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Research Article

Climate Profile over Jeldu Woreda of West Shewa Zone, Oromia, Ethiopia

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Abstract

Identifying the climate profile of an area is essential for effective water resource management, agricultural planning and disaster preparedness. This study focuses on characterizing rainfall patterns and identifying the variability of Jeldu woreda in Oromia, Ethiopia. Previously and recently, little study tried to show the woreda profile, which did not bases on station data properly. Forty years (1981-2020) of stations' rainfall and temperature data were utilized. The study area had natural forest, highland and mid land with varying topography. Based on the annual rainfall cycle, the woreda had bi-modal rainfall types, with the peak of the year being July. Statistical methods and python script were applied to identify the climate profile. The results show that main rainy seasonal rainfall starts on average from 12-14 June and ceases averagely around 10-15 October. During second rainy period, the rain starts from 25 February to 10 March. The mean annual rainfall of woreda is 1395.1 mm, and the average maximum temperature is 19.5 °. Kiremt contributes the highest percent, which is more than 64 % of the annual total rainfall. The 1987 and 2015 were the driest years, and 1996 and 2010 is the wettest during kiremt, 1987 and 2010 the wettest, and 1999 and 2015 the driest during Belg. Seasonal rainfall had a regular to moderate precipitation concentration over woreda. Identifying the causes of unseasonal rainfall that happened during dry season over the study area can help to decrease weather hazard during the season.

Keywords

Woreda, Climate Profile, Characterizing, Rainy Season

1. Introduction

1.1. Background

Delineating Climate profile is important in describing the climate of an area for identifying the characteristics of rainy and dry period. Characterizing rainy period can play great role in socio-economic activities of community in which dry and wet seasons, rainfall variability, irregularity and regularity in amount and distribution explained [1]. Here this study intended to describe the climate profile of Jeldu Woreda in West Shewa Zone, Oromia, Ethiopia.

Jeldu is one of the district (woreda) in the Oromia region of Ethiopia. Geographically bordered, on the south by Dendi, on

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the southwest by Ilfeta, on the north by Abuna Ginda Beret, on the northeast by Meta Robi, and on the southeast by Ejere. Towns in Jeldu are: Gojo, Osole, Shukute and Boni. Jeldu Woreda is located at 9°32’0” to 9°8’ 0”E longitudes and 37° 53’0” to 38°18’0 0” N latitude. It is approximately located 115 km west of Addis Ababa in West Shewa Zone of Oromia regional state. It has an elevation range of 1358-3051 masl (Figure 1). The total population of the Woreda is 202,655 (out of which 102,796 are female and 99,859 are males). The average household size is 7 persons in the Woreda. The Woreda has total area of 139, 389 ha with variable agro ecology of high lands (45%), midlands (30%) and lowlands (25%). According to the key informants, average land holding in the Woreda is 2 ha per household. The Woreda has a bi-modal rainfall pattern where the second rainy period starts on average from February 25-10 March. It receives the short rain ‘Belg’ rains between March and April that helps land preparation, planting of maize, sorghum and potato planting. The main rainy season starts from 12-14 June and continues up to first dekade of October during the main cropping is done. The topography feature of area includes mountain (hill area), rugged terrain and the other. Different soil types that includes black, brown grey, red and other (Jeldu woreda land administrative office in 2008). Land degradation affected the study areas in the history [2]. The climate of the study area characterized by high rainfall over high altitude and low over lower altitude.

Two rainy season is observed over the study where Kiremt (main rainy season) and Belg (second rainy) season. The annual mean rainfall is 1395.1 mm. The extreme daily maximum rainfall within 24 hour of the woreda is 62.8 mm during August 1990. The highest maximum temperature recorded was 28.3℃ during May 2015 and the lowest minimum temperature is 1℃ during January 2016. The land use pattern is summarized in Table 1.

Table 1. *Land use classification of Jeldu Woreda.*

Land use type	Area (ha)	Proportion (%)
Arable land	60,457	43.4
Grazing land	21,350	15.3
Forest land	5,400	3.9

Others (barren degraded lands, buildings, graveyards, roads, etc) 5,218,237.4 (Source: Jeldu Woreda Office of Agriculture and Rural Development Crop Production). Characterizing rainfall and climate profile benefits local users the reliable information on seasonal rainfall characteristics and variability [3]. This study intended to provide up to date and representative climate information during rainy period for the Woreda.

