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Research Article

EVALUATION OF CLIMATIC AGRICULTURAL POTENTIALS OF FARS PROVINCE USING PAPADAKIS TECHNIQUE

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ABSTRACT

Accurate and simultaneous recognition of climatic facts and ecological phenomena requires use of a technique which is free from ambiguities and generalized concepts and is based on robust fundamentals. With more than 440 subcategories, Papadakis climatic classification which emphasizes on the role of ecological factors has the aforementioned advantage in spite of its particular complexities. In the present paper, after a concise introduction of Papadakis method, meteorological data of 8 selected stations in Fars Province are processed and analyzed using EXCEL software based on the afore mentioned method. The analysis results will be illustrated in maps prepared in GIS software by means of ARCMAP software. The criteria of this method include: winter coldness and summer warmness, duration of frostless season, potential evapotranspiration, and water balance and its seasonal distribution. The research achievements are indicative of the fact that all stations are classified in cotton group in terms of summer temperature status. The stations under study are more diverse with respect to the winter temperature conditions such that two stations are classified in the oat or Avena sativa group (cooler), five stations in warmer oat group, one station in citrus group and one station in class of wheat. In terms of temperature regime, two stations are classified in warm continental group and 6 stations are regarded as warm subtropical climates. Concerning moisture regime, there are two stations in arid Mediterranean and 6 stations in semi-arid Mediterranean classes. The final result implies that all stations are classified in one group and 3 types. This is reflective of the agro-climatic diversity of Fars Province as well as high competence of Papadakis method in illustration of details and climatic subzones.

Keywords: *Papadakis, Fars Province, Climatic Potential, Agriculture*

INTRODUCTION

Among different factors influencing agricultural production, weather conditions is the most variables in natural environment that human is not able to control them, except in small scale with high cost. Lack of attention to capabilities of climate and traditional cultivation of agricultural Products has been resulted to low changing yield and even the destruction of crops in some years. Agro climatology assesses interaction relationship between climatic and hydorologic factors with agriculture. The aim of agro climatology is the use of climatic information in order to improve farming practices and increment the quality of agricultural products (Mohamadi, 2006). One of the basic ways for developing and progressing of country is the optimal use of land in accordance with their ecological conditions (Farjzadeh, 2002). It is necessary to determine the agricultural climatic regions in order to identify the existing problems and issues associated with climate and agriculture. Climatic classification system refers to a set of rules through which the regions with common characteristics can be differentiated and homogenous regions can be categorized together (Hojjatizadeh, 1993), Papadakis has great contribution in this field. Papadakis (1961) based his climatic classification on the severity of the winter, the warmth of the summer, seasonal distribution and access capability to moisture. Papadakis's classification method and his research in climate, agriculture, water, soil and ecological phenomena have been gradually developed in 1975. Azizi *et al.*, (2005) have evaluated the diversity and Iran's agricultural potentialities by use of Papadakis's method. Mohmadi *et al.*, (2005) have assessed the climatic conditions of date palm cultivation in Golestan province. This research

shows that Golestan province is suitable for cultivating of early ripen date palm. Hoden *et al.*, (2004) in a study using temperature and precipitation in connection with statistical techniques and providing simulation models have done climate zoning of agricultural crops in Irland. The results of research show that each area is suitable for a crop in accordance with climate. The intent of the present study is to investigate the climate and assess the agricultural potentials in Fars province.

The Region under Study

Fars Province, approximately located between 27° and 31°of northern latitude and 50° and 55° of eastern longitude. This province is bordered to Esfahan Province in the north, Hormozgan Province in the south and southeast, Bushehr Province in the southwest and west and kohkiluyeh and Buyerahamad, Province in the northwest, Kerman Province in east and Yazd Province in northeast. The surface area of the province is 122,608 km^2, being the largest Iran's province in this respect and accounting for around 8.1% of country's area (Figure 1)

