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GIS-Based Map for Best Suitable Place for Cultivating Permanent Trees in South-Lebanon

Kamel Allaw [α] & Leila Al-Chami [σ]

Abstract- To reduce the human influence on nature resources and to identify an appropriate land use, it is essential to carry out scientific land evaluation. Such kind of analysis allows identifying the main factors for agricultural production and enables decision makers to develop crop managements able to increase the land productivity. Land capability is the ability of land to sustain a type of land use permanently. The key is to match the type and intensity of land use with its natural capability. Therefore; in order to benefit from these areas and invest them to obtain good agricultural production, they must be organized and managed in full. Lebanon suffers from the unorganized agricultural use, we take south Lebanon as study area, due to it is the most fertile ground and have a variety in crops. The study aims to identify and locate the most suitable area to cultivate thirteen type of permanent trees which are: apples, avocadoes, stone fruits in coastal regions and stone fruits in mountain regions, bananas, citrus, loquats, figs, pistachios, mangoes, olives, pomegranates and grapes. Several geographical factors are taken as criterion for selection of the best location to cultivate. Soil, rainfall, PH, temperature and elevation, are main inputs to create the final map. Input data of each factor is managed, visualized and analyzed using Geographic Information System (GIS). Managements GIS tools are implemented to produce input maps capable of identifying suitable areas related to each index. The combination of the different indices map generates the final output map of the suitable place to get best permanent tree productivity. The output map is reclassified into three suitability classes: low, moderate, and high suitability. Results shows different locations suitable for different kinds of trees. Results also reflects the importance of GIS in helping decision makers finding a most suitable location for every tree to get more productivity and a variety in crops.

Keywords: agricultural production, crop managements, geographical factors, geographic information system (GIS), land capability, permanent trees, suitable location.

I. Introduction

The land capability depends on general characteristics with taking into consideration the kind of its use. There have a range of classes' from1 to 8. This classification help us in order to get suitable suit for a crops and unsuitable for another; therefore, land capability is very important in order to get the best productivity of the trees [1]. Suitability of the section of the land affords the production of crops in suitable way this evaluation help to get many opportunities for use of land planning and development [1]. Moreover, these kinds of analysis allows identifying the main limiting factors for agriculture production, and helps the decision makers such as land user, farmers and agricultural support services tp develop a crop managements able to overcome for increasing productivity [1].

According to the different kinds of soil then we get that not all agriculture lands are the same and not all lands are suitable for the same kinds of plants. In a Britch Colombia study they depend on two factors which are climate determining the heat energy and moisture inputs required for agriculture production. Topographic is important for the ability to use cultivation equipment. Although, soil is important key for agriculture, according to upon factors they may be appropriate for sustaining the production of certain agricultural products [2].

So, soil capability for land classification system for agriculture was developed for use across Canada national soil survey committee in cooperation with the federal administration provincial ARDA administrations [3]. Then, they get 8 classes for the soil classifications.[3]

Many factors affect the safety and gain of crops worldwide; from the effects like floods, drought, swarms of insects and poor farming techniques. Now a day, solutions are found one of them is using geographic information system because is being able to map and project current and future fluctuations in precipitation, temperature, crops output and more. Then, farmers and scientists can work together to create more effective and efficient farming techniques; this could help in increasing food production in part of the world that are struggling to produce enough for people around them. Although, GIS can analyze soil data combined; to determine what the best crops to plant, and how to maintain soil nutrition levels to best benefit the plants [4].

GIS in agriculture is not a new phenomenon any more. In order to protect the environment and to capable of providing excellent nutrition to the people, then the best choice for achieve that idea is technology and geospatial, which can create a dynamic and competitive agriculture. Although, because of natural inputs in cultivating is uncontrolled, so all data and information can be now understood and managed by GIS application. However, GIS can help in effective crop yield estimation, soil analyses and erosion identification this things can be more accurate and reliable crop estimate help reduce uncertainty [5]. Using sophisticated agriculture technology by the farmers can

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help them in saving time and money. For example; farmers use precision GPS on the field to save fertilizer. Also, satellites and drones collect the vegetation, topography and weather information from the sky. All of that make geographic information system (GIS), an extremely relevant tool for farmers, so all that data go into agriculture map for better decision maker [6].

Now from GIS we can get a maps and projects that help the farmers to know the annual precipitation, temperature and crops out etc. And also, that helps the farmers to achieve increased production and reduce costs by enabling better management of land resources [5].

Lebanon is one of many counties that have agricultural important sector, according to the rich soil, and moderate climate and abundant water resources provide it, that's why can take Lebanon as an ideal location for agriculture activities [11]. Moreover, Food and Agriculture Organization (FAO) made a study about the agriculture of Lebanon they found that 67% of Lebanese territory is covered by agriculture area, and 14% of the total area of Lebanon is considered arable, besides rainfall which is also an important factor for agriculture it is relatively abundant an average of 2.2 billion m^3/yr; and this is higher than average, Lebanon is rich with major rivers and water resources [7].

Because of this big conflict that Lebanon suffer from, so we took agriculture land capability as an project in order to start getting a solution for this problem. After that we start search about the most permanent trees cultivated in Lebanon especially in south Lebanon that hold the most variety in permanent trees cultivation, then we took a thirteen kind of permanent trees. Lebanese's agriculture occupies about 47% of permanent trees (fruit trees). Moreover, 28% of citrus trees category, 19% of apple trees, 15% of grape trees and 11% of banana trees [4].

