



Assessment of agricultural drought during crop-growing season in the Sudano–Sahelian region of Cameroon

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Abstract

Drought is a recurrent phenomenon in the Sudano–Sahelian region of Cameroon. However, it has received very little attention, especially, on its impacts on the growing season of crops. To fill this gap, this study assessed the drought hazard using standardized precipitation index at a 3-month scale, and phenology of the main crops in 19 rainfall stations in the Sudano–Sahelian region of Cameroon for the period 1980–2012. The trend of drought was studied using the Mann-Kendall technique. The agricultural drought hazard was quantified based on its frequency and intensity. Results show that there is a significant trend toward a more humid crop-growing period in the northern and southeastern parts of the study area, but significant dry trends during the maize and peanut growing periods in the southwestern part of the study area. Drought occurrence rates are 7.09, 4.22, and 3.17% for the moderate, severe, and extreme, respectively. Areas featuring high and very high agricultural drought hazards are distributed in the far north, central, and the southeastern parts of the study domain. Furthermore, the Sahelian and Sudanian climatic conditions were found to be very high agricultural drought hazard zones, especially, where the maize and peanut grain crops are concerned. However, significant dry trends and very high agricultural drought hazard zones during the maize and peanut growing periods are catastrophic for agriculture and, therefore, food security.

Keywords Sudano–Sahelian region · Drought hazard · Drought occurrence · Growing period · Phenology

1 Introduction

Drought is a regional, long-term phenomenon driven by regional climatic conditions originating from a deficiency of precipitation that results in water shortage needed for some anthropogenic activities (Adejuwon and Olaniyan 2018). Drought was frequently recorded in both the sub-humid and semi-arid regions (Dai 2010), and relatively better documented where populations tend to concentrate (Lugo and Morris 1982). Current

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climate studies predict that the driest zones of the world will become drier in the future, indicating a risk of drought persistence in many arid, semi-arid, and dry sub-humid zones, with greater and long-term negative impacts (ECOSOC 2008). For instance, the Sahel is known as one of the largest semi-arid regions in the world. Livelihoods of the rural Sahelian population rely mainly on rain-fed agriculture and livestock (Leisinger and Schmitt 1995). The Sahelian region is characterized by high intra-annual variability, which affects water resources and food security (Nicholson 1989, 1993; Barbé et al. 2002). Mohino et al. (2010) and Rodriguez-Fonseca et al. (2011) have shown that the 1970–1990 Sahel drought was linked to sea surface temperature (SST) anomaly patterns in the major tropical ocean basins but the recent rainfall recovery has been largely attributed to a climate change phenomenon from the mid-1990s, which is associated with the Atlantic Multidecadal Oscillation (AMO). Moreover, numerous studies have shown that rain in the Sudano–Sahelian region of West Africa is a result of organized Mesoscale Convective Systems (MCSs) (Dhonneur et al. 1981; Omotosho 1985; Mathon et al. 2002; Fink et al. 2006).

In a recent review by the Intergovernmental Panel on Climate Change, its special report on extreme events shows lack of detailed studies on the evolution of extreme rainfall and drought frequency in West Africa due to lack of data (IPCC 2012). Particularly, in Sahel West Africa, the number of rain gauge stations has decreased significantly in recent years (Sanogo et al. 2015; Eklund et al. 2016). This low number of stations has led to data unavailability. As a result, some studies on the Sahel West Africa such as those carried out by Ali and Lebel (2008), and Zhang et al. (2017), used the geographical distribution of available data to delimit the Sahelian region. Despite these efforts, no published study, to our knowledge, has been conducted in the Sudano–Sahelian zone of Cameroon to assess the impacts of drought during crop-growing seasons. Therefore, this study attempted to relate drought hazard characteristics with mean annual rainfall in Sudano–Sahelian regions where agriculture is rain-fed.

Agriculture in Cameroon is mainly rain-fed; therefore, it strongly depends on climate. The Sudano–Sahelian region includes two administrative regions that account for approximately 21% of the total area of Cameroon (PARM 2017). Agriculture is the main economic activity of this region. During the period September 1982 to the year 2000, this Sudano–Sahelian region has suffered from sixteen major droughts, which caused poor water quality, water and food shortage, famine, locust invasion, and decreasing of crop yield (MINEPDED 2016). This region is a major cultivator of cotton and cereal. Cotton is the fourth highest exported crop in Cameroon, contributing about 9.5% to the Gross Domestic Product (GDP) (Manyacka and Nguepjouo 2013). Other important crops associated with the cotton production include corn, rice, peanut, millet, and sorghum. However, since the 2000s, cereals have been the most affected crops during the cotton crises, due to change in fertilizer supply by the “Société de Développement du Coton (SODECOTON).” This change in fertilizer supply had as objective to improve the cotton yields as the same fertilizers are needed for cereal cultivation (Folefack et al. 2014).

