Analele Universităţii din Oradea, Seria Geografie **XXVIII**, no. 2/**2018**, pp. **231-244**
ISSN **1221-1273**, E-ISSN **2065-3409** Article no. **282109-781**

ANALYSIS OF DROUGHT TRENDS IN SENEGALESE COASTAL ZONE ON DIFFERENT CLIMATIC DOMAINS (1951-2010)

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Abstract: In this article, a quantitative evaluation of drought characteristics and their variability in Senegalese coast (and/or western) zone in different domains (south and north Sudanian and Sahelian) was carried out. Monthly precipitation data for ten selected stations. SPI analysis for 1, 3, 6 and 12 months was performed. Results of SPI analysis revealed an alternation of negative values indicating an occurrence of drought and positive values for wet conditions. SPI analysis showed several years of drought during the study period with decades 1971-1980, 1981-1990, 1991-2000 which witnessed a persistent drought on Senegalese coast. This drought is classified as light, moderate, severe and extreme. An in-depth examination shows the predominance of mild droughts with the greatest number of occurrences during study period on Senegalese coast. In the context of reducing the drought impacts, this study provides useful information for proactive intervention and effective planning of rain-fed agriculture on Senegalese coast.

Key words: Drought, Trend, Standardized Precipitation Indices, Coast, Senegal

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INTRODUCTION

Drought is a natural phenomenon that poses many problems around the world, insofar as it requires huge punctures on natural resources and particularly on water resources (Barua et al., 2009). Drought occurs in areas of high and low rainfall and almost all climatic regions, although in the past drought was only associated with arid, semi-arid and desert fringes when the definition was based solely on quantities. absolute precipitation (Omonijo and Okogbue, 2014). Drought is now associated with the dates of onset and cessation of rains, and the duration of the rainy season. Thus, it is better. In another context, drought is one of the extreme climatic conditions that affects more people than any other form of natural disaster (Wilhite, 2000). Indeed, in recent decades, the occurrence of major droughts occupying large territories on all continents highlights the importance of phenomenon (Beaudin, 2007). Both developing and industrialized countries are affected. In developing countries, effects can be very disastrous (Soro et al., 2014). According to Obassi (1994), nearly 1.3 billion people died from direct or indirect causes of the phenomenon. It is thus certain that the timely determination of the level of drought would help to support the decision-making process in its impact reduction objectives.

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Droughts occur in all climatic zones of Senegal. However, its characteristics vary considerably from one region to another (Faye et al., 2017). Drought is a recurring phenomenon in the coastal zone of Senegal and its hazards affect the economies of the predominantly agricultural population. If rainfall is insufficient or rainy season ends abruptly, crops may not ripen and yield will be very low (Oguntoyinbo and Richards, 1977).

The Sahelian drought that began in 1969 and lasted until 1973 affected Senegal and had enormous socio-economic repercussions on the area with pressure on available resources that has increased in the face of a fluctuating rainfall regime (Omonijo and Okogbue, 2014). The term drought is applied at a time when an unusual shortage of rain causes a serious hydrological imbalance like empty water supply tanks. The severity of drought is measured by the degree of moisture deficiency, its duration and the size of the affected area. Many countries have experienced considerable difficulties as a result of drought, famine and food insecurity, particularly in developing world where economies are linked to agriculture. The littoral zone is one of the most endangered areas of Senegal (Faye et al., 2017) and has suffered a prolonged drought of two decades (1970 and 1980).

Droughts tend to be more severe in some areas than in others. Catastrophic droughts usually occur in areas bordering the arid regions of the world, like Senegalese coastline. Drought causes insufficient precipitation to meet the socio-economic requirements of a region in terms of water supply for domestic and industrial uses, agriculture and the ecosystem. The reduction in rainfall resulting from drought in the Sahel was often seen as a result of human activity (clearing, overgrazing, and inappropriate land use practices) (Charney et al., 1977).

To characterize the persistence of drought on Senegalese coast (especially during the 1970s, 1980s and 1990s), a very simple and effective meteorological drought index was used: standardized precipitation index (Nalbantis and Tsakiris, 2009). This index, popular in the characterization of meteorological drought, is widely used throughout Senegal for drought analysis (Sow, 2007; Faye, 2013; Faye et al., 2015; Faye et al., 2017). It has been chosen because it allows to evaluate meteorological drought on different time scales, to measure the recent rainfall anomalies for a zone, to place current conditions in a historical perspective (Loukas et al., 2003) and to make spatial and temporal representations of droughts. Finally, this index has advantages in terms of statistical consistency, and has the capacity to describe, through different time scales (short, medium and long-term), the impacts of the drought in question.

In this climatic context of a possible increase in occurrence and impacts of droughts in coming years (Watson et al., 1997), it is essential to propose mitigation or adaptation measures to populations (Soro et al., 2014). It is in this context that the present study was initiated in Senegal, on the littoral zone. Its purpose is to analyze the trend of drought for period 1951-2011, through standardized precipitation index and on different time scales. This index was used to evaluate drought in Senegal over short periods (applications for agriculture) and over longer periods (applications for water resources management).

STUDY AREA

Senegal's 700-kilometre long coastline connects the Saint-Louis region to the natural region of Casamance from North to South. It is structured around the peninsula of Cape Verde and three mouths that form Senegal River, Sine Saloum and Casamance. Senegalese coastline can be broken down into 6 distinct geomorphological entities: Senegal River Delta, big coast or North Coast, Cape Verde peninsula, small coast, Sine Saloum Delta and Casamance (MEPN, 1997).

Senegalese coastline is limited to North by Senegal River Delta, to West by the Atlantic Ocean and to South by Guinea Bissau. The eastern limit corresponds to axis Thiès -Louga- Fatick-Ziguinchor which is parallel to coast (figure 1). The Senegalese littoral zone has a Sudano-Sahelian climate with an annual rainfall ranging between about 1250 mm in South to just over 200 mm in North. This climate is marked by an alternation between a rainy season and a dry season. The rainy season, which is monsoon period, extends roughly from June to October with a peak in

August-September. Rain varies digressively with latitude (Leroux 1983; Sagna 2005). On the coast, ocean brings freshness and temperatures are of the order of 16° C to 30° C. Given variations in rainfall in space and time, the South-North coastline is characterized by three climatic domains: southern Sudanian, northern Sudan and Sahelian domains.

