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Analysis of droughts and their trend in Malair plain of Hamadan province

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ABSTRACT

Drought is one of the manifestations of climate change, which occurs in every region and country and expresses the deviation from average or normal conditions in the field of precipitation. The occurrence of drought is inevitable in both dry and wet regions, but with the dry and semi-arid climate of Iran, the probability of drought is higher and it is one of the natural phenomena related to meteorology and hydrology. Therefore, the aim of the current research is to investigate the curve of intensity, duration and frequency of meteorological drought in Malair plain of Hamedan province at an interval of 22 years (1994-2015). Meteorological data from the water year (1994-2015) for Namileh station was prepared from the Provincial Meteorological Organization and after sorting the precipitation data on an annual scale, it was used to calculate the SPI index. The results of this research showed that according to these results, Malair Plain has witnessed a sequence of droughts and droughts with different intensities during the studied period. So that in the water year of 1997-1998, the most severe drought occurred in this region with a value of -2.72, while in 2009-2010 this region had the most drought with a value of 1.97. Drought in this region had the highest frequency with 13 occurrences and occurred only in 9 dry periods, after severe droughts, there was no significant rainfall in the region. Based on the continuity of time, in the region two broad periods of four and five years drought occurred in 1996-2000 and 2010-2014, respectively, but drought periods were mainly two years. In the statistical period, it was found that the conditions of the occurrence of drought were associated with a downward trend and the occurrence of drought decreased to a negligible amount.

Keywords: *rain gauge station, groundwater, climate change, spatial monitoring, soil erosion.*

1. Introduction

With one-third of the global average rainfall rate, Iran is located on the world dry belt, and the dryness is considered one of the inherent features of this country. In addition to this dryness, severe and extensive droughts lead to considerable economic, social, environmental, and even political effects on the country. Therefore, paying attention to this matter is of crucial importance. One solution is to document the drought events in different regions of the country and the positive and negative experiences resulting from how people and officials cope with this phenomenon so that an appropriate strategy can be applied to cope with such conditions in the

future (Samadi Borujeni and Ebrahimi, 2010). Drought is one of the manifestations of climate change in every region and country and indicates the deviation from average or typical precipitation conditions (Safi, 2012). The occurrence of drought in both dry and wet regions is inevitable. However, the probability of drought is higher in the dry and semi-arid climate of Iran, and it is regarded as one of the natural meteorological and hydrological phenomena. Although both flood and drought are climatic phenomena, unlike flood, drought occurs very slowly, and severe anxiety continues for an unknown period and significantly weakens and threatens human life and food resources.

Decrease in surface flow, water level, soil and atmospheric moisture, an increase in plants' evaporation and water needs, growth of algae and water recourses shortage in agricultural and industrial sectors, soil erosion, urban problems, destruction of agriculture and animal husbandry, weeds and insects invasion, decrease in food production, reduction in the health and nutrition level, and ultimately the poverty, economic and social disorders such as inflation, increase in imports and foreign debt, and trade balance deficit is of the apparent outcomes of severe and periodic droughts. The most critical dimension of drought is its severity, which is surveyed based on its influence on various economic, environmental, and social sectors of the affected area and is estimated at four normal, moderate, severe, and very severe levels (Sakirise, 2005; Danandeh Mehr et al., 2021). The drought frequency is one of the most important features used in estimating a region's drought, which can be surveyed on different monthly, seasonally, and annually time scales. The frequencies can be estimated concerning different levels of drought severity. Calculating the frequency distribution in different severities can be used for evaluating the potential of the studied area for various drought severities. This phenomenon can occur in a region of several hundreds of kilometers. However, its duration and severity may not be the same throughout different parts of the region (website of the National Meteorological Organization, 2013).

