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Research Article

DETERMINATION AND PREDICTION OF DROUGHT BY NORMAL Z AND DROUGHT ZONING BY GIS IN LARESTAN

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ABSTRACT
Drought is a climate phenomenon with considerable environmental, social and economic effects. The difference between drought and other natural disaster is in such case that it is complicated accurately determining its beginning and ending date. The drought is slowly being developed and its effects might be remained even after years. Studies indicate that the damages from drought are higher than other natural disasters. Therefore, it is inevitable extensively monitoring it and making a warning and precaution system in the regions susceptible to drought. This study investigated the drought in Larestan according to meteorological data collected during 18 years (1991- 2008) and based on climate factor, i.e. precipitation, by using Excel. The spatial and temporal model of meteorological drought has been determined by using the dimensionless measure and mobile mean of dry and wet years by using the meteorological stations of Ministry of Power. High evaporation and low moisture are the most important factors playing role in the drought of Larestan; low precipitation in this region forced people to increase the ground water usage. As we know, our country has been located next to the equator, for this reason, its temperature is high during summer. The type of the land in this region and removal of excess ground water in this region caused water table loss despites damaging and losing a main water source followed by lands leakage. Climate conditions, low precipitation, reduced surface waters, water salinity all caused drought and depressing the agricultural lands, certainly accelerated by interference of traditional and primitive animal husbandry.

Keywords: *Drought, Precipitation, Larestan, Interpolation, GIS*

INTRODUCTION
Tropical and sub-tropical climate has covered wide part of internal lands and southern and eastern sides of Iran. These desert areas comprise about 4.1 area of Iran. All regions through the world may occasionally encounter with drought, however this situation could be more seen in the regions irregularly and accidentally influenced by different climate systems (Raziati *et al.*, 2003). The main appearance of meteorological drought is reducing the precipitation lower than its normal level (long term mean). Reduced soil moisture and surface and ground waters are among further outcomes of the low precipitation. Due to its spatial situation, Larestan encountered with successive droughts such that its drought period is higher than wet period and this influences on reducing the agricultural products and water as well as increased desertification and losing the pastures and natural vegetation. Sever limitation of water sources in this area followed by increased demand for water on one side and occurrence of abundant drought for longer period, on the other side seriously complicated the water shortage. Determining the properties of drought or precipitation in a region is one of the fundamental needs for environmental and economic planning particularly planning for limitations of water sources. In most long term plans, it is necessary to draw a perspective from the future situation of precipitation and drought periods for the region. For this reason, the issue of predicting the drought and its properties is very important particularly in the water sources management.
By emergence of drought that is one of the climate properties of the region, there will be made many complications in the region as well. Climate fluctuations and occurrence of alternative droughts and precipitation are among main issues in the study of natural phenomena and is one of the discussions in the meteorology and other environmental sciences considered by specialists. Although climate considered as

the general and almost stable situation of atmosphere in a region, however such stability is relative and might change the climate of the region with different climate by drought and precipitation during different years (Alijani, 1996).

Drought is one of the climate properties of the region that couldn't be easily predicted and traced. The reasons for complicated determination and tracing the drought include: (1) it is slowly developing with uncertain beginning and ending; (2) its definition isn't accurate and isn't common (due to different variables directly and indirectly interfering on the drought emergence, there hasn't been provided a general and acceptable definition by researchers with various definitions for it based on different fields); (3) its effects are non-structural and mostly developed in wide area (Hisdel and Talaxen, 2000).

Occurrence of drought in both dry and wet regions is inevitable; however, by tropical and sub-tropical climate of Iran, it is more likely to have drought in this region. Drought is among natural phenomena related to meteorology and hydrology and influencing on environmental parameters and activities related to agriculture, vegetation, human life and wildlife as well as local and national economy and mostly accelerated by agricultural, animal husbandry and industrial activities of the man. For this reason, according to the a wide study on the definition of drought provided by World Meteorological Organization (WMO), droughts could be classified as below: (1) precipitation; (2) combination of precipitation and temperature, moisture and or evaporation; (3) soil moisture and or parameter of the crop; (4) climate factors and estimations of evapotranspiration; (5) general tendencies and definitions (Jiasilan, 2005).