Agriculture land capability with organization is a good solution for environment and for economics issues although forget more productivity. The selection of the best location for every tree should be controlled by several factors and criterion that identify the most suitable places for permanent trees. Several indices were defined to determine suitability factor and sustainable development had an important part in the selection process. This selection is managed by several data being mapped and organized using GIS to get output showing different suitability classes. The process of agriculture land capability selection will be accomplished on South Lebanon that suffered from the unorganized cultivation and low productivity of the planted trees.

a) Study Area

The South Lebanon Governorate spans along the Mediterranean cost, limited by the Nabatieh Governorate to its East and the Mount Lebanon Governorate to its North. The governorate has an average altitude ranging between 0 to 300 meters above sea level, with a few areas reaching 1,500 meters above sea level in the north. It encompasses few mixed rural areas mainly concentrated around its 3 main cities (Jezzine city, Saida city, and Tyr city), with a majority of natural areas, and main agricultural lands. It is crossed by 7 rivers, the Awali, Sayniq, Litani, Zahrani, Naqura, Qasmiye, and Hasbani Rivers.South Lebanon is an important agricultural region, spreading from Sidon to Tyr where intensive agriculture is also present in greenhouses. Greenhouse agriculture in South Lebanon covers an area of 6,277 dounoum (2010), 78% of which is used for the plantation of fruits. Permanent agriculture land covers an area of 201,539 dounoum, 38.9% of which is used for planting olives, and 31.6% used for citrus fruits. The Nabatieh governorate is divided into four districts that are the largest in South Lebanon (Nabatieh, Hasbaya, Bint Jbeil, and Marjeyoun).The governorate is located in the far South of Lebanon, with the Mount of Rihan and Jezine district on its northern border, Litani river valley to the East and South, and the fertile coastal plains to the west. It has a total surface area of 1,058 km^2 which constitutes 10% of the total Lebanese territory. Nabatieh city, the capital of the governorate, is 22 km away from Saida and 65km from Beirut.

The two districts are suffering from the lack organization of agriculture, like the other districts of Lebanon so we start to find a solution by south Lebanon, because the land in south Lebanon is so fertile and rich in variety in products due to the good characteristics in soil.

II. Methodology

a) Principle

GIS is capable of providing spatial analysis including manipulating and analyzing form maps. Site selection or suitability analysis is a type of analysis used in GIS to determine the best place for a project. The research methodology is based on using different GIS spatial analysis tool with intersections for the polygons in order to get the best location for every tree in the study area. The selection of the best location for the trees has been done by research around the word. Take thirteen kind of permanent trees which are: apple, avocado, stone fruits on the coastal region, and stone fruit on the mountain region, banana, citrus, figs, grape, mango, loquat, pistachio, olive and pomegranate. Moreover, the chosen factors were different depending on the kinds of trees in the study area. Thus, several factors have been first identified, based on the kinds of trees analysis, which defines the five main factors: soil, PH, rainfall, temperature and elevation. These factors are very important for the productivity of the trees. Each factor gas been classified into different classes

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according to the suitability range. The value 1 was given the most suitable place and different values show suitable and least suitable. Factors of each index were given a same weight. The intersection of these factors it gives the best suitable place for each tree with a single map.

b) Data and Methods

The method used is a combination of the data provided by remote sensing space and the tools of the geographic information system (GIS). It can be considered as an effective method that was used by S.Selvametal and Radhakrishnan. D in 2014 in India, and by Hsin-fu Yeh in Taiwan in 2008 [6].

It consists in choosing the factors affecting the procedure of the suitable location for permanent trees in south Lebanon and then establishing the existing relations between them. These factors are: soil, PH, rainfall, temperature and elevation, the relationship between these factors and suitable location for each tree. For each factor we have established a represented map depended on its effect on suitable location.

i. *Soil*

Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment [7]. Besides, the most suitable soil for cultivating should bet one of third of loam, one of third of clay and one of third of sandy. Although; the organic matter shouldn't be less than 3%, and the color of soil is red or black. So in our project we get the best soil type for every kind of permanent trees, according to FAO soil classification for south Lebanon, then we get the result as shown below in a table -1- depending on GIS maps [8].

Table 1: Soil classifications

Soil type	Most Suitable soil for cultivating this kinds
1. Andic Cambisols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Mango e. Pomegranates
2. Anthropic Regosols	a. Stone fruits in Coastal regions b. Avocado c. Citrus d. Loquat e. Figs f. Grapes g. Olives h. Mango i. Pomegranates
3. Association of Haplic Luvisols and Leptic Luvisols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Figs e. Grapes f. Olives g. Pomegranates
4. Association of Eutric Fluvisols and Eutric Vertisols	a. Stone fruits b. Pomme fruits c. Citrus d. Loquat e. Figs f. Grapes g. Olives h. Pistachio
5. Association of Hyper-calcaric Fluvisols and Hypereutic Vertisols	a. Stone fruits in Coastal regions b. Avocado c. Citrus d. Loquat e. Mango f. Pomegranates
6. Association of Hypoc-alcaric Fluvisols and Haplic Vertisols	a. Stone fruits in Coastal regions b. Avocado c. Banana d. Citrus

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	e. Loquat f. Pomegranates
7. Association of Vertic Luvisols and Eutric Cambisols	a. Figs b. Grapes c. Olives
8. Calcaric Combisols	a. Stone fruits b. Pomme fruits c. Figs d. Grapes e. Olives f. Mango g. Pistachio
9. Calcaric Fluvisols	a. Stone fruits in Coastal regions b. Avocado c. Banana d. Citrus e. Loquat
10. Calcaric Leptosols	a. Figs b. Grapes c. Olives d. Pomegranates
11. Calcaric Luvisols	a. Mango
12. Calcaric Regosols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Pomegranates
13. Eutric Arenosols	a. Stone fruits in Coastal regions b. Avocado c. Loquat
14. Eutric Cambisols	a. Stone fruits b. Pomme fruits c. Figs d. Grapes e. Olives f. Mango g. Pistachio h. Pomegranates
15. Eutric Fluvisols	a. Stone fruits in Coastal regions b. Avocado c. Bananas d. Citrus e. Loquat
16. Eutric Gleysols	a. Stone fruits b. Pomme fruits c. Pistachio d. Pomegranates
17. Eutric Leptosols	a. Stone fruits b. Pomme fruits c. Pistachio
18. Eutric Luvisols	a. Stone fruits
19. Eutric Regosols	a. Stone fruits b. Pomme fruits c. Pistachio
20. Haplic Calcisols	a. Stone fruits b. Pomme fruits c. Figs d. Grapes e. Olives f. Pistachio