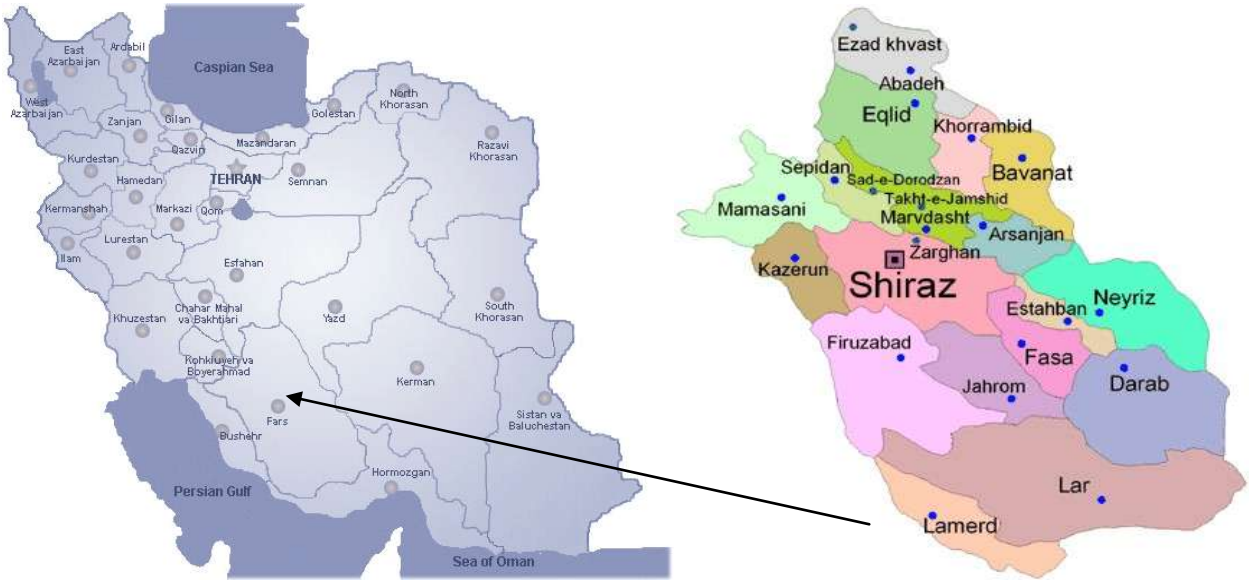


Figure 1: The region under study

In terms of climate, fars province is divided into three climatic zones. A) Mountainous area of north, North West and west, with cold winters. With an annual rainfall of four hundred to six hundred mm. B) Centeral regions with relatively mild winters, hot and dry summer. With annual rainfall of two hundred to four hundred mm. c) South and south east region, because of the low elevation and latitude, has temperate climate in winter and too hot in summer, rainfall in this region is 100 to 200mm. Like all areas, agriculture is affected by climate. Agriculture is allocated a major share of GDP. Fars province has the first place in terms of wheat, corn, oilseeds and tomato in Iran.

MATERIALS AND METHODS

The needed data for carrying out this research include: average monthly and annual precipitations, average maximum and minimum temperatures, average monthly and annual temperatures, and absolute maximum and minimum temperatures in each month for eight selected stations (Table 1).

The general Papadakis method consists of initially acquiring the temperature and moisture regimes and then determining the type of climate based on the respective information.

1- Temperature regime is acquired based on temperature status in winter and summer.

A- Winter temperature condition is acquired based on average minimum and maximum temperatures besides absolute maximum and minimum temperatures in the coldest month of the year (Table 2).

Table 1: Stations and their

Station	Elevation	Longitude	Latitude
Abadeh	2030	52.67	31.18
Fasa	1288.3	53.72	28.9
Lar	792	54.28	27.68
Neyriz	1632	54.33	29.2
Dorodzan	1620	52.43	30.22
Zarghan	1596	52.72	29.78
Lamerd	411	53.7	27.8
Shiraz	188	52.6	29.55

B- Summer temperature condition is derived based on frostless season, average maximum temperature in the warmest month of the year, and average of maximum temperatures of "n" warmest months of the year

Duration of frostless season is calculated in three forms; minimum: 7 °C, accessible: 2 °C, moderate: zero °C (the criterion for defining these three states is average monthly temperature minima), as presented in Table 2.

Table 2: Winter Types

Ecological feature	Average maximum temperature of coldest month	Average minimum temperature of coldest month	Absolute minimum temperature of coldest month	Type	
Minimal temperatures are suitable for oily palm, coconut, and kaocho	-	>18C	>7C	EC	1- Tropical crops
Frostless but too cool for oily palm, coconut, and natural rubber	>21C >21C >21C	13-18C 8-13C -	>7C >7C >7C	TP 1- Warm TP 2- Moderate TP 3- Cold TP	1- Tropical crops
Sufficiently suitable for citrus but is not frostless	>21C 10-21C	>8C -	-2.5-7C -2.5-7C	1- Arid ct 2- Ci citrus	1- Citrus
Winter is desirable for oat but isn't suitable for citrus	>10C 5-10C	>-4 -	-10 till-25C >-10C	1-Warmer Avena 2- Cooler Avena	1- Oat (Avena Sativa)
Temperate enough for winter wheat but unsuitable for oat	>5C 0-5C <0C	-	-29 till-10C >-29C >-29C	1- Wheat-oat(TV) 2- Warmer wheat (Ti) 3- Cooler wheat	1- Wheat
Insufficiently temperate for winter wheat; all crops are planted in spring	>17.8C <17.8C	-	<-29 <-29	Pr-1 Pr-1	1- Spring crops