Some studies have associated the annual variability of crop yield to extreme flood and drought events, which are becoming more frequent and severe due to climate change (Molua 2006; Tingem et al. 2008b). Despite these agricultural activities, this region is the poorest part of Cameroon. It is also occupied by the poorest population of the country with 56.3% of its population living below the poverty level (Donfack 1998; Tchiadeu 2000). Moreover, households are exposed to stresses related to food availability and production, low income, accessibility, coupled by real and perceived effects of current climate

variability (Molua 2012). This has increased the region's vulnerability to agricultural risks and food insecurity (PARM 2017).

Numerous studies have focused on the impact of climate parameters (precipitation, temperature, radiations, onset, and length of the rainy season) on agriculture (Tingem et al. 2008b; Sultan et al. 2009) and on the development of vegetation cover in general (Manetsa et al. 2011; Djoufack et al. 2012). Tingem et al. (2008b) used climate station data from 1979 to 2003 to validate two GCMs paired with an agronomic model to predict substantial yield increases for bambara groundnut, soybean, and groundnut, as well as to study changes in maize and sorghum yields due the climate scenario in the agricultural region by 2100. Manetsa et al. (2011) and Djoufack et al. (2012) reported spatio-temporal effects of seasonal rainfall and urban population growth with the normalized difference vegetation index (NDVI) in North Cameroon for the period 1987–2002 based on the kriging method at 1 km spatial resolution. Climatic parameters such as onset date and the length of the rainy seasons explain the sensitivity of cotton production to drought (Sultan et al. 2009). However, few studies have actually investigated the impacts of drought during the growing season.

Several indexes may be used to evaluate drought duration and intensity. Some of these indexes include the Standardized Precipitation Index (SPI; McKee et al. 1993) and the Standardized Precipitation Evapotranspiration Index (SPEI; Vicente-Serrano et al. 2010), both at the local and the global level (Zou et al. 2005; Raziei et al. 2008; Dai 2010; Sheffield et al. 2012; Vicente-Serrano et al. 2014; Guenang and Kamga 2014; Ajayi and Ilori 2020). The SPI computation is based solely on the precipitation variable, while the SPEI includes the potential evapotranspiration (PET) variable. Ajayi and Ilori (2020) showed that there exists a strong correlation between SPI and SPEI over West Africa using the regression plot at 95% confidence level. However, locally, SPI is the most frequently used index, as it requires a single variable (precipitation), therefore fewer computing resources. During SPI computation, Guenang and Kamga (2014) and Guenang et al. (2019) found that the statistical distribution functions of gamma and Weibull were suitable for the study of drought over the Sudano–Sahelian region.

This study aims to evaluate the agricultural drought hazard in the Sudano–Sahelian region of Cameroon during the crop-growing season using SPI. The spatial distribution of drought hazard, intensity, and frequency was examined with a horizontal grid of 2.3 km × 2.3 km at 0.5° spatial resolution (49,896 grid points cover study area). The results of this study are useful in filling the existing gap in the literature on agricultural drought hazards. It will also enable stakeholders to plan appropriate adaptation and resilience measures in the West African Sahel. The paper is organized as follows: The current section is the introduction; the next section describes the study area, the data utilized in the study, and the computational methods. Section 3 presents and discusses the results of the study; finally, the conclusion of the study is presented in Sect. 4.

2 Study area, data and method

2.1 Study area and data

The Sudano–Sahelian region of Cameroon lies in the latitudes 7°N to 13°N and longitudes 11.5°E and 16°E, with an area of about 100,000 km² as shown in Fig. 1. The major activity in the region is agriculture. It depends on cultivating crops such as millet, sorghum,

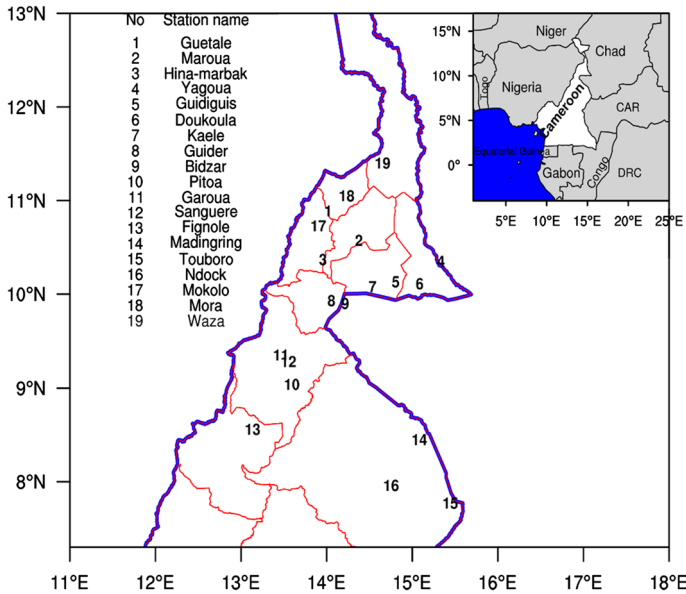


Fig. 1 Map and administrative divisions of the study area located in the Sudano–Sahelian region and the crop-growing zone. The country boundary in blue limit and the red line marks administrative divisions' boundaries. The numbers indicate the geographical locations of the rainfall stations

groundnut, rice, maize, cowpea, and cotton, which are the main cash crops. This agriculture is rain-fed and is greatly affected by drought. The annual rainfall range in this region is 1500 mm in the south and 300 mm in the north. There is a unimodal rainfall regime from May to October with its peak recorded in August. Climatically, this study area falls within the Sudano–Sahelian domain that portrays a high inter-annual variability in its whole area, increasing from south to north. This may be attributed to the topography of the region (Dassou et al. 2016), which features lowlands with altitudes within 95 and 795 m.