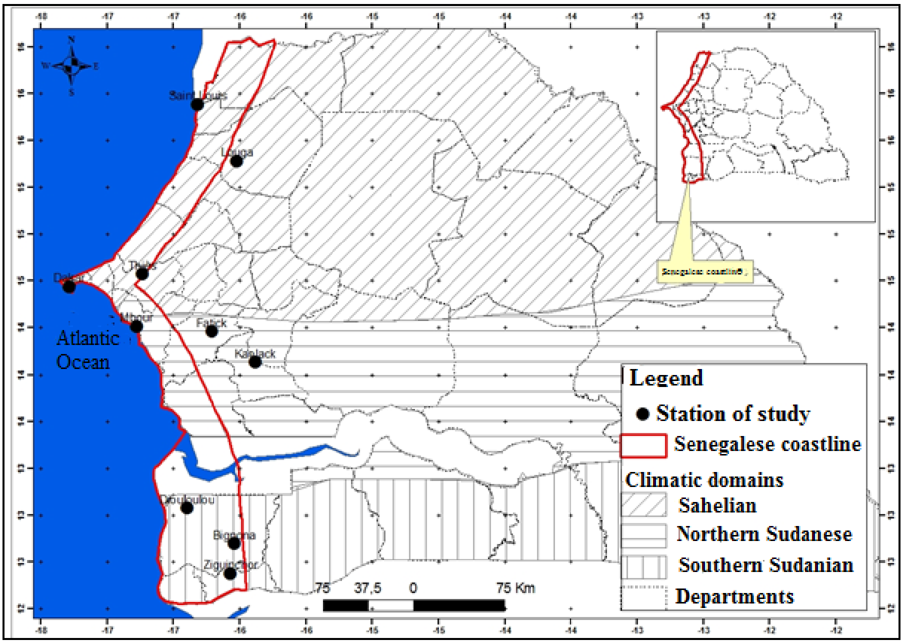

Figure 1. Location of study area and selected stations
(Source: CSE)

DATA AND METHODS

Data

Basic data consist of 60-year rainfall records (1951-2010) from 10 stations (table 1) located in the coastal zone of Senegal (and/or West) on different domains (South and North Sudan and the Sahel). This choice was made so as to allow the most homogeneous coverage possible of the study area. Data were made available to us by the National Agency of Climatology and Civil Aviation (ANACIM) of Senegal. The ten stations follow criteria of continuity, duration of available information and data quality. The 60 years (1950-2010) of the study were subdivided into 6 decades. The dataset has been used to assess and monitor drought over past 60 years through Standardized Precipitation Indices (SPI).

Methods

Standardized Precipitation Index (SPI)

Understanding that a rainfall deficit has a different impact on groundwater, reservoir storage, soil moisture and flow have led to the development of Standardized Precipitation Index (SPI) (McKee et al. 1993). SPI is a simple index adopted in 2009 by World Meteorological Organization (WMO) as a global instrument for measuring meteorological droughts (Jouilil et al., 2013). It is expressed mathematically as follows:

$$SPI = \frac{(R_i - R_m)}{S}$$

With Ri: the rain of month or year i; Rm: the average rainfall of series on time scale considered; S: the standard deviation of series on timescale considered.

Interpretation of SPI time scales

Precipitation data are normalized to a flexible multiple time scale (SPI 1, SPI 3, SPI 6 and SPI 12) respectively. According to the classification of Nigerian Meteorological Agency, 1 month (SPI1) represents meteorological drought, 3 months (SPI 3) agricultural drought, 6 months (SPI 6) hydrological drought and 12 months (SPI 12) socio-economic drought (Omonijo and Okogbue, 2014).

The 1-Month SPI (August) reflects relatively little soil moisture during growing seasons. It is more accurate because the distribution has been standardized. The 1-Month SPI deals with meteorological drought.

The 3-Month SPI (July-September) provides a comparison of precipitation over a specific 3-month period with precipitation totals for the same 3-month period for entire series. This time scale addresses both meteorological and agricultural droughts.

The 6-Month SPI (June-November) can be very effective in showing the rain on distinct seasons. The 6-month SPI may also begin to be associated with abnormal flow rates and reservoir levels; This scale is good for monitoring hydrological drought.

The 12-Month SPI (January-December) reflects long-term precipitation patterns. These delays are usually related to flows, reservoir levels and even groundwater levels at longer timescales.

Table 1. Classification of Dryness Sequences of Moisture
(Data source: Omonijo and Okogbue, 2014)

SPI Values	Drought Sequences	SPI Values	Wet Sequences
0.00< SPI <-0.99	Slightly dry	0.00< SPI <0.99	Slightly wet
-1.00< SPI <-1.49	Moderately dry	1.00< SPI <1.49	Moderately wet
-1.50< SPI <-1.99	Severely dry	1.50< SPI <1.99	Severely wet
SPI < -2.00	Extremely dry	2.00< SPI	Extremely wet

McKee et al. (1993) used classification system according to SPI values (table 1) and defined criteria for a "drought event" for all timescales. A drought event occurs whenever SPI is continuously negative and its value reaches an intensity of -1 or less and ends when the SPI becomes positive. Standardized precipitation index (SPI) was calculated for each time interval.

RESULTS

The illustrations (figures 2, 3, 4, 5, 6 and table 2) show the characteristics of standardized precipitation index calculated on different time scales.

