

Characterization of Drought Events in South Oran and South Algiers Steppes in Algeria

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ABSTRACT

Over the past three decades, Algeria has experienced a significant precipitation deficit that is characterized by recurring droughts. The present article aims at studying and describing the main characteristics of drought episodes in the steppes of South Oran and South Algiers, over the period extending from 1978 to 2013. To do this, the characteristic parameters of the dry periods, i.e. their duration, intensity and frequency, were analyzed using three methods. The first one consists of calculating the Standardized Precipitation Index (SPI) using three time scales, i.e. 3, 6 and 12 months. The second one is the quintile method and the third one is the Chronological Graphical Method of Information Processing (MGCTI). The results obtained showed a great variability in the SPI values at the time scale of 3 months whereas at the time scales of 6 and 12 months, these values were stationary and revealed less frequent but more severe and longer dry sequences. The findings obtained when using both the quintile and MGCTI methods also revealed the severe and recurrent character of drought observed during the period from 1992 to 2002. The most significant drought events, in terms of intensity, duration and geographical extension, occurred during the years 1983/1984/1985 and then from 1999 to 2002. This phenomenon manifested itself in a similar way over the entire region under study.

Keywords: Algeria, Drought characterization, South Oran steppes, Standardized Precipitation Index (SPI).

Mathematics Subject Classification: 62P12, 37N10

Journal of Economic Literature (JEL) Classification: Q54, Q01

1. INTRODUCTION

The northwestern part of Algeria, which covers a large part of our study area and whose climate is Saharan in the south and Sub-humid in the north, has also known, in the course of its history, many periods of drought of varying magnitude. Some of them sometimes had dramatic consequences on the living conditions of people, particularly those living in rural areas (1941-1943). However, the most severe and persistent ones are those that occurred in the decades from 1980 to 1990 and from 1991 to 2000. These droughts were characterized by a significant rainfall deficit which was estimated at 12% for the central region, 13% for the eastern region and 20% for the western region (Medjerab, 2005). These values indicate that the western portion of Algeria was the one that suffered the most. This drought had a negative impact on the flow regime of Wadis (Rivers) as well as on the groundwater recharge and dam filling rate (Khaldi, 2005).

The first research projects related to drought issues were carried out in the early 1980s (Djellouli, 1981; Mebarki, 1984; Aidoud, 1989; Rognon, 1996; El-Mahi et al., 2004; Medjerab, 2005;

Khaldi, 2005; Hirche et al., 2007; Meddi, 2009; Ghenim and Megnounif, 2011; Talia et al., 2011; Nouaceur et al., 2013; Akouche et al., 2017). It is important to note that the findings of these studies may be used as a basis for developing an early warning system to trigger an emergency program in order to mitigate the short-term effects of drought. It is in this context, and based on rainfall data, that the present article attempts to study the evolution of the parameters that characterize the drought in terms of intensity, duration and frequency, in a few stations in the steppe regions of Southern Oran and Southern Algiers, in Algeria.

The present research work was chosen particularly because of the great sensitivity of steppe vegetation to rainfall variations. Through the analysis of the rainfall series, for the period from 1978 to 2013, provided by 9 stations spread over the study area, this work attempted to focus on the characterization of the recent trend in order to determine the evolution of the drought that emerged in the late 1970s.

2. Data and methods

2.1. Presentation of the study area

Physically, the study area falls within the geographical area of the high steppe plains in South-Oran and South-Algiers (Figure 1a). These high plains form a vast monotonous ensemble whose altitude decreases progressively from the Moroccan border (1200 meters) to the Hodna depression (400 meters), as shown in Figure 1b. The study zone is limited to the West by the Chott El-Gharbi, to the East by the Chott El-Hodna, and to the North by the Tell Atlas Mountains; the Tell Atlas consists of a series of mountain ranges and massifs directed from West to East. The Saharan Atlas Mountains are in the south and are oriented in the direction of South West - North East.

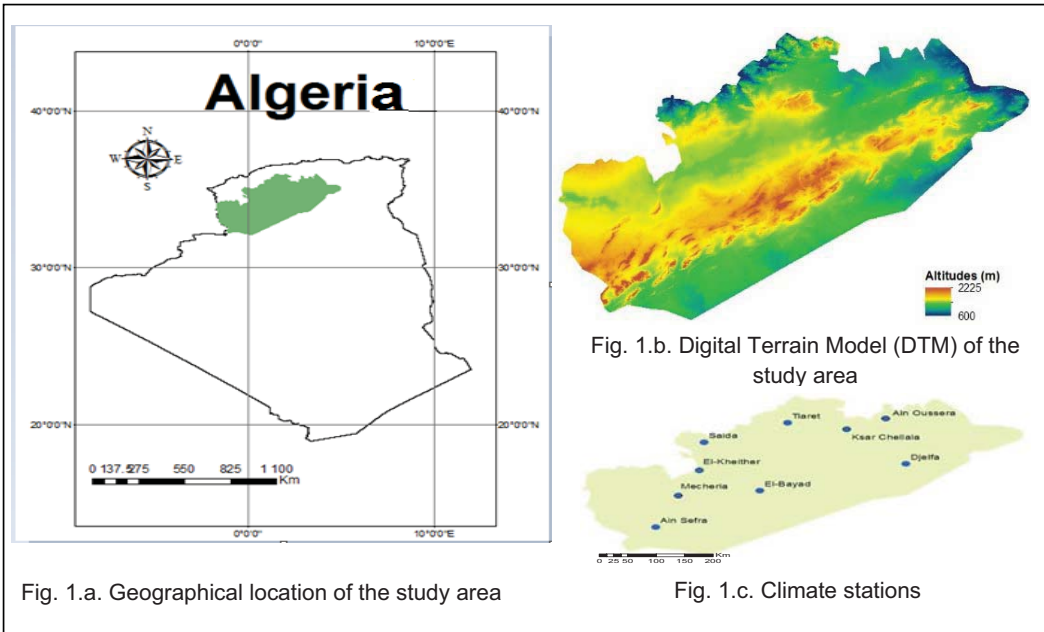


Figure 1- Location map of the study area

2.2. Climate framework

The area under study is characterized by a contrasting Mediterranean-type climate, with a dry and hot summer season alternating with a rainy and cold winter season. This area is also