During recent decades, Iran has suffered alternatively from droughts. Occurrence of drought has considerable effect on environmental conditions, human societies and generally environmental ecology. As combating with any devastating natural phenomenon is impossible without general knowledge about it, it has been studied by specialists in different fields and by different approaches and view. The objective of such studies by any approach and technique is accessing to a comfortable, cheap and accurate solution in different phases including precaution, preparation and prevention against damages from drought as well as detecting the reasons for occurrence of abnormalities in the climate system. Therefore they have been studied by various approaches such as statistical, synoptic, artificial neural networks and GIS data (Azizi & Shamsipour, 2006).

During recent years, there have been used different approaches including multi-variable statistical methods (Zehtabian *et al.*, 1999, Moses *et al.*, 1999, Vafakhah & Mahdavi, 1999, Alijani & Ramazani, 2002; Azizi & Shamsipour, 2006); Synoptic methods (Khoshakhlag, 1997; Azizi, 1999; Nazem Al-Sadat, 1999) and Geographical Information System (GIS) (Farajzadeh, 1996; Mohammadi & Shamsipour, 2003 & 2005) for studying the droughts.

Arbabi and Bayat (2001 & 2002) also studied the influence of drought in Qazvin desert and Damavand on ground waters. This study has used of multi-variable statistical method and GIS; for this reason, there has been determined the Normal Precipitation Indicator, Z, for determining the spatial and temporal patterns of drought with determining the drought periods in the region.

MATERIALS AND METHODS

Precipitation is the most important variable studied for climate and drought issues; in this study, the annual and seasonal average precipitation of studied stations during 1991 to 2008 has been used for analyzing the drought by using Normal Z factor. For calculating the intensity of climate drought, there was selected Normal Z factor by which the precipitation was calculated in annual and seasonal scales.

$$z = \frac{x_i - \overline{x}}{\delta}$$

Where, z is the normalized drought factor; x_i is the variable for year or season of study; $\overline{x}$ is the long term mean of climate variable and standard deviation. Z factor is a standard of statistical coefficients and is one of the main normal factors dealing with the possibility of occurrence or non-occurrence of drought. In z factor, coefficients are determined according to table (1).

Table 1: Normalized precipitation factor for calculating the precipitation (Larestan Station)

year	November	December	January	ZNovember	Z December	ZJanuary	Average
1991	120	39.9	73.3	1.9	-0.2	0.5	**0.7**
1992	23.2	261.9	270.7	-0.2	3.5	3.6	**2.3**
1993	0	15	6.7	-0.7	-0.6	-0.6	**-0.6**
1994	6.6	0	63.8	-0.6	-0.8	0.3	**-0.3**
1995	141.9	96.1	41.1	2.3	0.8	0	**1**
1996	0.6	16.7	47.8	-0.7	-0.5	0.1	**-0.4**
1997	17.4	61.7	81.9	-0.4	0.2	0.6	**0.2**
1998	0	32	29.8	-0.7	-0.3	-0.2	**-0.4**
1999	0	20.8	0	-0.7	-0.5	-0.7	**-0.6**
2000	66.1	10.1	0	0.7	-0.6	-0.7	**-0.2**
2001	13.4	68	3	-0.4	-0.3	-0.6	**-0.3**
2002	26.1	22.4	12.5	-0.2	-0.4	-0.5	**-0.4**
2003	18.9	32.1	19.1	-0.3	-0.3	-0.4	**-0.3**
2004	65.4	110.1	44	0.7	1	0	**0.6**
2005	0	17.4	3.6	-0.7	-0.5	-0.6	**-0.6**
2006	109.1	13.2	48.4	1.6	-0.6	0.1	**0.4**
2007	0	55.7	21.5	-0.7	0.1	-0.3	**-0.3**
2008	0	11.4	0.2	-0.7	-0.6	-0.7	**-0.7**

Introduction to Area under Study

Fars province has been located in the south, south west of the country between longitudes 50^{o} 36’ to 55^{o} 35’ eastern and latitudes 27^{o} 03’ to 31^{o} 40’ northern.

