Review

Investigation and zoning of agro-climatology of Mughan and Gilan plains for the economic development of *olive* (*Olea europaea*) cultivation in Iran

V. Safarian Zengir[1], A. Fatahi[2], B. Sobhani[3], F. Shafiei Sabet[4] and M. Kianian[5]

[1] Climatology, Faculty of Social Sciences, University of Mohaghegh Ardabili, Iran
[2] Department of Agricultural Economics, Faculty of Agriculture and Natural Resources, Ardakan University, Ardakan, Iran
[3] Climatology, Faculty of Social Sciences, University of Mohaghegh Ardabili, Iran
[4] Climatology, Faculty of Literature and Human Sciences, University of Mohaghegh Ardabili, Iran
[5] Desert Studies Faculty, Semnan University, Iran

Summary

Climatic elements in different parts of production of human food resources are affected. One of these sectors is agricultural and horticultural crops products. One of the garden crops in which cultivation climatic elements are highly effective, is the *olive* (*Olea europaea*) garden crop. *Olive* (*Olea europaea*) is the oldest plant used in the world. The aim of this study was to identify the effects of climate parameters on the yield of olive oil, which has been used for multi-criteria decision making. The data used in this study are total annual precipitation, average minimum temperature, average maximum temperature, average temperature, germination temperature, flowering temperature, humidity, elevation, gradient, evaporation, and freezing. In this study, 11 climatic variables of Mughan plain and nine climate variables in Gilan province were investigated with respect to the zoning of olive climate. In order to measure the land suitability of Mughan and Gilan plains for olive cultivation, eight stations have been used since the beginning of the year until 2018. The final results indicate that the two factors of precipitation and height are the most important factors affecting the olive because these two factors have the most weight among other parameters. According to the results of *TOPSIS* and *VIKOR*, according to ranking and weighting to each of the indicators, Germi and Rudbar were 97% and 58% respectively, and Parsabad and Manjil with the amount 0.03 and 0.20 have earned the last rank in the field of crop cultivation. According to the *VIKOR* model, the Q value of the studied climatic indexes, Germi, and Rudbar stations, ranked # 1 in the best condition for olive but Parsabad farming Rasht is ranked 4th in the worst situation.

Keywords
climatic elements, feasibility, multivariate decision making, zoning, *olive* (*Olea europaea*), garden cultivation development

Significance of this study

What is already known on this subject?
- Finding the relationship between climatic elements and *olive* cultivation.

What are the new findings?
- Effect of temperature and precipitation relative to other climatic factors in *olive* cultivation.
- Better quality of *olive* in Gilan province than in other provinces.

What is the expected impact on horticulture?
- According to the results obtained in this study, the quality of *olive* cultivated in Gilan province is high and can have good effects on nutrition.

Introduction

Anomalies of climatic parameters affect the production of agricultural and horticultural products. Finding a suitable climatic place for cultivation of any agricultural and horticultural crop is very important. The climate plays an important role in human life and is the only source of production that humans can use with the lowest cost (Kafi et al., 2015). Agriculture is one of the most important sectors of the economy. Nowadays it is possible to develop a rigorous and accurate agricultural development based on accurate scientific research and understanding of the environmental capabilities and capabilities of each region. Climate conditions are important factors in the production and identification of the species, and land utilization is largely based on the quality of this factor (Alijani and Doostan, 2016). This heterogeneity affects vegetation and crop type. *Olive* (*Olea europaea*) with numerous species and cultivars in the form of tree or shrubs, wild and domesticated, natural or modified in vast areas of both hemisphere, under Mediterranean climatic conditions in Africa, Asia, the Americas, Europe, and Oceania Scattered. This tropical plant is of Mediterranean type (WeiGuang et al., 2010). Today, agricultural work with the goal of profitability and the optimal use of natural resources requires the knowledge of adequate climate data, including temperature, precipitation, humidity, and other climate parameters. Therefore, the importance of agro-climatology in agriculture is twofold. Agriculture is considered as the main pillar of food supply for the people of a community and is the supplying factor for meeting the food needs of the people (Gholizadeh and Minaee, 2006). In the *olive*-growing world, especially in the Mediterranean, and also in Iran, several studies have been carried out by researchers on the climatic characteristics of *olive* cultivation, some of which are mentioned. According to the research, about 255 species damage (fungi, bacteria, and nematodes, etc.) have been detected on *olive* oil, however, only a small group of these factors cause economic damage to *olive* oil (Gilbert and Mifsud, 2007). Fruit rot is one of the most important *olive* diseases, causing significant damage to the *olive* product at pre- and post-harvest stage and decreasing the production of qualitative properties of *olive* oil (Sergeeva et al., 2008). Researchers examined the location of tropical beet in Kenya, and the results showed that 17% of the land was suitable for cultivation (Mandere et al., 2010). The agent also infects young branches and branches in addition to fruit. Flower contamination usually results in fruit rot (Sergeeva et al., 2008). This disease was reported by Sanei in Iran in 2005 from Rudbar, Golestan province, and Gilan province (Sanei and Razavi, 2012). Ramezani and Kazemnezhad (2011) in the study of the effect of precipitation fluctuations on agricultural production in Rudbar (Case study: *Olive* Product), using the SPI Drought Index (Standard Precipitation Index), the drought of the area during the period of 1978 to 2009 was extracted and the effect of drought on the production of *olive* crops was investigated. The results of this study indicate that the city has suffered from drought, in terms of frequency of occurrence during the statistical period in the years 2008–2009 and 1993–1994, respectively. On the other hand, there is a meaningful relationship between the amount of crop production and drought.

Types of *Olive*

Cured Olives. Depending on which method is used, curing *olives* can take from a few days to a few months. Lye curing has the shortest fermentation time while brining takes the longest. Green *olives* must be soaked in a lye solution before brining, whereas ripe black *olives* can proceed straight to brining. The longer the *olive* is permitted to ferment in its own brine, the less bitter and more intricate its flavor will become. (Moriondo et al., 2019).

Green Olive Varieties. There are many types of *olives*, but you may come across just a few in your local supermarket or gourmet grocer. The manzanilla is a Spanish green *olive* that is lightly lye-cured, then packed in salt and lactic acid brine. These *olives* are most often available pitted and sometimes stuffed. Another Spanish *olive* is the Gordal, which means "fat one", a fitting name for this plump, rounded green *olive*. They are meaty and rich tasting, and often served as a tapas. A French *olive* you might find is the Picholine, a salt-brine cured green *olive* with a subtle, slightly salty flavor. In the U.S., they are sometimes packed with citric acid as a preservative. Cerignola, Italy, produces a green *olive* by the same name. It is large in size, buttery in flavor, and crisp in texture. (Gilbert and Mifsud, 2007).