characterized by a great variability of intermensual and interannual rains and by relatively homogeneous but very contrasting thermal regimes, of the continental type (Le Houerou, et *al.*, 1977).

Precipitation

The average annual rainfall calculated for all the stations under study (Table 1) gives close average values for the stations located in the Zahrez (Ain Ouessera with 212.66mm) and Chott Chergui (El-Kheither and Ain-Sefra, with 217.51mm and 180.56mm, respectively). As for the stations located in the region of the Saharan Atlas, the average annual rainfall reaches 308.81, 272.48 and 232.76 mm, at the stations of Djelfa, El-Bayadh and Mecheria, respectively. Moreover, the interannual variability is significant; it is measured by the Coefficient of Variation (CV). The coefficients of variation are substantially identical for the regions of Saida, Tiaret, Mecheria, Ain-Ouessera and Djelfa, with respectively 28, 28, 31, 29 and 27%. Slightly higher values are noted for the stations located in Ain-Sefra and El-Kheiter (48 and 39%, respectively). The ratio of the maximum values to the minimum values (Max / Min ratio) varies between 3 and 11, which reflects the level of the statistical series and confirms the random nature of rains along with the importance of heavy showers which cause runoff and accentuate the disequilibrium in the already deficient water balance.

The seasonal distribution of rainfall is marked by the predominance of autumn and spring rains during the warm period. A certain quantity of water, which is rather low, is brought by thunderstorms whose frequency is the highest during the warm season (Le Houerou et *al.*, 1977).

Table 1: Descriptive characteristics of the series of annual observations

	Average (mm/year)	Median (mm/year)	Standard deviation	Coefficient of variation (CV) (%)	Max	Min	Extent (Level)
Ain-Oussera	212.66	202.55	62.38	29	350.90	111.00	239.90
Ain-Sefra	180.56	158.00	87.45	48	457.00	40.20	416.80
Djelfa	308.81	303.90	83.03	27	531.90	173.40	358.50
El-Bayadh	272.48	250.75	91.58	34	505.10	150.50	354.60
El-Kheiter	217.51	207.15	84.70	39	464.50	83.90	380.60
Mecheria	232.76	216.75	71.71	31	429.60	117.50	312.10
Saida	350.61	334.55	96.79	28	646.70	206.10	440.60
Tiaret	367.14	350.60	104.59	28	599.60	193.49	406.11
Ksar-Chellala	262.37	257.35	90.93	35	478.40	113.00	365.40

Thermal regime

Temperature data analysis for the period extending from 1972 to 2013 allows making the following observations:

- The western steppes know a contrasting thermal regime, of continental type;
- The annual thermal amplitude, for nearly the entire region under study, is between 20 and 22 °C;
- July is the hottest month (31.2 °C <M < 33.5 °C);
- The months of December, January and February are the coldest (-0.6 °C <m< 6.2 °C).

Bioclimatic framework

With the exception of the regions of Saida and Tiaret, which have a relatively short dry season (from June to August), the rest of the study area is characterized by a dry season that generally extends, more or less intensely, over six months. Le Houerou et *al.* (1977) established a map of the distribution of bioclimatic stages over the Algerian steppe as a function of the average annual rainfall

(P), the mean minimum temperature of the coldest month (m) and the mean maximum temperature of the hottest month (M'). The bioclimatic stages and sub-stages are shown in Table 2.

Table 2: Bioclimatic stages and sub-stages and thermal variants

Stations	Bioclimatic stages and sub-stages	Rainfall (mm/an)	Thermal variants	(m in °C)
Tiaret	Mediterranean semi-arid	367.14	Cool winters	1 to 3
Saida		350.61		
Djelfa	Mediterranean arid high	308.81	Cold winters	-2 to 1
El-Bayadh		272.48		
Ksar-Chellala	Mediterranean semi-arid	262.27	Cool winters	1 to 3
Mecheria		232.76		
El-Kheiter		217.51		
Ain-Ouessera		212.66		
Ain-Sefra	Mediterranean arid low	180.56	Cool winters	1 to 3

2.3. Data

The choice of rainfall data used in this study was made according to the criteria of continuity, duration of available information and quality of data. Nine stations were selected. Figure 1c illustrates the location of these stations. The data were provided by the National Office of Meteorology (NOM). This study is based on the monthly rainfall series recorded between September 1978 and August 2013. The stations were chosen according to the availability of data.

2.4. Methodology

Our approach is based on the characterization of drought using the most commonly used climate indices, namely:

- The standardized precipitation index (SPI) which is calculated for three time scales, i.e. the short (3 months), the average (6 months) and the long (12 months) time scales. The frequency, duration and intensity of the drought were determined at each station, and for each time scale;
- The quintile method was employed to classify, by year and by station, the limit values (Q1, Q2, Median, Q3, and Q4) calculated for all stations;
- With regard to the representation of rainfall trend at the regional scale, it was decided to also use the Chronological Graphical Method of Information Processing of the "Bertin Matrix" type.

