Emirates Journal for Engineering Research

Volume 25 | Issue 3 Article 2

6-2-2020

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Yaghoubzadeh, Navid; Pourdarbani, Razieh; Ghorbani, Ardavan; and Shahgholi, Gholamhossein (2020) "Agroclimatic Zoning for Cultivation of Saffron Using AHP Approach in SARAB," *Emirates Journal for Engineering Research*: Vol. 25 : Iss. 3 , Article 2.
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AGROCLIMATIC ZONING FOR CULTIVATION OF SAFFRON USING AHP APPROACH IN SARAB

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(Received 11th April 2020 and Accepted 2nd June 2020)

التقسيم الزراعي لزراعة الزعفران باستخدام نهج AHP في ساراب

ملخص

وفقا للخبراء الزراعيين ، الزعفران هو أحد المحاصيل التي يمكن أن تكون حلا جيدا لمشكلة الجفاف في حالة أزمة المياه. يعتبر النبات الذي يستخدم استهلاكًا منخفضًا للمياه ودخلًا اقتصاديًا مرتفعًا بديلاً جيدًا للقمح ، وهو محصول يستهلك المياه. لا يحتاج الزعفران إلى الماء على الإطلاق في الصيف ، وفي الخريف والشتاء ، سوف يسيل المطر هذا المحصول ويتطلب القليل جدًا من الماء خلال العام. أجريت هذه الدراسة لتحديد الموقع الأمثل لزراعة الزعفران ودراستها المقارنة في سراب فيما يتعلق بدور العوامل الهامة في تحديد المكان. لهذا الغرض ، تم استخدام المعايير المناخية بما في ذلك (متوسط درجة الحرارة ، درجة الحرارة القصوى ، درجة الحرارة الدنيا ، ساعات أشعة الشمس وهطول الأمطار) ، معايير الجيولوجيا (التربة) ، معايير الطبوغرافيا (الارتفاع ، المنحدر) والمعايير الاجتماعية والاقتصادية (استخدام الأراضي). نظرًا لتنوع المعلومات ، تم استخدام نهج AHP في التحليلات المكانية للمعايير المطلوبة لزراعة الزعفران ، ثم تم تراكب الطبقات. لتحديد إمكانات مناطق مختلفة من السراب لزراعة الزعفران ، بعد التحقق من طبيعية البيانات ، تم تطبيق النماذج الجغرافية الإحصائية على البيانات. ثم ، بناءً على نموذج AHP ، تم تقييم العوامل الفعالة. في النهاية ، يتم عرض النتيجة النهائية كخريطة تقسيم المناطق للمواقع المناسبة لزراعة الزعفران. أوضحت النتائج أن الأجزاء الشرقية والغربية من المدينة (46.5٪) لديها إمكانات عالية لزراعة الزعفران. في الأجزاء الشمالية والجنوبية من السراب ، بسبب المنحدر العالي وبالتالي التآكل العالي ، وكذلك وجود الهياكل البركانية في هذه المناطق ، تسبب في وجود المزيد من الصخور البركانية. وبالتالي فقد كانت لديهم إمكانات منخفضة لزراعة الزعفران.

Abstract

According to agricultural experts, saffron is one of the crops that can be a good solution to the problem of drought in a water crisis situation. A plant which uses low water consumption and high economic incomes is a good alternative to wheat, a water-consuming crop. Saffron does not need water at all in the summer, and in the fall and winter, rain will irrigate this crop and require very little water during the year. This study was conducted to select the optimum location of saffron cultivation and its comparative study in Sarab with regard to the role of important factors in locating. For this purpose, climatic criteria including (mean temperature, maximum temperature, minimum temperature, sunshine hours and precipitation), geology criteria (soil), topography criteria (elevation, slope) and socio-economic criteria (land use) were used. Due to the diversity of information, the AHP approach was used for the spatial analyzes of the criteria required for saffron cultivation, and then the layers were overlaid. To determine the potential of different areas of Sarab for saffron cultivation, after investigating the data normality, geo-statistical models were applied to the data. Then, based on AHP model, effective factors were evaluated. At the end, the final result is presented as a zoning map of suitable locations for saffron cultivation. Results revealed that the eastern and western parts of the city (46.5%) had high potential for saffron cultivation. In the northern and southern parts of Sarab, due to the high slope and consequently high erosion, and also the presence of volcanic structures in these areas, it was caused the presence of more volcanic rocks. Thus they got low potential for cultivating saffron.

Keywords: Locations, Saffron, GIS, AHP, Sarab, Cultivation.

1. INTRODUCTION

In Sarab, most crops are in high demand for water, and due to gradual changes in the atmosphere and rising global temperatures, the average annual precipitation has decreased and groundwater levels have fallen, so a crop with a very low water requirement like Saffron can be a great alternative for common crops in the area. Interestingly, even the smallest water requirement is related to September when other crops do not need much water. The water requirement of saffron using the FAO-Penman-Monteith method is estimated to be 2350 m3 per hectare (Ahmadi et al, 2017) while the water requirement of wheat is 5000 m3 (Sepahvand, 2009). On the other hand, todays, because of industrial poverty in Sarab, and also drought in recent years, most young people are migrating to capital cities and preferring being labor over farmer. Cultivation of saffron as a low-water and economical crop, so red gold, can be a solution to the business problems of the people of the region.

By studying the geographical coordinates of ancient and present saffron points, it is clear that elevation is one of the key factors for optimum yield of saffron. Historical documents show that saffron-rich regions are located at elevation of 2 m above sea level in Iran, such as Hamadan at 1800 m, Gonabad at 1100 m and Torbat-e-Heydarieh at 1350 m above sea level. Other influential climatic factors are latitude of the saffron zones, which should be located above 30^{o} (Abrishami, 2004). Although saffron is grown in temperate and arid regions, however its growing condition is such that aerial organs grow in the cold season (Monazzam & Kardovani, 2009). Molina et al. (2005) reported that the best temperature for saffron flowering is between 23-27^{oc}. In saffron, soil temperature is more important than air temperature. Although the soil temperature is a function of the air temperature, the fluctuation is less than the air temperature. It is recommended that the cultivation of saffron corms be at a depth of 15 cm and treatments that are cultivated at such depths have a higher yield than surface planting. The reason is to protect corms from soil temperature fluctuations (Kafi et al, 2006). The maximum temperature has been reported between 35 and 40^{oc} in Iran (Amir Gasemi, 2001).

