Feasibility Study of Olive Cultivation in Fars Province by Applying Weight Ranking Models of GIS

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Abstract

Nowadays, the problem caused by human's incorrect usage of productive lands has led to researchers and experts' great attention to land preparation and ecological models. In order to do so, they need to measure ecological resources of the earth by proper methods. This project intends to identify the effective ecological factors and elements in planting olive in Fars province, Iran. Also, it intends to zone the productive lands for planting olive based on ecological and environmental factors; to achieve this aim, geographical information system in combining different information levels is being used, also they are arranged in different models. In this research, through some studies on province ecological status, then comparing them with ecological olive prerequisite, an ecological and environmental data base of the province is provided based on Arc GIS software. Then it tries to clarify the resulted maps based on olive planting capability; it should be mentioned that this clarification is done based on the relationship between any of the effective environmental and ecological parameters in planting olive and function of olive products. Afterward it determines the values, the weight models (rank sum, reverse ranking, exponential ranking). Indeed, the achieved maps are mixed together in the context of Arc GIS. Then based on achieved results from the maps, 14 percent of the province area in average are considered proper to be planted with the olive. These special areas are mostly located in the middle part of the province.

Keywords: *Olive Planting, Fars Province, Geographical Information System, Ecology*

1. Introduction

One of the most significant and important aim of any government is the sustained agricultural growth and development; achievement of this goal is just possible through fundamental and all-dimensional evolution in agricultural structure, proper management and utilization of equipments and resources, and arranging the activities properly through logical and scientific programming. In this regard, agriculture unit enjoys special priority among development programs of country; the focal heed of the country is also paid to agriculture as the base and pivot of economic development. Regional potential and limitations in ecologic units, and their significance in regional agriculture, also special attention to sustained development and food security cause the permanent ability in producing agricultural products in ecologic units to be studied before any investment in its development (Zamaani Pour, 1995).

Determining potentials of a suitable region for generating the desired product seems to be a preface and pre-requisite for preparing the land and studies on regional planting pattern. Plants need proper weather, water and soil in the special environment to grow and pass the phonological stages. Different environments introduce different species to the world. In regional-agricultural classification initially the areas are classified according to statistics related to long term

parameters effective on growth of the desired products, the minimum and the maximum of temperature, the amount of rain and etc., then the proper and favorable areas for planting the special product are determined through identifying the required conditions such as heat threshold, the length of growth period and irrigation demands. Logical decisions about farming in an area are made, according to these stages and according to the resources importance level which can be human force, irrigation requirements, etc. (Ahmadian, 2002).

Olive is a plant from the family of Oleaceae and the genius of Olea. Oleaceae family has 30 to 35 geniuses and about 600 species which are mostly scattered in tropical regions of the world; they also exist as ornamental and industrial crops. Just one spice of Olive, European Olea, produces edible fruits. Olive tree exhibits great resistance to water shortage, also it's adapted to low-efficient and poor soils; meanwhile it produces a cheap but worthy product. From the economic point of view, it is considered important to the extent that it is known as the rich product of poor soils. Developing olive-based farming system as a plan initiated in the country since 1994 under the title of 'Tubaa plan'; it is still in progress.

Some researches were done on possibility and determining the potential areas for olive farming in some provinces (Mesji, 2002). Since Fars province enjoys suitable regional situations, water and soil have the potential talent in producing different cultivators of olive; this has led to development of olive orchards in recent years. Fars has achieved the first rank till the end of 2011 with 8000 tones of seeds (Kherad, 2012).

So, in order to gain higher amount of productivity, more studies on the possibility of farming this special tree in this province seems essential and indisputable.

2. Materials and Methods

In order to consider regional status of proper areas for growth of olive, also to investigate regional capabilities of Fars province in cultivating olives, first regional and environmental needs of olive are considered based on table 1.

Table 1. Olive Tree Ecological Condition (Sadeghi, 2010)

Circumstances of Olive	Very Good	Good	Average	Weak	Unsuitable
Average of Annual Temperature	16-20	20-23	23-26	13-26	<13
Average of Absolute Minimum Temperature	-4<	-4to-7	7to-10-	-10to-13	<-13
Average of Absolute Maximum Temperature	<40	40to42	42to44	44to46	>46
Annual Degree Day	5300<	4900to5300	4500to4900	4100to4500	<4100
Chilling Requirement	-200<	200to-150-	-150to-100	-100to-50	<-50
Average of Annual Rainfall	450<	350to450	250to350	150to250	<150
Odds of Temperature -7 c° and less	3>	3to6	6to9	9to12	>12
Odds of Temperature 38 c° and More	15>	15to30	30to45	45to60	>60

Then, data from weather stations in Fars province was used in order to consider homogeneous regional conditions with olive regional requirements in this province (Table 2).

