Drought Categorization on the basis of Climatological Components in Sistan& Balouchestan Province (Comparison between north and south of province)

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Abstract: Drought is one of the most dangerous natural misfortunes that influences on human society more than others. There are various Meteorological Drought Symbols to study drought. Although there isn't any absolute preference between these symbols but since each symbols has been synthesized for a specific aim, it might be various results based on being or not being drought, then some of them are better for specific areas and applications. Drought is a Meteorological phenomenon that can be found not only in arid and semiarid areas but it can be also found in the moist areas. Then, it is necessary to study on Drought scientifically to decrease effects of Drought. Since Drought can be considered as a hydrologic phenomenon, it should be used Hydrologic Phenomena Methodology to study. Hydrologic Drought is associated to significant decrease of water level of lacks, rivers, reservoirs, etc and Agricultural Drought is a position that moisture content in the soil isn't enough for products. Meteorological Drought is a position that real precipitation is lesser than expected precipitation in the area. If this Drought is continued, it will be led to Hydrologic Drought and Agricultural Drought. It is clear in the controlled area, i.e. Sistan& Balouchestan Province. In this study, Place and Time Patterns, Meteorological Drought Methodology in Sistan& Balouchestan Province are determined and categorized by Interpolation of Normal Z, Rainfall in Geographical Information System (GIS). Climatology of Meteorological Organization and Ministry of Energy will be also determined by using dimensionless criterion method and variable average of dry and wet years during statistical period. on the basis of results from categorizing drought, it found that Drought decreases from north to south and precipitation has been changed each year. Chabahar Station doesn't follow on the given theory and its humid is provided by the sea and doesn't need to ascending factor in the precipitation mechanism. But in other stations, it follows on Convectional Factor that experienced the most frequency and also high level disturbances that are the most plenty of ascending mechanism.
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1. Introduction

Arid and semiarid climates have covered wide area of internal lands, southern and eastern boundaries of Iran. These deserts and arid areas have involved about 1/4 of Iran. All of areas may be affected by Drought Phenomenon but this case is found in the areas where affected on different climate systems accidentally and irregularly, more than other areas (Raziati et al, 2003). The main appearance of emerging Meteorological Drought is to decrease rainfall to the lowest normal limit (long term average). Decreasing soil moisture and surface water and groundwater are the next results from decreasing rainfall. Kerman Province is located on the drought climate successively. On one side, time of drought period is longer than wet period, on the other side, intensity of we years is more than dry year. This case influences on decreaseing agricultural products and water and increasing deserts and drying pastures and natural herbal covers. Limitation of water resources of the considered province, increasing demand of water, on one hand, occurring drought in more frequency and in the longer period, on the other hand, have been caused that low water problem threatens this province seriously. It is necessary for environmental and economical planning to determine dry and wet year features in an area. It is necessary to draw a perspective of future rainfall condition and dry and wet years in many long-term plans. Because of that, it is important to predict drought and its features especially to manage water resources.

This Drought Phenomenon will cause many problems in the above-mentioned area. Climate fluctuation, alternative dry and wet years are the impotent subjects to study natural phenomena and it is one of the subjects of climatology and other environmental science that are considered by the specialists. Although, climate applies for general and approximately stable condition of weather in an area but this stability is relative and it may be changed during different years (Alijani, 1996)

Drought Condition is one of the environmental risks that cannot be predicted easily because 1) it is extended slowly 2) it isn't defined exactly and it isn't

generalized (because there are different varieties that interfere in Drought Phenomenon directly and indirectly, it isn't provided any general and reasonable definition for the researchers and researchers in different fields believe that the given definitions have specialty aspect) 3) its effects are nonstructural and it is often extended in a wide area. (Hisdal & Tallaksen, 2000)