Black Olive Varieties. Black *olives* aren't just plain and found in a can; there are plenty of interesting cured black *olives* to choose from, such as Italian *olives*. One is the Liguria, a black *olive* that is salt-brine cured with a vibrant flavor, and sometimes packed with their stems. Another Italian black *olive* is the Ponentine, salt-brine cured and then packed in vinegar; it has a mild flavor. The Gaeta is also a ripe *olive*; it is dry salt cured and then rubbed with oil. It has a wrinkled appearance, mild flavor, and is often packed with rosemary and other herbs. And one black Italian *olive* that is popular at tastings is the Lugano; it is usually very salty and sometimes packed with *olive* leaves (Mandere et al., 2010). So that the lowest amount of production in the year 2007–2008 with 6,270 ha and 3,249 tons, and the most are 1993–1994 years with 2,149 ha and 6,200 tons. Moshiri and Maarofnezhad (2012) in studying the potential and development prospects of *olive* cultivation in improving the economy of the villages of Izeh city concluded that due to the similarity of weather conditions in Izeh city in terms of temperature, the Mediterranean for the cultivation and development of *olive* groves is appropriate in the study area. Hejazizadeh et al. (2014) concluded that the role of each of the effective elements in *olive* cultivation is different, and the five climatic elements of annual precipitation, growth day temperature, annual temperatures, and the minimum temperature of the coldest month of the year (January) and relative humidity, reflect the expert weight and related scientific resources in the process of *olive* tree cultivation, have a greater effect and greater contribution and capability. Also, by adapting the weighed layers by considering the importance of each of the effective layers in the cultivation process in the ArcGIS environment, it is possible to identify the desirable value of the areas for cultivation of this valuable garden tree (Nemati and Orji, 2013). In an economic review of the use of some organic products in drought tolerance in *olive*, the economical use of biomaterials under low irrigation conditions is considered. For this purpose, two varieties of *olive* cultivars called oily and Yellow in *Olive* Red Crescent of Sarpul-Zahab were selected from Kermanshah province and were conducted in a split-split experiment in a randomized complete block design with three replications from 2010 for two years. After collecting data, an economic evaluation was carried out using partial budgeting method. The results show that the use of biological fertilizer in irrigated irrigation is uneconomical. Yaaghobi and Taheri (2013), in the study of the attitude of Tarom *olives* in relation to organic farming and its related factors, the statistical population included 111 Ovarian villagers from Tarom city to organic farming of 3.35% of the 5 which indicates a relatively desirable farmer to organic farming. Also, there was no significant relationship between age, agricultural history, the average amount of drought and farmers' attitude, but there was a significant relationship between *olive* cultivars, the average yield of *olive*, total land area, and farmers' attitude. There was no significant difference between farmers in terms of their attitude towards organic farming. Rezaei-banafsheh and Hosseinpoor (2011), while adapting the climatic conditions of selected stations of two provinces to the bio-ecological needs of the *olive* tree, have investigated the quantity and quality of the climatic elements in the region. The results indicate that the *olive* tree is very sensitive to the decrease in temperature and temperature is a limiting factor for its cultivation in the region. Of the stations examined, only the Pars-Abad station has the necessary conditions for the cultivation of *olive* oil. Beikzadeh and Chizari (2007), in a study entitled Marketing Channel Survey and Factors Affecting the Marketing Margin of *Olive* Grounds, have investigated that Iran is considered one of the most favorable *olive* producers in the study area in terms of special topographical conditions, weather conditions and susceptible lands. The results of this research show that production, exports, and transport costs indicators are one of the most important factors affecting the marketing margin of *olive* land. Given the close relationship between agriculture and climate, it can be said that without considering the climatic conditions, there will be no optimal cultivation of agricultural products.

The purpose of this study was to investigate the correlation and zonation of the agricultural climate of the *Olive* cultivar in Moghan Plain using multidimensional methods and to compare it with Roudbar area. Determination of the most important climatic element affecting the agricultural climate