Description of the Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is among the various indices of appreciation of the climatic drought; it is mostly used for the characterization of meteorological drought (Vicente-Serrano et al., 2004; El Bouqdaoui et al., 2006; Nunez Lopez et al., 2006; Ellouze et al., 2008; Eugenia and Carmen, 2009; Klein, 2009; Ghenim et al., 2011; Rahmouni, 2012; Sero et al., 2014; Khouldia et al., 2014). The standardized precipitation index (SPI) is used for drought monitoring with multiple time scales. The SPI can be evaluated for durations equal to 1, 2, 3, 6, 12, 24, and 36 months; however, its interpretation differs according to the time scale chosen.

Calculation of the Standardized Precipitation Index (SPI) requires the adjustment of long series of precipitation data to the two-parameter Gamma distribution. According to Klein (2009), the Gamma distribution is the best distribution for precipitation modeling.

Dryness is defined for SPI values less than -0.99. The duration of the dry sequence then coincides with the period during which the SPI values remain below this value (Nunez Lopez et al., 2006).

Finally, each value of the SPI is related to a degree of severity, as shown in Table 3; the probabilities of occurrence are also reported in the same table.

Table 3: Classification of the standardized precipitation index (SPI) values

Drought intensity	SPI value	Probability (%)
Extremely humid	$SPI \geq +2.00$	2.3
Critically humid	$+1.99 \geq SPI \geq +1.50$	4.4
Moderately humid	$+1.49 \geq SPI \geq +1.00$	9.2
Slightly humid	$+0.99 \geq SPI \geq 0$	34.1
Mild drought	$0 > SPI \geq -0.99$	34.1
Moderate drought	$-1.00 \geq SPI \geq -1.49$	9.2
Severe drought	$-1.5 \geq SPI \geq -1.99$	4.4
Extreme drought	$SPI \leq -2.00$	2.3

Source: McKEE et al. 1993

Quintile method

This method consists of classifying the data, by year and by station, with respect to the limit values (Q1, Q2, Median, Q3 and Q4) calculated for all the stations and over the whole series. The distinction between classes is made in such a way that when the rainfall totals are lower than the limit value of

the first quintile (Q1), the years considered are very deficient in rain (very dry). The years between the first quintile (Q1) and the second quintile (Q2) are considered as water-deficient (dry). The years with a rainfall amount between the second quintile and the median are normal but with a rather dry trend. In the interval between the median and the third quintile (Q3), the years are considered normal with a rather humid trend. Rainy years (wet years) are found between the third quintile (Q3) and the fourth quintile (Q4). Finally, all years with rainfall totals greater than the fourth quintile are considered as having excess rainfall (very wet).

Chronological Graphical Method of Information Processing

This method, which was developed in 2013 (Nouaceur et al., 2013), the Chronological Graphical Method of Information Processing (CGMIP) makes it possible, first of all, to analyze the spatio-temporal distribution of the climatic parameter and then to determine the dates of cycle changes using the regional analysis. After the data classification according to the quintile method, and based on the nomenclature presented in Table 5, this operation is followed by recoding the values using a range of colors (the color varies according to the position of the cumulative annual rainfall with respect to limit values). In order to determine the breaks and characteristic periods, a second operation is performed. It consists of assigning a number varying from 1 (very dry year) to 5 (very humid year) each year, according to the characters previously determined. The sum of the numbers from all the stations for each year is centered reduced. Finally, the projection of the results on a graph makes it possible to see the evolution of the phenomenon, at the regional scale, and to determine the dates of breaks and trend change.

3. Results and discussions

Analysis of the descriptive parameters of drought reveals that the steppe in South-Oran and South-Algiers experienced a significant rainfall deficit after the 1980s, with peaks in the years 1983/84, 1992/93 and 1999/2000.

3.1. Spatial distribution of drought in the study area

The analysis of the different droughts experienced by the nine stations selected in this study confirms the increased drying out of the period between 1978 and 2013. Figure 2 shows the percentage of stations that recorded drought conditions. At the time scale of 3 months, a phenomenon of greater magnitude was observed between the month of February 1999 and the month of August 1999. All the stations under study exhibited water deficits.

The analysis of observations at the 6-month time scale shows that this phenomenon took place between April 1982 and April 1983; all stations indicate a 12-month dry episode. By continuing this analysis at the 12-month time scale, one can note that this phenomenon occurred between January 1999 and March 2001, resulting in 28 months of drought, which actually represents the driest period in the study region. The work conducted by Nouaceur (2013) on northeastern Algeria confirms that the period between 1987 and 2002 was marked by the preponderance of drought conditions.

