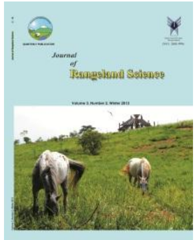
Contents available at ISC and SID

Journal homepage: www.rangeland.ir



Full Length Article:

ANP Application in Evaluating Ecological Capability of Range Management (Case Study: Badreh Region, Ilam Province)

Ali Mahdavi[A], Marzban Faramarzi[B], Omid Karami[C]

[A]Assistant Professor, Department of Forestry and Rangeland, Faculty of Agriculture and Natural Resources, University of Ilam, Iran. (Corresponding Author). Email: a_amoli646@yahoo.com
[B]Assistant Professor, Dept. Forest and Rangeland, Faculty of Agricultural Sciences, Ilam University, Ilam, Iran.
[C]Ph.D Student, Forestry, Natural Resource Faculty of Sari, Iran.

Received on: 01/03/2013
Accepted on: 21/05/2013

Abstract. Rangelands are important for plant productivity, livestock production, wildlife, conservation of soil and water resources, and etc. One of the main problem of rangeland is that has not been used based on its potential that leads to more degradation of rangelands. The purpose of this study was to evaluate the range management capability of Badreh region in Ilam province, Iran, using ANP (Analytic Network Process) and GIS (Geographic Information Systems) techniques. For this regard, firstly, the network of effective factors in evaluation was designed. Four clusters including vegetation cover, topography, pedology, and geology were divided into number of sub-criteria. For determining the relations among these clusters and sub-criteria, a number of questionnaires distributed among the experts and used to obtain their judgments about the relative importance of each criterion in rangeland capability. In the next step, based on the limited super matrixes the final weight of nodes was calculated. The weights of nodes in evaluating process were extracted by calculating the geometric mean of the questionnaire weights, as well. After determining the weights of nodes, they were transformed to data layers. Finally, ecological capability map for range management was provided using WLC (Weight Linear Combination) technique in GIS. The results showed that 3.00, 21.76, 58.46, 16.79 percent of the study area had very good (or excellent) condition (as first class), good condition (second class), fair condition (third class), and poor condition (fourth class) for capability of range management, respectively.

Key words: Ecological capability, Range management, Analytic Network Process (ANP), GIS

1. Introduction

Rangelands play an important role in Iran's economy (Amiri *et al.,* 2011). Because of rangeland is one of the most important sources of production in Iran. It can provide the main part of livestock forage, play a major role in ecosystem sustainability, and conserve soil and water resources (Mazhari and Khaksar Astaneh, 2010). Indiscriminate use of rangelands seems to be one of the major problems in Iran which lead to rangeland degradation (Arzani *et al.,* 2006).

During the last three recent decades, rangeland has been exposed to more degradation in comparison to other natural resources in Iran. Therefore, evaluating this valuable resource for identifying and determining production for exploiting and presenting an applied procedure to decrease degradation is of greet essential (Najibzadeh *et al.,* 2008).

Many studies have been carried out in Iran and other countries about ecological capability evaluation and rangelands capability. Among these studies, Arzani *et al.* (2006) conducted a study in Taleghan catchment (West of Tehran in Qazvin Province) to evaluate the rangelands.

They used FAO method and the technique of Geographical Information System (GIS) for their project that slope percentage and vegetation covers were the most important factors. As well, Bocco *et al.* (2005) in Mexico and Ziadat and Al-bakry (2006) in Jordan evaluated ecological capability for various uses, e.g. rangeland management. In this type of studies, McHarg (1969) invented systematic method with some regional modification was used. Babaie Kafaki *et al.* (2009) evaluated land ecological capability for various land use using Analytic Hierarchy Process (AHP) in Kordestan province-Iran. In this study, vegetation cover was one of the most important factors. Gavili *et al.* (2011) evaluated the suitability of rangelands productivity using AHP and GIS in Fereidonshahr, Iran. Analytical Hierarchy Process (AHP) is one of the most popular methods to obtain criteria weights in MCDM (Saaty, 1980; Saaty and Vargas, 1991; Ohta *et al*., 2007). The AHP has been employed in the GIS-based MCDM (Malczewski, 2004; Makropoulos *et al*., 2003; Marinoni *et al*., 2009).

It calculates the needed weights associated with criterion map layers. GIS-based AHP is popular because of its capacity to integrate a large amount of heterogeneous data and the ease in obtaining the weights of a large number of criteria, and therefore, it has been applied in tackling a wide variety of decision making problems (Nekhay *et al*., 2008; Hossain and Das, 2010).

A review of the related literature concerning evaluating of land ecological capability indicates that these evaluations have been conducted primarily by union geographic data manually. After developing GIS in the late19th, land evaluations by using this system have become more accurate and fast (Collins, 2001; Malczewski, 2004).

In recent years weighting methods like Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) in integration with GIS have become the more favorite methods for determining the importance of any factors in evaluation process. Moreover in recent years, the ANP was used in the most applicable method for determining and evaluating effective criteria's (clusters) and sub-criteria's (nodes) in land evaluation.

A number of studies were conducted this method for their study, such as Aragones-beltron *et al.* (2010) for Valuation of urban industrial land in Spain, Chen *et al.* (2010) in evaluation of environment watershed plans in Taiwan, Pourebrahim *et al.* (2011) for land use planning in coastal areas in Malaysia and Tuzkaya *et al.* (2008) for locating undesirable facilities in Turkey.

The ANP method is one of the most important multi criteria decision making techniques that were first introduced by Saaty (1996) in order to remove weak points of AHP (Saaty, 2004). Because the AHP hierarchical structure is not able to solve some of the problems of real world and this is not an accurate method when the criterions are dependent on each other, and also, there is not any dependency between them (Chung *et al.*, 2005; Ertay *et al.*, 2006; Yuksel and Dagdeviren, 2007).

