Zoning Of Apple Trees In Province Of Khorasan Razavi, Iran

Mokhtar Karami, Mehdi Asadi

Abstract: The main objective of this study was to investigate the feasibility of prone areas for apple cultivation in Razavi Khorasan province. Therefore, in this study, criteria and sub criteria were considered to determine suitable areas for growing apple trees, and due to the importance of data integration, Analytic Hierarchy Process (AHP) was selected to determine the weight of layers. The software ArcGIS version 10.2.2 was used to analyze the spatial and overlapping layers, after data analysis, in terms of growing apple trees, Razavi Khorasan province was divided into four levels: very good, good, average and bad. The results showed that suitable areas for growing apple trees in the studied area are located in the south, east, northeast and center of the province including Sarakhs, Neyshaboor, Gonabad and Kashmar stations with an area of over 4364789.32 hectares, which is about 48.34% of the total area of the province.

Index Terms: Zoning, Analytic Hierarchy Process (AHP), Khorasan Razavi, Geographical Information System (GIS).

1 Introduction

Understanding climate parameters and their effects on crops is one of the most important factors in increasing performance and consequently improving the production [25]. Therefore, knowledge of growing conditions and suitable sites' selection for growing this product under scientific principles makes it possible to achieve maximum efficiency per area unit. The literature review showed that many studies have been conducted on the use of GIS in determining suitable areas for crop cultivation in the past few decades and a few of them will be referred. Ress (1990) studied the effects of precipitation regime and temperature on the yield of wheat in the Baluchistan region of Pakistan. In this study, the possibility of needed precipitation for wheat growth in spring (for spring cultivation), autumn and winter (autumn cultivation) was calculated. The risk of frost and the number of ice days were also calculated and the relationship between maximum and minimum temperatures with the attitude of the region was specified. According to the results of the research, planting cold and drought resistant cultivars and winter crops were recommended for the eastern regions [21]. Veron (2004) divided the Pampas wheat region into 5 zones based on precipitation values [32]. Rathove (2005) categorized India into 9 wheat cultivating agro climatic zones through analyzing the annual and monthly precipitation values [20]. Sharma et al. (2006) studied the effect of high temperature on seed growth of different wheat cultivars. The study showed that the late planting of wheat (late December) can decrease the yield by 30 to 40 percent compared to November planting. The late planting of wheat affects phonological stages prior to pollination which determines the product yield. These effects will further develop to grain growth and filling stage and affect the growth and yield of grain [28]. In a study, Khan et al. (2009) assessed the arable lands of agricultural products, they assessed climatic factors and elements including attitude, slope, soil type, temperature, precipitation, Day length, evapotranspiration and their effects on crops and thereafter, combined these data through weighting each layer in GIS, and eventually produced a map of suitable areas for cultivation of these plants [10]. Other studies in this area are Oche (1998) [17], Sayta pariya (1999) [27], Norwood (2000) [16], and Aggarwal (2003) [1]. The following researches conducted inside Iran can also be mentioned. Mahmoudi (2003) used remote sensing and geographic information system to determine suitable areas for planting new varieties of wheat in Zanjan province. They used TM satellite images for the identification of agricultural land from other lands. In addition to climatic parameters, Kind et al. (2006) used slope gradient layer to determine areas with suitable slope as one of the criteria of proportionality in climacteric zoning for planting winter rain fed wheat in Moghan and Ardebil districts using GIS. They used four classes of winter wheat for classification in rain fed wheat conditions. In this study, the effects of climatic variables and topographic mapping on winter wheat were assessed individually and also as a group (information layers overlap) using GIS in a climate model location. Bazgir (2001) [3], Farajzadeh and Takaloubighsh (2002) [9], Makhdoum (2002), Sobhani (2006) [29] and Rasouli et al. (2006) [19] conducted zoning in Kurdistan, Hamadan and Ardebil provinces, respectively, through analyzing the climatic factors and elements in GIS, and found that agroclimacteric zoning is possible by analyzing elements in GIS. Thus, in this paper, we attempted to investigate the feasibility of prone/suitable areas for apple cultivation in Razavi Khorasan province.

