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Rainfall Trend and Variability Analysis in Borana Pastoral Lowland Areas: The Case of Yabello and Eel-wayye Station, Southern Ethiopia

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Abstract: Dry lands are traditionally used and managed by a pastoralist, characterized by variable precipitation, climate variability and water scarcity. Change in rainfall trend and variability's lead to severe production deficit and decline the balance between pasture and livestock on which pastoral livelihood depends on. The study was undertaken to assess the variability and trends of rainfall in Borana pastoral area using monthly rainfall record for the period 1987-2016 of Yabello and Eel-wayye station. Rainfall variability analysis has been done using variability indices like, coefficient of variation, precipitation concentration index and Standard anomaly index. Trend analysis was carried out using Man-Kendall trend test 5% significance level. The coefficient variation of the study area for Yabello was 21.2%, while for Eel-wayye it was 53% which showed high inter-annual variability. The negative anomalies at Yabello station was 53.3% While in Eel-wayye station, revealed 56%. The analysis result indicted that the rainfall concentration index value ranged from 13.2 to 30.23 for the stations which shows moderate to strong irregularly rainfall distribution. The year 2006 was the most drastic and distinct-wide extreme drought episode in both stations, Except short rainy season at Eel-wayye station, the Mann–Kendal test shows not statistically significant ($P<0.05$). Increasing tendencies of drought during main rainy season and decreasing tendencies of drought during short rainy season and annually were observed in the study area. This threats the livestock production systems, which is the backbone of the pastorals livelihood. The study, suggests policy makers to develop other sustainable water sources for lowlands pastorals.

Keywords: Borana, Rainfall Trend, Variability, Standard Anomaly Index, Precipitation Concentration Index

1. Introduction

Pastoralism is a way of life based primarily on raising livestock, particularly small ruminants, cattle and camels. In the dimension of livelihood, Pastoralism is a predominant livelihood in less favoured landscapes, such as dry lands, mountains and cold areas, where natural pastures are a primary resource [13]. Dry lands are traditionally used and managed by pastoralists, and host nearly one third of the world's human population and about half of the world's livestock [36, 12]. According to the FAO [19], only in 2006 study published by the Food and Agriculture Organization put the number at 120 million, which includes some people who also grow crops (known as ―agro-pastoralists‖). Of these, 50 million are in sub-Saharan Africa, 31 million in the Middle East and North Africa, 25 million in Central Asia, 10 million in South Asia, and five million in South and Central America. The arid and semi-arid zones of sub-Saharan Africa account for 55% of the continent's area and hold 57% of domestic ruminants [43]. The region contains about 25 million pastoralists and 240 million agro-pastoralists that rely on livestock grazing for their livelihoods [37].

Pastoralism contributes significantly to the agricultural gross domestic product (GDP), especially in developing countries e.g. 80% in Sudan, 84% in Niger, 30% in Mongolia, in Ethiopia 35% [15] and on average, 5.9% in Benin, between 1995 and 2005 [32]. Despite this fact pastoralism as a way of life has been affected by droughts, due to different factors in Pastoralist regions, for example by unpredictable droughts and highly variable rainfall [6, 46]. As the result drought bring a serious socio-economic challenge to many Pastoralists and agro pastoralists in the world.

In Borana lowlands there are four locally defined seasons comprising two rainy seasons (long rains − *ganna*, and short rains − *hagayya*) and two dry seasons (long dry season − bona hagayya and the short dry season − *adoolessa*). In normal years, the long rains are received between March and May, and the short rains between September and October. During the two rainy seasons, the onset and cessation of the rains are often irregular, but the *ganna* rains (main rain) season are more reliable than the *hagaya* (short rain) seasons in their amount, temporal and spatial [11, 52]. Livestock production is the main livelihood basis of the Borana pastoralists. Livestock plays a very important role by serving as a social, economic or financial and cultural asset for most pastoral communities [7].

