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Assessment of Rangeland Condition and its Application in Rangeland Management Using Multi-Criteria Analysis

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Abstract

This study is aimed at evaluating the modified four-factor method to determine the condition of rangelands using multi-criteria decision-making methods in two rangelands in Lorestan Province, Iran (Sarabsefid Boroujerd and Lasore Dorod). In this study, range condition was studied using the modified four-factor method. In both rangelands, three transects of 100m were located within the areas. Ten 1m^2 quadrates were randomly and systematically placed along each 100m transect. A total of 150 quadrates were placed in Sarabsefid and Lasore, respectively. The evaluation criteria and questionnaires completed by experts were compared and ranked using the multi-criteria decision-making methods (AHP and TOPSIS) in the AHP Solver and TOPSIS Solver software. The results showed that the percentage of plant cover was the most important criterion in determining rangeland condition in both areas in TOPSIS. In the hierarchical method (AHP), the percentage of plant cover had the highest weight in Sarabsefid and Lasore (0.5576 and 0.5983, respectively). Both multi-criteria analysis methods produced similar results in terms of evaluating the modified four-factor method and prioritizing expert opinions for both rangelands.

Keywords: Rangeland, AHP-TOPSIS, Modified four-factor method, Experts' opinions.

1. Introduction

Rangelands are among the most important renewable resources of every country, and they play an essential role in supporting livestock and supplying protein. To manage these vital resources, it is necessary to use appropriate methods and tools to monitor their health (Herrero et al., 2013). Managers must decide how to manage a rangeland and to adjust their approaches based on the rangeland's condition (Trollope, 1981). Rangeland condition refers to plant conditions in terms of long-term capability. Rangeland condition reflects the health of a rangeland compared with the climax stage and is one of the important factors in evaluating rangeland ecosystems (Ahmadpour et al., 2016). This metric is used to select appropriate strategies for rangeland management (Faramarzi et al., 2010; Mui-How and Minowa, 2005). Rangeland condition represents the history of effects of living and non-living factors on plant and soil. Therefore, analyzing factors influencing rangeland condition is essential to understand how the system reacts in response to wildlife, grazing and the effect of rangeland managers. It is also potentially useful in land-use assessment and in the conservation of natural values (Phelps and Kaplan, 2017; Dwyer, 1978). During the second half of the twentieth century in many countries, new changes and challenges emerged, which required the use of reliable methods that allow us to recognize such new changes and challenges (Getabalew and Alemneh, 2019). Lack of proper understanding of the potential of rangeland ecosystems and the adoption of incorrect management methods are two reasons contributing to the degradation of rangelands. A wide variety of factors, such as climate change, grazing, wildlife, the effect of rangeland managers and livestock producers are most likely affecting rangelands ecosystems' condition (Getabalew and Alemneh, 2019; Faramarzi et al., 2010; Anada and Herath, 2007). Different rangeland conditions require different management practices. For example, in good conditions, management practices try to maintain the prevailing state; in poor conditions, management strategies should be aimed at improving the conditions of the rangeland. For this reason, it is important to identify the condition of rangelands. The study of changes in rangeland condition and knowledge of the processes behind these changes is one of the important issues in planning and applying rangeland management. Most of the methods used to determine rangeland condition, such as the four-factor method, the African method, the six-factor method, etc., the usage of indices such as vigor and vitality of plants, plant composition, and soil conditions (Karami et al., 2014). Most of these approaches are qualitative, and are

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consequently subject to personal judgement (karami et al., 2014; Dettenmaier et al., 2017). It is very important to use quantitative methods to assess rangeland conditions since these methods are not influenced by personal variations in judgement and measurement. Multi-criteria decision-making methods are an effective way to quantitatively analyze rangeland conditions. Multi-criteria decision-making techniques enable us to select multiple qualitative and quantitative criteria to guide our decision making (Guarini et al., 2018; D'Urso and Masi, 2015; Ghassemi and Danesh, 2012). Two of the most important multi-criteria decision-making methods are the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP). AHP has become one of the pervasive MCDA tool and has gained immense appreciation in different areas of research because of its computational simplicity, flexibility to be integrated with other techniques irrespective of their limitations (Mukherjee, 2014).

TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives based upon simultaneous minimization of distance from an ideal point and maximization of distance from a nadir point (Olson, 2004). It is one of the classical MCDM approaches, based on aggregating function to find a solution which is nearest to positive ideal solution (PIS) and farthest from negative ideal solution (NIS); however, it does not consider relative importance of these distances (Opricovic and Tzeng, 2004). It has been reported that hierarchical analysis can reduce human error (Bababeipouya et al., 2017; Xiaoyan et al., 2015; Mardani et al., 2015; Kuselman et al., 2013).

In rangeland and environmental planning, low confidence in variables and large timescales has created a challenge in decision-making. Multi-criteria decision-making methods can respond to these challenges (Penadés-Plà et al., 2016; Anada and Herath, 2007; Šikšnelytė et al., 2018). These methods provide the appropriate decision-making framework for planning and management because they consider contradictory, ambiguous, multi-dimensional, and non-comparable goals (Inotai et al., 2018; Danesh et al., 2017; Danesh et al., 2018; Erdogan et al., 2019; Abubakar et al., 2019; Angelis and Kanavos, 2017). A correct understanding and evaluation of rangelands lead to proper decision making regarding their abilities, capabilities, and constraints. Therefore, it is necessary to develop methods that allow for the evaluation and discovery of these relationships, changes, and their direction (Kornhaber et al., 2016; Cain, 1932). This research is aimed at assessing rangeland condition using multi-criteria decision-making methods, which creates an opportunity for selecting and categorizing indicators and prioritizing expert opinions to find efficient solutions.

2. Materials and Methodology

2.1 Study Site

In this study, two locations in Lorestan province, Iran, were studied. The studied areas had similar climates and plants, which enables the modified four-factor method to determine the rangelands' conditions. The study sites included Sarabsefid Boroujerd with an area of 8580 ha and Lasore Dorod with an area of 2662 ha. The study area is located in 46º36′48″- 48º27′46″ eastern longitudes and 33º53′31″- 33º58′24″ northern latitudes in Lorestan Province of Iran. The elevation range is 1974-3451 m above sea level, and the average elevation is 2641 m. Mean 20 year rainfall of the zone is 450.9 mm. Maximum and minimum annual temperature rates are 39.2 and 11.5 ºC, respectively. This zone is dry for about four to five months a year.

2.2 Methodology and Data Collection

At first, two areas at three different levels of utilization including exclosure (low grazing intensity), key (average grazing intensity) and critical (high grazing intensity) areas were separated from each other. Sampling was carried out by the randomized-systematic method (Mesdaghi, 2008) so that three random transects were established in each plant type, then 10 plots of 1-m^2, were systematically selected along each transect (Cox, 2002). The current rangelands' condition was studied, and rangeland types were identified using field observation and GPS. The range condition was determined using the modified four-factor method. The modified four-factor method for each factor was carried out in the field survey according to the opinions of three experts. All classes were evaluated for all factors, and the rangelands' conditions were determined using the modified four-factor method. Then, the AHP technique and TOPSIS were applied to weigh the various criteria and to rank the alternatives affecting rangeland condition. Plant cover was measured using plot-transects selected by the random-systematic sampling. In this area, sixteen plant types were determined based on field data (Table 1).

Plots with a minimum area of 1 m^2 were used for sampling. At least three transects were selected, perpendicular to the slope. In order to determine the sample size, ten plots were systematically picked in each plant type and the mean and variance of canopy cover were calculated.

Then, the sample size was determined using the Cochran formula.

$$N = \frac{t^2 \times s^2}{P^2 \times \bar{X}^2}$$

N = minimum required number of samples

t = from Student's t-distribution, at 90% confidence level

X = average of initial samples

P = Error range (± 0.1)

$$S^2 = \sum x^2 - \left(\sum x^2\right)\frac{n}{n-1}$$

S^2 = variance of initial samples

n = number of initial samples (10)