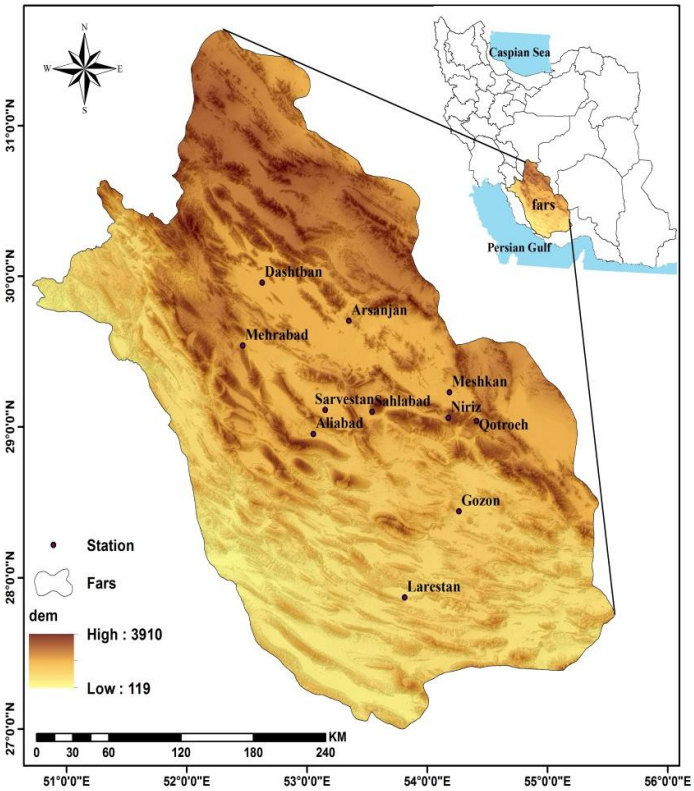

Figure 1: The situation of studied station area (Arbabi, Bayat)

With area of 133000 km^2 (8.1% total area of the country), Fars province has been located between Isfahan, Yazd, Bushehr, Kohkiloyeh and BoyerAhmad, Hormozgan and Kerman, with Shiraz is its province center with distance of 1088 km to Tehran. Larestan town has been located between 27^o 60' to 28^o 25' N and 52^o 25' to 55^o 38' E from Greenwich meridian. This town has been located at the south of Fars province ended to Jahrom from the north, Darab and Zarindasht from the eastern north, Firoozabad, Firoozkarezin and Khanjfrom western north, and Hormozgan, Lamard and Mehr from the south, Lamard and Mehr from the west and Fin district of Bandarabbas from the east.
With area of 18 thousand square kilometer, Larestan is the widest town in Fars comprising about 17% of total area of the province. Figure (1) the situation of studied station area.

Meteorological Data

Meteorological data used in the study 11 stations of Ministry power included of LARESTAN, sarvestan, Neyriz, Meshkan, Sahl Abad, Qatruyeh, Ali Abad, Gozon, arsanjan, Dashtban, Mehrabad in the region is obtained. (Data based stations during the period of the year (1387-1370) period of 18 years the spatial distribution and reliability of statistical data in the study area were selected. In the actual data source in this study is selected stations of Ministry power. Precipitation has been review and analysis monthly, quarterly and annually (table (2).

Table 2: Selected stations in the study area

Pos.	station	organization	Height (meter)	Longitude	Latitude
1	Larestan	Ministry of Energy	800	53.81	27.92
2	sarvestan	Ministry of Energy	1357	53.13	29.16
3	neyriz	Ministry of Energy	1357	54.18	29.11
4	meshkan	Ministry of Energy	2215	54.19	29.28
5	sahlabad	Ministry of Energy	1585	53.53	29.15
6	ghatroye	Ministry of Energy	1605	54.42	29.9
7	Ali abad	Ministry of Energy	1352	53.3	29
8	Gozon	Ministry of Energy	1239	54.27	28.49
9	Arastjan	Ministry of Energy	1648	53.18	29.54
10	Dashtian	Ministry of Energy	1345	52.58	30
11	Mehrabad	Ministry of Energy	1616	52.42	29.58

Studying the Situation of Drought in the Station of Study Area by using Normal Z Approach

The meteorological data used in the study obtained from 11 stations of Ministry of Power including Larestan, Sarvestan, Neyriz, Meshkan, Sahlabad, Ghatrouyeh, Aliabad, Gozon, Arsanjan, Dashtban, and Mehrabad (table (3).

