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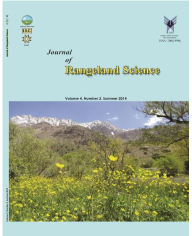

Full Length Article:

An Application of Fuzzy TOPSIS Method for Plant Selection in Rangeland Improvement (Case Study: Boroujerd Rangeland, Lorestan Province, Iran)

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Abstract. Species selection based on a new method such as a fuzzy method is one of the most important stages in the successful plantation management planning as choosing a suitable species for the site can be the key to success. This paper is based on a fuzzy extension of the Technique or Order Preference which is similar to Ideal Solution (TOPSIS) method. The purpose of this paper is to develop fuzzy TOPSIS method to improve the quality of decision making for species selection. For this propose, the selection of range species was done using Fuzzy-TOPSIS techniques in 2012 in Sarab Sefid rangeland in Boroujerd, Lorestan Province, Iran. In this method, the ratings of various species versus subjective criteria and weights of all criteria were assessed by linguistic variables represented by fuzzy numbers. Fuzzy numbers try to resolve the ambiguity of concepts that are associated with man judgments. A set of pre-defined linguistic variables parameterized by triangular fuzzy numbers was used by the group to evaluate the weights of various criteria and the ratings of each species. To determine the order of species, the closeness coefficient was defined by calculating the distances to Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS). Finally, for the application and verification, an empirical study was performed to demonstrate the model and identify the suitable species. Results show that Fuzzy-TOPSIS method is useful for species selection decision making and the proposed system can provide accurate results. Based on this method, *Bromus tomentellus* was the best species from frequency viewpoint for the range management.

Key words: Fuzzy logic, Species selection, Multiple Criteria Decision Making (MCDM), Fuzzy TOPSIS method

Introduction

Nowadays, proper selection of species is the first step in a long term pasture production and critical to achieve a sustainable range management. Hence, selecting the appropriate species for specific pastures where they will grow is practical and cost effective. Knowing criteria for pastures will make the selection much easier, too. There are many factors while considering the species selection for range management. Selecting the suitable range species is a vital and complex decision for the range managers.

The application of fuzzy set theory to multi-criteria evaluation methods has proven to be an effective approach (Mashayekhan and Mahiny, 2011). General utility of the alternatives with respect to all criteria is often measured by a fuzzy number where the alternatives are ranked based on the comparison of their corresponding fuzzy utilities (Chen and Hwang, 1992).

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method which is initially proposed by (Hwang and Yoon, 1981) is one of the well-known MCDM methods. In the classical TOPSIS, the rating and weight of criteria are known precisely. In a real-world situation, because of incomplete or non-obtainable information, human judgments including preferences are often vague and cannot estimate the preferences with an exact numerical data which are not often so deterministic; therefore, they usually are imprecise so that we try to extend TOPSIS for impressive data (Chen and Hwang, 1992; Hwang and Yoon, 1981). To resolve the ambiguity frequently arising in information from human judgments, fuzzy set theory has been incorporated in many MCDM methods including TOPSIS.

TOPSIS method is a technique for order preference by similarity to ideal solution. TOPSIS is one of the renowned methods for classical Multi-Criteria Decision-Making (MCDM) problems defining the positive and negative ideal solutions to maximize the benefit criteria and minimize the cost criteria (Hashemi and Amiri, 2013).

