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A Study on North Iraq Region's Meteorological Drought: Sulaymaniyah Sampling

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Abstract:

Drought is one of the phenomena of climate and is one of the catastrophic events that causes much damage each time. One of the ways of drought adjustment, evaluation and drought monitoring is based on indicators that can be used to determine the extent and continuity of it in a region. In this study, the drought analysis (intensity, duration, and severity of drought) of Sulaymaniyah province in North Iraq Region has been studied by using Standardized Precipitation Index (SPI) for time scales of 1,3, 6, 9 and 12 months. In order to observe the dry and wet periods and severity of drought and length of drought, the monthly rainfall data of 5 meteorological stations of the Sulaymaniyah province which are important city of the region. The period of 1979- 2013 was used to determining the SPI by using Matlab computer software and calculations were performed on the standardized precipitation index. The results of the study showed that the incidence of short-term (one-month) dry periods in all stations are more than 9, while the incidence of long-term dry periods in the 6, 9 and 12 month periods is much lower, the continuity of dry periods in the 6, 9, and 12-month periods was higher than the 1 and 3 time intervals. This analysis is important because it gives a wide information about longest dry and wet period for every station.

Key words: Drought, Standard Precipitation Index, Sulaymaniyah, North Iraq Region

1. Introduction

Natural disasters such as floods, thunderstorms, drought and etc. are constitutions of our environment. These disasters make a negative impact and irreparable damages to human life. According to literature, today the number and incidence of that events have increased over the past 30 years. About 25 percent of them are events related to climatic factors. Among these events, drought is one of the main and perhaps the most influential event (Kogan, 1998). Drought is one of the major hazards associated with meteorology. This natural hazard affects all aspects of our life. At the international level, there is no single definition of drought that is universally accepted. In general, drought occurs when there is a decrease in water, both at the site and at a specific time (Correia et al,1991). Each drought is characterized by three characteristics: Intensity, length, and width. The drought has a variety of types due to the length of the drought, and they are defined as follows.

•Meteorological drought, •Agricultural drought, •Hydrological drought, •Socioeconomic drought.

In this study, the estimation of meteorological drought severity for the 1, 3, 6, 9 and 12-month time scales using SPI method based on the data obtained from 14 meteorological stations. The temporal variations of drought in North Iraq, Sulaymaniyah is assessed and presented in this paper.

2. Materials and Method

2.1. Study Area

North Iraq as study has an area about 40,643 km^2 and northern latitudes of 36 degree and eastern longitude 44 degrees. The southern parts of Iraq are located in the tropics and its northern parts in the semi-arid regions. Figure 1 shows the study area. There are four main rivers in Iraq include the Euphrates, Tigris, Diyala and Zab.

