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THE QUERY OF SUITABLE AREAS FOR REAFFORESTATION OF *Cupressus sempervirens* var. Horizantalis ENDANGERED SPECIES BY USING GIS IN NORTHERN FORESTS OF IRAN

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ABSTRACT

Eslami A, Malekmohamadi S, Falahchi M (2015) The query of suitable areas for reafforestation of *Cupressus sempervirens* var. Horizantalis endangered species by using GIS in northern forests of Iran. *J. Soil Nature* 8(1), 14-18.

Cupressus sempervirens var. Horizantalis is a Mediterranean species and one of the native conifers of Hyrcanian forests which has been able to survive in the northern forests of Iran since the tertiary geological period until today, in spite of the adverse natural conditions and the human activities. The purpose of this research is to position this species according to its ecological characteristics in 88 watershed of Golestan Province in north of Iran. To achieve this goal, Multi Criteria and Fuzzy Logic Evaluation methods were applied. In Multi Criteria Evaluation (MCE) method, analytic hierarchy was used to prioritize the environmental factors affecting the maximum growth of this species. During this process, first the required effective natural factors were assessed and prioritized among 10 parameters. At the end, the ultimate map of appropriate areas for planting *C. sempervirens* var. Horizantalis was prepared according to MCE and fuzzy logic models. The task was carried out separately by combining the layers acquired from each model. According to findings of the study, from the total 30554 ha area of the studied region, based on Multi Criteria Evaluation and Fuzzy Logic methods, about 6647 and 1126 ha of the lands were estimated potential, respectively for planting *C. sempervirens* var. Horizantalis species. Considering the carried out evaluation, Fuzzy logic method was identified to be more accurate and correct and to have higher capabilities in terms of query for the dynamic ecological parameters, compared to multi criteria evaluation method.

Key words*: Cupressus sempervirens var. Horizantalis, MCE, fuzzy, ecological query, Iran*

INTRODUCTION

Cupressus sempervirens var. Horizantalis is a type of evergreen tree, from Pinopita conifers group and the Cupressacae cedar category. This type of conifers with a wide distribution in the world is a Mediterranean element which can be naturally observed in its habitat in Turkey, Greece, Cyprus, Iraq and Afghanistan (Sagheb Talebi 1996). Most of the people think this species is originated from Iran and Afghanistan. Results of the research indicate that the location of this species in north of Iran (Sagheb Talebi 1996). It is a long lived and resistant tree with a strong root that enables it to grow easily among the rocks and steep slopes and cliffs. It has a stand, grows slowly and has a medium height that reaches up to 20-25 m and sometimes 50 m. It has a straight trunk and a thin brown skin. It is a light-demanding tree able to do its physiological activities using large amounts of light. History of *C. sempervirens* var. Horizantalis goes back to 3300 years ago. *C. sempervirens* var. Horizantalis forests exists in compound forms together with hornbeam oak in most of the forests of Northern Iran from Guilan Province to Golestan Province, in an altitude of 400-800 m in transverse and dispersed forms. In this regards, present study seeks to position this species using Geographical Information System (GIS), in order to, on one hand, cultivated and develop it and on the other hand, to adapt it with the prevailing environmental condition. GIS is an important tool in spatial planning (Brail and Klosteman, 2001) and spatial planning includes decision making methods and has types like Multi-criteria and fuzzy logic evaluation methods. Multi-criteria evaluation method is one of the most principled decision making methods in GIS (Bogardi *et al.* 1996) and it is used as a spatial decision making back up tool for land planning (Wood and Dragicevic, 2006). This method may use several assessment criteria instead of one optimum assessment criterion (Asgharpour 2006). In this method, first a collection of the criteria proportional to the goal are determined by the experts and they are used for evaluation and query after weighting and prioritization (Xue *et al.* 2007). The research conducted by (Alami *et al*. 2014), (Eslami *et al.* 2010) can be mentioned as examples of the researches on query the plant species using this method. This research was conducted with the aim of query the endangered species of *C. sempervirens* var. Horizantalis and also comparing the multi-criteria and fuzzy approaches, using GIS for plantation and development of this species in north of Iran, in order to position the suitable areas for planting this endangered species and to plant it, ensured of its success and long term establishment in an appropriate area.

