Journal of
Earth Science & Climatic Change

Legese et al., J Earth Sci Clim Change 2018, 9:2
DOI: 10.4172/2157-7617.1000443

Case Report Open Access

Characteristics of Seasonal Rainfall and its Distribution Over Bale Highland, Southeastern Ethiopia

Wogayehu Legese[1]*, Deriba Koricha[2] and Kassahun Ture[3]

[1]College of Natural and Computational Science, Madda Walabu University, Bale Robe, Ethiopia
[2]USGS/Famine Early Warning Systems Network, Addis Ababa, Ethiopia
[3]College of Natural and Computational Science, Addis Ababa University, Ethiopia

Abstract

Agricultural productivity heavily depends on onset and cessation of rainfall and Length of Growing Period (LGP). Determining these variables is useful for early warning and preparedness. Therefore, the objective of this study was to show the onset, cessation and LGP of the seasons over Bale Highlands. Bale Highland is characterized by bi-modal rainfall types. In order to find Onset, Cessation and LGP of both Belg and Kiremt seasons, 30 years of rainfall data for periods of (1985 to 2014) in daily format from NMA (National Metrological Agency) Bale robe branch directorate was used. Additionally, for this study, 12 meteorological stations in the Bale Highlands were used. The study shows that there is high variability of onset and cessation in Belg season than kiremt season. The mean onset and mean cessation of Belg season over Bale Highland is March 28 and June 10 with mean standard deviation of 19 days, respectively. On the other hand, in kiremt season, mean onset and mean cessation were July 12 and October 31 with mean standard deviation of 16 and 12 days, respectively. During the major growing season (Kiremt) the mean LGP is 110 days with mean standard deviation of 19 days and for Belg season the mean LGP is 73 days with mean standard deviation of 26 days. The short in LGP and the variation of onset and cessation of the seasons will be considered by the concerned body to aware the local community on the onset and cessation as well as Length of growing period for both seasons. The result found more likely lead the traditional rain-fed agricultural practice in both seasons to shift to irrigation system.

Keywords: Onset; Cessation; GLP; Season; Bale highlands; Standard deviation; Coefficient of variation

Introduction

Rainfall in Ethiopia is characterized by high spatial and temporal variability as a result of the topographic variation and geographical location [1-13]. Topographic highs play a major role in releasing the conditional thermodynamic instabilities of the moist incoming air into the country strengthening convective developments, whereas precipitation patterns over topographic lows greatly depend on the strength of large scale rainfall producing systems, such as the Inter-tropical convergence Zone (ITCZ), the Tropical Easterly Jet, the creation of convergence zones and local convective systems [14]. When the windward side of the mountains is characterized with a rising moist air, the leeward side of the mountains is characterized with a descending warm dry air. Thus, rainfall activity on locations with the same altitude can differ depending on whether they are found over the windward or on the leeward side. As a result, one can observe great difference in the rainfall between the different parts of Bale Highlands which are on the same homogeneous types of rainfall [15-17].

In Ethiopia, an onset and cessation of seasonal rainfall vary considerably within few kilometers distance due to altitudinal variations, orientation of mountain chains and their physical influence on atmospheric flow [17].

Therefore, the objective of the current study was to examine the onset, cessation and LGP of seasons over Bale Highlands. There are limited attempt that made to employ appropriate scientific explorations on the seasonal onset, cessation and length of growing period over Bale Highlands in particular. The present study is therefore; supposed to show the start, end date and length of growing periods of the seasons over Bale Highlands.

Season Classification in Bale Highlands

Ethiopia is characterized by three distinct seasons. These are locally known as Bega (October to January), Belg (February to May) and Kiremt (June to September). The rainfall pattern is also named according to their rainfall distribution [18-22]. These classifications don't encompass the southern and southeastern lowlands of the country, which have a bimodal rainfall with rainfall periods from March to May and from September to November. Accordingly, there are two cropping seasons in Bale Highlands: Ganna (March to June) and Bona (July to December) seasons.

Bega

Bega is the dry season and covers the period from October to January. Bega season is mostly associated with hot dry days and cool nights. It is frosty in early mornings accompanied by occasional frost over most of the highland areas.

Belg

Belg is the small rainy period for most parts of Ethiopia except southern and southeastern low lands. It covers the period from February to May. Rainfall during the season is highly variable in time and space and high maximum temperature values are common [22]. From Belg season March, April and May months are the warmest months [18].