Table 2. Ecological Features of Fars Province Weather Stations

Weather Station	Average of Annual Temperature (c)	Average of Absolute Minimum Temperature (c)	Average of Absolute Maximum Temperature (c)	Annual Degree Day (c)	Chilling Requirement (hours)	Average of Annual Rainfall (mm)	Odds of Temperature -7 c and Less (percent)	Odds of Temperature 38 c and More (percent)
Abadeh	14.3	-12.1	37.3	4722	-644.9	133.3	11.5	11.5
Ardakan	14.8	-9.4	35.2	4929	-630.2	652	9.9	-
Arsanjan	18.3	-4.8	40.2	6226	-264	200.8	-	-
Estahban	17.5	-6.3	40.3	5853	-282.5	283.8	2	26
Eghlid	12.8	13.5-	34.5	4191	775.1-	317.7	17	-
Izad Khast	13.8	12.1-	36.9	4489	762-	148.7	14.7	6.7
Bavanat	13.6	12.6-	35.4	4394	660.2-	202.6	12.3	-
Perspolis	17.3	6.2-	40.8	5788	312-	298	0.9	35.8
Jahrom	20.5	3.6-	44.2	7437	85.3-	285.5	-	69.6
Darab	22.1	1.3-	45	7904	47.7-	263	-	74

Doroodzan	17.7	4.4-	39.5	5942	315.7-	474	-	25.8
Zarghan	16.2	7.4-	41	5574	365.2-	316.8	6	36.7
Zarrin Dasht	23.1	1.8-	45.4	8287	23-	200.2	-	-
Shiraz	18	5.4-	41.3	6287	240.8-	324.1	1.3	40.9
Safashahr	11.8	16-	35.6	3802	925.6-	190.9	29.6	-
Farashband	22.1	2.7-	45.7	7965	37.1-	245.4	-	-
Fasa	19.3	4.2-	43.2	6636	159.3-	295.3	-	56.7
Firooz Abad	20.7	1.3-	41.5	7425	66.2-	313.3	-	-
Ghir Karzin	26	0.6-	47.8	9394	6.3-	232.6	-	-
Kazeroon	22.9	0.7-	45.4	8157	53.7-	296	-	74.8
Lar	23.6	1.4-	46.2	8175	50.1-	204.9	-	77.5
Lamerd	25.4	1.3	48.5	9391	3.5-	215.7	-	83.8
Mamassani	21.2	1.9-	45.8	76.6	74.4-	393.8	-	-
Neyriz	19.4	4.6-	40.4	6694	184.5-	185.4	2	29.6

In order to estimate chilling and heat requirements of plant, the index of degree day is used.

HU=∑(TM + Tm/2) provided that (TM +Tm/2)>Tt

HU=Heat unit is consisted as effective temperatures which are gathered during N days.

TM= Maximum temperature during a day

Tm= Minimum temperature during a day

Tt= The base temperature or physiologic zero.

N= The number of days in a specific time duration.

CU=∑(TM + Tm/2) provided that (TM +Tm/2) <Tt

CU = Coldness unit is consisted of the temperatures which are collected during N days. Temperatures are in degree in hour.

Ct= The critical minimum of the temperature (Kazemi 2005).

Olive heat and cold requirements were identified by utilizing Excel software. Indeed, commencement, the end date of phonology stages and the possibility of occurrence of heat thresholds were calculated by Smada software. In order to prepare numeral maps in Arc GIS software by means of fundamental maps (Topography maps, the type of land, etc), indeed to calculate regional interpolation base on the possibility of accuracy and heat thresholds of olive, numeral calculations and relevant maps were done (Figures 1 to 12). Then qualitative and quantities classification of the resulted maps were done based on the studies related to any of the regional and environmental conditions, the olive product function data and experts' opinions.