1.2. Objective

1.2.1. General Objective

The main objective of this study is to describe climate profile of the Jeldu Woreda.

1.2.2. Specific Objectives

The specific objectives of this study are:

1. To characterize seasonal rainfall in terms of onset date and cessation of Jeldu Woreda
2. To identify the variability of the study area

1.2.3. Research Questions

This study aims to answer the following questions:

1. What are the recent characteristics of the seasonal rainfall over Jeldu Woreda?
2. What is the seasonal rainfall variability status of the study area?

1.2.4. Significance of the Study

This study provided relevant climate charactertics options that best suit for both rainy seasons and support agriculture and other sectors activities and planning.

The study effectively addressed the ambiguity surrounding the most recent seasonal onset and cessation that end users and agricultural professionals confronted with in woreda.

1.2.5. Scope

The spatial scope of the research covers only the Jeldu Woreda in the central Oromia. This study was limited to identify climate profile by characterizing Belg and Kiremt seasonal rainfall and evaluated the variability of the rainy seasons.

2. Materials and Methods

2.1. Study Area Description

Jeldu Woreda is an area found in the Abay River Basin encompassing Highlands, mid-land, plains, and lowlands, and its absolute location lies between 9°32’0” to 9°8’ 0”E longitudes and 37°53’0” to 38°18’0 0” N latitude, including different kebele with altitudes ranging from 1358 m to 3051 m above mean sea level (amsl) (Figure 1). The administrative center of the Jeldu woreda is nearly 40 km from Ambo town and about 115 km west of Addis Ababa. The woreda covers about 488861.3 hectares, or 48886.1 km^2, of the total area. Out of this, about 77.1% is middle-elevated land and 22.9% is low-elevated land. The topography features of the area include mountains (hills), rugged terrain, and others. Different soil types include black, brown, grey, red, and others (Jeldu Woreda Land Administrative Office, 2008). The climate of the study area is characterized by high rainfall at high altitudes and low rainfall at lower altitudes. Two rainy season is observed over the study. Kiremt (main rainy season) and Belg (second rainy) season. The annual mean rainfall is 1395.1 mm. The extreme maximum with in 24 hour rainfall of the woreda is 62.8 mm during August 1990. The highest maximum temperature recorded was 28.3℃ during May 2015 and the lowest minimum temperature is 1℃ during January 2016.

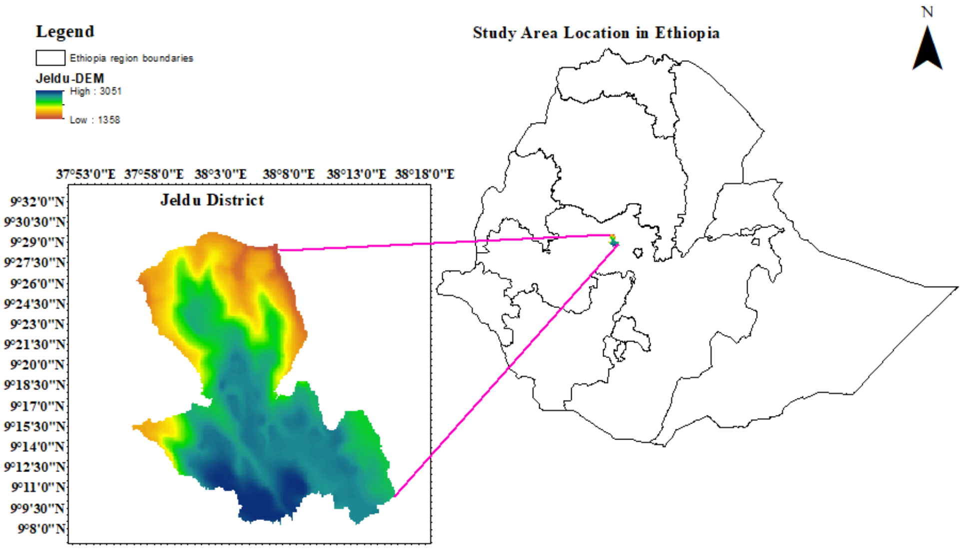


***Figure 1**. Location and topography of Jeldu Woreda.*

2.2. Data Types and Sources

Observed rain gauge daily rainfall from 1981-2020 was collected from EMI. Gridded data was used to fill in any missing data [4]. Homogeneity and availability testing were evaluated the quality of the data.