***Corresponding author:** Wogayehu Legese, College of Natural and Computational Science, Madda Walabu University, PO Box 247, Bale Robe, Ethiopia, Tel: +4940741052471; E-mail: wogmet@gmail.com; dnwog2000@yahoo.com

Received February 16, 2018; **Accepted** February 21, 2018; **Published** March 03, 2018

Citation: Legese W, Koricha D, Ture K (2018) Characteristics of Seasonal Rainfall and its Distribution Over Bale Highland, Southeastern Ethiopia. J Earth Sci Clim Change 9: 443. doi: 10.4172/2157-7617.1000443

Kiremt

Kiremt is the main rainy season in which about 85% to 95% of the food crops of the country are produced [8]. It covers the period from June to September following the Belg rains and is associated with frequent rains and homogeneous temperatures mainly in July and August. The magnitude of rainfall is higher as compared to the other seasons for many parts of the country [22].

Materials and Methods

Background of the study area

Highlands of Bale is located between 6.45°N to 7.45°N and 39.47°E to 40.77°E in the southern parts of Oromia National Regional State of Ethiopia. The elevation of the area ranges from 1500 to 3500 meter above sea level [9]. The study area is bordered in the south by Mena, in the west by West Arsi Zone, in the north by Arsi Zone, in the northeast by Legehida district, in the southeast by Guradamole district of Bale zone and in the east by Sewena district. The highest point in Bale Highland is Mount Tuludimtu (4377 m and Batu Mount (4307 m), Based on the topography Bale is divided into Dega (Highland), Waine Dega (mid lands), and Kola (low lands). Most of these districts are characterized by bimodal rainfall types. The average rainfall is about 590 mm in the Ganna and 560 mm in Bona season. In the study area, barley and wheat are highly produced [23-31]. Various studies indicate that the study area is dense or populous because the region is highly fertile and suitable for agricultural activities [20]. The current study is mainly focused on the Highlands (Figure 1) parts of Bale Zone.

Data Used and Method of Analyses

Observed meteorological data (Data sources)

All historical meteorological data were collected from National Meteorological Agency (NMA) of Ethiopia Bale Robe Meteorological Branch Directorate. The dataset was daily rainfall and the rainfall data was collected from 12 meteorological stations that govern by National Meteorological Agency in Bale Highlands.

Data analysis

Twelve selected stations were categorized as Central, Eastern, Western, Southern and Northern parts of Bale Highlands. The variability of seasonal rainfall was analyzed for its onset, end date, LGP. Statistical packages like the mean, standard deviation and coefficient of variation were determined and interpreted based on Australian Bureau of Meteorology rainfall index (Australian Bureau of Meteorology, 2010). For this study, the determining onset, end date and LGP was performed by adapting definition from the study by Stern et al. [29]. Accordingly, the day with accumulated rainfall of 20 mm over three consecutive days that were not followed by greater than 9 days of dry spell length within 30 days from planting day was said to be onset date. To determine the end of the growing season or rainy season, the stored soil water and its availability to the crop after the rain stops was a very useful criterion [29]. The end of the rainy season adopted in this case was defined as any day after the first of September/October/, when the soil water balance reaches zero [29]. In addition, a fixed average 3.5 to 5 mm of Evapo-transpiration per day, and 100 mm/meter of the maximum soil water holding capacity of the area [13] were considered. Given the above definitions, Instat Statistical programme Version 3.37 [29] was used for analysis using January to December calendar and in INSTAT climatic guide [29], threshold value 0.85 and 60 mm/day was used. The LGP was determined by subtracting onset date from end date.

