Agro-climatology assessment of Moghan and Gilan Plains for the development of olive (*Olea europaea*) cultivation, Iran

**ABSTRACT**

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, eleven (11) climatic variables of Moghan 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 Moghan and Gilan plains for olive cultivation, eight stations were used since the beginning of the year until 1394. 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, with respect to ranking and weighting to each of the indicators, Garmi and Roodbar were 97 and 58%, respectively, and Pars Abad and Manjil with the amount 03/0 and 20/0 earned the last rank in the field of crop cultivation. According to the VIKOR model, the Q value of the studied climatic indexes, Garmi and Rudbar stations, ranked # 1 in the best condition for olive but Parsabad farming Rasht is ranked 4th in the worst situation.

**Key words:** Olive, Moghan and Gilan plains, VIKOR, topsis.

**INTRODUCTION**

Climate plays an important role in human life and 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. Presently, 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 et al., 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 is scattered. This tropical plant is of Mediterranean type (WeiGuang, 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 two-fold.

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, 2006). In the olive-growing world globally, 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 damaged species (fungi, bacteria, and nematodes, etc.) were 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 the pre and post-harvest stage and decreases the production of qualitative properties of olive oil (Sergio 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 (Sergeeea et al., 2008). This disease was reported by Sanei in Iran (2005) from Roodbar, 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 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 to 2009 and 1993 to 1994 respectively. On the other hand, there is a meaningful relationship between the amount of crop production and drought such that the lowest amount of production in the year 1987 to 1986 with 6270 ha and 3249 tons, and the most are 1993 to 1994 years with 2149 ha and 6200 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.

Hejazi-Zadeh et al. (2013) concluded that the role of each of the effective elements in olive cultivation is different, and the five climatic elements of annual precipitation, grade-growth days, 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, thus, having a greater effect and greater contribution and capability. Also, by adapting the weighed layers considering the importance of each of the effective layers in the cultivation process in the GIS 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 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 was selected from Kermanshah province and was conducted in a split-split experiment in a Randomized Complete Block Design (RCBD) 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 farmer’s 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 Hosseinpooor (2011), while adapting the climatic conditions of selected stations of two provinces to the bio-ecological needs of the olive tree investigated the quantity and quality of the climatic elements in the region. The results indicate that the olive tree is less than the temperature. It is very sensitive and the 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 the problem that Iran, in terms of specific topography and climate conditions and susceptible lands is one of the most favorable olive producers in the region. 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 compare it with Roudbar area. Determination of the most important climatic element affecting the agricultural climate of the olive tree with emphasis on temperature and precipitation is another goal in 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 are then capable of
supporting its growth, 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.

**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 in 2015. Due to the purpose of the research, which is locating the need for data from ground stations such as topography land use is necessary. Since it is necessary to locate the application of various criteria and parameters 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 the weight for each of the criteria used. In this study, two climatological databases and ground source databases were used to achieve the desired goal. Climate databases 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 1394, daily data were collected. Thereafter, it was normalized and the database created in the GIS environment. Subsequently, each of the relevant parameters in the GIS 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 were 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 GIS 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 was classified according to the model and weighed and the layers and criteria evaluated.

**Topsis model**

The steps in doing topsis are in eight steps, which are as follows:

**Step 1:** Formation of the data matrix; matrix 1 is based on m option and n index:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{21} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

**Step 2:** Scalability of the data and the formation of an unbalanced matrix relationship 1 given as:

$$T_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{n} a_{kj}^2}}$$

**Step 3:** Calculation of a non-scale harmonic matrix: In fact, the matrix (v) and matrix 2 is multiplied by the unbalanced matrix in the weighted matrix:

$$V_{ij} = \begin{bmatrix} v_{11} & v_{22} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}$$

**Step 4:** Determine the positive ideals (the best performance of each indicator), which shows \((A^*)\).

$$A^* = \left\{ \max_{i,j} v_{ij} \right\}$$

**Step five:** Determine the negative ideals (the worst performance of each indicator) that represent \((A^-)\).

$$A^- = \left\{ \min_{i,j} v_{ij} \right\}$$

**Step six:** Determine the distance criteria between each
option from negative and positive ideals (Si⁺, Si⁻), relations 6 and 7 given as:

\[ d_j^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{j}^*)^2} \]  \hspace{1cm} (6)

\[ d_j^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{j}^-)^2} \]  \hspace{1cm} (7)

**Step 7:** Determine the relative closeness of the options, which is calculated from Equation 8 given as:

\[ C_i = \frac{d_j^-}{d_j^+ + d_j^-} \]  \hspace{1cm} (8)

**Step 8:** Ranking options is by the amount \( C_{i+} \).

That is, \( 0 < C_{i+} < 1 \). Accordingly, as much as one option approaches the ideal point, it \( C_{i+} \) tends to 1; the best option (Malchovsky, 2007).

