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The analysis of the frequency of occurrence, and drought severity in selected stations in Fars province using standardized precipitation index

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Abstract. Droughts are issues of importance in the study of natural disasters, and are studied from various perspectives in recent decades. The SPI index, due to its simplicity, usefulness in calculations of droughts' severity in different time scales, and its capability for monitoring simultaneous climatic, hydrologic, and agricultural circumstances, was used in the analysis of frequency of occurrence and severity of droughts in a number of stations located in Fars province. 18 stations were selected with respect to their availability of long – term statistical data, less data shortcomings, and suitable distribution with 32 years of shared statistical duration (1972-1973 to 2003 -2004). SPI index was calculated in a 24 months scale for the stations, during relevant statistic periods. Fitness of empirical quantities of SPI, with the functions of theoretical probability distribution, was conducted in several stations in the province, and on the basis of obtained results, location changes of drought's occurrence with different severity, and alternation period of these droughts for the stations were analyzed.

Keywords: Drought, Standardized Precipitation Index (SPI)

1. Introduction

With respect to climatic conditions of our country, drought occurrence is always expected , and understand ding its characteristics is considered as a crucial is due in dealing with its damages. Low rate of precipitation, and its high fluctuation, are two important features of Iran's climate. Negative fluctuations of precipitation cause different drought severity in the country, which in turn impose widespread damages on ecological, and economical systems of affected areas. Based on reports by representatives of humanistic and assisting international organizations, such as United States Agency for International Development (USAID), Department for International Development (DFID), World Food Program (WFP), Food and Agriculture Organization (FAO) and Office for Coordination of Human Affairs (OCHA), published up to 2001, over 60 million people in Iran , Afghanistan, western Pakistan, Tajikistan, Ozbakistan, and Torkamanistan have been seriously affected by droughts. In Iran droughts have imposed serious damages on more than 10 of 28 provinces (in the time of presentation of this study). According to the estimations made, 37 million people (more than a half of the population) have encountered serious nutritional damages and decrease in water resources, with most serious damages in Fars, Kerman, Khorasan, Sistan and Baluchestan in the southern parts of Iran(3,6).

To determine the severity of droughts, a variety of measurement indexes is used each one of them requiring special data. Of the most important indexes used in studying climatic droughts, are namely palmer

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drought severity index (PDSI), Standardized precipitation index (SPI), Percent of normal (PN), and Deciles method (DECILES), among others. Of these indexes, SPI is more frequently used in territorial analyses, and in contrasting and comparing of studies conducted in different areas. Mckee and colleagues (1993) used the SPI in Colorado state, and investigated different characteristics of drought in scales of 3, 6, 12 , 24 , and 48 months periods , and presented an classificatory system for determining droughts severity (7). Hayes and colleagues, in studying the 1996 's drought in the USA, using the SPI, found that, this index shows the onset of drought one month earlier than PDSI(5). Among other studies on droughts, using the SPI index, Lashani Zand (2003) , and Darvishi Baygi (2002) studies should be mentioned (1,2). One of the advantages of the SPI is its simplicity, so that in determining the severity of droughts, the only effective factor would be the rate of precipitation. While other indexes, including palmer's PDSI are more complex, and require time – consuming calculations. So regarding the current statistical shortcomings in Iran, through this method (SPI) , necessary information can be obtained to some extent. SPI index is also capable of calculations in any time scale. Therefore, SPI is capable of monitoring simultaneous climatic, hydrologic, and agricultural conditions. Moreover, by making use of this index, occurrences of severe droughts, and also a limit for every location, and in any time scale, can be classified. Regarding aforementioned explanation, and the main aim of this study, that is, territorial investigation, and determining the severity of droughts, continuity, and frequency of this phenomenon in Fars, the SPI was chosen for conducting this study. With respect to Mckee and colleagues classificatory table, a very severe drought (SPI<-2) occurs two or three times in a 100 years period, which is acceptable from the point of view of water management planning . regarding the remarkable differences between climatic conditions of Colorado area, and areas chosen for present study, if Mckee and colleagues' classification be assumed for SPI quantities in Fars province, more than 75% of the data will fall in near normal region, which is not so much acceptable, with respect to the location of the province in dry and semi- dry region, and also its hydrologic characteristics. Therefore, some modifications were made in Mckee's classification to suit to the studied area, and the results were presented in a table (2).