For solving this problem Saaty (1996) suggested the ANP that has a network structure. It is more complex than AHP structure, but it can remove the weak points of hierarchy methods in spite of its weaknesses. Analytic Network Process (ANP) is the successor of the popular Analytic Hierarchy Process (AHP) model developed by the AHP is a Multi- Criteria Decision Making (MCDM) tool at the core of which lies a method for converting subjective assessments of relative importance to a set of overall scores or weights. The AHP is a top-down decision model and, therefore, the criteria's and sub-criteria's are assumed independent. However, bias could occur when the criteria and sub-criteria are correlated with each other. Twenty five years after the publication of pioneering work in the field of Saaty (1980, 1996) developed the ANP model, which could handle this situation of inner dependence among elements in a network (Pourebrahim *et al.*, 2011).

The ANP is one of the most completed multi- criteria decision making method which has been presented up to now (Razmi *et al.*, 2009). This method was frequently used by the researchers for different purposes (Aragones-beltron *et al.*, 2008; Faraji Sabokbar *et al.*, 2009).

In addition, GIS technique is a very useful tool for land evaluation. It is as a spatial decision making support system which can be decreasing the costs and increasing the accuracy and speed of evaluation (Malczewski, 2004; Thirumalaivasan *et al.*, 2003; Ying *et al.*, 2007; Zhong-Wu *et al.*, 2007).

The main aim of this study was for evaluating rangeland capability using GIS and ANP techniques. A number of maps will be provided that can be used for a good management procedure for experts in governmental and non governmental organizations to prevent rangeland degradation and to improve techniques in degraded rangeland.

2. Materials and Methods

2.1. Study area

The study area is Badreh region that located in Ilam province, western Iran with latitude from 33˚29′27″ to 33˚8′45″ north, and longitude from 46˚47′21″ to 47˚14′50″ east (Fig. 1). The total area of Badreh is about 57028 ha that is placed on the Zagros chain. The average annual rainfall is about 528.3 mm and the average annual temperature is 20.95 °C. The climatic condition is semi-arid with cold winters based on Ampereje method. The common characteristics of this area are: forest hills, limestone bedrock, deep litho-soil, fair to good vegetation cover, and sharp slope with rill and sheet erosion.

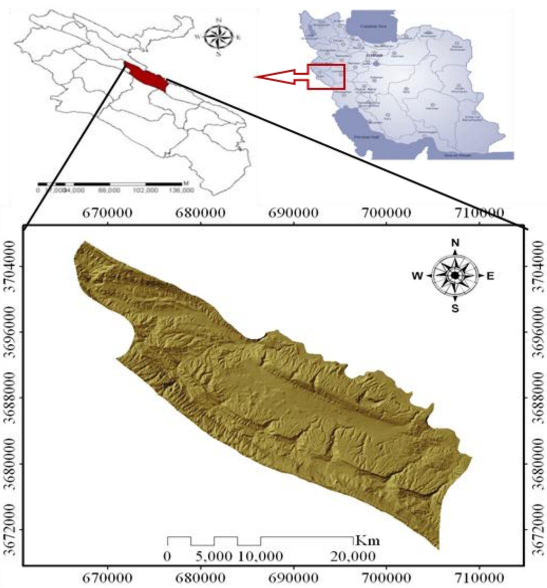


Fig. 1. The location of the study area

2.2. Assessment of criteria using ANP

Assessment and choosing a land for different activities needs a group of criteria's and sub-criteria's (Belfore, 2003). There are many techniques for assessing criteria's and sub-criteria's. Among these techniques, the multi-criteria decision techniques are very suitable for this purpose (Pourebrahim *et al.*, 2011).

In contrast to AHP method (Fig. 2a) which has a hierarchical system, ANP method (Fig. 2b) has a network structure, so, in this study, in order to evaluate and choose effective criteria of evaluating land potentiality for range management, ANP was used.

Analytic Network Process (ANP) takes place in three steps (Chen *et al.*, 2010; Neaupane and Piantanakulachi, 2006; Tsai *et al.*, 2010) (Fig. 3).

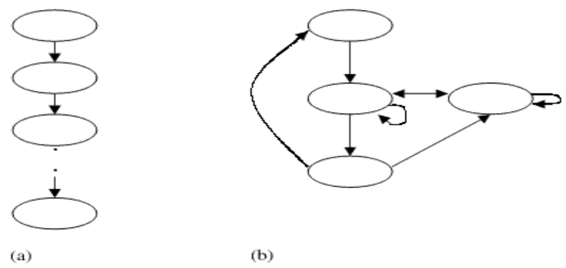


Fig. 2. The differences between AHP (a) and ANP (b) network structures. All dependency in hierarchical is considered in network structure (Yuksel and Dagdeviren, 2007)