MATERIALS AND METHODS

The Study area

Watershed 88 with a 30554 ha area is located in geographical coordinates of N 36˚ 44' 08" to 36˚ 55' 32" and E 54˚ 50' 06" to 55˚ 09' 42". Minimum altitude of the studied area is 119m and its maximum altitude is 2570m. In addition nature preserve of *Taxus baccata*, and *C. sempervirens* var. Horizantalis species of Puneharam and Afratakhte are within the area (Fig. 1).

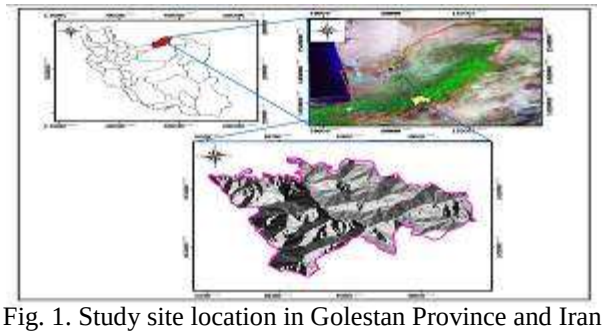

Fig. 1. Study site location in Golestan Province and Iran

RESEARCH METHOD

In the first step, some maps were provided in which the informational data like digital topographic maps, TM satellite images from 2010, collecting the weather stations to determine the annual precipitation and temperature, relative humidity of the air, soil type, vegetation type, density and lithology have been produced. In the next step, map of location of the areas which are the reserves of *C. sempervirens* var. Horizantalis species was provided. This was done using the Global Positioning System (GPS) in order to control and increase the accuracy and precession through land navigation and visit. In the next step, each parameter was weighted using AHP method to evaluate the ecological potential of the watershed (Salman Mahini *et al*. 2009). This weighting method is based upon expert knowledge and in order to assess the priority of the factors compared to each other, the pairwise comparison method was applied using Expert Choice 11 Software and the resulted data were studied and summarized and the parameters were weighted using MCE (Multi Criteria Evaluation) method and the areas prone to *C. sempervirens* var. Horizantalis species were identified in four classes. This method, based on data integration according to their importance in decision making, include numerical algorithms that define the suitability of a specific solution based upon the values and input criterion. Then the *C. sempervirens* var. Horizantalis species was positioned using the fuzzy logic method. In fuzzy logic theory, the action mechanism is as follows: first, the parameters impacting the subject of the study are identified and numbered from 0 to 255 that present the membership degree and its transformation can be discrete or continuous and appropriate to inappropriate forms are identified, then they are combined using the Fuzzy Inference Network. In order to make the operating maps fuzzy, it is necessary to determine the values of the criteria threshold and type and shape of the membership function is necessary, so, this research has determined values of threshold of the criteria using the expert opinions and review of the resources. The method applied to transform the benchmark maps into fuzzy layers is linear scale transformation method. Relationship (1):

$$Xi = \frac{Ri - R\,min}{R\,max - R\,min} * \text{Standardized range}$$

In which the minimum and maximum values are used as scaling points (Estman 2006). Finally, the map positioned through each method (multi-criteria and fuzzy logic) is obtained. It compares these two methods of proper query for planting this species in nature through transferring the coordinates of the natural habitats of *C. sempervirens* var. Horizantalis on the map positioned by GIS.

RESULTS

The impact of each factor on the final map was determined by summarizing the expert opinions about weight and importance of each informational layer. The obtained results are based on following basis: weight of the slope classes 0.094, direction classes 0.115, soil type classes 0.092, vegetation type classes 0.098 etc. were calculated. The important point about pairwise matrix is that, inconsistency rate should be less than 0.1. Inconsistency rate in this research equals IR = 0.051 that has a high compatibility.

