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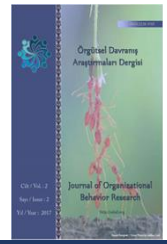

Investigating the Effect of Climatic Changes on Hormozgan Province's Droughts based on Standard Precipitation Index (SPI)

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ABSTRACT

The purpose of this paper is to assess the severity of climate change on drought conditions Vtrsaly province, province by conducting standardized precipitation drought zoning and mapping the extent of drought. To assess the drought situation, data from all weather stations collected in the study area and the quality and uniformity of rainfall data were examined.
In order to study the drought of the study area, three meteorological stations with the Ministry of Energy during the period of 20 years (74 to 94) were analyzed. Library and field data collection methods and to determine potential trends of climate change and drought, drought commonly used coefficients.
Therefore, based on available data can be indicators of drought like the Standardized Precipitation Index (SPI) used. Time scales of SPI in the first half, the second half of the year was calculated and areal extent watershed maps for these periods were produced in GIS.
The results showed that the areal extent in 1382-83 was more than statistical Sayrsalhay and large parts of the province and watershed are dominated by drought. 1383 annual drought map shows that most of the catchment Azhvzh the SPI class and a severe drought have been in drought conditions in the basin of Minab, Grove, Sereni, Hsnlngy and Middleman drought conditions that need to reduce the effects of drought in measures taken in these areas.

Keywords: *climate change, drought, famine, drought, desertification, Standardized Precipitation Index (SPI), Hormozgan*

INTRODUCTION

1. Introduction:

The investigation of the trends of the climatic data recorded during the past decades, archaeological studies and the results outputted by all the climate prediction models are reflective of the idea that non-ignorable changes are happening in the universal climate. Undoubtedly, these changes are the products of the negative effects caused by the human beings' activities that have added to the emission of greenhouse gases. Specifically, the emergence and the intensification of the borderline phenomena such as formidable typhoon, untimely icing, droughts and similar cases are the results of such changes by which the world has become sure that it is facing a universal threat (Esmaili et al, 2010, p.70).
Precipitation is one of the most important indicators influenced by the temperature variations' trend (Ghavidel Rahimi, 2010).

Therefore, considering Iran's geographical position and its being situated on one of the world's arid and semiarid belts, the global warming is warning the likelihood of the occurrence and intensification of droughts. The importance of such a subject as drought for a country like Iran for which the access to lakes, rivers and water resources is deemed as a huge problem has made the researchers engage in the study and evaluation of drought phenomenon in various ways (Khalili et al, 2003).

Drought is one of the most chronic and most harmful environmental instabilities causing disorder in the ecosystem and being accompanied by many detrimental socioeconomic effects; amongst the natural disasters worldwide, drought has been ranked first in terms of intensity, duration, the total area of impact and frequency (Gharabi et al, 2001). Considering the fact that Hormozgan Province is located in an arid and semiarid climatic region, the occurrence of repetitive droughts during the recent years has added to the significance of dealing with drought more than ever before. The study region includes the watershed basins between Bandar Abbas and Sedich (on the eastern side of Jask) as well as Kal River and Mehran River encompassing an area as big as the entire Hormozgan Province as well as southern parts of Fars Province, western parts of Kerman Province and eastern parts of Bushehr.

The study aims at evaluating the climatic changes' effects on the different intensities of the dry and wet years in Hormozgan province, calculating the relative drought frequencies in the watershed basins of Hormozgan province using standard precipitation index (SPI), zoning of Hormozgan Province's droughts using SPI and delineation of the drought breadth maps, zoning and determining the province's critical regions and offering solutions for reducing the droughts' adverse effects.

In order to investigate the study region's droughts, the data of three meteorological stations belonging to the ministry of power were analyzed for a common 20-year statistical period (1985-2005) and, then, SPI was calculated in three temporal scales, namely the first, the second and the third six-month periods, and the watershed basins' drought breadth maps were produced for the abovementioned periods in GIS environment. The annual 2004's drought map indicates that a large part of the province's watershed basin should be classified as mild and severe drought according to SPI with the drought being more acute in Minab, Gro, Sarney, Hasanlagi and Jalabi basins for which measures should be taken in line with the attenuation of the drought effects.

Considering the importance of precipitation in the province, gathering information about the drought status is of a great importance to all of the individuals residing the province, especially those working in offices and institutions affiliated with agriculture organization, natural resources organization, ministry of power and surface water offices.