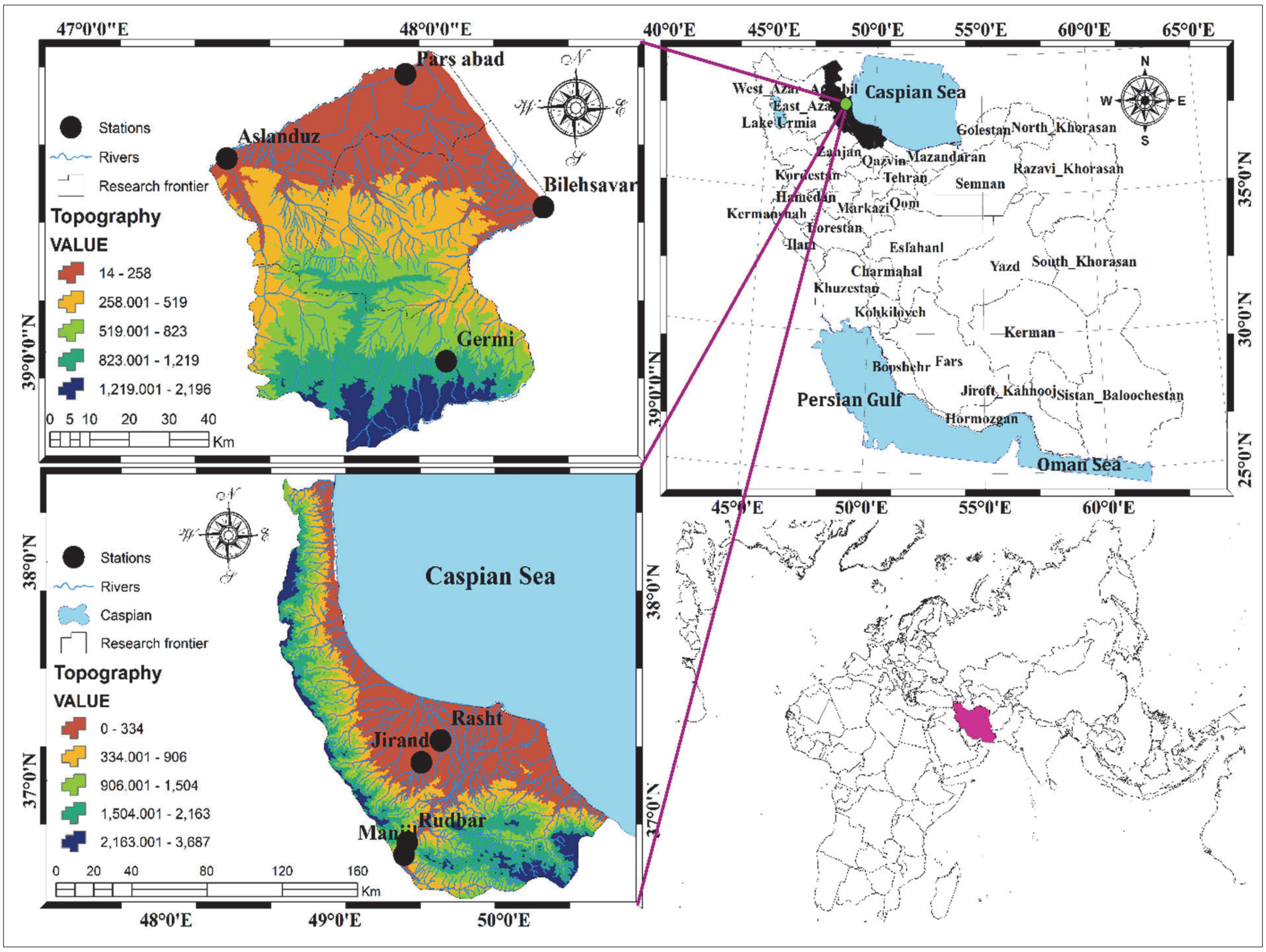

FIGURE 1. Location of study area in the country and province.

of the *olive* tree with emphasis on temperature and precipitation is another goal of this research.

Olive tree morphology

Olive trees are distinguished from other trees due to their long lifespan and perennial trunks. In *olive* trees, if it is destroyed by aging, the germs capable of supporting its growth, its survival and the creation of a new tree. It grows in difficult conditions and poor soils and, in addition, in semi-arid and dry climatic conditions, has a significant effect on the rate of development, and even in the time and extent of its fruit harvesting. Normally, the *olive* tree is small to medium to a maximum height of 12 m and a maximum diameter of up to 7 m or more, but is usually smaller due to its degradation. In some areas where human intervention has not been particularly high in terms of cutting down trees, it is not uncommon to see old *olive* trees up to 15 m high and sometimes over 1.5 to 2 m in diameter.

Materials and methods

Study area

The study area, which is classified according to the administrative boundaries of Bilesavar and Parsabad cities in the northern part of Ardabil province, is a natural unit with a history of its cultural history and centuries. This area was part of Azerbaijan in the past and then it was located in the Meshkinshahr political district. After a long time, its affairs were transferred to Mughan city to the center of Germi, and now the geographical range of the two cities of Bilesavar and Parsabad, which is studied as a single region due to natural unity and topography and the way of settlement and existence of social settlements in this research. This area is an imperfect pyramid whose head is in the north and neighbors from the north and east with the Republic of Azerbaijan, and the Aras river in the north forms the border between the Is-

TABLE 1. Geolocation of the stations studied.

Station	Latitude	Longitude	Height (m)
Parsabad	39°39'N	47°55'E	31.9
Germi	39°05'N	48°06'E	749
Bilesavar	39°39'N	48°35'E	120
Aslandoz	39°43'N	47°04'E	170
Rudbar	36°82'N	49°42'E	205
Jirande	36°71'N	49°80'E	1581.4
Rasht	37°32'N	49°62'E	-8.6
Manjil	36°73'N	49°41'E	338.3

lamic Republic of Iran and the Republic of Azerbaijan. The west is East Azarbaijan province and Ahar city, and Mughan is located in the southeastern part of the Gram region. In terms of geographic coordinates, the area of the investigated area is between 39°7' to 39°42'N and 47°22' to 48°22'E and the administrative centers of the study area of Bilesavar are in the geographical coordinates of 39°22' and 48°22' longitude, and Parsabad city are located at geographical coordinates of 39°40' and 47°55' longitude. The total area is 3,501.7 km^2, of which 1,945 km^2 is to Bilesavar and 1,556.75 km^2 belong to Parsabad city (Figure 1; Table 1).

Research methodology

In climate studies, weather data are considered to be the main source of information. In this research, with the selection of synoptic stations in the plain and province, the average climatic data such as relative humidity, temperature, rainfall, number of ice days and evaporation from the beginning of the establishment of the stations were extracted by 2018. Then, due to the purpose of the research, which is locating, the need for data from ground stations such as topography and land use is necessary. Since it is necessary to locate the application of various criteria and parameters, in this section, by identifying the criteria and parameters that affect the *olive* cultivation, we evaluate the importance of the criteria based on the genetic analysis by determining what the weight for each of the criteria will be. In this study, two climatological databases and ground source databases were used to achieve the desired goal. Climate databases that contain climatic elements of temperature, rainfall, number of freezing days, relative humidity and evaporation. From the data and statistics of 8 synoptic stations on the plains and provinces, from the time they were established up to 2018, daily data were collected. Then it was normalized and the database was created in the ArcGIS environment. Subsequently, each of the relevant parameters, in the ArcGIS environment, by generalizing the dot data (stations) to the surrounding levels, were mapped into information layers. Terrestrial databases include altitude elevation model (DEM) and a map of land use studies. A digital elevation model with a scale of 1:250,000 was obtained from the Agricultural Jihad Organization and a user map from the provincial governorate. Due to the capability of this map, topographic maps including slope, direction, and altitude layers were derived from the ArcGIS environment and used as information layers to determine the susceptible sites of the province's cultivation. Each of the information layers based on the ecological needs of the *olives*, classified according to the model, weighed and evaluated the layers and criteria.

