International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **11(2),** 25-30, April **(2022)** *Int. Res. J. Environmental Sci.*

Review Paper

Characterization of Onset, Cessation and Moisture Conditions in Rainy Seasons of Westrn Oromia

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Available online at: www.isca.in, www.isca.me
Received 28th March 2021, revised 6th December 2021, accepted 2nd February 2022

Abstract

In Ethiopia, Rainfall variability has a major impact on Agricultural productivity and economies. The study aims to analyses variability of onset, cessation, NRDs and Moisture conditions (SPI) in 3, 6, 9 and 12 time scales by using statistical method over western Oromia for the period of 1981-2016. The northern parts of the region (East & West Wollega) experiences high rainfall during Kiremt. Belg rainfall has a considerable amount contribution to the annual rainfall over the southern parts of region (Jimma and Illubabor). The early onset of rainfall occurred over Jimma zones in the 3rd dekade of March, in the 1st dekade of April over the most parts of Ilubabor, and lately in the 3rd dekade of April to 1st dekade of May over the east and west wellega following the northward propagation of ITCZ. Cessation was earlier over the most parts of East and West wollega before the first decade of November and before 3rd decade of November over the east and west of jimma and south of Illubabor zones. The study revealed the climate of rainfall and the region as whole experience more near normal moisture conditions (from 26 to 32 times) than other condition categories for all SPI time scales in 36 years events which are necessary information for agriculture operations, hydrological management and mitigation of impacts

Keywords: Climate, Rainfall, Variability, Rainy-days, drought, Ethiopia.

Introduction

The Ethiopian economy is largely dependent on rain-fed agriculture[1]. Inter-annual or seasonal rainfall variability has a major impact on their agricultural production and economies[2]. Since rain fed agriculture is the basis of the economy of Ethiopia, variability and changes in climate are directly reflected on the Gross Domestic Products (GDP) of Ethiopia[1]. Understanding rainfall variability helps to manage agricultural activities based on the climate of the region and enables to formulate strategies adaptation that reduces potential impacts of changing climate.

Variability of rainfall amount, onset, cessation and frequencies of events in growing season is very critical to agriculture. In Ethiopia's three seasons, locally known as Bega (Oct to Jan), Belg (Feb to May) and Kiremt (June to Sept)[3,4] has different climatological characteristic shows variations across time and space due to the complex topography of the country[3,5]. Nowadays, the country is most vulnerable to climate variability. Rainfall variability is the primary climatic factor that directly affecting agriculture activities, hydrologic dynamics and driver of food insecurity. In spite of different studies were done in climate variability at national level[4,6,7] regional based detail variability and characteristics of rainfall over Western Oromia are few. However, an onset and cessation of seasonal rainfall vary in Ethiopia, considerably within few kilometers distance[11-13]. Rainfall variability is the main cause of drought and flood in most part of Ethiopia. Information of spatial patterns of start, retreat of rainy season, and severity and frequency of dry/wet probable meteorological conditions are an important for agricultural operations. Understanding of rainfall climate of West Oromia and its manifestations provide important information that can aid farmers in improving their agricultural production process and make agricultural planning easier, as well as help disaster managers to further monitor flood, drought occurrence[1,2]. Thus, this study is aimed to present the seasonal spatial distribution and to determine pattern of mean onset and cessation date spatial variability, NRDs, the probability of occurrence of different categories of wet and dry periods (SPI) and PDSL of seasonal rainfall by using statistical method over western Oromia for the period of 1985-2016.

Methodology

Data and data Source: Daily gauge rainfall data were collected from NMA of Ethiopia for the period of 1985-2016. Stations were selected based on data availability for longer time, quality and agro-ecological representativeness. And satellite-derived rainfall approximations, the Climate Hazards Infrared Precipitation with Stations (CHIRPS) Rainfall data were obtained from the U.S. Geological Survey (USGS) and the

National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA CPC): https://data.chc.ucsb.edu/products/CHIRPS-2.0/. Seasonal and monthly totals were calculated from daily rainfall.