2 Research Methodology

2.1 Preparation

The research area, with an area of 146.954 square kilometers, including the geographic scope of Razavi Khorasan province, between the orbits of 30 degrees and 21 minutes to 38 degrees 17 minutes, north latitude and 55 degrees 28 minutes, east longitude and 61 degrees 14 minutes from the Greenwich meridian. (Figure 1). This province reaches Northern Khorasan province from the north and north-eastern, Afghanistan from the east, Southern Khorasan province from the south, and Yazd and Semnan provinces from the west and north-western.

- *Mokhtar Karami, Faculty of Geography and Environmental Sciences, Hakim Sabzevari University, Sabzevar, IRAN, PH+09156537277. E-mail: m.karami08@yahoo.co.uk*
- *Mehdi Asadi. Ph.D. Student Agricultural Meteorology, Hakim Sabzevari University, Sabzevar. IRAN, PH: +989142190338. E-mail: Asadimehdi11@yahoo.com*

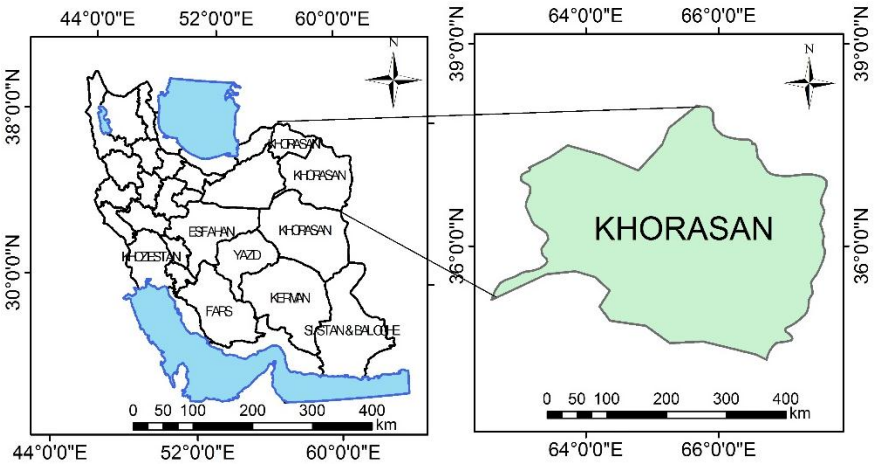

Fig. 1.*The location of the area of research in the country*

2.2 Data

In this study on the feasibility of apple cultivation, daily minimum and maximum average temperatures data from 12 synoptic stations of Mashhad, Sabzevar, Ghouchan, Golmakan, Neyshaboor, Sarakhs, Gonabad, Kashmar, Torbatjam, TorbatHeydarieh, Ferdous and Boshrooyeh in a 25-year period were used.

2.3 Analytical Hierarchy Process (AHP)

AHP is one of the best decision making techniques for the time that the decision maker has multiple criteria [31]. As it help analysts and decision-makers to organize critical issues [5]. Analytical Hierarchy Process begins with identifying and prioritizing elements of decision making. These elements are: objectives, criteria, characteristics and possible options that can be used to prioritize. In this process, the identification of elements and their relationships results in a hierarchical structure. Creating a hierarchical structure of the issue/problem is the first step of AHP and objectives, criteria and options, as well as their relationship are shown in the structure. The next steps in AHP include calculating the weight (coefficients) of criteria and sub criteria, calculating the coefficient of options (weight), the final calculation of options, and the evaluation of the logical consistency of judgments [22, 23, 24].