Technique for Order Preference by Similarity to Ideal Solution (*TOPSIS*) method

In a general sense, it is the aspiration of human being to make "calculated" decision in a position of multiple selection. In scientific terms, it is the intention to develop analytical and numerical methods that take into account multiple alternatives with multiple criteria. *TOPSIS* (Technique for Order Preference by Similarity to Ideal Solution) is one of the numerical methods of the multi-criteria decision making. This is a broadly applicable method with a simple mathematical model. Furthermore, relying on computer support, it is very suitable practical method. The method is applied in the last three decades (on the history of *TOPSIS*, see Hwang and Yoon, 1981; Tzeng and Huang, 2011), and there are many papers on its applications (Xu and Tao, 2012; Yoon, 1987; Yoon and Hwang, 1995). *TOPSIS* is a compensatory method. These kinds of methods allow the compromise between different criteria, where a bad result in one criterion can be compensated by a good result in another criterion. An assumption of *TOPSIS* method is that each criterion has either a monotonically increasing or decreasing preference. Due to the possibility of criteria modelling, compensatory methods (Zlatko and Vedran, 2013), certainly including *TOPSIS*, are widely used in various sectors of multi-criteria decision making (Balin et al., 2012; Huang et al., 2011; Hwang et al., 1983).

The steps of doing *TOPSIS* took eight steps that are as follows:

Step 1: Formation of data matrix based on m option and n index, Matrix 1.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{22} & x_{1\,n} \\ x_{21} & x_{22} & x_{2\,n} \\ \vdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ x_{m\,1} & x_{m\,2} & \cdots x_{m\,n} \end{bmatrix} \quad \text{(Matrix 1)}$$

Step 2: Without computing the data and forming an unmatched matrix, Equation 1.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \quad (1)$$

Step 3: Calculation of the Randomized Scale Matrix; in fact, the matrix (v) yields an unbalanced matrix in the matrix of weights, Matrix 2.

$$V_{ij} = \begin{bmatrix} v_{11} & v_{22} & v_{1\,n} \\ v_{21} & v_{22} & v_{2\,n} \\ \vdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \\ v_{m\,1} & v_{m\,2} & \cdots v_{m\,n} \end{bmatrix} \quad \text{(Matrix 2)}$$

Step 4: Determine the positive ideals (the best performance of each indicator) that they represent with (A*), Equations 2 and 3.

$$A^* = \left\{ (\max_i v_{ij} \mid j \epsilon J), (\min_i v_{ij} \mid j \epsilon J' \right\} \quad (2)$$

$$A^* = \{v_1^*, v_2^*, \ldots v_n^*\} \quad (3)$$

Step 5: Determine the negative ideals (the worst performance of each indicator) that represent them with (A), Equations 4 and 5.

$$A^* = \left\{ (\min_i v_{ij} \mid j \epsilon J), (\max_i v_{ij} \mid j \epsilon J' \right\} \quad (4)$$

$$A^- = \{v_1^-, v_2^-, \ldots v_n^-\} \quad (5)$$

Step 6: Determine the distance criterion for each option from positive and negative ideals (Si + and Si), Equations 6 and 7.

$$d_j^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \quad (6)$$

$$d_j^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad (7)$$

Step 7: Determine the relative closeness of the options, which is calculated from the following Equation 8.

$$C_i = \frac{d^-}{d_i^- + d_i^+} \quad (8)$$

Step 8: Ranking options by the amount (C_{i+}), so that $0<c_{i+}<1$. Accordingly, as much as one option approaches the ideal point, (C_{i+}) tends to 1; the best option is (Malchofsky, 2007).

VIekriterijumsko KOmpromisno Rangiranje (*VIKOR*) method

As it was said in the introduction, the interval numbers are more suitable to deal with the decision making problems in the imprecise and uncertain environment, because they are the simplest form of representing uncertainty in the decision matrix. The interval numbers require the minimum amount of information about the values of attributes. Specifying an interval for a parameter in decision matrix indicates that the parameter can take any value within the interval. Note that the interval numbers do not indicate how probable it is to the value to be in the interval, nor do they indicate which of the many values in the interval is the most likely to occur (Choobineh and Behrens, 1992). The *VIKOR* method was introduced as an applicable technique to be implemented within MCDM problem and it was developed as a multi-attribute decision making method to solve a discrete decision making problem with non-commensurable (different units) and conflicting criteria (Yu, 1973; Zeleny, 1982). This method focuses on ranking and selecting from a set of alternatives, and determines compromise solution for a problem with conflicting criteria, which can help the decision makers to reach a final solution. The multi-criteria measure for compromise ranking is developed from the LP-metric used as an aggregating function in a compromise programming method (Opricovic and Tzeng, 2004, 2007). If there is a multi-criteria decision-making problem, N criterion, and M option, then selecting the best option using this method is as follows (Ataei, 2007).

Step 1: Creating a Decision Matrix given the number of options and the evaluation of all the options for different criteria, in which X_{ij} represents the raw pixel i^th grade in the j^th criterion, the decision matrix consists of the Matrix 3:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{22} & x_{1\,n} \\ x_{21} & x_{22} & x_{2\,n} \\ \vdots & \dots & \dots \\ \dots & \dots & \dots \\ x_{m\,1} & x_{m\,2} & \dots x_{m\,n} \end{bmatrix} \qquad \text{(Matrix 3)}$$

where X_{ij} is the function of i (I = 1,2, ... m) in relation to the criterion j (j = 1,2, ... n).

Step 2: Dimensioning the decision matrix (standardization). At this stage, with the standardization of the data, the range of values (X_{ij}), which exist in different measuring units (as well as the unit of measurement, percent, and metric), are converted to a standard domain between 0 and 1. And we obtain the standardized values of the data (V_{ij}). In this process, we obtain a matrix of standard data that can be compared and interconnected, or in other words, at this stage, we try to convert the criteria to different dimensions into dimensionless ones, and the matrix V, the Matrix 4, is defined as follows:

$$V_{ij} = \begin{bmatrix} v_{11} & v_{22} & v_{1\,n} \\ v_{21} & v_{22} & v_{2\,n} \\ \vdots & \dots & \dots \\ \dots & \dots & \dots \\ v_{m\,1} & v_{m\,2} & \dots v_{m\,n} \end{bmatrix} \qquad \text{(Matrix 4)}$$

One of the simplest links for raw data standardization is to divide each raw score at the maximum value for a given criterion. This relationship is formally expressed in Equation 9.

$$= 1\frac{x_{ij}}{x_j^{max}} \quad x_{ij} \tag{9}$$

in which the standard score is for the IM (Option) I and J attribute. Represents a raw score and a maximum score for the J-character. The value of the standardized scores is between 0 and 1. The more value the scores are, the more valuable the criterion will be. Equation (1) is used at a time when the maximization criterion is considered (the higher the raw score is, the more desirable it is to perform). This type of measure is sometimes referred to as the profit or benefit criterion (Malchofsky, 2007).

