Global J. Environ. Sci. Manage., 2(4): 327-338, Autumn 2016
DOI: 10.22034/gjesm.2016.02.04.002

ORIGINAL RESEARCH PAPER

Improving farming practices using multi-criteria decision analysis in geographic information system for Damask Rose cultivating

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Received 20 March 2016; revised 22 April 2016; accepted 15 May 2016; available online 1 September 2016

ABSTRACT: Lack of awareness of the critical factors involved in production of plants and sometimes, the cultivation of plants in areas unsusceptible to plant, can increase the amount of chemical fertilizer consumption in order to compensate the subsequent reduction of plant yield. This would increase environmental pollution. Thus, identifying of suitable areas where could supply plants initial needs of the environment is critical. For this goal, several criteria including soil conditions, climatologically indicators, topography situation and agro-climatology criteria were taken into account of modeling processing. Doing so, standardization process was performed on criteria and weighting process was performed by using of analytic hierarchy process approach. Geographical information system based on multi-criteria decision analysis was employed for weighted overlapping of indicators. Initial results indicated that East-Azerbaijan Province in the northern part of Iran has high potential for cultivating of Damask Rose. Results indicate that about 34.4% of East Azerbaijan Province has classified to be high suitability for cultivating this plant, while about 65.5 and 0.1 % of this area classified to be in the moderate and low suitability category respectively. In comparison of Damask Rose production during the 2014 and resulted analytic hierarchy process map results showed that areas with high suitability are not more under cultivation of this plant. Then, the findings of this study are great of importance for the purpose of regional planning in East-Azerbaijan Province.

KEYWORDS: *Analytic Hierarchy Process (AHP); Climate; Damask Rose ; Feasibility assessment; Rosa damascene; Zonation*

INTRODUCTION

Damask Rose (*Rosa damascena* Mill) is widely founded in temperate and subtropical regions of the Northern hemisphere and involves over 190 shrub species (Cairns *et al.,* 2000; Bruneau, *et al.,* 2007). Generally speaking, roses are used for culinary, fragrance and ornamental purposes and beside these effects, several antioxidant, antitussive, anti-HIV, antibacterial, hypnotic, antidiabetic properties have been reported for pharmacological properties of this plant (Hongratanaworakit, 1994; Boskabady, *et al.,* 2011). It is known that *Rosa damascena* Mill is known as prominent species in the perfume industry made by petals (Kiani, *et al.,* 2009). According to this statement, strong bond could be considered between Iranian culture and Rosa plant. Moreover, the popularity of Rosa is also due to holy beliefs about it (Boskabady, *et al.,* 2011). The Damask Rose is an important essential oil yielding crop throughout the world and Iran. For the essential oil business, highly scented summer Damask Roses are developed in commercial rose

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Note: Discussion period for this manuscript open until December 1, 2016 on GJESM website at the "Show Article".

gardens in diverse regions of the Iran country (Pirseyedi, *et al.,* 2005). Right now, this plant is cultivating in several part of Iran including East-Azerbaijan province. This part of Iran (North West) provides suitable conditions for cultivation of Rosa and as Ministry of Agriculture and Natural Resources (MANR) of East Azarbyjan Province indicates Rosa is cultivated in about 957 ha. However, in despite of popularity of Rosa, less attention has been paid for considering the suitability assessment in Rosa cultivating. Recent progresses in field of Precision Agriculture lead to employ advanced technology such as Geographical Information System (GIS) for modeling the possibility assessment of cultivating Rosa and its yield in any area. Due to the specific condition of Rosa, this is great of importance to analysis the suitability assessment of this plant.

In order to improve agricultural productivity, it is essential to get information about productivity of each plant in geographical locations. For this goal, GIS leads to employ variety of spatial analysis methods and techniques for modeling crop suitability and productivity goals. In this regards GIS leads to spatially examine the capability of each area for cultivating agricultural crops (Ho, *et al.,* 2009). In particular, by using of this technique farmers stakeholders, consumers, researchers, policy makers and agricultural extension services could be able to use more efficient and effective from natural resources both in national and subnational levels (Irfan, 2014). In this sense, GIS based multi criteria decision analysis (MCDA) is primarily concerned with combining the information from several criteria to form an individual index of evaluation (Dooley, *et al.,* 2009; Chen and Zhu, 2010). GIS-MCDA procedures utilizing geographical data consider the user's preferences, manipulate the data, and combine preferences with the data according to specified decision rules (Malczewski, 2006; Feizizadeh, *et al.,* 2014). Analytical hierarchy process (AHP) is well known in the GIS-MCDA method which allows ranking the important each criterion according the objective of modeling (Saaty, 1990). Technically, AHP is applicable to facilitate the decision making process in a variety of indices units. Basically, AHP can be used in situations where a direct and established empirical relationship is unknown between dependent and independent variables. The concept of AHP is also used when multiple options are available to choose from but there is no direct ranking available to help the decision making process (Forman and Peniwati, 1998; Irfan, 2014). AHP method has been synthesized into GIS-based suitability procedures that utilized to derive ratio scales from paired evaluation and to present objectivity in weight assignment. (Marinoni, 2004). AHP allows the decision maker to assign different relative weights to objectives, sub-objectives and variables at different levels of the decision hierarchy (Sener, *et al.,* 2010; Yahaya, *et al.,* 2010). Within this study, in order to derive the AHP weights relevant criteria for cultivating Damask Rose were taken into account of AHP's pairwise comparison. This study has been performed to investigate the suitability of Damask Rose cultivation in East-Azerbaijan Province of Iran during 2015.