Results from AHP Method:

Results of weighting the informational layer, creating map of elevational classes, slopes, slope directions, lithology, relative humidity of the air, precipitation, temperature, soil type, vegetation and density of the canopy have been based on the importance of each of them (in form of the weight of each factor) in establishment of this species in the nature. After weighting the maps of layer classes, the results were revealed as follows (Table 1).

Table 1. Results of weighing the map layers using AHP method

Maps values the classes	Tree cover	Density of canopy	Precipitation (mm)	Centigrade degrees	Humidity (%)	Soil	Aspect	Slope (%)	Altitude (m)
Maximum weight	Carpinetum Type	60-80	640-560	18.60-17.80	70 -71	1,1,1	North	50-25	400-800
Minimum weight	Carpineto-Alnetum Type	>80	<470	<17	69 - 70	3,2,1	East	>100	1600-2000

In order to position the *C. sempervirens* var. Horizantalis species using the Multi Criteria Evaluation Model (MCE), weight of each factor was multiplied in percentage of its map and map of the appropriate places for *C. sempervirens* var. Horizantalis plantation was classified in 4 classes, from sum of the product of maps factors and based on milestones of the cumulative frequency curve of the pixels (Fig. 2 and Table 2).

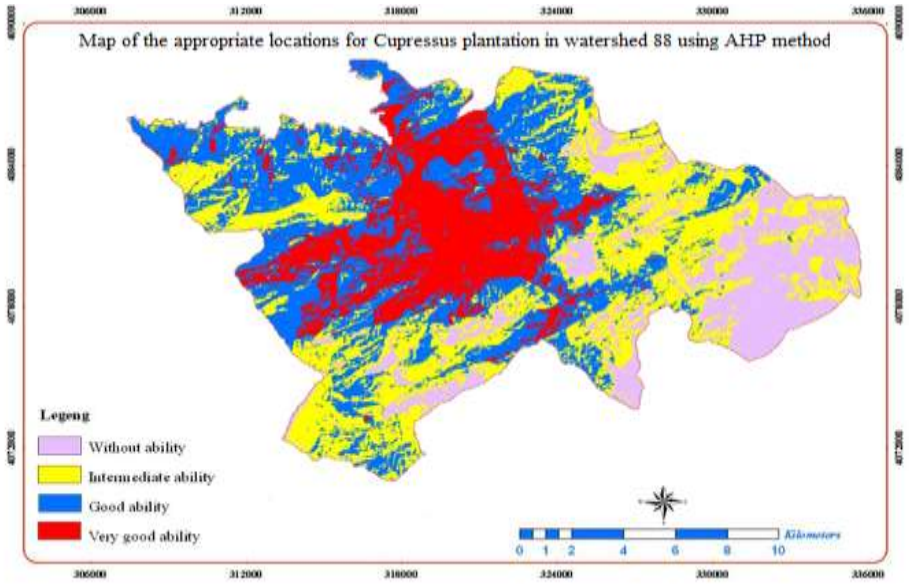

Fig. 2. Map of *C. sempervirens* var. Horizantalis Query Classes Using AHP Method

Table 2. Distribution of *C. sempervirens* var. Horizantalis query classes using AHP method

No.	Cupressus growth	Area (ha)	Percentage of the area
1	Poor	5593	16.20
2	Average	8687	30.90
3	Good	9627	33.66
4	Very Good	6647	19.25
Total		30554	100

Results from Fuzzy Method:

Standardization of interconnected factors including parameters, criteria threshold and shape and type of their membership function has been considered for the model. The different membership functions applied in this research include discrete functions, monotonic increasing and monotonic decreasing functions and symmetric functions in linear and trapezoidal shapes and they are selected depending on the target; for example, by using the map we know that the studied species does not grow in a slope higher than 100 percent and it grows in slopes of 25-50 percent, for the same reason, it is decreasing and the slopes higher than 100 percent are considered 100 percent. Therefore, names of the maps of factors, shape and type of the membership function and their thresholds for the interconnected parameters have been mentioned in Table 3.