Spatial variation of 1-Month SPI (August)

As in Senegal, generally monthly rainfall peaks are noted in August, this month's precipitation was used to analyze SPI1 over six decades (figure 6). The spatial pattern of drought classification with SPI1 is shown in figure 2. In general, the incidences of drought were most intense during 1971-80 decade (average SPI: -0.27), 1981-90 (average SPI: -0.22) and 1991-00 (average SPI: -0.14) while decades 1951-60 (0.50) and 1961-70 (0.33) are wetter. The decade of 2001-10 saw an alternation of positive SPI (-0.2 in Saint Louis, -0.18 in Louga and Kaolack, -0.29 in Diouloulou) and negative (0.17 in Thiès, 0.18 in Bignona, 0.13 in Fatick), corresponding respectively to a slight drought (on some stations) and a slight humidity (on others).

However, this decade, with an average SPI of -0.05, is very slightly dry. During the three decades of drought (1971-80, 1981-90 and 1991-00), the indices of different stations are negative, indicating a drier August, unlike the first two decades (1951-60 and 1961-70) where the month of August is wetter. In the wettest decade (1951-60), Kaolack station retains highest positive index (0.84) while it is the only station whose index is negative (-0.08) on the wet decade 1961-70. Over the 6 decades of study, the positive values of SPI1 indicate a littoral with slight humidity and those negative a littoral with light drought. Since the 1970s, the rainfall deficit noted in the area has affected rainfall in August, resulting in a slight drought on the almost entire coastline.

Table 2. Frequencies of drought occurrences of selected stations from 1951 to 2010
(Data source: ANACIM)

Saint Louis	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Louga**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	6.7	0	0	3.3	Slightly wet	2	0	0	0
Moderately wet	0	0	0	3.3	Moderately wet	10	2	0	0
Severely wet	5	5	3.3	6.7	Severely wet	6	0	2	2
Extremely wet	26.7	50	48.3	38.3	Extremely wet	30	44	46	42
Slightly dry	**50**	**43.3**	**48.3**	**35**	**Slightly dry**	**36**	**50**	**52**	**56**
Moderately dry	**11.7**	**1.7**	**0**	**5**	**Moderately dry**	**16**	**4**	**0**	**0**
Severely dry	**0**	**0**	**0**	**6.7**	**Severely dry**	**0**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**1.7**	**Extremely dry**	**0**	**0**	**0**	**0**
Dakar	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Thiès**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	5	0	0	0	Slightly wet	4	0	0	0
Moderately wet	3.3	0	1.7	0	Moderately wet	2	4	0	0
Severely wet	8.3	8.3	6.7	5	Severely wet	6	2	4	4
Extremely wet	23.3	35	36.6	41.7	Extremely wet	26	42	46	46
Slightly dry	**50**	**53.3**	**53.3**	**53.3**	**Slightly dry**	**48**	**46**	**50**	**50**
Moderately dry	**8.3**	**3.3**	**1.7**	**0**	**Moderately dry**	**10**	**6**	**0**	**0**
Severely dry	**1.7**	**0**	**0**	**0**	**Severely dry**	**4**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**0**	**Extremely dry**	**0**	**0**	**0**	**0**
Mbour	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Fatick**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	3.4	0	0	0	Slightly wet	2	0	0	0
Moderately wet	3.4	1.7	1.7	1.7	Moderately wet	2	4	0	0
Severely wet	3.4	6.8	3.4	3.4	Severely wet	14	6	6	4
Extremely wet	32.2	33.9	40.7	40.7	Extremely wet	30	42	40	40
Slightly dry	**49.2**	**52.5**	**52.5**	**52.5**	**Slightly dry**	**32**	**42**	**54**	**56**
Moderately dry	**6.8**	**3.4**	**1.7**	**1.7**	**Moderately dry**	**16**	**6**	**0**	**0**
Severely dry	**1.7**	**1.7**	**0**	**0**	**Severely dry**	**4**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**0**	**Extremely dry**	**0**	**0**	**0**	**0**
Kaolack	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Diouloulou**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	3.4	0	0	0	Slightly wet	1.8	0	0	0
Moderately wet	6.8	3.4	1.7	0	Moderately wet	3.6	0	0	0
Severely wet	3.4	3.4	1.7	3.4	Severely wet	10.7	3.6	1.8	1.8
Extremely wet	25.4	40.7	35.6	33.9	Extremely wet	37.5	55.4	48.2	48.2
Slightly dry	**52.5**	**50.8**	**59.3**	**62.7**	**Slightly dry**	**26.8**	**32.1**	**46.4**	**46.4**
Moderately dry	**8.5**	**1.7**	**1.7**	**0**	**Moderately dry**	**14.3**	**8.9**	**3.6**	**3.6**
Severely dry	**0**	**0**	**0**	**0**	**Severely dry**	**3.6**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**0**	**Extremely dry**	**1.8**	**0**	**0**	**0**
Bignona	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Ziguinchor**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	2.0	2.0	0	0	Slightly wet	3.3	0	0	0
Moderately wet	2.0	0	0	0	Moderately wet	5	0	0	0
Severely wet	3.9	5.9	2.0	2.0	Severely wet	6.7	6.7	5	5
Extremely wet	37.3	39.2	47.1	52.9	Extremely wet	33.3	41.7	41.7	41.7
Slightly dry	**43.1**	**45.1**	**49.0**	**43.1**	**Slightly dry**	**40**	**43.3**	**51.7**	**51.7**
Moderately dry	**5.9**	**7.8**	**0**	**0**	**Moderately dry**	**5**	**8.3**	**1.7**	**1.7**
Severely dry	**5.9**	**0**	**0**	**0**	**Severely dry**	**5**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**2.0**	**2.0**	**Extremely dry**	**1.7**	**0**	**0**	**0**