Table 1. Types of plants in this area and percentage of each type in all areas

Code	Type Name	Abbreviation	Area (Ha)	Percentage of all
1	Garden-Farm land	Ga-Fa	416.48	7.1
2	Astragalus adscendens-Eryngium noeanum	As.ad-Er.no	1094.09	18.66
3	Astragalus adscendens-Eryngium noeanum	As.ad-Er.no	969.8	16.54
4	Astragalus microcephalus–Annual grass	As.mi-An.gr	261.27	4.46
5	Astragalus microcephalus–Annual grass	As.mi-An.gr	205.67	3.51
6	Astragalus microcephalus-Cousinia jacobsii	As.mi-Co.ja	206.19	3.52
7	Astragalus microcephalus-Cousinia jacobsii	As.mi-Co.ja	491.37	8.38
8	Astragalus microcephalus-Cousinia jacobsii	As.mi-Co.ja	533.49	9.1
9	Astragalus microcephalus -Melica persica	As.mi-Me.pe	122.06	2.08
10	Astragalus microcephalus -Melica persica	As.mi-Me.pe	146.56	2.5
11	Astragalus microcephalus -Melica persica	As.mi-Me.pe	140.91	2.40
12	Astragalus microcephalus-Rhus coriaria	As.mi-Rh.co	269.35	4.59
13	Hordeum bulbosum-Astragalus microcephalus	Ho.bu-As.mi	361.35	6.16
14	Hordeum bulbosum-Astragalus microcephalus	Ho.bu-As.mi	327.6	5.59
15	Hordeum bulbosum-Astragalus microcephalus	Ho.bu-As.mi	116.75	1.99
16	Hordeum bulbosum-Astragalus microcephalus	Ho.bu-As.mi	201.29	3.43
Total			**5864**	**100**

Totally 150 quadrates were placed in Sarabsefid and Lasore, respectively. The hierarchical method (AHP) and TOPSIS were implemented using AHP Solver (version 1) and TOPSIS Solver, respectively (Khedrigharibvand et al., 2018).

An AHP questionnaire was designed to determine the weights of the four sub-attributes: the respondents were asked the following question for each pair of criteria: how important criterion A is compared with criterion B in the region? A nine-point scale was used, one representing equal importance, and nine representing complete dominance of one of the criteria (Saaty, 1980). In a TOPSIS questionnaire, the respondents were asked to score the alternatives against the applied criteria, based on the five-point Likert scale. The criteria were weighed based on the experts' preference values. Then, the consistency ratio was calculated to indicate if the experts compared the criteria with great care (Saaty, 1980). Finally, the TOPSIS was applied to the outcomes of the AHP to explore the most appropriate factors affecting rangeland condition.

2.3 Modified Four-factor Method

Considering the modified four-factor method, the studied factors include soil conditions (soil erosion and conservation), and plant conditions (plant composition, percentage of plant cover, vigor, and vitality of plant); range conditions were classified into five classes.

Using the modified four-factor method, rangeland condition was calculated based on the sum of scores obtained for four factors: soil erosion and soil conservation (in five classes, score of 0-20), percentage of plant cover (in ten classes, score of 1-10), plant composition (in five classes, score of 1-10), and vigor and vitality of plants (in four classes, score of 1-10) and rangeland condition levels involve excellent (45-100 scores), good (38-45 scores), fair (31-37scores), poor (20-30 scores) and very poor (0-20 scores). Scores of each element had been determined, then based on total scores, the range conditions were determined (Moghadam, 1994).

3. Results

3.1 Development of a Set of Decision-making Criteria

The criteria affecting range condition were expanded, and a list of suitable criteria was developed (Table 3). Ultimately, four sub criteria were developed based on the modified four-factor method (Table 2).

3.2 Evaluating the Weight of Criteria by the AHP Technique

The AHP technique was used to organize multiple-choice criteria into a hierarchy, assessing their relative importance, and to calculate the weight of each criterion and the overall weight of the criteria (Tables 11 and 13). The consistency ratio was calculated as 0.1%, which showed that the experts compared the criteria precisely. Although all criteria with high weights were considered effective for range condition, the two highest criteria in the context of the region included: soil erosion and conservation and percentage of plant cover. Plant composition and vigor and vitality of plant were ranked as the lowest sub-criteria respectively (Tables 11 and 13). Figures 1 and 2 illustrate the global weights of the evaluation criteria.

3.3 Ranking of Factors Affecting Range Condition

After assigning weight to each criterion using the AHP, the factors affecting range condition were ranked using the TOPSIS. In a descending order of preference, the factors are presented in Figure 10. The percentage of plant cover was found to the best factor based on the affecting factors, followed by Soil erosion and Conservation. Compared with the other factors, Plant composition and Plant vigor and vitality were found to have the lowest values.

3.4 Determination of Rangeland Condition by the Modified Four-Factor Method

Rangeland evaluation was conducted by three experts using the modified four-factor method (Table 2).