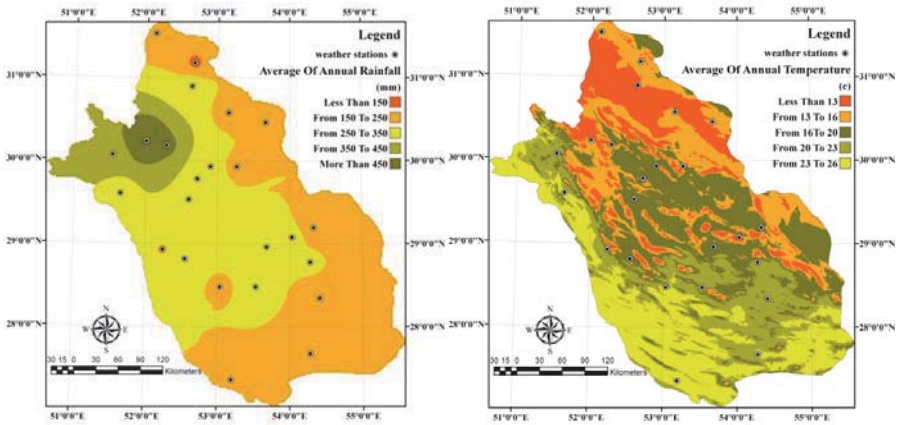

Figure 1 - Average of Annual Temperature Figure 2- Average of Annual Rainfall

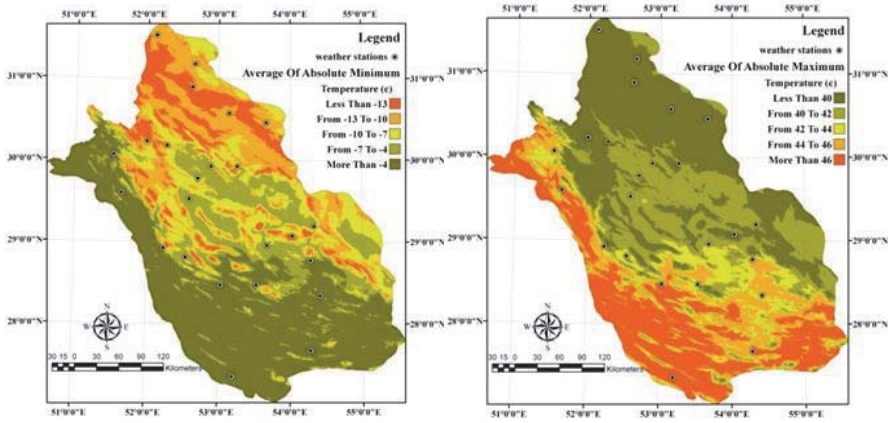

Figure 3 - Average of Absolute Min. Temperature Figure 4- Average of Absolute Max. Temperature

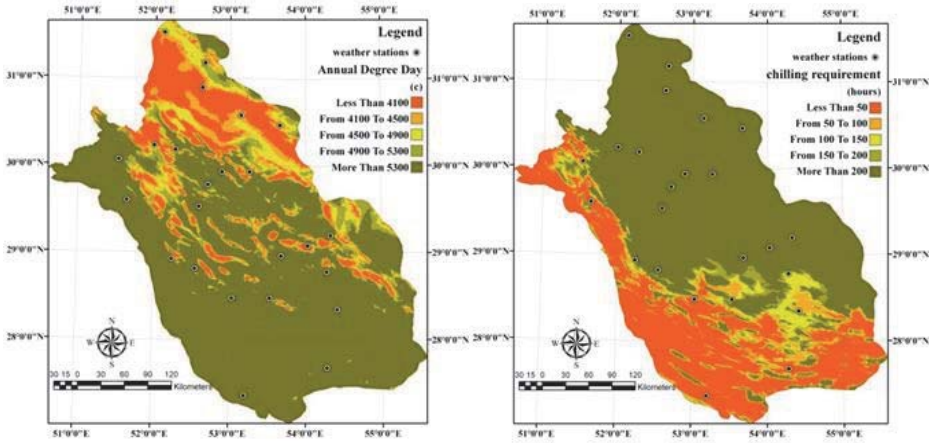

Figure 5 - Annual Degree Day Figure 6- Chilling Requirement

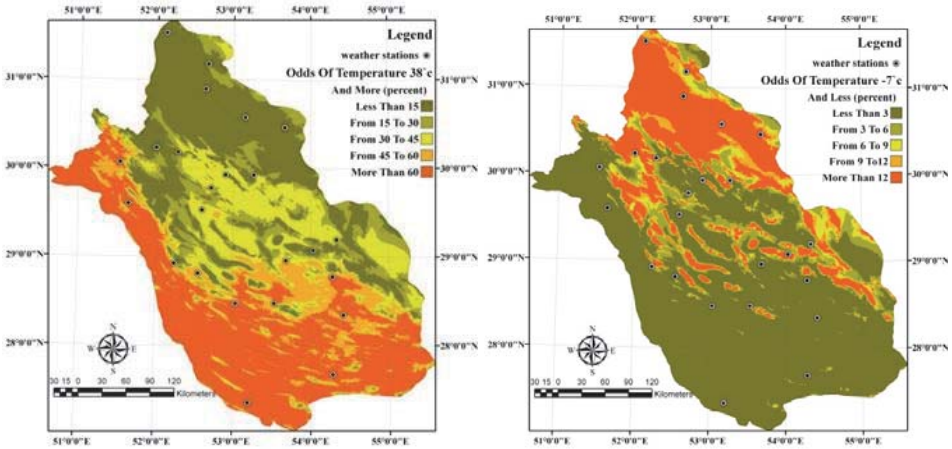

Figure 7 - Odds of Temperature 38° c and More Figure 8- Odds of Temperature -7 °c and More