In fuzzy TOPSIS, all the ratings and weights are defined by the means of linguistic variables. A number of fuzzy TOPSIS methods and applications have been developed in recent years. Triantaphyllou and Lin (1996) developed a fuzzy TOPSIS method in which relative closeness for each alternative is evaluated based on fuzzy arithmetic operations. Liang (1999) proposed fuzzy MCDM based on the ideal and anti-ideal concepts. Chen and Tsao (2008) extended the TOPSIS method based on Interval-valued fuzzy sets in decision analysis. Jahan shahloo *et al.* (2006) and Chu and Lin (2009) extended the fuzzy TOPSIS method based on alpha level sets with the interval arithmetic. Chen and Lee (2010) operated fuzzy TOPSIS based on type-2 fuzzy TOPSIS method in order to provide additional degree of freedom to represent the uncertainty and fuzziness of the real world. Fuzzy TOPSIS has been introduced for various multi-attribute decision making problems. Yong (2006) used fuzzy TOPSIS for plant location selection and Chen *et al.* (2006) used fuzzy TOPSIS for the supplier selection. Ashtiani *et al.* (2008) used the interval-valued fuzzy TOPSIS method aiming to solve MCDM problems in which the weights of criteria are unequal using interval-valued fuzzy sets' concepts. TOPSIS method has become a popular multiple criteria decision technique due to its theoretical rigorousness (Deng *et al.,* 2000), a sound logic one that represents the human rationale for the selection (Shih *et al.,* 2007) and the fact that has been proved as one of the most appropriate methods for solving traversal rank (Zanakis *et al.,* 1998). Recently, some researchers have focused on developing fuzzy TOPSIS methods to deal with imprecise information. Sun and Lin (2009) applied fuzzy TOPSIS to evaluate the competitive advantages of shopping websites. Chamodrakas *et al.* (2009) employed fuzzy TOPSIS to help suppliers to evaluate customers within the order acceptance process so that the resource allocation and the priority of orders could be identified. Chu and Lin (2009) designed a fuzzy TOPSIS model based on the interval arithmetic of fuzzy numbers. Kahraman *et al.* (2009) proposed an interactive group decision making methodology based on fuzzy TOPSIS to select information system providers using multiple criteria. Chen and Tsao (2008) extended the TOPSIS method based on interval-valued fuzzy sets in decision analysis. Abo-Sinna *et al.* (2008) extended the TOPSIS approach to solve multi-objective large-scale non-linear programming problems with block angular structure. Lin and Chang (2008) applied fuzzy TOPSIS for the order selection and pricing the make-to-order products when orders exceed production capacity. Li (2007) developed a Compromise Ratio (CR) methodology for Fuzzy Multi-Attribute Group Decision Making (FMAGDM) which is an important part of decision support system. Wang and Chang (2007) utilized fuzzy TOPSIS to help the Air Force Academy in Taiwan to select the optimal initial training aircraft in a fuzzy environment. Wang and Lee (2007) generalized TOPSIS to a fuzzy multi-criteria group decision-making approach by proposing two operators Up and Low which satisfy the partial ordering relation in fuzzy numbers to find positive and negative ideal solutions. When ones lack explicit parameters, they should use TOPSIS (Caterino *et al.,* 2008).

TOPSIS seems to be a procedure suitable to the decision problem about the species selection for the range management since it allows the selection of only one solution as the best one and it is able to manage each kind of variables and each type of criteria (Caterino *et al.,* 2008; Chu *et al.,* 2007).

Major purpose of this paper is the application of fuzzy TOPSIS based on the concept of positive and negative ideal solutions to select suitable range species while no published paper considered selecting suitable range species in rangeland study with fuzzy logic. Considering the fuzzy data, linguistic variables are applied to determine the weights of all criteria and the rating of each species with respect to each criterion. A fuzzy decision matrix and a weighted normalized fuzzy decision matrix are generated.

There are many examples of different applications of fuzzy TOPSIS in literature including plant location selection based on fuzzy TOPSIS (Yong, 2006), comparison of Fuzzy AHP and Fuzzy TOPSIS methods for plant species selection (Alavi and Alinejad-Rokny, 2011), plant type selection for the reclamation of Sarcheshmeh Copper Mine in Iran by Fuzzy-TOPSIS method (Alavi *et al.,* 2012) using fuzzy TOPSIS method for mineral processing plant site selection (Ataei *et al.,* 2012) and A decision support system for the selection of solar power plant location by applying Fuzzy AHP and Fuzzy TOPSIS.

According to the concept of TOPSIS, the Fuzzy Positive Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS) are applied. Advantages of new FPIS and FNIS are to present a more reliable and easier way which guarantees that the preferred species is closer to the positive ideal solution and farther from the final negative ideal solution. Based on closeness coefficient values, we verify the ranking order of all species and select the best species.

This study aims to develop fuzzy TOPSIS method in order to improve the quality of decision making for species selection.