Method of determination of onset and cessation: The rainfall onset and cessation dates of the rainy season were determined by mean cumulative rainfall and/or the rainy days method(s). The onset date is the one with 20mm of total rainfall received over three consecutive days that were not followed by greater than ten days of dry spell length within 30 days. The date of cessation occurs when the first day of dry spell with duration of at least 20 days occurred after seasonal rainfall activity. In addition, a fixed average 5 mm of evaporate-transpiration per day, and 100 mm/meter of the maximum soil water holding capacity of the area were considered[5,6,8].

Computation of Standard Precipitation Index (SPI): SPI calculation was performed by using the DrinC (Drought Indices Calculator) for five running time intervals (i.e. 3, 6, 9 and 12-months) for direct operational uses[15]. The SPI is based solely on rainfall input requirement, wide applicability and multiple time scales, which allows it to describe drought conditions important for a range of meteorological, agricultural, and hydrological applications[11,12]; used for determining the frequency of occurrence of wet/dry conditions as an indicator of the risk of flood and drought. It is calculated as following by using a probability density function as rainfall data fitted by a gamma distribution:

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{\frac{-x}{\beta}} (x > 0),$$

Where: Γ (a) = gamma function; x (mm) =precipitation amount; α is shape parameter (α>0); and β is scale parameter (β>0) [10-12].

Table-1: SPI Value and moisture conditions categories[13].

SPI Values	Categories	SPI
≥2.00	Extremely wet	Wet/Non Drought
1.5 to 1.99	Very wet	
1.00 to 1.49	Moderately wet	
-0.99 to 0.99	Near normal	
-1.00 to -1.49	Moderately dry	Dry/Drought
-1.5 to -1.99	Severely dry	
≤-2.00	Extremely dry	

Results and discussion

The spatial distribution of seasonal rainfall: The observed seasonal rainfall over western part of Oromia varies from location to location. It is the lowest in the season of Bega and the highest in the season of Kiremt. The northern part of the region (Central part of East & West Wollega) experiences high rainfall during kiremt as main rainy season. From figure note that, Belg (second rainy season) rainfall makes a considerable contribution in the more southern parts of Jimma and Illubabor zones, similarly Bega season based on both stations observation and Chirps data analysis. The four months (May, June, July and August) contributed comparable and the high amount to the annual rainfall.

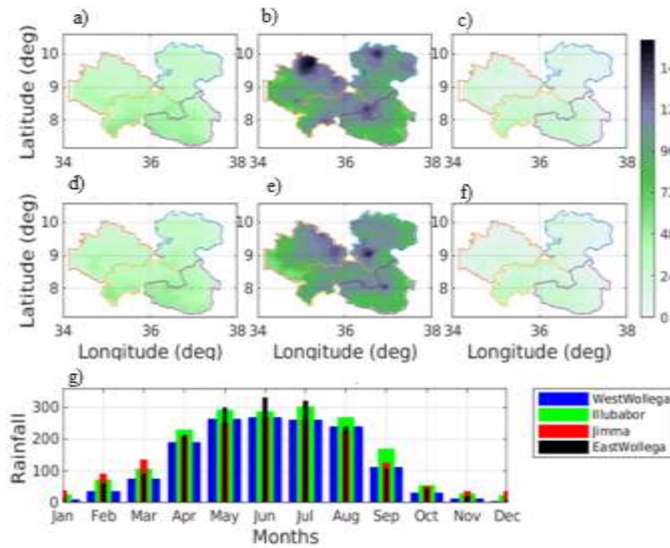

Figure-1: Seasonal distributions (a = Belg guage, b = Kiremt guage, c = bega guage, d = belg chrips, e = Kiremt chrips, f = bega chrips and f = Mean monthly pattern of rainfall over western Oromia (1985-2016).