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21. Haplic Luvisols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Pomegranates
22. Haplic Fluvisols	a. Stone fruits in Coastal regions b. Avocado c. Bananas d. Citrus e. Loquat f. Mango g. Pomegranates
23. Hypereutric Vertisols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Pomegranates
24. Hyperskeletic Vertisols	a. Stone fruits in Coastal regions b. Avocado c. Pomegranates d. Loquat
25. Hypoluvic Arenosols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Figs e. Grapes f. Olives g. Pomegranates
26. Leptic Andosols	a. Stone fruits in Coastal regions b. Avocado c. Loquat d. Figs e. Grapes f. Olives g. Pomegranates
27. Leptic Luvisols	a. Stone fruits b. Pomme fruits c. Pistachio
28. Rendzic Leptosols	a. Stone fruits b. Pomme fruits c. Pistachio
29. Vertic Cambisols	a. Figs b. Grapes c. Olives

ii. *Rainfall*

Water is obviously a key factor in plant growth, since the greater the average temperature the greater the amount of water required for plant growth. Besides, seasonal variation is important as different crops require water at different time, then looking for rainfall reliability so that we can select the most appropriate crop for the area [8].So, in Mediterranean; crops growth affected by summer drought despite high annual rainfall, since the rainfall is very high in winter month infiltration rates are comparatively low. From our study we get that annual range of rainfall in south Lebanon is between 500 ml/yr and 1300 ml/yr [9].

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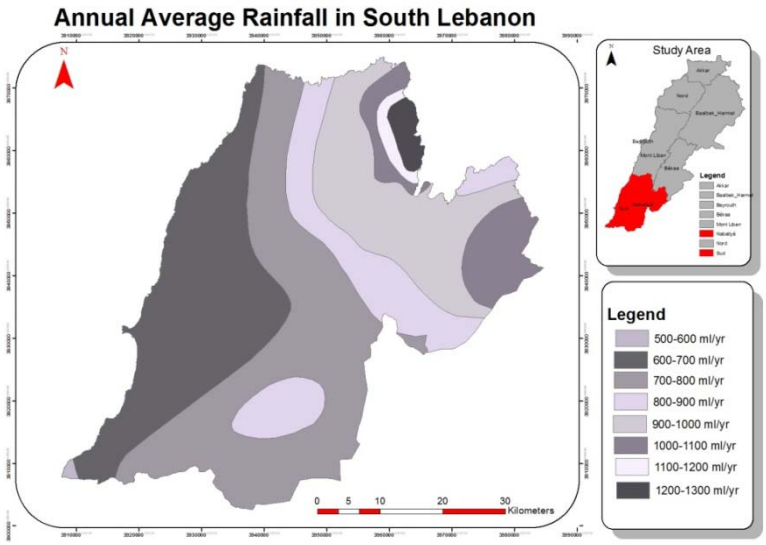

Figure 1: Annual Rainfall Average in South Lebanon

Then, in our project we get the best suitable rain fall for every kind of trees as shown in table-2- below:

Table 2: Rainfall classification

Kind of trees	Factors	Descriptive Scale	Domain of effect	Index
Coastal stone fruits	Rainfall	Most suitable	500-800 ml/yr	1
Stone fruits	Rainfall	Most suitable	900-1300 ml/yr	1
Apple	Rainfall	Most suitable	900-1300 ml/yr	1
Avocado	Rainfall	Most suitable	500-800 ml/yr	1
Banana	Rainfall	Most suitable	500-800 ml/yr	1
Pomegranate	Rainfall	Most suitable	500-1300 ml/yr	1
Citrus	Rainfall	Most suitable	500-800 ml/yr	1
Loquat	Rainfall	Most suitable	500-1300 ml/yr	1
Figs	Rainfall	Most suitable	500-1300 ml/yr	1
Grapes	Rainfall	Most suitable	500-1300 ml/yr	1
Mango	Rainfall	Most suitable	500-800 ml/yr	1
Pistachio	Rainfall	Most suitable	900-1300 ml/yr	1
olives	Rainfall	Most suitable	500-1300 ml/yr	1

iii. *PH*

Soil PH is a measure of the acidity and basicity (alkalinity), is considered a master variable in soil as it affects many chemical processes. It specifically affects plants nutrient availability by controlling the chemical reactions they undergo [10]. However, the optimum PH range for most plants is' between' 5.5 to 7.5, but many plants have adapted to thrive at PH value outside the range [9]. So, the result we get from our project is shown in the table-3- below:

Table 3: PH classification

Kind of trees	Factors	Descriptive Scale	Domain of effect	Index
Coastal stone fruits	PH	Most suitable	5.7-7.7	1
Stone fruits	PH	Most suitable	7.5-8	1
Apple	PH	Most suitable	7.5-8	1
Avocado	PH	Most suitable	5.7-7.7	1
Banana	PH	Most suitable	5.1-7.7	1
Pomegranate	PH	Most suitable	5.7-7.7	1
Citrus	PH	Most suitable	5.1-7.5	1
Loquat	PH	Most suitable	6-7.7	1
Figs	PH	Most suitable	6.8-8.32	1
Grapes	PH	Most suitable	5.7-7.7	1
Mango	PH	Most suitable	5.7-7.7	1
Pistachio	PH	Most suitable	7.5-8	1
olives	PH	Most suitable	6.8-8.32	1

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iv. *Temperature*

Producing trees are formed scientifically according to the number of hours under 7 ^{0}C. For example; bananas shrubs hold out from 50 to 100 hour only under 7 ^{0}C, and it must not reach 0 ^{0}C, while ajami apricot need more than 500 hour under 7 ^{0}CTemperature ranges in south Lebanon is between '17 ^{0}C and 23 ^{0}C [9].