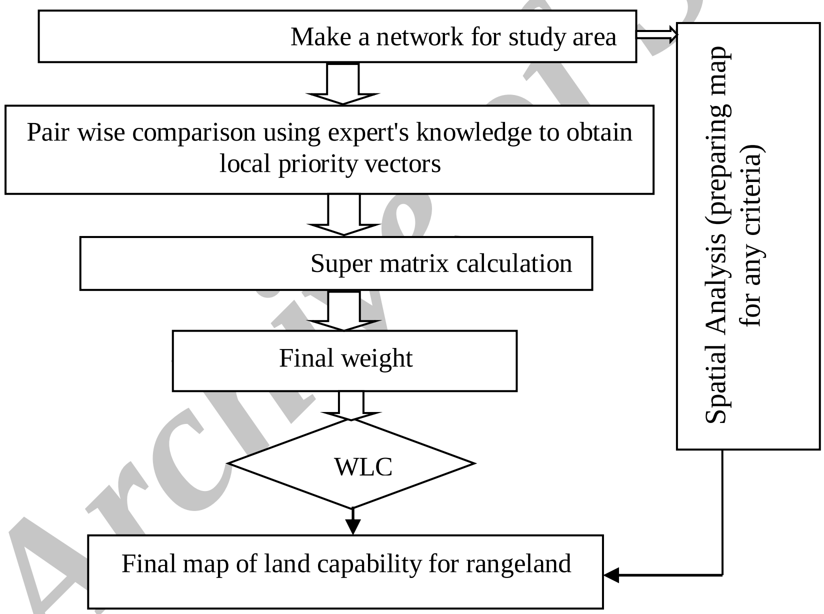


Fig. 3. Stages of this study

Step 1: making ANP model requires the development of the network to determine cognition of problem, cluster, node, and also the interaction between them. Each network includes a group of clusters (components), which the cluster has one or more than one Nodes. Generally, there are two kinds of dependency in every network. There are the dependency between clusters in a network and the dependency among nodes. So, every node may have a relation with nodes in the same cluster or other clusters. In this study, determining the clusters, nodes, and the relations among them was conducted by experts who are aware of the situation of the study area and the already existing studies that have been done by other researchers. Then the necessary cluster for assessing criteria in evaluating ecological range of potentiality was made.

Step 2: a pair wise comparison to obtain local priority vectors: like analytic hierarchical process, the decisions of nodes in each cluster were compared pair wise for their importance toward a control element using nine numerical scales (Saaty, 1980).

As well, the clusters were compared with each other according to their importance in achieving the aims. Similarity, to obtain the priorities vectors (weight) relevant to inter dependency of nodes in each cluster, inter dependency of every cluster nodes, dependency of two clusters nodes, and all the nodes with dependency on each other were compared pair wise. After comparing, the local priority vectors were achieved.

As well, Delphi method a method for relies on a panel of experts (Cuhls, 2001), was used to assess the clusters and nodes. Experts were given questionnaires and then they compared clusters and nodes pair wise to control criterion using nine numerical scales that suggested by (Saaty, 1980). Then, the incompatibility rate shouldn't be more than to 0.1 (Saaty, 1980) for the opinion to be acceptable. Finally local priority vectors for each comparison in questionnaire relating to each expert were carried out.

Step 3: super matrix calculation: Sum of relative local priority vectors firstly achieved from comparing elements in each matrix in the previous step, and then a weighted super matrix was obtained. In this matrix, the columns built up nodes in relation to the cluster.

In each column, with attention to upper control nodes, available rates presented the relative weight vectors of pair wise in comparison among nodes. After achieving the weighted super matrix, some column may not be the assumed column forms, or the sum of column elements was not equal to one number. In this case, all the columns must be normalized to make the sum of columns equal to one. The achieved matrix was named weighted super matrix. Afterwards in order to achieve overall priority vectors, the super matrix must be periodically multiplied in itself and the process will continue until making a convergent matrix in an acceptable range, which was named limited super matrix.

In addition, after doing pair wise comparisons, using Delphi method and expert's opinions, sum of relative weight vectors resulted from the questionnaires and the weighted and limited super matrixes were made and overall priority of nodes was determined in each questionnaire. At last, by calculating the geometric mean of achieved weights of expert's questionnaire, final weight was determined and all previous steps have been done using Supper Decision Software version 2.8.

2.3. Spatial analysis

After making network and determining overall priority of each node using network analysis process which was known as the first step of this study, in the next step data base of area was made in ArcGIS version 9.3 software. For doing that, maps of slope, aspect, and elevation of area were extracted from the Digital Elevation Model (DEM) (scale 1:50000). The map of vegetation cover was also prepared using interpretation of the image of Landsat TM 2003. Also, the pedology, lithology, and erosion maps of the study area were provided from department of natural resources. Each map was classified to four categories based on early researches, expert's opinion, and natural condition of the area. So, they were graded according to their importance as a result of high desirability, high grade low desirability, and low grade.

2.4. Assessment of ecological capability

In the last step of this study the Weight-Linear Combination (WLC) technique was used that is a simple process in decision making. All the maps with their related weights combined based on the below link in GIS. Finally map of the range management capability was produced.

$S_{ij}= \sum W_k X_{ijk}$ (Equation 1)

In this formula S_{ij} pixel proportion placed in i line and column j in network map to subjected usage. W_k is the intended weight to k factor and x_{ijk} is the amount of k factor in (i,j) pixel (Hajehforooshnia *et al.*, 2011; Toledo-Aceves *et al.*, 2011).

3. Results

In this study based on previous studies, area condition, and according to the expert's opinion, seven indexes including slope, aspects, elevation, soil, erosion, lithology, and vegetation were demonstrated in four clusters those of topography, pedology, geology, and vegetation. These factors were used to assess range management capability of the study area and to determine their relations (Fig. 4).

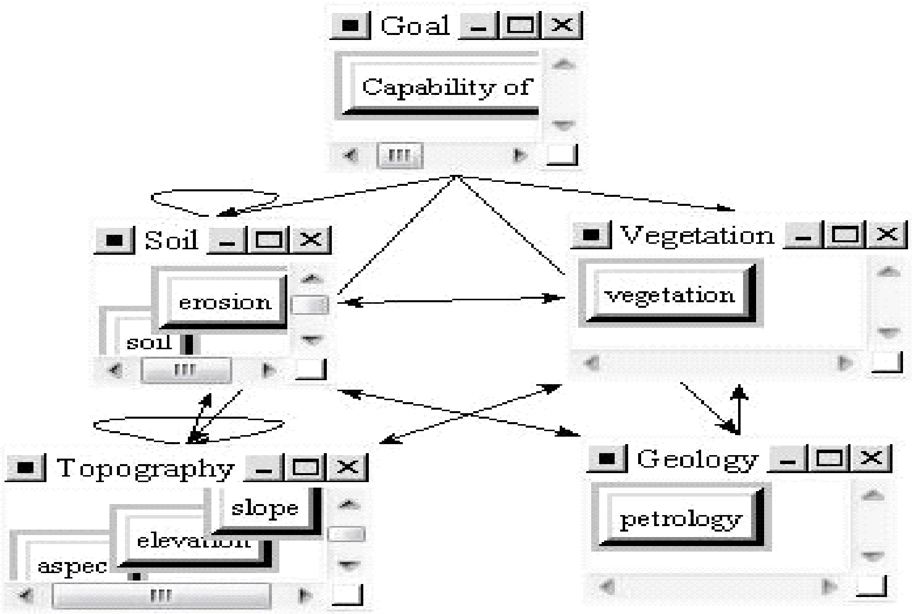


Fig. 4. Created network for evaluating range management capability of the study area in super decision software