Statistical methods

This method is based on statistical principles that describe random variation of a set of observations of process and they focus on the observations themselves rather than on the physical process which produced them. Statistics is a type of description but not causality because it assumes that the data is from pure random process [7]. The sample estimate of population parameters are given in the following equations [7].

$$\bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{\sum xi}{n} \quad (1)$$

Where, $\bar{x}$ = is sample mean n=is number of observation in individual observation For i = 1, 2, 3…n

The variance (S2) and standard deviation (√S2) respectively are given as;

$$s^2 = \frac{\sum\left(x - x^{-}\right)^2}{n-1} \quad (2)$$

$$\sqrt{S^2} = s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}} \quad (3)$$

Similarly, the coefficient of variation CV is given as;

$$CV = \left(\frac{SD}{\bar{X}}\right) * 100 \quad (4)$$

Results and Discussion

Onset Belg season over Bale Highlands

The first attempt of producing onset and cessation of the small season of Ethiopia were made by Tesfaye Haile in 1989. Onset of Belg season is difficult to define because of highly erratic characteristics. In Bale highlands Belg onset is differ from place to place. As Bale highland is partly Belg rain-benefiting areas, the Belg season is defined as the time when the first wet-spell of at least three days total rainfall amount of 20 mm or more occurs in March, provided there will not be continuous nine or more dry spell or dry days in the subsequent 30 days of the area [19].

The rains in April over eastern and southeastern regions are associated with the seasonal southward advance of the equatorial trough Inter-Tropical Convergence Zone (ITCZ) [19]. The Onset of Belg season over Bale Highlands was in the 3rd dekade of March but gradually advances eastward from western and southern parts of

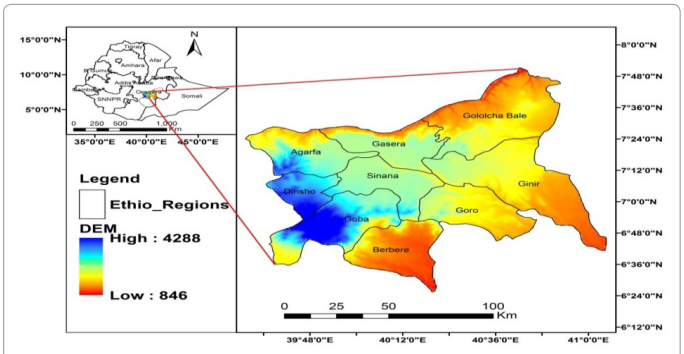

Figure 1: Map of the study area (Bale highlands).

Mean Belg season Onset is March 28 over Bale Highlands				
Mean variation of standard deviation onset of Belg season is 19 days over Bale Highlands				
Mean Coefficient of Variation in Belg season onset is 22% over Bale Highlands				
Parts of Bale Highlands	**Days of the Year**	**Starts of the season**	**Standard deviation days**	**Coefficient of Variation in %**
Central	85	March_25	17	20
West	84	March_24	19	23
North	86	March_26	21	24
South	91	March_31	35	38
East	89	March_29	14	16

Table 1: Mean onset, standard deviation and CV of *Belg* season from 1985 to 2014 over Bale Highlands.

Mean Kiremt season Onset is July 12 over Bale Highlands				
Mean variation of standard deviation of Kiremt onset is 16 days over Bale Highlands				
Mean Coefficient of Variation in kiremt onset is 8% over Bale Highlands				
Parts of Bale Highlands	**Days of the Year**	**Starts of the season**	**Standard deviation days**	**Coefficient of Variation in (CV) %**
Central	196	July_14	22	11
West	178	June_26	13	7
North	179	June_27	22	12
South	200	July_18	26	13
East	220	August_7	26	12

Table 2: Mean onset, standard deviation and coefficient of variation of *Kiremt onset* from 1985 to 2014 over Bale Highlands.

Mean Belg season Cessation is June 10 over Bale Highlands				
Mean variation of standard deviation of Belg cessation is 19 days over Bale Highlands				
Mean Coefficient of Variation in Belg cessation is 12 % over Bale Highlands				
Parts of Bale Highlands	**Days of the Year**	**End of the season**	**Standard deviation days**	**Coefficient of Variation in %**
Central	159	June_7	26	16
West	167	June_15	31	19
North	165	June_13	30	18
South	155	June_3	32	21
East	163	June_11	17	11

Table 3: Mean cessation, standard deviation and Coefficient of Belg cessation from 1985 to 2014 over Bale Highlands.

Highlands. The results presented in Table 1 revealed that, on average, the small rainy season (Belg) starts over Bale Highlands on March 28th day of the year (DOY, 88). Starts of the season begins March 25th (DOY, 85) for Central Bale Highland, March 29th (DOY, 89) for Eastern Bale highland, March 24th (day DOY, 84), for Western Bale highland, March 26th (DOY, 86) for Northern Bale Highland and March 31st (DOY, 91) for Southern Bale Highlands.