Table 3: Summer types

Ecological feature	Average maximum temperature of warmest month of the year	Average maximum temperature of warmer "n" months	Duration of frostless season	Summer type
Summer is warm and long enough for cotton farming	>33.5 <33.5	n=6>25	>4.5minimum5	Warmer G cotton Cooler g
Nights are cool enough for growth of Arabic coffee	<33.5	>21 n=6	Minimum 12	Coffee
Photo-period and thermal conditions are suitable for rice culture but not for maize	-	21-25 n=6	Minimum>4	Rice
Rice is a marginal crop	-	>21 n=6	>4.5 accessible	Maize
Thermal conditions and photo-period are appropriate for wheat culture but not for maize. The conditions are not suitable for wheat but the warmth is sufficient for frost	-	n=6<21 n=4>17	accessible 2.5-4.5	HotterT wheat Coolert
	-	>10 n=4	>2.5 Accessible	Polar (Taiga)
Vegetation is tundra	-	>6 n=2	Accessible>2.5	Polar (Tundra)
Not permanently covered by ice; ice-cap climate	0> 0<	<6 n=2	2.5 Accessible 2.5 Accessible	F f Frozen
Frost prevents from forest vegetation; the conditions are convenient for meadow	-	>10 n=4	Accessible<2.5mean	Andean-Alpine

C- Temperature regime is acquired based on winter and summer types (Table 4).

D-

Table 4: Categories of temperature regimes in Iran

Summer type	Winter type	Definition	Subcategory	Main category
G,g	AV or colder	Warm	1CO	Continental
M,O	Ti or warmer	Semi-warm	2CO	"
t	Pr,pr	Cold	3CO	"
G,g	ct	Semi-arid	Ts	Subtropical
G	Ci, AV	Warm	Su1	"
g	ci	Semi-warm	Su2	"

2-To determine moisture regime of each station, the potential evapotranspiration rates were initially evaluated via the following formula. The simplest way to calculate evapotranspiration is the correlation proposed by Papadakis [QUOANTA, 1982]. This correlation is expressed as below:

E (=0.5625 ema-emi-2)

Where; ema and ema-2 respectively are saturation vapor pressures corresponding to maximum and minimum monthly temperatures (derived from Papadakis' special table), and 0.5625 is Papadakis' constant. In the next step, the monthly and annual Humidity Indexes were determined based on the ratio of rainfall to potential evaportranspiration (R/E). In stations having humid periods (R>E), leaching index

(Ln) was calculated in order to specify the type of months in terms of humidity conditions. The months of a year were divided into humid, moderate and dry types based on the relation between precipitation (rainfall), evaporation and water storage in soil. The relations are as follows:

1- Dry R+WS < 50/ Peu
2- Moderate R+WS > 50% Pex
3- Humid R >Pey

In the relations above, rainfall, water storage and potential evapotranspiration are represented by R, WS and Pet, respectively leaching indexes (Ln) was calculated in this way. For moderate and dry periods, (R+WS)-E=Ln; and for humid period; Ln = ∑ (R-E). In the subsequent step, type of moisture regime in each station was determined using the indices and thresholds defined in Table (5) (Separate tables were adjusted for determination of moisture regime in each station).

Table 5: Types of moisture regimes in Iran

Some of features	Subcategory	
LN>20%pet and HI<%88	ME(Moist)	Mediterranean
LN<20%Petand%22<HI<%88	Me(dry)	
Me Very dry for Me category	me (semiarid)	
HI<%9 All months with maximum daily temperature of over 15 have HI below 0.25; HI<9%	da (absolute)	
No sufficiently dry for da Winter rainfall>Summer rainfall	de(Mediterranean)	
Da, de, do are not placed in any of categories	(lsohygrous) di	Desert
Not sufficiently dry for da category; July-August dryness is less than April-May	do(monsoon)	

3-The climatic groups of stations (Table 6) were specified after determination of thermal and moisture regimes according to Tables (4 and 5). The codes up to the second digit correspond to Table (7). The first and second digits denote group and climate type in a certain group, respectively.