3. Determining Criteria Values in Arc GIS Softwar

Regional and environmental criteria for identifying proper lands seem to be various, while they don't have the same

significance. So, the relative significance of criteria should be determined, in order to decide and evaluate more exactly.

Multi-criteria measuring methods which include determining value with qualitative and quantitative criteria are applied in order to show the significance of individual or group aims. Thus, this method is introduced as the proper method for decision- making based on their significance. Actually, GIS is a theoretical framework in which evaluation and modeling of local decision- making is provided through multi- level measuring methods. In this research, ranking models are used so that values of criteria be determined. In applying weight models by the usage of ranking system, the rankings are performed based on the importance of any of the factors.

The factors which have more importance enjoy the priority. After ranking, in order to determine the weights of the factors the methods, rank sum, reverse ranking and exponential ranking are used. The rank sum is described as the following equivalent (Malczewski, 1999);

$$Wj = \frac{n - rj + 1}{\sum(n - rj + 1)}$$

Wj= the standardized weights for factor j

n= The number of factors which are under study (k=1, 2, 33, …, n)

rj= The rank position of factor j

The reverse ranking method is calculated by inverting the rank of defined factor. It is calculated by the formula presented below (Malczewski, 1999);

$$Wj = \frac{\frac{1}{rj}}{\sum(\frac{1}{rj})}$$

In exponential ranking method, a value is added to the continuous information, then the weight of the factor which has more importance is determined (Malczewski, 1999).

$$Wj = \frac{(n - 2j + 1)^p}{\sum(n - rj + 1)^p}$$

P= The desired power

In order to clarify the issue, Table3 indicates the calculated values of weight by rank method for the annual temperature average parameter.

Table 3. Determination of Weight by ranking Method

Exponential Ranking		Reverse Ranking		Summing Up Method		Ranking Direct	Factor
Standard Weight	Weight	Standard Weight	Weight	Standard Weight	Weight		
.164	9	.146	.333	.2	3	3	1
.291	16	.219	.5	.267	4	2	2
.455	25	.438	1	.333	5	1	3
.073	4	.109	.25	.133	2	4	4

4. Mixture of Layers

The aim of mixture of layers through various methods seems to be obtaining the final map which indicates the distribution of the proper areas for olive cultivation; it should be noted that this is done after their weights were calculated. In this stage, after adding the standardized weights to the descriptive information table related to the maps, the final map is achieved by utilizing the local calculation part of Map Calculator. Then, based on olive cultivation potentiality (Figs 13 to 15) conclusions these maps are classified to four levels: very good, good, average weak, unsuitable.

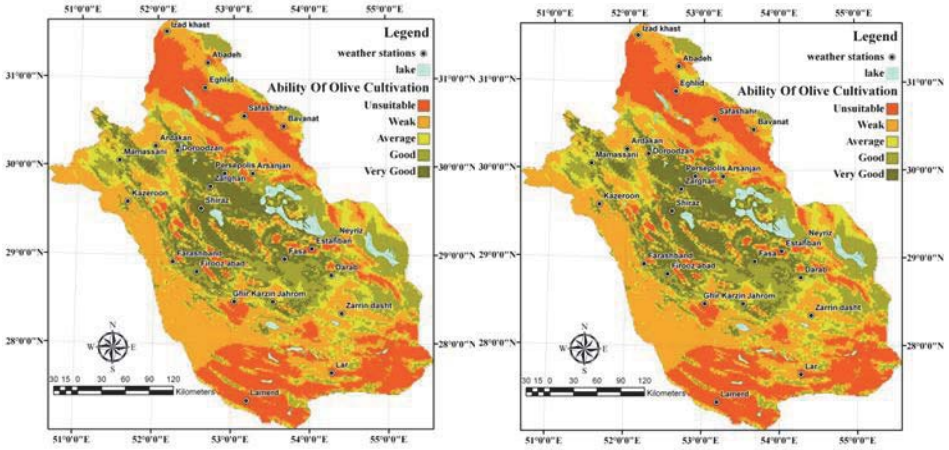

Figure 9. Rank-Sum Model, Feasibility Study on Suitable Areas Figure 10. Reverse Ranking Model, Feasibility Study on Suitable Areas