After producing the network, some questionnaires were distributed among the experts and they compared pair wise clusters and nodes to obtain unweighted, weighted, and limited super matrixes. For example, (Tables 1 to 4), present vectors of local priority weight of clusters to control clusters and unweighted, weighted and limited super matrixes resulted from questionnaire 1, respectively.

Table 1. Local priority vectors to control clusters in questionnaire1

	Goal	Vegetation Cover	Topography	Soil	Geology
Goal	0.00	0.00	0.00	0.00	0.00
Vegetation cover	0.33	0.00	0.33	0.33	0.33
Topography	0.44	0.44	0.56	0.00	0.00
Soil	0.14	0.33	0.12	0.44	0.67
Geology	0.10	0.00	0.00	0.20	0.00

Table 2. Unweighted super matrix derived from analysis of questionnaire1

Unweighted Super Matrix Obtained from Questionnaire1		Goal	Vegetation Cover	Topography			Soil		Geology
		Capability of Range Management	Vegetation Cover	Slope	Aspect	Elevation	Soil Depth	Erosion	Petrology
Goal	Capability of range management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetation	Vegetation Cover	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Topography	Slope	0.54	1.00	0.00	0.8	0.67	0.00	0.00	0.00
	Aspect	0.30	0.00	0.20	0.20	0.33	0.00	0.00	0.00
	Elevation	0.16	0.00	0.81	0.20	0.00	0.00	0.00	0.00
Pedology	Soil depth	0.66	0.75	0.33	0.5	0.00	0.00	1.00	0.75
	Erosion	0.33	0.25	0.67	0.5	0.00	1.00	0.00	0.25
Geology	Petrology	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

Table 3. Weighted super matrix achieved from questionnaire1

Weighted Super Matrix Achieved from Questionnaire1		Goal	Vegetation Cover	Topography			Soil		Geology
		Capability of Range Management	Vegetation Cover	Slope	Aspect	Elevation	Soil Depth	Erosion	Petrology
Goal	Capability of range management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetation	Vegetation cover	0.33	0.00	0.27	0.31	0.36	0.14	0.39	0.33
Topography	Slope	0.24	0.67	0.00	0.45	0.43	0.00	0.00	0.00
	Aspect	0.13	0.00	0.27	0.00	0.21	0.00	0.00	0.00
	Elevation	0.07	0.00	0.95	0.11	0.00	0.00	0.00	0.00
Pedology	Soil depth	0.09	0.25	0.51	0.06	0.00	0.00	0.61	0.5
	Erosion	0.04	0.08	0.02	0.06	0.00	0.86	0.00	0.16
Geology	Petrology	0.09	0.00	0.00	0.00	0.00	0.01	0.00	0.00

Table 4. Limited super matrix achieved from questionnaire1

Unweighted Super Matrix Achieved from Questionnaire1		Goal	Vegetation Cover	Topography			Soil		Geology
		Capability of Range Management	Vegetation Cover	Slope	Aspect	Elevation	Soil Depth	Erosion	Petrology
Goal	Capability of range management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetation	Vegetation cover	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Topography	Slope	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
	Aspect	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	Elevation	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Pedology	Soil depth	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	Erosion	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Geology	Petrology	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

The results of determining the weight of each effective nodes in the process of area capability assessment for range management was mentioned in questionnaire 1 (Table 4), which is the result of calculating limited super matrixes. The rates of all columns after making convergent were equal which showed the weight of each node in the second column (Table 4). After achieving the local priority vectors in each questionnaire, the geometric mean calculated from weights of them and then final weights of nodes were calculated. From the obtained results, vegetation cover, elevation, slope, and the soil depth were most effective factors and had a high weight and lithology of area had the lowest weight. After achieving final weights related to each node, spatial database of the study area was formed by ArcGIS version 9.3. Then the affective nodes in assessment process were transformed to data layer. (Table 5), shows the clusters, nodes, final weight, and the way of classifying layers which used in this study.

The rangeland capability map (Fig. 9) was extracted from the layers of slope percentage (Fig. 5a), slope aspects (Fig. 5b), vegetation cover (Fig. 6a), elevation (Fig. 6b), soil depth (Fig. 7a), lithology (Fig. 7b), and erosion (Fig. 8). So, the rangeland capability was classified into four classes those of excellent, good, medium, and poor. As well, using GIS and WLC techniques each effective factor for assessment of range management capability was combined with its weight, and then the final map of range management of the study area was prepared.