In this study, monthly precipitation data for the period 1980–2012 from nineteen meteorological stations were studied. The data were provided by the SODECOTON network (Table 1). Few stations (less than 4%) have missing values. Dassou et al. (2016), recently used most parts of this dataset. Our study focuses on the seasons of major crop cultivation in northern Cameroon, for the period 1980–2012 (from the sowing season to the harvesting season). The growing seasons of the seven major crops were considered in this study, shown in Table 2.

2.2 Methodology

2.2.1 Standardized precipitation index (SPI)

To investigate drought occurrence in the study area, Standardized Precipitation Index (SPI) was used. Compared with the other indices, SPI is based only on rainfall data and is not affected by topography (He et al. 2011). The use of rainfall data only made SPI the most suitable index for our study area due to data unavailability. In addition, SPI is able to distinguish droughts at different scales. This is beneficial for meteorology, agriculture, and

Table 1 Geographical descriptions of the data, altitude, and the percentage of missing data

N°	Stations	Latitude(°N)	Longitude(°E)	Altitude(m)	Missing (%)
1	Guertale	10.89	13.90	490	3.2
2	Maroua	10.575	14.27	428	0
3	Hina-marbak	10.369	13.85	544	3
4	Guidiguiss	10.13	14.70	362	3
5	Doukoula	10.11	14.98	340	3
6	Kaélé	10.10	15.05	388	3.1
7	Guider	9.93	13.95	356	0
8	Bidzar	9.9	14.11	470	2.2
9	Pitoa	9.04	13.51	274	2.1
10	Sanguere	9.28	13.47	241	0
11	Figrole	8.56	13.05	523	0
12	Madingring	8.45	15.00	430	2.2
13	Touboro	7.77	15.36	500	4
14	Ndok	7.96	14.67	489	0
15	Mokolo	10.73	13.82	795	0
16	Mora	11.05	14.15	438	0
17	Waza	11.40	14.57	311	0
18	Yagoua	10.35	15.23	329	0
19	Garoua	09.35	13.37	242	0

Table 2 The computation periods of the standardized precipitation index (SPI) values for drought estimation during the different crop-growing seasons in Sudano-Sahelian region of Cameroon as defined by the crop calendar. (Source:<http://www.fao.org/agriculture/seed/cropcalendar/cropcalendar.do>)

Crop	Season	Period(Month)
Cotton/soybean	May–October	6
Maize/peanut	May–August	4
Sorghum/millet	May–September	5
Rice	June–November	6
Cowpea	June–October	5

hydrology. In our study, a 3-month time step SPI was computed to study the characteristics of drought in a short-range time scale affecting agricultural practices. SPI was calculated by establishing a gamma distribution for different time scales for each month of the year. This allowed establishing the classification values for SPI (McKee et al. 1993), the SPI values are summarized in Table 3.

2.2.2 Trends in drought

The non-parametric Mann-Kendall test (M-K; Mann 1945; Kendall 1955) was applied to determine drought trends and the significance test in time series of the SPI (at a 3-month

Table 3 Drought categories defined for SPI value, weight, and rating as assigned to each drought severity theme, occurrence rate, respectively

SPI	Drought severity	Weight	Occurrence rate	Rating
0 to – 0.99	Mild drought	–	–	–
– 1.00 to – 1.49	Moderate drought	1	Low	1
			Medium	2
			High	3
			Very high	4
– 1.50 to – 1.99	Severe drought	2	Low	1
			Medium	2
			High	3
			Very high	4
≤ – 2.00	Extreme drought	3	Low	1
			Medium	2
			High	3
			Very high	4

timescale) from 1980 to 2012. This method is widely applied in hydro climatic trend analysis (Dassou et al. 2016; Shiru et al. 2019; Ayugi and Tan 2018).

The test statistic Z was computed as follows:

$$Z = \begin{cases} \frac{S-1}{\sqrt{\text{Variance}(S)}} & \text{if } S > 0 \\ 0 & \text{if } S < 0 \\ \frac{S+1}{\sqrt{\text{Variance}(S)}} & \text{if } S < 0 \end{cases} \tag{1}$$

where S was calculated with the following equation:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sgn}(x_j - x_i) \tag{2}$$

where

$$\text{sgn}(x_j - x_i) = \begin{cases} 1 & x_j > x_i \\ 0 & x_j = x_i \\ -1 & x_j < x_i \end{cases}$$

A positive value of Z shows an upward trend, while a negative value shows a downward trend. $|Z| > 1.96$ denoted the confidence level of 95%.