Materials and Methods

Study area

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 about 4 to 5 months a year (Fig. 1).

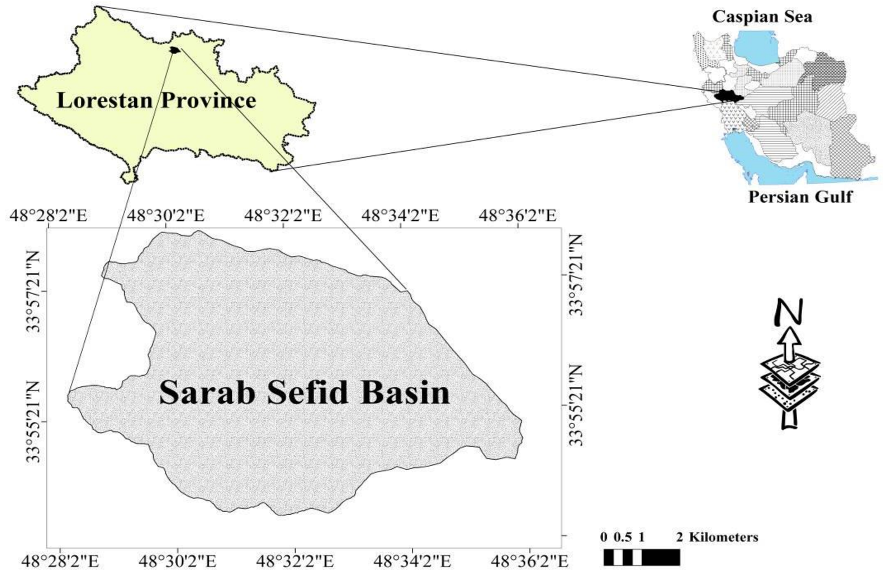

Fig. 1. Geographic location of Sarab Sefid in Lorestan province, Iran (Ariapour *et al.*, 2013)

Fuzzy sets and fuzzy numbers

Fuzzy set theory introduced by Zadeh (1965) to deal with the problems in which a source of vagueness is involved has been utilized for incorporating the imprecise data into the decision framework. A fuzzy set Ã can be defined mathematically by a membership function $\mu_A(x)$ which assigns each element x in the universe of discourse x a real number in the interval [0, 1]. A triangular fuzzy number Ã can be defined by a triplet (a, b, c) as illustrated in Fig. 2.

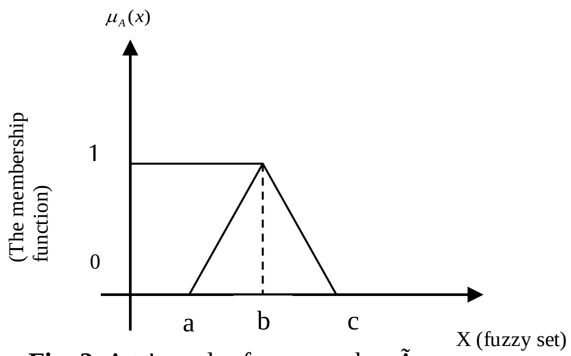

Fig. 2. A triangular fuzzy number Ã

The membership function $\mu_A(x)$ is defined as below (Equation 1):

$$\mu_{\bar{A}}(X)\begin{Bmatrix} \frac{x-a}{b-a} & a \le x \le b \\ \frac{x-c}{b-c} & b \le x \le c \\ 0 & otherwise \end{Bmatrix} \quad \text{(Equation 1)}$$

Where

a, b, c: fuzzy numbers

x: membership function

Basic arithmetic operations on triangular fuzzy numbers $A_1 = (a_\downarrow 1, b_\downarrow 1, c_\downarrow 1)$, where

$a_1 \le b_1 \le c_1$ and $A_2 = (a_\downarrow(2), b_\downarrow 2, c_\downarrow 2)$, and $a_2 \le b_2 \le c_2$, can be shown as follows (Equations 2, 3, 4, 5):

Addition: $\overline{A_1 \oplus B_1} = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$ (Equation 2)

Subtraction: $\overline{A_1 \theta B_1} = (a_1 - c_2, b_1 - b_2, c_1 - a_2)$ (Equation 3)