Drought Phenomenon is inevitable in both arid and humid areas but it is possible to be drought more than other conditions because Iran is suffered by arid and semiarid climate. Drought Phenomenon is one of natural phenomena that related to meteorology and hydrology. It affects on environmental parameters and activities that related to agriculture, herbal cover, and human's life, and wild life, local and national economy and it can be aggravated by agriculture and animal husbandry. On the basis of it and an extensive study on drought by World Meteorology Organization, the drought conditions are categorized on the basis as follow: 1) Rainfall 2) combination of rainfall and temperature, humidity and evaporation 3) soil moisture and parameter of product 4) climate indices and evaluations of evaporation and transpiration 5) definitions and general branches (Jiasilan, 2005)

In the recent decades, Iran has been affected by drought conditions alternatively. Drought Phenomenon influences on environmental condition, human communities and generally environmental ecology seriously. It is necessary to know this natural phenomenon to overcome, and then specialists have considered it in different views and methods. The aim of these researches is to obtain easy, cheap and precise solution in different phases of notice, preparation and prevention against any losses from drought condition and also to find the reasons of available disorders in the climate systems. Therefore, it has been studied in various methods such as statistic, synoptic, artificial neural network and remote sensing, etc. (Azizi & Shamsipour, 2006)

In the recent years, multivariable statistic methods (Zehtabian et al, 1999, Moussa et al, 1999, Vafakhah and Mahdavi, 1999, Alijani and Ramezani, 2002, Azizi & Shamsipour, 2006), synoptic method (Khoshakhlagh, 1997, Azizi 1999, Nazem Alsadat, 1999), Geographical Information System (Farajzadeh, 1996, Mohammadi and Shamsipour 2003 and 2005) have used to study on drought condition. Also, Arbabi and Bayat (2001-02) have studied on drought effect of Ghazvin and Damavand plains on the groundwater.

In this research, multivariable statistic methods and Geographical Information System have been used and Normal Z Index that is to set time and pace patterns is defined and drought periods of Kerman province are specified.

2. Materials and Methods

Drought is studied on the basis of statistics and data from measurement of synoptic stations. Meteorological Data has been recorded in number, and then it can be used in statistical and mathematical models easily. Also, Meteorological parameters have been considered in the physical models because they have dynamic features. Rainfall is the most important variable that studied in the climate and drought subjects. Average annual and seasonal rainfalls of the controlled stations (1986-2007) have been used to analyze the drought by Normal Z Index. Normal Z Index is selected to calculate Intensity of climate drought, then, rainfall has been calculated in annual and seasonal scales.

Where, z is normalized drought index, $\underline{x}$ is variable of measured year or season, $\underline{x}$ is the average of long term climate variant and standard deviation. Standard Z Index is one of Statistical coefficients and one of the important normal indices that considers possibility of occurring drought and nonoccurrence of drought. In Z index, the coefficients are determined in table 1.

Table (1): Normalized Rainfall Index to calculate Rainfall of Zahedan Station (Iran Meteorology Organization)

Year	January	February	March	January z	February z	March z
1986	3.6	33.5	24	-0.8	1.3	0.7
1987	0	4	16.9	-1.0	-0.6	0.2
1988	9.8	14.7	7.4	-0.3	0.1	-0.3
1989	0.4	27	4.8	-1.0	0.9	-0.5
1990	16.4	15.3	0.9	0.1	0.1	-0.7
1991	49.7	35.2	71.8	2.3	1.4	3.6
1992	6.8	0.5	9.3	-0.5	-0.9	-0.2
1993	25.3	2	0.6	0.7	-0.8	-0.8
1994	31.4	1.3	15	1.1	-0.8	0.1
1995	2.9	4.5	12.5	-0.8	-0.6	0.0