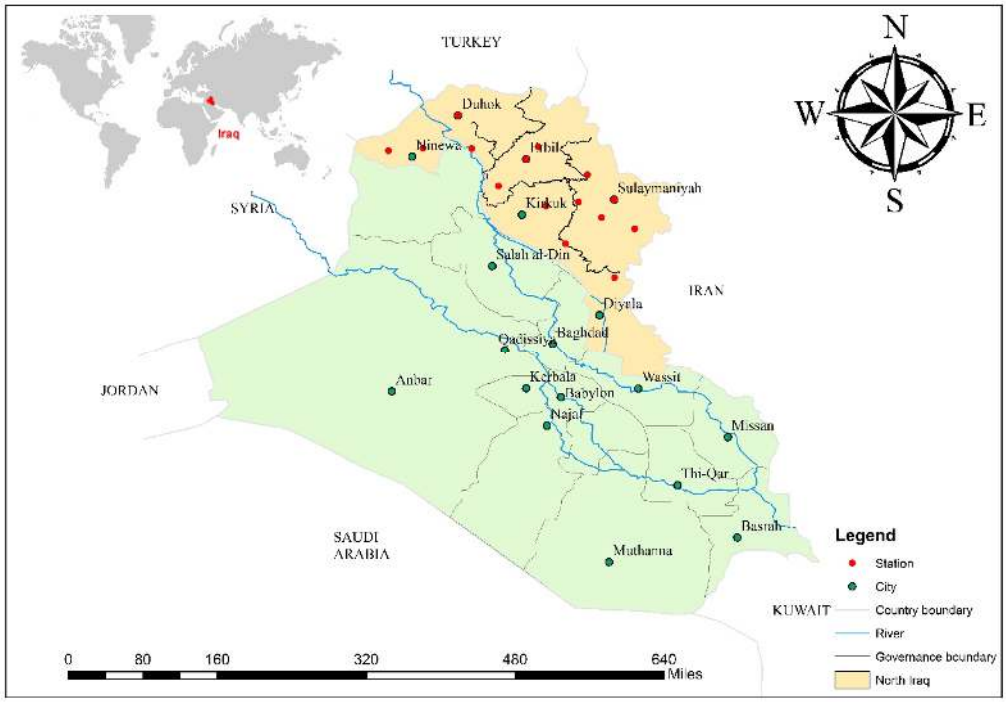

Figure 1. Study area

2.2. Data

In this study, the rainfall data, collected from the metrological observation stations in different cities of North Iraq (Meteorological Organization of North Iraq and Global Weather Data), are used to determine metrological drought indices (Figure 2). Table1 gives the geographical information of the precipitation stations used in the drought analysis. According to this, in addition, Sulaymanya with the number (354453) has the highest rainfall amount in the studied stations, and Darbandikhan with the number (351456) has the least amount of rainfall. Average Annual Precipitation values change from (765 mm-505 mm) at all stations.

Table 1. Geographic and climatic characteristics of stations and data

Station No	Station ID	Station Name	Location	Longitude	Latitude	Height (m)	Available Years range	Annual Precipitation (mm)
1	354453	Sulaymaniyah	Sulaymaniyah	45.375611	35.564112	886	1979-2013	765
2	351456	Darbandikhan	Sulaymaniyah	45.695272	35.110939	532	1979-2013	505
3	354447	Chamchamal	Sulaymaniyah	44.821728	35.529211	859	1979-2013	555
4	351453	Sangaw	Sulaymaniyah	45.179867	35.285127	770	1979-2013	631
5	361450	Dokan	Sulaymaniyah	44.962103	35.949559	529	1979-2013	670

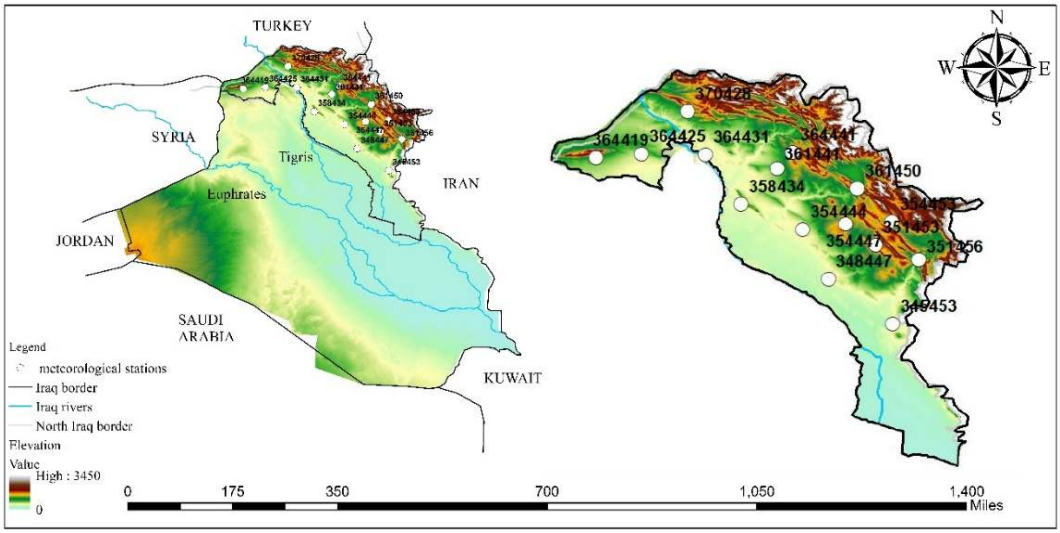

Figure 2. The distribution of meteorological stations of North Iraq.