**VIKOR model**

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 (Atay and Michael, 2007).

**Stage one: 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 \( i \) in criteria \( j \), the decision matrix consists of matrix 3:

\[
\begin{bmatrix}
X_{11} & X_{21} & X_{1n} \\
X_{21} & X_{22} & X_{2n} \\
\vdots & \vdots & \vdots \\
X_{m1} & X_{m2} & \ldots X_{mn}
\end{bmatrix}
\]  \hspace{1cm} Matrix (3)

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

**Step 2: No scaling of decision matrix (standardization)**

At this stage, with the standardization of the data, the range of values \( (X_{ij}) \) that exist in different measuring units (such as the ranging, percent and metric measurement unit) to a standard domain at a range of 0 to 1 conversion determine the standardized values of the data \( (V_{ij}) \). In this process, the matrix of standard data can be compared and combined, or, in other words, at this stage, we try to transform the criteria with different dimensions into non-dimensional criteria, and the matrix \( V \) is defined as the matrix 4. In order to scale the data in the present study, Equations 1 and 2 are used.

\[
V_{ij} = \begin{bmatrix}
v_{11} & v_{22} & v_{1n} \\
v_{21} & v_{22} & v_{2n} \\
\vdots & \vdots & \vdots \\
v_{m1} & v_{m2} & \ldots v_{mn}
\end{bmatrix}
\]  \hspace{1cm} Matrix (4)

One of the simplest formulas to standardize raw data is to divide each raw score into the maximum value for a given criterion. Relationship 9 is expressed as:

\[ = 1 \frac{x_{ij}}{x_{j}^{\text{max}}} \]  \hspace{1cm} (9)

In which the \( x_{ij} \), standard score is for the \( i \) Option and \( j \) attribute. \( x_{ij} \) represents a raw score and \( x_{j}^{\text{max}} \) 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 measurement is sometimes referred to as the profit or benefit criterion.

If the criterion is the type of minimization (that is, the lower the score is, it is more desirable to execute) as used from Equation (2). This type of measure is also referred to as the cost criterion. On the other hand, raw data can be standardized on the basis of the scale-based method. In this process, the following equations are used (Malchovsky, 2006).

**Stage three: Determining the weight of the criteria**

At this stage, we determine the weights \( (w_j) \) assigned to each attribute; the total weights should be such that we get \( 1 \leq w_j \leq W_j \) and \( \sum_{j=1}^{n} W_j = 1 \). According to the importance coefficient of different criteria in the decision taking, the vector is defined as relation 10:

\[ W = \{w_1, w_2, \ldots, w_n\} \]  \hspace{1cm} (10)

**Step 4:** Determining the best (positive ideal) and the worst
(negative ideal) amount from the available values for each criterion. The best ($f_j^\ast$) values for the positive and negative criteria are calculated from relationships 11 and 12 respectively:

\[ f_j^\ast = \min_i f_{ij} \]  \hspace{1cm} (11)  
\[ f_j^\ast = \max_i f_{ij} \]  \hspace{1cm} (12)

The worst ($f_j^-$) value for the positive and negative criteria are calculated from relations 13 and 14 respectively:

\[ f_j^- = \min_i f_{ij} \]  \hspace{1cm} (13)  
\[ f_j^- = \max_i f_{ij} \]  \hspace{1cm} (14)

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

**Step five:** Calculation of the ideal or utility value (S) and the antidote or regret (R) amount is calculated according to equations 15 and 16:

\[ S_i = \sum_{h=1}^{n} W_j \frac{f_j^h - f_{ij}}{f_j^\ast - f_j^-} \]  \hspace{1cm} (15)  
\[ R_i = \max \left\{ W_j \left\{ \frac{f_j^h - f_{ij}}{f_j^\ast - f_j^-} \right\} \right\} \]  \hspace{1cm} (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 solution (the best combination) and ($S$) indicates the maximum discomfort of option $I$ to avoid the ideal solution It should be. In the agreement planning method, if the parameter $P$ is equal to one, the same value $S_i$ is obtained. Relationship 17:

\[ L(A_i) = \sum_{j=1}^{n} W_j \frac{f_j^\ast - f_{ij}}{f_j^\ast - f_j^-} = S_i \]  \hspace{1cm} (17)

In the agreement planning method, if the $P$ parameter is equal to $\infty$, the same value of $R_i$ is obtained. Equation 18:

\[ L_{\infty}(A) = \max_i \left[ W_j \left( f_j^\ast - f_{ij} \right) \right] = R_i \]  \hspace{1cm} (18)

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

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

Where $S_i = \min S_i$, $s^\ast = \max S_i$, $R_i = \min R_i$, and $R^\ast = \max R_i$.