MATERIALS AND METHODS

Study Area and Dataset

The study area was East-Azerbaijan Province (EAP). This area is located in the north-west of Iran (37.9036° N, 46.2682° E) (Fig. 1). The EAP with area of 45773.14 km^2 includes 20 counties, 57 cities and 3094 villages. This area with about 3.7 million populations is important in terms of housing, industrial and farming practices. (Statistical Center of Iran, 2011). The climate of this area is arid and semi-arid and the annual precipitation amount is approximately 300 mm (Meteorological organization of Iran, 2015). In order to model the suitability of Damask Rose cultivating, the Damask Rose plant ecological requirements criteria were considered as GIS-dataset which are described in below:

- Meteorological data were collected from 15 synoptic stations for the period of 15 years. This dataset was used to create average precipitation, temperatures, sun hours, evaporation, humidity percentage, soil temperatures in depth of 5 and 10 cm (Meteorological organization of Iran, 2015). Digital topographical maps were used in a scale of 1:50,000 to create digital elevation model (DEM) which was accordingly used to obtain slope and aspect maps, respectively.
- Land use/cover maps were derived from Landsat ETM + satellite images with spatial resolution of 30 m based on image processing techniques (MANR, 2013).

The pH of soil map and Damask Rose production data were derived from Department of Agriculture, East-Azerbaijan Province.

The Meteorological data was used to compute plant growth degree day (GDD) as an important index for cultivation of crops.

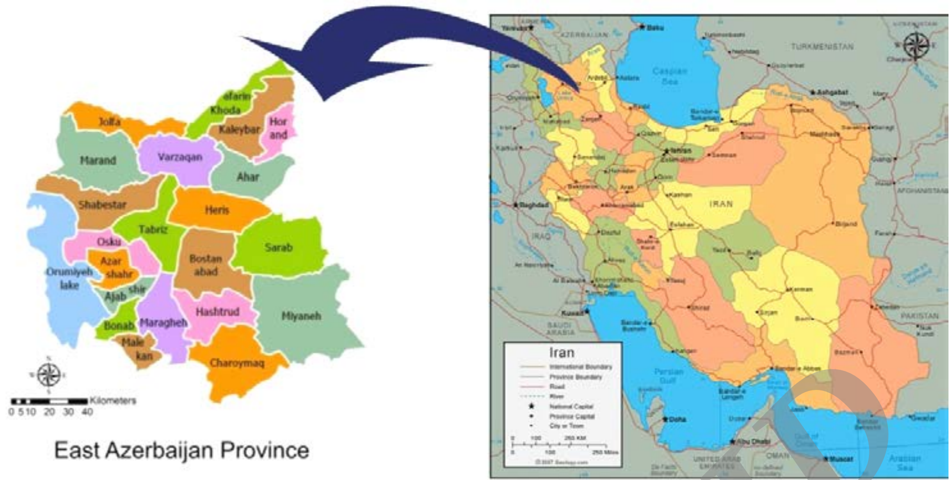

Fig. 1: Location of the case study area within Iran and East-Azerbaijan

Table 1: Scales for pairwise comparisons (Saaty and Vargas, 1991)

Intensity of importance	Description
1	Equal importance
3	Moderate importance
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2,4,6,8 Reciprocals	Intermediate values Values for inverse comparison

It has been used a thermal index of GDD, for investigating the required energy value of Damask Rose plant for flowering. In this research, the thermal index of GDD was employed (Mohammadi, *et al.,* 2011) to evaluate the degree-day which is computed as Eq. 1:

$$GDD = \sum_{i=1}^{n} [\frac{(Tmax + Tmin)}{2} - Tb] \quad (1)$$

Here, GDD indicates the degree-day gathered for n days. T_{max}: daily maximum temperature, T_{min}: daily minimum temperature, T_b: basic temperature and/or physiologic zero of plant which for Damask Rose is 5.2 ^{o}C (Khoshhal, *et al.,* 2014) n: number of days for a given time.

Criteria Standardization

In order to perform suability process, it is necessary to collect data in raster format. Thus, there were a variety of units that should be converted to the comparable mode. The initial step included standardizing the indicator variables to a typical numeric range using re-class function. In this study, criteria at the lowest importance get 5 rank and the highest important criteria get 1 rank. Based on this approach, the cells in a map, which were highly suitable for achieving the goal, obtained high standardized values, and less suitable cells obtained low values (Azizur Rahman, *et al.,* 2012, Feizizadeh, *et al.,* 2013). In order to map the results of the selected criteria, a spatial interpolation technique, i.e. inverse distance weighting (IDW) was used in this research.