Table 2. Results of the evaluation conducted by different experts using the modified four-factor method

Rangeland Condition	Score	Factors	experts	Area
Good	15-19	Soil erosion and conservation	Expert1	Lasore Dorod
	9	Percentage of plant cover		
	8	Plant composition		
	10	Plant vigor and vitality		
Good	15-19	Soil erosion and conservation	2 expert	
	9	Percentage of plant cover		
	8	Plant composition		
	7	Plant vigor and vitality		
Medium	10-14	Soil erosion and conservation	3 expert	
	8	Percentage of plant cover		
	6	Plant composition		
	7	Plant vigor and vitality		
Medium	10-14	Soil erosion and conservation	Expert 1	Sarabsefid Boroujerd
	8	Percentage of plant cover		
	4	Plant composition		
	7	Plant vigor and vitality		
Good	15-19	Soil erosion and conservation	2 expert	
	6	Percentage of plant cover		
	6	Plant composition		
	10	Plant vigor and vitality		
Poor	10-14	Soil erosion and conservation	3 expert	
	4	Percentage of plant cover		
	4	Plant composition		
	5	Plant vigor and vitality		

Score: Score of Range condition's estimation method

3.5 Multi-criteria Decision-making Method for the Condition of Sarabsefid Boroujerd Using TOPSIS

The results of TOPSIS analysis according to the experts' opinions are shown in Tables 3 to 6.

Table 3. Normalization of the decision matrix, Sarabsefid Boroujerd

Un-scaled matrix	expert1	expert2	Expert 3
Soil erosion and conservation	2821/0	467/0	4961/0
Plant composition	094/0	1648/0	1654/0
Plant vigor and vitality	1646/0	2747/0	2067/0
Percentage of plant cover	9405/0	8242/0	8269/0

In this step, the scales in the decision matrix were un-scaled. Therefore, each of the values was divided by the vector size of the same index.

Table 4. Normal matrix weighing, Sarabsefid Boroujerd

Weighted matrix	expert1	expert2	Expert 3
Soil erosion and conservation	1411/0	2335/0	2481/0
Plant composition	047/0	0824/0	0827/0
Plant vigor and vitality	0823/0	1374/0	1034/0
Percentage of plant cover	4702/0	4121/0	4134/0

The decision matrix is parametric and needs to be quantified. For this purpose, the decision-maker allocated a weight for each index, and the sum of the weights was multiplied into the normalized matrix.

Table 5. Determination of positive and negative ideal solutions, Sarabsefid Boroujerd

ideal solution	expert1	expert2	Expert 3
+	4702/0	4121/0	4134/0
-	047/0	0824/0	0827/0

The two virtual options are the worst and best solutions.

Table 6. Calculation of closeness to the positive and negative ideal solutions, and the ranking of options, Sarabsefid Boroujerd

Result	closeness coefficient
Percentage of plant cover	1
Soil erosion and conservation	3724/0
Plant vigor and vitality	1077/0
Plant composition	0

The results obtained from Table 5 show that the percentage of plant cover, soil erosion and conservation, plant vigor and vitality, and plant composition were ranked 1st, 2nd, 3rd, and 4th, respectively. After normalizing the opinions in Table (3) and weighing the criteria in Table (4), the distance from the ideal positive and negative solutions as well as the relative closeness to the ideal solution were calculated and are presented in Table (5). Experts' opinions were arranged as expert 1, expert 3, and expert 2.

Finally, decision options were prioritized (Table 5). The ranking of decision options was based on the relative closeness to the ideal solution, so that the closer to 1 a decision option is, the higher its desirability. According to experts' opinions in the modified four-factor method, the rangeland's condition was reported as good, medium or poor. In TOPSIS, priority was given to the medium rangeland condition according to opinion of expert 1.

3.6 Multi-criteria Decision-making Method for Condition of Lasore Dorod Using TOPSIS Method

The results of TOPSIS analysis based on experts' opinions are shown in Tables 7 to 10.

Table 7. Normalization of the decision matrix, Lasore Dorod

Un-scaled matrix	expert1	expert2	Expert 3
Soil erosion and conservation	3543/0	4115/0	3632/0
Plant composition	1667/0	1646/0	1362/0
Plant vigor and vitality	2084/0	144/0	1589/0
Percentage of plant cover	8962/0	8848/0	9079/0

In this step, the scales in the decision matrix were un-scaled.