So far, many definitions have been presented for drought, but every one of these definitions has been proposed from a specific perspective. However, the lack of a comprehensive and precise definition and the variety of definitions expressed from different perspectives has led to a misunderstanding of the concept of drought. Now, since drought affects, directly and indirectly, all the aspects of life and different parts of society, especially the natural environment, not understanding its meaning leads to doubt and stagnation in various economic, managerial, and policy-making sectors. For experts, various definitions have been proposed for the term "drought". Palmer has proposed one of the most comprehensive definitions. According to him, drought is a persistent and abnormal moisture shortage. The term "persistent" refers to the continuity of the shortage, and the term "abnormal" refers to the departure of the desired index from the normal state compared to the average state (Palmer, 1965). Drought is generally divided into four categories: meteorological (climatic), hydrological, agricultural, and economic-social (Yang, 2010; Lotfirad et al., 2022).

Since the change in precipitation is the most important determining factor in meteorological drought, several indices, including the standardized precipitation index (SPI), have been used to analyze the drought trend and severity. The SPI index is widely used worldwide in research and executive affairs for drought monitoring. This index is known as the most appropriate index for drought analysis, especially spatial analyses, due to the simplicity of calculations, use of available

rainfall data, its calculation capacity for any arbitrary time scale, and its capacity for spatial comparison of the results (Guttman, 1999; Wu et al., 2005; Belayneh et al., 2014, and Salas-Martínez et al., 2021). Due to the subject significance, several studies have been done by the researchers applying the SPI index as follows: Bhunia et al. (2020) in India; Liu et al. (2021) in Sichuan Province of China; Cammalleri et al. (2022) in Central Europe; Shakiba et al. (2010) in the east of Kermanshah province; Ghabaei Sough and Mosa'edi (2012), in the dry and semi-dry stations of Iran; Gholami and Malekian (2017), in the Azna-Aligudarz Basin; Kalehoei et al. (2018), in the Caspian Plain margin; Navabi et al. (2021) in Urmia Lake Basin. Regarding the importance of drought and the necessity of regional monitoring of this phenomenon, the present research aims at investigating the drought trend in the Malayer plain of Hamadan province. Analyzing droughts and understanding their trends can help planners cope with crises.

2. Materials and methods

Introduction of the studied area

Malayer Plain is located in the upper area of the Karkhe River Basin between the two provinces of Hamedan (Malair city) and Markazi province (Arak city). The total area of the region is 2965 square kilometers, 855.07 square kilometers, which includes the studied area. The maximum and minimum temperature was 39.87 and -9.05 degrees Centigrade, respectively. The Haran-Abad River is the main river of Malayer Plain (Malayer Water), which originates from Sarband of Arak and flows towards Malayer after joining with another river from the heights of Borujerd (the big branch).

Research Method

Preparation and review of meteorological data

Meteorological data related to the water years 1994-95 to 2015-16 obtained from Namileh station was provided by the Meteorological Organization of Hamedan province. After the related annual scale arrangement, rainfall data were used for calculating the SPI index. The SPI index is considered one of the best, most comprehensive, and most straightforward methods of estimating drought and wet periods and their related features. Mckee presented this index in 1993 based on the probability of precipitation throughout time. Therefore, it can be calculated for different periods (Table 1) and indicates the influence of drought on available water resources in a given interval. Whereas this index is dimensionless, it can be used to compare the rainfall data of different regions and produce drought trend maps with precise accuracy (Agnew, 2000); this index is calculated using the following relation:

Relation (1) $$SPI = (Pi - P) / \sigma$$

Where SPI is the standardized precipitation index, Pi is the annual precipitation, P is the long-term average precipitation, and σ is the standard deviation of precipitation during the statistical period (Mkee et al., 1993). They introduced a classification system to define drought, in which positive SPI values indicate more than average precipitation and negative values mean the opposite. Regarding this method, the drought period occurs when SPI is constantly negative and reaches an intensity of -1,0 or lower, and it ends when the SPI value is positive. This practical

and simple method can be calculated by the involvement of the main precipitation criterion. Therefore, DIP software was used to classify the drought for 22 years (1994-2015) based on the rainfall data of the Namileh station located in the studied region.