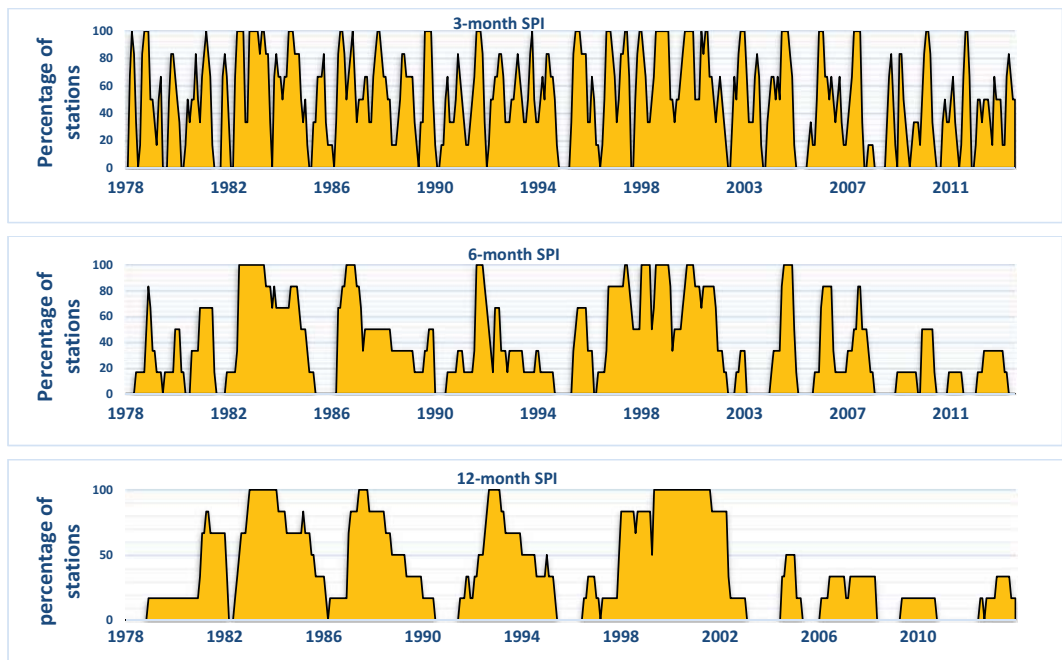


Figure 2 - Percentage of stations with SPI values less than -0.99, between 1978 and 2013, based on 3, 6 and 12 months time scales.

3.2. Analysis of descriptive parameters of dry sequences

The analysis of the frequency and duration of drought sequences observed in the study area was carried out according to the three time scales selected.

Short-term drought

In the short term, 27, 25, 24 and 27 dry sequences were recorded at the stations of Saida, Djelfa, El-Kheiter and Ain-Sefra, respectively (Table 4). Analysis of the duration of dry events shows the existence of 8 dry sequences whose duration exceeded 10 consecutive months, at the station of

Ain-Sefra. The longest of these sequences was between October 1982 and September 1985, i.e. 36 months, with an intensity of -2.67 (Fig. 3a). Regarding the station of Djelfa, 25 drought events were recorded, each lasting an average of 6.32 months. The most remarkable event, still in the short term, occurred in 1999 and lasted 7 months during which extreme drought occurred (Fig. 3b). At the station of Saida, 27 drought events were recorded, each lasting an average of 5.81 months (Fig. 3c). As for the station of El-Kheiter, it is important to underline the existence of 24 dry events whose average duration was 6.29 months. The longest dry period was between December 1999 and August 2000, i.e. 21 months; this period was characterized by extreme drought. The longest dry periods at this time

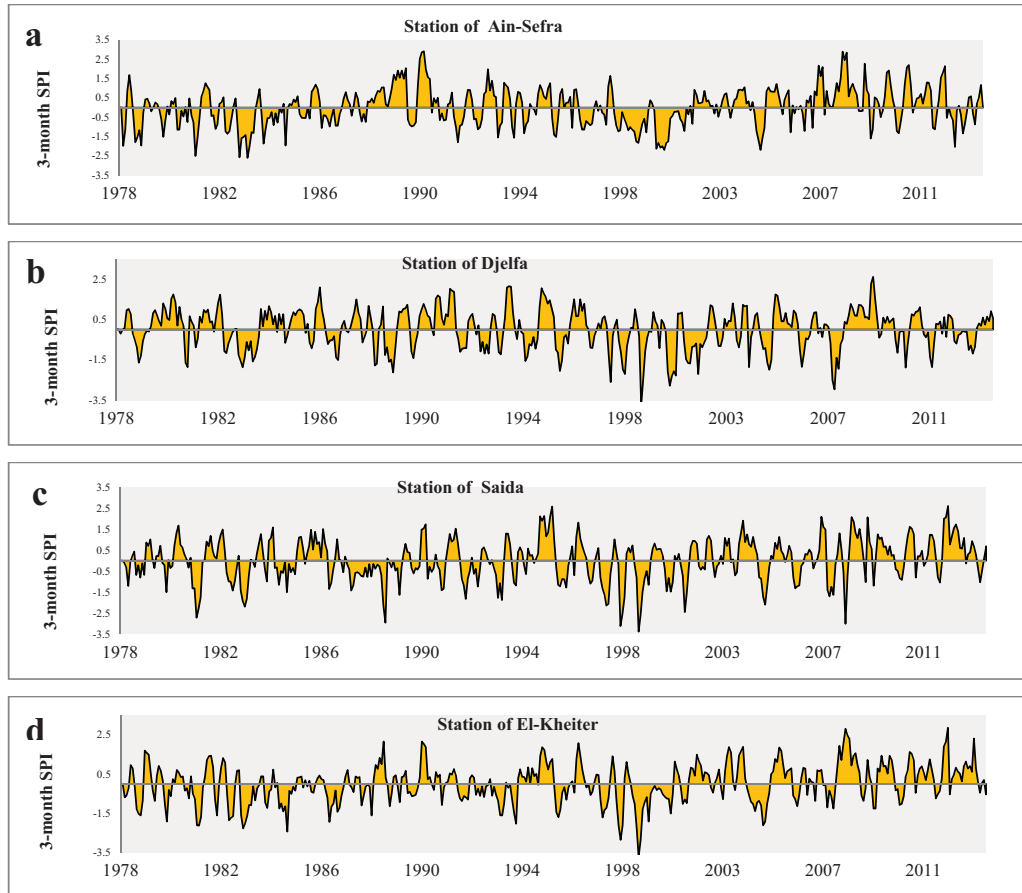


Figure 3: Evolution of short-term climate drought at the stations of Saida, Djelfa, Ain-Sefra and El-Kheiter, between 1978 and 2013