Table 3: Precipitation

year	Larestan	Sarvestan	Neyriz	Moshkan	Sahlabad	Ghatruyeh	Aliabad	Gozon	Arsanjan	Dashtban	Mehrabad
1991	263.6	283	205.5	304	257	186	276	391.4	336	393	393.5
1992	634.1	491	370	497	511.5	361.5	481	719.6	523.5	591.5	563.1
1993	107.3	215	142	236	186.6	174	192.5	210.2	222.5	199.5	207.5
1994	164.2	336	335	381	371	290	434.5	407.9	498	618.5	560
1995	597.3	445	395.5	337	418	407	550.5	617.5	499	567.5	622.5
1996	247.5	180	191.5	351	181.5	140.1	212	240.4	227.5	291.5	278.5
1997	291.91	302.5	161.5	324	203	35.7	321	367.7	398.5	504.6	494.5
1998	144.5	237	246	301	294.5	203.3	269.5	398.6	365	314	384.5
1999	25.1	140	96	172	127	72.1	207	155.7	186.5	201	218.4
2000	98.11	166	100	206	162	102	197.5	201.9	192.5	211.5	263.2
2001	117.11	295.5	185.5	343	220.5	116	315.5	267.7	447	491.5	517.9
2002	141.5	238.5	182.5	326	214	224.7	287	338.2	290.5	328.1	351.2
2003	169.9	283	284	398	320	294.3	408.5	387.5	418	426	449.7
2004	279.2	339.5	298	424.5	286.5	290.8	526.5	468.1	489.5	544.5	531.3
2005	38.9	207.1	159	242	168.5	147	224	182.7	225	356	352.5
2006	191.91	218.5	204	292.5	201.5	217	317.5	322.9	333.5	348	395.6
2007	151.9	101	41	100	60.5	43.3	99	124.6	79	96.5	108.4
2008	24.31	125	144.5	246.5	195	164.8	148.5	223.1	169	201	218.6
Temporal rainfall	204.91	255.76	207.86	304.53	237.70	192.76	303.78	334.76	327.81	371.34	383.94

The stations have been selected based on the statistical period from 1991 to 2008, i.e. a 18 years period with local distribution in the study area and reliability of the statistical data and were used for this study. In the actual ground data that their source in this study is the stations selected by Ministry of Power, the variable precipitation, on monthly, seasonal and annual based have been studied and analyzed.

According to table (4), precipitations through the province are irregular with high variability; this indicates the governance of dry climate and occurrence of many droughts with high densities. Table (4) indicates the coefficients of Z factor in the precipitation of study stations.

Table 4: Precipitation indicators of selected stations in the study area

Index boundary	concept
less than -100	Very dry
-100 to -50	dry
-50 to 50	normal
50 to 100	wet
More than 100	very wet

Investigating the Drought Zoning in the Study Area

As indicated in Figure (2), there has been formed a high precipitation core at December in Larestan station with higher precipitation than northern stations; and stations located in the east of the region, i.e. Moshkan, Neyriz, Ghatrouyeh and Gozon have least precipitation than the stations of the study area.

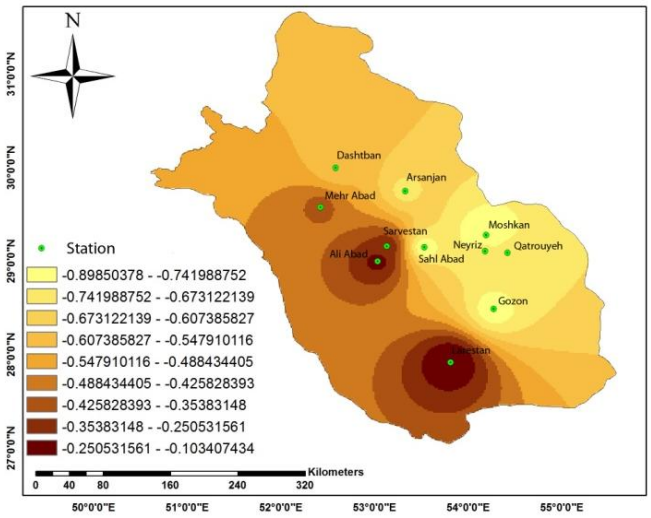

Figure 2: Drought zoning of the study area at December (Arbabi, Bayat)

