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Characterization of Rainfall Indices for Crop Production in Kersa District, Eastern Ethiopia: Farmers' Advisory

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The study was conducted in Kersa district, eastern Ethiopia to characterize the rainfall indices for crop production. Thirty four years of rainfall data were collected from National Meteorological Agency of Ethiopia. INSTAT+v 3.37 software was employed to analyze the data. Whereas, Mann-Kendall trend test was used to determine the trend of rainfall in the area. The results indicated that Kersa district received 869 mm/year over the last three decades; of this, Kiremt season contributed 58% and Belg season contributed 30.5%. The onset of Kiremt and Belg season rainfall was on average 175 Days of the Year (DOY) and 94 DOY, respectively. Kiremt season ceases at 282 DOY, and Belg season ceases at 170 DOY. Length of growing period for Kiremt season ranges from 18 to 151 days, with high CV value of 29%. The annual and seasonal rainfall showed a decreasing trend as per the Mann-Kendall trend test, though not statistically significant. The decrement for annual, Kiremt, and Belg season rainfall was estimated to be 10, 7, and 3 mm/yr, respectively. The district was mostly under a dry period as per anomaly index. Overall, characterization of rainfall plays a key role to improve the farmer's livelihood through awareness creation. The study encourages other similar studies to be conducted on temperature.

Key words: characterization, Rainfall indices, Seasons, Farmers advisory

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INTRODUCTION

Climatic risks threaten lives and prosperity across many parts of Africa, and there are clear signs that the impacts of climate change are already being felt. The health, livelihoods and food security of people in Africa have been affected by climate change (IPCC, 2014). People who are socially, economically, culturally, politically, institutionally or otherwise marginalized in society are often highly vulnerable to climate change induced risks (IPCC, 2014).

In Ethiopia, it has been recognized via historical climate data analysis that there was a rapid climate change with adverse effects on every lives and activities in the environment. Rainfall in the country was highly variable, both temporally and spatially, unpredictability with no apparent trend over the country, yet the country has experienced both dry and wet periods (Mamo, 2005; NMA, 2007). Agriculture which is a key in the economy of the country is mainly depending on the rainfall (Gray and Saddoff, 2005; Gebreegziabher et al., 2011). Shortage of water could lead to limit the opportunities to maintain or extended the cultivated agricultural lands through the use of irrigation which only accounts 5% in the country

(Awulachew et al., 2010).

For this purpose, natural rainfall plays a key role as a source of water for crop production and other purposes. Deformations of rainfall pattern would limit crop productions and this would bring untold, physical and socio-economic hardships for the farmers. A number of studies (Osman and Sauerborn, 2002; Hagos et al., 2009) reported rainfall variability poses challenges to agricultural production, reduced by 20% and rises up the poverty level up to 25%. Therefore, the success of agricultural production in the country is measured with the amount of rainfall received. Furthermore, FAO (2008) opined that reduction and inavaliabily good quality water for crop at certain times of the year will negatively affect food supplies. The IPCC stresses the importance of integrating adaptation and mitigation strategies into long term development planning (IP CC, 2014).

It is, therefore, essential to assess rainfall pattern over Kersa district so as to create awareness among the farmers to enable them to react against the rainfall driven headaches. Meaning that, it could be translated into best adaptation options according to the development potential and specific challenges under a specific farming zone. Thus, the specific objective of this study was to characterize agriculturally important rainfall indices at site specific level to enhance farmers well recognize about rainfall feature of their area and get ready for the coming rainfall associated risks.

MATERIALS AND METHODS

Description of the Study Area

Kersa district is located at 9.321^0N latitude and 41.917^0 E longitudes at an elevation ranging from 1400-3200 m above sea level. According to a survey of the land in Kersa, 28.5% is arable or cultivable, 2.3% pasture, 6.2% forest, and the remaining 56.3% is considered as a degraded land. Coffee (*Coffee arabica*), *Khat (Catha edulis),* fruits and vegetables are important cash crops in the district.

Data collection and Quality Control

A baseline thirty four years of daily rainfall data were collected from National Meteorological Agency of Ethiopia (NMA). Then prior to any analysis the data were subjected for its quality using the cumulative deviation test (Sahin and Kerem 2010), common in detecting for climatologically time series data (Sahin and Kerem, 2010; Kang and Yusof, 2012).