Step 3: Determining the vector of weight criteria. At this stage, we determine the weights (w_j) assigned to each attribute; the total weights should be such that we obtain 1 0 and 1 =; further, according to the importance factor of the various criteria in decision making; the vector is defined as Equation 10.

$$w = \{w_1, w_2, \dots w_n\} \tag{10}$$

Step 4: Determining the best (ideal positive) and the worst (ideally negative) amount from the available values for each criterion: The best (f_j^*) value for the positive and negative criteria is calculated from Equations 11 and 12, respectively:

$$f_j^* = \min_i f_{ij} \tag{11}$$

$$f_j^* = \max_i f_{ij} \tag{12}$$

The worst (f_j^*) value for the positive and negative criteria are calculated from Equations 13 and 14, respectively.

$$f_j^- = \min_i f_{ij} \tag{13}$$

$$f_j^- = \max_i f_{ij} \tag{14}$$

In these relations (fj*) the best value of J is among all the options and (fj-) the worst criterion of J is among all the options. If you combine all (fj*) together, you will have an optimal combination with the highest score (ideal point) and in case of the worst score (the ideal is the negative).

Step 5: Calculate the ideal or useful value (S) and the antidote or regret (R) value, which are calculated according to Equations 15 and 16:

$$s_i = \sum_{h=1}^{n} w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \tag{15}$$

$$R_i = max\left\{w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}\right\} \tag{16}$$

where w_j is the amount of weight for the criterion J, (S_j) indicates the relative distance of option I from the ideal positive solution (the best combination) and (s) indicates the maximum discomfort of option I to avoid the ideal solution. In the agreement planning method, if the parameter P is equal to one, the same value is obtained Equation 17.

$$L(A_i) = \sum_{j=1}^{n} w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} = S_i \tag{17}$$

In the agreement planning method, if the parameter p is equal to the same value ∞, the Equation is 18.

$$L_\infty(A) = max\left[w_j \left(\frac{f_j^* - f_{ij}}{f_j^* - f_j^-}\right)\right] = R_i \tag{18}$$

Step 6: Calculate the *VIKOR* Index (Q value): The Q value is calculated according to the Equation of 19.

$$Q_i = v\left[\frac{s_i - s^-}{s^* - s^-}\right] + (1 - v)\left[\frac{R_i - R^-}{R^* - R^-}\right] \tag{19}$$

$$S^{i^-} = \min S_i \quad s^* = \max S_i \quad R^- = \min R_i \quad R^* = \max R_i$$

In these relationships,

$\frac{s^{*}-s^{-}}{s_i-s^{-}}$ expresses the distance from the ideal, and

$\frac{R^{*}-R^{-}}{R_i-R^{-}}$ expresses the distance from the anti-ideal solution.

And the parameter $\upsilon(\in[0,1])$ is chosen according to the decision of the decision-maker, which, in the above agreement, is more than 0.5, if the agreement with the majority of votes is equal to 0.5. And in the case of a lower agreement, its value is less than ./5 will be. The value of Q is a function of (R_iوs_i), which itself is the values of the ideal solution for P=1 and P=∞ respectively in the planning agreement.

Calculate the final weight of options

At this stage of the combination of these coefficients, the final score of each of the options will be determined by using the principle of hierarchical hierarchy of hours, which results in the creation of a priority vector, taking into account all the judgments in all Levels of Hierarchy, Equation 20 (Jafarbeiglo and Mobaraki, 2008).

$$J = \Sigma_k^n = \Sigma_i^m = WK = W_j \qquad (20)$$

W_k Importance coefficient ikw, importance coefficient of sub-criterion I, Jig, The option score j in relation to the sub-criterion i, W_k Importance coefficient ikw, importance coefficient of sub-criterion I, Jig, the j option score in relation to the sub-criterion i (Jafarbeiglo and Mobaraki, 2008). Ultimate Score Option: The coefficient of importance criterion ikw coefficient of significance sub-criterion i. Jig the –j rating option in relation to the sub-criterion i (Jafarbeiglo and Mobaraki, 2008). The coefficient of importance criterion ikw coefficient of significance sub-criterion i. Jig the j option points in relation to the sub-criteria i (Jafarbeiglo and Mobaraki, 2008).

Results and discussion

Validation of land suitability for *olive* cultivation

In order to study the ability of Mughan and Gilan plains areas in terms of *olive* cultivation using the *VIKOR* and *TOPSIS* model, we first used to calculate and analyze the statistical data for each of the parameters used and then, the desirability and undesirable of each of the studied stations was studied in terms of climatic indicators. Based on the classification of the *VIKOR* and *TOPSIS* model, the Gilan and Mughan plains are divided into four levels in terms of *olive* cultivation, the first level indicating the best and most suitable area and the fourth level is the worst area in terms of *olive* cultivation. Make finally, the ranking of options is based on CI, the above range fluctuates between zero and one. CI is equal to 1 represents the highest rating, CI is 0 is the lowest. In the present study, according to the ranking and weighting to each of the indicators, CI of Germi and Rudbar were 0.97 and 0.58, respectively, and Parsabad and Manjil with CI of 0.03 and 0.20 have earned the last rank in the cultivation of *olive* crops (Tables 2 and 3). If finally the appropriate option was selected from the relative closeness to the ideal, the results of the analysis of the model *VIKOR* and *TOPSIS* were transmitted to the ArcGIS environment and IDW mapping was prepared using maps of susceptible *olive* cultivars (Figures 2–5)

Discussion and validation of research results

According to the modeling performed in this study and the results of this study, *TOPSIS* and *VIKOR* models showed

TABLE 2. Calculation of proximity to the positive and negative ideal solution, and also the ranking of options (Moghan).

Station	Rank	CI
Germi	1	0.97
Aslandoz	2	0.19
Bilesavar	3	0.06
Parsabad	4	0.03

TABLE 3. Calculation of proximity to the positive and negative ideal solution and also the ranking of options (Gilan).