Medium-term drought

The results obtained by studying the 6-month SPI temporal variations (in the medium term), whose main statistics are summarized in Table 4, show that the frequency of drought sequences decreases while the average duration increases; it is larger than that found in the short-term. At the station of Djelfa, a town located in the High Plains of South Algiers, 18 dry events are identified; they cover 38% of the entire analysis period. Note that the average duration of each event is 9.17 months. The longest and most remarkable dry event took place between the month of April of the year 1982 and the month of September of the year 1984; it is characterized by SPI values below -2.21 (Figure 4a). For Saida, a town located in the Southern Plains of Oran and characterized by a semi-arid climate and cool winters, 16 dry events were observed with an average duration of 10.63 months.

Figure 4b illustrates the historical 6-month SPI records for this station. The longest, most intense and most frequent, droughts were recorded between February 1987 and August 1989; they are characterized by SPI values less than -1.58. For the region of El-Kheiter, which is located in the northwestern part of the study area, 14 dry events were observed, with an average duration of 12.93 months; these drought periods spanned over 41.9% of the entire analysis period. Four (04) large-scale and long-lasting events were observed (Figure 4c). The first period, characterized by extreme drought, was between the month of April of the year 1982 and the month of April of the year 1985; it lasted 37 months. The second dry period, described as severe, lasted 22 months; it occurred between the years 1992 and 1994. The third period was severely dry and lasted 21 months. Finally, the fourth dry period was observed between the late 1990s and early 2000s; it lasted 20 months. The data from the station of Ain-Sefra, a town located in the southwestern portion of the study area, showed 13 dry sequences with an average duration of 12.31 months; they extended over 37.04% of the total analysis period. The longest and most remarkable event took place between the month of October of the year 1982 and the month of September of the year 1985; it is characterized by SPI values lower than -2.67 (Fig. 4d).

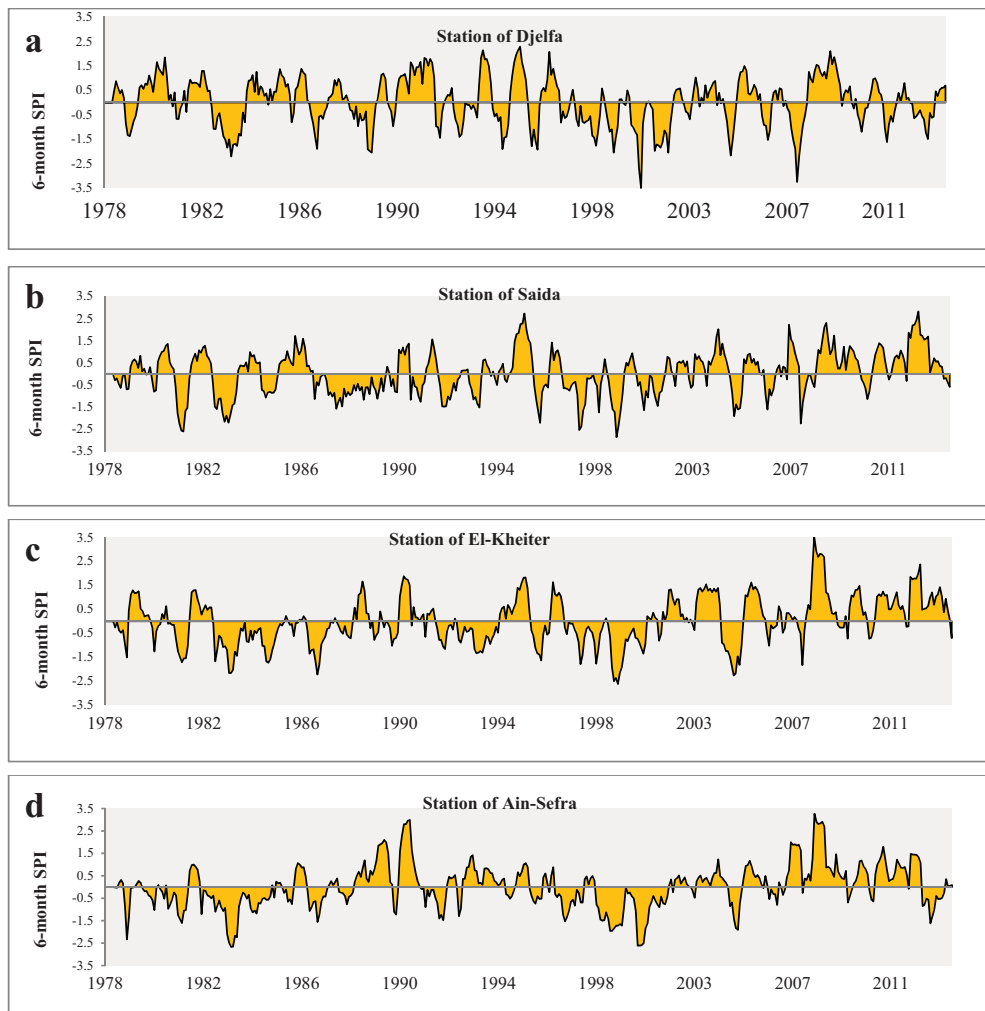
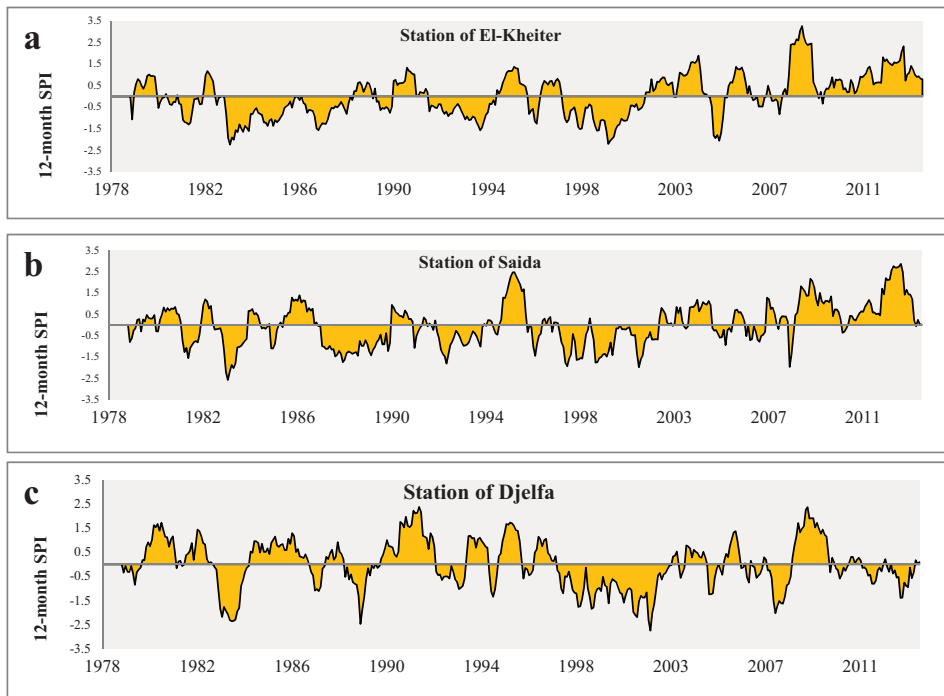