2.2.3 Drought hazard index (DHI)

The crop vulnerability to drought at different time scales was identified based on the frequency of occurrences and severity of drought hazard (He et al. 2011). However, drought occurrence is calculated during the growing season for each crop. The start of the growing season in each station was defined as the planting month, while the end of the season was

defined as the harvest month. The periods used for the calculation of the SPI and drought occurrences for all the crops are given in Table 2. Each drought severity theme is given a particular weight, and each feature of the theme is given a rating to compute drought hazard. The weights and ratings used are described in Table 3. For each station, the percentage of drought occurrences was calculated as follows: occurrence rate of drought category = (the number of drought category months in the 3-month time scale of SPI which occurred in the growing season during 1980–2012) \times 100% / (total number of months during 1980–2012).

In order to assess the risk of drought, it is necessary to analyze the drought hazard. Drought hazard can be defined as the probability of occurrence of droughts (He et al. 2011). According to Eq. (3), the drought risk was calculated for each station, and then interpolated over the study area. The drought hazard index used to analyze the spatial distribution characteristics of agricultural drought hazard in the study area was calculated as:

$$DHI = (MD_r \times MD_w) + (SD_r \times SD_w) + (VD_r \times VD_w) \quad (3)$$

where MD_r is ratings accorded to moderate drought occurrence classes. MD_w is weight attributed to the moderate drought occurrence theme. SD_r is ratings associated with severe drought occurrence classes. SD_w is weight attached to the severe drought occurrence theme. VD_r is ratings of very severe drought occurrence classes, whereas VD_w is weight attached to very severe drought occurrence theme.

Meanwhile, to generate the spatial distribution map of drought hazard which was between 6 and 24, the drought hazard was divided into four grades: low, medium, high, and very high (Shahid and Behrawan 2008; He et al. 2011; Geng et al. 2015), according to the Jenks natural breaks classification method (Jenks 1967) (Fig. 5).

2.2.4 Kriging interpolation

The kriging interpolation method was used to change the stations' data into spatial data. It was also used for the mapping of spatial extents of drought trend, occurrence rate of drought, and DHI from station data. The GIS geostatistical analysis tool in R analysis software was used for this purpose. Kriging is a stochastic interpolation technique (Journel and Huijbregts 1978; Isaaks and Srivastava 1989) and is largely recognized as a standard approach for surface interpolation based on scalar measurements at different locations (Shahid and Behrawan 2008). Djoufack et al. (2012) and Dassou et al. (2016) showed that Kriging gives better global predictions than the Inverse Distance Weighting (IDW) in the current study domain.

3 Results and discussion

3.1 Distribution of drought occurrences in the crop-growing season

Identifying the distribution of drought occurrences during the crop-growing season allows a better interpretation of the drought hazard. This is because the drought occurrence rate could provide drought frequency information. Figure 2 shows the spatial extent of moderate, severe, and extreme drought occurrences from a 3-month SPI in the Sudano–Sahelian region of Cameroon. The results represented in three maps, exhibited different patterns across the study area. The output of the study also showed

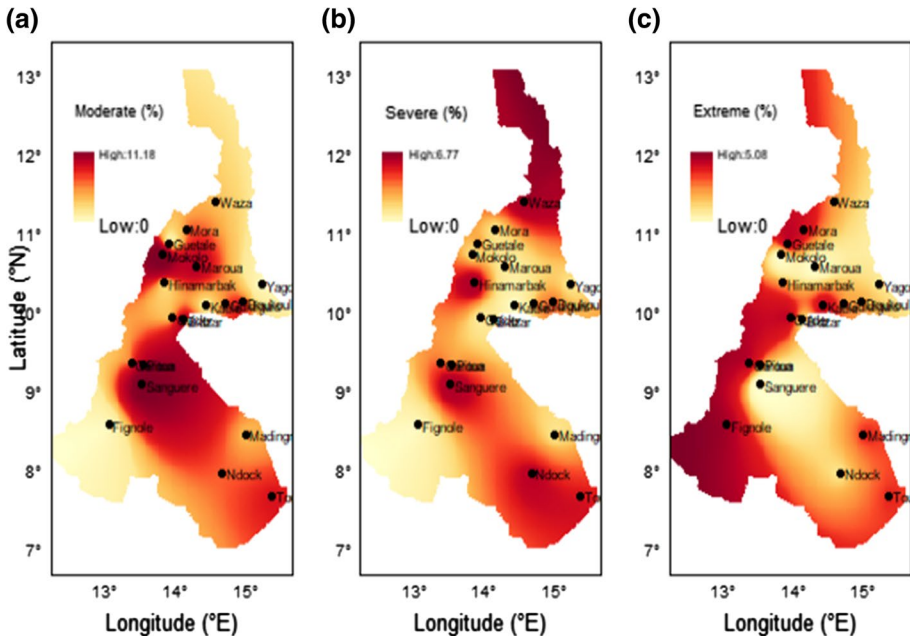


Fig. 2 Spatial distribution map of **a** occurrence rate of moderate drought (%), **b** occurrence rate of severe drought (%), and **c** occurrence rate of extreme drought (%) at a 3-month time step in Sudano-Sahelian region