2.4 Determining the coefficients of criteria and sub-criteria

In AHP, priority among the options is determined through pairwise comparison between them. In pairwise comparison procedure to check two options, one of them intended and through which the priority or importance of two options are evaluated with each other [30]. In this process the numbers 1 to 9 are used as a standard scale to determine the importance of the alternatives (from equal importance to immense importance) with each other (Table 2). In pairwise comparison matrix the value of 9 shows the immense importance of a criterion compared to another one and the value of 1.9 represents extremely low value of a criterion compared to another one and the value of 1 shows the equal importance [26, 13].

TABLE 1

9 hourly quantity scale for pairwise comparison [6, 7, 11].

Score	Definition	Explanation
1	Equally important	In achieving this objective, two measures have equal importance
3	Little more important	Experience shows that the importance of I is greater than j in investigations
5	More important	Experience shows the importance I is much more than j.
7	Very important	Experience shows the importance I is much more than j.
9	Absolutely important	I is much more important than j absolutely proven
2, 4, 6, 8	Average values between two adjacent judgment	When there is a moderate mode

2.5 Compatibility rate

One of the hierarchical processes is that it specifies the consistency of conducted comparisons. This rate shows how much can be trusted in the achieved priorities of group members or the priorities of mixed tables. Experience has shown that if the compatibility rate (CR) is less than 1.0, the consistency comparisons can be accepted; otherwise the comparisons should be done again [4, 15]. Compatibility rate is measurable through the following formula [12].

$$C.R. = C.I./R.I \quad (1)$$

$$C.I. = \lambda Max - n / n - 1 \quad (2)$$

In the above equations n shows the number of criteria and R.I. Random Compatibility index.

3 Results and Discussion

In this section, the weights of the main criteria used in the study were determined based on their importance in zoning of suitable areas for apple cultivation. Figure 2 presents paired test of the original layers criteria in the suitable areas zoning for apple cultivation, as based on previous studies and the opinions of outstanding researchers the weights in the selected stations were determined using Expert Choice software and analyzed using ARCGIS (Valuation and paired

tests were performed for each layer which will not be mentioned to prevent the prolongation of the content). In which, the temperature criterion weighing 0.565 and geographic criterion weighing 0.055 had the highest and lowest impacts on the feasibility of prone areas, respectively. Furthermore, the adjustment rate was 0.04 which was less than its standard value of 1.0, and shows the accuracy of weight determination.

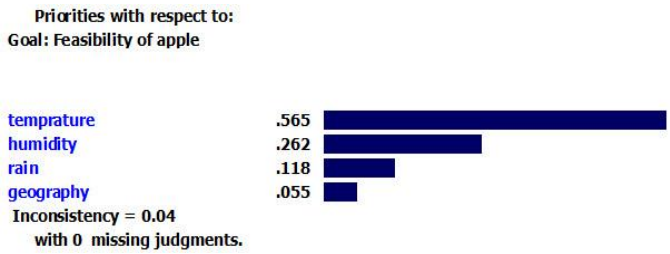

Fig. 2.*The determined weights of the criteria in Expert Choice software.*

3.1 HUMIDITY

Humidity is a very important factor in apple growth. The drier air with low humidity damages plant and its growth, and results in wilting and grain shrink, because, the water absorption from land (which is done by hairy root) and the evaporation of leaves is disrupted. In this case, the plant needs water, and irrigation is recommended [8].Therefore, after the valuation of relative humidity options, ARCGIS software functionalities were used for data analysis (Figure 3). As it is shown in the figure, in terms of relative humidity, a very major part of Razavi Khorasan province is very suitable for the cultivation of apple trees (representative area are including; Ghouchan, Golmakan, Mashhad, Sarakhs, Neyshaboor and TorbatHeydarieh and suitable area are includes; Sabzevar and Torbatjam).