Table 6: Main climatic groups in Papadakis method

Moisture regime	Temperature regime	Main groups
HU, Hu, MO, Mo, mo	EQ, Eq, TR, Tr, tr, Tt, tt	1-Tropical
HU, Hu, MO, Mo, mo	TF, Tf, tf, An, an, aP, ap, aF	2-Tierra Fria
da, de, di, do	No limitation and the emphasis is on moisture regime	3-Desert
HU, Hu, MO, Mo, mo	Ts, SU, Su	4-Subtropical
St, Si, Mo, mo	PA, Pa, pa, TE, MA, Ma, ma, SU, Su	5-Pompeian
ME, Me, me	No limitation and the emphasis is on moisture regime	6-Mediteranean
HU, Hu	Mm, MA, Ma, ma, TE, Te, te, Pa, pa	7-Marine
HU, Hu, Mo	Co, Co, Co	8-Humid continental
St, Si, Mo, mo	Co, Co, Co, Po, Te, te	9-Steppe
Temperature regime is determining	Po, Po, Fr, fr, AL, al	10-Polar

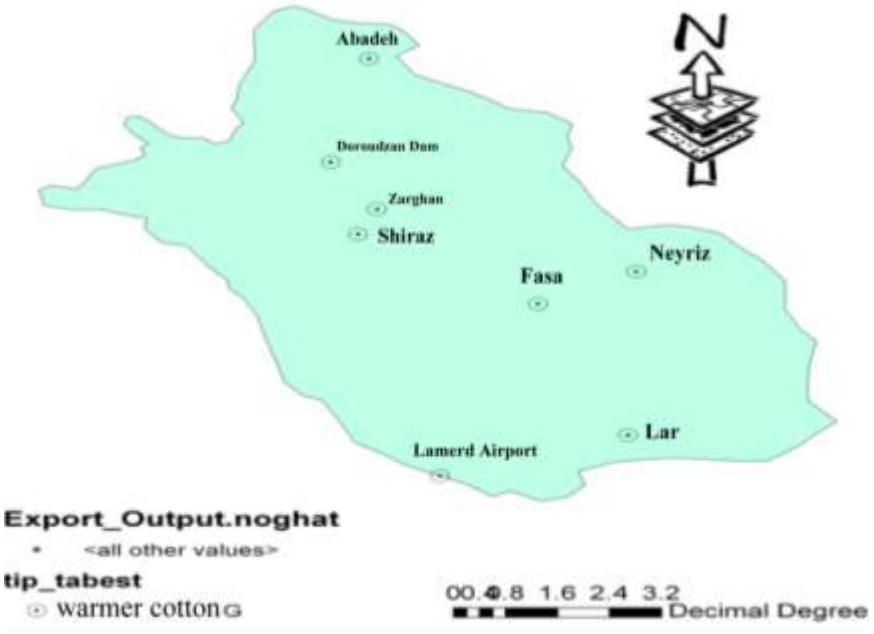
Table 7: Types of Mediterranean and desert climates in Papadakis method

Moisture regime	Temperature regime	Climate type
		6-Mediterranean
ME, Me	SU, SU	6-1- Subtropical
ME, Me	MA, Mm	6-2- Marine
ME	Ma	6-3- Cold marine
ME, Me	Tr	6-4- Tropical
ME, Me	TE	6-5- Temperate
ME, Me	Te, te, Po, Pa	6-6- Cold temperate
ME, Me	Co, Co, Co	6-7- Continental
Me	SU, SU, Tr, tr, MA	6-8- Semiarid subtropical
Me	Co, Co, Co, TE, Te, te	6-9- Semiarid continental
		3- Desert climate
Da, de, di, do	EQ, TR, tr	3-1- Hot tropical
Da, de, di, do	TS, Su	3-2- Hot subtropical
Da, de, di, do	Eq, Tr, tr	3-3- Cool tropical
Da, de, di, do	SU, MA, Mm	3-4- Cool subtropical
Da, do	Tt, tt, TF, tf, An, an	3-5-Low-latitude elevated
Da, de, di, do	Co, Co, Co, te	3-7- Continental
Da, de, di, do	PA, TE	3-8- Pompeian
Da, de, di, do	Pa, pa	3-9- Pathogenic