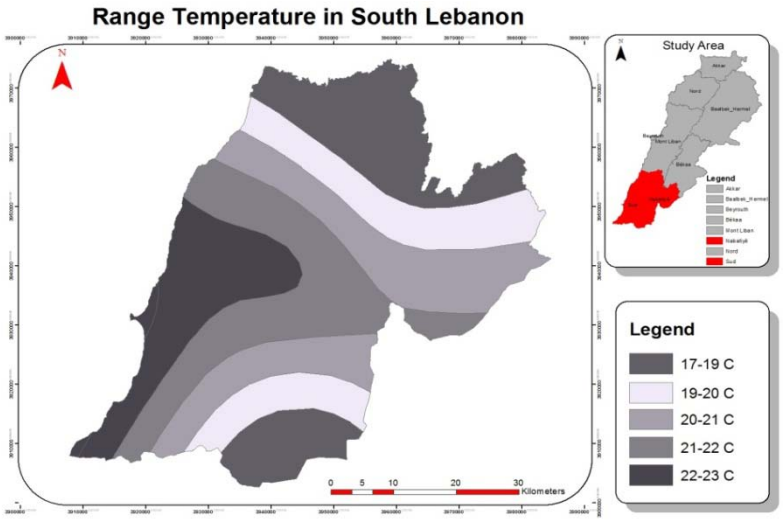

Figure 2: Temperature range Map

Table 4: Temperature classification

After that we search about best suitable temperature for every kind of tree then we get this result that shown in the table-4- below:

Kind of trees	Factors	Descriptive Scale	Domain of effect	Index
Coastal stone fruits	Temperature	Most suitable	21-23 ^{0}C	1
Stone fruits	Temperature	Most suitable	17-20 ^{0}C	1
Apple	Temperature	Most suitable	17-20 ^{0}C	1
Avocado	Temperature	Most suitable	21-23 ^{0}C	1
Banana	Temperature	Most suitable	22-23 ^{0}C	1
Pomegranate	Temperature	Most suitable	17-23 ^{0}C	1
Citrus	Temperature	Most suitable	21-23 ^{0}C	1
Loquat	Temperature	Most suitable	17-23 ^{0}C	1
Figs	Temperature	Most suitable	17-23 ^{0}C	1
Grapes	Temperature	Most suitable	17- 23 ^{0}C	1
Mango	Temperature	Most suitable	21- 23 ^{0}C	1
Pistachio	Temperature	Most suitable	17-20 ^{0}C	1
olives	Temperature	Most suitable	17- 23 ^{0}C	1

v. *Elevation*

There is a relation between climate and elevation. That's why every type of agriculture has a suitable height from mean sea level, so this elevation is taken into consideration because some types of trees shouldn't hold out a high altitude [10].

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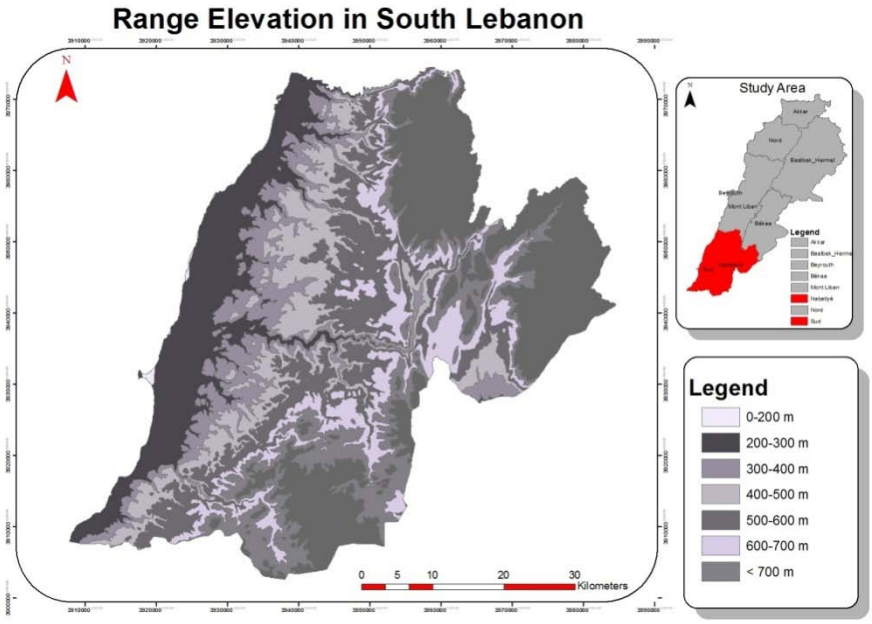

Figure 3: Range elevation in south lebanon

Now as before we practice this map for every kind of trees according to the most suitable elevation for every trees as shown in the table below:

Table 5: Elevations classification

Kind of trees	Factors	Descriptive Scale	Domain of effect	Index
Coastal stone fruits	Elevation	Most suitable	0-600 m	1
Stone fruits	Elevation	Most suitable	600-3000 m	1
Apple	Elevation	Most suitable	600-3000 m	1
Avocado	Elevation	Most suitable	0-400 m	1
Banana	Elevation	Most suitable	0-200 m	1
Pomegranate	Elevation	Most suitable	0-600 m	1
Citrus	Elevation	Most suitable	0-400 m	1
Loquat	Elevation	Most suitable	0-3000 m	1
Figs	Elevation	Most suitable	0-600 m	1
Grapes	Elevation	Most suitable	600- 3000 m	1
Mango	Elevation	Most suitable	0-300 m	1
Pistachio	Elevation	Most suitable	600- 3000 m	1
olives	Elevation	Most suitable	0-600 m	1

c) Implementation of simple additive weight method

The simple weight method was used as multi attribute decision technique. A score is calculated for each alternative by multiplying the scaled value given of the alternatives of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the product for all criteria. The SAW was used in generating each index map taking the weight of each factor with its obtained score from several associated factors, as well as in producing the final map considering the index weight with the obtained score from each index map.