Research approach

Determination of Onset, Cessation, Length of Growing Period and Number of Rainy Days

For this particular study, a rainfall of 20mm accumulated over three consecutive days after specified date (via informal interview with local farmers) with no dry spell greater than 9 days in the next 30 days was adopted (Stern *et al*., 1982). Therefore, for all seasons of Ethiopia (*kiremt*, *Belg*, and *Bega*) the same criteria were used to determine the rainfall onset. Similarly, the end of the season was defined as the date when the available soil water content drops to 10 mm m^{-1} of available water (Tesfaye and Walker, 2004), whereas, the length of growing period was calculated as the difference between the onset date and date of the end of the season. On the other hand, based on the definition of NMA, a day is considered as a rainy day if it accumulates 1 mm or more rainfall (NMSA, 2001). Thus, for all seasons, same procedures were adopted to determine the number of rainy days for the study area. Collected data were subjected to INSTAT+ $_{3.37}$ statistical software to characterize all the rainfall indices (Stern, 2006). Whereas, Mann-Kendall trend test was used to determine the trends of rainfall in the study area.

RESULTS AND DISCUSSION

Kiremt season rainfall indices

In the study area, kiremt season (JJAS) is found to be the period when much rainfall is received and farmers in this area practices rainfed agriculture. The study revealed that Kiremt (JJAS) season contributed about 58% to the total annual rainfall. Similarly, study indicated that kiremt season was determined to set on average by 175 DOY (06 June) and ceases at 282 DOY (09 October). Beside this, the onset date for kiremt season ranges from 153 to 256 DOY. The length of growing period in the area ranges from 18 to 151 days, with 155 numbers of rainy days (Table). This can support only agricultural activities fitting these days. However, in the district, many other agricultural practices such as production of cash crops, *khat* (*Catha edulis*), coffee (*Coffee arabica*) and perennial fruits like mango, orange, papaya, etc. are common which requires much water. Surprisingly, farmers have already recognized and working against this problem, though they did not have very precise information about the onset and cessation of rainfall and other critical indices of rainfall. Comparing the CV values of kiremt rainfall indices, the order of variability was investigated as: LGP > onset date > cessation date > NRDs (Table 1).

Table 1. Kiremt season rain fall indices for Kersa district for the period 1980-2013

	n	Mean	Min.	Max.	Median	SD (%)	CV
Onset	34	175	153	256	168.5	25.6	14.6
Cessation	34	282	274	314	275.5	12	4.2
LGP	34	107	18	151	115.5	31.3	29.3
NRDs	34	155	153	177	153	4.8	3.1

n, number of observed data; LGP, length of growing period; NRDs, number of rainy days; SD, standard deviation; CV, coefficient of variation in percentage.

Table 2. *Belg* (FMAM) season rain fall indices for Kersa district for period 1980-2013

	n	Mean	Min.	Max.	Median	SD (%)	CV
Onset	34	93.80	32	142	96.5	27.3	27.3
Cessation	34	170.5	152	289	154	37.8	37.8
LGP	34	76.70	21	223	58.0	48.0	48.0
NRDs	34	57.60	32	103	55.5	21.8	21.8

n, number of observed data; LGP, length of growing period; NRDs, number of rainy days; N, number of observation, SD, standard deviation; CV, coefficient of variation in percentage.

Belg season rainfall indices

Analysis of the results of rainfall data indicated that Belg (FMAM) season set on average on 94 DOY (04 April) and ceases at 170 DOY (09 June) over the last three decades (Table 2). This shows the late start of Belg season associated with early cessation, little bit merged to the start of kiremt season. This result agreed with what has been found by IPCC. Belg (FMAM) season contributed about 30.5% to the total annual rainfall in Kersa district. Farmers in area basically use this season for land preparation like, ploughing, hoeing, weeding, so as to enhance the productivity of the land.

This is due to the reason that this season has shorter length of growing period on average 77 days with very high CV value of 48%, which cannot really support any crops to be grown. It has been noted that all the indices of Belg season rainfall was found to be highly variable than kiremt season, comparing the CV values (Table 2).

Bega season rainfall indices

In Ethiopia, Bega (ONDJ) season is known for its insignificant amount of rainfall or known as dry period. In line with this, only about less that 10% was contributed to the total annual rainfall in Kersa district. As indicated in the table 3, the model out couldn't not detect any days with rainfall, the length of growing period was also found to be negative value, showing that the season cannot support any kind of crops to be cultivated (Table 3). Often, the rainfall of this season has been used for grazing lands to grow grasses and drinking water for cattle. Looking in to CV value for Bega season, it is 152%, which characterize the season as extremely variable pattern with insignificant rainfall to be received (Table 3).