2. Methodology:

A host of 18 stations located in the province's townships were chosen. According to different issues including: possession of long- term data, less statistical shortcomings, and suitable distribution in the whole province, and following the recommendations of the world's meteorological organization, a 32 years statistical period (1972-1973 to 2003-2004) was considered. To make use of above- mentioned statistic, first monthly precipitation data from all stations were investigated through RUN TEST statistic model to ensure their accuracy and homogeneity . After ensuring the data homogeneity, each station's lost data were estimated using the nearest base station, and EM algorithm (expectation maximization algorithm), through SPSS software. Then, SPI index was calculated with a 24 month time scale for the stations, in related statistical period. With respect to calculated SPI quantities, and data of table 2 , the severity of droughts' occurrence was obtained for various stations.

3. Results

Fig 1, shows fitness of experimental quantities of SPI index with the functions of theoretical probability distribution, for a number of stations among studied ones. Table 3, shows years, during the statistical period investigated. As it is seen, the most severe drought has occurred in 2000. Which is to some extent, effected also by the previous year's drought. A similar case has occurred in 1984. Quantities relevant to this table are given in table 4. Based on the results given in the table, on most of the stations studied, the alternation period of very severe drought occurrence, is obtained as 15 years , that is , in accord with the results obtained in table3. Regarding varieties in places, it can be said, generally, that the behavior of changes from low severity to high severity are from the northwest to the southeast of the province. The alternation period of drought occurrence with mild severity in the studied stations varies from 3 to 10 years . These quantities for average droughts, and very severe droughts are obtained as 5 to 15, and 10 to 15 years respectively.

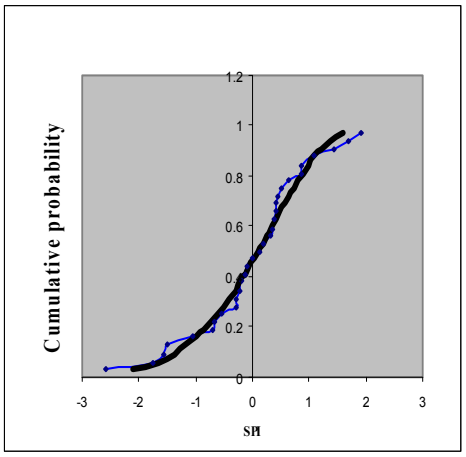
Table 1. Classification of SPI index (Mckee et al.)

Class	*SPI quantities*
Intensely humid	>2
Highly humid	1.5 to 1.99
Average humid	1 to 1.49
Almost normal	-0.99 to 0.99
Average dry	-1 to -1.49
Highly dry	-1.5 to -1.99
Intensely dry	<-2

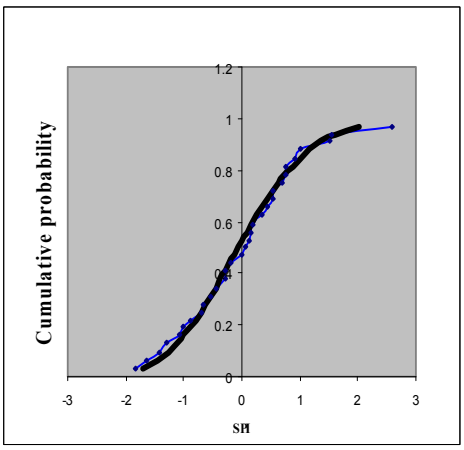
Table 2. Classification of SPI index in the studied areas(2)

Class	*SPI quantities*
Intensely humid	>2
Highly humid	1.5 to 1.99
Average humid	1 to 1.49
Mildly humid	.5 to 0.99
Almost normal	0.49 to -0.49
Mildly dry	-0.49 to -0.99
Average dry	-1 to -1.49
Highly dry	-1.5 to -1.99
Intensely dry	<-2

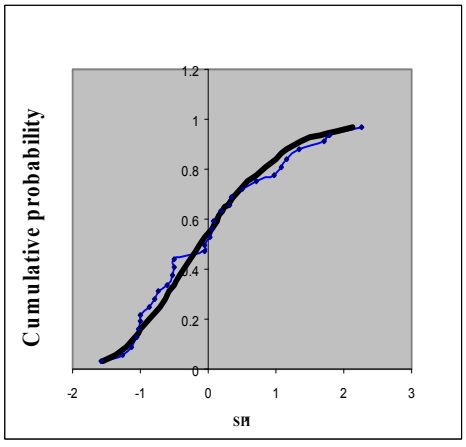
Fig 1. Fitness of experimental quantities of SPI index with the functions of theoretical probability distribution in a number of stations