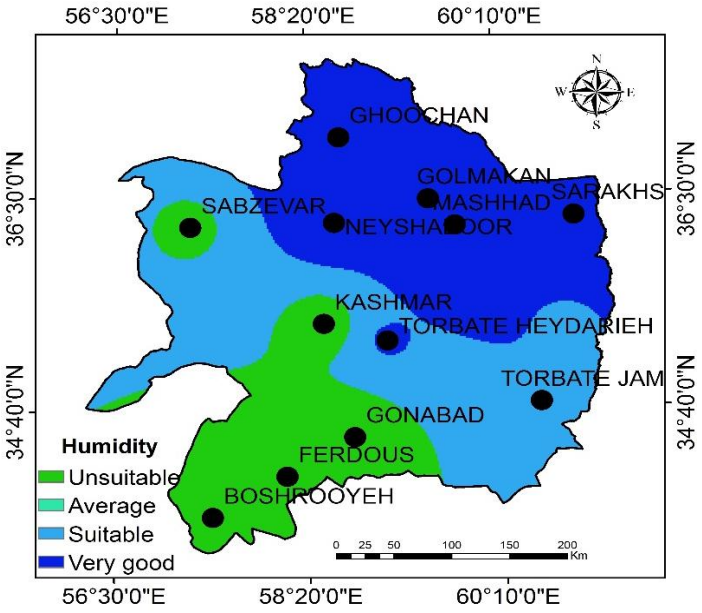

Fig. 3. *The relative humidity in the zoning map of suitable areas for apple cultivation*

3.2 RAINFALL

Rainfall is the most vital element that affects almost every aspect of the life on the earth. In the meantime, several studies have demonstrated that the precipitation is the most important climatic element affecting traditional agricultural practices. Therefore, precipitation volatility highly affects product's final yield, for this reason, the annual rainfall of the region was discussed to assess apple production.

3.3 ANNUAL RAINFALL

Annual volatility in rainfall amount and its distribution have a key role in apple production. Studies have shown that in areas with the annual rainfall of 350-300 mm, crop production is highly depended on the seedling emergence and establishment of plants in the ground, but, researchers believe that flowering and grain filing are the most sensitive growth stages in terms of providing the humidity. Thus, based on previous studies and the opinions of outstanding researchers, annual rainfall calculations in the selected stations were evaluated using Expert Choice software, were analyzed using ARCGIS software functionalities. Figure 4 shows the annual rainfall map in the zoning of prone areas for apple cultivation, where Ghouchan and TorbatHeydarieh stations have a very good condition and Gonabad, Ferdous and Boshrooyeh stations have the worst conditions for the cultivation of apple in terms of annual rainfall.

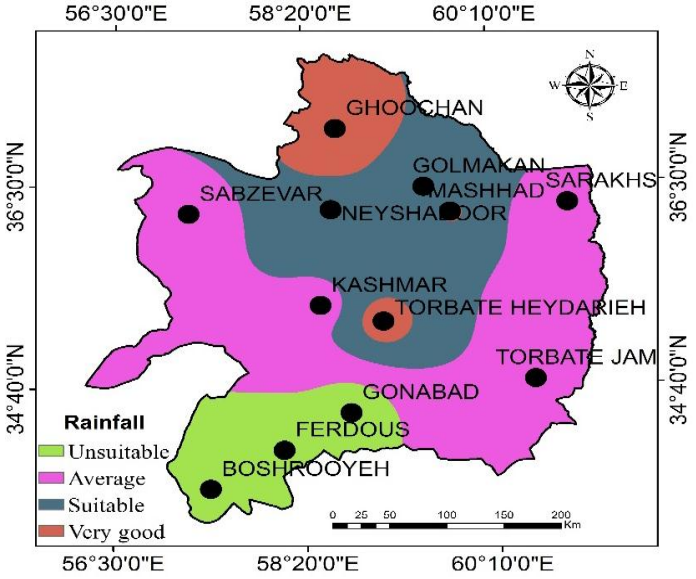

Fig. 4. *The annual rainfall map in the zoning of suitable areas for apple cultivation.*

3.4 GEOGRAPHICAL CRITERION

Geographical criterion consists of altitude and slope criteria which will be discussed separately.