Table 3. Parameters, the threshold criteria, shape and type of membership function in fuzzy method

No.	Parameter	Shape and type of the membership function	Desirability
1	Slope	Decreasing-monotonic linear	Slopes between zero to100(equal to 0-255), slopes higher than 100 equal to zero
2	Vegetation density	Increasing-monotonic linear	A density greater than 80 (equal to 0), below 80, to the minimum amount (equal to 0-255)
3	Temperature	Decreasing-monotonic linear	A temperature below 17(equal to 0), temperatures higher than 17, to the maximum equal to 0-255
4	Precipitation	Increasing-monotonic linear	Precipitation less than 560mm (equal to 0), precipitation more than 560mm, to the maximum amount equal to 0-255
5	Altitude	Decreasing-monotonic linear	An altitude less than 0 to1600m (equal to 0-255), altitudes more than 1600m equal to 0
6	Humidity	Increasing-monotonic linear	A humidity less than %70.69 (equal to 0), humidity more than %70.69 to the maximum amount equal to 0-255

Standardization of discrete parameters according to weight of the maps based on fuzzy method was done using the increasing linear method.

The Final Map Obtained from Fuzzy Method: Considering the weighting procedure of the layers using fuzzy method and overlaying the maps, the regional desirability of the land was categorised into 4 classes. So that,

class1 was considered as high potential (equal to a desirability more than 200), class2 medium potential (equal to a desirability from 150-200), class3 weak potential (equal to a 50-150 desirability) and the rest of the area has been considered with no potential (equal to a desirability less than 50). Results using Fuzzy method were show in the Fig. 3 and Table 4.

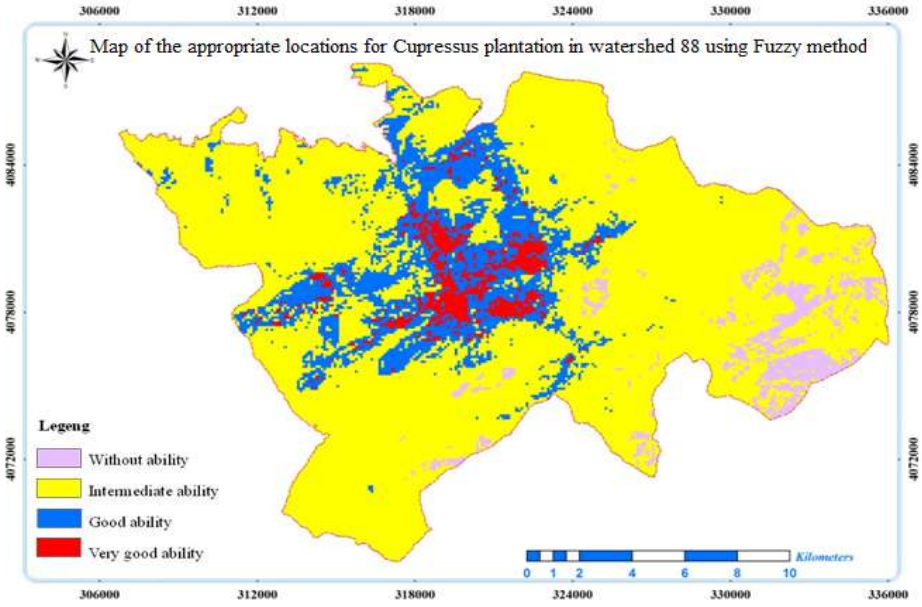

Fig. 3. Map of *C. sempervirens* var. Horizantalis Query Classes Using Fuzzy Method

Table 4. Distribution of *C. sempervirens* var. Horizantalis Query Classes Using Fuzzy Method

