourth development plan, Pooneh Press. (In Persian).

Butler, L. D., Cropper, J. B., Johnson, R. H., Norman, A. J., and Shaver, P. L., 1997. The National Range and Pasture Handbook (NRPH), Natural Resources Conservation Service (NRCS).

FAO, 1991. Guidelines: Land evaluation for extensive grazing. FAO Soils Bulletin No. 58. FAO, Rome, Italy. 170 pp.

FAO, 1993. Guidelines for land use planning. FAO Development Series, No: 1, FAO, Rome, 96 pp.

Ilanloo, M., 2012. Estimation of soil erosion rates using MPSIAC models (Case Study Gamasiab basin). *Inter. Jour. Agri. Crop Sci.* 4(16): 1154-1158.

Gholinejad, B., PourBabaei. H., Farajollahi. A., and Parvane. E., 2012. Assessment and Comparison of Different Methods for Estimating Forage Production (Case Study: Rangeland of Kurdistan Province). *Jour. Rangeland Sci.* 2(2): 483-489. (In Persian).

Johnson, C. W., and Gembhart. A. C., 1982. Predicting sediment yields from sagebrush rangelands. In proceedings of workshop on estimating erosion and sediment yield on rangelands, Tucson, Arizona, March 1981 US Department of Agriculture, Agricultural Reviews and Manuals, *Western Series*, 26: 145-156 pp.

Jung, H.G., 2006. Analysis of forage fiber and cell walls in ruminant nutrition, *Jour. Nutrition*, 127: 8105-8135.1987.

Kakolarimi, A., Tamartash. R., Soleymani. K., and Amini. S. 2009. Range suitability determination of Lasem rangeland in Haraz for grazing sheep, *Rangeland Jour*. 2: 77-288. (In Persian).

Makhdom, M., 2001. Environment evaluation and planning using GIS, Tehran University Press, 298 Pp. (In Persian).

Mehrabi, H. R., Zeinivand. H., Hadidi. M., 2012. Site Selection for Groundwater Artificial Recharge in Silakhor Rangelands Using GIS Technique. *Jour. Rangeland Sci*. 2(4): 687-696 (In Persian).

Minor, T., 2002. Range Land Evaluation in Freson Conty, California, based on livestock carring capacity modeling using GIS, Proje : County of freson, California and Agricast, Inc.

Moghadam, M., 1998. Range and range management, Tehran University. (In Persian).

Mohtasham Nia. S., 2000. Range suitability determination of semi-steppe rangeland of Fars province using GIS. Range management thesis, Natural Resources and Marine Science College, Tarbiat Modares University. (In Persian).

Wallace. O. C., Qi. J., Heilma. P. and Robin. C. M., 2003. Remote Sensing and GIS for Cover Change Assessment in Southeast Arizona. *Jour. Range Management*. 56: 402-409.

Paul, T., and Nevada, R., 2001. Remote Sensing of Range Production and Utilization. *Jour. Range Manage*, 54: A77-A89.

PSIAC (Modified Pacific South West International Agency Committee), 1968. Report of the Water Management Subcommittee on Factors Affecting Sediment Yield in the Pacific Southwest Area and Selection and Evaluation of Measures for Reduction of Erosion and Sediment Yield. ASCE, 98, Report No. HY12.

SRM (Society for Range Management), 1991. A Glossary of Terms Used in Range Management, Third edition, Compiled and edited by the Glossary Revision Special Committee, Publications Committee, 1839 York Street, Denver, CO 80206.

Sour, A., Arzani, H., Feizizadeh, B., Tavili, A., and Alizadeh, E., 2013. GIS Multi-Criteria Evolution for Determination of Rangelands Suitability for Goat Grazing in the Middle Taleghan Rangelands. *International Jour. Agronomy and Plant Production*. 4(7): 1499-1510.

Tueller, P. T., 1982. Remote Sensing Technique for Range Management, Chapter 12, pp125-140, IN: Johnson and Sanders (eds.), Remote Sensing Technique for Resources Management, Soil Conservation Society of America.

Young, A., 1987. Distinctive Features of Land use planning for Agroforestry. *Soil Survey and land evolution*, 7: 133-140 pp.

Zander, P., and Kachele, H., 1999. Modeling objectives of land use for sustainable development. *Agricultural Systems*, 59: 311-325 pp.