2.3. Data Quality Control

In this part data quality were tested and checked using data availability, outliers detecting and homogeneity test methods. Here data availability carried out to check the availability of the data used in the analysis in percent as shown below in figure 3. Homogeneity test done to detect the variation in a data set caused by non-climatic factors such as stations changes in instrumentations, surrounding, instrument inaccuracies, observational and calculation procedures [5]. The standard normal homogeneity test which was applied by Alexanderson and Moberg (1997) used in this study.

2.4. Methods

2.4.1. Characterizing Season

This study was conducted to characterized and evaluate variability of Belg and Kiremt seasonal rainfall. To characterize seasonal rainfall, various methods were required in calculating rainfall amount and timing [6]. Rainy days are determined when daily measured rainfall exceed 0.1 mm per day [7]. There are number of respective methodologies applied for determining rain-fall onset, cessation, LGP, dry/wet years, number of rainy days (NRDY), coefficient of variation (CV), standard deviation (SDV), and standardized anomaly index (SAI). Each approach is listed and described as follows and more description is on the paper. Onset date determined when the first days of the year's first wet-spell of at least three days totaling 20 mm or more, provided there were no sequences of eight or more dry (<0.1 mm) days in the subsequent 30 days. Cessation is defined as the first day of a dry-spell (<0.1 mm/day) of at least 20 days duration that occurred after onset. Nevertheless, to avoid false cessation, if rain occurs on more than 2 days in a 30-days period after an extended dry-spell, the search for a cessation date advanced so that a date satisfying the above criterion is determined from the last day of the dry-spell.

LGP defined by the length and cessation of rainy days or duration from onset up to cessation. As the study indicated [8], it is calculated as the cessation date minus the onset date plus one: LGP = Cessation - Onset + 1.

2.4.2. Rainfall Variability Index (RVI)

It is important to identify the mean rainfall, coefficients of variation (CV), standard deviation of rainfall (SDV), wet years, dry years and number of rainy days (NRDY).

$$\text{NRDY}= \sum_{n=1}^{31}(X_i) \quad (1)$$

Where X_i > 0.1 mm represent daily rainfall value and n number of days

Standard Deviation: $SDV=\sqrt{\frac{\sum(X_i-\bar{X})^2}{n-1}}$ (2)

Where X_i > 0.1 mm represents daily rainfall value, $\bar{X}$ is mean rainfall, n number of days

CV is used to assess the variability of seasonal and annual rainfall data. A higher value of CV shows a larger variability of the rainfall time - series data, and was computed using the following formula

$$CV = \left(\frac{\sigma}{\bar{x}}\right) * 100 \quad (3)$$

Where, σ is the standardized deviation and $\bar{x}$ is the average rainfall data. Commonly, the values of CV were classified as; less (CV<20%), moderate (20%<CV<30%), high (CV>30%) and very high (CV> 40%) [9].

Standardized anomaly index (SAI) is one method for rainfall variability assessment and is used to examine the nature of the trends, and to determine the dry and wet years in the records [10]. SAI can be computed as follows:

$$SAI= \frac{X-\mu}{\sigma} \quad (4)$$

Where, X is the seasonal rainfall; μ is the mean seasonal rainfall for observation, and σ is the standard deviation of seasonal rainfall throughout the observation. The negative value of SAI in equation (4) indicates a drought period as compared to the chosen reference period while the positive ones indicate a wet situation. According to [11], SAI value classification is extremely wet (SAI >2), very wet (1.9> SAI >1.5), moderately wet (1.49< SAI >1.0), near normal (0.99> SAI >-0.99), moderately dry (-1.0> SAI >-1.49), severely dry (-1.5> SAI >-1.99), extremely dry (SAI <-2). Precipitation Concentration Index (PCI applied to evaluate the seasonality of rainfall and it is an index used to indicate the distribution of monthly and seasonal rainfall data and can be used as an indicator of floods and droughts. PCI will be computed as the following formulas indicated as below equation (5) [12-14]:

$$PCI_{season}= \frac{\sum_{i=1}^{4} p_i^2}{\left(\sum_{i=1}^{4} P_i\right)^2} * 25 \quad (5)$$

Where, P_i is the monthly rainfall amount in i^{th} month.