The main source of water for the sector is natural rainfall, so any change in rainfall amount and distribution lead to serious production deficit and undermining the delicate balance between pasture and livestock on which pastoral livelihood depends [17, 24]. Evidences from empirical and theoretical studies come up with the finding that in Borana lowland rainfall is decreasing and becoming more erratic in its distribution and amount [1, 3]. The unpredictable rainfall amount and distribution behaviour has become a restricted access for the livestock production [26]. Berhanu and Beyene [9] also stated that the Zone has on the average experienced a long-term declining trend in mean annual rainfall in the last several decades. The decline of the annual rainfall increases the frequency of the drought especially in the lowlands [25]. This threat Livestock production system, which recurrently erodes the livestock asset before full recovery achieved [2]. So the study therefore aimed to show the current rainfall trend and variability in the study area.

2. Methodology

Rainfall data of 1987 to 2016 were obtained from the National Meteorological Service Agency. Pattern and distribution Mean monthly annual rainfall was calculated. Monthly rainfall concentration also computed based on UNFAO cited in [22].

$$RC = \frac{Actual\ rainfall}{Expected\ rainfall} \text{ x } 100$$

Which RC=Rainfall concentration Desg.=Designation of the rainfall concentration in the months Dry=RC<0.6; Rainy=RC>0.6; BRM=Big rains with moderate concentration where RC=1.0-1.9; BRH=Big rains with high concentration with RC=2.0-2.9.

Coefficient of variation, precipitation concentration index, and Standardized rainfall anomaly index, were used as descriptors of rainfall variability. The rainfall variability for representative meteorological stations was determined by calculating the coefficient of variation (CV) as the ratio of the standard deviation to the mean rainfall in a given period (CV%, when expressed as a percentage) as used by [4, 18, 8].

$$CV = \frac{\delta}{\dot{x}}$$

Where CV=Coefficient of Variations

δ=Standard Deviation

ẋ=Mean

CV<20% indicate low variability, CV between 20% and 30% indicate moderate rainfall variability, CV>30% indicate high, CV>40% very high and CV>70% indicate extremely high inter-annual variability of rainfall as used by [4, 8, 23, 18].

Standardized Anomaly Index was calculated as the difference between the annual total of a particular year and the long term average rainfall records divided by the standard deviation of the long term data. Different authors had used SAI to demonstrate the intensity and frequency of drought at various time scales and reported as helpful to indicate the drought characteristics [10, 4, 35]. According to WMO [48], the characteristic of the SAI have contributed to its popularity for application drought monitoring and also makes possible the determination of the dry and wet years in the record. Its formula is given as:

$$Z = \frac{(X - \mu)}{\delta}$$

Where, *Z* is standardized rainfall anomaly; X is the annual rainfall total of a particular year; μ is mean annual rainfall over a period of observation and δ is the standard deviation of annual rainfall over the period of observation. The value of Standardized anomaly index was categorized according to McKee [33] classification (Table 1).

Table 1. *SAI Value classification table.*

SAI value	Category
2.0+	Extremely wet
1.0 to 1.49	Moderately wet
1.5 to 1.99	Severely wet
-.99 to. 99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and less	Extremely dry

Source McKee (1993).

Precipitation concentration index (PCI) was used to investigate heterogeneity of monthly rainfall [39].

$$PCI = \frac{(\sum_{i-1}^{12} Pi2)}{(\sum_{i-1}^{12} Pi)2} * 100$$

Where, pi is the monthly rainfall in month i. The seasonal scale of Rainfall Concentration Index was calculated using the equation:

$$X = (\sum_{i-1}{}^{pi2}) / (\sum_{i-1} pi)^{2} * 25$$

Annual and seasonal rainfall concentration index according to Oliver’s classification:

i) PCI < 10 indicates uniform rainfall distribution (low rainfall concentration),
ii) PCI > 11 and < 15 indicates moderate rainfall concentration;
iii) PCI >16 and < 20 indicates irregular distribution,
iv) PCI > 20 indicates a strong irregularity (that is, high rainfall concentration) [39].

The main aims of analysis of annual and seasonal Precipitation Concentration Index (PCI) is to characterize spatial and temporal distribution of rainfall, I and PCI value of 16.7 will indicate that the total precipitation concentrated in ½ of the period and a PCI value of 25 will indicate that the total precipitation occurred in 1/3 of the period [31]. Assessing trends and variability in rainfall based on past records helps with better understanding of problem associated with drought, floods and various water use [27]. For the Borana pastoralist whose is life is depending on rainfall its strength their ability to develop the adaptation strategies toward the drought impacts.