2. Study Background:

- In an article named "investigating the frequeny and status of Khuzestan province's droughts based on SPI in GIS software", Nahid Jamalizadeh and Reza Borna (2012) evaluaed the drought status and intensitites in Khuzestan Province and determined the critical regions based on the information received from various meteorological stations. In a research termed "investigating the status of drought in Golestan Province using SPI", Ummolbanin Bazrafshan et al (2010) used SPI as the best index for monitoring drought in the province's selected stations for a common 25-year statistical period. The investigation of the maps signified that the droughts' vastness is reduced with the increase in the temporal scale with the breadth of the droughts being reduced in Golestan Province from the west towards the east. In a research called "zoning the drought risk using SPI in Gilan Province", Naser Ebrahimnejad Gaskarli (2009) used the SPI for an annual temporal period to do drought zoning and investigation and, considering the fact that the method is based on Gamma distribution, they seminally applied statistical programs to examine the usability of the inedx for the region and eventually prepared drought zones' map for the province. Eslamian et al (2006) performed droughts' spatial grouping using SPI in Isfahan Province and concluded that droughts' intensities and durations change with the longitude and latitude along Isfahan Province.

- Karawatiz et al (2011) used SPI for Greece's drought. They expressed the use of SPI as the most important objective of the study for, as believed by them, it enables a better perception of the duration, amount and spatial expansion of drought in such semiarid regions as Greece. To do so, the applied the precipitation data from 46 stations during the years from 1947 to 2004 and their results indicated that SPI is highly capable of predicting drought and declaring warning. Kaseti et al (2010) studied the drought specifications in the watershed basin of Volta River in West Africa through the use of the information from 52 meteorology stations. They evaluated the drought intensity, vastness and freqeuncy using SPI for the statistical period from 1961 to 2005. Sakiri et al (2007) examined regional drought to recognize the drought intensity, duration and area based on drouhgt identification index; in this study, the authors proposed the use of the new drought identification index along with SPI as well as deciles method. Because of onsidering precipitation, climatological parameters and evaporation/transpiration potentials, the drought identification index was found outperforming the other methods. The identification of the drought properties using the aforesaid indices was carried out on watershed basins of Mornos and Nestos Rivers in Greece.
- Moghaddam et al (2000) showed for Sistan-Baluchestan and Khorasan-e-Shomali Provinces that the drought evaluation would be more precise in case of using SPI as compared to the deciles and percentile methods.
- Akhtari et al (2006) monitored drought based on SPI and effective drought index (EDI) to show that the abovementioned indices deal with spatial variables and that the weighted moving average method features sufficient precision for spatial drought analyses.
- Hayes et al (1999) realized SPI as a flexible and competent index for drought analysis in every temporal scale. The results obtained by Banejad et al (2006) indicated that the exponential model and SPI give more optimum results in monthly scale, spherical model in seasonal scale but if used in conjunction with kriging method and the inverse distance weighting in six-month, annual and biennial scales.
- Nassaji Zavvareh and Sane'ei (2001), as well, utilized SPI for monitoring and grading the drought intensities in 3-, 6-, 12-, 24- and 48-month time spans based on information procured from Zabol and Isfahan's synoptic stations.
- Moghaddasi et al (2005) used DI, EDI and SPI for investigating the drought inidents from 1999 to 2001 in Tehran Province and came to this conclusion that EDI outperforms the

other two and that SPI falls short of showcasing adequate reaction to the precipitation shortages.
- Bordy et al (2001) used standardized precipitation index for drawing maps of monthly drought zones in short-, mid- and long-term scales in Italy.
- Brinini et al (2001), as well, demonstrated that the standardized precipitation index can be very helpful in quantifying and monitoring droght.

Iran's being positioned in an arid and desert region of the world has made it to naturally have more years with lower than average precipitation as compared to years with above avberage precipitation for a long period of time; it is noteworthy that during 13 out of the past 23 years, Iran has been enjoying lower than average precipitation (2001). Now, considering what was mentioned above, the first step for fighting with drought and moderating its disordering effects is the recognition and perception of droughts. The next and more important step is the adoption and selection of solutions based on which the phenomenon's outcomes can be counteracted and its detrimental consequences can be reduced to the maximum possible extent.

3. Study Method:

The study uses field and library research for gathering information. Using the limited Persian resources and the credible Latin articles and dissertations as well as the documents and statistics existing in ministry of power and meteorology organization and following their analyses, descriptive and analytical data were obtained; then, hypothesis tests were carried out using field study (investigation of SPI) in geographical information system (GIS).

At first, the existing information and data were organized through the creation of an information base by the use of climatic elements and information procured from climatological synoptic stations following rain and precipitation assessments for the aforementioned statistical period of the province; then, SPI was applied to process the attained information. Next, the corresponding maps were prepared in this way that the data were inserted for analysis into GIS and statistical software packages. In order to elaborate and analyze the data and answer the study questions, the dominant information and prevalent properties of the region were figured out and, in the end and in proportion to the study's hypotheses, statistical techniques were utilized to test the hypotheses and, subsequently, drought intensities and drought return periods were drawn for the selected spans of time after which the final results were extracted accordingly.

