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Evaluating drought indices and its effect on Hour-al-Azim Lagoon

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A B S T R A C T

Drought is a repetitive phenomenon in different climates and its effect is not limited to dry and semi-dry regions; it likely happens in rainy regions or different seasons of the year. As a slow phenomenon with wide spatial spread, drought leads to several damages on different economic parts. Therefore, its mapping as an important principle is considered in macro planning. In this research, we evaluate drought intensity in two stations namely Abadan and Ahwaz using rainfall anomaly index (RAI), standardized precipitation (SPI), Bahlm and Mooly droughtinde (BMDI) and deciles index (DI). The reason for choosing these two stations is longer statistical years compared to other stations and its destructive effects on social, economic, physical and natural environment of the area is studied.

Introduction

Rainfall is one of important climatic factors, which plays a significant role in economics, agriculture, industry and tourism. Even though obtained water from rainfall has a very different utility according to communities' development and different temporal and season conditions, its surplus, which contains a more percentage than optimal usage, uncontrollably leads to flooding and corresponding damages. However, drought issue and its damages always brought several problems for plant, animal and human communities. Drought is one of inappreciable natural disasters, which takes place due to rainfall shortage in a specific time, which is usually a season or more.

Drought is one of natural disasters, which damages to human life and natural ecosystems. This phenomenon is different with other natural accidents such as flood, hurricane and earthquake. The most part of these differences lies on progressive effect of drought during a relative long period, lack of possibility for precise determination of end, start time, and effect geographical scope. On the other hand, lack of a precise global acceptable definition for drought multiplies its complexity and confusion. Generally, droughts have three types: meteorological drought, hydrological drought and agricultural drought. Meteorological or climatic drought is resulted from rainfall shortage and if this

kind of drought insists, it will lead to agricultural and hydrological droughts. Rainfall is the most parameter in drought definition. That is, drought and rainy-year are measured according to less or more rainfall among average rainfall of an area. In order to reducing effects of this phenomenon and its risk management, it is crucial to evaluating drought and its period continuum (Palmer, 1965). Iran has a dry and semi-dry climate due to locating in drought belt and neighboring high-pressure torrid periphery, therefore, it has severe droughts during most years. Initial works on mapping started with frequency analysis of drought area in small-scale in 1966 by Whipple. Then, other researchers for some states in U.S. that were imposed to drought more than other states followed this procedure. SPI index can estimate drought state in different temporal scales and drought type surveillance and long-term measurements about hydrologic drought (McKee *et al.*, 1993). Rainfall anomaly index is based on calculating rainfall amount deviation from normal amount.

Bahlm and Mooly index determines percentage of rainfall amount deviation from normal amounts and its temporal measurement is monthly and annual. In deciles index, occurred rainfall distribution is divided to 10 parts. Each part is called deciles. The first deciles show a rainfall that its amount is less than 10 percentages of total rainfall. The second deciles show a rainfall that its amount is less than 20 percentages of rainfall (Table 4). The used indices in this research are as follow: rainfall anomaly index (RAI), standardized precipitation (SPI), Bahlm and Mooly drought index (BMDI) and deciles index (DI). According to importance of Hour-Al-Azim lagoon in western south of Iran, this research evaluated drought and its effect on Hour-Al-Azim lagoon (Fig. 3).

Materials and Methods

Khuzestan province with 64055 square meters area is located on western south of Iran. Climatically, low points in this province, which include Ahwaz and Abadan, are warm and dry; and those points with higher altitude have step climate with winter rainfall. Khuzestan is one of Iran province that has unique lagoons including salt water and sweet water lagoons that each one has an important role in their locating region and the residents' lives depend on them. Each lagoon has a high potential for attracting tourism and many attractions for bird watching in Iran.

This research study drought of Ahwaz and Abadan stations using RAI, SPI, BMDI and DI indices and its effect on Hour-Al-Azim lagoon.

Synoptic meteorology stations' data in Ahwaz and Abadan are used to evaluating droughts during (1990–2013). Specifications of aforementioned stations are shown in Table 1.

According to accumulated statistical data from monthly rainfall in synoptic station of Ahwaz and Abadan, RAI, BMDI, SPI, DI are used to determining drought intensity based on existing rainfall data during aforementioned years (Fig. 1 & 2).

Discussion and Conclusion

According to Table (5, 6) drought in Ahwaz and Abadan stations which is conducted during time period of (1980–2013) and using mentioned indices, is provided as monthly differentiation (Table 3). According to reducing rainfall in the region (Table 2), drought will be dominant in the region with different severity. Therefore, it is necessary to providing a pilot for better and more

appropriate management of water by studying drought, determining its specifications, surveillance and prediction. As an effective component in pre-informing system of risk management for natural disasters, Drought surveillance using drought indices such as RAI, BMDI, DI and SPI allows to identifying regions, which are damaged by droughts. The management should start proper management and planning of water resources in water shortage years by considering possibilities and predicting drought occurrence according to fragile ecosystem of these regions damaged by drought.