Station	Rank	CI
Rudbar	1	0.58
Jirande	2	0.56
Rasht	3	0.43
Manjil	4	0.20

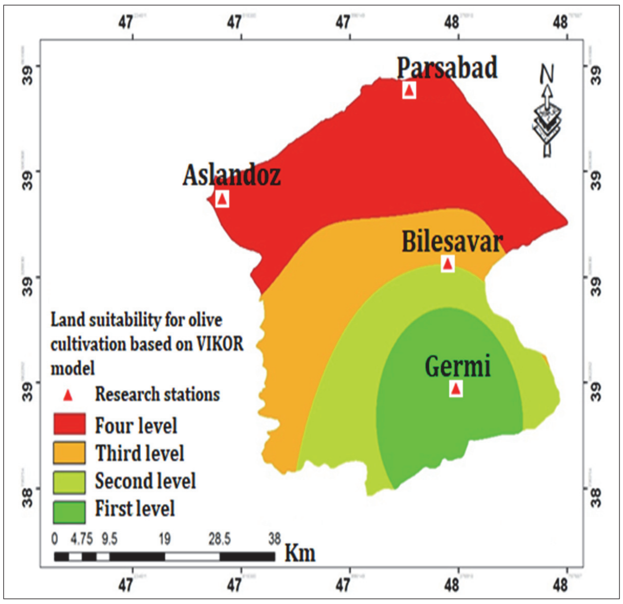

FIGURE 2. Validation of land suitability for Mughan plain for *olive* cultivation based on the *VIKOR* model.

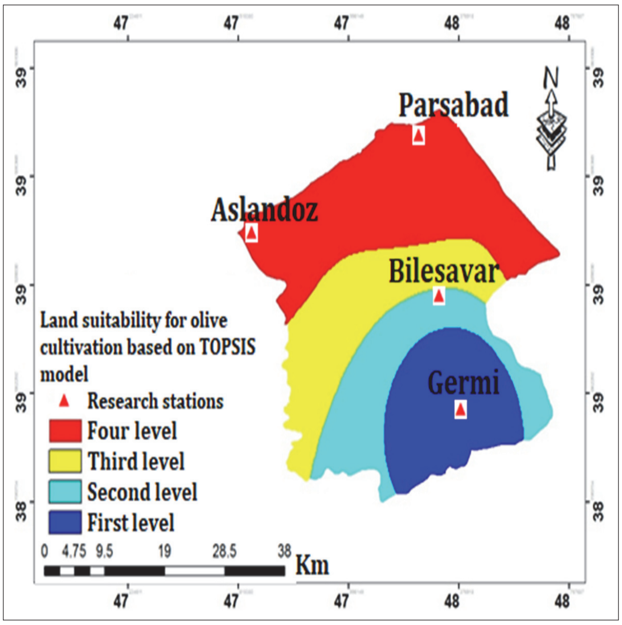

FIGURE 3. Validation of land suitability for Mughan plain for *olive* cultivation based on the *TOPSIS* model.

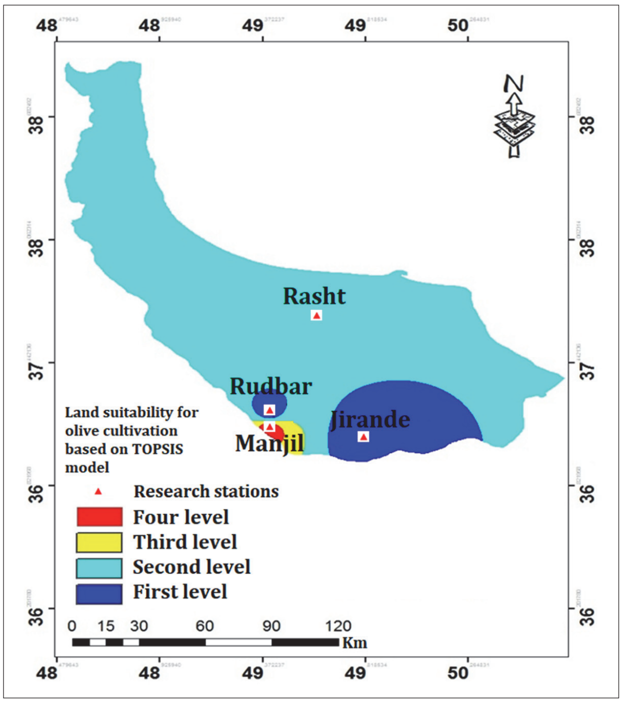

FIGURE 4. Validation of land suitability for *olive* cultivation in Gilan province based on the *TOPSIS* model.

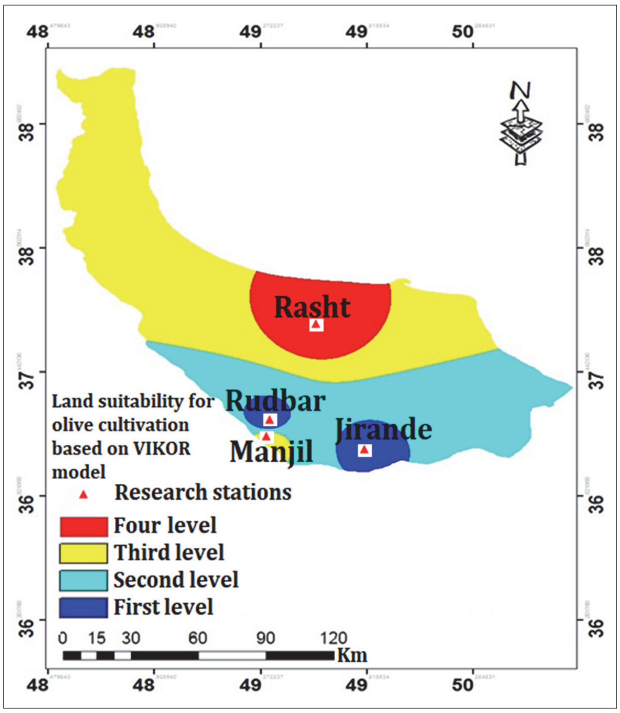

FIGURE 5. Verification of land suitability for *olive* cultivation in Gilan province based on the *VIKOR* model.