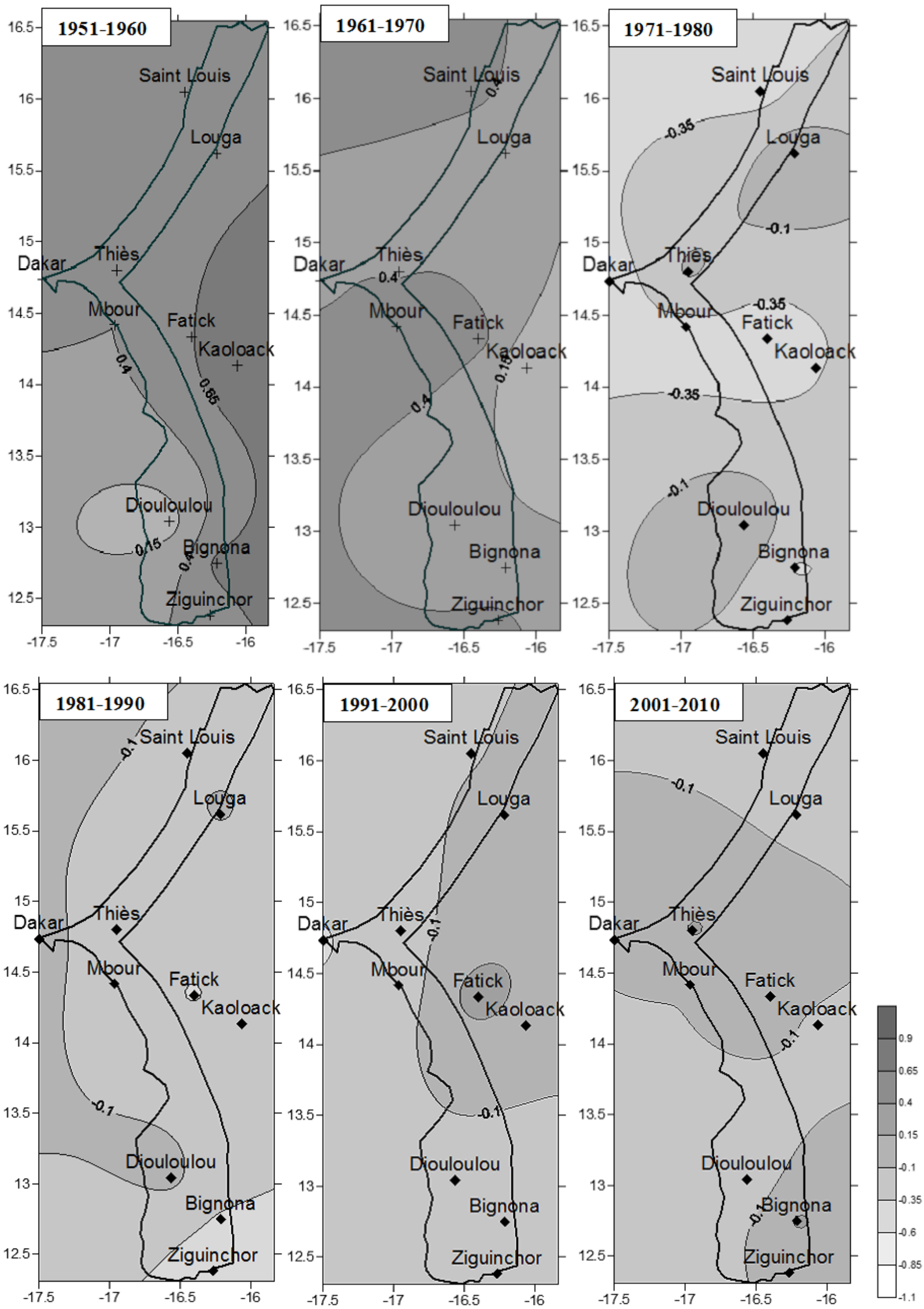

Figure 2. Spatialization of SPI1 (August) by decade on Senegalese coastline
(Source: ANACIM)