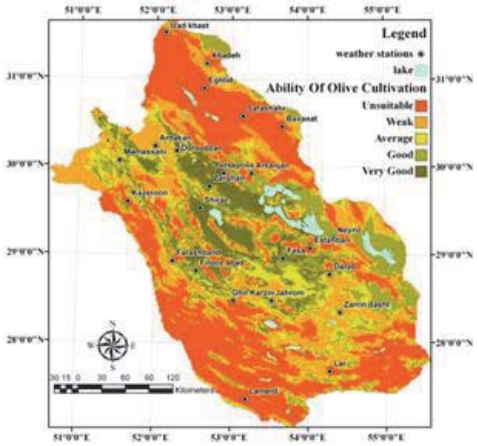

Figure 11. Exponential Ranking Model, Feasibility Study on Suitable Areas

Fars province enjoys various ecological diversities since it is located in a unique geographical point in Zagros chain of mountains. An exact planning in Agricultural development in Fars province seems necessary since this province includes regional and ecological diversity and differences in rainfall and temperature level.

Comparing annual values related to regional element of Fars province with olive tree regional requirements, it is observed that most of areas in this province have the potentiality to be cultivated by olive.

The following results are obtained based on any individual stations according to physiological features of olive, regional and ecological features of the province weather stations, also the final maps achieved by mixing the layers.

Stations which are located in North or North- East of the province highlands, including Abadeh, Eghlid, Izad Khast, Safa Shahr, Bavanat and Ardakan face basic limitations from the point of view of supplying the olive tree with annual heat requirements, so it is concluded that they don't have the potentiality of olive cultivation. Chilling supplies in these stations are more than the required amount, and it indicates harsh, long and chilly winter with severe glacier time. In these stations, odds of temperature $-7^{\circ}C$ and the possibility of its occurrence seem to be seen more frequently, since olive tree is sensitive to glacier, these stations don't have the potentiality of olive cultivation. Furthermore, the length of olive growth period in these stages is too short, and the adequate heat requirements are not provided. The only positive point about these stations is that odd temperature 38 doesn't occur, while its influence in comparison to the low temperatures seems to be trivial. It should be noted that the average of rainfall varies widely in these stations; Ardakan station evidences the most amount of rainfall while Abadeh station gains the least amount.

The stations which are located in the center or on the East including Shiraz, Takhte- Jamshid, Doroodzan, Zarghan, Arsanjan, Estahban, Neyriz and Fasa enjoy proper situation for olive cultivation based on annual heat supply

requirements. There's no limitation from the point of view of supplying olive tree with chilling requirement. These stations are in favorable status from occurrence possibility and the length of occurrence period of odds of temperature -7ºc , also they are approximately in favorable status from occurrence possibility and the length of occurrence period of odds of temperature 38 ºc. Most of these stations are in proper state based on average of annual rain in companion to other stations, but in order to supply olive's complete irrigation requirement, irrigation seems necessary. In this area, Doroodzan allocates the most amount of rainfall to itself, while the least amount of rainfall belongs to Neyriz. So, it can be concluded that these areas are considered as the best for olive cultivation.

The stations which are located in the middle between the center and South, and are stretched from the West to South- East include Jahrom, Darab, Farashband, Firuzabad, Kazerun, Noorabad- Mamasani.

These stations can properly provide the annual heat requirement for olive cultivation. These stations stand in a middle state from chilling requirement supply point of view. Based on occurrence possibility and the length of occurrence period of odds of temperature $-7^{\circ}C$; these stations are in an extremely well situation. But in comparison with the North and the central stations, they are faced with limitation of olive planting because of the occurrence possibility and the period length of odds of temperature 38 and more. These stations seem quite proper according to average of annual rainfall, and the extra water requirement of olive trees should be supplied by irrigation. Cultivation of native compatible cultivars is recommended in these areas, because the weather temperature is increasingly high in warm seasons.

Lower- altitude stations which are located in the south of province include Laar, Lamerd, Ghir Karzin, Zarin Dasht. These stations enjoy suitable conditions. But they can't provide chilling requirement properly. From occurrence possibility point of view, also from duration of odds of temperature $38^{\circ}C$ and other points of view; these stations are involved with serious limitations in cultivation than other province stations. These stations are considered moderate from the average of annual rain point of view.

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