The effect of droughts on environment is widespread as some of these effects are not identifiable in short time and they show themselves in long term. The long term and sustainable effects will show themselves in lagoon ecosystem, because these ecosystems are mostly located in bottom of basins and incur the highest pressures resulting from water shortage and droughts. Generally, drought effects can be divided to environmental, economic and social effects. Reducing water level of lakes, rivers and lagoons is one of clear cue for drought. Reducing rainfall will destruct interactions between lakes and peripheral land, and coastal shallow areas, lagoons, growing patterns and chemical cycles will be changed. Following reduction of lagoons' water and reduction of water flows, DOC entering shows a significant reduction during drought periods.

Other environmental effects of drought on lagoons include enhancement of alga efflorescence phenomenon, destruction of plant species, extinction of animal species, destruction of habitats, effect on air quality, reduction of biological diversity, qualitative reduction and destruction of landscapes, soil erosion, and enhancement of desert spread.

5 following factors are important along with drought management in lagoons:

Identification of drought specifications, determination and selection of authorities, notification of drought occurrence, reduction in water consumption and keeping economic structure and manner of surveillance on observation of water consumers' plan.

Lagoons' changes are associated with water changes in rivers, which lead to them. Therefore, due to changes occurred in water supplements, lagoon changes have some oscillations. These changes, which are actually natural transformations, are taking place continuously during years; but we should consider the second type of changes, which originate from human interventions. These changes are either due to implementation of projects and special operations on lagoons' limits directly or due to actions regarding preparation of basins and exploitation of water sources of Hour before reaching to it and they lead to area variation of lagoons during several years, indirectly. Drought in this region results in parching the lagoon and destructive effects on social, economic, physical and natural environment of the region. Some of these effects are demonstrated as below:

The effect of drought on physical environment are accompanied with reduction of nutrients in soil surface due to increasing wind erosion, increasing wind and water erosion in the region, reduction of nutrient transfer in soil, increasing dust typhoons and destruction of context and structure of soil. The effect of drought on biological environment is accompanied with below symptoms:

reduction of biological diversity of the region, reduction of plant coverage and animals, perishing wild and aquatic animals

of the region, interruption in wild animals breeding, tacking wild animals to agricultural lands and villages and simplifying their hunting and vulnerability in hunting, change in diet and immigration of wild life, increasing wild life disease and invasion of insects to native plant coverage of the region

Increasing irrigation and feedstuff costs, severe reduction of farmers and ranchers' income and reduction of plant and stock production are other effects of drought in this region. Even though there are changes in rainfall and temperatures of the province, but the destructive trend of Hour-Al-Azim lagoon cannot be considered just due to these changes; because it is found that human non-scientific interventions have the most share on this destructive trend. Therefore, the lagoon management and providing an appropriate ecological condition for it is a very crucial issue. If parching of Khuzestan lagoons and their destruction continuo, it will impose inexpiable damages and side effects to environment, which need a long time for recovery and restoration and it can have diverse effect on human health through spreading hazes.

Table.1 Specifications of synoptic stations

Statistical duration (year)	Altitude (meter)	Latitude (degree)	Longitude (degree)	station
1990–2013	22.5 meters	31 degree, 21 min northern	48 degree, 15 min eastern	Ahwaz
1990–2013	66.6 meters	31 degree, 21 min northern	48 degree, 15 min eastern	Abadan

Table.2 Specifications of rainfall in synoptic stations of Ahwaz and Abadan

kurtosis	Skewers	Range	Minimum	Maximum	Variance	Standard deviation	Median	Mean	Station
1.08	0.69	392	76.8	468.8	7530.32	86.78	2.65	224.54	Ahwaz
0.08	0.53	261.1	36.8	297.9	3822.39	61.83	145.55	152.47	Abadan

Table.3 Different classes of study drought indices

(BMDI)	(RAI)	(SPI)	rak	Drought severity class
-0.99 to +0.99	-0.3 to +0.3	-	0	normal
-1.99 to -1	-1.2 to -0.3	-0.99 to 0	1	Weakly dry
- 2.99 to -1	-2.1 to -1.2	-1.44 to -1	2	Moderate dry
- 3.99 to -1	-3 to -2.1	-1.99 to 1.5	3	Severe dry
Less or equal -3	≤-3	-2.0	4	Too severe dry