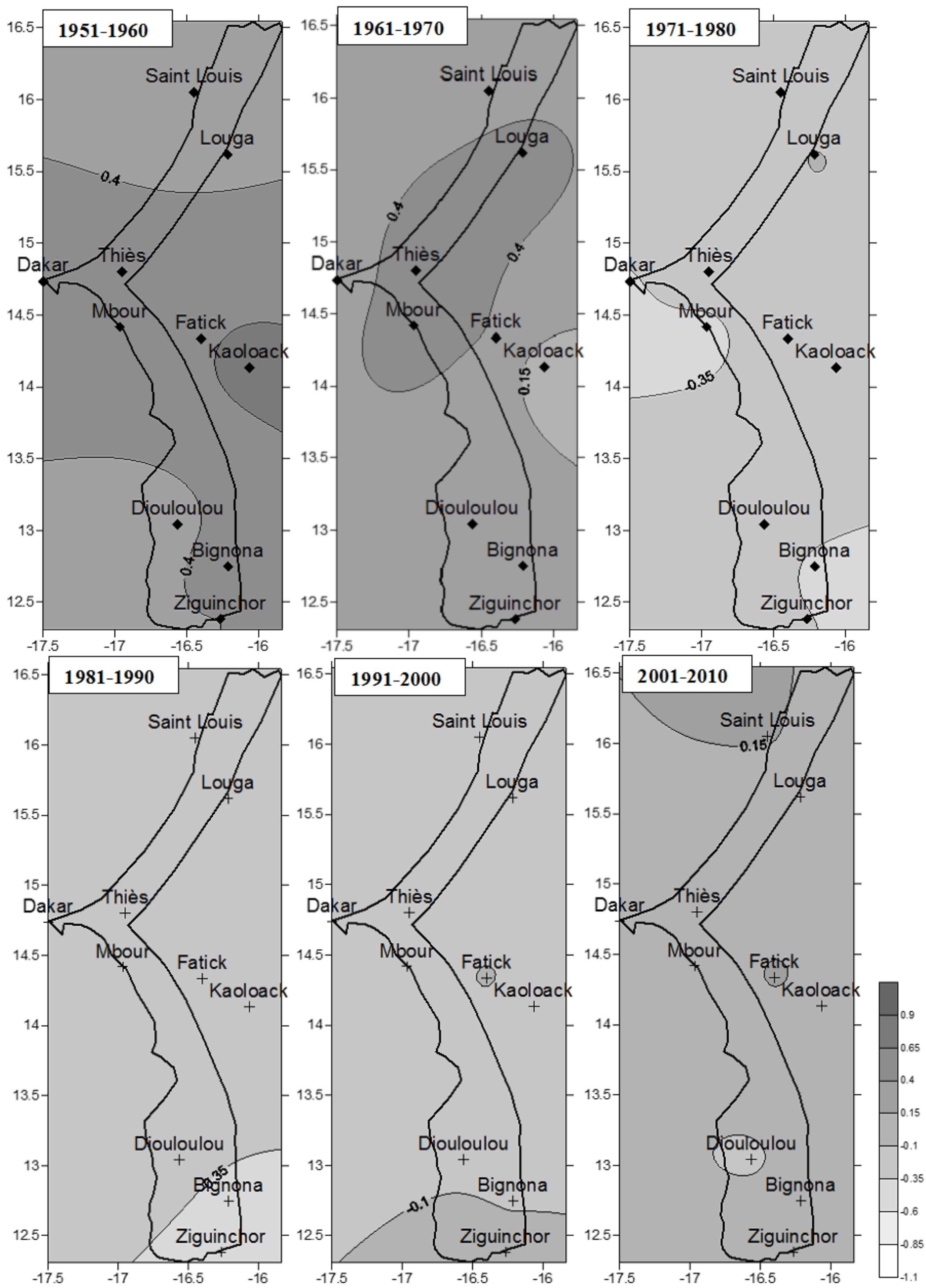

Figure 3. Spatialization of SPI3 (July-September) by decade on Senegalese coastline
(Source: ANACIM)

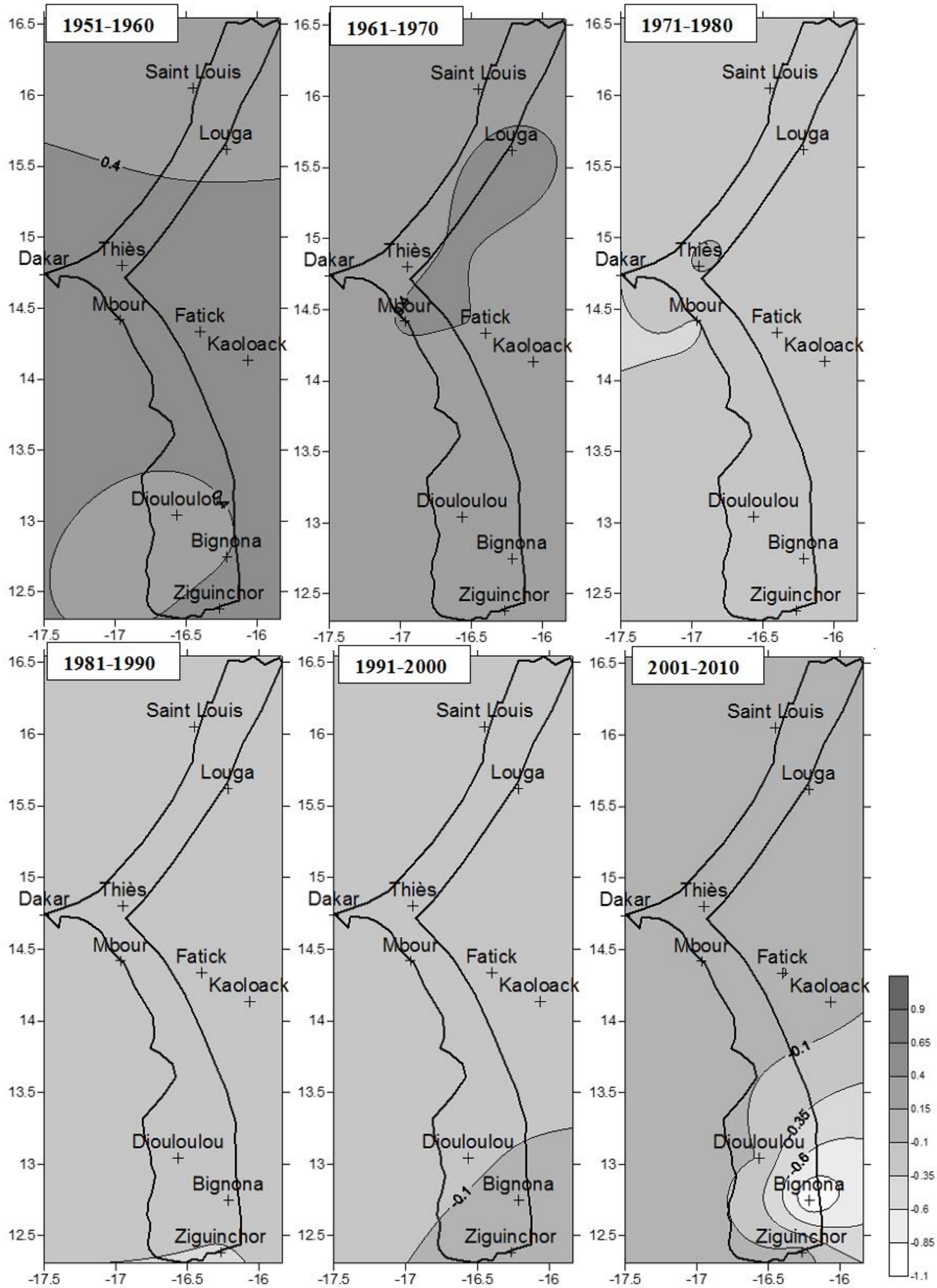

Figure 4. Spatialization of SPI6 (June-November) by decade on Senegalese coastline
(Source: ANACIM)