Multiplication: if K is a scalar $K \otimes A_1 = \begin{cases} ka_1, kb_1, kc_1 & k > 0 \\ kc_1, kb_1, ka_1 & k < 0 \end{cases}$ (Equation 4)

$A_1 \otimes A_2 \cong (a_1 a_2, b_1 b_2, c_1 c_2)$, if $a_1 \geq 0, a_2 \geq 0$

Division:

$$A_1 \emptyset A_2 \cong \left(\frac{a_2}{c_2}, \frac{b_1}{b_2}\frac{c_1}{a_2}\right), if\ a_1 \geq 0, a_2 \geq 0$$

(Equation 5)

Although multiplication and division operations on triangular fuzzy numbers do not necessarily yield a triangular fuzzy number, triangular fuzzy number approximations can be used for many practical applications (Kaufman and Gupta, 1988). Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems including species selection for range management. The primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation (Karsak, 2002). A linguistic variable is defined as a variable whose values are not numbers but words or sentences in natural or artificial language. The concept of a linguistic variable appears as a useful tool for providing approximate characterization of phenomena that are too complex or ill defined to be described in conventional quantitative terms (Zadeh, 1975).

Methodology

Fuzzy TOPSIS method

This study applied the TOPSIS method for the species selection in the rangeland of Lorestan province as shown in Fig. 3.

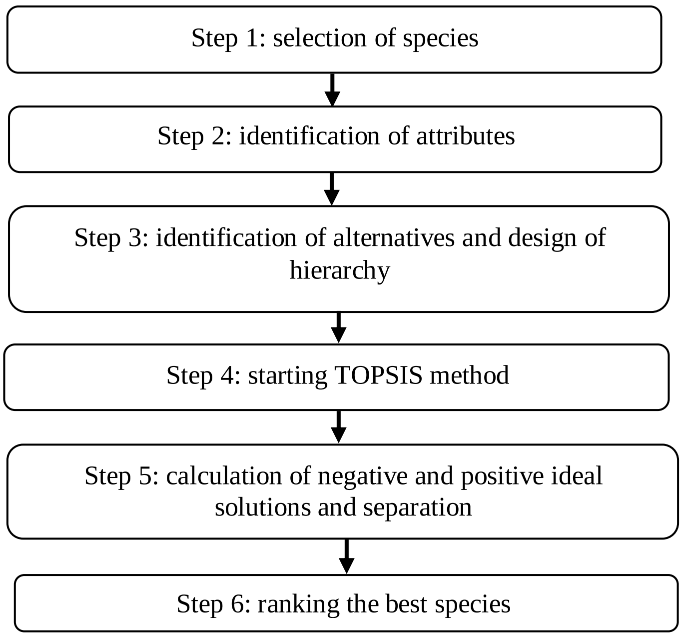

Fig. 3. A schematic outline of fuzzy TOPSIS methodology

Important species that have been working on them are *Bromus tomentellus, Astragalus gossypinus* and *Hordeum bulbosum.*

In this study, there were four criteria that are palatability, resistance against lime, resistance against flood water and protection of soil. The importance weights of various criteria and the ratings of qualitative criteria are considered as linguistic variables (very poor, poor, poor, medium poor, fair, medium good, good, very good).

This study uses this method to select species for range management. TOPSIS views a MADM problem with m alternatives as a geometric system with m points in the n-dimensional space. The method is based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution. TOPSIS defines an index called similarity to the positive ideal solution and the remoteness from the negative ideal solution. Then, the method chooses an alternative with the maximum similarity to the positive ideal solution (Wang and Chang, 2007). It is often difficult for a decision maker to assign a precise performance rating to an alternative for the desired attributes. The merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers. This discussion extends the TOPSIS to the fuzzy environment (Yang and Hung, 2007). This method is particularly suitable for solving the group decision-making problem in a fuzzy environment. The rationale of fuzzy theory is reviewed briefly before the development of fuzzy TOPSIS.

