Agroclimatic zoning of Azarbayjan-Sharghi province for rainfed almond using GIS

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Abstract

Limitations in soil and water resources together with irregular rate of population increasing, cause that we choose a usefull landuse in our available resources. In order to do this, climatic investigations are necessary. The objective of this study was classification of Azarbaijan Sharghi Province in aspect of climatic potential of Almond in dryland farming. For this purpose, the precipitation and evaporation data as well as temperature parameters of ten meteorological stations of area were collected and analysed. Following indices were selected for Almond in dryland farming:

- Probability of chilling occurrence on bud and flower of Almond
- Probability of rainfall greater than 250mm
- Spring and summer precipitation to annual precipitation ratio
- Probability of occurrence of growing degree days greater than 3500 G.D.D (base temperature 0 celsius)
- Amount of available moisture index

For each of above parameters a coverage layer was prepared in GIS environment, in the second stage five mentioned coverage layers were crossed and overlapped to obtaining the agroclimatic map of area. Finally agroclimatic map reclassed to highly favorable, favorable, weak and not suitable area.

Key word: Agroclimate + GIS + Almond

Introduction

Precision farming aims to optimize the use of natural resources. Geographical information systems (GIS) are systems for the storage, analysis and presentation of spatial data. A combination of GIS and simulation models is highly relevant for precision farming. Agroclimatic classifications have proved to be of great utility for planning and management of various agricultural and forestry activities. Several climatic conditions may affect annual yield of deciduous fruit trees. Air temperature and rainfall are the most important climatic factors for grown and development of plant species.

The objective of present work is to use GIS, along with the model obtained, to find suitable areas for rainfed Almond.

Material and methods

Azarbaijan sharghi with 45480 Km² area is one of the northwest provinces of Iran. Daily mean, maximum and minimum temperature data and evapotranspiration as well as precipitation information were obtained from the synoptic and climatic stations of the area for a 25 year period (1971-1995) (Table 2-1). The phenological (flowering date) and effective rainfall data also were collected from ministry of Agriculture for the same period.

Tab.(2-1): List of meteorological station of area
Climatic requirements of Almond

Almond (Prunus amygdalus) is one of the delicious fruits with low water requirement but very sensible flowers, buds, and young fruits to chilling (Vezvai 1999). The threshold amount of rainfall for dryland farming of Almond is annual precipitation greater than 250 mm. Not only the amount of precipitation but the distribution of it (summer and spring precipitation to annual precipitation ratio) is very important. The growing season is another factor influences the yield of almond.

The most important limitation factor for almond planting is chilling on flowers, buds, and young fruits. The threshold temperature for chilling injury is −1 degree centigrade. The above mentioned climatic parameters are the main factors that limit almond growing specially in dryland farming. In present investigation five information layers were calculated as following:

- Probability of chilling occurrence on flowers, buds, and young fruits (PCO).
- Probability of occurrence annual precipitation greater than 250 mm (POAP).
- Summer and spring precipitation to annual precipitation ratio (SSPAR).
- Moisture Available Index (MAI).
- Probability of occurrence of growing season greater than 3500 degree days (POGS).

Information layers preparation in GIS

Digital elevation model (DEM)

Digital elevation model (DEM) was prepared using topographic map. For this purpose Arc/Info software and a Digitizer were used. Considering zone 38 as a base zone the digitized map converted to UTM project system. By exporting the layer prepared in Arc/Info to IDRISI software the format of the map was converted from vector to raster base. DEM of area is illustrated in Fig.(2-1).