Criteria weighting and ranking

Analytic hierarchy process can be implemented in three simple consecutive steps: 1) Computing the vector of criteria weights, 2) Computing the matrix of option scores, and 3) Ranking the options. Criterion weights are the weights depended to the goal and characteristic maps (Meng, *et al.,* 2011; Feizizadeh, *et al.,* 2013). AHP model could rank the criteria weights based on their relative importance degree, then was organized through hierarchal order with the weights derived from the 'pairwise comparison' procedure (Chen and Zhu, 2010; Vukicevic and Nedovic-Budic, 2012). The most critical step in the AHP is preparing comparison matrix. To make comparisons, scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared. In this study, two criteria were evaluated in the term of relative importance whereas index value varied from 1 to 9 (Table 1).

Thus, the reciprocal comparison matrix (Table 2) was produced using this technique (Chen and Zhu, 2010). The maximum latent root of λ_{Max} in the comparison matrix A has an eigenvector of W; the estimation of criterion weights is to calculate eigenvector W, which makes as Eq. 2.

$$AW = \lambda_{m} \ .w \qquad (2)$$

The calculation of the eigenvector is as Eqs. 3 and 4:

$$\bar{a}_{i.} \frac{a_{i.}}{\sum_{k=1}^{n} a_{k}} \qquad i, j = 1,2, \ldots, n \qquad (3)$$

Then adding by row:

$$\bar{W}_i = \sum_{j=1}^{n} \bar{a}_{i.} \qquad i, j = 1,2, \ldots, n \qquad (4)$$

Vector W= [W1; W2; . . . ;Wn]^T is standardized as Eq. 5:

$$W_i = \frac{\bar{w}_i}{\sum_{j=1}^{n} \bar{w}_i} \qquad i, j = 1,2, \ldots, n \qquad (5)$$

Eigenvector Wi=[W1, W2, . . . , Wn]^T is obtained. But consistency verification is necessary, and maximum latent root ›$_{Max}$ is calculated firstly as Eq. 6:

$$\lambda_{max} = \sum_{j=1}^{n} \frac{(AW)_i}{nW_i} \qquad (6)$$

where (AWi) represents the i-th element in AW, and consistency index (CI) is calculated as Eq. 7:

$$CI = \frac{\lambda_{m} - n}{n-1} \qquad (7)$$

The consistency ratio (CR) is calculated with a random consistency index (RI) as Eq. 8:

$$CR = \frac{CI}{RI} \qquad (8)$$

Pairwise comparisons have usually some inconsistencies, arise from different expert's opinions. The CR is a substantial indicator for achieving the reliability of an individual's pairwise comparisons. Then, the consistency ratio (CR) is calculated as the ratio of consistency index and random consistency index (RI). The RI is the random index representing the consistency of a randomly generated pairwise comparison matrix (Gorsevski, *et al.,* 2006) and is depend on the number of criteria being compared (Table 3). If CR $\leq$ 0.1, the pairwise comparison matrix is considered to be consistent enough. In the case CR $\geq$ 0.1, the comparison matrix should be improved. (Boroushaki and Malczewski, 2006).

RESULTS AND DISCUSSION

Temperature

Damask Rose plant for better growth and flowering, needs for 18-20 centigrade temperature and some degrees above and below of this rate may be suitable for it. (Emad, *et al.,* 2012). Five to ten degree centigrade

Table 2: Pairwise comparison matrix for dataset layers of susceptibility areas analysis resulted from questionnaire

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13
(1) Mean temp.	1	3	1/2	1/2	1/2	2	2	1/2	2	3	3	3	3
(2) Min temp.		1	1	1/3	1/2	3	1/2	1/3	3	2	2	2	1/2
(3) Max temp.			1	1/3	1/2	2	1/3	1/2	3	2	2	2	2
(4) Precipitation				1	1/2	3	3	1	3	2	3	3	3
(5) Elevation					1	3	2	1/2	3	1	2	2	2
(6) Humidity						1	1/3	1/4	1/3	1/3	3	2	1/2
(7) Evaporation							1	1/3	3	3	3	3	1/2
(8) Sun hours								1	3	3	3	3	3
(9) PH									1	2	3	3	2
(10) Slope										1	3	3	1
(11) Soil temp.5cm											1	2	1/3
(12) Soil temp.5cm												1	1/3
(13) Aspect													1
In consistency	0.08												

Table 3: Random inconsistency indices (RI).

Number of criteria	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.52	1.54

Note: Adapted from Saaty (1977).

temperature differences between day and night degrees (As maximum and minimum temperature respectively) could well induce flowering of this plant (Khoshhal, *et al.,* 2014), thus, areas that had low differences between day and night temperatures were more important in this study (Table 4). Temperature is critical factor on the growth of rose shoot, axillary buds and following time (Marcelis–van Acker, 1995). Weight and length of the flower-bearing shoot decline when temperature exceeds 24 °C (De Vries, *et al.,* 1982). These results were applied in weightings of maximum and minimum temperatures for getting desire results. Then, according to the Fig. 2 (A, B and C) south-east (around Mianeh City) and west of EAP especially north-west and south-west of this region (Jolfa, Ajabshir, Bonab, shabestar regions) had warm temperatures than the other regions such as Charuymaq, Sarab, Varzeghan and kaleybar regions. In the term of susceptible areas, about 26.5% (1212615.6 ha) of this province mean temperature varied between17.94-20.93°C, in addition, 56.4% of maximum temperature varied between 20.73-23.34 °C whereas 39.8% of min temperature varied between 11.01-14.45 °C. Generally, based on mean temperature, 9.2 % of area (421709.6 ha) couldn't well supply plant thermal required (Table 5).