2.3. Method: Standard Precipitation Index (SPI)

Standard precipitation index is used for investigation of updated drought. The drought depends on the precipitation in the Sulaymaniyah province evaluated by using SPI (McKee et all., 1993). One of the main criteria in the evaluation of drought is Standardized (SPI), its calculation requires average and Long-term standard deviation of rainfall amounts during the period under study (Bonaccorso et al., 2003). This measure is provided essentially to define and monitor drought and rain (Tsakiris et al., 2004) and allows the analyst to defined and identify the number of drought events and happened wet period for any described time (Mckee et all., 1993). Since this index is dimensionless, that information can help to compare different areas and produce drought range with greater accuracy (Agnew., 2000) among other advantages of this index is that it can be identify and fitted probability density function and frequency analysis for severe droughts and severe wet areas performed on it (Livida et al, 2007). The detail of the SPI method can be found in Gumus and

Algin (2017). The SPI values have been classified by Edossa et al. (2010) into eight classes that vary within the range from extreme wet to extreme drought as shown in Table 2.

Table 1. The SPI Classification (Edossa et al., 2010)

SPI classes	Period classification
SPI≤−2	Extreme drought
−2<SPI≤−1.5	Severe drought
−1.5<SPI≤−1	Moderate drought
-1<SPI≤0	Mild drought
0<SPI≤1	Mild wet
1<SPI≤1.5	Moderate wet
1.5<SPI≤2	Severe wet
SPI>2	Extreme wet

3. Results

In this study, the drought analysis of the Sulaymaniyah area is carried out by using long-term monthly total rainfall data measured from five meteorological observation stations in Sulaymaniyah province.

The (SPI) method is used to determine the drought and temporal drought values are evaluated according to the 1, 3, 6, 9 and 12-month time scales. Temporal distribution of SPI values and Distribution of SPI values are given in Figure 3 and Figure 4, respectively. Dry months and percentages of the SPI-1, SPI-3, SPI-6, SI-9, SPI-12 values of all stations considered are given in Table 3. According to the figures and table, for the SPI-12, the longest dry periods for Sulaymaniyah, Darbandikhan, Chamchamal, Sangaw and Dokan stations are found to be 93, 60, 125, 58 and 107 months, respectively. The start dates of the longest dry periods of all the examined stations are determined generally between 2010 and 2013, according to the SPI 12 values.

The highest dry month percentage within the SPI-1 values obtained for all stations (Figure 4). This occurs at Dokan station with 36%. The highest "extreme dry" month percentage in dry months is found at Sangaw station with 2.38%. According to the classification of drought, the highest "Severe Dry" month rate is determined 3.81% in Sangaw, Dokan, the "Moderate Dry" month percentage is 6.43% in Darbandikhan and "Mild Dry" month percentage is 25.24% in Chamchamal station.

When SPI-3 values are examined, the highest dry month percentage is found in Sulaymaniyah, Dokan station with%46. The highest "extreme dry" month percentage in dry months is found at Dokan station with 2.7%. According to the classification of drought, the highest "Severe Dry"

month percentage is found 5.15% in Darbandikhan, Dokan, the "Moderate Dry" month percentage is 8.95% in Chamchamal and "Mild Dry" month percentage is 31.37% in Sangaw station.