Figure 4: Evolution of the medium-term drought at the stations of Saida, Ain-Sefra, El-Kheiter and Djelfa, between 1978 and 2013.

Long-term drought

Few dry sequences were detected at the 12-month time scale, at the selected stations. At that time scale, the Standardized Precipitation Index can be used to define the periods of deficit or excess of precipitation with higher precision. To that end, 10, 9, 7 and 7 dry periods were recorded in Saida, Djelfa, El-Kheiter and Ain-Sefra, respectively (Table 4). For the station of El-Kheiter, 7 dry events were identified; four of them were particularly extreme in both intensity and duration. The first one appeared between September 1983 and October 1986; it spanned over 38 months and was characterized by extreme drought. The second occurred between December 1986 and May 1988, and can be considered as severely dry. The third event appeared between February 1992 and September 1995. The fourth dry event was the longest since it occurred between September 1998 and April 2001. It lasted 44 months, and is described as extremely severe in intensity (Fig. 5a). At the station of Saida, 10 events were identified, and the most severe occurred between February 1987 and February 1990, and lasted 37 months; it is considered as severely dry. The longest dry periods at the 12-month time scale were observed during the years between 1982 and 1984, 1987 and 1990, 1992 and 1994, and finally between 1999 and 2002. The first period, which lasted 18 months, was severely dry; the second one was classified as severe and lasted 37 months. The third one, which was also severely dry, lasted 25 months. Finally, the fourth dry period took place between the late 1990s and early 2000s and persisted for 36 months (Fig. 5b). Regarding the station of Djelfa, 9 dry events were recorded. Three of them were particularly extreme in intensity and duration. The first event occurred between August 1982 and February 1984 and spanned over 19 months; it can be described as extremely dry. The second one appeared between May 1988 and November 1990, and can also be described as extremely dry. The third event was the longest since it covered the period from September 1998 to September 2003, and lasted for 61 months; it is described as extremely severe in terms of intensity (Figure 5c). Similarly, at the station of Ain-Sefra, 7 dry events were identified. The longest was between May 1998 and December 2002. The drought periods detected represent 37.04% of the entire analysis period, with an average duration of 26.43 months. Two important events were observed for the 12-month SPI. The first one extended over a relatively long period (43 months), between March 1982 and September 1986; the second one lasted 44 months, i.e. between May 1998 and December 2002 (Fig. 5d).



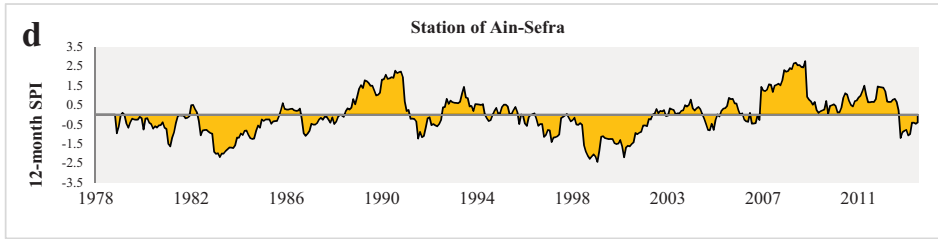


Figure 5: Evolution of long-term drought at the stations of Saida, Djelfa, Ain-Sefra and El-Kheiter, from 1978 to 2013.