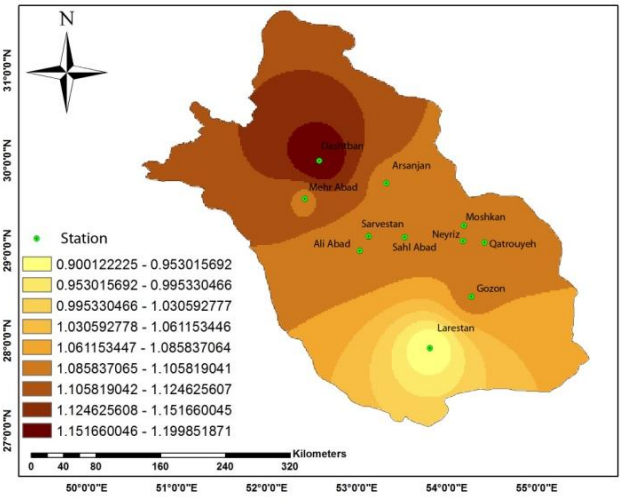

Figure 3: Drought zoning of the study area at January (Arbabi, Bayat)

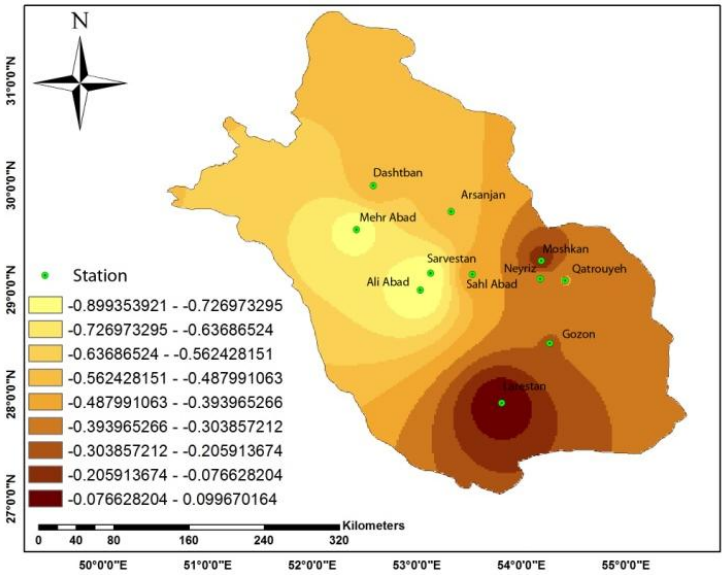

Figure 4: Drought zoning of the study area at February (Arbabi, Bayat)

According to Figure (3) indicating the drought zoning in the region, at January, according to the drought zoning by movement from the north to the south of the province the precipitation will be reduced and Larestan station has received minimum precipitation than other stations under study. Northern stations such as Dashtban and Mehrabad have higher latitude followed by increased precipitation.

According to Figure (4), at February, precipitation has been reduced in all stations with average to severe drought almost in the north and center and western north of the region and Larestan, Meshkan and Neyriz and Gozon had wet conditions in this period.

After calculating the index of normal precipitation percentage of the stations for analyzing the region, there was used of standard distribution of table (5) for indicating the trend of drought.