The highest dry month percentage according to SPI-6 values are found in Sulaymaniyah, Darbandikhan, Dokan station with 47%. The highest "extreme dry" month percentage in dry months is found at Darbandikhan station with 4.17%. According to the classification of drought, the highest "Severe Dry" month percentage is 5.39% in Dokan, the "Moderate Dry" month percentage is 11.27% in Chamchamal and "Mild Dry" month percentage is 30.64% in Darbandikhan, Dokan stations. The highest dry month percentage according to SPI-9 values occurs in Dokan stations with 50%. The highest "extreme dry" month percentage in dry months is found at Dokan station with 3.19%. According to the classification of drought, the highest "Severe Dry" month percentage is 5.39% in Sangaw, the "Moderate Dry" month percentage is 11.03% in Sulaymaniyah and "Mild Dry" month percentage is 33.82% in Dokan, station. The highest dry month percentage according to SPI-12 values is found in Dokan station with 53%. The highest "extreme dry" month percentage in dry months is found in Sangaw, Dokan، Darbandikhan stations with 2.45%. According to the classification of drought, the highest "Severe Dry" month percentage is 6.37% in Darbandikhan, Sangaw the "Moderate Dry" month percentage is 11.76% in Sulaymaniyah and "Mild Dry" month percentage is 36.76% in Dokan, station.

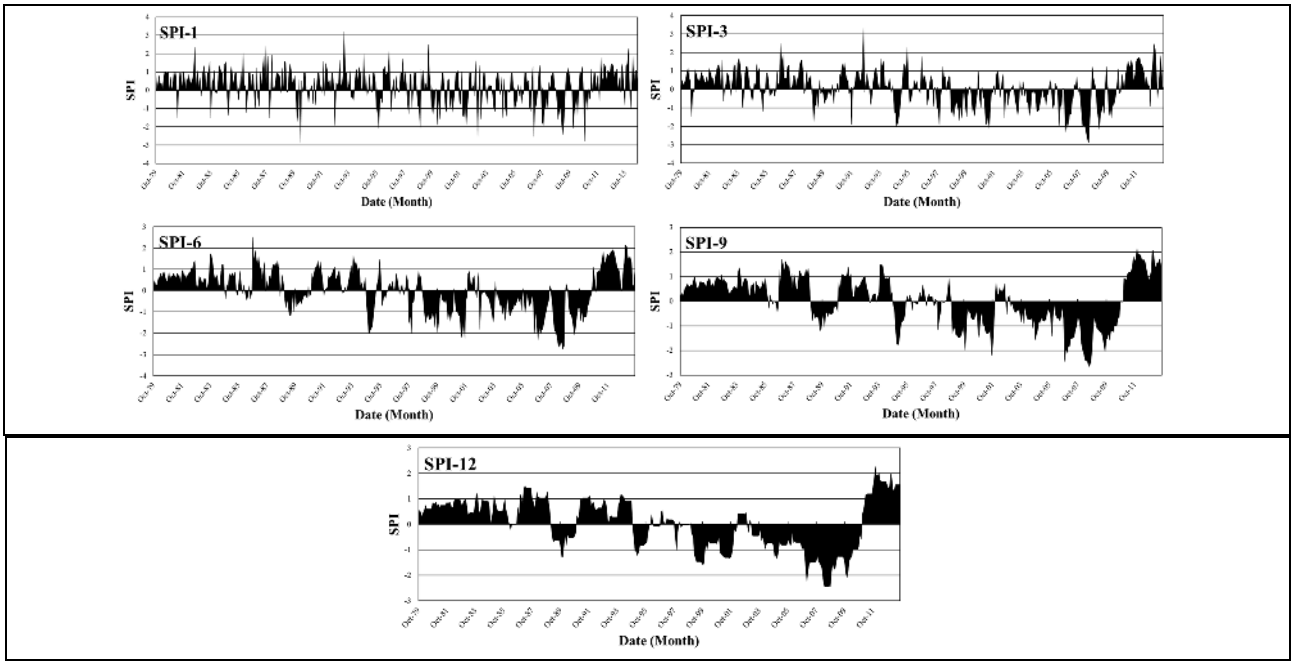

Figure 3. Temporal distribution of SPI values at 1, 3, 6, 9 and 12 months for Sulaymaniyah station