Another important environmental factor is frost days. Saffron is low temperature resistant but at flowering time, temperatures below zero and freezing temperature can destroy flowers and reduce yield (Masoudian, 2011). Saffron is a plant whose growing season is most consistent with the rainfall pattern of southern of Khorasan province in Iran. In other words, with the onset of autumn rains, plant growth begins, and with the end of spring rainfalls, growth ceases, and as a result, rainfall has the greatest impact on plant growth. During the growing season, especially in winter, the water requirement of other plants is scarce, and in the case of running water such as aqueducts and rivers, the water requirement of saffron does not require a high cost (Sadegi, 1998). Soil of Saffron field should be well permeable. It grows well in silica, clay, lime and gypsum soils because organic matter is well degraded in calcium-containing soils (Vafabakhsh, 2002). Essential elements of Saffron include nitrogen (Yasribi & Karimian, 1994), phosphorus (Samadi & Gilkes, 1998), potassium (Khorasani & Haghnia 2002), sodium (Esvaran et al, 1993) and lime (Ganbari et al, 2002) which play a role. Some of the studies conducted to identify saffron cultivated areas are as follows:

Appropriate locations for cultivation of saffron in Torbat-e-Heydariyeh were determined using AHP based on soil-water parameters. The results indicated that about 55% of the fields had suitable conditions for saffron cultivation (Rashid Sorkh Abadi et al, 2016). Sobhani (2016) studied on agro-climatic zoning of saffron cultivation in Ardabil province using hierarchical method. Climatic data such as annual rainfall, growth period rainfall, annual temperature, growth period temperature, absolute minimum temperature and number of frost days, slope, soil and altitude were used to determine and identify appropriate sites of saffron cultivation. The results showed that about 91%, 57% and 93% of Ardabil is in suitable, moderate and unsuitable conditions, respectively. Yazdchi (2010) evaluated potential of Marand region for planting Saffron based on the ecological and environmental needs. The results showed the effectiveness of hierarchical analytical methods in measuring the land potential for saffron cultivation and accordingly, Marand was divided into three arable, relatively arable and non-arable parts. During two-year, Behdani (2008) studied on fluctuations in yield and ecological zoning of the most important saffron production centers in the four cities of Iran namely Birjand, Qain, Gonabad and Torbat-e-Heydariyeh. In this study, the relationship between yield and various growth and management parameters related to saffron was investigated. The results showed that recognizing the relationships between yield and the factors affecting, achieves higher yield in many zones in the study areas.

The necessity of this research can be attributed to the present water crisis in Iran and the low water requirement of Saffron compared to other common crops such as wheat. At the same time, the high rate of employment (280 person-day per ha), no need for sophisticated machinery, compliance with the economic conditions of the farmers and exchange

value added are other advantages of saffron cultivation in the region.

2. METERIAL AND METHODS

2.1. Characteristics of the study area

Sarab with an area of 24.3485 km^2 is located in the northwest of Iran and in the southeastern region of East Azerbaijan province (7°56′27″N, 47°32′12″E). Figure 1 shows the location of Sarab in the Iran and in the East Azarbaijan province.