The study was employed Mann-Kendall's test for rainfall trend analysis. Mann-Kendall's test checks the hypothesis of no trend versus the alternative hypothesis of the being increasing or decreasing trend [14]. The study of Yue [51], and Viste [45] noted that these tests have to identify trends in time series.

$$S=\sum_{i-1}^{N-1}\ \sum_{J=I+1}^{N} \text{sgn}\ (xj-xi)$$

Where S is the Mann-Kendal's test statistics; xi and xj are the sequential data values of the time series in the years i and j ($j > i$) and N is the length of the time series.

$$\text{Sign}\ (xj - xi) = \begin{cases} +1, \text{if}\ (xj - xi) > 0 \\ 0, \text{if}\ (xj - xi) = 0 \\ -1\ \text{if}\ (xj - xi) < 0 \end{cases}$$

The variance of S, for the situation where there may be ties (that is equal values) in the x values, is given by:

$$\text{Var(S)}=\frac{1}{18}\left[N(N-1)(2N+5) - \sum_{i=1}^{M} t((t_i - 1)(2\,t_i + 5)\ )\right]$$

Where, m is the number of tied groups in the data set and ti is the number of data points in the ith tied group. For n larger than 10, ZMK approximates the standard normal distribution [40, 50] and computed as follows:

$$Z_{MK}=\begin{cases} \frac{S-1}{\sqrt{Var(S)}}\ if\ S > 0 \\ 0\ if\ S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}\ if\ S < 0 \end{cases}$$

The presence of a statistically significant trend is evaluated using the Z_{MK} value. In a two-sided test for trend, the null hypothesis Ho should be accepted if at a given level of significance. Z1-α/2 is the critical value of Z_{MK} from the standard normal table. For example, for 5% significance level, the value of Z1-α/2 is 1.96.

MK test, used by many researchers for trend detection due to its robustness for non-normally distributed data, was applied in this study to assess trends in the time series data [29, 34]. The significance level of the slope was estimated using Sen's method. Sen's slope (Q) estimates methods accounts for seasonality of the precipitation data. This method uses a simple non-parametric procedure developed by sen's [14] to estimate the slope. The nonparametric tests are used to detect trends but don't quantify the size of the trend or change. Hence, magnitude of the observed trend can be estimated with sen's slope estimator when significant [41].

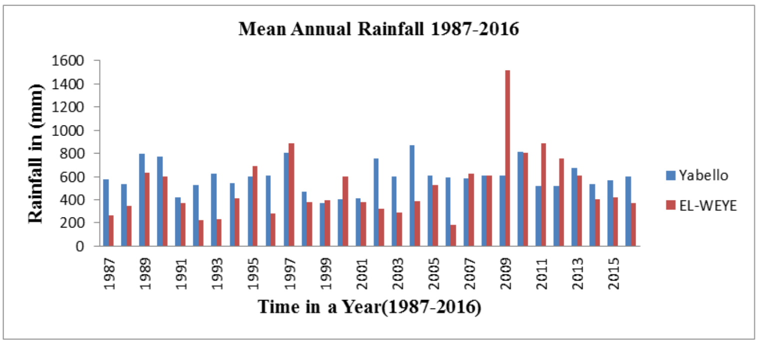
3. Result and Discussion

3.1. Study Area Descriptions

The research was conducted in two districts of Oromia region, Southern Ethiopia (Yabello and Eel-wayye) which is located between the 4°30′55.81″ and 5°24′36.39″ N latitude and the longitude of 37°44′14.70" and 38°36′05.35" E, at about 570 kilometres away from Addis Ababa, the capital of Ethiopia. Altitudes range between 500-1500 and 1,485 meter above mean sea level. The altitudinal ranges give the study area Arid and semi-arid agro ecological zones. The study area comes under the influence of a bi-modal monsoon rainfall type, where 60% of the 300-900mm annual rainfall occurs during March to May (*Ganna*) and 40% between September and october (*Hagaya*) [52]. Pastoralism is a predominant livelihood and the main economic activities in the area.