that the mean occurrence rates for moderate, severe, and extreme drought were 7.09, 4.22, and 3.17%, respectively. The observed spatial distribution of moderate droughts (Fig. 2a) indicates that they tend to occur more frequently in the central (i.e., from 10 to 11°N), and in the southern parts (i.e., from 10°N downward). Severe droughts (Fig. 2b) show a pattern slightly different from the moderate drought. The far north part of the study area (i.e., from 11°N upward) was found to be mostly prone to severe drought, whereas the central and eastern parts of the area were found to be moderately prone. Figure 2c shows extreme droughts occurring in the central and southwestern parts of the area with high frequency. The southeastern and far northern parts (i.e., from Guetale upward) show moderate frequency, while the southern and northern parts show less frequency.

Moreover, Fig. 3 shows the occurrence rates of moderate, severe, and extreme drought in the different stations studied. Among those stations, Sanguere, Hina-marbak, and Waza were the least drought-prone regions, while Guider, Fignole, Kaélé, and Guetale were the most drought-prone stations. Guenang and Kamga (2014) presented heavy intensities and frequencies of drought in the Sahelian and in the Adamawa Plateau regions represented by the Kaélé station which displayed moderate, severe, and extreme drought occurrences of 12, 8, and 5%, respectively, from 1951 to 2005. Compared to this earlier study, our research also aimed to reveal the heavy intensities and frequencies of drought hazards in relation to the crop-growing seasons. It also agrees with the findings of these earlier studies.

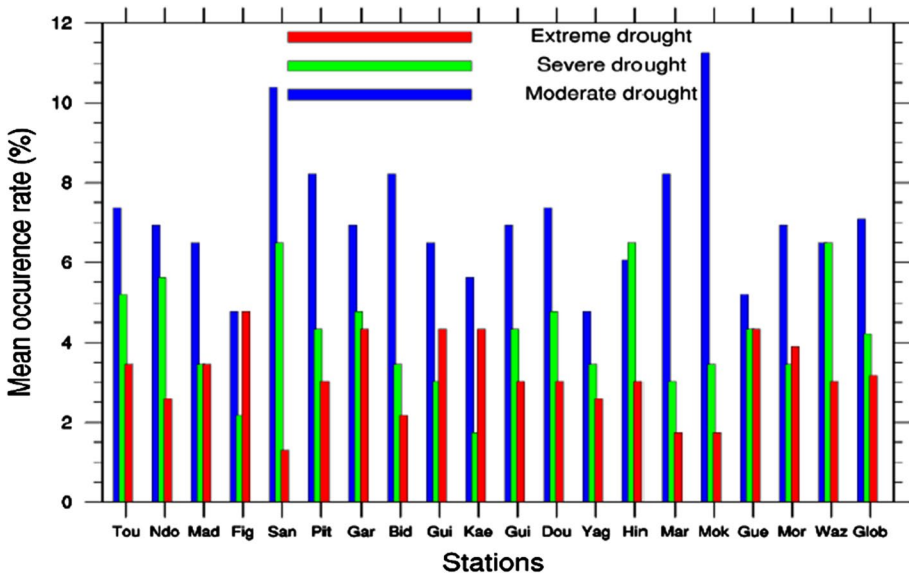


Fig. 3 Occurrence rates per 3 months for moderate, severe, and extreme drought of each station studied

3.2 Drought trends

Figure 4 shows that for the entire growing season, Z values of SPI were positive for over half of the area, and Z values were greater than 1.96 in the northern and southwestern part of the study area. This was also the case for the growing season of all other crops (Fig. 4a–f). This means that the whole growing season had a wet trend during 1980–2012 in these regions. This result attained a 95% confidence level in the northern and southeastern parts of the study area. Drought trends for the maize and peanut growing season had a dry trend from 1980 to 2012 for over half of the area, which was more significant in the southwestern part of this region during this period (Fig. 4f). Overall, these results show more humid periods than drought periods, which are similar to the results of Sylla et al. (2016) between 1983 and 2010 in the Sahelian part of West Africa. At the local scale, this study also corresponds to another recent study by Shiru et al. (2020), who employed the multi-model ensemble (MME) mean of bias-corrected General Circulation Models’ (GCMs) projections to Nigeria to reveal an increase in frequency of all categories of droughts for all the growing seasons under all scenarios Shiru et al. (2019) noted that the highest increase in drought frequency was observed during the corn-growing season in Nigeria, which shares the same boundary and eco-climatic region with the Sudano–Sahelian region of Cameroon. In light of this, this study recommends a further study to discuss expected future droughts relative to these past documented drought events.