4. Standard Precipitation Index (SPI):

The perception of the idea that the precipitation exerts various effects on water resources such as groundwater, surface water reservoirs and snow made researchers use SPI for reaching the results. SPI serves the measurement of precipitation shortages in various resources. Soil moisture reflects the abnormal rainfall conditions for a shorter period of time whereas the groundwater level, surface streams and surface water reservoirs are indicative of abnormal precipitation conditions for a longer period of time. SPI should be computed for every region based on long-term statistics within a given period of time. To do so, the goodness of fit index and normal data distribution are estimated based on data for a long period of time; then, SPI is calculated with the positive values reflecting rainfalls above the average and negative values designating rainfalls below the average. Since SPI has been standardized, it can be applied for arid and humid regions and the results can be compared for a certain period of time. Based on this method, drough occurs when SPI is found constantly negative or reaching -1 or below it and it ends when

SPI is found taking a positive value; cumulative SPI values are indicative of the magnitude and intensity of the drought period. Table (1) gives the classifications of SPI.

Table 1: SPI values' classification

SPI	Indication
0.2 and higher	Very very humid
1.99-1.50	Very humid
1.49-1.00	Relatively humid
-0.99 to 0.99	Nearly normal
-1.00 to-1.49	Relatively dry
-1.50 to -1.99	Very dry
-0.2 and lower	Very very dry

It is worth explaining that SPI should be calculated for a given period in every region based on the long-term precipitation data. The goodness of fit index is estimated firstly for this long-term period based on the data distribution; then, the cumulative distribution function is calculated using the following probability relations of the random variables based on standard normal distribution with a mean zero value and a unit standard deviation:

$$Z = SPI = -\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \quad t = \sqrt{\ln\left[\frac{1}{(H(x))^2}\right]} \quad 0 < H(x) \leq 0.5$$ (relation 1)

$$Z = SPI = +\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \quad t = \sqrt{\ln\left[\frac{1}{(1 - H(x))^2}\right]} \quad 0.5 < H(x) < 1$$ (relation 2)

H(X) is the cumulative probability finction and c0, c1, c2, d1, d2 and d3 are constants (relations 3 and 4).

$$c_0 = 2.515\,517 \quad c_1 = 0.802\,853 \quad c_2 = 0.010\,328$$ (relation 3)

$$d_1 = 1.432\,788 \quad d_2 = 0.189\,269 \quad d_3 = 0.001\,308$$ (relation 4)

Therefore, SPI is the normalized variable Z with a zero mean value and a unit standard deviation. SPI is applied for studying the various drought aspects, including drought repetition, spatial and temporal scattering and climatic impacts.

5. Study Region:

Hormozgan Province is situated in the south of Iran and north of Hormoz strait. The province is stretched in the east to Oman Sea and in the west to Persian Gulf.

Hormozgan Province contains 11 counties, 23 cities, 33 districts, 71 villages and 2170 boroughs.

Hormozgan Province is situated in 25° 24' 28" of the northern latitude and 53° 41' 59" of the eastern latitude from Greenwich meridian. The province is about 68 thousand square kilometers in area and it is considered in this regard as the eighth largest province in Iran. Hormozgan is neighboring with Kerman province on its east and notheast side, with Fars and Bushehr Provinces on its west and northwest sides, with Sistan and Baluchestan on its east side and with warm waters of Persian Gulf and Oman Sea on its south side for an approximate length of 900 kilometers (figure 1). In brief, the special geographical position of Hormozgan Province has made it enjoy climatic effects of various adjacent and remote lands like Siberia, Indian Ocean, Saudi Arabia and Africa's deserts and Mediterranean Sea and Atlantic Ocean. During the cold period of the year, this land is influenced by Siberia's widespread high pressure in such a way that it imposes a dry and nippy chill onto the region.

During the hot season, the warm weather from the southern and southeastern sides as well as from Saudi Arabia and Africa influence the climate of the region. The humidity of the Indian Ocean, especially bay of Bengal, enters the region through general air circulation from Pakistan's low pressure front that ends in summertime scats and rainstorms in the southeastern and southern sections of Iran in case of being adequately thick. The western and southwestern deserts send hot and dry air into this region and this causes the blowing of dry and scoching winds in the region despite passing over Persian Gulf due to their long constancy and huge dryness.