3.2. Rainfall Pattern and Distribution

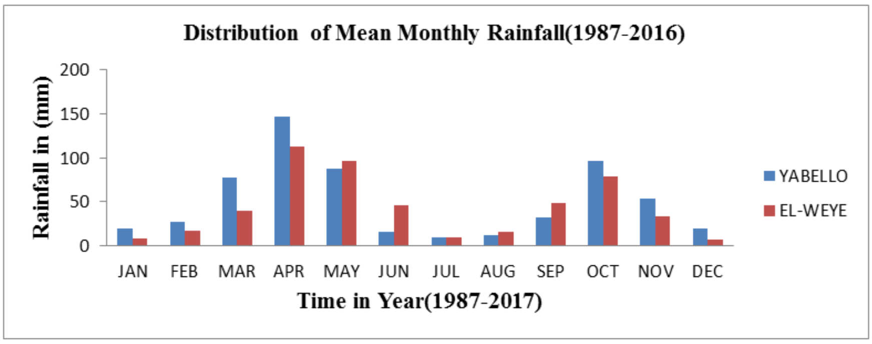
The temporal distributions of mean annual rainfall of the two areas are presented in Figure 1. The total annual rainfall ranges between 372mm (1999) to 873mm (2004) at Yabello station. While in Eel-wayye station ranges from 186mm (2006) to 1514mm (2009). Therefore it can be concluded that both highest and lowest annual rainfall was recorded in Eel-wayye station.



Source; Computed based on data from NMSA.

Figure 1. *Annual Rainfall Patterns.*

The monthly rainfall distribution in past decades 5/12 (MAMSO) months received relatively higher amount of mean monthly rainfall which ranges from 53mm to 146mm at Yabello station and whereas in Eel-wayye station it ranges from 49.5mm to 112.3mm. The monthly pattern of rainfall distribution shows rainfall 7/12 months (JFJJAND) received relatively low amount of mean monthly rainfall in the last three decades Figure 2.



Source; Computed based on data from NMSA.

Figure 2. *Distribution of mean monthly rainfall.*

The pattern of seasonality is determined by computing the value of rainfall concentration (RC) for each month based on the method employed by the UNFAO and adopted by [22]. The computed result revealed that more or less both station shows similar rainfall concentration even though vary in number Tables 2 and 3. According to this computation (JFJJlAD) receives small rains as RC is < 0.6 (60%) at Yabello station where as at Eel-wayye station receives small rains (JFJlAD) RC is < 0.6 (50%) of the rainfall module and designated as dry months. While in both station April is rain months which RC is between 2.0-2.9 and designated as big rain with high concentration. The difference was exists between two stations in which Yabello station shows dry months in June where as big rain was recorded at Eel-wayye station. Generally, the other lefts months (MAMSON) are rainy periods RC>0.6 with different rainfall concentration in both station.

Table 2. *Yabello Mean Monthly Rainfall and Rainfall Concentration (P and RC are in mm).*

	J	F	M	A	M	J	Jl	A	S	O	N	D
P	19.6	27.0	77.2	146.	87.9	16.1	9.33	12.1	32.0	96.6	53.6	19.6
RC	0.39	0.54	1.54	2.93	1.76	0.32	0.18	0.24	0.64	1.93	1.07	0.39
Desg	Dry	Dry	BRM	BRH	BRM	Dry	Dry	Dry	Rainy	BRM	BRM	Dry

Source: Computed from NMSA.

Table 3. *Eel-wayye Mean Monthly Rainfall and Rainfall Concentration (P and RC are in mm).*

	J	F	M	A	M	J	Jl	A	S	O	N	D
P	7.9	17.4	40.1	112.3	95.9	46.2	9.1	16.4	48.3	79.2	33.4	7.58
RC	0.19	0.41	0.94	2.62	2.24	1.08	0.21	0.38	1.13	1.85	0.78	0.18
Desg	Dry	Dry	Rainy	BRH	BRH	BRM	Dry	Dry	BRM	BRM	Rainy	Dry

Source: Computed from NMSA data.