In the previous studies by Messay [19] the regularity onset and cessation over the study area is not clearly cited due to less meteorological station but the region consider as a Belg-growing areas and the onset and cessation period was in average 1st dekade of March and 1st dekade of June, respectively. Table 1 shows that variability day of the mean onset days of the growing season. The mean standard deviation of onset day of Belg season over Bale highlands was 19 days. It is highly variable, with standard deviation across the highlands ranging from 14 to 35 days. South parts of the highlands have the highest onset variability with standard deviation of 35 days, whereas Eastern parts of the highlands have the lowest onset variability with standard deviations 14 days. Central, Western and Northern parts of the highlands have onset variability with standard deviation 17, 19 and 21 days, respectively.

The mean Coefficient of Variation (CV) of onset Belg season over Bale Highlands was 22% which is moderate variation. The Central, Eastern, Western, Northern and southern parts of Bale Highland experienced Coefficient of Variation (CV) of 20%, 16%, 23%, 24% and 38%, respectively (Table 1). Overall, start of the season ranges between March 24th to 31st days or 3rd dekade of March as shown in Table 1, which indicate that start of the season does not vary significantly over Bale Highlands, this result agrees with the findings of Korecha and Barnston [17], which stated that Bale Highlands possess one Homogeneous Rainfall Regime.

Onset Kiremt season over Bale Highlands

Indicated that over Bale Highlands the onset of Kiremt start's from June 25th [26]. The Onset of Kiremt season starts from the first month on the seasons that is June and defined the time when the first wet-spell of the first month of the seasons for Kiremt June month occurs at least three days total rainfall amount of 20 mm or more, provided there were no continuous nine or more dry spell or day days in the subsequent 30 days.

The mean onset of the main growing season (Kiremt) which is consistent with the previous work of Segele and Lamb [26] was July 1st over Bale Highland which represent by Robe station only for their study. In this study 12 meteorological stations were used. On the average the main rainy season (Kiremt) starts on July 12 (DOY, 194) over Bale highlands which is similar to the Segele and Lamb [26] in Robe starts on 1st dekade of July. But Kiremt season onset over Bale Highlands was gradually advances eastwards from Western and Northern parts of the highlands. As a result of Table 2 starts of kiremt season originates July 14th (day of the year (DOY, 196), for Central parts of Bale Highlands, August 7th (DOY. 220), for Eastern parts of Bale Highlands, June 26th (DOY, 178), for Western parts of Bale Highland, June 27th (Day of the year (DOY, 179) for Northern parts of Bale Highland and July 18th (Day of the year (DOY, 200) for Southern parts of Bale Highlands.

Mean Kiremt season Cessation is October 31 over Bale Highlands				
Mean of standard deviation for Kiremt Cessation is 12 days over Bale Highlands				
Mean Coefficient of Variation in Kiremt cessation is 4% over Bale Highlands				
Parts of Bale Highlands	**Days of the Year**	**End of the season**	**Standard deviation days**	**Coefficient of Variation in %**
Central	305	October_31	14	5
West	304	October_30	18	6
North	301	October_27	13	4
South	302	October_28	18	6
East	311	November_6	17	5

Table 4: Mean cessation, standard deviation and coefficient of variation for Kiremt cessation from 1985 to 2014 over Bale Highlands.

Mean LGP of Belg is 73 days; mean standard deviation of LGP in Belg s is 26 days and mean CV of LGP in Belg is 36 days over Bale Highlands						
Mean LGP of Kiremt is 110 days; mean standard deviation of LGP of Kiremt is 19 days and mean CV of LGP in Kiremt is 17 days over Bale Highlands						
Parts of Bale Highlands	**Belg LGP**	**Kiremt LGP**	**STDV Belg LGP**	**STDV Kiremt LGP**	**CV Belg LGP**	**CV Kiremt LGP**
Central	74	110	32	24	43	22
West	83	126	33	23	40	18
North	78	123	38	25	48	20
South	68	102	22	30	32	30
East	75	91	21	30	28	33

Table 5: Mean length of growing period of *Belg* and *Kiremt* seasons over Bale Highlands.