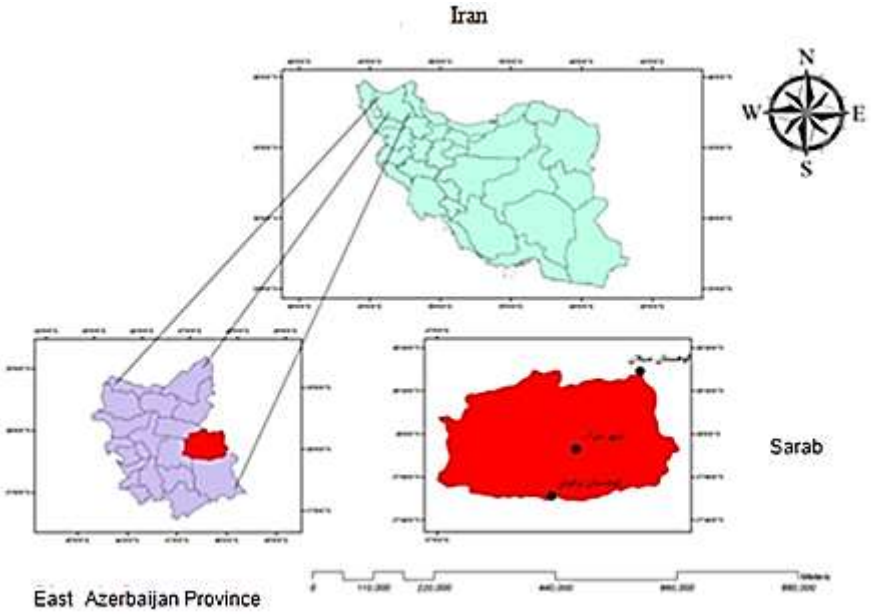

Figure1. Map of the geographical location of Sarab

2. Methodology

In this study, to identify appropriate areas for saffron cultivation, climatic criteria including (average temperature, maximum temperature, minimum temperature, sunshine and precipitation), criteria including (soil), topography criteria including (elevation, slope) and socio-economic criteria including (Land use) were used. At the end, the final result was presented as a prioritized map. The information layer and tools used in the research were geological map at the scale of 1: 100000, topographic map at the scale of 1: 50000, road map at the scale of 1: 250000; LANDSAT8 satellite imagery for land use mapping; DEM digital elevation model derived from aster Terra satellite sensor; slope map; soil information layers; climate data information layers. Since the locating process is a multi-attribute decision-making problem and can be implemented using a raster model. Thus, GIS was selected for multi-trait analysis. In this study, expert opinions were used to determine the preference of different factors. The data were collected through a questionnaire and the statistical population of the study consisted of 20 experts, managers and officials. After calculating the final value of the options and examining the compatibility using the Expert Choice software, the required spatial information layers were created in ArcGIS 10.6.1. In general, the incompatibility rate of pairwise comparison matrices should be less than 0.1. The inconsistency rate is an index that measures the level of consistency of the responses of the experts to the pairwise comparisons. In other words, with the help of the inconsistency rate index, it can be seen whether there is consistency between pairwise comparisons in the questionnaires. In this study, OLI Landsat8 satellite images (no. 165-355) were used to obtain the land use map. The images were investigated for any geometric and radiometric errors before any data analysis and data processing. To check the geometric status of the images, vector layers of roads were placed on the satellite images, which ensured the geometric accuracy of the images used. Envi software was used to determine the wavelength, sensor type and image integration required. Then, the merged image in ArcMap10.6.1 software was cropped according to the study area and finally saved in IMAGINE Image format to prepare for land use classification.

3. Results and Discussion

4. Pairwise comparison and prioritization the criteria using Expert Choice

To enter the information into Expert Choice software, experts were first given a pairwise comparisons matrix in the form of a questionnaire.

The data were then entered into the software and *significance factor* of each criterion were determined. Figure (2) shows the weights obtained for each of the sub-criteria. The rate of compatibility of the criteria was 0.03, indicating acceptable accuracy of this pairwise comparison (Figure 3).

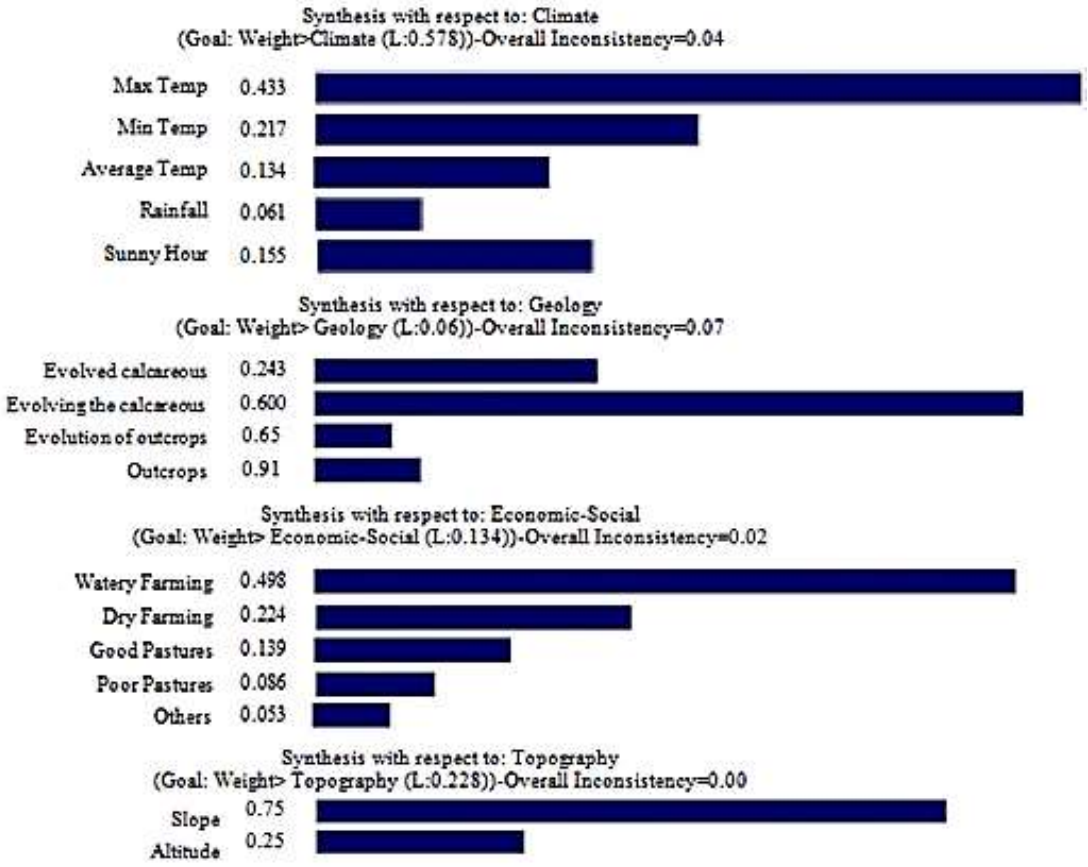

Figure2. *Significance factor* (weights) obtained for each factor using Expert Choice

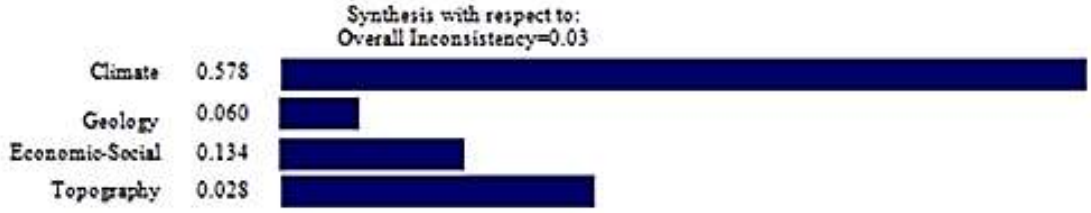

Figure3. *Significance factor* (weights) obtained for each criterion using Expert Choice

a. Classifying information layers and evaluating them

In this section, according to climatic, geological, topographic and socio-economic factors, different maps were prepared using GIS. Finally, all of these maps have been merged after weighting that shows the appropriate sites for saffron cultivation in terms of importance and accessibility.

b. Selection of suitable zones based on climatic parameters

i. Average temperature

Temperature is one of the determining factors in the geography of crops. Saffron flowering is mainly controlled by temperature (Kafi, 2002). Given that saffron is inherently a semi-tropical plant, it can be said that the warmer the temperature, the better the growth, especially at the stage. On this basis, the

lowest average temperature of 8.7°C and the highest average temperature of 11.3°C were estimated in study area (Table 1). According to figure 4, many parts of the east as well as parts of the north of the Sarab have a good potential for saffron cultivation in terms of mean temperature.