3.3. Rainfall Variability Analysis

3.3.1. Coefficient of Variation

The coefficient of variation of the seasonal and annual rainfall of the stations is presented in Table 4. The result indicated that rainfall variability at Yabello CV=21.2% while, Eel-ayye station has CV=53%. The region has moderate and very high Rainfall variability respectively. Main rainy season (March, April, May) rainfall contributed the highest Percentages 52.2% and 48.3% of rainfall to annual rainfall at Yabello and Eel-wayye respectively and short rainy season (September and October) also contribute 21.4% and 24.7% at Yabello and Eel-wayye station respectively. This result agreed with the findings of Koricha [30] and Eshetu [18] who reported that main seasons contributed the highest contribution to annual rainfall.

The main rainfall season, coefficient of variation range was 32.6% at Yabello station which shows high variability while 71.2% at Eel-wayye station which implies very high variability in the study area Table 4. This shows during the main rainy season, the rainfall is highly variable. In line with other studies in Ethiopia, see Berhanu [9]. The analysis of coefficient of variation for Short season (September to October) at Yabello station was 48.3% which shows very high variability and 94.4% at Eel-wayye station which is extremely variable. This shows that variability in both areas is higher than main seasonal rainfall which agreed with many other authors [23, 8, 18]. The short rainy season rainfall at both stations shows the highest variation of rainfall distribution with the highest coefficient of variation, followed by the main rainy season and annual rainfall respectively. This is consistent with previous studies; Desalegn [16] conclude that greater rainfall variability is experienced during the small rainy season than the main rainy season and annual rainfall. General, the study site experiences moderate to extremely high inter annual rainfall variability.

As reported by Woldeamlak [49] and Ayal and Muluneh [3] extreme high and low rainfall values within the study period could influence the rainfall trend. So both seasonal and annual rainfall distribution variability, negatively affect the socio economic activities of the pastorals community that mostly depend on rain fed. Bekele [7] stated thus, it is prudent to assume that increased climatic variability will increase the risk that most rangelands will be affected by conditions that lead to degradation. Angassa and Oba [2] also stated that an increased incidence of droughts, related to changes in precipitation variability, may also affect forage production and herd size. This indirectly affects the pastorals community that livestock production is the backbone for their daily livelihood.

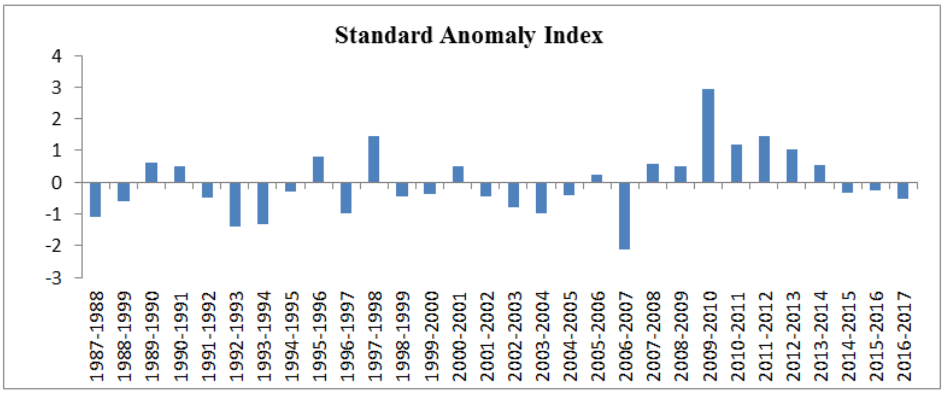
Table 4. *Annual and seasonal rainfall variability for Yabello and Eel-wayye Station.*

Station	Annual			Main Rainfall Season				Short Rainfall Season			
	Mean	SD	CV	Mean	SD	%	CV	Mean	SD	%	CV
Yabello	597	126.94	21.2	311.6	101.6	52.2	32.6	128	62.13	21.4	48.3
Eel-wayye	514.3	272.7	53.0	247.2	176.1	48.3	71.2	127.6	120.5	24.7	94.4

SD standard deviation, CV coefficients of variation.