Table 8. Normal matrix weighing, Lasore Dorod

Weighted matrix	expert1	expert2	Expert 3
Soil erosion and conservation	1772/0	2058/0	1816/0
Plant composition	0834/0	0823/0	0681/0
Plant vigor and vitality	1042/0	072/0	0794
Percentage of plant cover	4481/0	4424/0	454/0

The decision matrix is parametric and needs to be quantified. Therefore, the decision-maker allocated a weight for each index, and the sum of the weights was multiplied into the normalized matrix.

Table 9. Determination of positive and negative ideal solutions, Lasore Dorod

ideal solution	expert1	expert2	Expert 3
+	4481/0	4424/0	454/0
-	0834/0	072/0	0681/0

The two virtual options are the worst and best solution.

Table 10. Calculation of closeness to the positive and negative ideal solutions and the ranking of options, Lasore Dorod

Result	closeness coefficient
Percentage of plant cover	1
Soil erosion and conservation	306/0
Plant vigor and vitality	0364/0
Plant composition	0158/0

The results obtained from Table 10 show that the percentage of plant cover, soil erosion and conservation, plant vigor and vitality, and plant composition were ranked 1st, 2nd, 3rd, and 4th, respectively. After normalizing the opinions in Table (7) and weighing criteria in Table (8), distance from the ideal positive and negative solutions as well as the relative closeness to the ideal solution were calculated and are presented in Table (9). Experts' opinions are arranged as expert 3, expert 1 and expert 2.

Finally, decision options were prioritized (Table 9). The ranking of decision options was based on the relative closeness to the ideal solution, hence the closer to 1 an option scores, the higher its desirability. According to experts' opinions on the modified four-factor method, the rangeland's condition was reported as good and medium. In TOPSIS, priority was given to the medium rangeland condition according to the opinion of expert 3.

3.7 Multi-criteria Decision-making Method for Condition of Sarabsefid Boroujerd Using AHP Method

Determination of the pair matrices and weight calculation for criteria and options are shown in Tables 11 and 12.

Table 11. Weight and rank of criteria in Sarabsefid Boroujerd

Factors	relative weight of factors	rank of factors
Soil erosion and conservation	2594/0	2
Plant composition	0705/0	4
Plant vigor and vitality	1124/0	3
Percentage of plant cover	5576/0	1

Table 12. Experts' opinions and prioritization in determining the condition of Sarabsefid Boroujerd

Condition	Sum of row	Percentage of plant cover	Plant vigor and vitality	Plant composition	Soil erosion and conservation	Indices	
Medium	43714/0	318662/0	035985/0	01763371/0	06485888/0	expert1	Options
Good	386923/0	159331/0	062607/0	03526742/0	12971775/0	expert2	
Poor	175937/0	079666/0	013779/0	01763371/0	06485888/0	expert3	

The results in Table 11 show that the percentage of plant cover, soil erosion and conservation, plant vigor and vitality, and plant composition were ranked 1st, 2nd, 3rd, and 4th, respectively; and the percentage of plant cover had the highest weight (0.5576). Figure 1 shows the same results. Table (12) shows that expert 1 evaluated the rangeland's condition as medium (at a value of 0.43714) with a priority of 1.

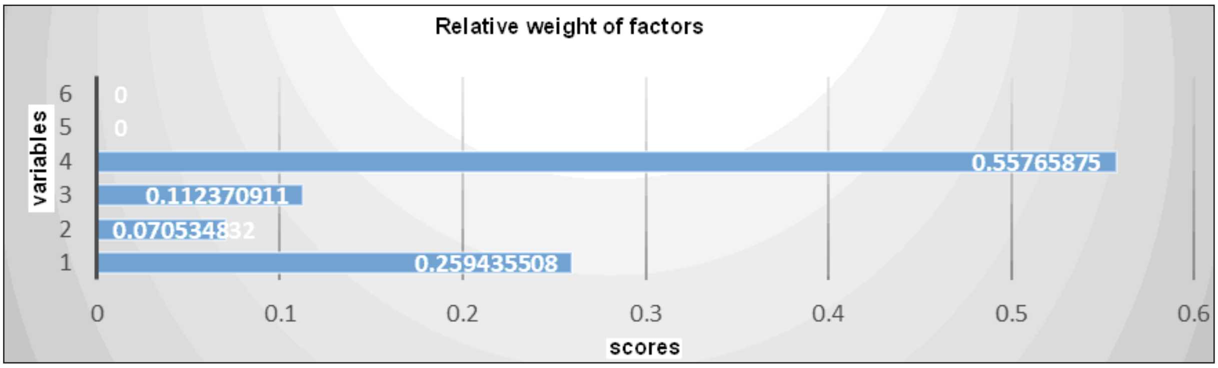

Figure 1. Relative weight of factors in the four-factor method for Sarabsefid Boroujerd using AHP