Rainfall Trend Analysis

The trends of rainfall for Kersa district has been indicated and discussed hereafter. It has been noticed that over the study area, the annual rainfall ranges between 298 and 2228 mm/yr, this is due to the area is with full of various topographical landscapes ranging from lowland to highlands having different vegetation coverage and other factors. On average the district received about 869 mm/year over the last three decades. However, as per the trend analysis of Mann-Kendall trend test, the rainfall over the district showed a decreasing trend although not statistically significant. The decrement was by (-10.61 mm/yr) (Table 4). Similarly, it could be seen from table 4 that except for Bega season (ONDJ) rainfall where it increases by 0.76 mm/yr, the rest two seasons (Kiremt and Belg) showed a decreasing trend, but not statistically

Table 3. Bega *(ONDJ)* season rain fall indices for Kersa district for period 1980-2013

	n	Mean	Min.	Max.	Median	SD (%)	CV
Onset	34	157.8	0	342	275	152	152
Cessation	34	31	31	31	31	0	-285
LGP	34	-110	-311	31	31	154.6	-254
NRDs	34	-	-	-	-	-	-

n, number of observed data; LGP, length of growing period; NRDs, number of rainy days; SD, standard deviation; CV, coefficient of variation in percentage.

Table 4. Descriptive Statistics and Mann-Kendall trend test of annual and seasonal rainfall for Kersa district

Variable	n	Mean	Min.	Max.	median	SD	CV	ZMK	Slope
Annual RF (mm)	34	869.20	297.80	2228.0	796.00	382	44	-1.60	-10.61
JJAS (mm)	34	506.00	148.40	996.60	494.00	226	45	-1.81	-7.33
FMAM(mm)	34	265.00	40.70	974.00	248.40	167	63	-1.16	-3.04
ONDJ(mm)	34	81.00	9.00	315.00	50.00	73	89	0.70	0.76

n, number of observed data; ZMK is Mann–Kendall trend test, Slope (Sen's slope) is the change (^{0}C)/year; + shows the trend is positive and n = number of data observed, SD, standard deviation; CV, coefficient of variation.

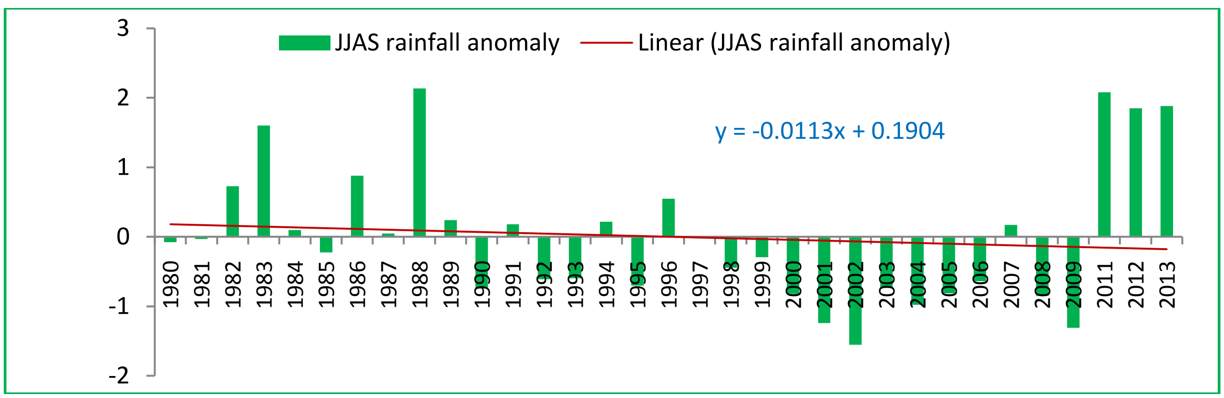

Figure 1. Kiremt season (JJAS) rainfall anomaly

significant. The same result has been reported by NMSA, where annual rainfall in north and eastern Ethiopia showed a decreasing trend, however, there was an increasing trend of annual rainfall in the central part of Ethiopia (NMSA, 2001). Kiremt season which supports much of agricultural activities in Kersa district showed the highest decrement by -7.33 mm/yr compared with the rest two seasons. This implies that the district was highly under the influences of various lengths of dry spells. With this regard, the area is well known for its receipt of food aids from governmental and non-governmental organizations till recent time.

Seasonal Rainfall Anomaly Index

As per the classification of the rainfall anomaly index used by van Rooy (1965), kersa district faced many dry periods. Figure 1 illustrated kiremt season rainfall anomaly, revealing that from 1990-2010; which means for almost a decades, the area was under the dry period though the extent of dryness varies with the years. This leads the area to be highly vulnerable to every climatic shock and dependent on food aids.