Table1. Classification of the average temperature of Sarab

Criterion	Classification		Value
Average temperature (°C)	Suitable	10-11.3	9
	Relatively suitable	9.5-10	4
	Unsuitable	8.7-9.5	1

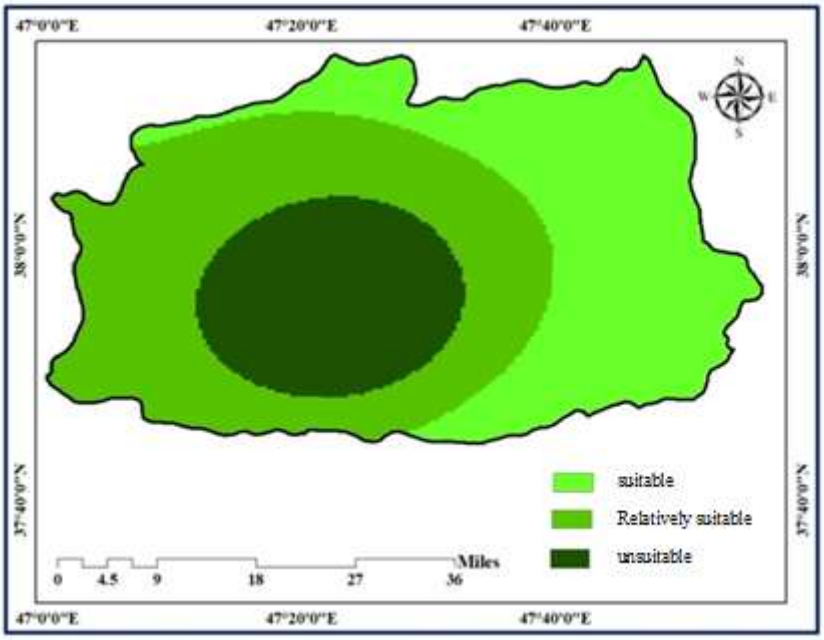

Figure4. Zoning Sarab based on average temperature

ii. The maximum temperature

The maximum temperature for saffron growth is between 35 and 40°C. Based on relevant data in the study area, the lowest maximum temperature is 16°C and the maximum highest temperature is 17.8°C (Table 2). The little parts of the southeastern of Sarab have the potential for saffron cultivation in terms of maximum temperature.

Table2. Classification of the maximum temperature of Sarab

Criterion	Classification		Value
Max temperature (°C)	Suitable	17-17.8	9
	Relatively suitable	16.7-17	4
	Unsuitable	16-16.7	1

iii. The Minimum Temperature

As saffron is a tropical plant and cold weather covers most areas in winter, thus, the areas with maximum temperature will be suitable for saffron cultivation. According to the study area, the lowest temperature is estimated to be at least 1.9°C and the highest temperature is at least 5.7°C. Therefore, the regions with temperatures between 4.8-5.8 and 4-5.8 °C were considered suitable for location (Table 3). The north and east parts of Sarab have a good potential for saffron cultivation in terms of minimum temperature.

Table3. Classification of the min temperature of Sarab

Criterion	Classification		Value
Min temperature (°C)	Suitable	**4.8-5.7**	9
	Relatively suitable	**4-4.8**	7
	Average	**3-4**	5
	Relatively Unsuitable	**2-3**	3
	Unsuitable	**1-2**	1

iv. The amount of precipitation

The amount of precipitation is one of the most influential climatic factors. According to the study area, the lowest precipitation l is 241 mm and the highest precipitation is estimated to be 328 mm.

Thus, areas with precipitation between 328-290mm are considered suitable for location (Table 4). Figure5 shows that the northern part of Sarab has a good potential for cultivation. Also, the southern part due to the higher altitude has more precipitation is important in terms of precipitation.

Table4. Classification of precipitation of Sarab

Criterion	Classification		Value
Precipitation (mm)	Suitable	**241-261**	9
	Relatively suitable	**261-280**	7
	Average	**280-299**	5
	Relatively Unsuitable	**299-318**	3
	Unsuitable	**318-328**	1

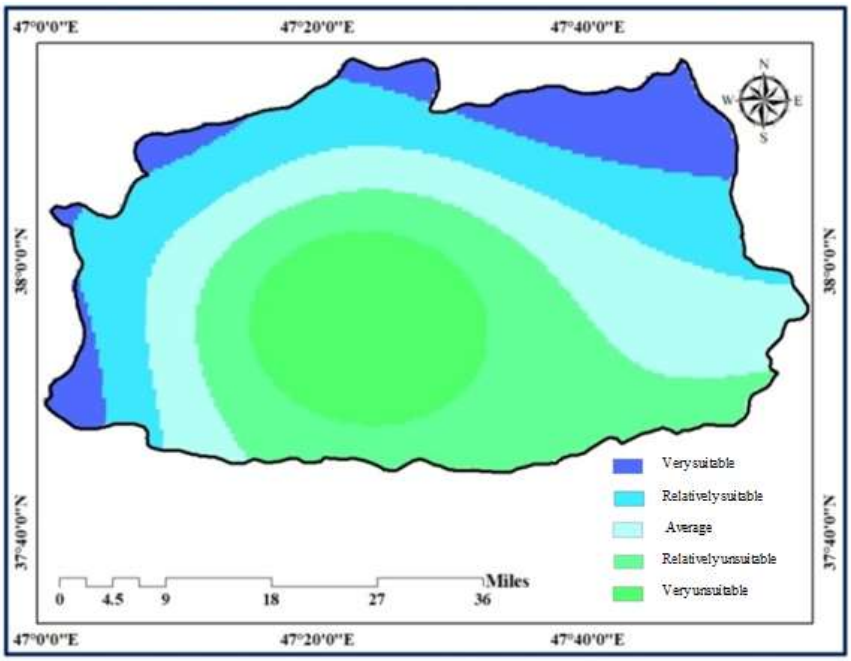

Figure5. Zoning Sarab based on precipitation

v. Sunshine Hours

Areas with more sunshine hours are important because they receive more light and temperature and thus are suitable for the growth of Saffron. In the study area, the lowest sunshine hours is 6 and the highest is 8 (Table 5). The central and southwestern parts of Sarab have a good potential for saffron cultivation (Figure 6).