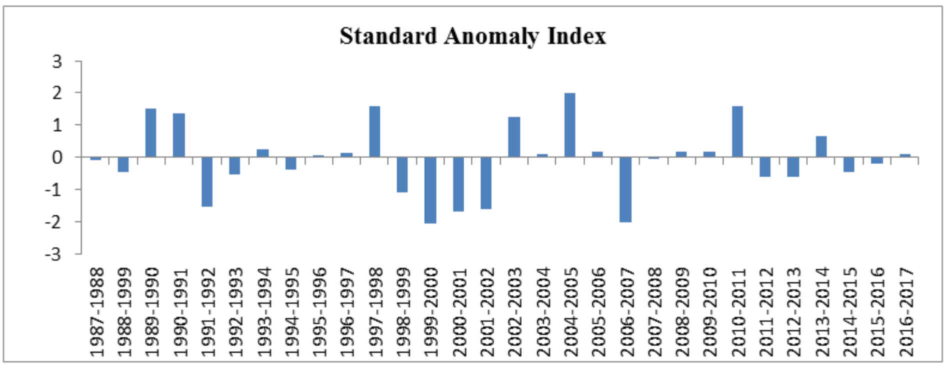
3.3.2. Standard Anomaly Index

The result from analysis of the standard anomaly index for the stations is presented in (Figures 3 and 4). To reveal the frequency of drought and intensity and inter-annual variation at different time scales and area the study used the standard anomaly index. The negative anomalies at Yabello station was 53.3% during the period of 1987 to 2016. While in Eel-wayye station, negative anomalies revealed 56% of years over the period of 1987 to 2016. The differences between the frequencies of occurrence of the dry and wet years range for the studied area were small difference. Negative anomaly index was observed in 1987, 1991, 1992, 1994, 1998, 1999, 2001, 2006, 2014, and 2015 in both stations. The rainfall pattern in the studied stations exhibits certain characteristics that a dry year is followed by another two or three dry years and vis-à-vis for the wet years. This study is significant with [23, 18].



Source: Computed from NMSA data

Figure 3. *Yabello standard Anomaly Index for period (1987-2016).*



Source: Computed from NMSA data

Figure 4. *1 Eel-wayye standard Anomaly Index for period (1987-2016).*

The Year 1999 and 2006 were the extreme drought (SAI value of less than -2) years in Yabello station, which SAI values is -2.04 and -2.01 respectively, while extreme drought year in Eel-wayye station registered only in 2006 which its SAI value is -2.14. On the other hand, in Yabello station Extreme wet (SAI value of more than 2) period occurred only in 2004, which its SAI value is 2.01 while in Eel-wayye station extreme wet year registered in 2009 with SAI value of 2.93. This study was in line with Eshetu [18].

Table 5. *Standardized Anomalies indices with the frequency and percentages of occurrence over the period of 1987 to 2016 in the Yabello and Eel-wayye (1987- 2016).*

Drought categories	Percentage and frequency occurrences			
	Yabello		Eel-Wayye	
	Frequency	percentage	Frequency	percentage
Extremely wet	1	3.34	1	3.34
Moderately wet	2	6.6	3	10
Severely wet	3	10	1	3.34
Near normal	18	60	20	66.6
Moderately dry	0	0	3	10
Severely dry	4	13.34	1	3.34
Extremely dry	2	6.6	1	3.34

Source Computed from NMSA data.

From the Table above, the frequency of nearly normal drought categories is high at both stations. This shows 60% and 66% nearly normal drought was registered for past three decades in Yabello and Eel-wayye stations respectively. However in the last decades the frequency of drought became decreasing in both stations. This impacts the pastoral ability to cope against coming drought. Nkedianye [38] states the increasing frequency and intensity of drought events are negatively impacting pastoral livelihoods and ecosystems.