$S=\sum W_iX_i$ Eq.(!)

Where;

S= Suitability index

W_i= weight of ith factor

X_i= score of the ith factor attribute

Then, the weighted was assigned in our project is equal, since there is no appropriate or exact value for agriculture, so we use it as 0.2 for all of the factors, in order to get the final map for every tree and get the most suitable location for it.

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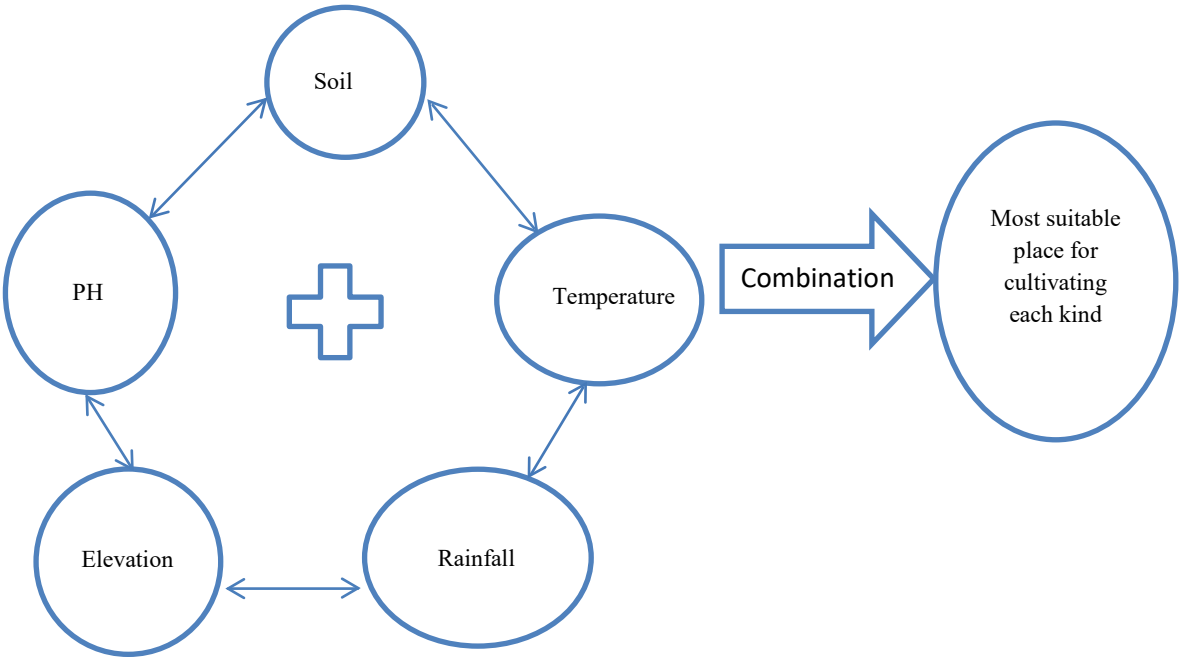
III. Modeling



IV. Results and Discussions

a) Results

Since many factors are incorporated in the agricultures land capability selection for the best location of permanent trees, GIS is identify this kind of study to accomplished using Arc GIS software. Vector data type was used as a data type for all factors. For each determined factor a map was produced and classified according to suitability classes. Several geoprocessing tools were applied to generating the map representing each factor. A classification was obtained for each map by assigning values from 1 to 3 to its own attribute table according to the suitability classes. The factors maps related to each index were used to produce the index map. After getting five maps for the five factors for every tree we use the intersection tool which helps us to get a final map for every kind of tree. The simple weighting method was then implemented to calculate the suitability index for each produced polygon based on the assigned weight for each factor. The generated index map was classified using the natural break classification; which was found the best suitable location for every permanent trees of area of study; as most suitable (class 1), suitable (class 2) and least suitable (class 3). The procedure was applied for all of the thirteen kind of trees I was shoes them in our study. We are going to present 13 types of trees with their maps after unifying the 5 factors we talked about in chapter 3 and we classified them into 3 classes: first class which is "most suitable" that represent from 1 to 1.4, second class which is "suitable" that represent from 1.4 to 2, third class which is "least suitable" from 2 to 3. The maps for each kind of tree will be shown below:

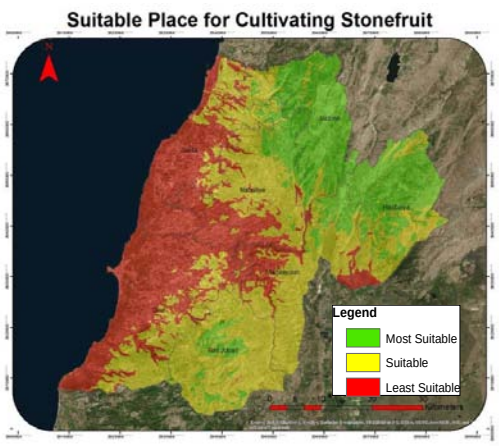


Figure 5: Stone Fr Uits Map

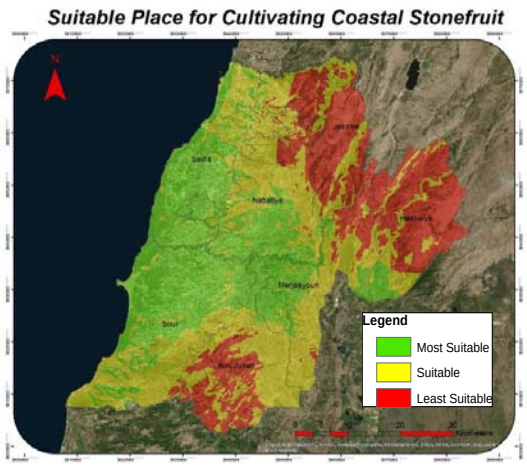


Figure 6: Coastal Stone Fruits Map

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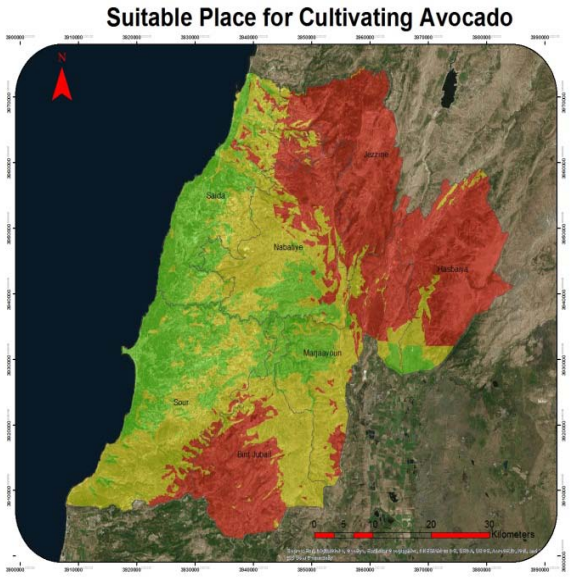