3.3 Spatial pattern analysis of drought hazard

As illustrated in Fig. 5, the Sudano–Sahelian zone observes mainly a moderate, high, and very high drought hazard sequence accounting for an area percentage of 3.51, 59.93,

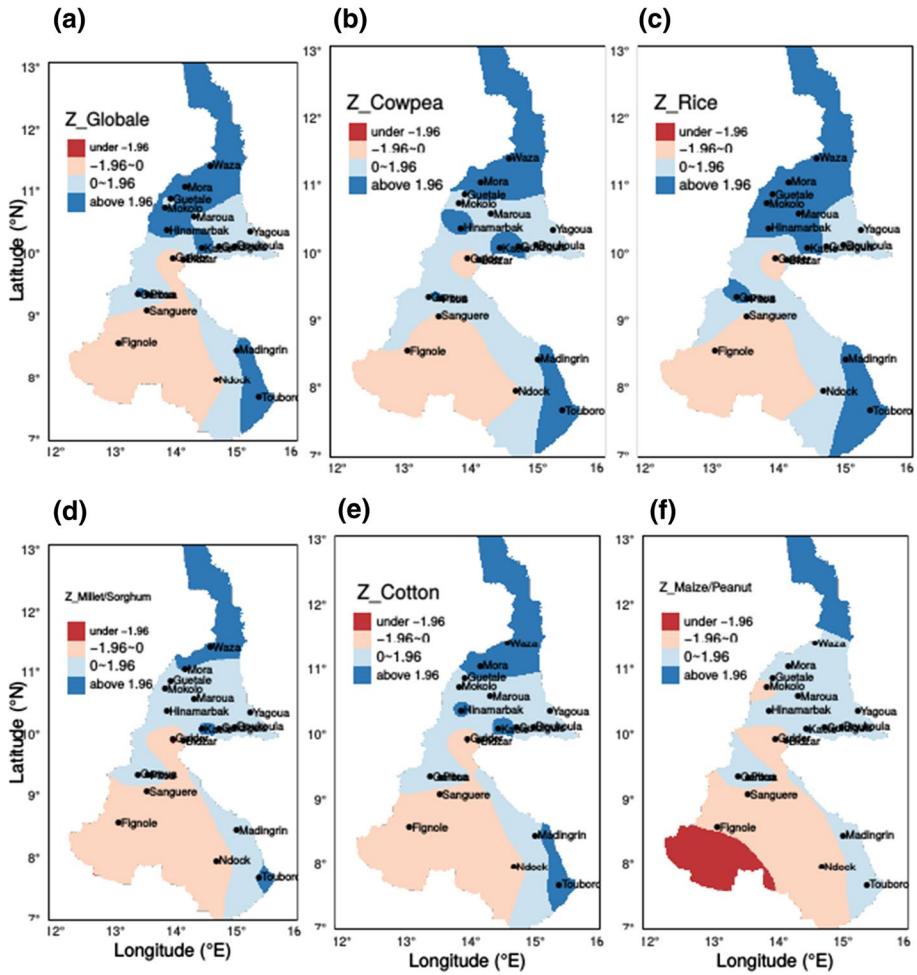
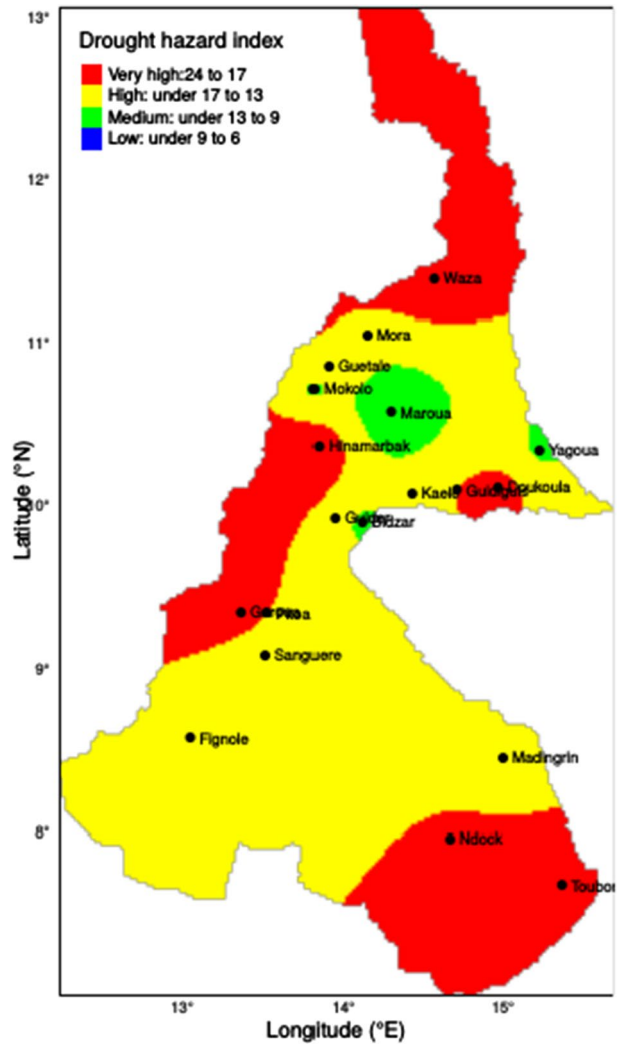


Fig. 4 Spatial distributions of Z values of SPI from 1980 to 2012 during: **a** the whole, **b** cowpea, **c** rice, **d** millet and sorghum, **e** cotton, and **f** maize and peanut growing season

and 36.56% respectively. On the other hand, the study area can be regrouped into one broad high to very high drought hazard zone in the northern, southeastern, and central-western parts (Fig. 5). Figure 6 indicates that Hina-marbak and Waza stations had very high drought hazard, whereas Maroua had a moderate drought hazard. However, these stations are localized in the semi-arid area.