Table5. Classification of the sunshine hours of Sarab

Criterion	Classification		Value
sunshine (hr)	Suitable	**7.4-8**	9
	Relatively suitable	**7-7.4**	5
	Unsuitable	**6-7**	1

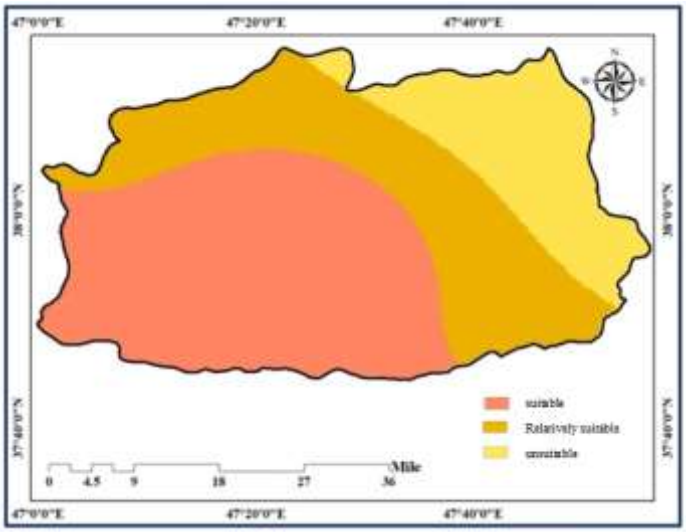

Figure6. Zoning Sarab based on sunshine hours

Eventually all the climatic parameters were merged. Figure (7) shows the final map of saffron cultivation zoning by climatic criteria in Sarab.

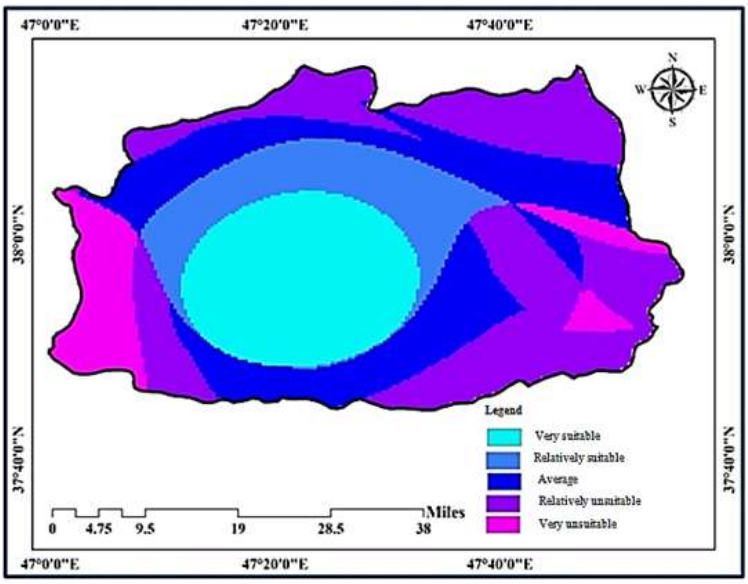

Figure7. Final map according to climatic criteria

c. Selection of suitable zones based on geological parameter

i. Soil classification

Since saffron crocus remain relatively long (5-7 years) in the soil, the soil should be drained and loamy, lemon, clayey, sandy and lime with a PH between 7 and 8. Also, cultivation of saffron is not suitable in fields with rubble and weeds. It was found that the central regions of Sarab have evolved and evolving soil and the rest is composed of rock outcrops (Fig. 8). Therefore, central, eastern and little areas of the western part of Sarab are considered suitable due to evolved and evolving calcareous soils (Table 6).

Table6. Soil Classification of Sarab

Criterion	Classification		Value
soil	Suitable	**A**	9
	Relatively suitable	**B**	6
	Relatively unsuitable	**C**	2
	Unsuitable	**D**	1