Soil Temperature

Optimum soil temperature for roses varied between 20-30° C day and 18-20° C night temperatures, whereas, low night temperature of 10-12°C inhibits flowering (Weiss, 1997; Pal and Singh, 2013). Low temperature in these plants increase several photosynthetic enzymes activities such as stromal fructose-1, rubisco, 6-bisphosphatase, sucrose-phosphate synthase and also, anthocyanin content (Harborne, 1967; Ushio, *et al.,* 2008). Thereby in consideration for finding the areas with 18-20 C temperature, results indicated that almost all areas of EAP had optimum soil 5 and 10 cm temperature (during April-mid July) which it varied between 17-26 °C. In this sense, north-west and south-west of the Province had warmest soil temperature that the others (Figs. 2D and E).

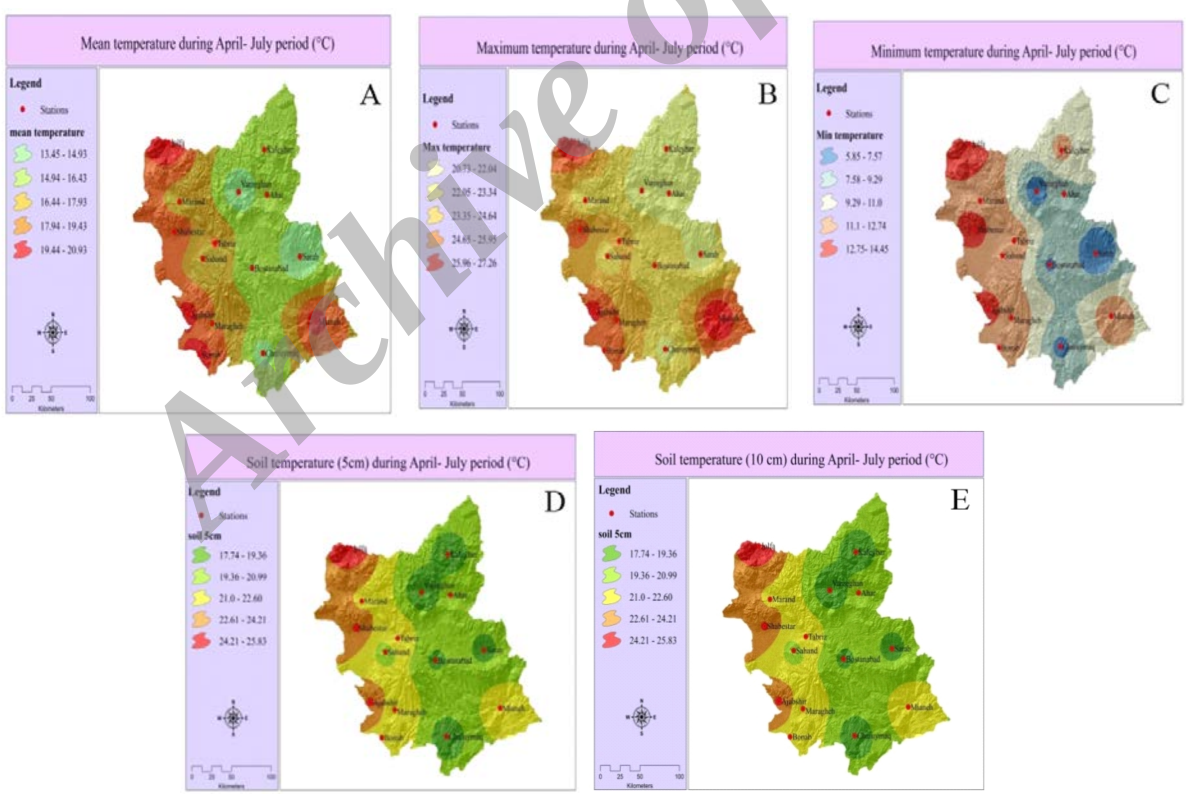

Fig. 2: Maps of air and soil temperature during April-July: A) Map of Mean temperature B) Map of maximum temperature C) Map of minimum temperature D) Map of soil temperature (5cm) E) Map of soil temperature (10 cm)