1996	**51.1**	**8.2**	**27.3**	**2.4**	**-0.4**	**0.9**
1997	**16.1**	**7**	**3.4**	**0.1**	**-0.4**	**-0.6**
1998	**16.8**	**17.2**	**6.9**	**0.1**	**0.2**	**-0.4**
1999	**14.4**	**26.7**	**5.2**	**0.0**	**0.9**	**-0.5**
2000	**24.9**	**0.1**	**13.3**	**0.7**	**-0.9**	**0.0**
2001	**2**	**3**	**6**	**-0.9**	**-0.7**	**-0.4**
2002	**0.6**	**3.5**	**1.2**	**-1.0**	**-0.7**	**-0.7**
2003	**7.4**	**14.8**	**6**	**-0.5**	**0.1**	**-0.4**
2004	**17**	**0**	**0**	**0.1**	**-0.9**	**-0.8**
2005	**4.5**	**55**	**25.6**	**-0.7**	**2.8**	**0.8**

Also, standard dimensionless method has been used to specify the drought condition in the selected stations. Wet year and dry year are divided on the basis of this index as negative numbers indicates drought or dry year and positive numbers indicates wet year. The ratios are stated on the basis of percent.

Extent of limit	**Meaning**
Lower than -100	High Arid
-100 to -50	Arid
-50 to 50	Normal
50 to 100	Moist
More than 100	High Moist

Index is obtained as follow:

Where, is amount of rainfall annually (in mm)

p is annual rainfall averagely (in mm)

SD is standard deviation of annual rainfall in Zahedan Station

That, its results is as the same as results from rainfall method of Normal Z.

3. Definition of Studied Limit

Sistan & Balouchestan Province, 187500km^2, where is equal to 11/4% of total area of Iran. It is one of the largest provinces in Iran. This province is located on 25º 3´ in latitude to 31º 27´ of northern latitude from the equator and 58º 50´ in longitude to 63º 21´ of eastern longitude from line of longitude. This province is limited to southern Khorassan province and Afghanistan from the north, to Afghanistan and Pakistan (1107km soil border), to Oman Sea (300km) from the south, Kerman and Hormozgan Provinces from the west (see from Hamoon to Oman 16: 2001,and Sistan & Balouchestan Planning and Budget Organization 1997:4). Generally, this province has been divided in two geographical areas, Sistan in the north and Balouchestan in the south.

Fig.1: Topography of studied limit (Arbabi, Bayat 2012) (Omit)

4. Data of Meteorology Stations

Data of Meteorology Stations that belonged to Meteorology Organization and Ministry of Energy includes Zahedan, Khash, Saravan, Chabahar, Zabol, Iranshahr, Jalogh, Nahouk, Ghasr ghand, Daman, Bampour Dam (table 2). Long term data of the stations has been used to study general condition and to determine the main patterns of climate elements. Then, data of rainfall, temperature, relative humidity in annual and seasonal scales are used to calculate wet and dry years and climate categorizations. Also, there are other climate variables such as direction and speed of wind, cloudy and sunny hours, atmospheric pressure, number of rainfall evaporation and transpiration days. Then, drought is measured by categorizing climate drought with rainfall normal Z. Map 2 shows situation of selected stations.

Table 2: Specifications of selected stations

Raw	**Name of Station**	**Name of Organization**	**Height (m)**	**Longitude**	**Latitude**
1	Zahedan	Meteorology Organization	**1370**	**60/53**	**29/28**
2	Khash	Meteorology Organization	**1394**	**61/12**	**28/13**
3	Saravan	Meteorology Organization	**1195**	**62/20**	**27/20**
4	Chabahar	Meteorology Organization	**8**	**60/37**	**25/17**
5	Zabol	Meteorology Organization	**489/2**	**61/29**	**31/2**
6	Iranshahr	Meteorology Organization	**591/1**	**60/42**	**27/12**
7	Jalogh	Ministry of Energy	**944**	**62/42**	**27/36**
8	Nahouk	Ministry of Energy	**1377**	**62/.20**	**27/38**
9	Ghasr ghand	Ministry of Energy	**382**	**60/34**	**25/45**
10	Daman	Ministry of Energy	**800**	**60/48**	**27/23**
11	Bampour Dam	Ministry of Energy	**668**	**60/34**	**27/28**