RESULTS AND DISCUSION

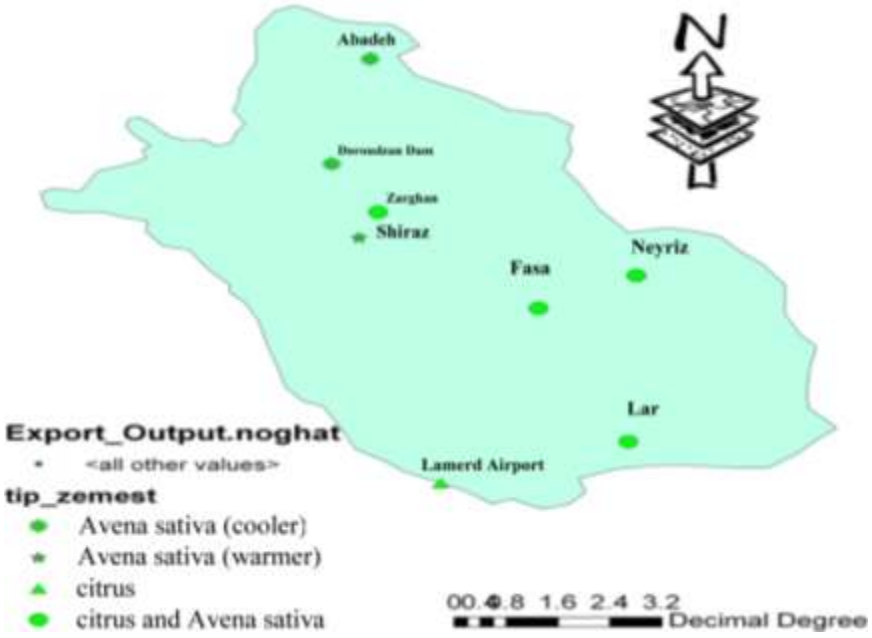
The findings of the current study are summarized in Table (9, 10). In this table, moisture and temperature characteristics of each station and climatic categories and subcategories are provided along with features of each climatic type.

1- ***Summer conditions*:** As observed in Map (1), all stations have been classified in cotton category in terms of summer conditions. Therefore, Fars Province is suitable for planting cotton.



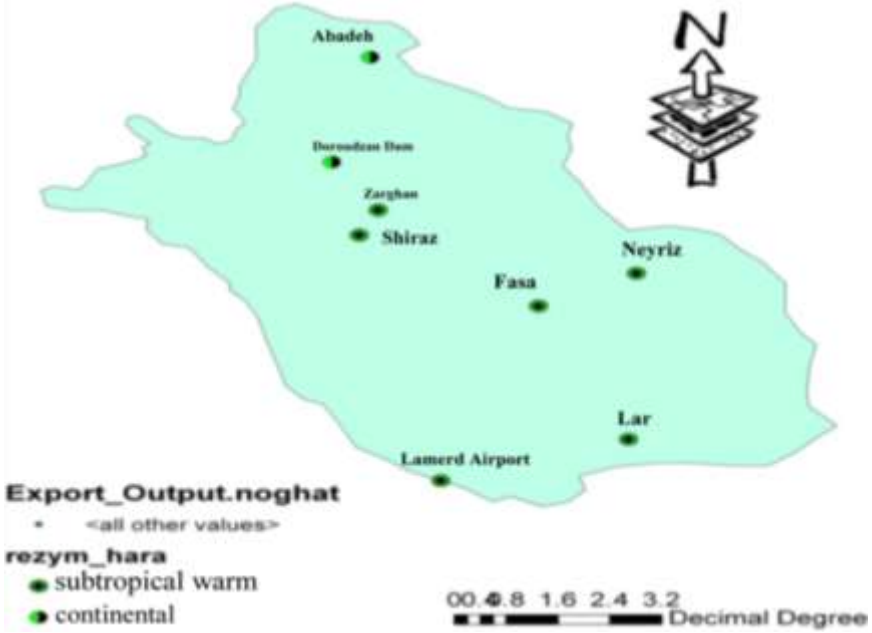
Map 1: Summer type based on Papadakis method

2- ***Winter conditions:*** As illustrated in Map (2); Abadeh and Doroudzan Dam are classified in cooler oat (Avena sativa) group, Shiraz in warmer oat group; Zarghan, Neyriz, Fasa and Lar in circus and warmer oat group and Lamerd in citrus group.