Spatial variability of onset, cessation and Number of Rainy Days in rainy seasons: Onset and cessation of the rainy season is linked to the north and southward migration of the Inter Tropical Convergence Zone (ITCZ). It determine the time of the planting, harvesting, and post harvesting activities. In Figure-3 it is shown that how the mean onset and cessation date varied over region. The early onset of rainfall occurred over Jimma zones in the 3rd dekade of March and lately over the north (East & West Wellega) in the 1st dekade of May following the northward propagation of ITCZ. High spatial variability of mean onset date of rainfall was observed. Therefore, sowing and planting before 3rd dekade of March over the most parts of Jimma zone (Chira, Jimmaand L/Genet), before 1st dekade of April over the most parts of Ilubabor (Gore nad Bedele) and before 3rd dekade of April is possible over the most parts of East and west Wollega are possible in the Belg season. On the other hand, the rainy season retreats earlier over the most parts of East (Shambu, Nekemt and Arjo) and West wollega (Ayira, Dembidolo and Ghimbi) before the first dekade of November and lately in the 3rd decade of November over the east and west of jimma and south of Illubabor zones (Figure-3 and 4). Farm operations and decisions related to harvesting, transporting and storage or marketing could be adjusted accordingly.

Standard Precipitation Index (SPI) and frequency of its categories: The SPI is computed over multiple time scales ranging from 3 to 12 months that reflect the soil moisture conditions (SPI-3) or the underground waters, river flows and lake water levels (SPI-12). SPI on shorter (3 & 6 months) can be tailored to drought events affecting agriculture while longer ones (9 & 12 months) are more related to water resource management. Figures-6a-d shows the wet and dry condition for different time scales in different location. The worst drought years of 1985, 1986 and 1988 in the study area show severe to extremely dry conditions for all time scales over West Wellega parts of the region. The maximum dry conditions of SPI-3 -2.77(1995) and -2.07 (2008) were seen in Jimma in and - 2.05 (1990) in East wellega. From this, we concluded that there was no intense dry condition that affects agricultural production in the period of study in the region. The SPI 12-month time scale shows that there were near normal to very wet conditions for most of the study period. Figure-6 indicates that generally, all stations experience more near normal moisture conditions (from 26 to 32 times) than other condition categories for all SPI time scales in 36 years events.

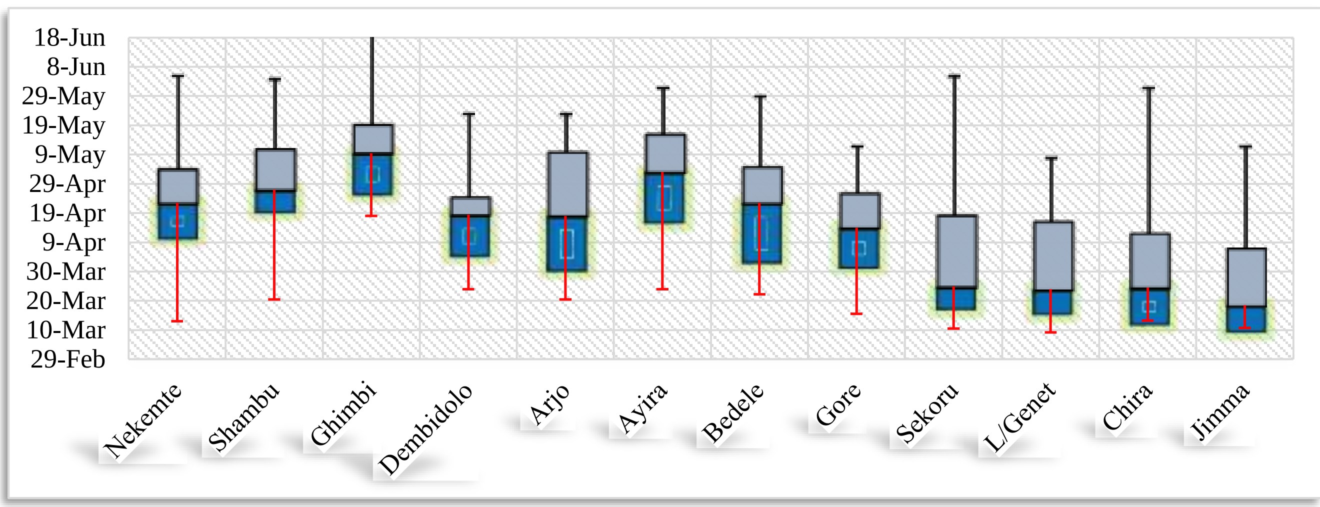

Figure-2: Onset of rainy season over Western Oromia (1985-2016); Solid bar: 25th-75th percentiles; Median: 50th percentiles and whiskers: 10th /90th percentiles.