5. Discussion and Conclusion

Environmental threats are one of the important limiting factors to develop. These threats are influnced differently on the basis of intensity, frequency and range of affecting. For example, flood and earthquake have low frequency and high intensity and wide depth in the center of event. According to the diffusion theory, if they are nearer to the center of event; their effect will be more intense and obvious. But, drought as a climate phenomenon has wide geographical range, more frequency and effective. Because of fast effective on water resource, herbal cover, providing drinking water, agriculture, food products and industries, natural threats are influenced more than other threats.

As environmental researches in natural categorization has been considered carefully and the better results have been presented. Because of rainfall changes of Sistan & Balouchestan Province where is one of the biggest and driest province, and its various topography, the considerable stations are selected on the basis of geographical condition from the most northern stations to the southern stations. This researches suggest that the extent of this province, various topography and adjacent to Lout Desert, on one hand, and adjacent to boundaries of Oman Sea and affected by seasonal rainfall system, on the other hand, its rainfall has internal homogeneity and it can't be managed uniformly. Regarding, difference of climate area and calculated intensities, it is useful to select the methods of management to determine the same areas in drought,

Low rainfall, herbal cover and animal life depend on the small and big available water resources, spite of the considerable herbal cover resist the long dry conditions severely. Because drought is result from climate fluctuations and it makes a disorder in natural condition of area then, the drought can be influenced on herbal life and ecology of this area destructively.

On the basis of spreading rising factor, Iran is divided in six areas where southeastern area, Sistan & Balouchestan Province, is one of them. In this area, convectional factor is the most frequency and high level disorders are the most rising mechanism.

All over Iran, The rising mechanism is high level disorders in the cold seasons that it is decreased from the south to the north and it is only allocated to the southeast of Iran.

In summer, the disorders have decreased in all over the country. In autumn and spring, high level disorders are the most raising factor in all over the country. In the hot season, the seasonal winds spread tropic hot and humid airs that entered to the south by two methods. Also, Bashagerd Mountains play important role to provide humidity of Oman Sea and amount of rainfall.

Rainfall Coefficient of Variation shows that Chabahar Station has the highest Rainfall Coefficient of Variation (99.47) and the most rainfall is in the summer that it uses rainfall system of sea and Zabol Station (on the north of the province) has the lowest Rainfall Coefficient of Variation (48.56) and the most rainfall is in December that it receives west wind rainfall system in autumn. More percent (40%) of this index in rainfall shows high abnormality of rainfall and arid condition in the considered stations.

Table 3: Annual Statistical Rainfall Index in the considered stations (1986- 2005)

Station	Average **Xi/n=∑μ**	Standard Deviation **X1-X)¯2/n-1=√∑(σ**	Cœfficient of Variation **CV=σ/X*100**
Zahedan	**75/1**	**44/1**	**58/7**
Khash	**150/5**	**101/9**	**59 /4**
Saravan	**106/8**	**52 /5**	**49 /1**
Chabahar	**113/3**	**112 /6**	**99 /5**
Zabol	**61/2**	**29/7**	**48 /5**
Iranshahr	**104/9**	**57/7**	**55**
Jalogh	**56/5**	**33**	**58 /4**
Nahook	**107/5**	**64/5**	**60**

According to table3, rainfall is abnormal and in high variability that shows arid conditions and drought. Analyze of alternative drought by using unstable average, standard distribution and dimensionless criterion suggests that drought is decreasing from north to the south of the province. These rainfalls are different from year to year and its coefficient of variation is increased.

Table 4 and graph 1 show coefficients of index Z in the considered stations and graph 2 shows coefficient of index Z in Zahedan stations. Map 3 shows categorization of drought in the considered area.