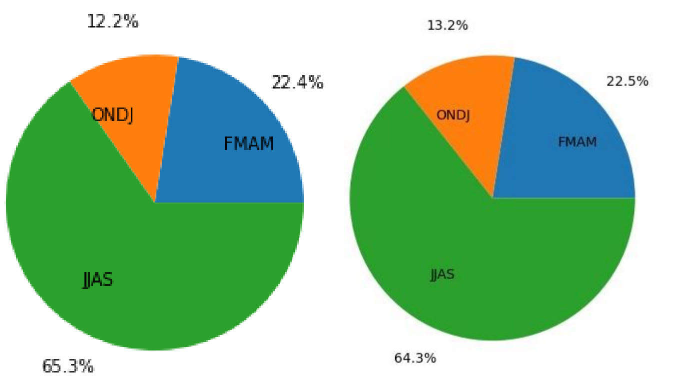
3. Result and Discussion

This discussion focuses on the interpretations derived from the results of analyses conducted using various methods in the study. An interpretation provided for the results based on the statistical analysis. Characteristics such as number of rainy days, seasonal rainfall onset, cessation and LGP as well as SDV, SAI, PCI, and CV were identified for study area using Python script and Geographical Information Systems (GIS).

3.1. Characterizing the Season

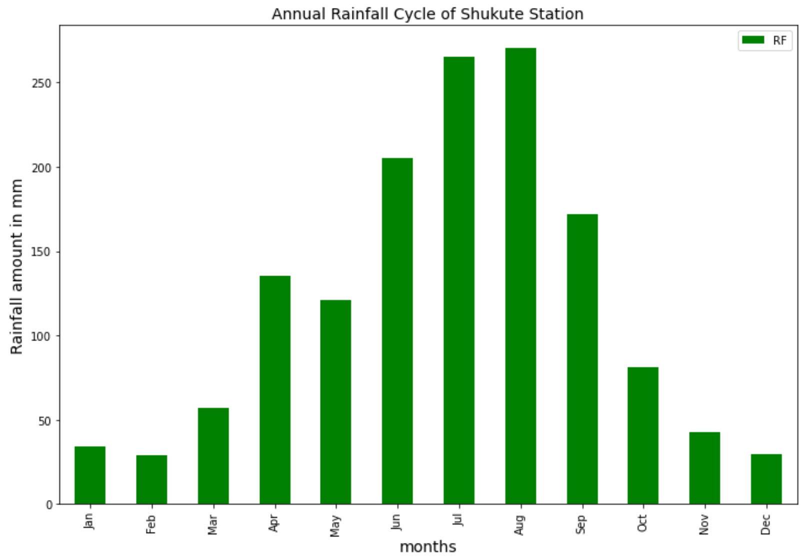
The peak of the rainy days is up to 94 days during the main rainy period at Shukute station and 41 during the second rainy period. For Jeldu station, the peak of rainy days is up to 98 days and 51 during the main season and second rainy period, respectively. The seasonal rainfall contribution to the annual rainfall of the woreda is 65.3% during JJAS, 22.4% during FMAM, and 12.2% during ONDJ at Shukute station. It had little difference over Jeldu Station, where JJAS had 64.3%, 22.5% FMAM, and 13.2% ONDJ had seasonal rainfall contributions for the annual rainfall amount observed over the woreda (Figure 2). The season had bi-modal rainfall, with August being the peak for Shukute station and July being the peak of the year at Jeldu station. April is the peak of the second rainy season at both stations. January and December are the dry months when harvest mainly takes place over woreda.

The onset of the main rainy season (Kiremt) over Woreda begins averagely around 12-14 June whereas the cessation is averagely on 10-15 October. The LGP over the woreda is averagely ranging from 105 to 112 days. During the second rainy season (Belg) the season starts with average from 25 February to 10 March and ceases at mid-of May third dekade. The LGP is averagely ranging from 77 to 88 days.