3.8 Multi-criteria Decision-making Method for Condition of Sarabsefid Boroujerd Using AHP Method

Determination of the pair matrices and weight calculation for criteria and options are shown in Tables 13 and 14.

Table 13. Weight and rank of criteria in Lasore Dorod

Factors	relative weight of factors	rank of factors
Soil erosion and conservation	2686/0	2
Plant composition	0523/0	4
Plant vigor and vitality	0808/0	3
Percentage of plant cover	5983/0	1

Table 14. Experts' opinions and prioritization in determining the condition of Lasore Dorod

Condition	Sum of row	Percentage of plant cover	Plant vigor and vitality	Plant composition	Soil erosion and conservation	Indices	
Good	344632/0	239327/0	040388/0	020927/0	04398956/0	expert 1	Options
Good	230161/0	119664/0	020194/0	010463/0	07984007/0	expert 2	
Medium	425207/0	239327/0	020194/0	020927/0	14475858/0	expert 3	

The results in Table (13) show that the percentage of plant cover, soil erosion and conservation, plant vigor and vitality, and plant composition were ranked 1st, 2nd, 3rd, and 4th, respectively. The percentage of plant cover factor had the highest weight at 0.59832. In addition, Figure 2 shows the same results. Table (14) shows that expert 3 evaluated the rangeland's condition as medium (at a value of 0.4252) with a priority of 1.

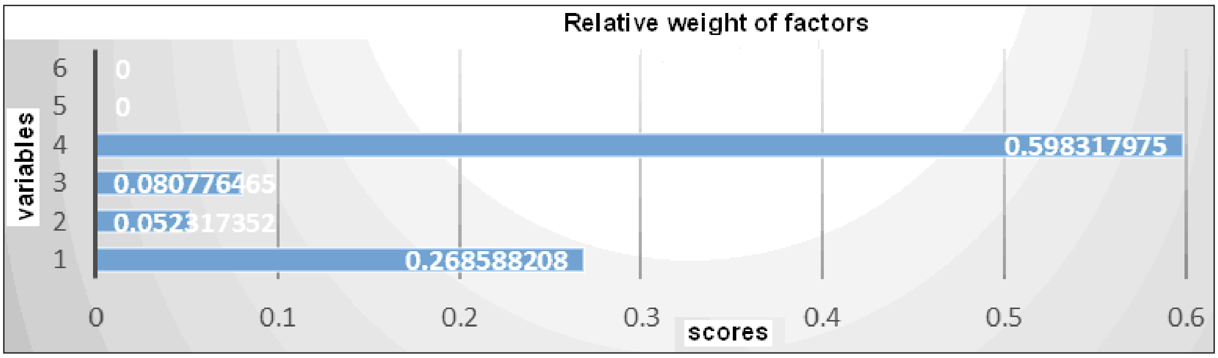

Figure 2. Relative weight of the four-factor method for Lasore Dorod using AHP method

The results of both methods of multi-criteria decision making (TOPSIS and AHP) show that the percentage of plant cover, soil erosion and conservation, plant vigor and vitality, and plant composition were ranked 1st, 2nd, 3rd, and 4th , respectively. Hence, similar results were obtained. The experts' opinions were also ranked according to priorities, and the medium condition was placed in priority 1. Both multi-criteria decision-making methods in this study showed that the percentage of plant cover and soil erosion and conservation were the most important factors among the four factors. The purpose of determining rangeland condition was to identify the extent of plant cover change associated with the changes in soil, as occurs in rangeland communities (14). The prioritization of experts' opinions suggests their different views on rangelands; depending on various factors their opinions may vary. Multi-criteria decision-making methods (TOPSIS and AHP), through prioritizing experts' opinions, showed that the rangeland might have a good condition, but the plant composition and the Soil erosion and conservation might be in a poor state. This disagreement shows that ratings may be made with error. Priority is given to the ideas that have the least error. Depending on experts' opinions, different views have been adopted for determining rangeland condition, leading to significant impacts on rangeland management decisions. Using GIS, two rangeland conditions (medium and poor) of Sarabsefid Boroujerd and Lasore Dorod were determined according to the plant type of the area (Figure 4).