Table 4: Frequency and duration of dry sequences, recorded during the period from 1978 to 2013, at different time scales.

Time scales	Parameters noted	Saida	Djelfa	El-Kheiter	Ain-Sefra
Short term 3-month SPI	Frequency	27	25	24	27
	Average duration (months)	5.81	6.32	6.29	5.85
	Percentage of time in drought	35.65	36.57	34.95	36.11
	Extreme SPI value (date of occurrence)	-3.38 (March 1999)	-3.76 (March 1999)	-3.71 (March 1999)	-2.59 (January 1983)
Medium term 6-month SPI	Frequency	16	18	14	13
	Average duration (months)	10.63	9.17	12.93	12.31
	Percentage of time in drought	39.58	38.19	41.9	37.04
	Extreme SPI value (date of occurrence)	-2.86 (June 1999)	-3.25 (April 2007)	-2.62 (June 1999)	-2.67 (January 1983)
Long term 12-month SPI	Frequency	10	9	7	7
	Average duration (months)	16	17.67	25.29	26.43
	Percentage of time in drought	37.04	36.57	41.9	42.82
	Extreme SPI value (date of occurrence)	-2.57 (December 1983)	-2.57 (October 2002)	-2.21 (September 2000)	-2.44 (August 1999)

3.3. Analysis of rainfall trend

As already discussed and explained in this article, the quintile method takes into account the law of rainfall data distribution. In order to perform a detailed analysis, it was decided to take into account a period that is common to all four stations in the study area, between the years 1978 and 2013. The table below gives the values of the rainfall thresholds for the selected stations.

Table 5: Thresholds used in the characterization of years of drought by the quintile method, for the period between 1978 and 2013

Station	Very dry years	Dry years	Normal years	Wet years	Very wet years
Ain-Sefra	≤ 104.7	≤ 144.8	$147.9 \leq x_i \leq 212.1$	≥ 215.5	≥ 245.6
Djelfa	≤ 221.2	≤ 271.9	$274.9 \leq x_i \leq 328.7$	≥ 333.4	≥ 377.4
El-Kheiter	≤ 132.9	≤ 171.7	$179.4 \leq x_i \leq 236.6$	≥ 261	≥ 327.7
Saida	≤ 243.3	≤ 284.4	$292.2 \leq x_i \leq 333.5$	≥ 349.8	≥ 401.9

The thresholds of dry and very dry years are close for the two stations of Ain-Sefra and El-Kheiter; on the other hand, the threshold value reaches 243.3 mm for very dry years and 284.4 mm for dry years, at the station of Saida. However, at the station of Djelfa, it is equal to 221.2 mm for very dry years and 271.9 mm for dry years. For normal years, the range varies from one station to another. Looking at the previous table, one can clearly notice that the thresholds of wet and very wet years progressively decrease when moving from Saida towards Ain-Sefra and from Saida towards El-Kheiter.

The analysis of rainfall using the chronological graphic method of information processing in all the stations considered makes it possible to identify three periods which have marked the rainfall history of the study area (Figure 6).

- The first period is marked by a high variability from 1978 to 1991. The matrix cannot identify any specific trend over that period. The evolution of the reduced centered index shows that this index is almost the same for the years with a positive index (08 years) and for those with a negative index (06 years).
- The second period, which is observed during the period extending from 1993 to 2002, is drier. It is represented on the colored matrix by a strong decrease in wet and very wet years. This dry period is characterized by a high frequency of dry and very dry years.
- The third period, which starts from the year 2003, is close to normal; it appears clearly on the colored matrix.

One can also note that for the first period, from 1978 to 1991, the normal years are the most frequent and the frequency of wet and very humid years is very high. During that period, 29% of years were wet and very humid, 37% were normal years, and 34% were dry and very dry years. Frequent droughts, of moderate to extreme intensity affecting all the studied stations, were observed between 1993 and 2002. A significant decrease in the number of wet and very wet years was observed in all the stations (19% of wet and very wet years, 29% of normal years and 52% of dry and very dry years); this is clearly shown in Figure 6. This decade, from 1993 to 2002, seems to be even more affected by this drought phenomenon. Dry years were increasingly recurrent and drought periods were progressively longer. The years 1992, 1993, 1998, 1999, 2000, 2001 and 2002 were characterized by a very high percentage of dry and very dry years at all stations. Regarding the evolution of the reduced centered index over that period, one can observe a greater frequency of dry and very dry years. Indeed, there are 8 years with a negative index; however, the index of wet and very wet years changes inversely as it goes from 8 years to only 2 years. During the third period, i.e. between 2003 and 2013, the return of wet years is clearly displayed on the colored matrix, with a fairly high frequency (50%); however, the frequency of normal years is lower (30%). This period is also marked by the lowest percentage of dry and very dry years since 1978 (21%).