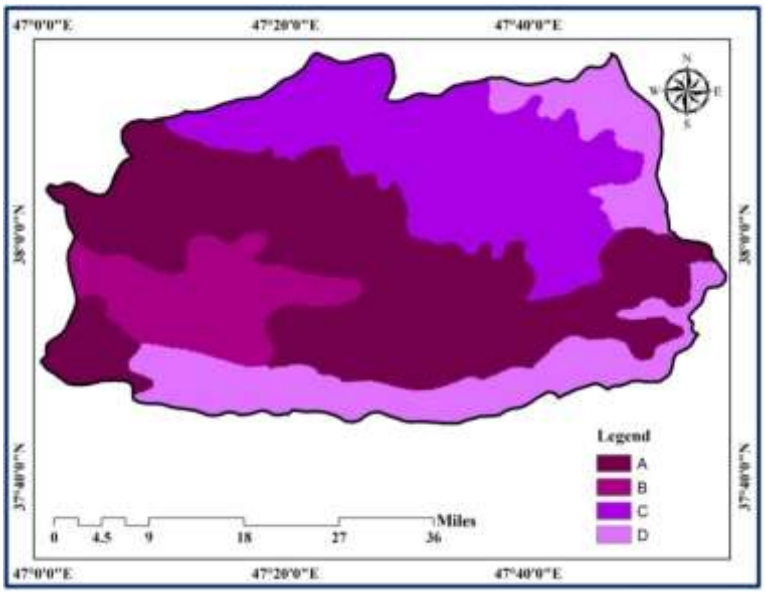

Figure8. Zoning Sarab based on Soil type

ii. Slope

In areas with high slope, erosion is increased and eventually organic matter of soil and its residue cover become poor. Given that saffron cultivation requires appropriate soil with specific organic conditions, so the presence of the slope factor restricts the organic matter and ultimately reduces the cultivation of this valuable crop. Give. It can be stated that the lower slope would be suitable for saffron fields due to reduced erosion. According to the study area, the lowest slope was 0-8% and the highest slope was 47%. Therefore, slopes of 0-8 and 8-18 are considered suitable for locating saffron cultivation (Table 7). According to figure 9, the central and western parts of Sarab have a good potential for cultivation of saffron.

Table7. Classification of slope in Sarab

Criterion	Classification		Value
Slope (%)	Suitable	**0-8**	9
	Relatively suitable	**8-18**	7
	Average	**18-31**	3
	Relatively Unsuitable	**31-47**	2
	Unsuitable	➢ **47**	1

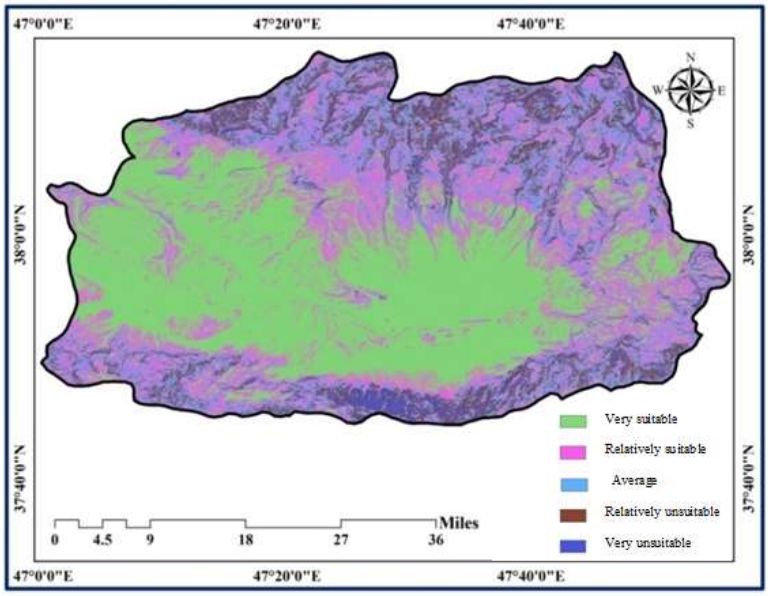

Figure9. Zoning Sarab based on slope

iii. Elevation

According to the researchers, the most suitable elevation is between 1300 and 2300 m. So the higher and lower than this will be lead to limited cultivation of Saffron. The lowest elevation was estimated at 1550- 1900 m and the highest was 4154-2800 m (Table 8). The central and western parts of Sarab have a good potential for cultivation the Saffron.

Table8. Classification of elevation in Sarab

Criterion	Classification		Value
Elevation (m)	Suitable	**1500-2100**	9
	Relatively suitable	**2100-2500**	7
	Relatively unsuitable	**2500-3000**	2
	Unsuitable	**3000-4154**	1

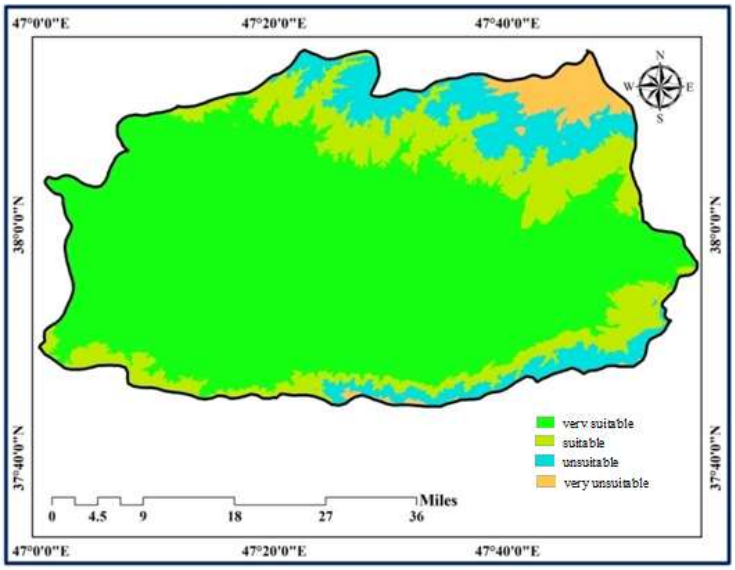

Figure10. Zoning Sarab based on elevation

Eventually all the geological parameters were merged. Figure (11) shows the final map of saffron cultivation zoning by geological criteria in Sarab.