3.3.3. Precipitation Concentration Index

The precipitation Concentration Index values for the annual were calculated at both studied stations, based on the equations. The analysis result indicted that the rainfall concentration index (PCI) value ranged from 13.2 to 30.23 for the stations. The rainfall concentration index calculated at annual level showed values ranges from 13.2 to 29.8 in the Yabello station, which is moderate to strong irregularly rainfall distribution. Where as in Eel-wayye station, the annual level value showed ranges from 14.04 to 30.23, which shows moderate and strong irregular distribution. This shows the variation in the annual distribution of monthly rainfall in different years See Table 6.

Table 6. *Annual Precipitation Concentration Index (PCI).*

Station	Moderate	Irregular	Strong irregular
Yabello	10 (1989, 1990, 1991, 1992, 1996, 1998, 2002, 2009, 2013, 2015)	10 (1998, 1995, 2000, 2001, 2004, 2005, 2007, 2008, 2011, 2014)	10 (1987, 1993, 1994, 1997, 1999, 2003, 2006, 2010, 2012, 2016)
Eel-wayye	7 (1992, 1997, 2001, 2006, 2011, 2013, 2014)	12 (1988, 1995, 1996, 19981999, 2000, 2004, 2007, 2009, 2010, 2015, 2016)	11 (1987, 1989, 1990, 1991, 1993, 1994, 2002, 2003, 2005, 2008, 2012)

3.4. Rainfall Trend Analysis

Rainfall trends in the study area have been analyzed seasonal and annual period by using Mann-Kendall test. The results of statistical analysis for annual rainfall data using Mann-Keld test have both positive and negative trends. The results obtained for annual rainfall series indicated increasing trend at both studied station. This implies decreasing of incidences of drought. The result for main rainfall season revealed that the occurrence of negative rainfall anomalies or frequent droughts were observed in the 1990s and 2000s in Eel-wayye station while in Yabello station frequent droughts were observed in 2010s. The main rainfall season trend shows decreasing in Yabello and increasing in Eel-wayye station. The short rainfall season in Eel-wayye station showed increasing trends, which indicates declining of occurrences of droughts from time to time across the study stations while the Yabello station showed decreasing trends which implies increasing the occurrences of droughts in the area. The frequent drought was observed in 1990s and 2000s in both studied area. This result is consistency with Findings from national and regional level that stated rainfall trends analysis reported both increasing and decreasing trends [28, 47, 42, 8].

The MK trend test showed decreasing changes in Yabello stations, which implies increasing the tendency of drought incidences at main rainy season, while Eel-wayye station showed increasing trend that implies declining of the tendency of drought incidences Table 7. On the other hand during Short rainy season showed increasing changes at both stations, similar increasing trend of drought was also observed annual in both stations. The trend analysis shows except at short rain season in Eel-wayye station there was no statistical significance ($p < 0.05$) of any positive or negative trend of drought severity and frequency for both stations. Generally, Detection of trends using nonparametric methods, including Sen's method and the Mann-Kendall test, showed increasing tendencies of drought during main rainy season and decreasing tendencies of drought during short rainy season and annual scale in the study region.

Table 7. *Seasonal and annual rainfall trend for Yabello and Eel-wayye station.*

Stations	Short rainy season			Main rainy season			Annually		
	Trend	P-value	Sen Slope	Trend	P-value	Sen's slope	Trend	P-value	Sen's slope
Yabello	0.05	0.98	0.008	-0.10	0.4	-0.02	0.01	0.94	0.002
Eel-wayye	0.28*	0.03	0.048	0.12	0.32	0.03	0.23	0.07	0.04

*=significant at $p< 0.05$.

The trend of main rain season rainfall reduction was found to be statistically insignificant at both station ($p<0.05$), this season contributes the largest amount of rainfall to annual series (table 7), however the short rain season at Yabello station revealed insignificantly increasing. This shows short rain season is compensate for main season rainfall decline and the study is in line with [9] who stated the average increase in *hagaya (short season)* rainfall has been particularly considerable to compensate for the average declines in the main season rainfalls at Yabello station. Eshetu [18] also indicate in his study the main season revealed negative trends at Setema and this season contributes the largest amount of rainfall to annual series.