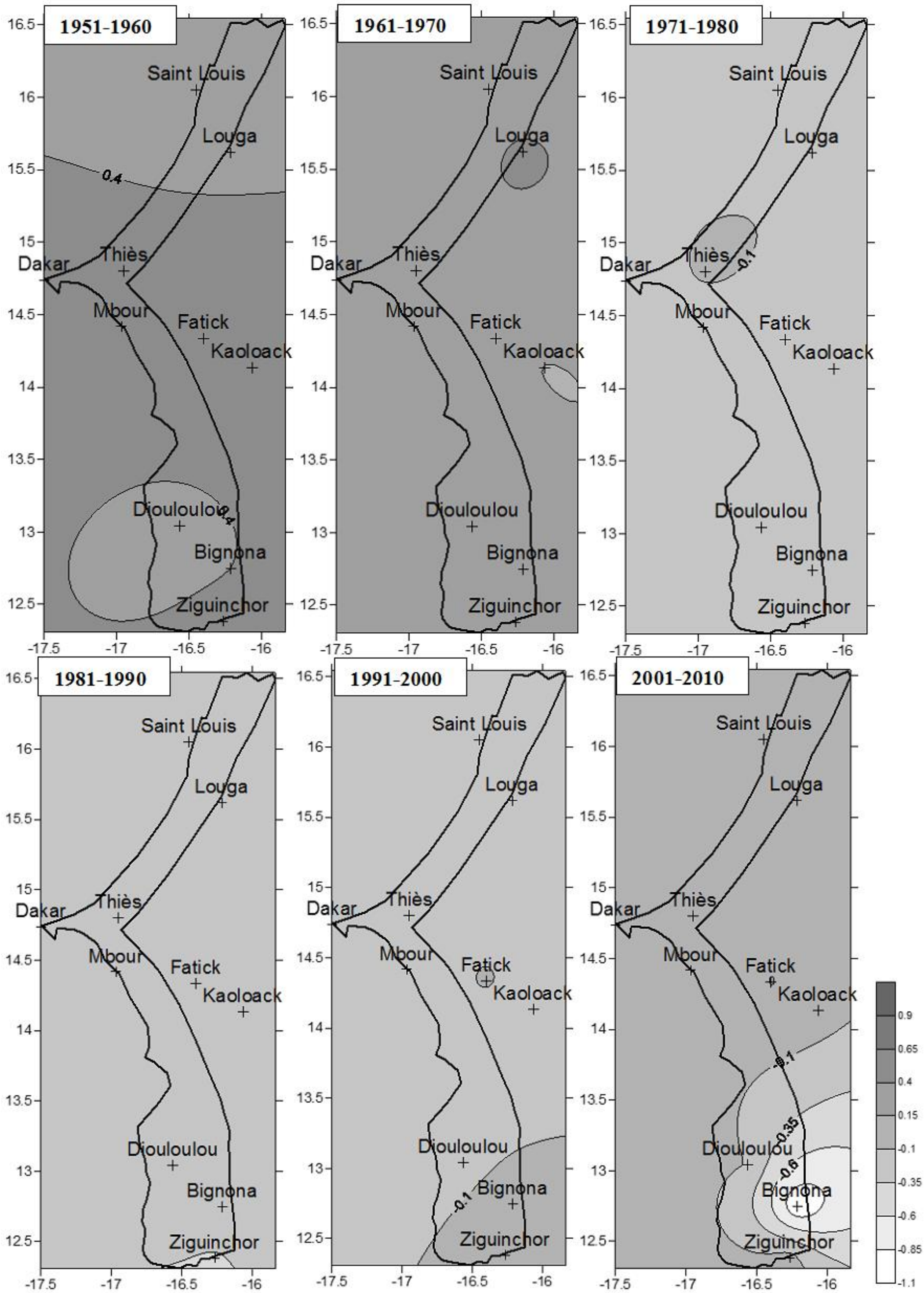

Figure 5. Spatialization of SPI12 (January-December) by decade on Senegalese coastline
(Source: ANACIM)