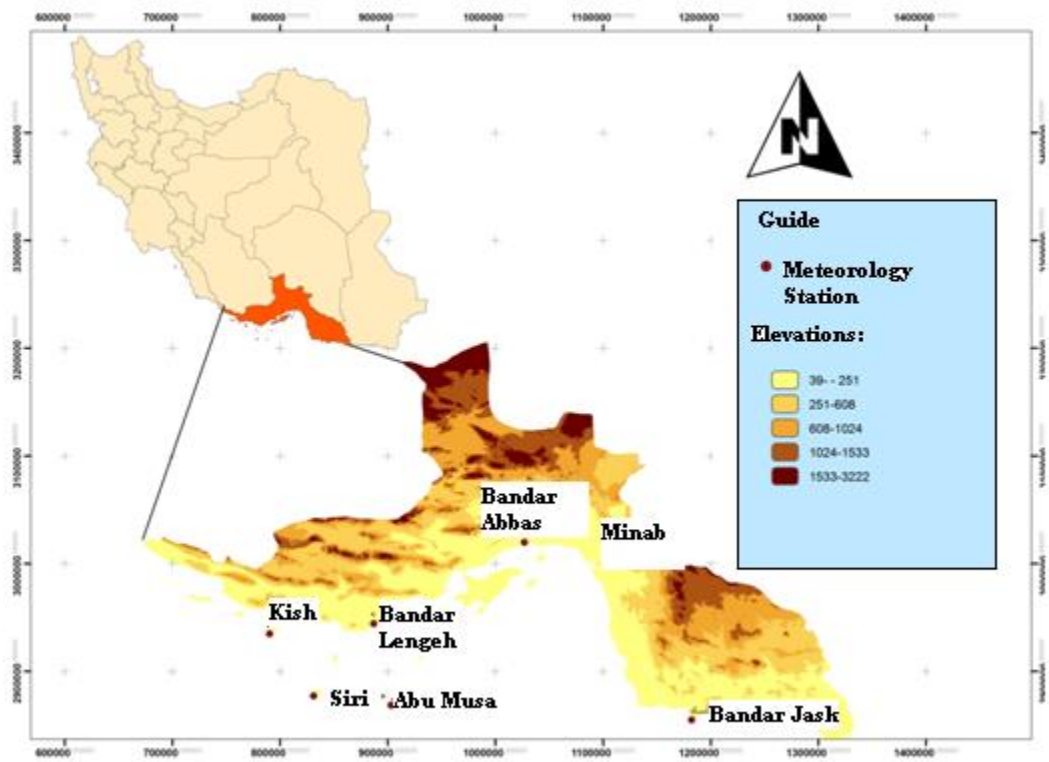

Figure (1): the position of the study region and the selected meteorological stations

6. **Investigating the Meteorology Stations within the Study Region for Evaluating Drought Status: Overall Statistics**

The data of the meteorological stations within the study region were collected and the quality of the precipitation data's uniformity was assessed. A 20-year period from 1995 to 2015 was chosen as the study's foundation. Considering the choice of a 20-year period, many of the newly established stations with statistical periods below the intended time were discarded. In the end, data were acquired from a total number of 102 meteorological stations inside and outside the province as the study's base.

7. **Study Findings' Analyses:**

In this section, ArcGis Software's facilities were utilized for data analyses. Two primary tasks were accomplished:

1) Analysis of the region's rainfalls: in order to estimate the rainfalls within the study areas, processed statistics were utilized and facilities of ArcGis Software, version 9.1, were employed to draw the study areas' annual isohyetal maps. As it is seen, the region's rainy core is situated in the section from which Jalabi River (Jamash) originates and a rainfall amount of 420mm has been documented for it; the more distances are moved away from this rainy core, the rainfall amount is accordingly more reduced. The secondary rainy core, as well, can be seen in the middle section of the aforementioned basin for which a 400-millimeter rain has been evidenced; the tertiary rainy core is found in the part from which Rudan River stems and a rainfall rate of 380mm has been observed for it.

The comparisons of the rainfall scattering in the watershed basin are reflective of the idea that the maximum precipitation is received by Jalabi (Jamash) River's source, Hasanlangi (Shemil) River and Rudan River with the highly rainy pole of Hormozgan Province's basins being also concentrated in this area. Fortunately, due to the absence of the salty domes in these regions, the rivers have fresh drinkable water. It is observed following the investigation of ten maps that a general rule cannot be defined regarding the precipitation variations' trend in this region but it can be stated in general that the low coastal regions enjoy lower rainfalls in contrast to the elevations and mountaneous regions. Of course, in every place in the watershed basins, the relationship between the precipitations and elevation is not significant. For example, a low-rain core within the study region (for which a rainfall of 120mm has been documented) is the source of Dah Sheikh River which is located in elevations above 2000m.

Moreover, it is seen following the study of the maps that the rainfalls are lower in the eastern basins of the province (Sedich and Gabric) than the western basins (Mehran and Rasul) with them respectively receiving rainfalls for about about 120mm and 240mm. The amount of rainfall, about 120mm, in the islands near Persian Gulf as well as the Persian Gulf itself is lower than the other regions within the province. The regions with the lowest rainfall are the watershed basins of Hormozgan Province located within the low coastal sections, namely Sedich Watershed Basin, Gabric Watershed Basin and Jegin Watershed Basin for which rainfalls below 100mm have been evidenced. Thus, the maximum rainfall, 266.31mm, goes to Jalabi (Jamash) Watershed Basin and the minimum rainfall, 122.3mm, goes to Sedich Watershed Basin.