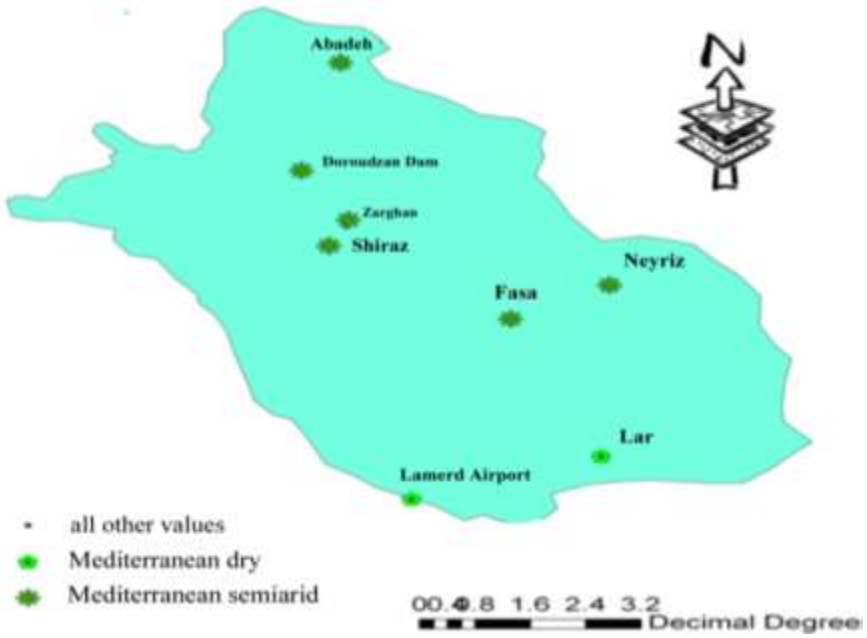
Map 2: Winter type based on Papadakis method

3- ***Temperature regime:*** According to Map (3), Fars Province is divided into two temperature regions based on Papadakis method, which include: 1- Warm subtropical (Lamerd, Lar, Fasa, Neyriz, Shiraz and Zarghan); 2- Warm continental (Doroudzan Dam and Abadeh)



Map 3: Temperature regime based on Papadakis method

4- ***Moisture regime:*** According to Map (4), Fars Province is divided into two moisture regions including: 1- Dry Mediterranean(Lar,lamerd) 2- Semiarid Mediterranean (Fasa, neyriz, Shiraz, Zarghan, Doroudzan Dam and Abadeh)



Map 4: Moisture regime based on Papadakis method

5- ***Seasonal humidity index***: Frequencies of dry, moderate and humid seasons of each station are presented below (Table 8).

Table 8

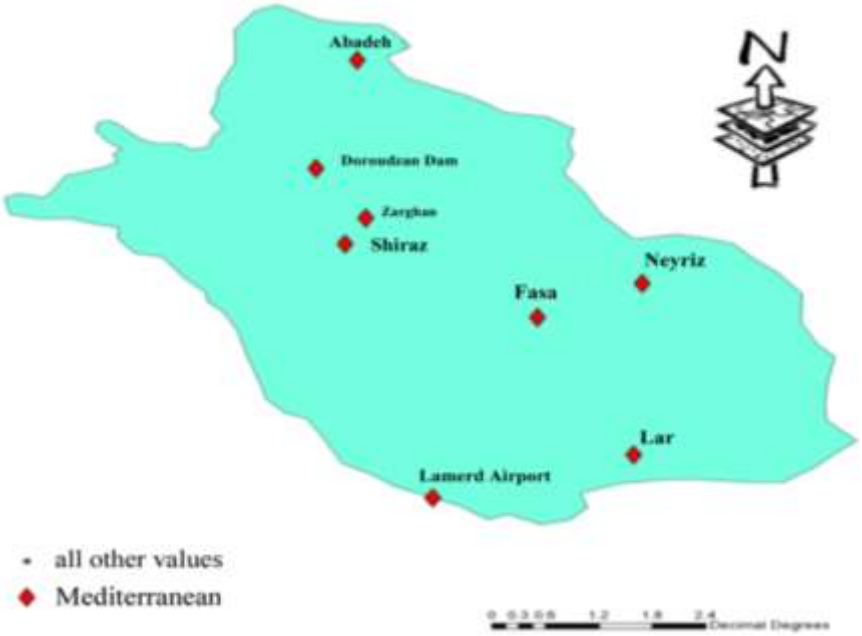
Station	Humid Season	Moderate Season	Dry Season
Abadeh	2	1	9
Fasa	4	0	8
Lar	2	2	8
Neyriz	2	1	9
Doroudzan Dam	4	2	6
Zarghan	4	0	8
Lamerd Airport	1	2	9
Shiraz	4	0	8

1- ***Climatic categories:*** All stations under study are classified in one main category and 3 subcategories, namely: Continental Mediterranean, Subtropical Mediterranean and Semiarid Subtropical Mediterranean (Maps (5) and (6)). In this technique, type of climate in a station is determined knowing its moisture and temperature regimes.