(a) (b)

Figure 2. *Shukute (a) and Jeldu (b) Station seasonal Rainfall Contribution.*



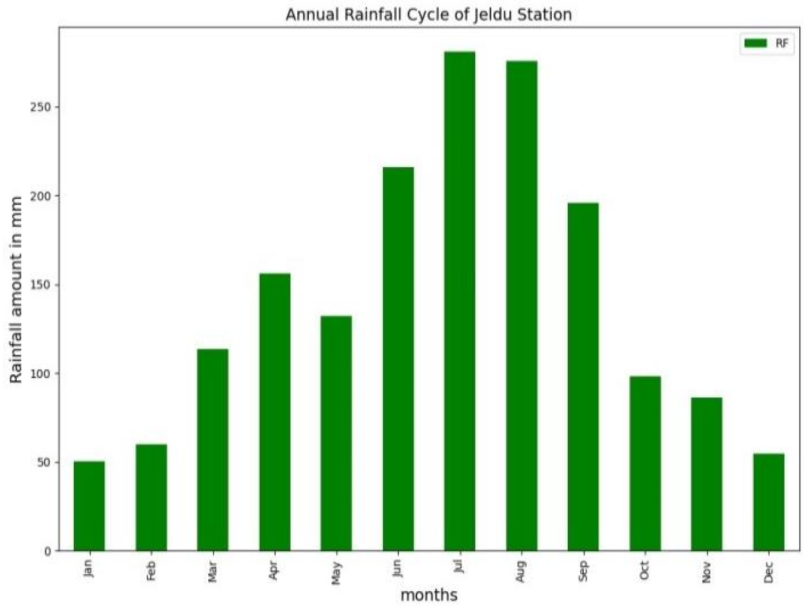


Figure 3. *Annual Rainfall Cycle over Woreda.*

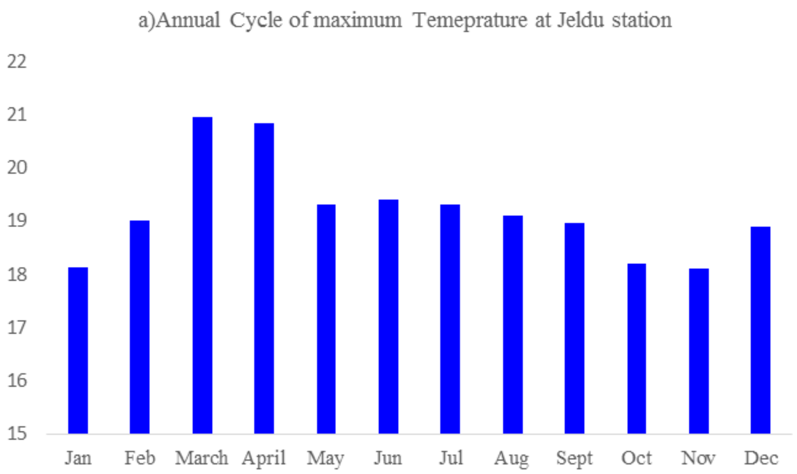


Figure 4. *Temperature Annual Cycle over Woreda.*

3.2. Rainfall Variability Index (RVI)

Seasonally, the rainfall SDV varies over the woreda between the main and second rainy period. The rainfall value in average varied from 143.9-154.8 mm in the Kiremt and 118.5-124.6 mm in the Belg. Coefficient of variation is relatively less over Jeldu but moderately varies over Shukute and from the graph of CV Kiremt had less CV value than Belg (Figure 4).