Table 5. Clusters, nodes, final weight, and way of classifications applying layers

Clusters	Final Weight		Layer Classification			
	Nodes	Final Weight	1	2	3	4
Vegetation cover	Vegetation cover	0.12	Moderately Dense Rangeland (25-50)	Poor Rangeland (5-25)	Thin forest	Other lands
Topography	Slope(%)	0.18	0-15	15-30	30-45	45>
	Aspect	0.03	Northern	Western	Eastern	Southern
	Elevation(m)	0.06	500-1000	1000-1500	1500-2000	2000>
Pedology	Soil depth	0.04	Deep with few rock particles	Deep with more rock particles	Shallow with many rock particles	Very shallow with most rock particles
	Erosion	0.02	Very high	high	fair	low
Geology	Petrology	0.04	Lime stones	Alluvial fan	Alluvial soils	Marns and gypses

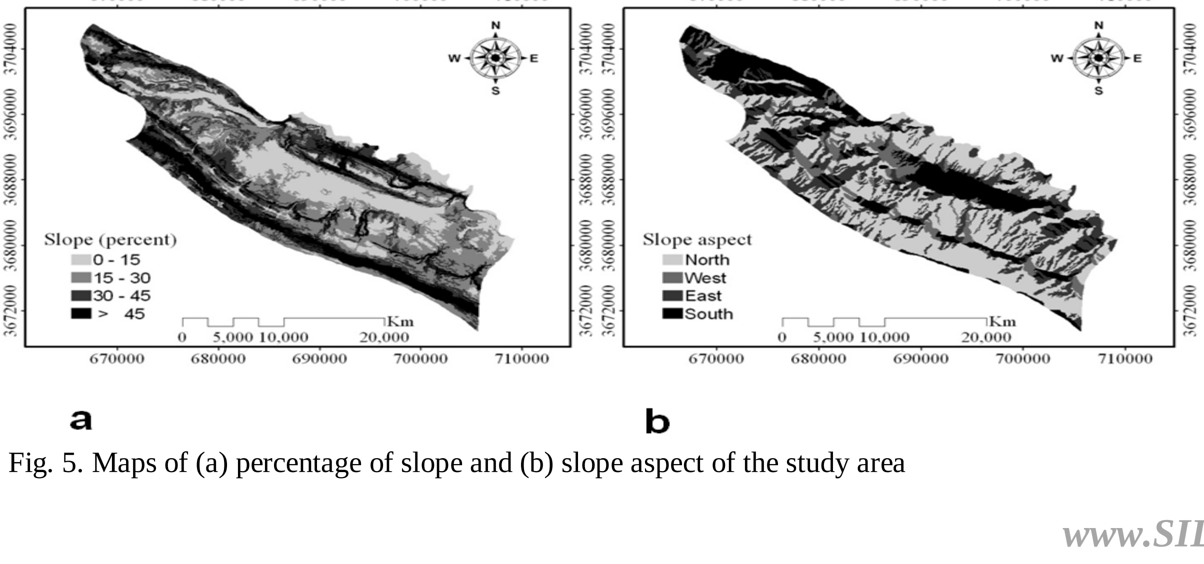


Fig. 5. Maps of (a) percentage of slope and (b) slope aspect of the study area

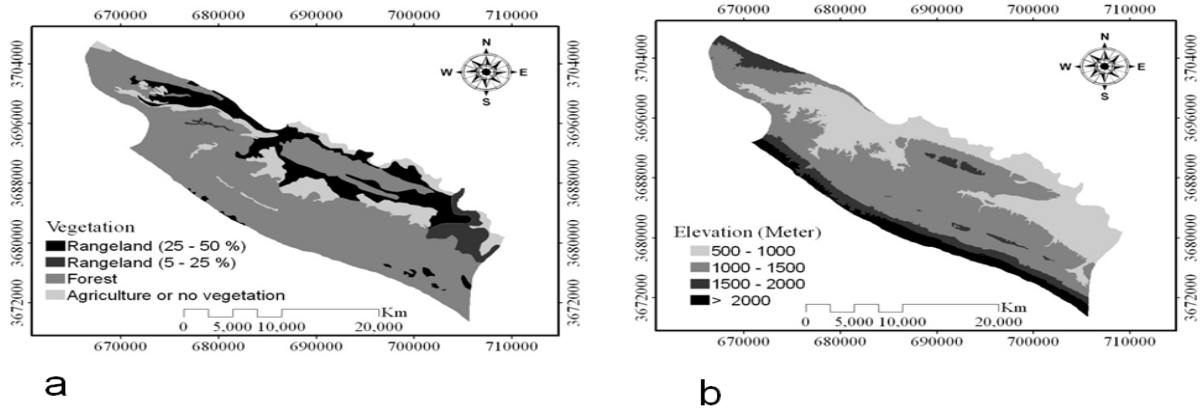


Fig. 6. Maps of (a) vegetation cover and (b) elevation of the study area

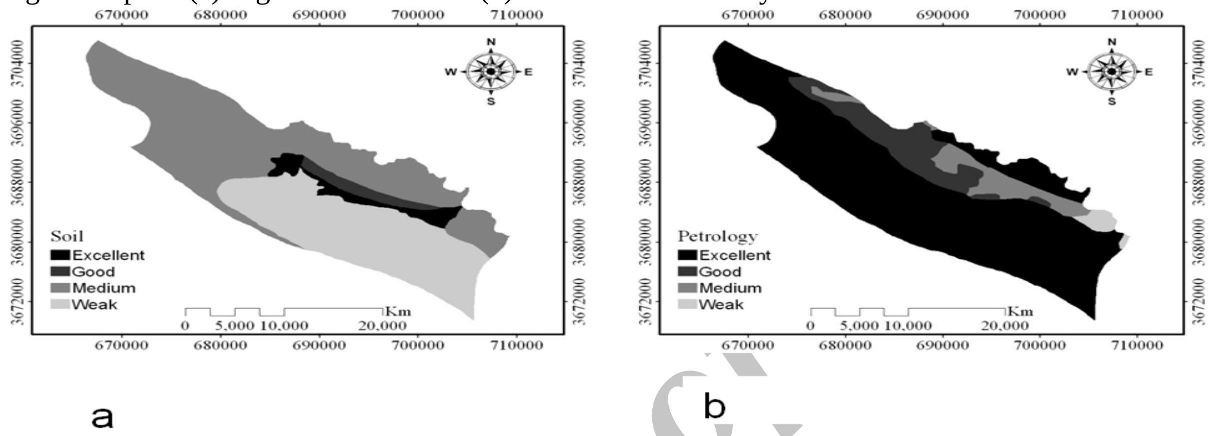


Fig. 7. Maps of (a) soil depth and (b) lithology of the study area

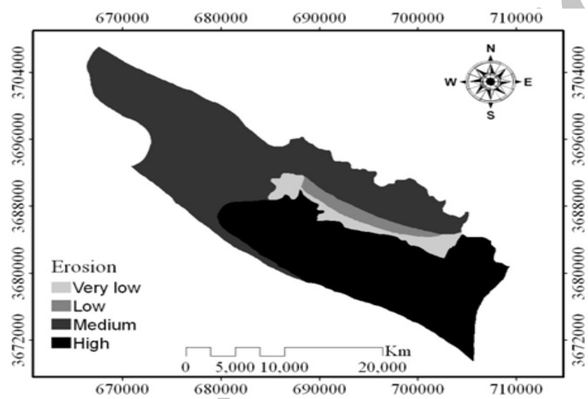


Fig. 8. Erosion map of the study area

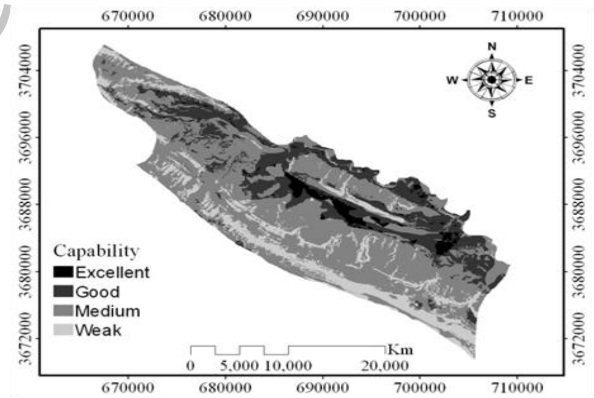


Fig. 9. Rangeland capability map of the study area

The results showed that three percent (1702 ha) of the study area had only the first class of capability or excellent capability for range management (Table 6). As well, 21.76 percent (12412 ha), 58.46 percent (33339 ha), and 16.8 percent (9574 ha) had the second, third, and fourth classes of range management (Table 6).

Table 6. Area of different classes

Class	Area (ha)	Area (%)
1	1702.6	3.0
2	12412.3	21.8
3	33339.6	58.5
4	9574.1	16.8

4. Discussion

Based on the results of analyzing expert's questionnaire vegetation cover, slope, and soil were the most important factors in this study. Vegetation cover had a significant role for range management capability. Because it showed that the dense rangeland had more capability than moderately dense rangeland. As well, forest land had a low capability for different activities such as: grazing and herbal medicines.

Sharp slope made many limitations for range management. Percentage of slope affects water storage and soil surface stability. The areas with steep slope are unstable and then soil particles fall to lowlands prevent the growth and development of plant communities.

Soil as the growth bed of plants provides four requirements: creating balance and establishing roots, storing water, storing foods, and storing air. Furthermore, soil is a very important factor in evaluating range management capability. Vegetation cover and slope have been introduced as the most effective factors in evaluating rangelands (Arzani *et al.*, 2006). Bacco *et al.* (2005) showed that these three factors have been evaluated as the most important factors in range management capability evaluation. Vegetation cover has been introduced as a factor for evaluating the capability of the rangeland area (Babaii Kafaki *et al.*, 2009). Gavili *et al.* (2011) named the vegetation cover as a significant factor in evaluating rangelands. Other factors like slope aspect, elevation, erosion, geology were used in this study based on the previous studies (Babaii kafaki *et al.*, 2009; Najibzadeh *et al.*, 2008; Zidat and