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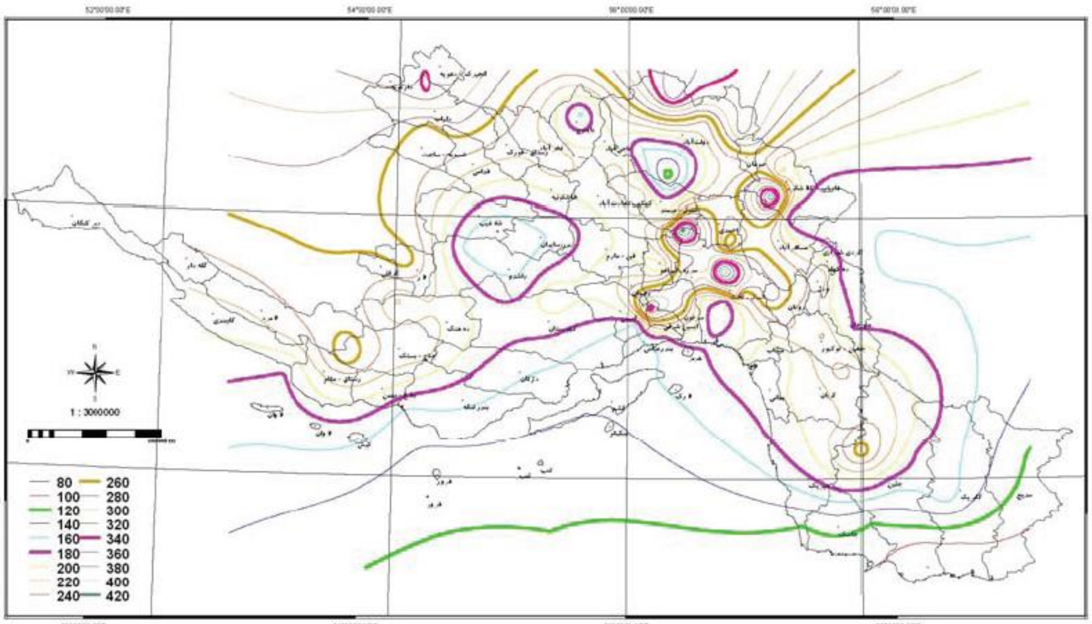

Figure (2): isohyetal lines of the studied areas

8. SPI Calculation and Drought Zoning:

SPI falls within seven abnormality classes in a range from +3 to -3 with the former indicating intensive wet year and the latter indicating severe dry year. Table (1) presents the various categories of this index.

In order to estimate SPI for the study region, the precipitation data of every station were categorized into three parts, namely the first six-month, the second six-month and the third six-month. Then, SPI values were calculated for each temporal step based on SPI formula in every station (a total of 102 stations).

Considering the calculations for each of the stations within the study region, SPI values were categorized in one of the groups given in table (1); then, the percentages of the stations falling within the various wet and dry years' periods were determined based on whih the most severe wet and dry years were specified for the studid region. Based on the annual time table (table 2), 1995-96 is the most severe dry year within the 20-year statistical period.

In 2004, out of the total number of the studied stations, 41.1% were found falling within the normal class, 56.9% within the drought class and, lastly, 2% within the severe drought class. Furthermore, based on the foresiad table, 1996 should be envisioned as the the most intensive wet year. In terms of the rainfall status, 64.7% of the stations have experienced extremely intensive wet years, 23.5% have experienced intensive wet years and 9.8% have experienced wet years and, finally, 2.0% of the stations have experienced normal years. In the same abovementioned year, none of the stations were found categorizable in various drought groups.

Table 2: percentages of various SPI classes' occurrence within the annual period of time in the studied stations

Year	Extremely severe drought	Severe drought	Drought	Normal	Wet year	Intensive wet year	Extremely intensive drought
1985~86			8	92			
1986~87			2	87	8	3	
1987~88			1	98	1		
1988~89			7	93			
1989~1990			6	90	3	1	
1990~91				100			
1991~92				85	13	1	1
1992~93				20	9	14	57
1993~94			25	75			
1994~95				96	1	3	
1995~96				1	11	23	65
1996~97				97	3		
1997~98				59	18	10	13
1998~99			1	99			
1999~2000		4	33	63			
2000~2001			34	66			
2001~2002			10	90			
2002~2003			7	93			

2003-2004		2	57	41			
2004-2005				89	10		1

In order to recognize the spatial distribution of the region's droughts, SPI values' map was drawn in an annual scale considering the most severe cases of drought occurred within the 20-year statistical period.

Figure (2) displays the SPI values for the studied period. Using the prepared maps and applying GIS facilities, the drought zoning maps were prepared for the study region's areas. figures (2-4) exhibit the drought zones for an annual time scale within the studied 20-year period.