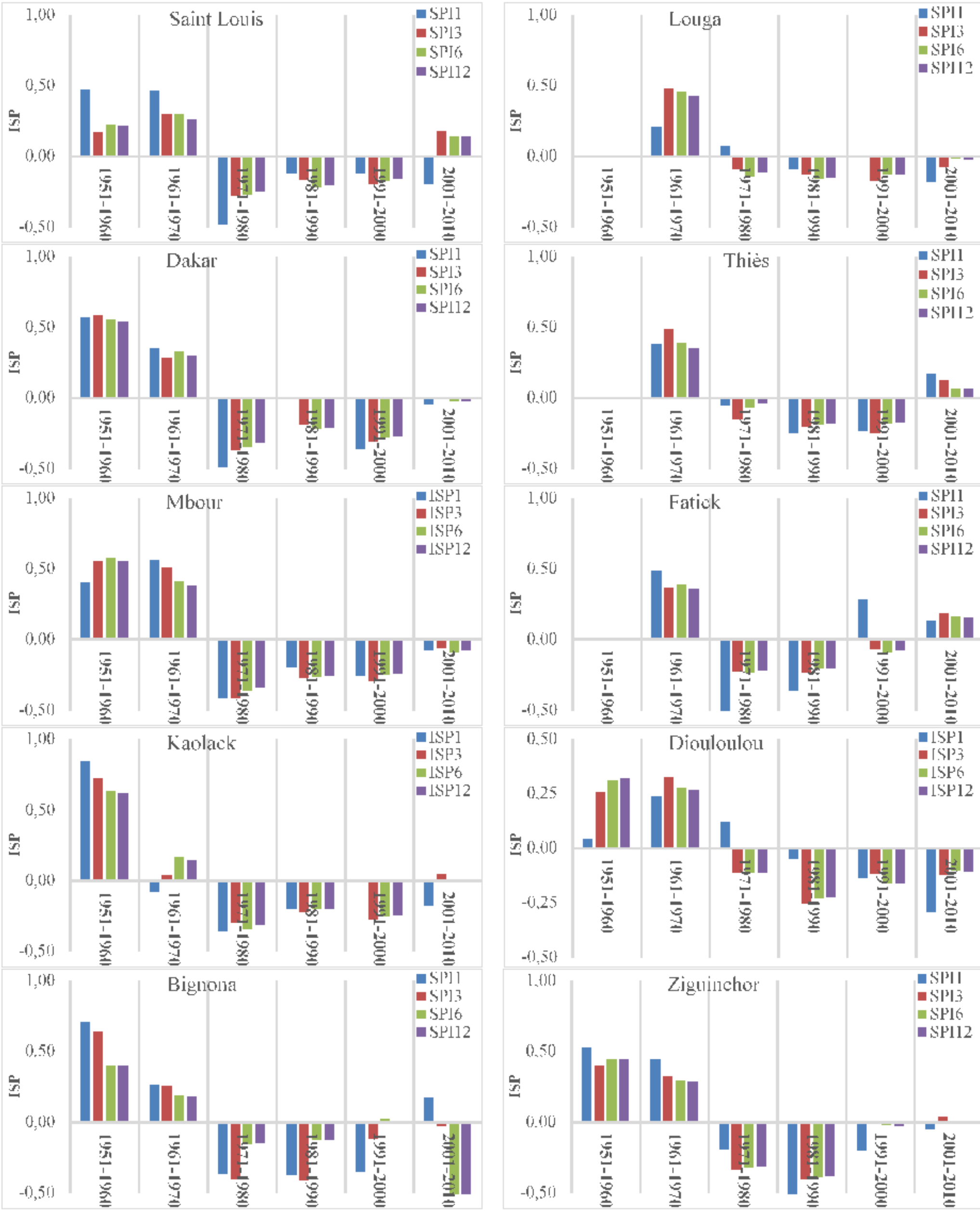

Figure 6. Evolution of SPI at different time scales in the area
(Source: ANACIM)

Over study period (1951-2010), SPI1 values indicate a slight drought on most coastal regions, with occurrence frequencies reaching 50% at station levels (50% in Dakar and Saint Louis; 52.5% in Kaolack). Frequencies of occurrence of moderate drought are also noted and may even exceed 10% in some stations (16% in Louga and Fatick; 14.3% in Diouloulou) (table 2).

The incidence of the most severe drought of the study period was observed during the decade 1971-80 and at Fatick station (-0.53) followed by Diouloulou (-0.52) over the decade

1981-90, two decades which is simply the period of the great drought of the 1970s and 1980s. If, per decade, drought and moderate humidity are absent, they have been observed in some parts of coast in some years.

Spatial variation of 3-Month SPI (July-September)

The 3-month time scale (July-September) of the SPI was calculated using monthly precipitation in July, August and September (figure 6). This period is at the heart of the rainy season on the entire coast of Senegal. The spatial trend of drought classification with SPI3 is given in figure 3. The SPI3 indicates characteristics quite similar to SPI1, unlike first two decades (1951-60 and 1961-70) called wet, drought was noted over the rest of the study period, particularly after years 1971-80, 1981-90 and 1991-00 during which the indices for all stations were negative. Mean SPI3 is positive over the decades 1951-60 (0.47) and 1961-70 (0.34) and negative over the decade 1971-80 (-0.27), 1981-90 (-0.25) and 1991-00 (-0.18). The last decade (2001-10), unlike SPI1, has a mean positive SPI of 0.03 (with 6 out of 10 wet stations). This slight humidity is more pronounced in the central part of the coast. All occurrences of SPI3 drought are slight overall decades, with a minimum value of -0.42 noted over the years 1971-80 (at Mbour station) and 1981-90 (at Bignona station).

The decrease in precipitation from the 1970s is also noted over the months of July, August and September until 2010, leading to a slight drought, although some parts of coastline show a slightly wet state over the last decade (Saint. Louis and Fatick with 0.18; Thies with 0.13...). This is why in the last decade light drought has covered less surface area than in previous three completely dry decades. During the decade 2001-10, it was noted in Senegal an increase of rainfall forecasting the improvement of rainfall regimes in the country compared to the drought period of the preceding decades, although the persistence and the durability of current increase are still to be proven, knowing that climatological scale, ultimately, is the thirties (Faye *et al.*, 2017).

Over the study period (1951-2010), like SPI1, SPI3 values indicate a slight drought on most coastal regions, with occurrence frequencies exceeding 40% at all levels. stations (52.5% in Mbour, 50.8% in Kaolack, 50% in Louga). Moderate drought is also noted with occurrence frequencies of less than 10% (highest being recorded in Diouloulou with 8.9%) (table 2).

Spatial variation of 6-Month SPI (June-November)

The SPI 6-month time scale was calculated using wettest 6 months (June-November) on the Senegalese coastline (figure 6). The spatial trend of SPI6 drought classification is presented in figure 4. Beyond a slight humidity observed at all stations over the first two decades (with an average of 0.45 and 0,32 respectively in 1951-60 and 1961-70), all four other decades recorded a slight drought, but to varying degrees and gradually decreasing (on average -0.24 in 1971-80, -0.22 in 1981-90, -0.15 in 1991-00 and -0.09 in 2001-10).

The SPI6 importance of the decade 1971-80 is explained by its position at the heart of the drought of the 1970s, whereas the weakness of the index of the decade 2001-10 is related to the recent improvement of conditions rainfall in the country. Some stations recorded a positive SPI6 (0.16 at Fatick, 0.14 at Saint Louis, 0.06 at Thiès). For humid decades, the humidity conditions are light, but the character of humidity is more accentuated in the central and southeastern part of the coast. This slight humidity is also more pronounced in the central and northern part of coast over the last

Spatial coverage of light drought has increased sharply to be total along the entire coastline since the 1970s. SPI6 values generally indicate a type of light, drought, over most coastal areas from 1951 to 2010, frequencies of occurrence reaching 59.3% in Kaolack, 54% in Fatick, 53.3% in Dakar, 52.5% in Mbour... It is followed by the moderate drought whose values of frequencies of appearance range from 1.7% (in Dakar, Mbour, Kaolack and Ziguinchor) to 3.96% (in Diouloulou) (table 2). The important frequencies of light, drought is closely followed by those of light moisture.