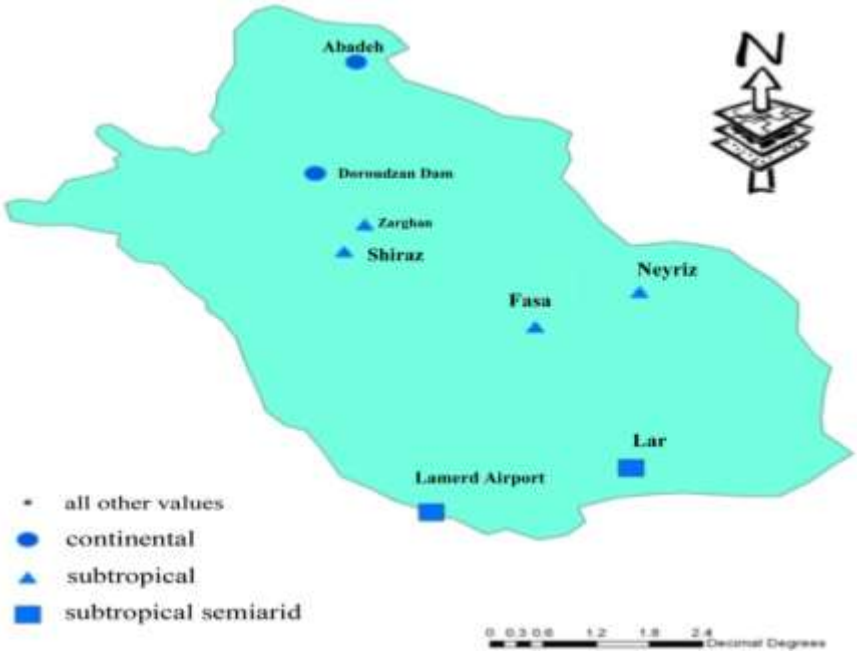
Subtropical Mediterranean Climate

In this climatic domain, good crops can be produced for winter non-irrigated cultures such as wheat, oat, beans, peas and so on besides garden products including olive, grape, fig and peanut as well as irrigated products such as cotton, citrus, cold-weather fruits and variety of early and delayed-culture vegetables. If winter is a part of Ci, citrus and various early and delayed-culture vegetables can be appropriately grown. If the dry month starts from March, even wheat will need irrigation. If the dry season begins from May,

non-irrigated culture, except for wheat, will face problems. Some maize cultivars produce crops without irrigation. Fasa, Neyriz, Zarghan and Shiraz stations belong to this climatic group.



Map 5: Climatic group based on Papadakis method



Map 6: Climate type based on Papadakis method

Continental Mediterranean Climate

Winter cereals (wheat and stuff) are regarded as major non-irrigated crops in this climatic group. Abadeh and Doroudzan Dam belong to this group.

Table 9

Station	latitude	longitude	elevation	Annual precipitation	Annual temperature	Duration of frostless season	Humid season	Dry Season
Abadeh	31.18	52.67	2030	143.4	14.8	4.5< At least	jan-des	mar
Doroudzan Dam	30.22	52.43	1620	516.9	17.6	4.5< At least	jan-feb-mar-des	Apr-nov
Fasa	28.9	53.72	1288	301.7	20.6	4.5< At least	jan-feb-mar-des	0
Lar	27.68	54.28	792	225.5	25.1	4.5< At least	jan-des	feb-mar
Neyriz	29.2	54.33	1632	204.9	-	4.5< At least	jan-des	feb
Zarghan	29.78	52.72	1596	360.2	18.3	4.5< At least	jan-feb-mar-des	0
Lamerd	27.3	53.11	411	237.1	26	4.5< At least	jan	Mar-des
Shiraz	29.55	52.6	1488	344.2	17.6	4.5< At least	jan-feb-mar-des	0