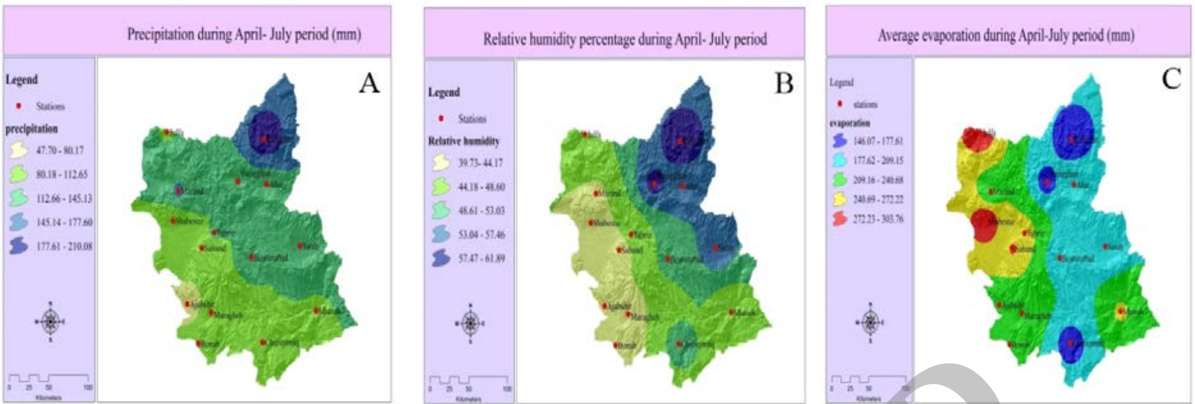

Fig. 3: Map of hydrological parameters during April-July: A) Map of precipitation B) Map of relative humidity percentage C): Map of average evaporation

Precipitation

Damask Rose is a tolerant medicinal plant to the drought stress, diseases, aphids and also is resistant to the unsuitable environmental conditions (Yadollahi, *et al.,* 2012; Emad, *et al.,* 2012). Optimum precipitation for this plant during the growth period is x>250 mm (Yadollahi, *et al.,* 2012) which would be supply by spring precipitations or supplementary irrigations, however, excessive irrigation or precipitation can increase the risk of diseases and aphid infestations (Luck, *et al.,* 2011). Important parts of Damask Rose plant in medicinal science are petals then, in this study more focused on flowering period of this plant. According to the Table 5, during April to mid-July months, areas with high suitability for this plant cultivation included 3.3% (149107.1 ha) of total studied Province. However, 8.1% of areas (371189.7 ha) had suitable condition. Regard to the results about 2.0% of areas identified as unsuitable areas for this purpose (89845.8 ha). According to the Fig. 3A, north-east of East Azerbaijan province had relative high precipitation rate compare to the other regions ($177 \leq x \leq 210$ mm). However, most parts of this province had moderate precipitation rate.

Relative Humidity Percentage

Atmospheric humidity could influence on plants growth indirectly through its influence on precipitation phenomena, outbreak of pest and disease epidemics, while excessive air humidity could significantly influence on roses (Mortensen and Fjeld, 1995). Thereby, optimum humidity for Damask Rose is 70 % during spring and early summer (Pal and Singh, 2013). Thus, areas with humidity percentage about 70% are more favor to Damask Rose plant (Table 5). According to the Table 5, about 26.2% of this province humidity varied between 53-62% and north-west of East-Azerbaijan had favor relative humidity. However, west parts of the province due to the low precipitation rate (Fig. 3A) had low relative humidity (Fig. 3B).

Evaporation

According to the Fig. 3C, although east sides of this province had low evaporation rate, however, west and north-west of EAP had high evaporation rate which indicates 48.7% of this area had over 240 mm evaporation rate during the April and mid of July (Table 5). High evaporation rate resulted to low available water in the soil while low evaporation rate could supply plant water requirements due to the high available water in the soil then, based on this assumption, within in this study high evaporation rate areas take low value (Table 5).

Elevation

East-Azerbaijan mountainous province elevation varies from flat to mountains altitudes and optimum elevation for Damask Rose plant varies from almost 1300-1800 meters from the sea level. It had been reported that areas with high elevation were more suitable for this plant cultivating (Emad, *et al.,* 2012; Yadollahi, *et al.,* 2012). Almost central regions of this province by having 1484-2340 meter elevation above sea level could well supply this plant (Fig. 4A).

Sun Hours

Damask Rose plant is sun-loving plant that prefers full sunlight (Emad, *et al.,* 2012; Pal and Singh, 2013).

Table 4: Factors, priority influence and scale value of the data layers according to the questionnaire