TOPSIS process defined by Chen and Hwang (1992) is carried out as follows:

1. Create an evaluation matrix consisting of criteria and alternatives;
2. The matrix is normalized based on the normalization method;
3. Calculate the weighted normalized decision matrix;
4. Determine the worst alternative and the best alternative;
5. Calculate the distance between the alternative and worst or best conditions;
6. Calculate the similarity to the worst conditions;
7. Rank the alternatives.

The mathematics concept borrowed from Ashtiani *et al*. (2008) is described as follows:

Step 1: Determine the weighting of evaluation criteria

A systematic approach to extend the TOPSIS is proposed to select species in a fuzzy environment here. In this paper, the importance weights of various criteria and the ratings of qualitative criteria are considered as linguistic variables (Table 1) (Chen *et al.,* 2006).

Table 1. Linguistic scales for the importance of each criterion

Linguistic Variable	Corresponding Triangular Fuzzy Number
Very poor	(0.0, 0.0, 0.1)
Poor	(0.0, 0.1, 0.3)
Medium poor	(0.1, 0.3, 0.5)
Fair	(0.3, 0.5, 0.7)
Medium good	(0.5, 0.7, 0.9)
Good	(0.7, 0.9, 1.0)
Very good	(0.9, 1.0, 1.0)

Step 2: Construct the fuzzy decision matrix and choose the appropriate linguistic variables for the alternatives with respect to criteria (Equation 6).

$$D = \begin{matrix} \\ A_1 \\ A_i \\ A_m \end{matrix} \begin{bmatrix} x_1 & x_j & x_n \\ \tilde{x}_{11} & \tilde{x}_{1j} & \tilde{x}_{1n} \\ \tilde{x}_{i1} & \tilde{x}_{ij} & \tilde{x}_{in} \\ \tilde{x}_{m1} & \tilde{x}_{mj} & \tilde{x}_{mn} \end{bmatrix}$$

$$\tilde{x}_{ij} = \frac{1}{k}\left(\tilde{x}_{ij}^{1} + \tilde{x}_{ij}^{2} + \cdots + \tilde{x}_{ij}^{k}\right) \quad \text{(Equation 6)}$$

Where

$\tilde{x}_{ijk}$ is a rating of alternative A_i with respect to criterion c_j is evaluated by k expert and $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$.

Step 3: Normalize the fuzzy decision matrix

The normalized fuzzy decision matrix denoted by $\tilde{R}$ is shown as follows (Equation 7):

$\tilde{R} = [\tilde{r}_{ij}]_{m.n}$ *i=1, 2, …, m; j=1, 2, …, n* (Equation 7)

Then, the normalization process can be performed by the following (Equation 8):

$\tilde{r}_{ij} = (\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+})$ $c_j^+ = max_j\ c_{ij}$ (Equation 8)

The normalized $\tilde{r}_{ij}$ is still a triangular fuzzy number. For trapezoidal fuzzy numbers, the normalization process can be conducted in the same way. The weighted fuzzy normalized decision matrix is shown as the following matrix $\tilde{V}$ (Equations 9 and 10):

$\tilde{V} = [\tilde{V}_{ij}]_{m.n}$, *i=1, 2, …, m; j=1, 2, …, n* (Equation 9)

$\tilde{V}_{ij} = \tilde{r}_{ij(.)}\widetilde{W}_{ij}$ (Equation 10)

Step 4: Determine the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS)

According to the weighted normalized fuzzy decision matrix, we know that the elements $\tilde{V}_{ij}$ are normalized positive TFNs and their ranges belong to the closed interval [0, 1]. Then, we can define the FPIS A^+ and FNIS A^- as follows (Equations 11 and 12):

$A^+ = (\tilde{V}_1^+, \tilde{V}_2^+, \dots, \tilde{V}_n^+)$ (Equation 11)

$A^- = (\tilde{V}_1^-, \tilde{V}_2^-, \dots, \tilde{V}_n^-)$ (Equation 12)

$\tilde{V}_J^+ = (1, 1, 1)$ and $\tilde{V}_J^- = (0, 0, 0)$

j=1, 2, …, n

Step 5: Calculate the distance of each alternative from FPIS and FNIS

The distances (d_i^+ and d_i^-) of each alternative A^+ from and A^- can be currently calculated by the area compensation method (Equations 13 and 14).