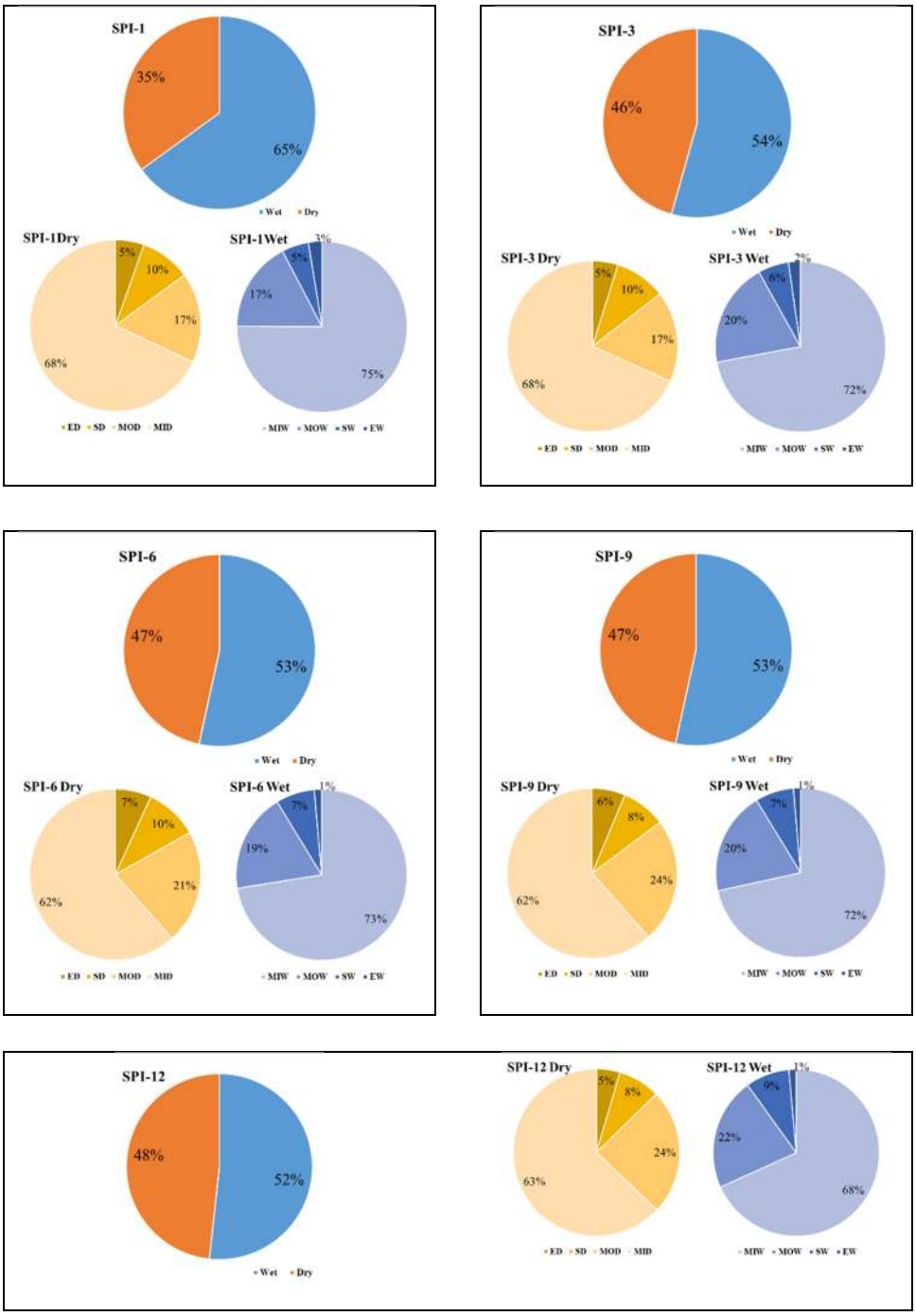

Figure 4. Distribution of SPI values at 1, 3, 6, 9 and 12 months for the Sulaymaniyah station.