that the two factors of precipitation and height were the most important factors influencing *olive* cultivation and the most weighted among other climate parameters. As a result, it can be said that by using modeling, it is possible to determine the climate potential of the area. In this study, Mughan plain has a spatial non-conformance in terms of cultivation conditions. It is suitable in the north of the plain and in the southern part is inappropriate, but it has no restrictions on cultivation, but it does not produce a high-quality, economical product. *Olive* trees are able to tolerate low soil water availability and quality and develop physiological adaptations to cope with water and salt stress (Trabelsi et al., 2019). Regarding the virgin *olive* oil (VOO) quality, the use of the ICP did not affect the marketable parameters and total phenol content, while in terms of the process efficiency, the ICP obtained a higher value than the conventional process and improved the extraction yield (Tamborrino et al., 2019). The model includes a phenology sub-model simulating the sequence of *olive* tree vegetative and reproductive stages for determining changes in biomass allocation and the timing of possible environmental stresses (heat and water stress) that may reduce final yield. The results pointed out that the model is able to faithfully reproduce water balance of the system, biomass accumulation and yield of *olive* tree and grass cover biomass. We concluded that this model is a useful prognostic tool to test the effectiveness of management practices for improving economic viability of *olive* tree cultivation (Moriondo et al., 2019). Agro-climatology study of Mughan and Gilan plains for the development of *olive* (*Olea europaea*) cultivation, Iran, in this research done, this method has been used in most studies, an appropriate method for tracking, analyzing and comparing. Including: Chiumenti et al. (2019), Molecular characterization of a novel gemycircularvirus associated with *olive* trees in Italy. Trabelsi et al. (2019), Impact of drought and salinity on *olive* water status and Tamborrino et al. (2019), combined industrial *olive* oil extraction plant using ultrasounds, microwave, and heat exchange: Impact on *olive* oil quality and yield. Moriondo et al. (2019), a simple model simulating development and growth of an *olive* grove. They took action and the performance of the models used confirmed. However, with all the comparisons done, this model is in the present study Agro-climatology Study of Mughan and Gilan plains for the development of *olive* (*Olea europaea*) cultivation, Iran, an acceptable performance.

Conclusions

In the development and cultivation of horticultural and agricultural crops in any place, it is necessary to study and determine the climatic elements required for that horticultural and agricultural crops. At present, agriculture is one of the most important economic sectors of the country, to the extent that it can be said that the country's economic growth is not possible without agricultural growth. Because each agricultural product requires specific climatic and environmental conditions, researchers and experts in natural resources and climatologists have paid special attention to land use and based on ecological models – agriculture, ecological resources of the earth with proper methods of identification, evaluation and for specific purposes, they can be validated. The results of the analysis of *TOPSIS* and *VIKOR* models showed that the two factors of precipitation and elevation are the most important factors affecting *olive* cultivation because these two factors have the highest weight among other parameters. By examining the information layers obtained from ArcGIS, annual rainfall in Mughan plain cannot provide the water requirement of a high-quality product, but it is not a limiting factor, and with this amount of rainfall, the area cultivated *olive*, provided that the water deficit is supplied from sources other than precipitation, but with the difference that the product will not be economically viable. Also, in the least temperature, the southern parts of the Mughan plain are not suitable due to the low temperature for *olive* cultivation. In general, with a general view, the Mughan plain, in terms of *olive* cultivation conditions, has a spatial mismatch of climatic conditions with environmental conditions, so that in the north of the plain, suitable climatic conditions and in southern parts such as the warming city, the environmental conditions it is appropriate. An overview of climatic studies in two regions of Gilan and Mughan plain showed that among the studied stations, Rudbar but the climatic element of precipitation in other climatic elements, as well as environmental factors, could have the best climatic conditions of *olive* cultivation inside the country.

Acknowledgment

The authors would like to thank the I.R. of Iran Meteorological Organization (IRIMO) for providing the meteorological data for this study. We also acknowledge the support from Mohaghegh Ardabili University.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

References

Alijani, B., and Doostan, R. (2016). Determination of areas susceptible to the cultivation of *Berberis vulgaris* in South Khorasan province using GIS. Geogr. Reg. Developm. Mag. *8*, 14–13.

Ataei, M. (2007). Multi-criteria Decision Making, 1st edn. (Shahrood Univ. of Technology), p. 245 (in Persian).

Balin, A., Alcan, P., and Basligil, H. (2012). Performance comparison on CCHP systems using different fuzzy multi criteria decision making models for energy sources. Fuelling the Future, p. 591–595.

Beikzadeh, S., and Chizari, A.H. (2007). A survey of marketing channels and factors affecting the marketing margin of potatoes. Agric. Econ. Developm. *57*, 21–39.

Bonofiglio, T., Orlandi, F., Sgromo, C., Romano, B., and Fornaciaria, M. (2009). Evidences of olive pollination date variation relation to spring temperature trends. Aerobiologia *25*, 227–237. https://doi.org/10.1007/s10453-009-9128-4.

Chiumenti, M., Greco, C., Antelmi, I., Sion, V., Altamura, G., Nigro, F., and Saldarelli, P. (2019). Molecular characterisation of a novel gemycircularvirus associated with olive trees in Italy. Virus Res. *263*, 169–172. https://doi.org/10.1016/j.virusres.2019.01.016.

Choobineh, F., and Behrens, A. (1992). Use of intervals and possibility distributions in economic analysis. J. Oper. Res. Soc. *43*(9), 907–918. https://doi.org/10.1057/jors.1992.129.

Farajzadeh Asl, M. (2005). Geographical Information System and its Application in Planning and Tourism, 1st edn. (Samt Publishing), p. 90.

Gholizadeh, I., and Minaee, M. (2006). Study of the weather conditions of North of West Azarbaijan province in order to discover olive and its zoning in the region. M.Sc. thesis (Tabriz, Iran: Tabriz Univ., Nat. Hist. Dept., Fac. Humanities and Social Sci.).

Gilbert, H., and Mifsud, D. (2007). Pests and diseases associated with olive trees in the Maltese Islands (Central Mediterranean). The Central Mediterranean Naturalist *4*, 142–161.

Hejazizadeh, Z., Saligheh, M., Balyani Yadollah, M., and Mohammad, H. (2014). Site selection of olive cultivation using climatic and terrestrial parameters by genetic analysis method. Case study: Fars Province. J. Appl. Geosci. Res. *30*, 40–66.

Huang, I.B., Keisler, J., and Linkov, I. (2011). Multi-criteria decision analysis in environmental science: Ten years of applications and trends. Sci. Total Environm. *409*, 3578–3594. https://doi.org/10.1016/j.scitotenv.2011.06.022.

Hwang, C.L., and Yoon, K. (1981). Multiple Attribute Decision Making: Methods and Applications (Berlin, Heidelberg, New York: Springer-Verlag). https://doi.org/10.1007/978-3-642-48318-9.

Hwang, C.L., Lai, Y.J., and Liu, T.Y. (1983). A new approach for multiple objective decision making. Comp. Operational Res. *20*, 889–899. https://doi.org/10.1016/0305-0548(93)90109-V.

Jafarbeiglo, M., and Mobaraki, Z. (2008). Land suitability assessment of Qazvin Province for cultivating saffron based on multi-criteria decision making methods. Nat. Geogr. Res. *66*, 118.