Table 4: Rainfall Coefficient in the considered stations

Year	Zahedan	Khash	Saravan	Chabahar	Zabol	Iranshahr	Jalogh	Nahook	Ghasr ghand	Daman	Bampour Dam
1986	**0.1**	**-0.3**	**0.3**	**0.5**	**0.4**	**-1.1**	**0.2**	**0.5**	**0.0**	**-0.3**	**-0.2**
1987	**-0.5**	**-0.5**	**-0.4**	**0.2**	**-1.8**	**0.1**	**0.0**	**0.6**	**-0.5**	**-0.4**	**-0.5**
1988	**-0.6**	**-1.0**	**-0.1**	**-0.1**	**0.3**	**0.4**	**0.2**	**0.0**	**0.4**	**0.5**	**0.5**
1989	**-0.6**	**-0.4**	**0.1**	**0.5**	**-1.2**	**0.9**	**-0.2**	**-0.4**	**-0.9**	**0.2**	**0.0**
1990	**0.2**	**0.0**	**-0.1**	**0.3**	**1.2**	**0.5**	**-0.1**	**0.4**	**1.3**	**0.9**	**0.9**
1991	**2.0**	**0.4**	**0.3**	**-0.5**	**0.8**	**-0.2**	**0.0**	**1.1**	**0.6**	**0.1**	**0.0**
1992	**0.2**	**1.2**	**1.2**	**0.4**	**0.7**	**1.7**	**0.0**	**-0.1**	**-0.1**	**0.0**	**0.2**
1993	**-0.8**	**-0.6**	**-1.1**	**-0.7**	**-0.3**	**-0.7**	**0.2**	**-0.7**	**-0.2**	**-0.1**	**0.5**
1994	**0.3**	**0.2**	**1.1**	**-0.4**	**1.9**	**0.7**	**2.1**	**0.2**	**-0.4**	**-0.3**	**0.0**
1995	**1.6**	**1.5**	**0.4**	**0.5**	**0.5**	**0.9**	**-0.5**	**0.0**	**0.1**	**-0.5**	**-0.4**
1996	**1.2**	**1.4**	**0.1**	**-0.1**	**0.8**	**0.7**	**1.9**	**1.3**	**0.9**	**2.4**	**2.4**
1997	**1.2**	**2.1**	**2.9**	**3.8**	**0.5**	**1.8**	**0.6**	**0.6**	**0.4**	**1.0**	**0.4**
1998	**-0.6**	**0.4**	**-0.2**	**-0.2**	**0.0**	**0.3**	**1.0**	**1.9**	**2.5**	**1.9**	**1.1**
1999	**-0.4**	**0.0**	**-0.3**	**-0.6**	**0.9**	**-0.5**	**-0.1**	**-0.9**	**-0.6**	**-0.6**	**-0.7**
2000	**-0.7**	**-1.3**	**-0.8**	**-0.6**	**-1.2**	**-1.5**	**-1.2**	**-1.5**	**-1.6**	**-1.2**	**-1.5**
2001	**-1.2**	**-1.3**	**-1.9**	**-1.0**	**-1.8**	**-1.7**	**-1.3**	**-1.3**	**-1.2**	**-1.0**	**-1.4**
2002	**-0.8**	**-1.1**	**-1.1**	**-0.6**	**-0.8**	**-1.2**	**-1.5**	**-1.4**	**-1.0**	**-1.0**	**-1.1**
2003	**-0.9**	**-1.2**	**-0.2**	**-0.4**	**-1.0**	**-0.5**	**-0.5**	**-0.2**	**-0.1**	**-0.8**	**-0.2**
2004	**-0.2**	**-0.3**	**-0.7**	**-0.6**	**-0.1**	**-0.9**	**-1.7**	**-1.5**	**-1.1**	**-1.3**	**-1.5**
2005	**0.6**	**0.9**	**0.3**	**-0.3**	**0.2**	**0.3**	**0.8**	**1.1**	**1.3**	**0.6**	**1.5**

Graph3: Coefficients of Z in Zahedan Stations

Map 3 Drought Categorization in the considered area (Arbabi, Bayat 2012)

6. Study on Drought Condition in the considered stations by using method of Normal Z

Zabol is the most north station of province that has arid condition. During statistical period (1987, 1989, 2000, 2001, 2003), it is high drought, in 1993, 1998, 2002, 2004, it was low and middle drought and it was moist in the rest years.