3.4.1 ALTITUDE

Land shape and attitude are effective on crop yield. Based on the general rule of precipitation, increase in attitude results in increase in precipitation [2].The attitude plays an important role in the development or limitation of cultivation through influencing on precipitation from one hand and a direct effect on the temperature on the other hand (Figure 5).According to figure 5, the north, north east, eastern, south, south east,

south west and the west are very suitable for apple cultivation.

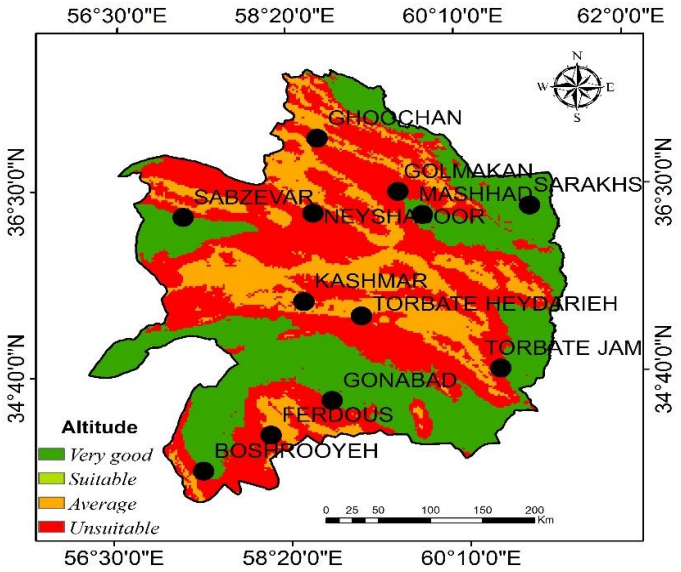

Fig. 5.*The attitude map in the zoning of suitable areas for apple cultivation*

3.4.2 SLOPE/GRADIENT

Land slope is one of the most important physical factors having a strong influence on the cultivation of agricultural crops. Because low slopes result in more rain penetration into the ground and increase soil moisture storage. On the other hand, the range of temperature changes in low slopes is less than in steep slopes which is also a positive factor for plant growth. Steep slope has negative effects on plant growth, since; with the beginning of rainfall not only less water penetrates into the ground, but also running waters will wash away soil nutrients [2]. To assess the slope of the area, the province slope map was divided into four classes: very good, good, average and poor (Figure 6) as the map shows most of the regions are suitable for apple cultivation in terms of slope.