Al Bakry, 2006) those were in the line with them.

According to the results from evaluating range managements capability, most of the surface of study area had a fair capability (3rd class) and about 24 percent of the area had excellent and good (1st and 2nd classes) for range management. Considering the overall weight of effective factors, the roles of vegetation cover and slope were made clear in this study that vegetation cover had a high weight. In some places there exists a good vegetation cover, but range management capability is not desirable. The reason for this problem is back to the limitations of slope in some places, and also limitations of soil factor in other places (Arzani *et al.*, 2006).

In the study area, soil factor was very limited and only small surface area had good soil condition. The places with the first class capability for range management were at the center of the study area. These places are moderately dense rangelands (25-50) and had good soil condition with slight slope. Unsuitable places for range management (4th class) have been located in west-eastern of the study area and include mountains regions with high elevation, steep slope with rocky outcropping, and shallow soil with rock particles.

5. Conclusion

In our study for evaluating range management the ANP procedure was used. The technique of ANP was more beneficial option than other decision methods because it considered and measures all relation effects of clusters and nodes with each other (Saaty, 2004). This characteristic of ANP along with considering complexities of related matters to environment made this method superior in compression with other methods. For example, in evaluating the land for range management it was clear that there was a relation and dependency among soil, vegetation cover factors, and topographic characteristics. Soil factor was one of the most important factors that ascertain the amount and quality of vegetation cover of the area. On the other hand, vegetation cover influenced the soil characteristics. Topographical variables such as slope, aspect, and elevation not only had an influence on range management capability but also affect the vegetation cover of the study area which was one of the factors determining range management capability.

Moreover, ANP method not only had the direct and evident effects existed among clusters and nodes, but also it was able to involve a lot of the hidden impacts and dependencies that exist in the network and are not designed because of not having a direct relationship.

In this study expert's perception was used for determining and evaluating criteria and nodes influenced the capability of range management. The most important characteristic of using expert's perception was for decreasing errors probability. In fact one of the features of this study was for range management capability evaluation model by using two kinds of data; physical data (slope, aspects, elevation, vegetation cover, petrology, and erosion) and subjective data that included expert's judges. Accuracy of these judges was studied by calculating rate incapability. This method was used in many studies for evaluating and determining criteria as the same this study.