$d_i^+ = \sqrt{1/3 \sum_{j=1}^{n} (\tilde{V}_{ij} - V_j^+)^2}$ (Equation 13)

$d_i^- = \sqrt{1/3 \sum_{j=1}^{n} (\tilde{V}_{ij} - V_j^-)^2}$ (Equation 14)

Step 6: Obtain the closeness coefficient (cc) and rank the order of alternatives

CC_i is defined to determine the ranking order of all alternatives once d_i^+ and d_i^- of each alternative have been calculated. Similarities to ideal solution should be calculated. This step solves the similarities to an ideal solution by (Equation 15):

$CC_i = \frac{d^-}{d^- + d^+}$, $i = 1,2,\dots,m$ (Equation 15)

According to the CC_i, we can determine the ranking order of all alternatives and select the best one from a set of feasible alternatives. In recent years, some fuzzy TOPSIS methods were developed in a different applied field. Lin and Chang (2008) adopted fuzzy TOPSIS for the order selection and pricing of manufacture (supplier) with make-to-order- basis when orders exceed the production capacity.

Illustrative

The proposed approach was applied in a species selection process located in Lorestan, Iran. We worked out a numerical example to illustrate our TOPSIS method for decision making problems. Through the literature investigation and experts' opinions, four main criteria were selected. Several criteria are concerned and in this study, these are palatability, resistance against lime, protection of soil and resistance against flood water. The hierarchical structure of this decision problem is shown in Fig. 4. Experts' opinions develop the fuzzy criteria and use the linguistic variables (Table 1) to assess the ratings of alternatives with respect to each criterion as showed in Table 2. We get the decision matrix of fuzzy ratings of conceivable alternatives with respect to criteria as in Equation 7 and the weights of criteria and then, construct the fuzzy decision matrix, fuzzy weight matrix and normalized fuzzy decision matrix shown in Tables 2, 3 and 4 as defined by (Equation 6).

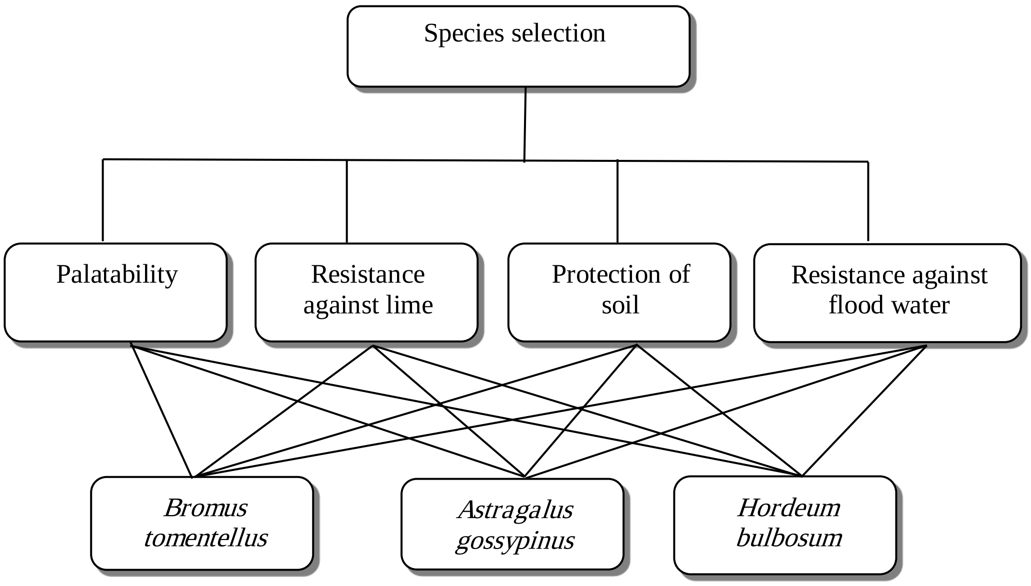

Fig. 4. Hierarchical structure of species selection process

Table 2. Fuzzy decision matrix and fuzzy weights of criteria

Species	Palatability	Resistance Against Lime	Protection of Soil	Resistance Against Flood Water
Bromus tomentellus	(9, 10, 10)	(7, 9, 10)	(7, 9, 10)	(3, 5, 7)
Astragalus gossypinus	(1, 3, 5)	(7, 9, 10)	(9, 10, 10)	(5, 7, 9)
Hordeum bulbosum	(3, 5, 7)	(7, 9, 10)	(7, 9, 10)	(3, 5, 7)
weight	(0.7, 0.9, 1)	(0, 0.1, 0.3)	(0.9, 1, 1)	(0.5, 0.7, 0.9)