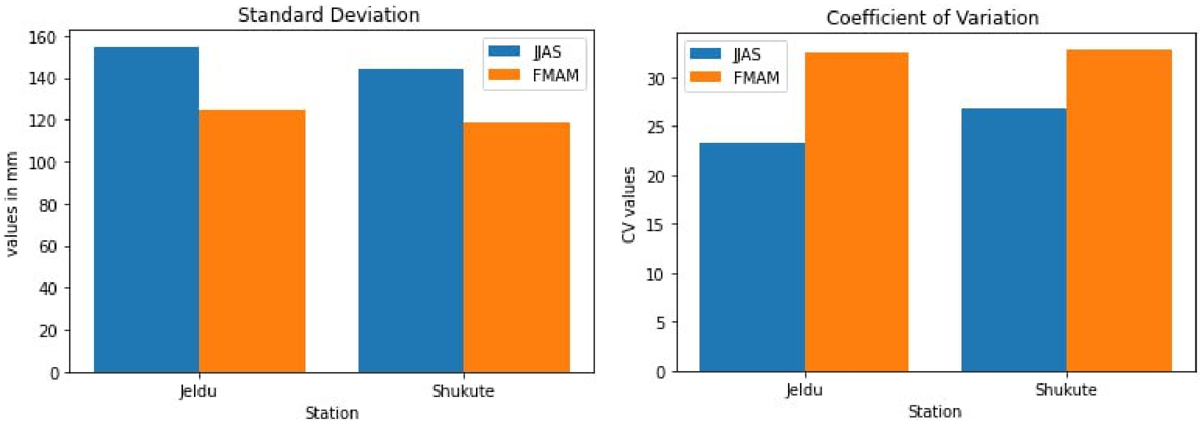


***Figure 5**. SDV and CV over Jeldu woreda.*

3.3. Standardized Anomaly Index (SAI)

Season-based SAI analyses result indicates that over the woreda extreme rainfall years and seasonal rainfall variation observed. During Kiremt season, 1996, 2006, 2008, 2010 and 2020 were the wettest while 1987, 1997, 2002 and 2015 were the driest year. During Belg season 2012, 2015, 2017 and 1999 were driest and 1987, 1993, 1996, 2010 and 2005 were wettest. From the study, it was found that extreme dry years frequently observed in the recent decades, and the study area more exposed to dryness in Belg than Kiremt (Figure 6a & b). In contrast to this, the wet years experienced in the past than recent years and for both rainy period the last decade dominated by dryness rather than wetness. Therefore, the SAI of the district indicates annual rainfall variation observed in the two rainy seasons (Belg and Kiremt).

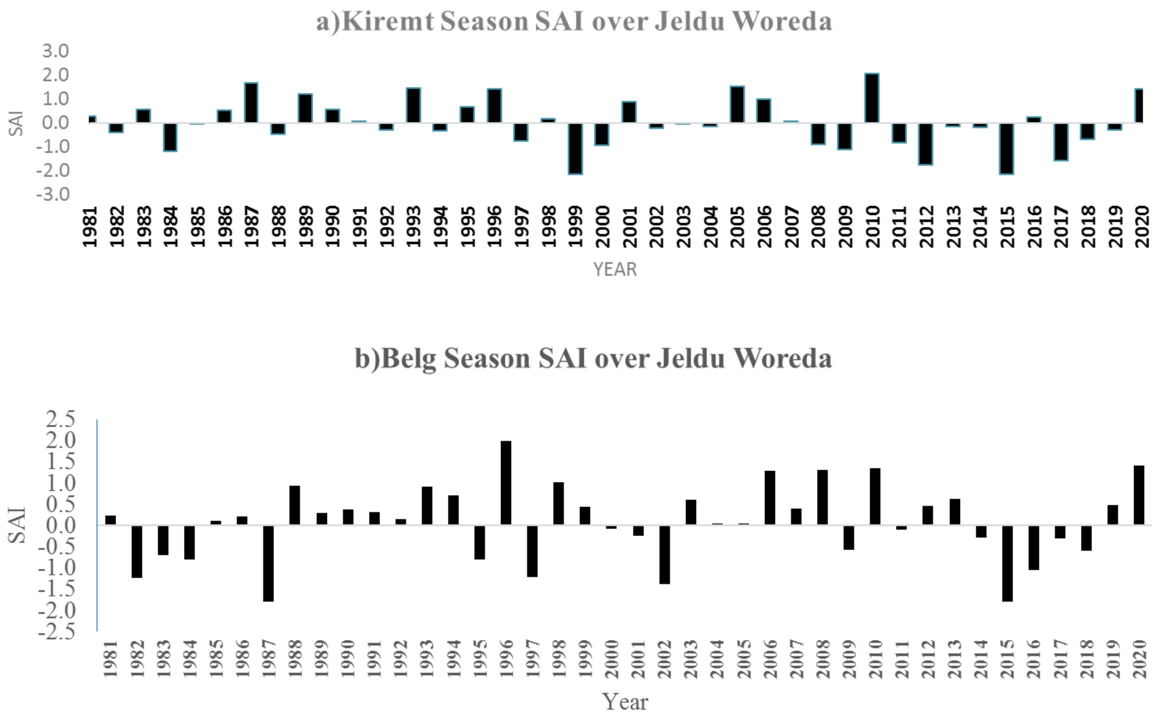


***Figure 6**. Standardized Anomaly Index (SAI) over Jeldu Woreda.*

3.4. Precipitation Concentration Index (PCI)

In the woreda, the seasonal rainfall analysis identify the regularity of seasonal rainfall based on stations data. From the analyzed result, the value of PCI <10 and < 14 Figure 7. As defined by Oliver (1980) cited by (De Luis et al., 2011; Zhang et al., 2019) PCI values less than 10 represent a uniform precipitation distribution (i.e low precipitation concentration). PCI value from 11 to 15 denote a moderate precipitation concentration and the PCI values 16 to 20 denote irregular precipitation concentration, and the values above 20 represent strong irregularity (i.e., high precipitation concentration). From this study finding the value of PCI at Jeldu and Shukute during JJAS shown that regularly distributed seasonal rainfall observed, whereas during FMAM moderately concentrated rainfall observed Figure 7.