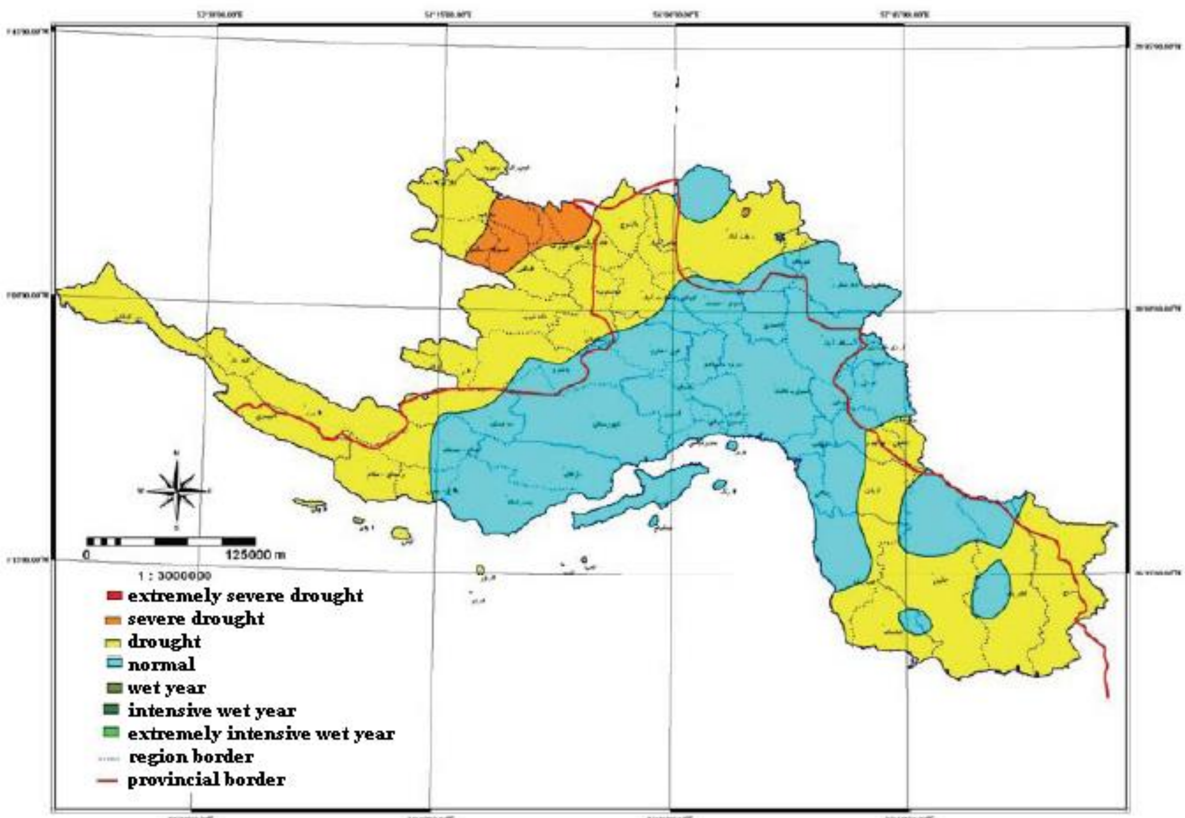

Figure (3): drought zoning within the annual time scale (1999-2000)