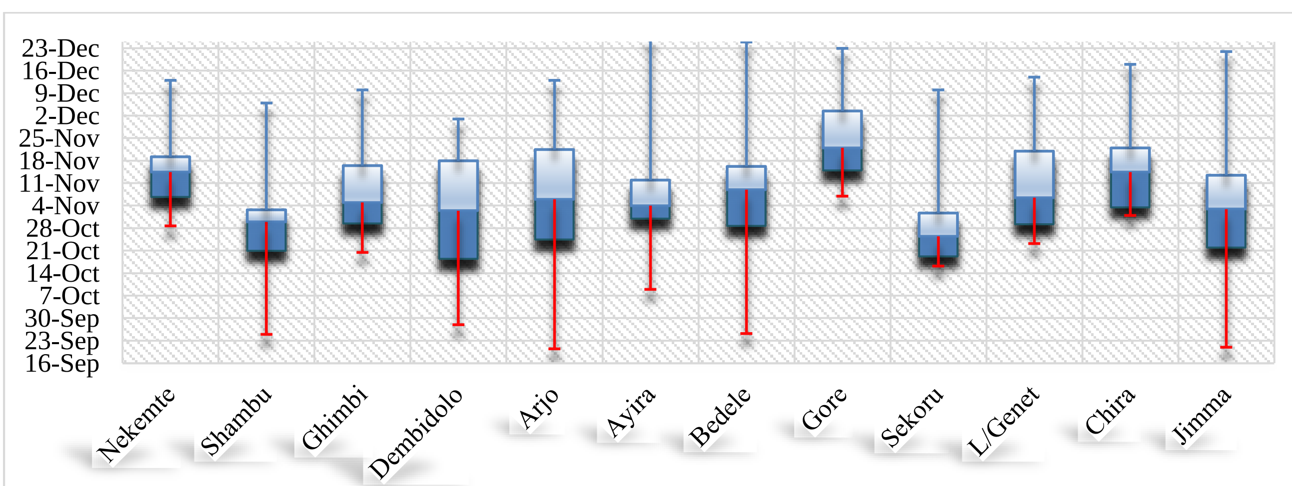

Figure-3: Cessation of rainy season over Western Oromia (1985-2016); Solid bar: 25th-75th percentiles; Median: 50th percentiles and whiskers: 10th /90th percentiles.

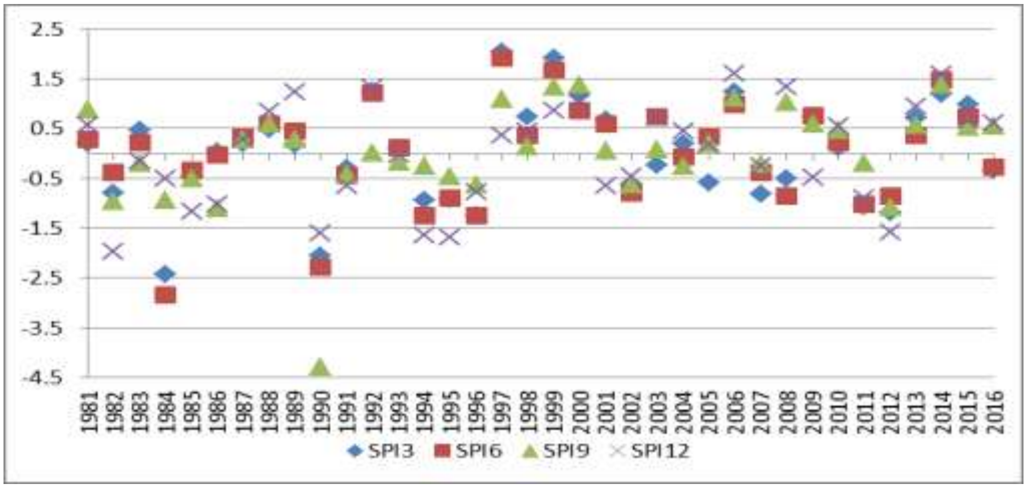

Figure-4a: Moisture conditions of East Wollega (Ghimbi) expressed by the multiple time scales SPI for 36 hydrological years.