Factors	Priority influence	Scale value	Factors	Priority influence	Scale value
Precipitation (mm)			*Sun hours*		
40.7-80.17	0.137	5	950-1007	0.15	5
80.18-112.65		4	1008-1064		4
112.66-145.43		3	1065-1119		3
145.43-177.60		2	1120-1176		2
177.60-210.08		1	1177-1232		1
Mean temperature (℃)			*pH*		
13.45-14.93	0.098	5	1.5-4.40	0.057	5
14.94-16.43		4	4.41-6.50		3
16.44-17.93		3	6.51-7.70		1
17.94-19.43		2	7.71-8.60		2
19.44-20.93		1	8.61-11.35		4
Maximum temperature (℃)			*Slope*		
20.73-22.04	0.079	1	0-5.527	0.055	2
22.05-23.34		2	5.528-13.128		1
23.34-24.64		3	13.129-23.147		3
24.65-25.95		4	23.148-52.514		4
25.96-27.26		5	52.514-88.100		5
Minimum temperature (℃)			*5 cm soil temperature (℃)*		
5.85-7.57	0.062	5	17.74-19.36	0.027	3
7.58-9.29		4	19.37-20.99		1
9.30-11.0		3	21.0-22.60		2
11.01-12.74		2	22.61-24.21		4
12.75-14.45		1	24.22-25.83		5
Elevation			*10 cm soil temperature (℃)*		
0-957	0.119	4	17.53-18.97	0.031	3
957-1484		3	18.98-20.41		1
1485-1877		1	20.42-21.85		2
1878-2340		2	21.86-23.29		4
2341-4365		5	23.30-24.73		5
Relative humidity percentage			*Aspect*		
39.73-44.17	0.033	5	Flat	0.063	5
44.18-48.60		4	North		1
48.61-53.03		3	Northeast		1
53.04-57.46		2	East		2
57.47-61.89		1	Southeast		4
Evaporation (mm)			South		4
146.07-177.61	0.09	1	Southwest		5
177.62-209.15		2	West		3
209.16-240.68		3	Northwest		1
240.69-272.22		4	North		1
272.23-303.76		5			

Thereby, in this study, regions with high sun hours get more weight and also high influence priorities resulted from agricultural experts' opinions confirmed this issue (Table 4). Areas with high sun hours during April- mid July included 66.6 % of East-Azerbaijan province (Table 5) which is more extended from north-west to the south-east of this region especially in Sahand, Shabestar, Maragheh and Bostanabad regions (Fig. 4E).

pH, slope and aspect

Suitable pH for most of the plants such as Damask Rose varies between 6.5 - 8. Although 61.17% of east-Azerbaijan province pH varies between 6.50-8.60 but

Table 5: Factors susceptibility percentages and covered areas

Factors	%	Area (ha)	Factors	%	Area (ha)
Precipitation (mm)			*Sun hours*		
High suitable	3.3	149107.1	High suitable	6.1	277967.6
suitable	8.1	371189.7	suitable	65.5	3000427.5
Moderate suitable	47.4	2168993.3	Moderate suitable	13.6	624959.6
Low suitable	39.3	1800966.7	Low suitable	11.2	513177.4
No suitable	2.0	89845.8	No suitable	3.6	163561.3
Mean temperature (℃)			*pH*		
High suitable	5.0	227573.5	High suitable	31.25	1431721.2
suitable	21.5	985042.1	suitable	42.12	19229452
Moderate suitable	24.7	1132088.6	Moderate suitable	6.78	310628.6
Low suitable	39.6	1813679.8	Low suitable	19.05	872525.2
No suitable	9.2	421709.6	No suitable	0.88	40524.6
Maximum temperature (℃)			*Slope*		
High suitable	25.1	1148931.5	High suitable	31.08	1423760.1
suitable	31.3	1432168.6	suitable	44.41	2034386.8
Moderate suitable	25.0	1146045.8	Moderate suitable	17.46	799774.5
Low suitable	13.8	633357.3	Low suitable	6.95	318339.9
No suitable	4.8	219593.5	No suitable	0.18	8375.1
Minimum temperature (℃)			*5 cm soil temperature (℃)*		
High suitable	7.5	342208.7	High suitable	44.2	2024401.0
suitable	32.3	1477435.7	suitable	28.6	1310161.2
Moderate suitable	26.3	1205981.7	Moderate suitable	12.7	580359.4
Low suitable	27.6	1265108.6	Low suitable	12.3	561511.4
No suitable	6.3	289386.2	No suitable	2.3	103642.5
GDD			*10 cm soil temperature (℃)*		
High suitable	5.6	254999.7	High suitable	44.2	2024401.0
suitable	29.8	1367118.4	suitable	28.6	1310161.2
Moderate suitable	64.6	2957986.5	Moderate suitable	12.7	580359.4
Low suitable	0	0	Low suitable	12.3	561511.4
No suitable	0	0	No suitable	2.3	103642.5
Relative humidity %			*AHP*		
High suitable	6.2	282661.0	High suitable area	0	0
suitable	20.0	914946.2	Suitable area	34.4	1574318.3
Moderate suitable	18.6	850497.2	Moderate suitable area	65.5	2998376.9
Low suitable	33.9	1553849.0	Low suitable area	0.1	5892.2
No suitable	21.4	978146.8	Unsuitable area	0	0
Evaporation					
High suitable	3.7	170597.2			
suitable	15.9	730482.3			
Moderate suitable	31.7	1450729.5			
Low suitable	40.3	1844847.5			
No suitable	8.4	383429.3			

just 7.66 % of this province had unsuitable pH for this plant. As it shown in Fig. 4D, almost south of the province, margins of Urmia Lake (due to the high concentration of NaCl), North of Maragheh City, east of Marand region and north-east of studied province had unsuitable pH.