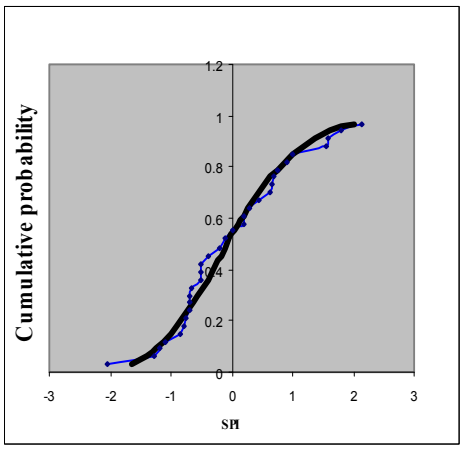
Koosangan Mamasany Station



Shiraz Station



Forg Darab Station



Meshkan Niriz Station

Table 3. severity of drought occurrence, according to year of occurrence and station

Station	52	62	63	64	67	68	69	78	79	80
Izadkhast	Average dry	Almost normal	Humid	Humid	Mildly dry	Average dry	Mildly dry	Mildly dry	Average dry	Humid
dehkadeh sefid	Mildly dry	Highly dry	Highly dry	Mildly dry	Average dry	Mildly dry	Almost normal	Average dry	Intensely	Almost normal
koosangan	Highly dry	Average dry	Highly dry	Almost normal	Mildly dry	Almost normal	Almost normal	Highly dry	Intensely	Mildly dry
moorvazeh	Average dry	Average dry	Highly dry	Mildly dry	Mildly dry	Almost normal	Almost normal	Highly dry	Intensely	Almost normal
droodzan	Average dry	Mildly dry	Average dry	Mildly dry	Mildly dry	Average dry	Almost normal	Average dry	Intensely	Almost normal
dehbeed	Almost normal	Average dry	Highly dry	Highly dry	Almost normal	Average dry	Average dry	Mildly dry	Highly dry	Humid
parishan	Average dry	Average dry	Highly dry	Intensely	Almost normal	Mildly dry	Almost normal	Mildly dry	Average dry	Almost normal
shiraz	Highly dry	Average dry	Average dry	Average dry	Mildly dry	Mildly dry	Almost normal	Average dry	Highly dry	Almost normal
arsenjan	Average dry	Average dry	Highly dry	Average dry	Almost normal	Average dry	Almost normal	Mildly dry	Highly dry	Almost normal
mazijan	Mildly dry	Almost normal	Average dry	Mildly dry	Almost normal	Mildly dry	Mildly dry	Highly dry	Intensely	Mildly dry
brak	Average dry	Mildly dry	Highly dry	Mildly dry	Mildly dry	Average dry	Mildly dry	Mildly dry	Average dry	Mildly dry
meshkan	Average dry	Almost normal	Mildly dry	Mildly dry	Mildly dry	Average dry	Mildly dry	Mildly dry	Intensely	Mildly dry
tange karzin	Average dry	Mildly dry	Highly dry	Average dry	Mildly dry	Average dry	Mildly dry	Mildly dry	Average dry	Mildly dry
fasa	Average dry	Mildly dry	Highly dry	Average dry	Average dry	Average dry	Mildly dry	Mildly dry	Highly dry	Average dry
estahban	Highly dry	Mildly dry	Highly dry	Average dry	Mildly dry	Average dry	Mildly dry	Mildly dry	Highly dry	Mildly dry
hagiabad	Average dry	Mildly dry	Highly dry	Mildly dry	Mildly dry	Average dry	Mildly dry	Average dry	Highly dry	Average dry
forg	Average dry	Mildly dry	Average dry	Mildly dry	Average dry	Average dry	Mildly dry	Average dry	Highly dry	Average dry
larestan	Average dry	Mildly dry	Average dry	Mildly dry	Mildly dry	Mildly dry	Mildly dry	Average dry	Average dry	Mildly dry

Table 4. alternation period of drought occurrence according to severity of occurrence and station.

Station	City	Mild	Average dry(moderated)	Highly dry	Intensely dry
Izadkhast	Abadeh	5	6	------	------
dehkadeh sefid	Eghlid	6	10	15	*
koosangan	Mamasany	10	*	10	*
moorvazeh	Sepidan	10	15	15	*
droodzan	Marvasht	7	7	-------	*
dehbeed	Khorambid	6	10	10	------
parishan	Kazeron	7	10	*	*
shiraz	Shiraz	7	8	15	------
arsenjan	Arsanjan	7	6	15	------
mazijan	Bavanat	5	*	*	*
brak	Jahrom	4	10	*	------
meshkan	Niriz	3	10	------	*
tange karzin	Khirokarzin	5	7	*	------
fasa	Fasa	7	6	15	------
estahban	Estahban	4	15	10	------
hagiabad	Zarrindasht	5	7	15	------
forg	Darab	4	5	*	------
larestan	Larestan	4	7	-------	------

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