No.	Cupressus growth	Area (ha)	Percentage of the area
1	Poor	1628	5.33
2	Average	23185	75.89
3	Good	4615	15.11
4	Very Good	1126	3.68
Total		30554	100

DISCUSSION

Development and plantation of this species should be done considering all of the environmental conditions and availability of only one condition can not cause development and plantation of the species, because *C. sempervirens* var. Horizantalis is an endangered Mediterranean conifer species and it has limited development places. It used to include a broad area in Northern forests in a not so distant past but now it possesses a limited area. In order to protect and develop plantation of this historical species, it is necessary to select an appropriate place for planting this species. Results of weighting using the AHP method showed that the highest weight belonged to altitude classes that can be a determining factor; also, the precipitation factor had the lowest weight. These results show that precipitation factor has a low effect on query this species. Results the studies Mossadegh (1993); Salman Mahiny & Kamyab (2009), showed that *T. baccata* species is sensitive to different factor changes and its distribution has direct relationship with ecological factors particularly climatic and physiographic factors, also the results study by Alami *et al.* (2014), showed ecological characteristics are effective factors in query *T. baccata* Species, all this results are consistent with the findings of this research.

Zare *et al*. (2011), in a research aimed at introducing the appropriate plant species for afforestation in Darre Vasie watershed in north of Iran, in Southern slopes of Alborz Mountains, using the multi criteria evaluation and GIS and 8 informational layers of slope, geographical direction, hypsometry, precipitation, temperature, soil layers, geology and river concluded that the altitude informational layer is more effective than other informational layers which is consistent with the findings of this research. Also, the conformity among the slope map and the query map of the *C. sempervirens* var. Horizantalis species using MCE method showed that the broadest area in terms of possibility of presence of the *C. sempervirens* var. Horizantalis species belongs to the slope class 25-50 and the largest area in terms of impossible presence of *C. sempervirens* var. Horizantalis species is related to above 100 percents slope classes. The results are inconsistent with researches of Esmaeel Zadeh and Hoseini (2007), in terms of dominance of *C. sempervirens* var. Horizantalis species distribution in the slopes more than 70 percents. The largest area in terms of possible presence of *C. sempervirens* var. Horizantalis species in MCE method belongs to north-east class and the broadest area in terms of impossible

presence of this species is related to north and north-west classes. But the north-east class and the flat class with a not very good potential have the largest areas in terms of possible presence of *C. sempervirens* var. Horizantalis species in fuzzy method. The results of this study are consistent with researches conducted by Esmaeelzade and Hoseini (2007), in terms of distinction between plant ecological groups due to physiographic variables of altitude, slope and mountain slope directions. The soil type 1.1.1. (young brown to Ranker undeveloped soil) has the highest presence possibility of *C. sempervirens* var. Horizantalis species in the very good class and the soil class 1.2.2 (forest brown with loam silk texture) own the largest area in the class with no growth capacity for *C. sempervirens* var. Horizantalis in both methods.

CONCLUSION

The results of this research imply that *C. sempervirens* var. Horizantalis species has different ecological needs, because *C. sempervirens* var. Horizantalis shows sensitivity to each of the different parameters and different environmental factors are involved in determination of an appropriate place for planting *C. sempervirens* var. Horizantalis species that significant results can be achieved from overlapping and combining the informational layers produced from effective parameters in query. Considering the results and comparing the mentioned methods, we concluded that both methods have a high potential for query because both of them have the capability to weight and rank all of the factors and parameters and not to consider each of them as equals and since forest are dynamic and alive ecosystems, they need more accuracy in query. Fuzzy logic method has more capabilities and accuracy compared to MCE method and adaptation of layers of the areas and the reserve of *C. sempervirens* var. Horizantalis species has a higher adaptation with the final layer obtained from fuzzy method, in other words, since the positioned maps have the most overlap with natural habitat, they are closer to reality.

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