Meanwhile, a global study conducted to assess the impacts of drought hazard on agriculture identified that areas in southern Nigeria are among the areas classified as high to very high agricultural drought hazard zones in the world (Geng et al. 2015), where the main crops grown in the area are yam, rice maize, millet, peanut, and sorghum. The increasing frequency of droughts and their impact are also a focus of this study. This study clearly demonstrated that the region is highly affected by the agricultural drought.

Fig. 5 Map of the drought hazards in the Sudano–Sahelian region of Cameroon



3.4 Agricultural drought hazard for the main crops

Figure 7 indicates that the far north and southeast of the Sudano–Sahelian region of Cameroon that mainly grows cotton, cowpea, rice, millet, and sorghum are very high drought hazard zone. Maize and peanut are grown in the very high drought hazard zone of quasi-totality part of the study area. Further, Table 4 shows that 53.73% of total Maize and peanut growing area is located in a very high hazard area; cotton, millet and sorghum, rice, and cowpea are 35.2%, 35.14%, 26.06%, and 31.7%, respectively. Drought losses are directly related to agricultural drought. Tingem et al. (2008a) reported that generally during the dry scenarios there was a slight decrease in maize yields (about 100–300 kg decrease/ha) and an increase in yield variability across different locations. Other studies have shown that maize and sorghum (both C4 crops) yields decreased by 14.6 and 39.9%, respectively, across the whole country under GISS 2080 scenarios by baseline climate 2020 (Tingem

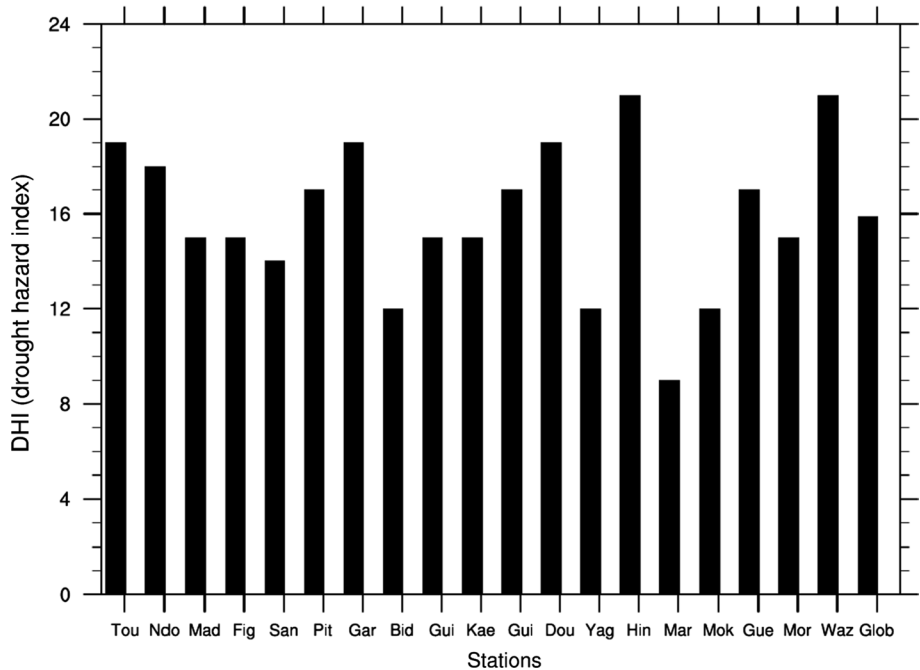


Fig. 6 Drought hazard index in different stations of the study area

et al. 2008b,c). On the other hand, Gérardaux et al. (2012) predicted unexpectedly that a climate change scenario between the years 2005 and 2050 in North Cameroon would have a positive effect on cotton yields due to the expected increase in temperature and the fertilizing effect of CO₂. In general, previous studies, including Laux et al. (2010), focused on the contribution of future climate change as it alters the availability of CO₂, which in turn causes a direct fertilization effect while causing the indirect effects of expected temperature and precipitation change. These changes according to some early studies have a combined positive impact on crops such as rice, cotton, and cowpea but detrimental to maize, groundnuts, millet, and sorghum in our study area.

4 Conclusion

Drought is a phenomenon present in Cameroon and recurrent in the Sudano–Sahelian region than elsewhere in the country. This study investigated the spatial characteristics of drought hazard in North Cameroon based on the monthly precipitation data for the period 1980–2012 from 19 rainfall stations and the phenology data of main grain crops on a 2.3 km × 2.3 km grid points interpolated in R software constructed using a 3-month Standard Precipitation Index (SPI). As agriculture is the major sector that suffers from the effects of drought, the agricultural drought hazard was assessed. Furthermore, a comprehensive drought hazard assessment was carried out and the spatial pattern of drought hazard in the Sudano–Sahelian region of Cameroon was analyzed. This study came to the following conclusions.