Figure 7: Avocadoes Map

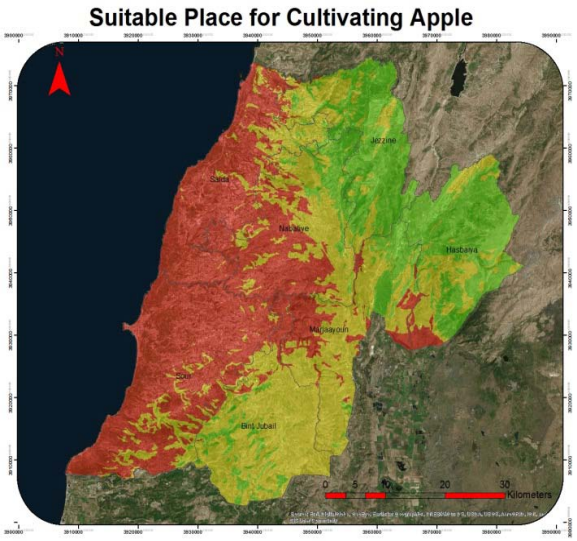

Figure 8: Apples Map

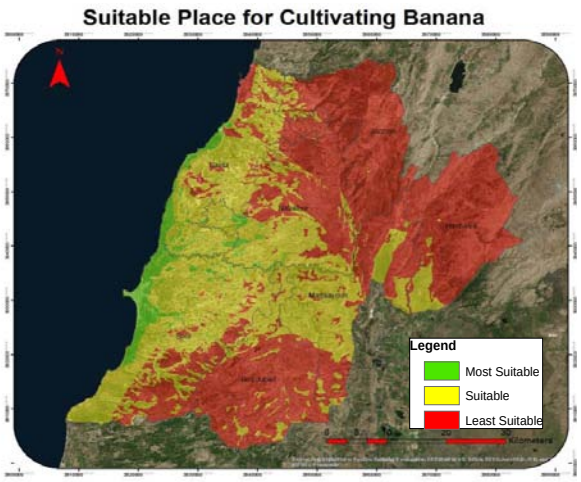

Figure 9: Bananas Map

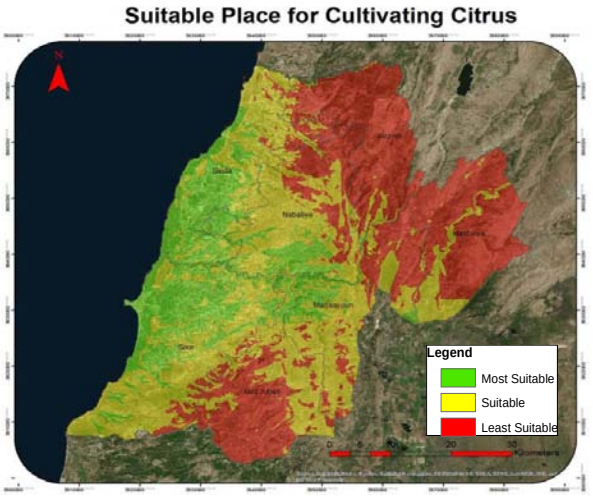

Figure 10: Citrus Map

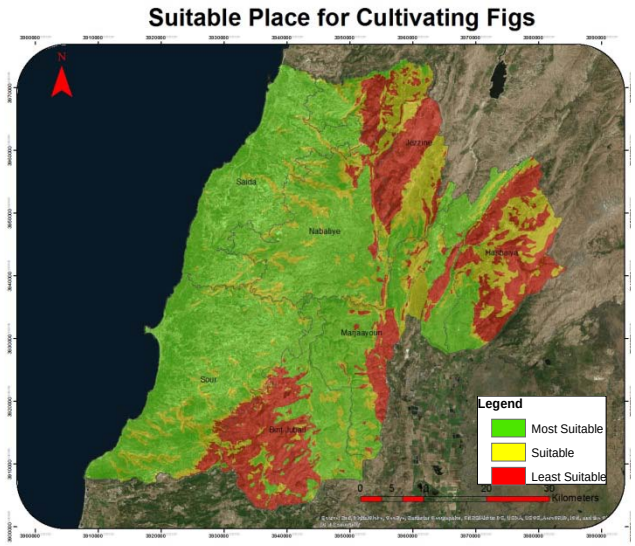

Figure 11: Figs Map

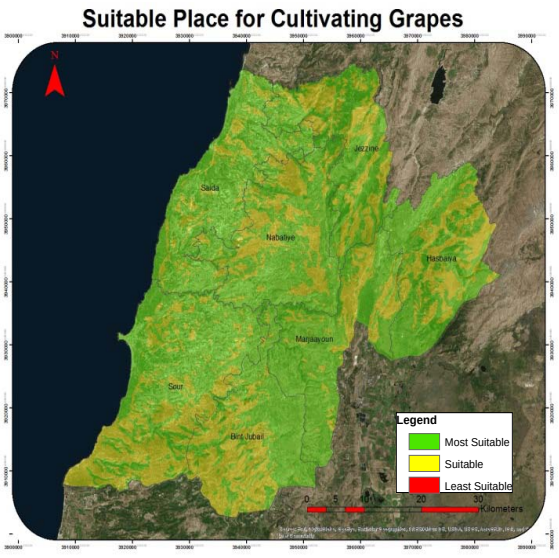

Figure 12: Grapes Map

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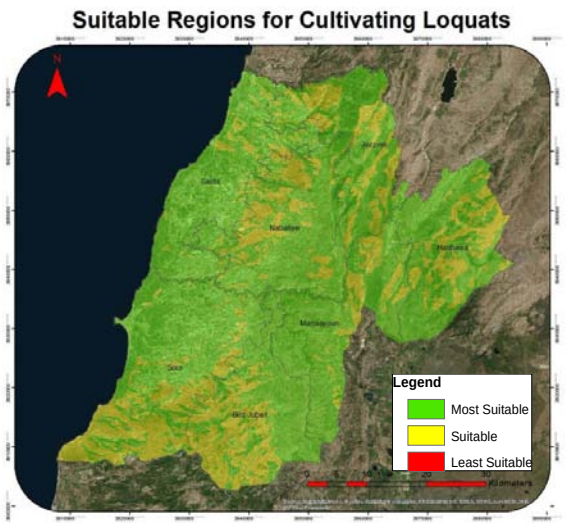