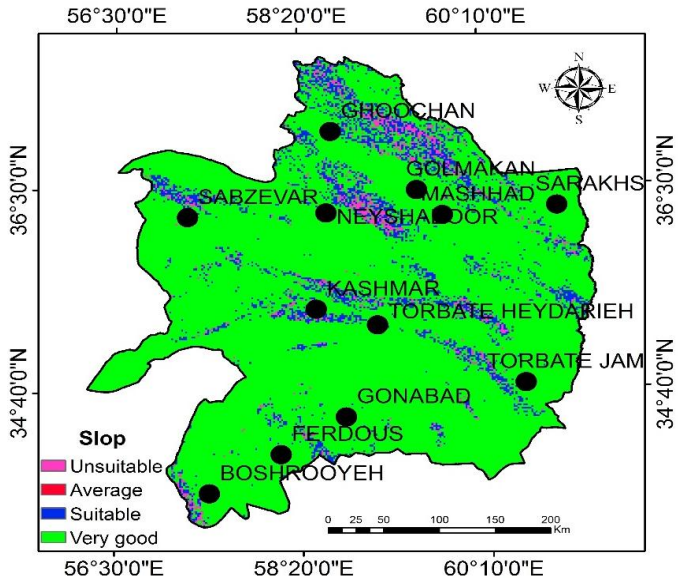

Fig. 6*. The slope map in the zoning of suitable areas for apple cultivation*

3.5 TEMPERATURE

In addition to being a significant climate factor, temperature is a vital factor in crop production [8]. Temperature has a particular importance in each growth stages, but also is more important due to plant sensitivity to climate changes [18]. For this purpose, in this study to investigate the possibility of apple cultivation in terms of temperature, temperature data (degree-days) of stations in the province and ARCGIS software for data analysis were used. Finally, in terms of temperature, the province was classified into four levels of temperature: very good, good, average and poor, where Boshrooyeh and Ferdous stations have very good conditions for apple cultivation. As we advance from the south to the north, the areas capabilities for apple cultivation are reduced so that the conditions for apple cultivation in Ghouchan and Mashhad stations are unsuitable. Figure 7 presents temperature map in the zoning of suitable areas for apple cultivation.

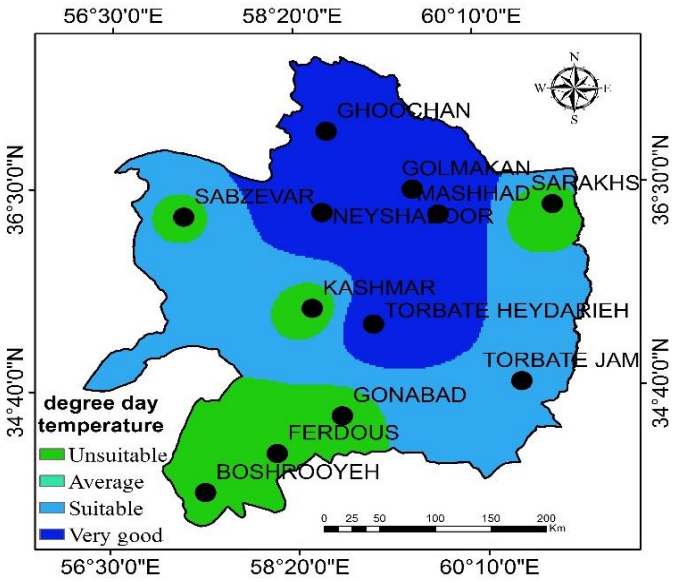

Fig. 7. *The degree per day temperature on the zoning map of suitable areas for apple cultivation*

3.6 DATA LAYERS INTEGRATION

After preparing all data layers and the factors related to the zoning of suitable areas for apple cultivation and modeling and analysis of spatial data using GIS, the process map preparation of the effective factors in the zoning of suitable areas for apple cultivation was carried out. After weighing layers in cultivation zoning based on Analytic Hierarchy Process (AHP), the capabilities of GIS were used for the integration and overlapping of the maps and suitable areas' map was prepared for apple cultivation. The map was classified in four classes: very good, good, average or poor. Very good areas for apple cultivation in the area are located in the east, north, east, central and southern region, including Sarakhs, Golmakan, Neyshaboor, Kashmar and Gonabad stations with an area of over 4364789.32 hectares and Torbat Jam, TorbatHeydarieh and Sabzevar stations are good areas with an area of 5401892.61 hectares. However, the middle class with an area more than 1586845.06 hectares, including Mashhad, Ghouchan and northern parts of Torbat Jam stations. The zoning of suitable areas for apple cultivation is shown in figure 8. Table 2 shows the zoning map of suitable areas for apple cultivation.

TABLE 2
The zoning map's characteristics

	rank	class	Area	%of the province's surface
The whole area	1	inappropriate	1304625.38	10.31
	2	medium	1586845.06	12.54
	3	good	5401892.61	42.67
	4	very good	4364789.32	34.48