Table.4 Different classed of drought index (deciles index)

Deciles number	Drought severity	Occurrence frequency	Deciles number	Drought severity	Occurrence frequency
6	Normal		1	Very severe drought	Less than 10%
7	Almost wet	60–70%	2	Severe drought	10–20%
8	wet	70–80%	3	Drought	20–30%
9	Very wet	80–90%	4	Almost normal	30–40%
10	Severe wet	More than 100%	5	Normal	40–50%

Table.5 Drought severity using RAI, BMDI, DI, SPI indices in Ahwaz station

Date	Precipitation	Drought Severity SPI	Drought Severity RAI	Drought Severity BMDI	Drought Severity DI
1980	295.6	Near normal	Normal	Weak Dry	Much above
1981	234.1	Near normal	Normal	Normal	Slightly above normal
1982	361.4	Near normal	Normal	Normal	Much above
1983	187	Near normal	Moderately dry	Moderately Dry	Slightly below normal
1984	256.4	Near normal	Normal	Weak Dry	Above normal
1985	159.4	Moderately dry	Severely dry	Moderately Dry	Much below normal
1986	327.4	Near normal	Normal	Normal	Much above
1987	250.9	Near normal	Moderately dry	Weak Dry	Slightly above normal
1988	185	Near normal	Weakly dry	Moderately Dry	Slightly below normal
1989	224.8	Near normal	Moderately dry	Moderately Dry	Normal
1990	136	Moderately dry	Extremely dry	Severely Dry	Much below normal
1991	410.3	Moderately wet	Normal	Normal	Very much above normal
1990	302.5	Near normal	Near normal	Weak Dry	Much above
1993	219.1	Near normal	Normal	Moderately Dry	Normal
1994	228.2	Near normal	Normal	Moderately Dry	Normal

1995	86.4	Extremely dry	Near normal	Severely Dry	Very much below
1996	289.9	Near normal	Normal	Weak Dry	Above normal
1997	468.8	Moderately wet	Normal	Normal	Very much above normal
1998	170.9	Near normal	Severely dry	Moderately Dry	Below normal
1999	227.8	Near normal	Normal	Moderately Dry	Normal
2000	234.8	Near normal	Near normal	Weak Dry	Slightly above normal
2001	227.3	Near normal	Normal	Moderately Dry	Normal
2002	171.3	Near normal	Moderately dry	Moderately Dry	Below normal
2003	218.8	Near normal	Moderately dry	Moderately Dry	Normal
2004	271.8	Near normal	Normal	Weak Dry	Above normal
2005	188.1	Near normal	Normal	Moderately Dry	Slightly below normal
2006	269.1	Near normal	Normal	Weak Dry	Above normal
2007	153.7	Moderately dry	Weakly dry	Severely Dry	Much below normal
2008	105.1	Severely dry	Severely dry	Severely dry	Very much below normal
2009	222.5	Near normal	Moderately dry	Moderately Dry	Normal
2010	76.8	Extremely dry	Extremely dry	High Severely Dry	Very much below normal
2011	173.4	Near normal	Extremely dry	Moderately Dry	Below normal
2012	89.3	Extremely dry	Extremely dry	Severely Dry	Very much below normal
2013	210.3	Near normal	Moderately dry	Moderately Dry	Slightly below normal

Table.6 Drought intensity using RAI, BMDI, DI, SPI in Abadan station

Date	Precipitation	Drought Severity SPI	Drought Severity RAI	Drought Severity BMDI	Drought Severity DI
1980	207.2	Near normal	Normal	Normal	Above normal
1981	112.9	Moderately dry	Moderately dry	Moderately dry	Below normal
1982	169.4	Near normal	Normal	Weak Dry	Slightly