Figure 13: Loquat Map

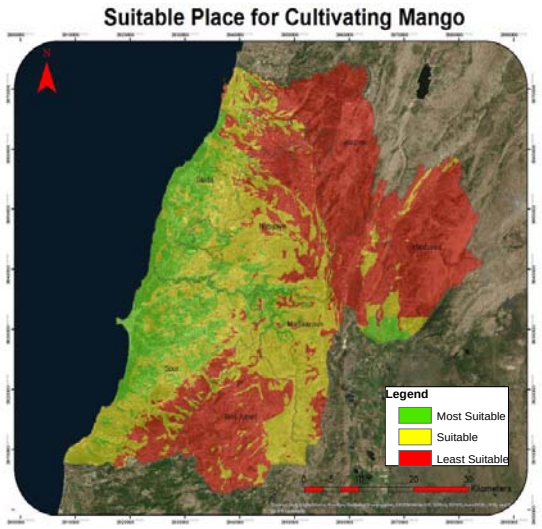

Figure 14: Mangoes Map

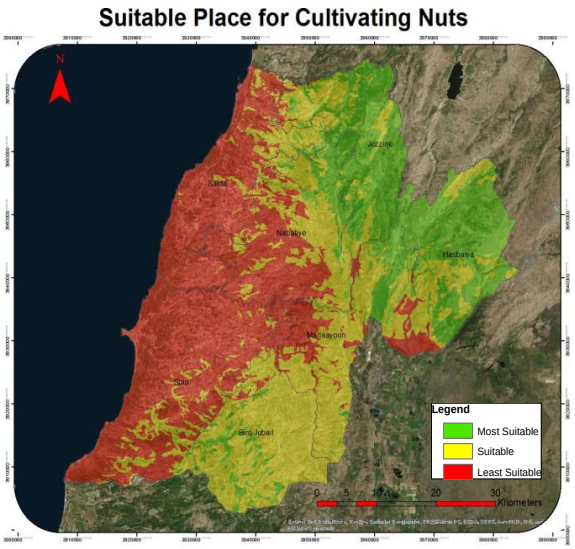

Figure 15: Nuts Map

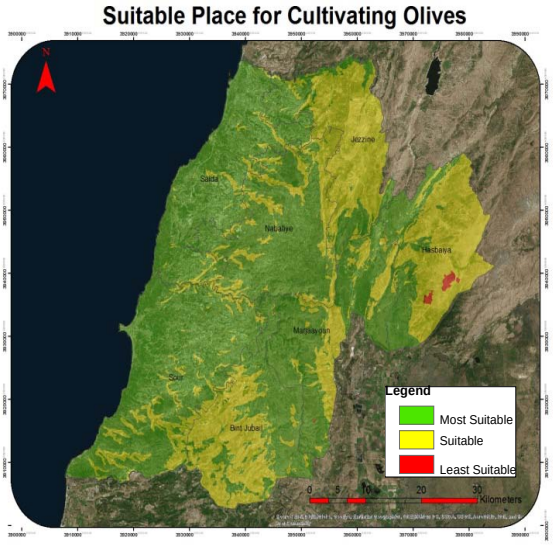

Figure 16: Olives Map

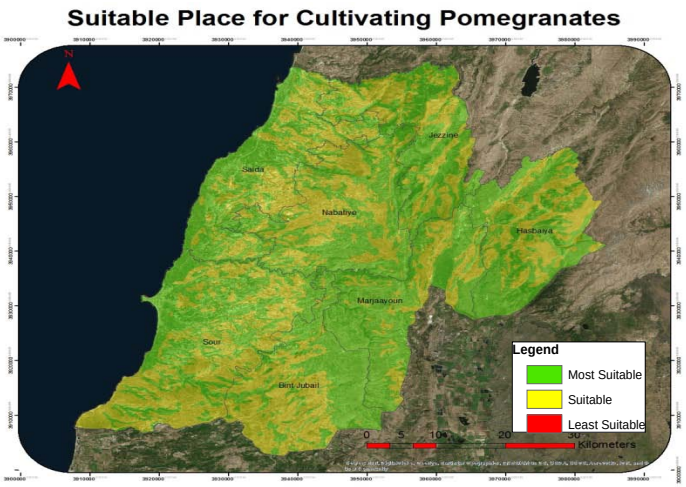

Figure 17: Pomegranates Map

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The map obtained in figure 4.14 and its classified into 5 classes: first class is "zero" means no trees can cultivated in this place, second class is "one" means only one kind can be cultivated, third class is "between 2 and 4" trees that can be cultivated, fourth class is "between 5 and 7" trees that can cultivated, the last class is "between 8 and 10" trees that can be cultivated.

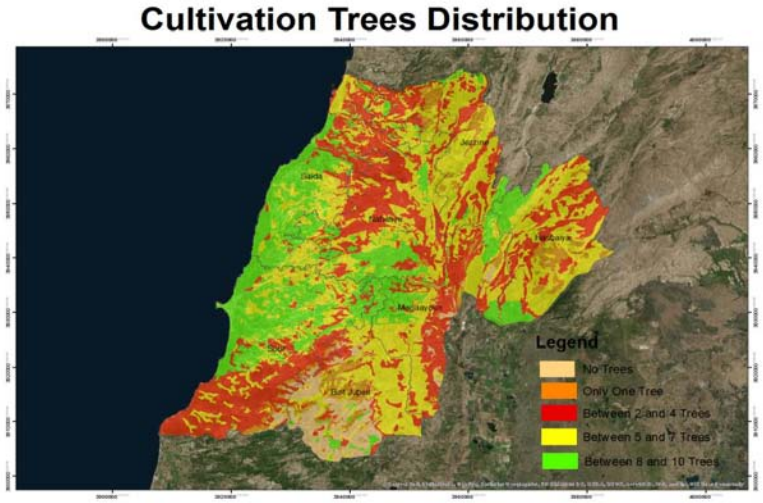

Figure 18: Trees distribution

Then by using "identify tool" in GIS we can get the kind of trees we can plant in its suitable place "1" means found and "0" means cannot be cultivated in this place, like it is shown in figure 4.2 below.

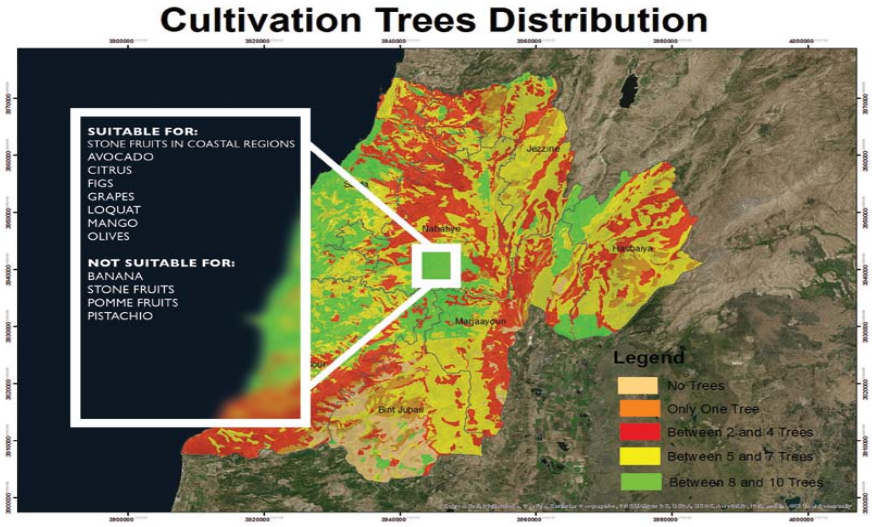

Figure19: The trees we can cultivate in this place.

From this figure we can see that in the same place we can plant Coastal stone fruit, avocado, citrus, figs, Loquat, grapes, mango, pomegranates, and olives.

V. Discussion

In this project we took South Lebanon as a study area and we chose 13 types of trees to know the suitable location for planting these types to have high productivity.

It is a study to organize the agriculture in Lebanon. We noticed that in South Lebanon 40% of land we can plant from 5 to 7 trees, and 20% of land we can plant from 8 to 10 trees, and 30% we can plant from 2 to 4 trees, and 6% of land we can't plant anything. So I have the choice of planting between 2 and 4 trees, and 5 and 7 trees, and 8 and 10 trees, so we made this Atlas to guide the farmers and people where to plant the type of trees, so they can have high productivity and this Atlas is a beginning in organizing agriculture in Lebanon.

VI. Conclusion

To sum up this study, we can conclude that the coastal strip up to an altitude of 300 m is most suitable

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for planting tropical and sub-tropical fruit trees, such as mangoes, bananas as long as the soil cultivated in is high in organic matter and low on clay matter and low Ph, and as for citrus and avocadoes cultivation can be successful up to 600m elevation regardless. Regarding pomegranates, olives, grapes, figs, loquat and stone fruits, we find that they can be cultivated over the entire area regardless of elevation or soil type, except for a few stone fruits varieties like Ajami Apricot which require higher chill requirements and accordingly need to be planted at higher elevations.

Finally, Pomme fruits and Pistachios, since they require high chill requirements to fruit dictates that they be cultivated higher than 700m, with the exception of a few apple varieties like Gala and Anna, which can be cultivated at elevation as low as 250m.

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