Table 5: Index for dimensionless measure of Larestan Station

year	Larestan	Percentage	Quantitative description
1991	263.3	34.53	Normal
1992	634.1	252.47	Very wet
1993	107.3	-574.1	Dry
1994	164.2	-23.94	Normal
1995	597.3	230.82	Very wet
1996	247.5	25.06	Normal
1997	291.91	51.18	Wet
1998	144.5	-25.53	Normal
1999	25.1	-105.76	Very dry
2000	98.11	-62.82	Dry
2001	117.11	-51.64	Dry
2002	141.5	-37.29	Normal
2003	169.9	-20.59	Normal
2004	279.2	43.71	Normal
2005	38.9	-97.65	Dry
2006	191.91	-7.64	Normal
2007	151.9	-31.18	Normal
2008	24.31	-106.23	Very dry

Table (6) indicates the average drought and precipitation periods and current trend of related stations. According to following map, the length of the drought period in the stations is more than precipitation period except Mehrabad, Arsanjan and Meshkan where the number of precipitation period is higher.

Table 6: Average drought and precipitation periods and current trend of the stations

Station	Length of wet	Length of Drought	Current Process
Larestan	6	12	Drought
Ali Abad	8	10	Drought
Gozon	9	9	Drought
Ghatrouyeh	9	9	Drought
Mehr Abad	10	8	Drought
Arsanjan	10	8	Drought
Dashtban	9	9	Drought
Dahl Abad	6	12	Drought
Moshkan	11	7	Drought
Neyriz	8	10	Drought
Sarvestan	8	10	Drought

CONCLUSION

Conclusion and Recommendations

Environmental threats are among factors confining the development. These threats have different effects based on the intensity, frequency and ranges influencing on development. Some of such threats such as flooding and earthquake have low frequency and high intensity with extended depth at the center of the event and according to the distribution theory, the more they are closer to the center of the event, the more they be influenced by the event.

According to its properties, drought as a climate phenomenon has wide geographical range, higher frequency and severe influence. Due to their quick effect on water source, vegetation, supplying potable water, irrigation water followed by food and industrial sources, natural disasters has wider effects than other threats.

Drought is considered as a main problem for tropical and sub-tropical areas; while study area has been located in the south and eastern south of Fars with a tropical nature.

According to the first theory, there is a significant correlation between Normal Z factor of precipitation and precipitation rate as a climate indicator. During the years that the precipitation and moisture has been reduced, the Normal Z Factor was negative followed by increased drought and reversely during the years with increased precipitation and moisture, the Normal Z Factor was positive. Reduced precipitation is the most important factor for creating the drought in the study area.

Meteorologically, Larestan is classified among hot and dry weather and it has temperate winters and very dry and hot summers. Maximum annual precipitation is related to January and February with the property of precipitation during these months has low intensity and longer precipitation duration mostly resulting in formation of seasonal flooding and runoff, however, July and August indicate minimum precipitation followed by high intensity and shorter period of precipitation. According to second theory, precipitation in this town is dispersed and in some periods the precipitation is high and other periods with low precipitation. As Larestan has been located in a high pressure region close to the tropical area, it suffers dispersed precipitation.

The soil moisture in this area is low with high evaporation and this caused unsuitable soil for agricultural purpose and most plants growing in this area are among drought-resistant plants and forage plants and these forages are suitable for livestock and it might be another reason for draught.

The quality of the soil in Larestan isn't desirable; presence of a few salt domes in different regions caused salinity problem in the region. In the regions that seems to have suitable quality of soil and water, the lab analysis even indicate its low quality. Low precipitation and dry air caused depression of vegetation.

Overall, as the precipitation is very low in the region and precipitations are also in specific periods during the year, and land has lower potency to absorb the water, therefore it cause flooding followed by lowest absorption rate in the soil and this caused a factor to reduce the penetration of moisture in the soil with reducing the vegetation.

Promoting the public awareness along with proper and optimal access to the potable water sources are among other plans that could be effective for combating with and reducing the effects of draught.

Evaluating the national plans for combating with draught are among actions must be taken in this field with modifying the defects and shortages. As indicated before, draught is a repeating phenomenon, for example during two recent decades, our country experienced 13 years of draughts with different intensity and weakness; therefore, it is vital to revise the plans for combating with draught for improving the approaches and plans for fighting with future draughts.

Dry climate of Larestan with low annual precipitation, reduced the possibility of harvesting the agricultural products. Presence of uncultivated lands with sparse vegetation against climate precipitations provides different reflection with lands having dense vegetation. On the other hand, dense vegetation may reduce the intensity of runoffs with reducing the flooding in the area.

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