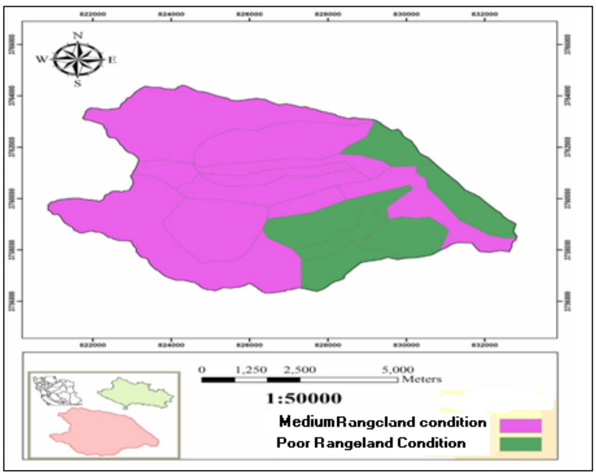

Figure 3. Sarabsefid Boroujerd Rangeland Condition

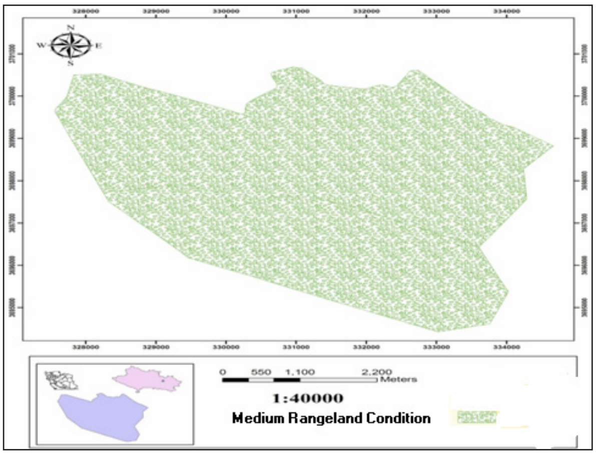

Figure 4. Lasore Dorod Rangeland Condition

The AHP method provides a framework for analyzing and transforming difficult and complex problems into a more logical and simplified hierarchy, through which the planner can easily evaluate the options with the help of criteria and sub-criteria. In TOPSIS method, the percentage of plant cover was the most important criterion in determining rangeland condition in both areas (Sarabsefid Boroujerd and Lasore Dorod). Using the AHP method, the percentage of plant cover had the highest weight in Sarabsefid Boroujerd and Lasore Dorod with 0.55576 and 0.5983 respectively (figures 1 - 2), supported by experts' opinions in the questionnaire (Tables 2, 6, 11 and 13). Multi-criteria decision-making methods produced the same results in prioritizing criteria in this study.

According to the results of prioritization of rangeland conditions, Sarabsefid Boroujerd was evaluated to be in medium condition according to both methods (TOPSIS and AHP; Tables 4 and 11). The medium condition was obtained for Lasore Dorod using both methods (Tables 8 and 13), which was consistent with results of Majiri et al. (2013). Using the multi-criteria methods, it was shown that no area is in good condition in Sarabsefid Boroujerd and Lasore Dorod. According to the estimates made by the Forests, Rangelands and Watershed Management Organization of Iran in 1995 of the 90 million ha of rangelands in Iran, 45.48% are poor to very poor, 41.45% are medium to poor and 10.33% are in a good condition (http://www.frw.org.ir). Currently, there are no rangelands in the good condition in Iran; or their area is too small to be significant compared to the total area of rangelands. According to plant type, two rangeland conditions (medium and poor) of Sarabsefid Boroujerd were mapped using GIS (figure 4). Rangeland conditions for Lasore Dorod was medium and according to Tables 5, 9, 13, and 16, the evaluation is accurate. The results showed that the determination of rangeland conditions was more accurate using the methods, and emphasized the possibility of updating and forecasting the condition of rangelands. The determination and application of the best management practices for optimal resource management is necessary. The most effective management methods known in the world for integrating possible management practices in rangelands are approaches based on the development of management scenarios. Because each of the possible scenarios will have different and sometimes conflicting consequences, scenarios with priority and highest importance can be predicted using multi-criteria decision-making methods. The main objectives of rangeland management include the promotion of effective cooperation, a balanced and adequate planning and management, and a sustainable use of natural resources.