<table>
<thead>
<tr>
<th>Num.</th>
<th>Station</th>
<th>Elevation(m)</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sarab</td>
<td>1651</td>
<td>37 56</td>
<td>47 32</td>
</tr>
<tr>
<td>2</td>
<td>Bostanab</td>
<td>1750</td>
<td>37 50</td>
<td>46 50</td>
</tr>
<tr>
<td>3</td>
<td>Mianeh</td>
<td>1094</td>
<td>37 25</td>
<td>47 42</td>
</tr>
<tr>
<td>4</td>
<td>Tabriz</td>
<td>1361</td>
<td>38 05</td>
<td>47 16</td>
</tr>
<tr>
<td>5</td>
<td>Maragheh</td>
<td>1420</td>
<td>37 24</td>
<td>46 16</td>
</tr>
<tr>
<td>6</td>
<td>Sharafkhane</td>
<td>1302</td>
<td>38 11</td>
<td>45 29</td>
</tr>
<tr>
<td>7</td>
<td>Khodaafarin</td>
<td>300</td>
<td>38 08</td>
<td>46 56</td>
</tr>
<tr>
<td>8</td>
<td>Azarshahr</td>
<td>1400</td>
<td>38 26</td>
<td>45 45</td>
</tr>
<tr>
<td>9</td>
<td>Jolfa</td>
<td>704</td>
<td>38 57</td>
<td>45 38</td>
</tr>
<tr>
<td>10</td>
<td>Ahar</td>
<td>1300</td>
<td>38 29</td>
<td>47 03</td>
</tr>
</tbody>
</table>
Probabilities of annual precipitation greater than 250mm map

Rainfall is very important in dryland farming so we prepared a coverage for it. First, all the best statistical distribution for rainfall data was determined using HYFA software. Probability of occurrence annual precipitation greater than 250mm was calculated then for each station. Regression equation between elevation and POAP was calculated (Table 2-2). Finally, this equation was applied on DEM of the area and obtained map was classified based on the following conditions (Fig. 2-2):

- Areas in which POAP is more than 0.80 is known as the first class.
- Areas in which POAP is between 0.60 to 0.80 is known as the second class.
- Areas in which POAP is between 0.40 to 0.60 is known as the third class.
- Areas in which POAP is less than 0.40 is known as the fourth class.

Table (2-2): Correlation equations between studied parameters and elevation (m)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation equation</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-PCO</td>
<td>1-PCO = 0.0006 - 0.00051Z - 0.644*</td>
<td></td>
</tr>
<tr>
<td>POAP</td>
<td>POAP = 0.023 + 0.00043 Z</td>
<td>0.624*</td>
</tr>
<tr>
<td>POGS</td>
<td>POGS = 0.99001 - 0.00038Z</td>
<td>-0.731*</td>
</tr>
<tr>
<td>SSPAR</td>
<td>SSPAR = 0.071 + 0.00053Z</td>
<td>0.656*</td>
</tr>
<tr>
<td>MAI</td>
<td>MAI = 0.0094 + 0.00031Z</td>
<td>0.699*</td>
</tr>
</tbody>
</table>

Fig. (2-2): Precipitation map of Azarbaijan shargi province
Probability of chilling occurrence map:
Similar to precipitation layer after fitting a good statistical distribution to minimum temperature the PCO was calculated for each station in order to draw geographical distribution of PCO and elevation was determined for the area (table 2-2). Existing map was classified to 4 zones (Fig 2-3) as following:
Areas in which the PCO is less than 0.25 are known as the first class zone.
Areas in which the PCO is between 0.25 to 0.50 are known as second class.
Areas in which the PCO is between 0.50 to 0.75 are known as third class.
Areas in which the PCO is more than 0.75 are known as fourth class.

Geographical distribution of MAI
Moisture available index (MAI) is one of the most important factors in dryland farming. MAI obtained by effective rainfall divided by evapotranspiration according to:
\[ \text{MAI} = \frac{\text{Pe}}{\text{ETC}} \]
Where Pe is the sum of effective rainfall and ETC is total crop (Almond) evapotranspiration in the growing season.
Geographical distribution of MAI was obtained in same approach as PCO. Four distinguished areas can be recognized from MAI map (Fig 2-4) as following:
Areas in which MAI was more than 0.60 are known as the first class.
Areas in which MAI was between 0.40 to 0.60 are known as the second class.
Areas in which MAI was between 0.20 to 0.40 are known as the third class.
Areas in which MAI was less than 0.20 are known as the fourth class.