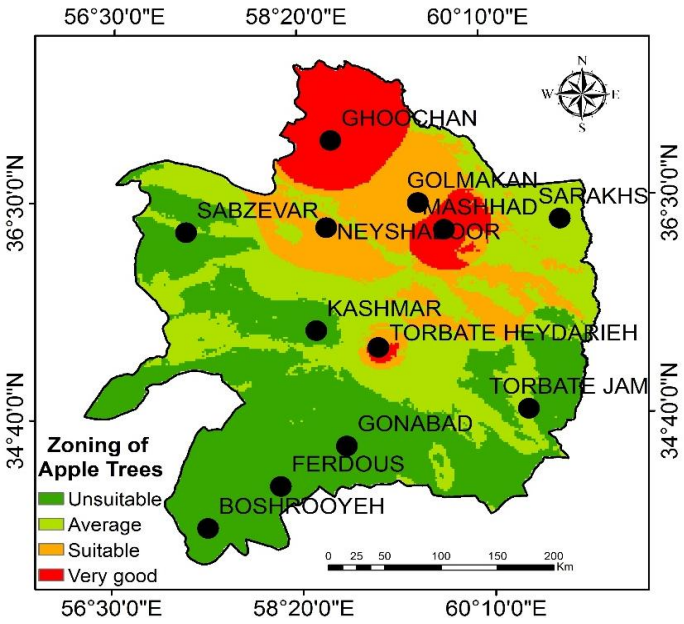

Fig. 8. *The zoning map of suitable areas for apple cultivation*

4 CONCLUSION

The geographical location of Razavi Khorasan province, its natural conditions and capabilities has resulted in the formation of agricultural, animal husbandry and related activities over the history. The aim of this study is to identify talents or restrictions created by the climate in the region namely agricultural-climatic zoning of apple trees cultivation using environment climatic factors in GIS. To do this research, the studies related to climate capabilities of apple cultivation were reviewed and through precipitation, temperature and humidity data during 25 years of statistical observations, the use of overlay interpolation methods in GIS environment, the map of suitable areas for apple cultivation in Razavi Khorasan province was prepared. The results of this study show that in terms of zoning, suitable areas for apple cultivation are Sarakhs, Neyshaboor, Gonabad and Kashmar stations located in the east, north, and east, central and southern of the region which have a more suitable situation. However in terms of temperature some areas have perfect conditions for growing apples but as we have considered other factors in the zoning of suitable areas for apple cultivation (altitude, slope, humidity and precipitation etc.), so they are not suitable areas in terms of apple cultivation.

5 REFERENCES

[1] Aggarwal, P.K. (2003). Impact of climate change on Indian agriculture. J .plant boil.30:189-198.

[2] Arkhy, P., Lotfi, S. (2010). Efficiency of geo statistical methods in determining suitable areas for wheat cultivation using GIS (Case study: Tehran), Geomatics Conference and Exhibition.

[3] Bazgir, S. (2001). Assessing climate potential of rain fed agronomy (Case study: Kurdistan), Master thesis, Faculty of Agriculture, Tehran University.

[4] Bertolini, M, M, Braglia, (2006). Application of the AHP methodology in making a proposal for a public work contract, 17 January.

[5] Bevilacqua, M. D'Amore, A. & Polonara, F. (2004). A Multi-Criteria Decision approach to Choosing the Optimal Blanching–Freezing System. Journal of Food Engineering, 63: 253-263.

[6] Bowen, William M, (1990). Subjective judgments and data environment analysis in site selection, Computer, Environment and Urban Systems, Vol. 14, Pp. 133-144.

[7] Dey, P. K, E. K, Ramachadran, (2007). Analytic hierarchy process helps select site for limestone quarry expansion in Barbados, Journal of Environmental Management. Pp. 1384-1395.

[8] FalahQalhari, Gh. A., Dadashi Roudbari, A. (2003). Zoning suitable areas for cultivation of wheat in Mazandaran province using AHP, Hakim University of Sabzevar, and Project No. 11123.

[9] Farajzadeh, M., Tekloubeighash, A. (2002). Agro climacteric zoning of Hamadan using GIS with an emphasis on wheat, Journal of geographical preceding studies, 41.

[10] Khan. M. R, Debie. C. A. J. M, Van keulen. H, Smaling. E. M. A and Real. R, (2009). Disaggregating and mapping crop statistics using hyper temporal remote sensing, International Journal of Applied Earth Observation and Geo information, G Mode JAG-281; No ofPages 11.