Kafi, M., Ganjali, A., Nezami, A., and Shariatmadar, F. (2015). Weather and Yield of Agricultural Crops. (Jahad Daneshgahi Publ., Univ. of Mashhad), p. 311.

Malchofsky, G. (2007). Geographic Information System and Multi-criteria Decision Analysis (Tehran, Iran: Samt Publ.) (in Persian).

Mandere, N.M., Persson, A., Anderberg, S., and Pilesjö, P. (2010). Tropical sugar beet land evaluation scheme: development, validation and application under Kenyan conditions. GeoJournal *75*, 215–228. https://doi.org/10.1007/s10708-009-9302-9.

Moriondo, M., Leolini, L., Brilli, L., Dibari, C., Tognetti, R., Giovannelli, A., Rapia, B., Battista, P., Caruso, R., Gucci, G., Argenti, A., Raschi, M., Centritto, C., and Cantini, M. (2019). A simple model simulating development and growth of an olive grove. Eur. J. Agron. *105*, 129–145. https://doi.org/10.1016/j.eja.2019.02.002.

Moshiri, S.R., and Maarofnezhad, A. (2011). Investigating the potentials and prospects for the development of olive cultivars in improving the situation of villages in Izeh City by SPSS method. Geograph. Land J. *33*, 21–44.

Nemati, A., and Orji, I. (2013). An economic review of some organic products in drought tolerance in Olive. Sixth Conf. on Agric. Res., Sanandaj, Kurdistan University.

Opricovic, S., and Tzeng, G.H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. Eur. J. Oper. Res. *156*(2), 445–455. https://doi.org/10.1016/S0377-2217(03)00020-1.

Opricovic, S., and Tzeng, G.H. (2007). Extended VIKOR method in comparison with outranking methods, Eur. J. Oper. Res. *178*, 514–529. https://doi.org/10.1016/j.ejor.2006.01.020.

Orji, I. (1998). Effect of water irrigation water circuit on vegetative growth of two young seedlings of *Olea europaea*. M.Sc. thesis (Tehran, Iran: Horticulture group, Tarbiat Modarres University).

Parizgar Akbar and Atta Ghafari Gilandeh (2011). Geographic Information System and Multi-Criteria Decision Analysis, 4th edn. (Tehran), p. 415.

Poli, L., and Yu, A. (1973). Class of solutions for group decision problems. Mgt. Sci. *19*(8), 936–946. https://doi.org/10.1287/mnsc.19.8.936.

Ramezani, B., and Kazemnejad, Z. (2011). Investigating the effect of drought on the change in the yield of olive crop in Rudbar city. Geograph. J. *15*, 36–54.

Rezaei-banafsheh, M., and Hosseinpoor, G. (2011). Investigating the climate potential of East Azarbaijan and Ardebil provinces for the cultivation of Olive. Geograph. Rural Planning *16*(36), 25–40.

Sanei, S.J., and Razavi, S.E. (2012). Survey of olive fungal disease in north of Iran. Annual Rev. & Res. Biol. *2*, 27–36.

Sergeeva, V., Spooner-Hart, R., and Nair, N.G. (2008). First report of *Pseudocercospora cladosporioides* on olive (*Olea europaea* L.) berries in Australia. Austral. Plant Disease Notes *3*, 24. https://doi.org/10.1071/DN08010.

Tamborrino, A., Romaniello, R., Caponio, F., Squeo, G., and Leone, A. (2019). Combined industrial olive oil extraction plant using ultrasounds, microwave, and heat exchange: Impact on olive oil quality and yield. J. Food Engin. *245*, 124–130. https://doi.org/10.1016/j.jfoodeng.2018.10.019.

Trabelsi, L., Gargouri, K., Ben Hassena, A., Mbadra, C., Ghrab, M., Ncube, B., Van Staden, J., and Gargouri, R. (2019). Impact of drought and salinity on olive water status and physiological performance in an arid climate. Agric. Water Mgt. *213*, 749–759. https://doi.org/10.1016/j.agwat.2018.11.025.

Tzeng, G.H., and Huang, J.J. (2011). Multiple Attribute Decision Making: Methods and Applications (New York, U.S.A.: CRC Press). https://doi.org/10.1201/b11032.

WeiGuang, W.U., Huang, J., and Deng, X. (2010). Potential land for plantation of *Jatropha curcas* as feedstocks for biodiesel in China. Earth Sci. *1*, 120–127. https://doi.org/10.1007/s11430-009-0204-y.

Xu, J., and Tao, Z. (2012). Rough Multiple Objective Decision Making (New York, U.S.A.: CRC Press). https://doi.org/10.1201/b11061.

Yaaghobi, J., and Taheri, S. (2013). A survey on the attitudes of olive growers of Tarom region in comparison with organic farmers and related factors. Second Natl. Congress of Organic Agric., Ardebil, Mohaghegh Ardebil Univ.

Yoon, K.P., and Hwang, C. (1995). Multiple Attribute Decision Making: An Introduction (California, U.S.A.: SAGE Publ.). https://doi.org/10.4135/9781412985161.

Yoon, K.A. (1987). A reconciliation among discrete compromise situations. J. Oper. Res. Soc. *38*, 277–286. https://doi.org/10.1057/jors.1987.44.

Yu, P.L. (1973). A class of solutions for group decision problems. Mgt. Sci. *19*(8), 936–946. https://doi.org/10.1287/mnsc.19.8.936.

Zeleny, M. (1982). Multiple Criteria Decision Making (New York, U.S.A.: McGraw-Hill).

Zlatko, P., and Vedran, N. (2013). Notes on TOPSIS Method. Intl. J. Engin. Res. Gen. Sci. *1*(2), 5–12.

Received: Dec. 8, 2018
Accepted: May 20, 2019

Addresses of authors:
V. Safarian Zengir[1,*], A. Fatahi[2], B. Sobhani[3], F. Shafiei Sabet[4] and M. Kianian[5]

[1] Climatology, Faculty of Social Sciences, University of Mohaghegh Ardabili, Iran
[2] Department of Agricultural Economics, Faculty of Agriculture and Natural Resources, Ardakan University, Ardakan, Iran
[3] Climatology, Faculty of Social Sciences, University of Mohaghegh Ardabili, Iran
[4] Climatology, Faculty of Literature and Human Sciences, University of Mohaghegh Ardabili, Iran
[5] Desert Studies Faculty, Semnan University, Iran
* Corresponding author; E-mail: V.safarian@uma.ac.ir