References

Amiri, F., Rashid, A, B., Shariff, M. and Arekhi, S., 2011. An Approach for Rangeland Suitability Analysis to Apiculture Planning in Gharah Aghach Region, Isfahan-Iran. *World Appl Sci JJour.*, **12(7):** 962-972. (In Persian).

Aragones-Beltran, P., Pastor-Ferrando, J, P., Garcia-Garcia, F. and Pascual-Agullo, A., 2010. An Analytic Network Process approach for siting a municipal solid waste plant in the Metropolitan Area of Valencia (Spain). *Environ Manage*, **91:** 1071–1086.

Arzani, H., Yousefi, Sh., Jafari, M. and Farahpour, M., 2006. Rangeland suitability model for sheep grazing using GIS, a case study Taleghan area. *Environ Stud*, **37:** 59-68. (In Persian).

Babaie-Kafaky, S., Mataji, A. and Ahmadi Sani, N., 2009. Ecological capability assessment for multiple-use in forest areas using GIS-based multiple criteria decision making approach. *Am Jour. Environ Sci*, **5(6):** 714-721. (In Persian).

Belfore, S., 2003. The growth of integrated coastal management and the role of indicators in integrated coastal management: introduction to the special issue. *Ocean Coast Manage*, **46(3–4):** 225–234.

Bocco, G., Vela zquez, A. and Siebe, C., 2005. Using geomorphologic mapping to strengthen natural resource management in developing countries. The case of rural indigenous communities in Michoacan, Mexico. *Catena*, **60:** 239-253.

Chen, Y. Ch., Lien, H. P. and Tzeng, G. H., 2010. Measures and evaluation for environment watershed plans using a novel hybrid MCDM model. *Expert Syst Appl*, **37:** 926–938.

Chung, S. H., Lee, A. H. L. and Pearn, W. L., 2005. Analytic Network Process (ANP) approach for product mix planning in Semiconductor Fabricator. *Prod Econ*, **96:** 15–36.

Collins, M. G., Steiner, F. R., Rushman, M. J., 2001. Land-use suitability analysis in the United States: historical development and promising technological achievements. *Environ Manage*, **28 (5):** 611–621.

Cuhls, K., 2001. Delphi method. Fraunhofer Institute for Systems and Innovation Research. Germany. 96 pp.

Faraji sabokbar, H., Salmani, M., Fereidoni, F., Karimzadeh, H. and Rahimi, H., 2008. Landfill Site Selection by AHP Model: case study: Villages around Ghochan city, Human Sciences MODARES, **1(4):** 127-149. (In persian).

Gavili, E., Vahabi, M, R., Arzani, H. and Ghasriani, F., 2011. Production suitability assessment in rangeland by Geographic Information System (Case study: Fereidoonshahr, Isfahan province), *Jour. Appl RS & GIS Tech Natu Res Sci*, **2:** 63-77. (In Persian).

Ertay, T., Ruan, D. and Tuzkaya, U. R., 2006. Integrating data envelopment analysis and analytic hierarchy for the facility design in manufacturing systems. *Inform Sciences*, **176:** 237–262.

Hajehforooshnia, Sh., Soffianian, A., Mahiny, A, S. and Fakheran, S., 2011. Multi objective land allocation (MOLA) for zoning Ghamishloo Wildlife Sanctuary in Iran. *Nature Conservation* **19:** 254-262. (In Persian).

Hossain, M. Sh. and Dos, N. G., 2010. GIS-based multi-criteria evaluation to land suitability modelling for giant prawn (*Macrobrachium rosenbergii*) farming in Companigonj Upazila of Noakhali, Bangladesh. *Compu Elec Agri*, **70:** 172–186.

Makropoulos, C., Butler, D. and Maks imovic, C., 2003. A fuzzy logic spatial decision support system for urban water management. *Jour. Water Res Plan Manage*, **129(1):** 69–77.

Malczewski, J., 2004. GIS-based land-use suitability analysis: a critical overview. Prog Plann, **62:** 3-65.

Marinoni, O., Higgins, A., Hajkowicz, S., and Collins, K., 2009. The Multiple Criteria Analysis Tool (MCAT): a new software tool to support environmental investment decision making. *Environ Modell Softw*, **24(2):** 153-164.

Mazhari, M., and Khaksar Astaneh, H., 2010. Effect of Range management schemes on Efficiency of rangeland (case study Khorasan Razavi province). *Agri Econ Develop*, **23(2):**12-20. (In Persian).

McHarg, I., 1969. Design with Nature. The Natural History Press, 197 p.

Najibzadeh, M, R., Sepehry, A., Heshmati, GH, A. and Rasouli, A, A., 2008. Evaluating land capability of Yekkeh Chenar Maraveh Tappeh for range application using ERAMS model and GIS. *Iran Jour. Range Desert Res*, **15(2):** 200-214. (In Persian).

Neaupane, K, M. and Piantanakulchai, M., 2006. Analytic network process model for landslide hazard zonation. *Eng Geol*, **85:** 281-294.

Nekhay, O., Arriaza, M. and Guzmán-Álvarez, J. R., 2008. Spatial analysis of the suitability of olive plantations for wildlife habitat restoration. *Comput Elec Agri*, **65:** 49-64.

Ohta, K., Kobashi, G., Takato, S., Kagaya, S., Yamada, H., Minakami, H. and Yamamura, E., 2007. Analysis of the geographical accessibility of neurosurgical emergency hospitals in Sapporo city using GIS and AHP. *Int Jour. Geog Inform Sci*, **21(6):** 687–698.

Pourebrahim, Sh., Hadipour, M., Bin Mokhtar, M. and Hj Mohamed, M. I., 2011. Analytic network process for criteria selection in sustainable coastal land use planning. *Ocean Coast Manage*, **53:** 544-551.