Table 3. Dry months and percentages of the SPI-1, SPI-3, SPI-6, SI-9, SPI-12 values of all stations considered

SPI 1												
Station No	Station Name	Months number	percentage of dry	Number of dry months	Extreme drought		Severe drought		Moderate drought		Mild drought	
					months number	percent (%)	months number	percent (%)	months number	percent (%)	months number	percent (%)
354453	Sulaymaniyah	420	35	147	8	1.90	14	3.33	25	5.95	100	23.81
351456	Darbandikhan	420	31	131	6	1.43	14	3.33	27	6.43	84	20.00
354447	Chamchamal	420	35	148	9	2.14	10	2.38	23	5.48	106	25.24
351453	Sangaw	420	35	145	10	2.38	16	3.81	16	3.81	103	24.52
361450	Dokan	420	36	151	8	1.90	16	3.81	26	6.19	101	24.05
SPI 3												
Station No	Station Name	Months number	percentage of dry	Number of dry months	Extreme drought		Severe drought		Moderate drought		Mild drought	
					months number	percent (%)	months number	percent (%)	months number	percent (%)	months number	percent (%)
354453	Sulaymaniyah	408	46	186	9	2.21	18	4.41	32	7.84	127	31.13
351456	Darbandikhan	408	38	155	9	2.21	21	5.15	25	6.13	100	24.51
354447	Chamchamal	391	44	173	9	2.30	14	3.58	35	8.95	115	29.41
351453	Sangaw	408	45	182	10	2.45	17	4.17	27	6.62	128	31.37
361450	Dokan	408	46	189	11	2.70	21	5.15	30	7.35	127	31.13
SPI 6												
Station No	Station Name	Months number	percentage of dry	Number of dry months	Extreme drought		Severe drought		Moderate drought		Mild drought	
					months number	percent (%)	months number	percent (%)	months number	percent (%)	months number	percent (%)
354453	Sulaymaniyah	408	47	190	13	3.19	19	4.66	41	10.05	117	28.68
351456	Darbandikhan	408	47	191	17	4.17	16	3.92	33	8.09	125	30.64
354447	Chamchamal	408	46	188	11	2.70	17	4.17	46	11.27	114	27.94
351453	Sangaw	408	46	186	14	3.43	19	4.66	35	8.58	118	28.92
361450	Dokan	408	47	193	14	3.43	22	5.39	32	7.84	125	30.64
SPI 9												
Station No	Station Name	Months number	percentage of dry	Number of dry months	Extreme drought		Severe drought		Moderate drought		Mild drought	
					months number	percent (%)	months number	percent (%)	months number	percent (%)	months number	percent (%)
354453	Sulaymaniyah	408	47	190	12	2.94	16	3.92	45	11.03	117	28.68
351456	Darbandikhan	408	48	196	14	3.43	20	4.90	40	9.80	122	29.90
354447	Chamchamal	408	49	200	12	2.94	18	4.41	36	8.82	134	32.84
351453	Sangaw	408	45	184	12	2.94	22	5.39	37	9.07	113	27.70
361450	Dokan	408	50	206	13	3.19	16	3.92	39	9.56	138	33.82
SPI 12												
Station No	Station Name	Months number	percentage of dry	Number of dry months	Extreme drought		Severe drought		Moderate drought		Mild drought	
					months number	percent (%)	months number	percent (%)	months number	percent (%)	months number	percent (%)
354453	Sulaymaniyah	408	48	197	9	2.21	16	3.92	48	11.76	124	30.39
351456	Darbandikhan	408	47	192	10	2.45	26	6.37	41	10.05	115	28.19
354447	Chamchamal	408	51	210	8	1.96	19	4.66	34	8.33	149	36.52
351453	Sangaw	408	44	181	10	2.45	26	6.37	38	9.31	107	26.23
361450	Dokan	408	53	217	10	2.45	15	3.68	42	10.29	150	36.76

4. Conclusions

The results of this study, the temporal drought values in the North Iraq region, have been examined in detail. Based on the finding from the present drought analysis on the Sulaymaniyah province using monthly precipitation time series, the following conclusions may be drawn.

According to the SPI 12 values, the longest dry periods for Sulaymaniyah, Darbandikhan, Chamchamal, Sangaw and Dokan stations are determined 93, 60, 125, 58 and 107 months, respectively. The start dates of the longest dry periods of all the examined stations are determined generally between 2010 and 2013. The highest dry month percentage according to SPI-12 values is found in Dokan station with 53%.

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