Table 1: drought classification based on standardized precipitation index (SPI)

Drought classification	SPI values
The very severe wet period	Higher than 2
Severe wet period	1.5 to 2.99
Light wet period	1 to 1.49
Normal	0.99 to 0
Light drought	0 to -0.99
Average drought	-1 to -1.49
Severe drought	-1.5 to -1.99
Very severe drought	-1 and lower

3. Results and Discussion

Figure 1 represents the extracted results of the dry and wet periods using the SPI index. According to these results, the Malayer Plain had a sequence of dry and wet periods with different severities in the studied period. The most severe drought occurred in this region in the water year of 1997-98 with a value of -2.72, while the year 2010-11 was the wet period of this region with a value of 1.97. The highest frequency of drought occurrence in this region has been reported at 13, and the wet period has been reported only in 9 periods. After severe droughts, there was reported no significant rainfall in the region for the following periods. Further, two broad periods of four- and five-year drought occurred respectively, 1996-2000 and 2010-2014, but wet periods were mainly two years. Moreover, the positive value of the index fitting line slope (SPI = 0.0284) during the statistical period revealed that the drought occurred with a downward trend and decreased insignificantly.

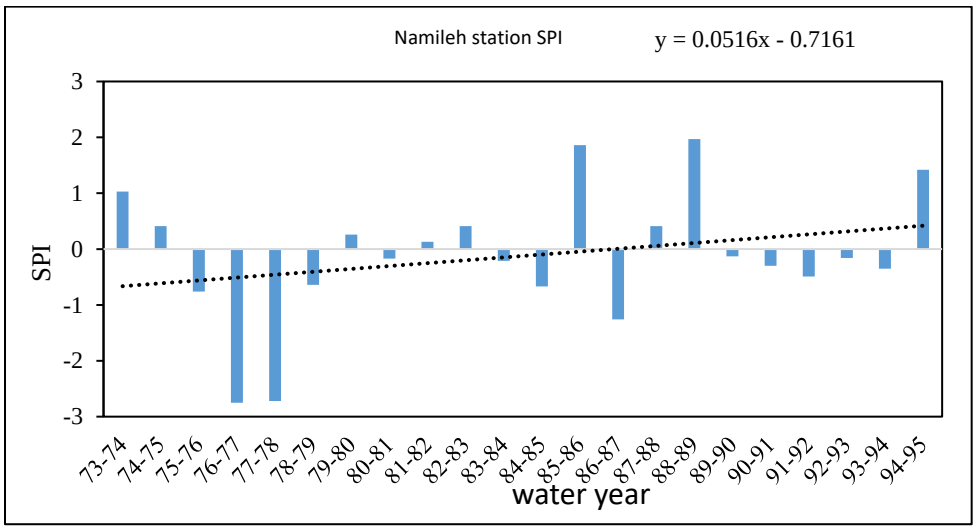

Figure 1: Graph of annual SPI changes of Namileh rain gauge station

The Malayer Plain Basin, with an average annual rainfall of 322.9 mm, is located in a semi-arid and mountainous area. For this reason, it has not been in good condition regarding surface and groundwater resources. The lack of sufficient rainfall in this region can have various impacts on the region's land cover, land use, and ecosystem. Meteorological drought can lead to land-use change (Ghiaei, 2014). Due to its climatic conditions, the Malayer plain has little annual rainfall. The occurrence of numerous droughts with different severities and the increase of under-cultivation lands for planting orchards and vineyards have made the farmers extract groundwater, which would lead to the fragile ecosystems in this region.
Furthermore, the decrease in rainfall leads to the drying of the agricultural groundwater wells, the increase of grazing pressure on the pastures, the decrease in vegetation, etc. The results of the present research correspond to the findings of studies done by Yerdelen et al. (2021); Nohegar et al. (2016), Rostami et al. (2017); Nadi and Shiyoukhi (2020). Monitoring the drought and determining its trend over different periods can be an appropriate tool for the relevant officials to control the crises caused by the drought.

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