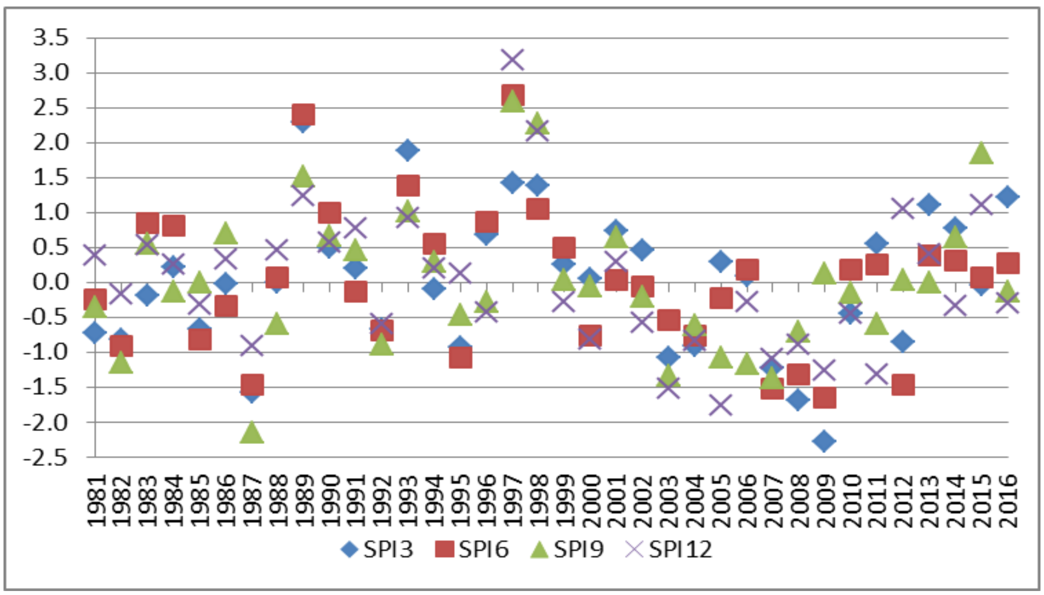

Figure-4b: Moisture conditions of Illubabor (Gore) expressed by the multiple time scales SPI for 36 hydrological years.

Figure-4c: Moisture conditions of Jimma expressed by the multiple time scales SPI for 36 hydrological years.