Zahedan Station is one of the north stations and its altitude from the sea is 1370m and its latitude is 29/28. On the basis of Normal Z method, Zahedan has had high arid in 2001 and 2003, middle arid in 1989, 1993, 1998,2000, 2002, low arid in 1987, 1988,1999, normal condition in 2004 and humid condition in the rest years.

Totally, the northern stations show arid conditions and droughts because it is far from humidity recourses and adjacent to the deserts.

Saravan Station where selected as a representative of central region in 2001 has very highly drought, highly drought in 2002, lowly drought in 2003, 2003, 2005 and normal condition in the rest years.

Chabahar Station is an only station where has very highly drought in 2001 and normal condition in the rest years. Chabahar Station is located on 8m altitude from the sea and 25/7 in latitude. This station is located almost on sea level and affected by humidity of Oman Sea. It isn't founded any highly drought in this station except in 2001.

After calculating Rainfall Normal Percent Index of Stations, unstable average index of 3, 5 and 7 years in graph 3 and standard distribution of table 5 are used to draw drought process.

Graph 3: Unstable Average of Zahedan Station

Table 5: Method of dimensionless index in Zahedan Station

Year	Zahedan	Percent	Quality
1986	**81.7**	**14.97**	Normal
1987	**50.2**	**-176.65**	High Arid
1988	**47**	**-183.26**	High Arid
1989	**44.1**	**-189.26**	High Arid
1990	**82.5**	**-109.92**	High Arid
1991	**173.1**	**77.27**	Arid
1992	**83.6**	**-107.64**	High Arid
1993	**35.6**	**-206.82**	High Arid
1994	**91.8**	**-90.70**	Arid
1995	**152**	**33.68**	Normal
1996	**131.7**	**-8.26**	Normal
1997	**134.8**	**-1.86**	Normal
1998	**44**	**-189.46**	High Arid
1999	**56.3**	**-164.05**	High Arid
2000	**40.7**	**-196.28**	High Arid
2001	**18.3**	**-242.56**	High Arid
2002	**34.3**	**-209.50**	High Arid
2003	**31.6**	**-215.08**	High Arid
2004	**64.9**	**-146.28**	High Arid
2005	**103.6**	**-66.32**	Arid

Table 6 shows average of dry and wet years and current process of the considered stations, except Chabahar Station that its current process is dry year, the rest stations are passed through wet year process.

Table 6. Average of dry and wet years and current process of the stations

Current Process	Number of Wet years	Number of Wet years	Stations
Wet year	9	11	Zahedan
Wet year	10	10	Khash
Wet year	9	11	Saravan
Dry year	7	13	Chabahar
Wet year	12	8	Zabol
Wet year	11	9	Iranshahr
Wet year	11	9	Jalogh
Wet year	11	9	Nahook
Wet year	9	11	Ghasr ghand
Wet year	9	11	Daman
Wet year	11	9	Bampour Dam

7. Directions & Suggestions

1- Long and short term plans should be hold in the field of direct and create new sights to develop field works and studies in the Geographical Department.
2- Far measurement in the studies to increase level of analyzing and interpreting data.
3- Developing new methods of studding as a new sciences and technique regarding the important studies such as drought
4- Increasing number of synoptic stations in the considered area
5- Educating and informing people the correct methods of irritation and water consumption
6- Using environmental components of surface moisture to study on drought climate
7- Paying attention to the environmental information basics to increase ability level of analyzing and interpreting the results

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