Fig. (2-3): Chilling occurrence probability map
### Table 4-1: The criteriaes determined suitability of area to Almond dryland farming

<table>
<thead>
<tr>
<th>Class</th>
<th>Parameter</th>
<th>PCO</th>
<th>POAP</th>
<th>MAI</th>
<th>SSPAR</th>
<th>POGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very suitable</td>
<td>&lt;0.25</td>
<td>&gt;0.80</td>
<td>&gt;0.60</td>
<td>&gt;0.60</td>
<td>&gt;0.85</td>
<td></td>
</tr>
<tr>
<td>Suitable</td>
<td>0.25-0.50</td>
<td>0.60-0.8</td>
<td>0.40-0.60</td>
<td>0.40-0.60</td>
<td>0.65-0.85</td>
<td></td>
</tr>
<tr>
<td>Weak</td>
<td>0.50-0.75</td>
<td>0.40-0.60</td>
<td>0.20-0.40</td>
<td>0.20-0.40</td>
<td>0.45-0.65</td>
<td></td>
</tr>
<tr>
<td>Not suitable</td>
<td>&gt;0.75</td>
<td>&lt;0.40</td>
<td>&lt;0.20</td>
<td>&lt;0.20</td>
<td>&lt;0.45</td>
<td></td>
</tr>
</tbody>
</table>

Fig. (2-5): Geographical distribution map of POGS
Geographical distribution map of POGS:

Geographical distribution of POGS(fig2-5) determined in same method as previous elements.Distinguished areas can be ranked as following:

Areas in which POGS was between 0.65- 0.85 are known as the first class. Areas in which POGS was between 0.45 to 0.65 are known as the third class. Areas in which POGS was less than 0.45 are known as the first class.

Geographical distribution map of SSPAR:

Although the amount of annual precipitation is a main factor in dryland farming but its distribution during the year is very important too, in order to draw geographical distribution of SSPAR regression equation between elevation and SSPAR was determined(table( 2-2) and applied to DEM.Major classified zones are as following (Fig(2-6)):

Areas in which SSPAR was more than 0.65 are known as the first class.
Areas in which SSPAR was between 0.45 to 0.65 are known as the second class.
Areas in which SSPAR was between 0.25 to 0.45 are known as the second class.
Areas in which SSPAR was less than 0.25 are known as the second class.

Results

To producing the Agroclimatic map of Azarbaijan province for Almond dryland farming the 5 above mentioned maps(PCO,POAP,MAI,SSPAR and POGS maps) were overlaid and crossed.resultant map can be classified to four distinguished zones as following (refer to table( 4-1) and fig(4-1)):

![Agroclimatic map of Azarbaijan for Almond](image)

**Fig. (4-1): Agroclimatic map of Azarbaijan for Almond**

**Very suitable zones(first class)**

There is a high correspondence between climatic conditions of area and the climatic requirement of Almond in this zone.The areaofth is zone is about 4852.9 km2 ndincludes: Hurand, Kalaleh and Ghareaghaj regions.
Suitable areas (second class)
Although there is a weaker correspondence between climatic conditions and requirements of Almond in these areas compared to the first zone, it is possible to make conditions better with supplemental irrigation and other agricultural activities (such as planting tolerant species to drought and chilling). The area of this zone is about 2833 km² and includes: Azarshahr, Maraghe, Bostanabad, Sarab, Zenuz, and Varzaghan.

Weak areas (third class)
These areas have low potential and low yield for dryland farming of Almond. The area of this zone is about 10052 km² and includes Malekan, Sharafkhane, Kalibar, Bonab, Marand, and Tabriz regions.

Not suitable areas (fourth class)
This zone considers areas that are not suitable for Almond dryland farming because of a non-corresponding between climatic conditions and requirement of Almond. The most important factor that limits planting of Almond in these areas is chilling injury on flowers, buds, and young fruits. The area of this zone is about 2242.1 km² and includes: Tasuj, Khomarloo, and Haris regions.

References
- Khambete-NN, 1992, Agroclimatic classification for assessment of crop potential of kharantaka, Mausam, 43:1, 91-98
- Lamba-Bs, 1991, Agroclimatic zoning of Panjab and Haryana on the basis of MAI, Mausam, 42:211-213