Generally study revealed rainfall fluctuation was occurred both in annual variability and inter-annual variability. Such inter-annual variability problems in rainfall would negatively affect the ability of Pastoralist to cope with any change and variability [4]. Eshetu [18] stated it is obvious that drought phenomenon will create more vulnerable environment for the subsistence farming sector. For borana pastoralist that their life is depending on rainfall water, they will be more susceptible to drought which results in declining of the main asset Livestock production.

3.5. Local People Perception on Rainfall Trend and Variability

Perception of Pastoralists and agro pastoralists on variability and trends of rainfall is presented in Table 8. Majority of the respondents 94.1% noticed changes in rainfall trends and variability in the study area. Whereas only 5.9% respondents stated didn't notice any change. In the case of rainfall variability 89.6% of the respondents stated there is high rainfall variability followed by 7% and 3.4% that respond varies and decreasing respectively. This study is in line with the observed metrological data. In regard to the perceptions on rainfall trends the majority of the respondents (89.6%) stated decreasing which means that increasing of the drought incidences, especially Short rainy season (*Hagaya)*. However, the perception of Pastoralist that indicates short rain season is decreasing did not agree with observed meteorological data of the area. This disagreement could have evolved due to the fact that rainfall amount received during the recent years was below the long term average. According to the respondents (67.4%) the change was started from Gada Boru mada (1993-2001) and respondents (31.6%) stated the change started from Gada Boru Guyo (1985-1992). Key informants and members of the focus group discussion also perceived the change in rainfall amount and its variability in the same way to the surveyed households.

Generally, the perception of the community and observed meteorological data of the areas shows that the rainfall is highly variable and also annual and seasonal shows 50 per cent and above, this shows prevalence of the drought at both rainy seasons and annual. As a result, this change has been affecting the socioeconomic activity of the pastoralist and agro pastoralists from the result of drought frequency and severity which is being increasing from time to time.

Table 8. *Pastoralist and agro pastoralist perception on Rainfall trends and variability.*

Questions	Frequency		Percentage
Have you noticed any changes of rainfall in your area?	YES	271	94.1
	No	17	5.9
How do you perceive rainfall variability in your Locality?	Increasing	258	89.6
	Decreasing	10	3.4
	No change	-	-
	Varies	20	7.0
How do you perceive the trend of drought in you locality?	Increasing	-	-
	Decreasing	258	89.6
	No change	18	6.3
	Varies	12	4.2
From the two rainfall season in your area which season trend is more decreasing?	Hagayya	258	89.6
	Ganna	27	9.0
	Both	3	1.0
From when does rainfall is being change in your Locality?	Gada Kura Jarso (2017- present (2019)	-	-
	Gada Guyyo Gobba (2009-2017)	-	-
	Gada Liban Jaldesa (2001-2009)	-	-
	Gada Boru mada (1993-2001)	94	67.4
	Gada Boru Guyo (1985-1992)	194	32.6

Questions	Frequency		Percentage
How many times in One Gada period does drought occur?	Once	-	-
	Twice	-	-
	Three times	196	68%
	Four times	92	32%

Source: Field survey, 2019

Gada is a n indigenous democratic system of governance means of ruling period for only eight years.

4. Conclusion

The distribution and pattern of rainfall shows both highest and lowest annual rainfall was recorded in Eel-wayye station. The monthly pattern of rainfall distribution shows rainfall 7/12 months received relatively low amount of mean monthly rainfall in the last three decades. The computed result revealed that more or less both station shows similar rainfall concentration even though vary in number. Generally the study revealed rainfall fluctuation was occurred both in annual and inter-annual variability. The standardized anomalies of annual rainfall shows moderate to strong irregularly rainfall distribution. Mann-Kendall test, showed increasing tendencies of drought during main rainy season and decreasing tendencies of drought during short rainy season and annual scale in the study region. The trend analysis shows statistical significance ($p < 0.05$) short rain season only in Eel-wayye station.

Rainfall is the main source of water in lowlands of Borana pastorals. So, always the variability of rainfall in area affects pasture and livestock on which pastoral livelihood depends on. Such inter-annual variability problems in rainfall would negatively affect the ability of Pastoralist to cope with any change and variability. The study suggests policy makers to develop other sustainable water sources for lowlands pastorals.

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