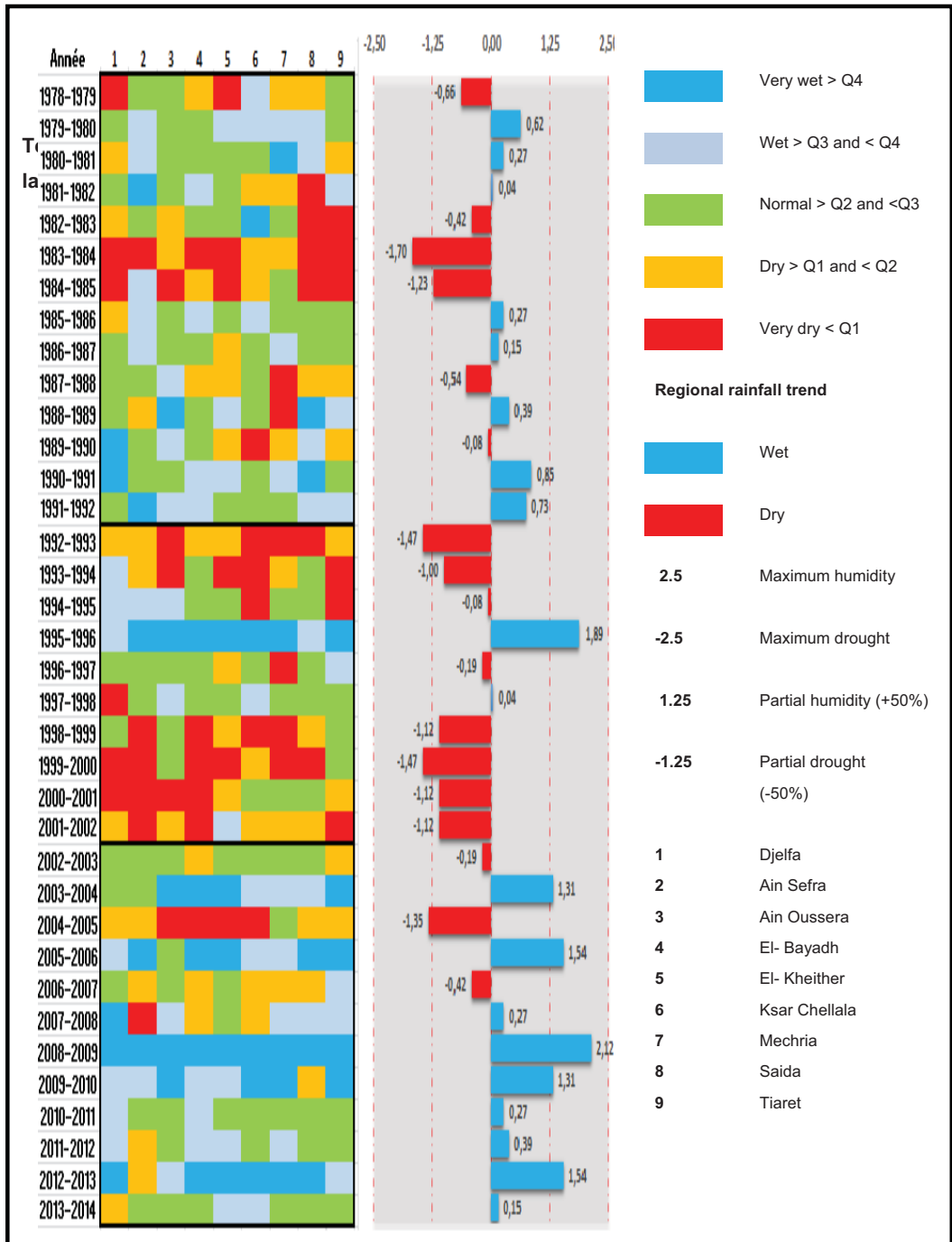


Figure 6 - Historical graphical information processing method applied to the rainfall observed in the study area, between 1978 and 2013.

4. Conclusion

Analysis of the descriptive parameters of dry sequences of the steppe stations in the high plains of southern Oran and southern Algiers, using drought indices, allowed us to identify three periods which marked the variability of rainfall in the region under study. The first period was marked by a strong variability between 1978 and 1999; the second one was drier and appeared between 1993 and 2002, and the third one, between 2003 and 2013, was characterized by near normal rainfall.

The analysis of the rainfall series during the period between 1978 and 2013 and using the standardized precipitation index (SPI) at the time scales of 3, 6 and 12 months, made it possible to identify a succession of periods of dry years and wet years. In general, regardless of the time scale considered and whatever the station concerned, one can say that droughts occurred during 34 to 42% of the analyzed period. Moreover, this study also allowed identifying many dry sequences throughout this period with the existence of 4 dry sequences whose durations exceed 20 months. The standardized precipitation index (SPI) made it possible to define more precisely the periods of rainfall deficit. Consequently, it can be said that long-term drought sequences can occur in semi-arid regions, which receive significant rainfall (stations of Saida and Tiaret) and in arid regions as well (stations of Ain-Sefra and Ain-Ouessera).

The 3-month SPI, which expresses the probability of rainfall over short periods of time, is particularly useful for predicting and planning sowing periods in order to assess the impact on the development of natural vegetation or to predict the influence of the climate on biomass production. The 12-month SPI should rather be considered as an index allowing the long-term estimation of the quantities of surface water (dams); it also helps to measure groundwater levels at the annual as well as the decennial scale.

The most severe droughts in terms of intensity, duration and frequency were those observed in 1983-1984, 1999-2000 and 2001-2002, whatever the time scale considered.

This region is important in Algeria because of its major natural resources. Policymakers have invested in water-resource-related-projects such as dams. Moreover, large sites are used for animal husbandry (especially sheep) and rare plants, such as "*Stipa tenacissima*, *Artemisia herba alba*" (considered an essential natural resource), can survive only in this region.

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