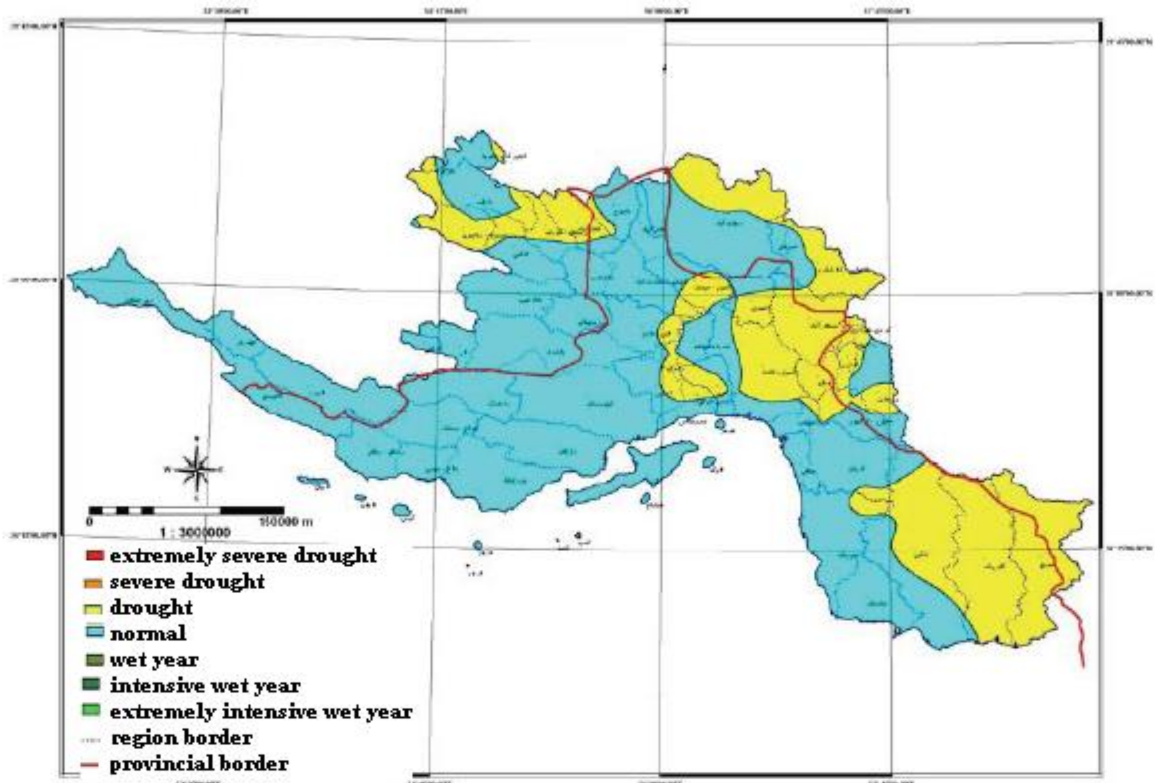

Figure (4): drought zoning within the annual time scale (2000-2001)

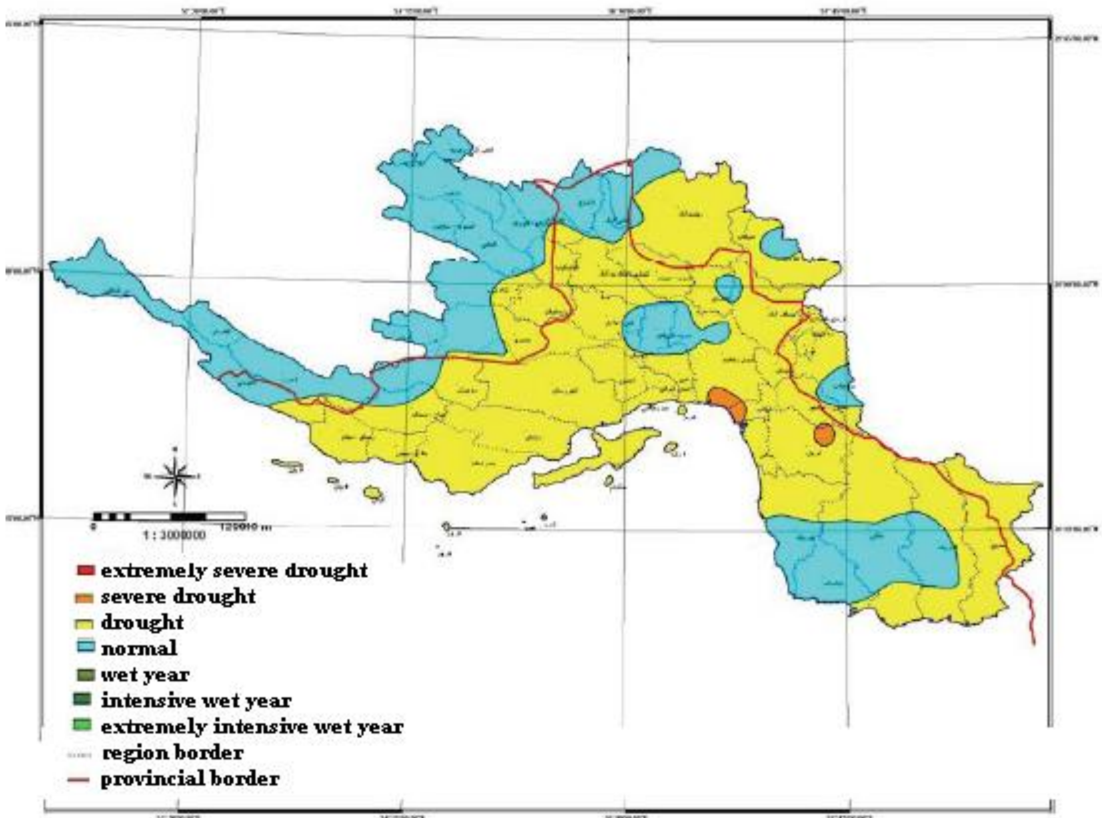

Figure (5): drought zoning within the annual time scale (2003-2004)

Based on the other research results obtained by Dr. Ghasem Azizi and Ali Asghar Rowshan and published in the seasonal journal of geographical research for three stations in Bandar Lengeh, Bandar Abbas and Minab, it can be seen that Bandar Lengeh has experienced intermediate to weak droughts during a 37-year statistical period (1966-2002); Bandar Abbas and Minab can be also observed to have experienced similar droughts for respetively 22-year and 20-year periods.

Table 3: number of wet and dry years with their annual various intensities

	Severe dry year		Intermediate dry year		Weak dry year		Weak wet year		Intermediate wet year		Intensive wet year		Very intensive wet year	
	-1.49 to -1		-0.99 to 0.5		-0.49 and higher		0.49 and lower		0.99 to 0.5		1 to 1.49		1.5 and higher	
	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency
Bandar	18.9	7	16.2	6	18.9	7	16.2	6	16.2	6	2.7	1	10.8	4

Lengeh														
Bandar Abbas	10.8	4	32.4	12	16.2	6	16.2	6	5.4	2	5.4	2	13.5	5
Minab	13.5	5	27	10	13.5	5	18.9	7	13.5	5	5.4	2	8.1	3

Bandar Lengeh has experienced wet years for 17 years of the statistical period with the wettest year being 1995 with 433.5mm rainfall and a freqeuncy of 2.7. the intensity of the wet years recorded for this station ranges from very intensive, intensive, intermediate and weak. Bandar Abbas and Minab were found having experienced wet years for 15 and 17 years, respectively, with intensities similar to those of Bandar Lengeh.