Table 3. Normalized fuzzy decision matrix

Species	Palatability	Resistance Against Lime	Protection of Soil	Resistance Against Flood Water
Bromus tomentellus	(1, 1, 1)	(1, 1, 1)	(0.77, 0.9, 1)	(0.6, 0.71, 0.77)
Astragalus gossypinus	(0.11, 0.3, 0.5)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)
Hordeum bulbosum	(0.33, 0.5, 0.7)	(1, 1, 1)	(1, 1, 1)	(0.6, 0.71, 0.77)

Table 4. Fuzzy normalized weighted decision matrix

Species	Palatability	Resistance Against Lime	Protection of Soil	Resistance Against Flood Water
Bromus tomentellus	(0.7, 0.9, 1)	(0, 0.1, 0.3)	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)
Astragalus gossypinus	(0.07, 0.27, 0.5)	(0, 0.1, 0.3)	(0.9, 1, 1)	(0.5, 0.7, 0.9)
Hordeum bulbosum	(0.23, 0.45, 0.7)	(0, 0.1, 0.3)	(0.9, 1, 1)	(0.3, 0.5, 0.7)

By equations (10) and (11), the ideal and negative ideal solution casn be obtained as:

A^{+}= (0.7, 0.9, 1) (0, 0.1, 0.3) (0.9, 1, 1) (0.5, 0.7, 0.9)

A^{-}= (0.07, 0.27, 0.5) (0, 0.1, 0.3) (0.7, 0.9, 1) (0.3, 0.5, 0.7)

Results and Discussion

In this paper, we propose fuzzy TOPSIS method and real application related to the species selection in Lorestan Province, Iran. In order to rank the selected species, the researchers used TOPSIS method. In TOPSIS, distance from ideal and anti-ideal solutions was calculated and the procedure of TOPSIS has been defined in Fig. 2; an empirical case study for species selection is used to exemplify the approach. As a result, the proposed method is practical for solving Multi Criteria Decision Making (MCDM) problems with fuzzy data and ranking species in terms of their relative closeness to the ideal solution.

By (Equations 12 and 13), the distance of each alternative from ideal and negative ideal solutions can be easily obtained and by (Equation 14), the closeness coefficient of each alternative can be produced as C_1(Palatability)= 0.64, C_2 (Resistance against lime)= 0.358 and C_3 (Protection of soil)= 0.335.

According to the closeness coefficient, the ranking order of three species is A_1 (*Bromus tomentellus*), A_2 (*Astragalus gossypinus*) and A_3 (*Hordeum bulbosum*). Thus, the best species selection for range management is *Bromus tomentellus*. By fuzzy TOPSIS method steps and calculation, the ranking of best species are acquired (Table 5).

Table 5. Final evaluation of alternatives

Species	d^+	d^-	CC	Rank
Bromus tomentellus	0.329	0.589	0.640	1
Astragalus gossypinus	0.589	0.329	0.358	2
Hordeum bulbosum	0.612	0.309	0.335	3

d^+: distances to the Fuzzy Positive Ideal Solution, d^-: distances to the Fuzzy Negative Ideal Solution, CC: Closeness Coefficient

According to experts' opinions through fuzzy TOPSIS approach, the best species based on the regional condition is *Bromus tomentellus* and the rank of each species using TOPSIS has come out as (Table 6).