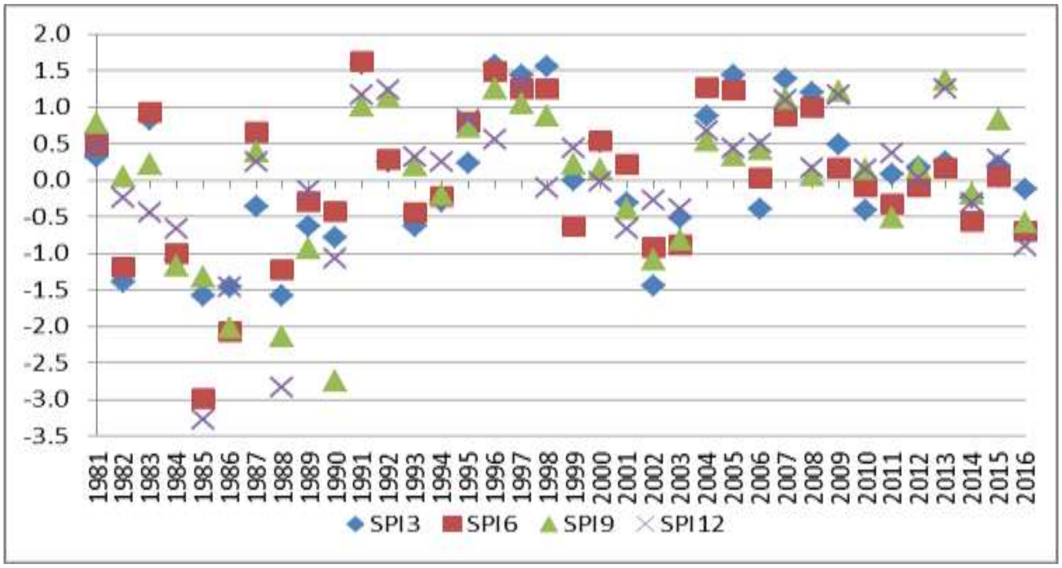

Figure-4d: Moisture conditions of West Wollega (Nekent) expressed by the multiple time scales SPI for 36 hydrological years.

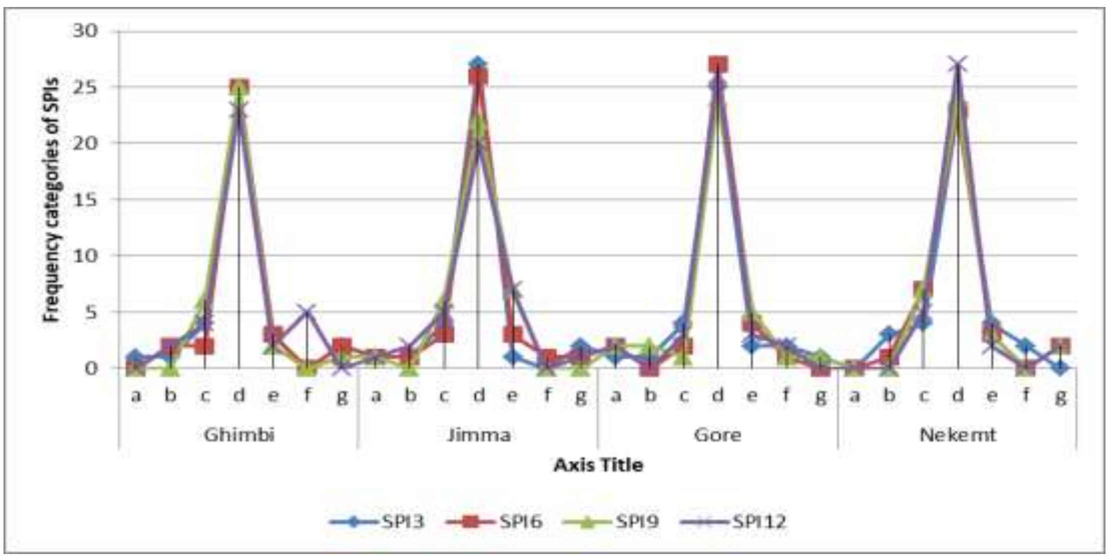

Figure-5: SPI categories of frequency: a=extreme wet, b=severe wet, c=moderate wet, d= near normal, e= moderate dry, f= severe dry, g= extreme dry.

Analysis of the frequency of SPI categories provides evidence that most of the near normal events have been concentrated with some districts experience of the moderately wet and moderately dry conditions in the western parts of Oromia over the period 1985-2016 (Figure-6). The analysis confirmed that the region is suitable for rain-fed agriculture where the risk of drought shocks is less[2,3].

Conclusion

Based on statistical methods analysis, the study area has experienced variable seasonal spatial rainfall distribution, onset, and cessation of rainfall and standardized precipitation index as moisture conditions indicator. The findings of this study have important for understanding local scale rainfall climate of Western Oromia in monitoring and planning for adapt and prevent potential negative impacts of rainfall variability due to climate change, and also are supporting and valuable for hydrological and rain fed agricultural operational activities in the area. Additional studies are recommended to be done to other rainfall characteristics special related to variations of extreme rainfall and other climate indices for this region.

Acknowledgment

The authors would like to acknowledge NMA of Ethiopia, Western Meteorological Service Center for providing climate data and Mr. Gemechu Raga for his technical support in the time of study.

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