4. Discussion

The following sections shows the application of the AHP-TOPSIS Approach in Ranking Factors Affecting Rangeland Condition

4.1 Development of Decision-making Criteria

When selecting the factors which affect rangeland condition, specifying a set of factors that measure progress for the sake of having a sustainable range management is important. Due to the increasing complexity in the decision-making process and ensuring the right decision is made, a specific number of factors should be considered (Jalalifar et al., 2009). In the end, four factors affecting rangeland condition were determined using the modified four-factor method.

4.2 Weighting of Factors by the AHP Technique

Through the application of the AHP technique, the factors' weights were obtained. Under the conditions stated in this article, it appeared that the percentage of plant cover was considered more important than other factors. Regarding the factors affecting range condition, studies noted that the percentage of plant cover is essential for determining range condition (Khedrigharibvand et al., 2017; Getabalew and Alemneh, 2019).

4.3 Application of the TOPSIS

After the application of the TOPSIS, the percentage of plant cover was found to be the best factor, followed by soil erosion and conservation, plant vigor and vitality, and plant composition. Thus, the percentage of plant cover factor had the highest weight in rangeland condition determination. In comparison with other factors, plant vigor and vitality, and plant composition had the lowest values; these results deemed them to be affecting rangeland condition the least for a sustainable range management. However, all factors affecting rangeland condition should be considered for sustainable range management in general. In line with this, studies emphasized the importance of four factors affecting range condition for sustainable range management (Khedrigharibvand et al., 2015; Asgari et al., 2018).

5. Conclusions

In this study, to simplify decision-making activities, and make effective decisions and solve real- world problems, it was essential to apply a decision-making procedure (Shih et al., 2007). In line with this, the applications of decision support systems have been expanded in various study area (Khedrigharibvand et al., 2018; Shih et al., 2007; Yue, 2011). Regarding the application of the AHP and TOPSIS approach here, not only were factors affecting rangeland condition by multicriteria decision-making approach, but this was the first study to explore the most appropriate factors affecting rangeland condition. Concerning its applicability in dealing with the factors affecting rangeland condition, this approach (i.e. the AHP-TOPSIS multicriteria decision making approach) could be introduced as a way forward for approaching range management. For range management, the experts ranked the criteria and appropriate factors affecting range condition. The criteria weighing was assigned using the AHP technique. The factors affecting range condition were ranked using the TOPSIS. At the end, the most appropriate factor was extracted. This study concluded that all the factors affecting range condition (soil conditions and plant conditions), including the highest and lowest ranking, are important for approaching range management at the Lorestan province, Iran. This study suggests that the factors affecting range condition with the lowest values (i.e. plant composition and plant vigor and vitality) should still be considered for range management, and that government, institutions and people themselves should be responsible for supporting factors through supportive strategies (Khedrigharibvand et al., 2015). However, the potential of each region for the factors affecting range condition with the highest values should be explored as a priority. This implies that more supports and investments should be allocated for the most appropriate factor (percentage of plant cover). Criteria such as job opportunities were deemed important, and awareness of them was high. Regarding the most appropriate factors, developing non-resource-based factors (hunting, recreation and etc) can greatly reduce pressure on natural resources, and can create new job opportunities and prevent unemployment. Addressing these factors affecting range condition can stabilize the population of each area, while creating a balance between humans, livestock, and natural resources. In considering these factors, this research demonstrated that the selection of factors affecting range condition was a complex and complicated decision. Thus, the approach presented in this study (AHP-TOPSIS) is suitable for rangeland managers to achieve a sustainable range management. Future studies may consider non-resource-based criteria and more experts randomly. Also, to assess uncertainty in judgments, further research can examine other techniques including ELECTRE, entropy-AHP-TOPSIS, fuzzy-AHP-TOPSIS, AHP-VIKOR, AHP-PROMETHEE. The combination of the AHP-TOPSIS approach and a GIS tool can create sources for additional information for the sake of examining the suitability of each factor.

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