Razmi, J., Amalnik, M.S. and Hashemi, M., 2008. Selection of supplier by fuzzy analytical network process, *Jour. technical faculty*, **7(42):** 935-946. (In Persian).

Saaty, T. L., 1980. The analytical hierarchy process, planning priority. Resource Allocation. RWS Publication, USA, 287 pp.

Saaty, T. L., 1996. Decision making with dependence and feedback: the analytic network process. Pittsburgh: RWS Publications, 278 p.

Saaty, T. L., 2004. Fundamentals of the analytic network process–multiple networks with Benefits, Costs, Opportunities and risks. *Jour. Systems Science and Systems Engineering.* **13(3):** 348-379.

Saaty, T. L. and Vargas, L. G., 1991. Prediction, Projection and Forecasting. Kluwer Academic Publisher, Dordrecht, 251 pp.

Thirumalaivasan, D., Karmegam, M., Venugopal, K., 2003. AHP-DRASTIC: software for specific aquifer vulnerability assessment using DRASTIC model and GIS. *Environ Model Softw,* **18:** 645–656.

Toledo-Aceves, T., Meave, J, A., González-Espinosa, M. and Ramírez-Marcial, N., 2011. Tropical montane cloud forests: Current threats and opportunities for their conservation and sustainable management in Mexico. *Environ Manage*, **92:** 974-981.

Tsai, W. H., Chou, W. C. and Lai, C. W., 2010. An effective evaluation model and improvement analysis for national park websites: A case study of Taiwan. *Turism Manage*, **31:** 936-952.

Tuzkaya, G., Onut, S., Tuzkaya, U, R. and Gulsun, B., 2008. An analytic network process approach for locating undesirable facilities: An example from Istanbul, Turkey. *Environ Manage*, **88:** 970–983.

Ying, x., Guang-Ming, Z., Gui-Qiu, C., Lin, T., Ke-Lin, W. and Dao-You, H., 2007. Combining AHP with GIS in synthetic evaluation of eco-environment quality-A case study of Hunan Province, China. *Ecolo Model*, **209:** 97-109.

Yuksel, I. and Dagdeviren, M., 2007. Using the Analytic Network Process (ANP) in a SWOT analysis –A case study for a textile firm. *Inform Sciences*, **177:** 3364–3382.

Zhong-Wu, L., Guang-Ming, Z., Hua, Zh., Bin, Y., Sheng, J., 2007. The integrated eco environment assessment of the red soil hilly region based on GIS-A case study in Changsha City, China. *Ecol Model*, **202:** 540–546.

Ziadat, F, M. and Al-Bakri, J. T., 2006. Comparing existing and potential use for sustainable land utilization. *Jordan Jour. Agri Sci*, **4:** 327-386.

کاربرد فرآیند تحلیل شبکه‌ای در ارزیابی توان اکولوژیکی مدیریت مراتع (مطالعهٔ موردی، منطقهٔ بدره، استان ایلام)

علی مهدوی، استادیار گروه علوم جنگل، دانشکدهٔ کشاورزی و منابع طبیعی، دانشگاه ایلام (نویسندهٔ مسئول)
مرزبان فرامرزی، استادیار گروه مرتع و آبخیزداری، دانشکدهٔ کشاورزی و منابع طبیعی، دانشگاه ایلام
امید کرمی، دانشجوی دکتری جنگل‌داری، دانشکدهٔ منابع طبیعی، دانشگاه علوم کشاورزی و منابع طبیعی ساری

چکیده

مراتع برای تولید گیاهان، تولید حیوانات اهلی، حیات وحش، حفاظت از منابع آب و خاک و غیره مهم هستند. یکی از مشکلات اساسی اراضی مرتعی در ایران این است که از مراتع براساس پتانسیل و شایستگی آنها استفاده نمی‌شود و این استفاده نادرست سبب تخریب بیشتر آنها شده است. هدف از این مطالعه ارزیابی توان مرتعداری منطقه بدره در استان ایلام با استفاده از فرآیند تحلیل شبکه‌ای (ANP) و سامانه اطلاعات جغرافیایی (GIS) بود. برای این منظور ابتدا شبکه عوامل موثر در ارزیابی طراحی شد. چهار خوشه از معیارهای اصلی شامل پوشش گیاهی، توپوگرافی، خاکشناسی و زمین‌شناسی به تعدادی زیرمعیار تقسیم شدند. برای تعیین روابط بین این معیارها و زیرمعیارها، پرسشنامه‌هایی بین کارشناسان توزیع گردید و از قضاوت‌های آنها برای مشخص کردن اهمیت نسبی هر معیار در توان اکولوژیکی مرتع استفاده شد. در مرحله بعد با محاسبه سوپرماتریس حدی در هر پرسشنامه وزن نهایی گزینه‌ها در آن پرسشنامه تعیین شد و با میانگین هندسی گرفتن از وزن‌های حاصل از هر پرسشنامه وزن نهایی گزینه‌های موثر در فرآیند ارزیابی محاسبه شد. پس از تعیین وزن گزینه‌ها، گزینه‌ها به لایه‌های اطلاعاتی تبدیل شدند. در نهایت با استفاده از تکنیک ترکیب وزنی خطی (WLC) در محیط GIS نقشه توان اکولوژیکی برای مرتع‌داری تهیه شد. نتایج نشان داد که به ترتیب ۳، ۲۱/۷۶، ۵۸/۴۶ و ۱۶/۷۹ درصد از سطح منطقه دارای توان اکولوژیکی خیلی خوب، خوب، مناسب و ضعیف (به ترتیب طبقه‌های ۱، ۲، ۳ و ۴) برای مرتع‌داری است.

کلمات کلیدی: توان اکولوژیکی، مرتع‌داری، فرآیند تحلیل شبکه‌ای، سامانه اطلاعات جغرافیایی