In similar fashion, figure 2 shows Belg (FMAM) season rainfall anomaly, with only a certain periods under wet climatic condition over the last three decades. During

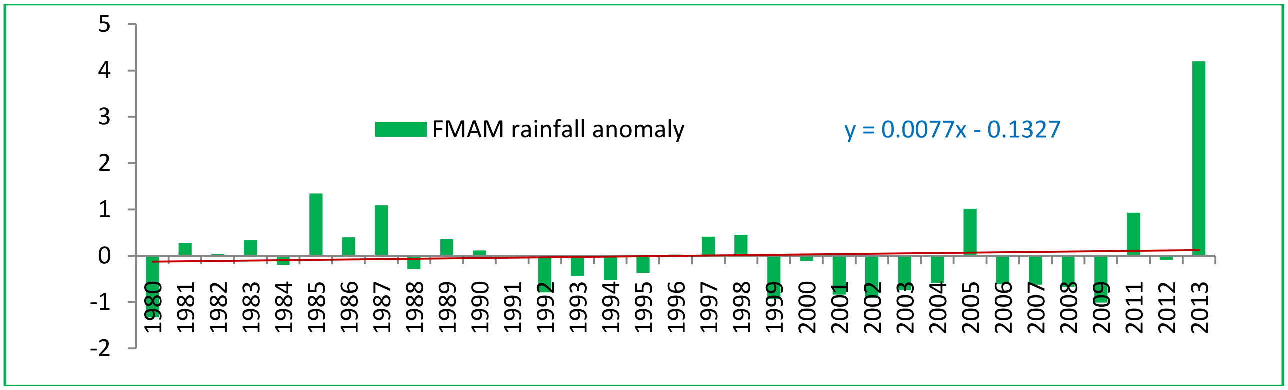

Figure 2. Belg season (FMAM) rainfall anomaly

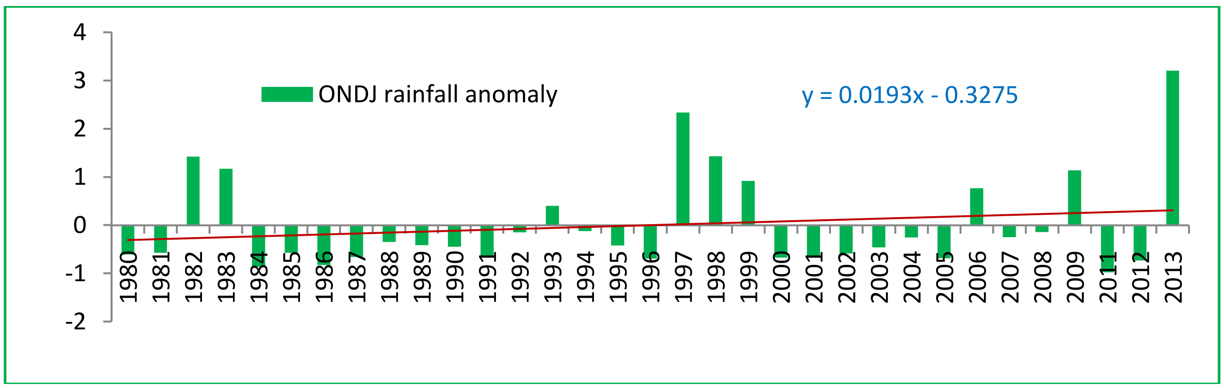

Figure 3. Bega season (ONDJ) rainfall anomaly

2013, the area received much amount of rainfall, about 2228 mm. On the other hand, figure 3 illustrated the Bega season rainfall anomaly, where majority of the years were under dry condition causing the big shortage of water used for agriculture. However, the equation of trend line indicated an increasing pattern.

CONCLUSION AND RECOMMENDATION

To recap, characterization of rainfall indices, onset, cessation, length of growing period and number of rainy days is very important where the livelihood of people depend on agriculture and agriculture in turn depends on rainfall patterns. Therefore, this study attempt to summarize all the indices of rainfall pertinent to agriculture as an information for the farming communities, as they could learn from the past events and adjust themselves against problems coming associated with a changing climate, particularly, rainfall. However, much has to be done by all stakeholders, governmental and non-governmental organizations, experts and others in creating awareness about how to conserve rainfall soon it starts to rain and use it sustainably for agricultural production. Therefore, in this way, farmers could be climate resilient and food secured. Finally, the study encourages other similar *studies to be conducted on temperature.*

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