According to the table 4 and 5, 75.49 %s of East-Azerbaijan province slopes vary between 1-13.5 degrees. As Fig. 4B indicated, most of the studied area had acceptable slope and only 7.13 % of mountainous area had less suitability for cultivating of this plant. Although west, south and south-east of this region by almost more flat areas are suitable for getting more sunshine and optimum temperature, however, as this plant is currently cultivated in submontane regions thereby, this plant could be cultivated in hilly and mountainous areas (Emad, *et al.,* 2012). Low slope degree increases better penetration of water and soil moisture storage and in the critical period of growth,

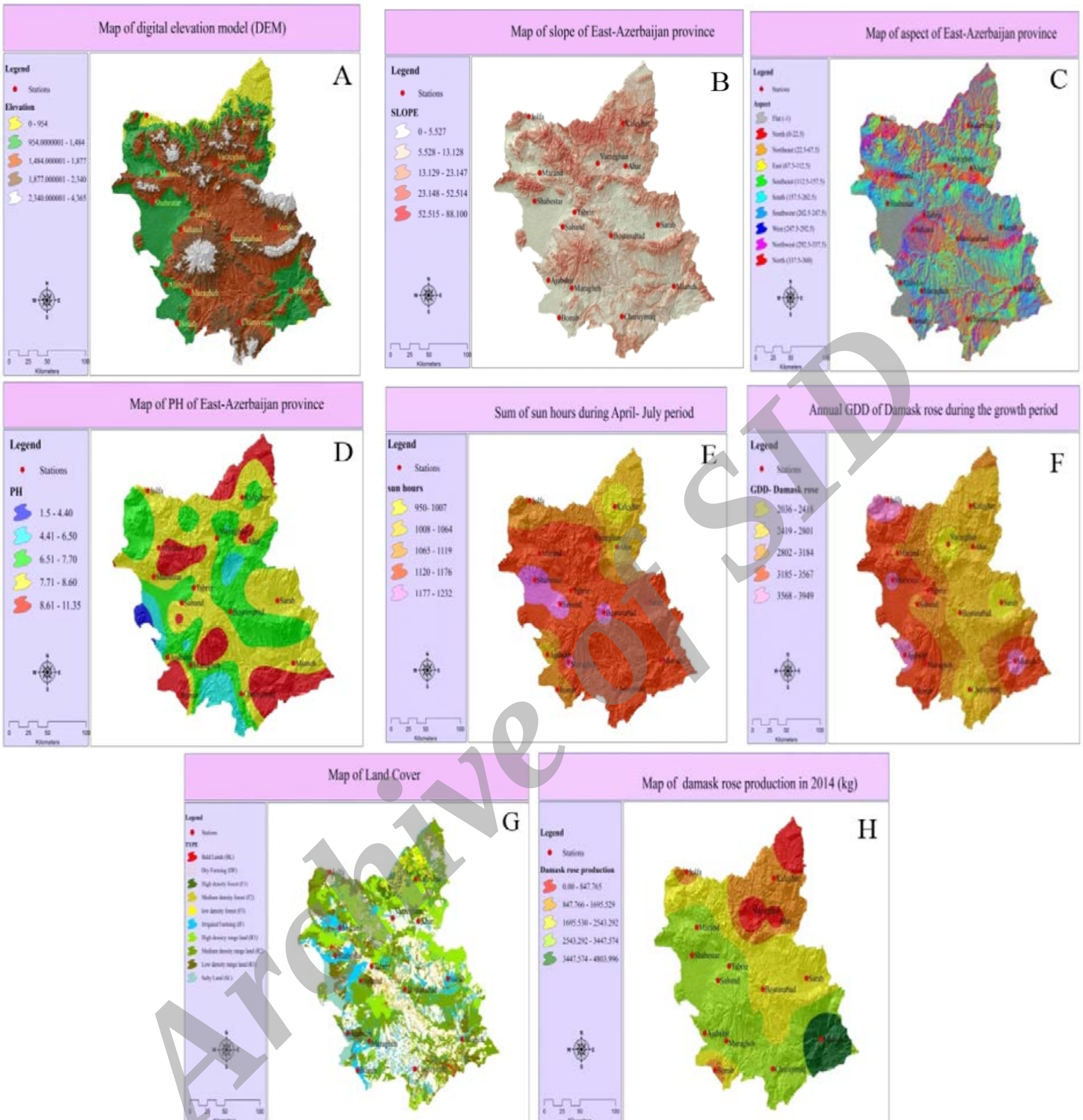

Fig. 4: Criteria spatial distributions of the study area: A) Map of digital elevation model of East-Azerbaijan B) Map of slope C) Map of aspect D) Map of soil pH in 2013 E) Map of sun hours during April-July period F) Map of growth degree days for Damask Rose plant G) Map of land cover of East-Azerbaijan H) Map of Damask Rose production in 2014

water supply will eliminate the problem of water deficit (Alavi Zadeh, *et al.,* 2013). In the northern hemisphere of earth facing south and horizontal surfaces always have maximum power of the sun at noon, however, Damask Rose plant prefer north aspects. Generally, high elevations with north aspect could increase the quality of essence for example Hongratanaworakit (1994) indicated that roses grown in northern countries have more minerals and vitamins A, B, B2 and C than those in southern countries. Thereby, northern aspects of this studied province get high weight than the others (Table 4 and Fig. 4C).