The wettest year for the two stations, as well, is 1995 with respectively 506.9 and 526.9 millimiters of rainfall. Very severe drought has not been experienced by any of the three aforementioned stations during the study period. This is while their very intensive wet years are quite notable in terms of frequency. As seen in table (3), Bandar Lengeh and Bandar Abbas have had one and two long-term drought periods (five years and more), respectively, in terms of the continuation of the dry and wet years wheareas the longest wet-year period evidenced in the aforesaid two stations for the same year is very short (one and two consecutive years, respectively).

Table 4: continuation of the annual wet and dry year periods

	Five or more dry years		**Three or four dry years**		**One or two dry years**		**One or two wet years**		**Three or four wet years**		**Five or more wet years**	
	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency	Percentage	frequency
Bandar Lengeh		1		2		5		5		1		1
Bandar Abbas		2		1		5		5		2		0
Minab		0		3		7		9		1		0

Dry years in Hormozgan Province are quite more frequent (than wet years) and they are usually categorized as weak to intermediate dry years but with high continuity.

This is while the province's wet years are less frequent and they are often classified as very intensive to intensive wet years with low continuity (one or two conseutive years). Province's dry years with a weak to intermediate range and a high continuity rate result in hydrological and agricultural dryness. The wet years, as well, with an intensive to very intensive range and a low continuity are full of very devastative floods, severe soil erosion, agricultural damages and financial and life losses.

9. Conclusion and Suggestions:

The analysis of the annual drought zoning maps offers a vivid perspective about the watershed basins' and studied areas' drought statuses. The annual SPI zoning map of 1999-2000 for the areas studied in Hormozgan Province makes it clear that a vast part of the study region's north, east and west falls in drought status in terms of SPI class. In the meanwhile, the middle parts of the study region and the sources of Gabric and Jegin rivers and, also, Qeshm Island and the other islands in its periphery are normal in terms of the rainfall. The most severe drought status has been recorded for the same aforesaid statistical year in the middle sections of Abshur Watershed Basin and it has to be viewed as severe drought-prone area based on its SPI class. The investigation of SPI zoning map for 2000-2001 is reflective of the idea that the drought has been expanding in a lower pace in comparison to 1999-2000 and, considering the SPI classes, it has only influenced the eastern sections of the study region, including Sedich, Gabric and Jegin Watershed Basins and, also, the northeastern and northwestern sides and a narrow strip in the central section with all the other points of the basin being in normal situation in terms of precipitation. In terms of SPI classifications for the aforementioned statistical period, no area was found having been dominated by severe drought or extremely severe drought.

The SPI zoning map for 2003-2004 indicates that vast parts of watershed basin are in drought situation based on their SPI classes. The coastal sections of Minab, Hasanlangi and Jalab Rivers' basins and, also, sections of Sarney and Gro basins have been found dominated by severe drought based on their SPI classes. In this period, the head branches of Kal River were found having scattered SPI values; the center and northeast as well as breadths of Vas, i.e. eastern side of Hormozgan, have also experienced a normal sate in terms of rainfall.

It is inferred based on a comparison between SPI zoning maps for 1999-2000, 2000-2001 and 2003-2004 that drought has impacted a wider area during 2003-2004 with vast parts of the watershed basins being dominated by drought. It is also clearly seen that the eastern side of Hormozgan has undergone drought in all the aforesaid statistical years with parts of the region having experienced drought only in one of the abovementioned statistical years. The adverse consequences of the several recent years' drought have overshadowed all the aspects of people's lives as well as the province's developmental activities with these outcomes being more evident in the eastern and northeastern sides of the province. The agricultural and drinkable water shortage and crisis as a result of the severe drop in groundwater level followd by the drying of the gardens and reduction in the agricultural lands' surface area in these regions, reduction in the quality of groundwater resources, decrease in the discharge rate of the permanent rivers, livestock losses and some others are amongst the outcomes of drought in Hormozgan Province and the subsequent falling of the foresaid region in the drought domain; thus, it seems necessary to prepare plans for mitigating the drought effects in this region more han other areas in the province; amongst these interventions, the preparation of a comprehensive provincial watershed management plan, determination of development strategies based on lands' usabilities and potentials, revitalization of the traditional systems like rainfall-catching surfaces, sewage and wastewater management, water-saving plans via promulgation of the proper consumption culture, prevention of digging illegal wells and immethodical use of the groundwater resource and conservation of the natural arenas can be pointed out.

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