					above normal
1983	119.3	Near normal	Moderately dry	Moderately Dry	Slightly below normal
1984	169.2	Near normal	Normal	Weak Dry	Normal
1985	93.5	Moderately dry	Severely dry	Moderately Dry	Much below normal
1986	297.9	Moderately wet	Normal	Normal	Very much above normal
1987	112.1	Moderately dry	Moderately dry	Moderately Dry	Below normal
1988	138.9	Near normal	Weakly dry	Moderately Dry	Normal
1989	115.5	Near normal	Moderately dry	Moderately Dry	Slightly below normal
1990	81.3	Severely dry	Extremely dry	Severely Dry	Very much below normal
1991	294.4	Moderately wet	Normal	Normal	Very much above normal
1992	153.8	Near normal	Near normal	Weak Dry	Normal
1993	177.6	Near normal	Normal	Weak Dry	Slightly above normal
1994	227	Near normal	Normal	Normal	Much above
1995	147	Near normal	Near normal	Weak Dry	Normal
1996	176.7	Near normal	Normal	Weak Dry	Slightly above normal
1997	236.2	Near normal	Normal	Normal	Much above
1998	88.9	Moderately dry	Severely dry	Severely Dry	Much below normal
1999	228.5	Near normal	Normal	Normal	Much above
2000	155.5	Near normal	Near normal	Weak Dry	Normal
2001	191.3	Near normal	Normal	Weak Dry	Above normal
2002	114.6	Near normal	Moderately dry	Moderately Dry	Slightly below normal
2003	115.2	Near normal	Moderately dry	Moderately Dry	Slightly below normal
2004	208	Near normal	Normal	Normal	Much above
2005	192	Near normal	Normal	Weak Dry	Above normal
2006	198	Near normal	Normal	Normal	Above normal
2007	144.1	Near normal	Weakly dry	Weak Dry	Normal
2008	102.6	Moderately dry	Severely dry	Moderately Dry	Much below normal
2009	126.6	Near normal	Moderately	Moderately	Normal

			dry	Dry	
2010	36.8	Extremely dry	Extremely dry	High Severely Dry	Very much below normal
2011	82	Severely dry	Extremely dry	Severely Dry	Very much below normal
2012	57.5	Extremely dry	Extremely dry	Severely Dry	Very much below normal
2013	112.4	Moderately dry	Moderately dry	Moderately Dry	Below normal

Fig.1 Temperature and rainfall in Ahwaz station

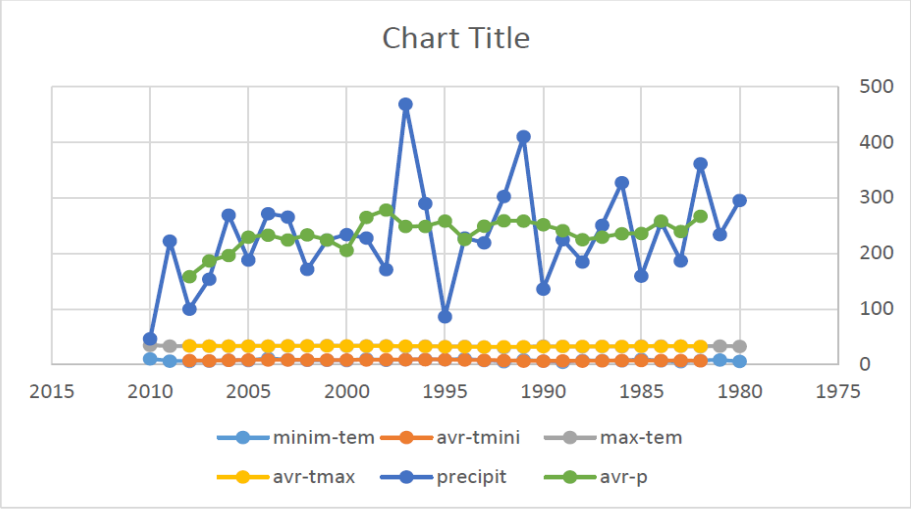

Fig.2 Temperature and rainfall in Abadan station

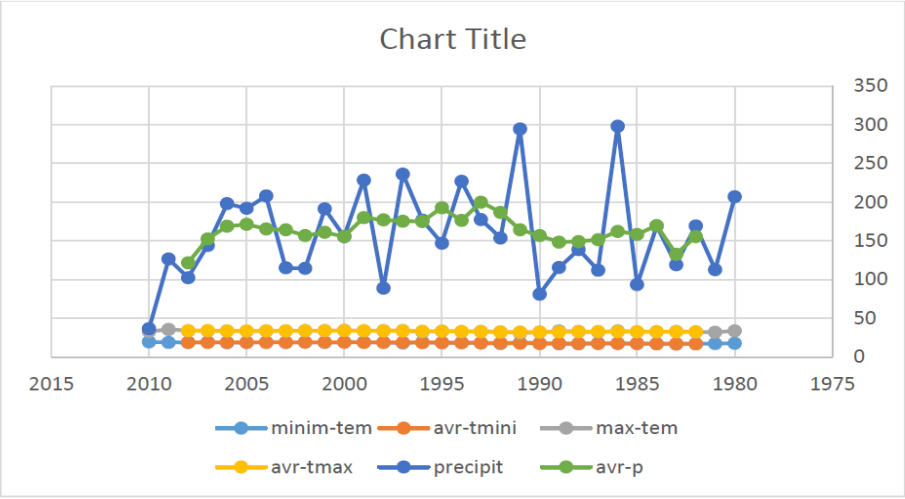

Fig.3 Hour-al-Azim lagoon, Sept. 2014

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