Table 6. Species rank calculation

Species	Result	Rank
Bromus tomentellus	0.640	1
Astragalus gossypinus	0.358	2
Hordeum bulbosum	0.335	3

Natural resources managers, conservation organizations and governments need to prioritize suitable species in order to manage and achieve the best socio-economic and ecological benefits. Here, we have presented a prioritization system on species selection and species are thus ranked according to the scientific decision makers. Using scientific information on species, this prioritization system can ensure the highest priority species for management. Successful rangeland management plan begins with proper species selection and it is one of the most important decisions in a rangeland. Since proper species selection in rangeland affects a wide range of environments, a multi-criteria approach is needed to deal with this problem while it is easy to use a tool for species prioritization. In present case study, the model uses a multi-criteria technique called TOPSIS which contributes to rank the species relative to environmental conditions. According to the outcomes of the research, multi attribute decision making is an appropriate model and TOPSIS is a proper technique to select species in rangeland management plan.

In this approach, the distance values of each alternative from ideal and anti-ideal solutions are calculated using the concept of ranking fuzzy numbers.

Finally, the closeness coefficients are defined to attain the ranking order of all alternative strategies. In fact, this method is very simple and flexible. Hence, it is expected that the proposed method in this study may have more potential management applications in future research. According to the decision maker's preferences, we use TOPSIS method and rank the species. Information provided in this paper is useful for decision-making process and many valuable purposes such as rehabilitee of rangeland and planning.

Decision makers face the uncertainty and vagueness from subjective perceptions and experiences in the decision-making process (Ertugrul and Karakasoglu, 2006). Using fuzzy TOPSIS, uncertainty and vagueness from subjective perceptions and experiences of decision maker can be effectively represented to achieve a more effective decision. In the case of the large number of decision makers being involved, the proposed approach can obtain the ranking faster. Results are supported by the studies conducted by Zanakis *et al.* (1998) Deng *et al.* (2000); Shih *et al.* (2007) and Wang and Chang (2007). They emphasize the significant fuzzy TOPSIS as the well known multiple criteria decision making method.

In summary, we have presented a framework for prioritizing species according to the environmental conditions which involve palatability, resistance against lime, protection of soil and resistance against flood water. In theory, this framework could be implemented for any groups of species considered for rangeland management and we encourage the use of this framework as a useful prioritization and decision making tool in species selection.

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کاربرد روش فازیTOPSIS در انتخاب گونه به منظور مدیریت مرتع (مطالعه موردی: مراتع بروجرد، لرستان، ایران)

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چکیده. انتخاب صحیح گونه یکی از مهمترین مراحل در طرح مدیریت بوده و کلید موفقیت در هر منطقه است. در روش فازی TOPSIS رتبه‌دهی گونه‌ها، وزن معیارها و زیر معیارها با اعداد فازی بیان شده و به کمک این اعداد، ابهام قضاوت انسانی حل می‌شود. هدف این مقاله استفاده از روش فازی TOPSIS به منظور تصمیم‌گیری بهتر برای انتخاب گونه مناسب است. این تحقیق در مراتع سراب سفید حوزه آبخیز بروجرد برای انتخاب گونه گیاهی مناسب از گونه‌های پیشنهاد شده به کمک روش فازی TOPSIS در سال ۱۳۹۱ صورت گرفت. نتایج موفقیت روش فازی TOPSIS را در انتخاب گونه نشان داد. در این مطالعه به منظور ارزیابی وزن معیارهای مختلف و رتبه‌دهی گونه‌ها از اعداد فازی مثلثی مطابق با متغیرهای زبانی استفاده شد و در نهایت به منظور رتبه‌دهی گونه‌ها، فاصله از ایده آل مثبت و ایده آل منفی محاسبه شد. در نهایت در این تحقیق به منظور نشان دادن کاربرد روش فازی TOPSIS مناسب‌ترین گونه انتخاب شد. نتایج نشان داد که روش فازی TOPSIS برای انتخاب گونه مفید واقع شد و سیستم پیشنهاد شده می‌تواند نتایج دقیقی در حوزه مورد نظر (استان لرستان) فراهم کند و گونه ***Bromus tomentellus*** بهترین گونه از لحاظ فراوانی برای مدیریت در مراتع حوزه سراب سفید بروجرد انتخاب شد.

کلمات کلیدی: منطق فازی، انتخاب گونه، تصمیم گیری چندمعیاره، روش فازی TOPSIS