[11] Kholil, Rahma Octaviani, (2013). Application of AHP Method for selecting the best strategy to reduce environmental damage caused by non-metallic mining Case study in Gunungkidul Regency, Yogyakarta, Indonesia, International Journal of Environmental Engineering Science and Technology Research, Vol. 1, No. 7, PP: 98-109.

[12] Kordi, M., (2008). Comparison of fuzzy and crisp analytic hierarchy process (AHP) methods for spatial multi criteria decision analysis in GIS, university of Gavle Department of technology and built environment.

[13] Kunz, J. (2010). The Analytic Hierarchy Process (AHP), Eagle City Hall Location Options Task Force, pp.1-25.

[14] Mehreban, A., Ghaffari, A., GhanbariBanjar, A., Glory, N. 1384. Climatic zoning for winter rainfed wheat Magan and Ardabil areas using GIS, Journal of Agricultural Science, No. 4.

[15] Moreno-Jimenez, J.M., et al. (2005). A spreadsheet module for consistent consensus building in AHP-group decision making, Group Decision and Negotiation 14 89–108.

[16] Norwood, Charles, a (2000). Dry land Winter Wheat as Affected by Previous Crops, Agronomy Journal.

[17] Oche, c.Y. (1998). Agro climatic zonation for wheat production in the savanna regin of Nigeria Singapore journal of Tropical Geography volume 19:1. pp. 55-65.

[18] Orlandi, L. Ruga, B. Romano, and M. Fornaciari. 2005. Olive flowering's an Indicator of Local Climatic Change, Department of Plant Biology andAgro Environmental Biotechnology, University of Perugia. Italy, PP. 169-171.

[19] Rasouli, A.A., Ghasemi Golezani, K., Sobhani, B. (2006). The role of precipitation and elevation in determining suitable areas for wheat cultivation using GIS (Case study: Ardabil), Journal of Geography and Development, 200-183.

[20] Rathove, P. S 2005. Techniques and Management of field crop production. Agro bios, Indian.

[21] Ress, D. 1990. Precipitation and temperature regimes in unplanned Baluchistan: their influence on rain-fed crop production. Agricultural and Forest met. 52. pp. 381-396.

[22] Saaty, Thomas L. (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. Pittsburgh: RWS Publications.

[23] Saaty, Thomas L. (1990). Decision Making for Leaders. Pittsburgh: RWS publications.

[24] Saaty, Thomas L. (1996). The Analytic Network Process. Pittsburgh: RWS Publications.

[25] Sari Sarraf, B., Bazgir, SA. Mohammadi, Gh. (2010). Climatic capabilities zoning of wheat cultivation in Western Azerbaijan province, Development geography, No. 13, 5-26.

[26] Sarkis, J. & Talluri, S. (2004). Evaluating and Selecting E-Commerce Software and Communication Systems for a Supply Chain. European Journal of Operational Research, 159: 318-329.

[27] Sayta, pariya. (1999). GIS-Based Spatial crop yield modeling. Www. GIs development net.

[28] Sharma Natu P., Sumesh K.V., Lohot Vaibhav, D. and Ghildiyal M.C. (2006). High temperature effect on grain growth in wheat cultivars and evaluation of responses, Indian Journal of Plant Physiology, 11:239-245.

[29] Sobhani, B. (2006). Agro climacteric zoning of Ardabil province using satellite images in GIS, Doctoral dissertation in geography, University of Tabriz.

[30] Taha, H.A. (2003). Operations Research. Pearson Education Inc. Fayetteville.

[31] Taylor, B.W. (2004). Introduction to Management Science. Pearson Education Inc. New Jersey.

[32] Veron, Santiago R. And Other, 2004. International Variability of Wheat Yield in the Navigating Pampas during the 20 Century. Agricultural Ecosystem and Environment. Vol. 103.