Spatial variation of 12-Month SPI (January-December)

SPI12 was calculated using average monthly precipitation from January to December (figure 6). The spatial pattern of drought classification with SPI12 is shown in figure 5. SPI12 records, on average, similar values to SPI6: slight moisture at all stations on both first decades (0.44 in 1951-60 and 0.29 in 1961-70) and a slight drought over another four decades (-0.22 in 1971-80, -0.22 in 1981-90, -0.15 in 1991-00 and -0.09 in 2001-10).

The decade 2001-10, while being dry with average, still records this alternation of positive SPI (0.16 to Fatick, 0.14 to Saint Louis, 0.01 to Kaolock) and negative (-1.07 to Bignona, -0.11 to Diouloulou, -0.08 in Mbour). Thus, from the 1970s, a light drought was observed on the whole coastline, from South to North, whereas the decade 2001-10 is the only one which recorded a light humidity in only some parts of the littoral. Of all-time scales used, the SPI6 and SPI12 are only ones that have recorded, per decade, a moderate type of drought (Bignona station over the decade 2001-10).

After being a total of 1970 of, the spatial coverage of light, drought has been declining all along the coast in recent years, with the return of wet years. From 1951 to 2010, only the station of Saint Louis, in the North of littoral, recorded all the categories of drought (light with 35%, moderate with 5%, silver with 6.7% and extreme with 1.7%). Beyond that, the category of light drought is most represented on the entire coastline. Thus, the frequencies of appearance of light, drought reach 62.7% in Kaolack, 56% in Louga and Fatick, 53.3% in Dakar, 52.5% in Mbour... On the other hand, those of

The SPI used for the rainfall deficit assessment from 1951 to 2010 show a significant fluctuation of dry and wet periods with a strong tendency to drought, especially over the period 1971-2000. The longest drought period that affects Senegalese coastline extends from 1970 to 2000. On the various climatic domains and studied stations of littoral, SPI indicate very important frequencies on slightly dry sequences (approximately 50%), modest on moderately dry (less than 10%) and very weak sequences on severely dry sequences. Thus, the number of occurrences per classification decreases with increasing severity. On different time scales, the indices frequencies on different climatic domains and studied stations of littoral are quite close. The values of indices on different time scales show that South-Sudanian coastal climate domain is less affected by droughts than the Sahelian climatic zone of the coast. A closer look at the number of occurrences of drought in the area shows that the extreme northern parts of coastline are more sensitive to extreme and severe drought. On the other hand, this is in tune with the northern parts of the country which are more prone to drought and desertification.

DISCUSSION

The analysis of standardized precipitation index (SPI) calculated for time scales of 1 month, 3 months, 6 months and 12 months for 10 stations of Senegalese littoral with different climatic regimes, revealed that the Senegalese coastline knew a major rainfall deficit since the 1970s, a deficit that lasted for the 1980s and 1990s. These results confirm the research carried out by Goula et al. (2005), Soro et al. (2014), Omonijo and Okogbue (2014) in West Africa. In Senegal, the works of Faye (2013), Faye et al. (2015) and Faye et al. (2017) who showed that the 1970s, 1980s and 1990s were dry periods marked by a high rainfall deficit.

Although the rainfall decline intensified in Senegal during 1980s and 1990s, it did not persist in 2000s as noted by some authors (L'Hôte et al., 2002; Soro et al., 2014). During the 2000s, it was noted in Senegal that an increase in rainfall predicted the improvement of rainfall patterns in the country compared to the drought period of previous decades, although the persistence and sustainability of current increase are still to prove, knowing that climatic scale ultimate is the thirties (Faye et al., 2017). However, this improvement in rainfall conditions is in concert with the work of some authors (Ali and Lebel 2009; Ozer et al., 2009; Bodian, 2014) who suggest the end of Sahelian drought during the 1990s over the period 2001-2010, statistical indices have detected in Senegal important wet sequences even if the optimum of the 1960s is not yet reached.

Results obtained vary by station, scale and domain. By climatic domains, the SPI values of different stations on different time scales show that South-Sudanian climatic domain is least affected by droughts than the Sahelian climatic domain. In terms of the intensity of drought and the frequency of appearance of dry sequences, the results obtained are similar on different time scales. In this study, dry sequences were characterized strictly with rainfall data, an approach highly dependent on the quality of data measured in situ, especially as the mesh of stations on Senegalese territory is very loose. To remedy this, other authors (Bayarjargal et al., 2006; Beaudin, 2007) use satellite imagery in their studies to monitor weather and environmental conditions. Indeed, this technique offers both the possibility of acquiring daily data for the desired territory, increases the accuracy and monitoring of drought conditions and helps explain the contribution of temperatures in drought analysis.

CONCLUSION

In this paper, Standardized Precipitation Index (SPI) was evaluated at different timescales to study the drought intensity and frequency using monthly rainfall data from 10 stations located in different locations. climatic domains of Senegalese littoral for period 1951-2010. Drought occurs in all parts of the globe and negatively affects lives of a large number of people, causing considerable damage to economies, environment and property. Drought also affects countries or regions differently and has a greater impact on poor countries or regions. On many occasions, droughts have been so severe that local people have been forced to migrate. Results revealed that Senegalese coastline is generally facing severe and prolonged drought events.

Analyzes revealed that most remarkable droughts in intensity, duration and frequency were observed during the period 1971-2000, regardless of time scale and domain considered. These dry episodes reached their peak in 1972 and 1983 with extreme and severe droughts. However, light drought is predominant over the 60 years of study because having the greatest number of occurrences on Senegalese coastline. Of ten stations studied, those in the Sahelian field (Dakar, Matam) seem to be the most affected by drought. Of four time scales considered, one at 12 months seems most appropriate for describing drought sequences because, at this time step, the index becomes stable thus making it possible to define with more precision dry episodes.

This study therefore confirmed that there was no consistent timetable for the onset of drought. It also confirmed the high intensity of droughts over the period 1970-90. Analysis showed that some stations are already in wet situations during the last decade of study. This study demonstrates need to put in place measures that can be used to address and improve the impact of drought in their next reappearance.

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Submitted:	Revised:	Accepted and published online
June 02, 2018	September 20, 2018	November 29, 2018