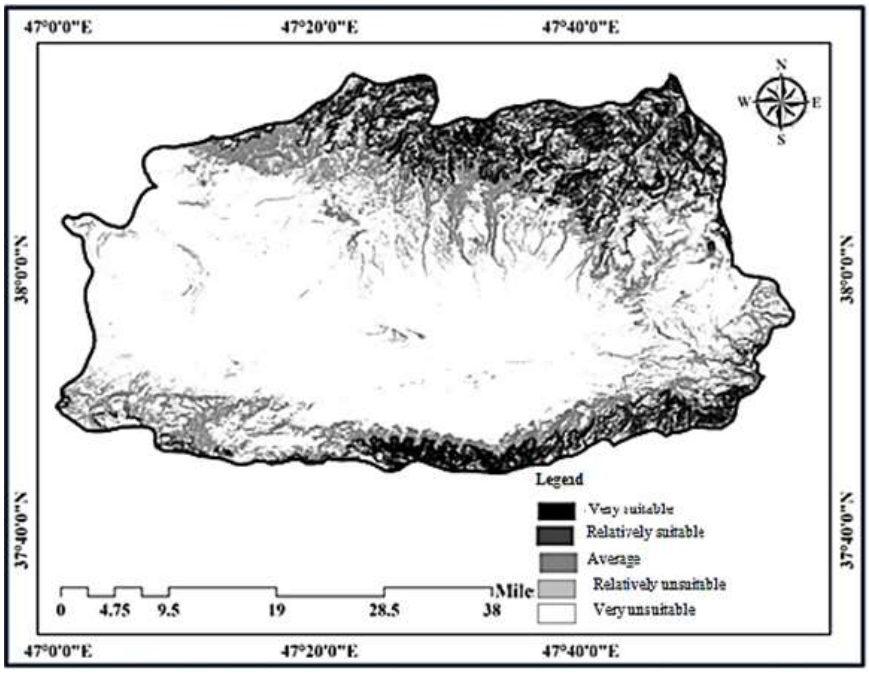

Figure11. Final map according to geological criteria

d. Selection of suitable zones based on socio-economic parameter

i. Land Use

Land use, such as forest land, saline land, lakefront land, garden land, non-vegetated land, meadows and bushes, lakes and reservoir dams, rock outcrops and finally the city should not be allocated to saffron cultivation. Lands such as irrigated farms, dry lands and good pastures are of great value for saffron cultivation (Table 9 and Figure 12).

Table9. Classification of different land uses in Sarab

Criterion	Classification	Value	Classification
Land Use	irrigated farm	A	Suitable
	Dryland	B	Relatively suitable
	good pastures	C	Average
	Poor pastures	D	Relatively Unsuitable
	forest land, saline land, lakefront land, non-vegetated land, meadows	E	Unsuitable

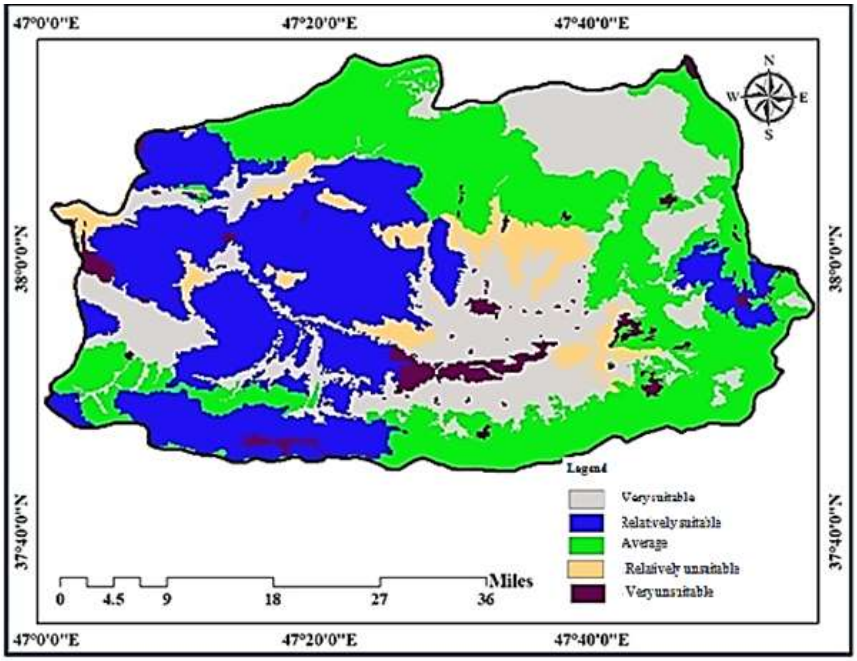

Figure12. Final map according to Land use criteria of Sarab

At the end, all layers were merged to provide the final map for identifying suitable saffron cultivation areas.

Figure13 shows that the eastern parts are perfectly suitable places for saffron cultivation. These areas cover 315 km^2, or 9.1% of the total area of Sarab. Parts of the east and west, which are also highly dispersed, have a relatively good potential for saffron cultivation. The north and south areas and most of the center have poor or no potential for saffron cultivation, which covers a total of 1846 which occupy the largest area of Sarab (Table 10).

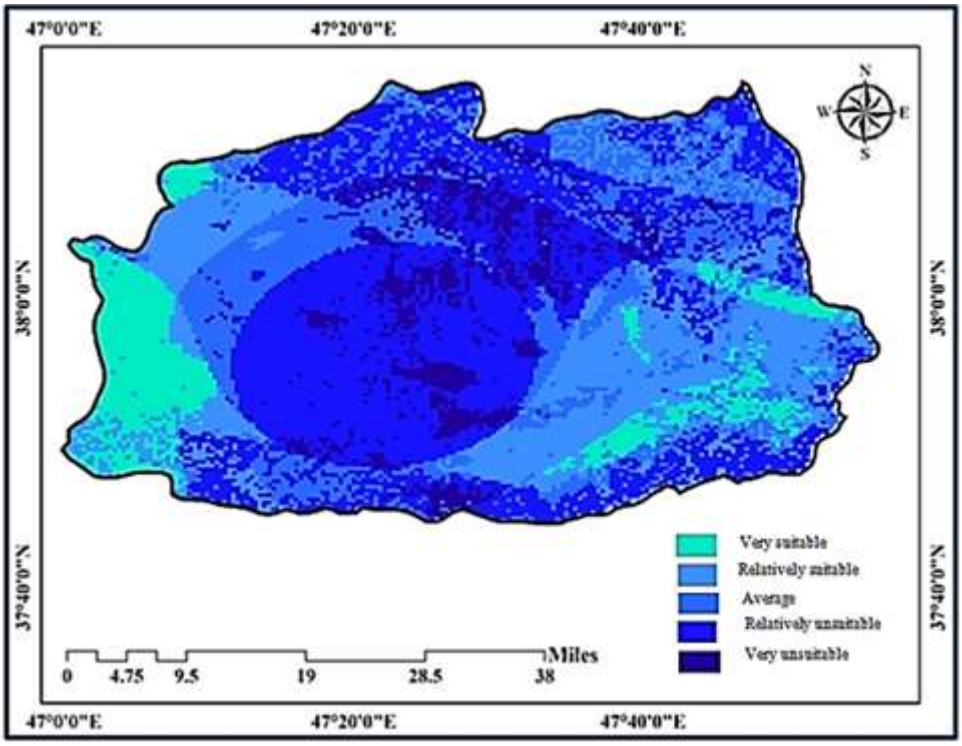

Figure13. Classification the areas of Sarab for cultivation of saffron

Table10 - Area of each evaluated zone for saffron cultivation (in km^2)