In these relationships, $\frac{s^\ast - s^-}{s^\ast - s^-}$ represents the distance from the ideal solution and the parameter $v (\in [0,1])$ is chosen according to the decision of the decision maker, which is the agreement and is more than 0.5. Agreed with a majority of votes equal to 5, and in the case of a lower agreement, its value is less than 0.5. The value of Q is a function of ($S_i$ and $R_i$), which itself is the values of the ideal solution for $P = 1$ and $P = \infty$ respectively in the planning agreement.

The final weight of options at this stage of the combination of these coefficients is calculated and the final score of each of the options determined by using the principle of hierarchical of hours, which results in the creation of a priority vector, taking into account all the judgments in all hierarchy levels achieved (Jafarbeiglo and Mobarak, 2008).

Ultimate score option: \[ J = \sum_{k=1}^{n} = \sum_{i=1}^{m} = WK = W_j \]

$W_k$, is the coefficient of the important criterion; ikw, coefficient of significance sub- criterion I; Jig, is the j option and points in relation to the sub-criteria I; $W_k$, is the coefficient of the important criterion and ikw, coefficient of significance to sub-criterion I; Jig, is the j option and points in relation to the sub-criteria i (Jafarbeiglo and Mobarak, 2008).

**Study area**

The study area, which is classified according to the administrative boundaries of Bilshavar and Parsabad cities in the northern part of Ardebil province, is a natural unit with a history of its cultural history and centuries. This area was part of Azerbaijan in the past and was located in the Meshkinshahr political district. After a long time, its affairs were transferred to Moghan city to the center of Garmi, and now the geographical range of the two cities of Bileşivar...
and Pars Abad 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 river Rârs in the north forms the border between the Islamic Republic of Iran and the Republic of Azerbaijan. The west is East Azerbaijan province and Ahar city, and Moghan 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 39.49° 39′ and 22°47′ to 22°48′E and the administrative centers of the study area of Bildoosvar are in the geographical coordinates of 22° 39′ and 22°48 Longitude and Pars-Abad city are located at geographical coordinates of 40° 39 and 55° 47 longitude. The total area is 3501.7 thousand square kilometers, of which 1945 km² is to Billshosvar and 1556.75 km² belong to Pars Abad city (Figure 1 and Table 1).

RESULTS AND DISCUSSION

Validation of land suitability for olive cultivation

In order to study the ability of Moghan and Gilan plain areas in terms of olive cultivation using the Wikoor and Topsis model, we first used calculated and analyzed the statistical data for each of the parameters used. The desirability of each of the studied stations was studied in terms of climatic indicators, and 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 GIS environment and IDW mapping prepared using maps of susceptible olive cultivars (Figures 2, 3, 4 and 5).

Based on the classification of the Wikor and Topsis model, the Gilan and Moghan Plain are divided into four levels in terms of olive cultivation; the first level indicates the best and most suitable area, while the fourth level is the
Figure 2: Validation of land suitability for Moghan plain for olive cultivation based on the VIKOR model.

Figure 3: Validation of land suitability for Moghan plain for olive cultivation based on the Topsis model.
Figure 4: Validation of land suitability for olive cultivation in Gilan province based on Topsis model.

Figure 5: Verification of land suitability for olive cultivation in Gilan province based on the VIKOR model.
worst area in terms of olive cultivation. Finally, the ranking of options is based on CI, the aforementioned range fluctuates between zero and one. CI is equal to 1 represents the highest rating, while CI is 0 is the lowest. In the present study, according to the ranking and weighting to each of the indicators, CI of Garmi 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).

Conclusion

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 influencing olive cultivation because these two factors have the highest weight among other parameters. By examining the information layers obtained from GIS, annual rainfall in Moghan 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 cultivated area 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 last temperature, the southern parts of the Moghan Plain are not suitable due to the low temperature for olive cultivation. In general, the Moghan 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 the warming city, the environmental conditions. It is appropriate. An overview of climatic studies in two regions of Gilan and Moghan plain showed that among the studied stations, Rudbar and 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.

According to the modeling performed and the results of this study, Topsis and VIKOR models showed 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, Moghan 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 it is inappropriate, but it has no restrictions on cultivation and does not produce a high-quality, economical product.

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