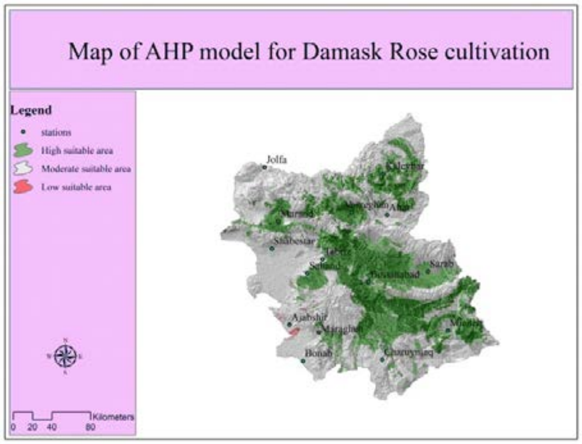

Fig. 5: Suitable areas for cultivation of Damask Rose based on AHP technique

Growth degree day (GDD)

Regions with optimum temperature and more than basic temperature for an individual plant, logically could supply plant growth degree day requirements. Khoshhal, *et al.,* (2013) in their study indicated that Damask Rose need for 866.2 GDD for its flowering. Fig. 4F indicated that most part of EAP could supply plant annual required GDD and its' value varied between 2036-2949 GDD. In this sense, east side of this province except Mianeh region had low GDD and subsequently cold temperature than the other parts and there were no regions couldn't supply plant GDD needs (Table 5). On the other hand, it could be concluded in areas with high GDD, blooming and flowering is getting earlier than other regions and it could be happen in May- mid June period. Fig. 4F shows map of growth degree days for Damask Rose plant. Consideration of important factors influence on plant growth and yield, analytic hierarchy process makes a chance for weighting and finding of the importance of studied factors (Table 4) and finally could suggest the best regions for cultivation of each plant such as Damask Rose medicinal plant. In this way, by using of agricultural scientists opinions and preparing of a questionnaire final map of Damask Rose plant cultivation feasibility prepared. According to the Fig. 5, almost center, east and North-east of this province had high potential in production of Damask Rose. Although around areas of Sahand, Varzeghan, Bostanabad, Maragheh, Marand, Tabriz stations were more suitable however, other parts of this province had moderate potential for this purpose and there will be a possibly decrease in yield compared to the regions with high susceptibility conditions. At all 34.4%e of this province had good suitability (1574318.3 ha), 65.5% had moderate suitability (2998376.9 ha) and 0.1% (5892.2 ha) had low suitability in cultivation of this plant (around Ajabshir and Urmia Lake regions). In this study, weighting over lay ranges analysis indicated that, there was no region that could supply all plant needs to produce the highest possibly yield, moreover, there was no region that been completely unsuitable for cultivation of this plant (Table 5).

In comparison of Damask Rose production during the 2014 and resulted AHP map, most of the Damask Rose production in this province is achieved from Mianeh region and areas with almost moderate suitability however, areas with good suitability are not more under cultivation of this plant such as Varzeghan and Kaleybar regions (Fig. 4H). By consideration of land cover of East-Azerbaijan (Fig. 4G), it could be found that Jolfa, Kaleybar, Bostanabad, Marand and Ahar regions by having high, moderate and low range lands could better use from these natural resources and develop its agricultural products by cultivation of Damask Rose. In addition, by considering land cover map, it could be concluded that low Damask Rose production on center and north-east of East-Azerbaijan Province is due to the dry farming cultivations so, further economic studies are necessary for any recommendations for any changes in cultivation of this regions.

CONCLUSION

Selection of medicinal plant species adapted to the arid and semi-arid areas and better usage of natural resources with high efficiency in these regions is very important toward the sustainable agriculture. One of the first steps in cultivation of any plant is consideration of regions and requirements of the plant that is going to be plant there. AHP by combination of prepared dataset could suggest best regions for cultivation of an individual plant. This study by evaluating of East-Azerbaijan Province and collecting the important factors that influence on Damask Rose cultivation and matching of these with plant requirements could resulted that this province had high potential in production of Damask Rose plant and Kaleybar, Varzeghan, Bostanabad, Maragheh, Marand, Sahand and Tabriz regions are very suitable for this purpose. Results of this research are great of important for regional planning and decision makers for understanding the physical condition of East-Azerbaijan Province and its potentiality for cultivating Damask Rose.

ACKNOWLEDGEMENT

The authors would like to thank the Meteorological Organization of East-Azerbaijan Province and Ministry of Agriculture and Natural Resources of East-Azerbaijan Province in Iran for data support throughout this study.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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HOW TO CITE THIS ARTICLE

Shokati, B.; Asgharipour, M.R.; Feizizadeh, B., (2016). Improving farming practices using multi-criteria decision analysis in geographic information system for Damask Rose cultivating. Global J. Environ. Sci. Manage. 2(4): 327-338.

DOI: 10.22034/gjesm.2016.02.04.002

URL: http://gjesm.net/article_19779.html