Classification	Area	Percentage of total area
Suitable	**315**	**9.1**
Relatively suitable	**1291**	**37.4**
Average	**721**	**20.9**
Relatively Unsuitable	**769**	**22.3**
Unsuitable	**356**	**10.3**
Sum	**3452**	**100**

5. Conclusion

Most crops need a lot of water, and due to global warming, the average annual rainfall has decreased and groundwater levels have dropped; therefore, products such as saffron, which have a very low water requirement compared to other common products, can be a very good alternative.

For this purpose, the appropriate areas were identified for saffron cultivation in Sarab. According to results, significant areas (46.5%) of Sarab have the potential to cultivate saffron.

It was found that east and a little part of west of Sarab have high potential for saffron cultivation. High precipitation in north and south of Sarab due to high elevation and high slope has been led to low potential for saffron cultivation.

In other words, high slope and consequently high erosion of poor vegetation and also the presence of volcanic formations cause more volcanic rocks and consequently very weak soil and therefore little potential cultivate the Saffron. The results showed that AHP with GIS has a high capability for locating saffron cultivation.

According to the map of land use, it can be stated that in those parts of Sarab which were labled as suitable and relatively suitable areas, cereal crops such as wheat and barley are cultivated that are not economically viable compared to saffron. Therefore,

it can be said that the saffron has a higher economic, social and environmental priority than the cultivated crops.

REFERENCES

Abrishami, m. (2004). *Saffron from ancient times to today* (1_{st} ed). Amir Kabir Publishing.

Ahmadi, M. Khashei, A. Siuki and Sayyari, M.H. (2017). Comparison of Efficiency of Different Equations to Estimate the Water Requirement in Saffron (*Crocus sativus* L.) (Case Study: Birjand Plain, Iran), *Journal of Agroecology*, 8(4):505-520. (In Farsi)

Amir Gasemi, T. (2001). *Iranian Red Sacrificial Saffron*, Aydanegan Publishing.

Behdani, M. (2005), *Ecological zoning and monitoring of yield fluctuations of saffron in Khorasan*. PhD dissertation. Mashhad Ferdowsi University. Iran.

Eswaran, H. E. Berg, V. D. and Almaraz, R. (1993). Global Distribution of aridisols and their characteristics. *In: Proc. Of the Internatuonal Workshop in Classification and Management of Arid Desert Soils*. Urumqi, China

Ganbari Telaki, F. Dianti Tilki, Q. and Wafaqah, M. (2012). Comparison of Interpolation Methods for Mapping Distribution of Lime Percent in Balade Rangelands. 1st national desert convention.

Kafi M. Koochaki A. Rashed M.H. Nasiri M. (2006). *Saffron (crous sattivus) production and processing* USA science publishers.

Khorasani, R; and Haghnia, Gh. H. (2002). Calcium-potassium balance in some calcareous soils of Khorasan. *Science and Technology of Agriculture and Natural Resources*. 6 (3): 34-25. (In Farsi)

Masoudian, A. (2011). *Iran's climate*, Sharia tous publishing.

Molina R. V. Valero M. Navarro Y. Guardiola j.L. and Garcia-Luis A. (2005). Temperature effects on flower formation in saffron (Crocus sativus). *Sciatica Hort.Sci*.103(3): 361-379.

Monazzam, A. and Kardovani, P. (2009). The Role of Agricultural Products with Emphasis on Saffron in Rural Development in Kashmar. *Territory*, 7(26):31-51.(In Farsi)

Rashid Sorkh Abadi,M. Shahidi, A, and Khashei-Siuki, A. (2016). Determining Suitable Places for Saffron Planting Using Fuzzy Hierarchical Analysis Process in the City of Torbat Heydarieh. *Saffron Agronomy & Technology*, 3(4):261-272.

Sadeghi, B. (1998), *Effect of summer irrigation on saffron yield*, Iranian Scientific and Industrial Research Organization publication, Khorasan Center.

Samadi, A. and Gilkes, R. J. (1998). Forms of phosphorus in virgin and fertilized calcareous soils of western Australia. Australian. *Journal Soil Research*. 36:585-601. (In Farsi)

Sepahvand, M. (2009). Comparison of Water Requirement, Water Productivity and Economic Productivity in Wheat and Canola in the West of Iran during Rainy Years. *Iranian Journal of Water Research*, 3(4): 68-72. (In Farsi)

Sobhani, B. (2016). Agroclimatic Zoning cultivation Saffron in Ardabil Province using of method AHP. *Journal of Saffron Research*. 4(1):72-86.

Vafabakhsh, J. (2002). Potential of Saffron cultivation areas in Iran, 5th Saffron Festival, Qain.

Yasribi, C . & Karimian, N. (1994). Distribution of different N forms in soils under the Droodzan dam of Fars province. *3rd Iranian Soil Science Congress*. 2: 117-108.

Yazdchi, S. and Rasoulif A.A. Mahmoodzadeh, H. Zarinbal M. (2010), Measuring Marand Province Land Capability for Saffron Cultivation Based on Multi-Criteria Decision Making Techniques, *Journal of Knowledge soil and water*, 20(3):151-170.