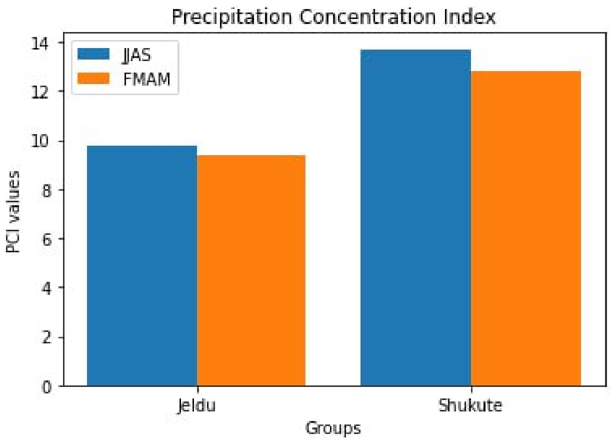


Figure 7. *Seasonal PCI over Jeldu woreda.*

4. Conclusions and Recommendations

Jeldu woreda had different topography, ecology, natural resource and with moderately varying climate. There is an emerging interest to identify the climate of woreda based on the meteorological data that shown the climate of information with the annual and seasonal basis for the purpose of socio-economic and agricultural planning, hydrological advisory. This study planned to identify the climate profile of the woreda. The goal of the study is to update the recent rainfall charactertics and evaluate variability. The Seasonal rainfall characterized and variability evaluated identified using different statistical methods. The study findings revealed significant differences in seasonal rainfall patterns within the study area, with distinct variations between the main and second rainy seasons.

Findings indicated that the number of rainy days, onset dates, and cessation dates, and length of growing period had a little beat vary. The season starts in average around 12-14 June during JJAS whereas it ceases 10-15 October. The LGP over the woreda is averagely ranging from 105 to 112 days. During FMAM, the rain starts in average from 25 February to 10 March and ceases at mid-of May third dekade. The LGP is averagely ranging from 77 to 88 days.

The variability in rainfall pronounced during the Belg season compared to Kiremt. The CV of seasonal rainfall values is moderate. SAI indicates extreme dryness frequently observed in recent years, Belg season more exposed to dry, and wet years experienced in the past years. The PCI value results indicate regular to moderate rainfall distribution in kiremt, but irregularity was observed in Belg over the study area. Utilizing of this climate profile for agricultural planning, and hydrological advisory services can be highly beneficial. It is recommended to integrate this into actionable strategies and policies. This information should be disseminated to relevant organizations involved in agricultural advisory services, water resource management, and public health sectors. A future study focusing on dry season charactertics is recommended to show the dry period rainfall and climate status.

Abbreviations

CDT	Climate Data Tool
CV	Coefficient of Variation
DEM	Digital Elevation Model
EMI	Ethiopian Meteorology Institute
ENACTS	Enhancing National Climate Services
ENSO	El Niño Southern-Oscillation
FAO	Food and Agriculture Organization
FMAM	February March April May
JJAS	June July August September
LGP	Length of growing Period
NMSA	National Meteorological Service Agency
NRDY	Number of Rainy Days
ONDJ	October November December January
PCI	Precipitation Concentration Index
RF	Rain Fall
RVI	Rainfall Variability Index
SAI	Standard Anomaly Index
SDV	Standard Deviation

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Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Abdisa Hirko Wami: Assistance researcher at Ethiopian Meteorology Institute. Completed BSc. & MSc. in Meteorology Science at Arba Minch University of Water Technology Institute in Ethiopia. Had experience on weather forecasting. Works as Aeronautical Meteorology Forecaster at Bole International Airport under Aviation Meteorology. Joined East and Central Oromia Meteorology Service Centre as forecaster. Currently working as Assistance researcher and also acting as Lead Executive Officer. On different title, two own and seven group paper published. Plan to do research on weather forecast to improve the forecasting skill.