Table 10

Station	Dry Season	Humidity Index	Winter Type	Summer Type	Temperature Regime	HumidityRegime	Climatic Group	Climate Type
Abadeh	Apr-may-june-july-aug-sep-oct-nov-feb	0.23	Tv	G	CO1	(Medry)	Mediterranean	Continental
Doroudzan Dam	May-june-july-aug-sep-oct	0.88	av	G	CO2	(Medry)	Mediterranean	Continental
Fasa	Apr-may-june-july-aug-sep-oct-nov	0.33	AV	G	SU1	(Medry)	Mediterranean	subtropical
Lar	Apr-may-june-july-aug-sep-oct-nov-feb	0.2	AV	G	SU1	(me semiarid)	Mediterranean	Semiarid subtropical
Neyriz	Apr-may-june-july-aug-sep-oct-nov-feb	0.3	AV	G	SU1	(Medry)	Mediterranean	subtropical
Zarghan	Apr-may-june-july-aug-sep-oct-nov-feb	0.47	AV	G	SU1	(Medry)	Mediterranean	subtropical
Lamerd	Apr-may-june-july-aug-sep-oct-nov-feb-feb	0.19	Ci	G	SU1	(me semiarid)	Mediterranean	Semiarid subtropical
Shiraz	Apr-may-june-july-aug-sep-oct-nov-feb	0.44	AV	G	SU1	(Medry)	Mediterranean	subtropical

Semiarid Subtropical Mediterranean Climate

In this climate, winter cereals are remarkably damaged by drought. In places where dry season starts from May, wheat and other cereals produce good amount of crops without irrigation, and in the case that the dry season starts from April, these crops suffer damage. Culture will not be possible without irrigation if the dry season begins from March or sooner. Good deal of crops can be produced with irrigation for variety of winter products, cotton and other summer cultures as well as various cold-climate fruits and vegetables. Lar and Lamerd belong to this climate category.

REFERENCES

HODJATIZADEH, Rahim (1992). Climatic Zonation of Iran, Master Thesis in Geography, University of Tehran.

Ramezani, Bahman (1997). *Agricultural Climatology, Iran's Meteorology Organization* (Gilan University's Publications).

Azizi Qasem (2001). Cultivar Classification of Selected Climatic Stations in Iran using LITIN ESXES Method. *Geographic Research* **41** 37-51.

Alijani, Bohloul and Kaviani, Mohammadreza (1992). *Principles of Climatology* (SEMAT Publications).

Farajzadeh Manowchehr and Taklobighash AbbasS (2001), Agroclimatic Zonation of Hamadan Province using Geographic Information System. *Journal of Geography Researches*, **4** 93-105.

Fesharaki, Paridokht (1990), Glossary and Terminology of Natural Geography.

Kuchaki, Avaz and Khazanehdari, Leili (1997). Climate and Agricultural Geography. *Quarterly of Geographic Researches* **40** 56-71.

Quanta (1982), *Agricultural Meteorology Studies* (Iran's Meteorology Organization) (Gilan University's Publications) **1**.

Burgos (1995). *World Trend in Agro Climatic Surveys* (UNESCO).

FAO (1993). Agro-ecological assessment for national planning: the example of Kenya.

Gates D (1993). *Climate change and its biological consequences* (Sinauer Assocates Inc) 150-161.

Kenny G *et al.*, (2000). Investigating climate change impacts and Thresholds. *Climate change* **46** 91-113.

Lambers RH and *et al.*, (2001).Vegetation pattern formation in semiarid grazing system. *Ecology* **82** 50-61.

Lenka D (1998). *Climate, weather and crop in INDIA (*Kalyani publishers).

Mavi HS(1990). *Introduction to agro meteorology* (oxford and IBH publishing co). 211-219.

Minnen J *et al.*, (2000). Deriving and applying response surface diagrams for evaluating climate change impacts on the crop production. C*limate Change* **46** 317-338.

Papadakis J (1996). Climate of the world and their agricultural potentialities, Buenos Aires.pp.1-48.

Parry ML (1998). *The impact of Climate variations on agriculture* (Kluwer Academic Publisher) 473-482.

Prentic K (1990). Bioclimatic distribution of vegetation for GCM studies, *Geophysics research*, 1181-11830.

Prentic K and fung L (1990). The Sensitivity of terrestrial carbon storage to climate change. *Nature* **346** 48-54.

Sivakumar M and *et al.*, (1993). *Agroclimatology of West Africa: Niger (*ICRISAT) 5-25.

UNESCO (1995). *Agroclimatological method, proceeding of the reading symposium* 211-220.

Yates D *et al.*, (2000). Comparing the Correlative Holdridge Model to Mechanistic Biogeographical Models for Assessing Vegetation Distribution Response to Climatic Change. *Climatic Change* **44**(1-2) 59-87.