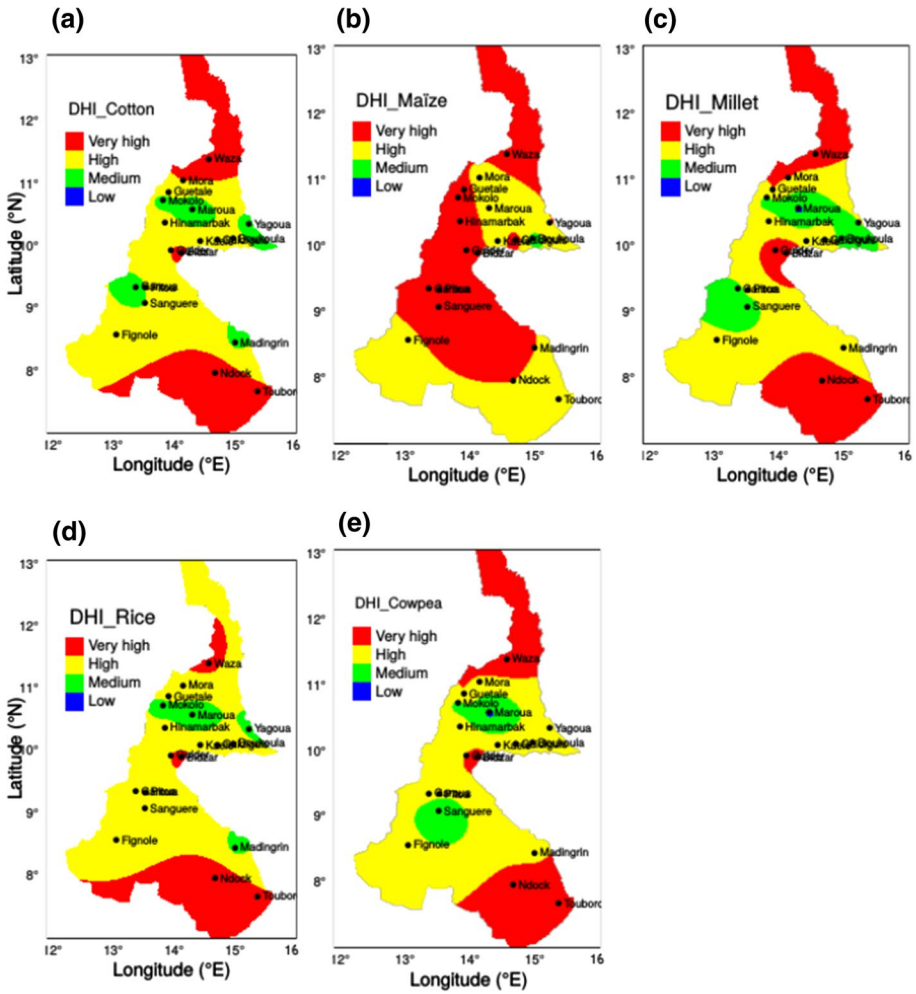


Fig. 7 The spatial patterns of drought hazard during cotton, maize or peanut, millet or sorghum, rice, and cowpea growing season for the period 1980–2012

Table 4 Relationship between area percentage of drought hazard distribution and main grain crop planting

Drought hazard	Main crop				
	Cotton	Maize/peanut	Millet/sorghum	Rice	Cowpea
Low	0	0	0.12	0	0.14
Moderate	10.1	0.45	15.12	7.25	10.43
High	54.70	45.82	49.72	66.70	57.73
Very high	35.20	53.73	35.14	26.06	31.70

There is some spatial variability within the same rainfall domain. Most drought-prone regions were located in the far north, central, and the eastern parts of the study area. Moreover, high and very high agricultural drought hazard zones were also distributed in these areas. The area percentages of the medium, high, and very high agricultural drought hazard zones were 3.51, 59.93, and 36.56%, respectively.

SPI MK trend test revealed a significant wet trend in almost all the growing seasons and dry trend for the maize and peanut growing season during the 1980–2012 study period in the northern and southeastern part and in the southwestern part of the study area, respectively.

Most part of the study area was found to be very high agricultural drought hazard zones for the growing of maize and peanut. This could be due to the occurrence of drought at the beginning of the rainy season and a consequent increase in temperature, resulting in a faster than normal growth of crops during the growing season of the studied crops. However, drought hazard analysis is the most important part of drought risk assessment as it also allows for a study of socio-economic vulnerability. Our study on the analysis of agricultural drought allows decision-makers to take adequate measures for adaptations in order to reduce the impacts of climate change on agriculture, which is a source of revenue for the entire country and subsistence for households in the Sudano–Sahelian region of Cameroon.

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Author's contribution All authors contributed to the study conception and design. NI, DAV, EFD, BOA, and RN contributed to then conceptualization of the study. The first draft of the manuscript was written by NI, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.




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