The mean onset in practicability and regularity within the region under kiremt season over Bale Highlands was July 1st (DOY, 183) over of south in eastern Ethiopia that represented by Robe station [26]. Table 2 showed that there was a slight agreement the onset of season over the Bale Highlands. Table 5 shows that the variability day of the onset of the main growing season (Kiremt) less than Belg season. The mean standard deviation of Kiremt season onset over Bale highlands was 16 days. Its variability's, with standard deviation across the highlands ranging from 13 to 26 days. Southern and Eastern parts of the highlands have the highest onset variability with standard deviation of 26 days, whereas Western parts of the highlands have the lowest onset variability with standard deviations 13 days. Central and Northern parts of the highlands have onset variability with standard deviation 22 days.

The mean Coefficient of Variation (CV) onset of Kiremt season over Bale Highlands was 8% which is less variation. The Central, Eastern, Western, Northern and southern parts of Bale Highland experienced Coefficient of Variation (CV) of 11%, 12%, 7%, 12% and 13%, respectively (Table 2). Overall, start of the season ranges between June 26th to August 7th days or 3rd dekade of June to 1st dekade of August (Table 2) which indicate that start of the season does not vary significantly over Bale Highlands; this result coincides with the findings of Korecha and Barnstorn [17], which stated that Bale Highlands possess one Homogeneous Rainfall Regime.

Belg season Cessation over Bale Highlands

The end of rainy season is obtained when a dekadal rainfall amount is less than half of the corresponding reference evapo-transpiration (ETo) at the end of rainy season. In the previous studies there is no exact cessation of Belg season for Bale highlands due to less Meteorological stations data.

The mean end date of Belg (small rainy) season for Bale Highland was on June 17th (DOY, 162). Table 3 has mention as Belg season cessation advances East-north-westward from south-central parts of Bale Highlands. South and Central Bale Highland has the earliest cessation on the first decade of June (June 3 and June 7, respectively), followed by eastern, northern and western parts of Bale Highlands, which have cessation in 2nd dekade of June (June 11, June 13 and June 15, respectively).

The mean cessation of the small growing season (Belg) is less variable (19 days) temporally than the mean onset, with standard deviation of 17 to 32 days (Table 3) over Bale Highlands. The highest variability of the mean cessation occurs over Northern, south and western parts of bale Highlands which have standard deviation of 30, 31 and 32 days, respectively, while the lowest variability is over eastern parts of Bale Highland, where the standard deviation is 18 days.

The mean Coefficient of Variation of cessation of the small rainy season (Belg) over Bale Highland is less variable which is 12 days shown in Table 3. The highest variability of the mean CV of cessation occurs over southern parts of bale Highlands which has 21 days and it is under moderate variation, while the lowest variability is over eastern parts of Bale Highland, where the coefficient of Variation is 11 days.

Kiremt season Cessation over Bale Highlands

According to Segele and Lamb [26] over Bale highland the Cessations of Kiremt season is from Oct-15 to Oct-26 from eastern to western of the highland, respectively. The mean value of end date of Kiremt (main rainy) season over Bale Highland is October 31st (Day of year (DOY, 305). The main rainy season cessation advances eastwards from northern and southern parts of Bale Highlands in November 6 (DOY, 311), October 27th (DOY, 301), October 28th (DOY, 302), respectively.

The mean cessation in practicability and regularity within the region under kiremt season over Bale Highlands was October 28 (302) over of south in eastern Ethiopia that represented by Robe station. [26]. Table 4 showed that there was a slight agreement in the cessation of season over the Bale Highlands. The mean variability of cessation of the main rainy season (Kiremt) is less variability with standard deviation is 12 days over Bale Highlands. The highest variability of the mean cessation occurs over south and western parts of Bale Highlands which have standard deviation of 18 days, while the lowest variability is over northern parts of Bale Highland, where the standard deviation is 13 days.

The mean Coefficient of Variation of cessation of the main rainy season (Kiremt) over Bale Highland is less variable which is 4% shown in Table 4. The highest variability of the mean CV of cessation occurs over southern and western parts of Bale Highlands which has 6% and it is under less variation, while the lowest variability is over northern parts of Bale Highland, where the coefficient of Variation is 4% days.

Length of the growing period (LGP) in Belg season over Bale Highlands

The average value of length of growing period (LGP) for small rainy season over Bale Highlands was 73 days. It has less special variability with values ranging from 68 to 83 days. Western part of Bale Highland has the longest mean growing season 83 days, followed by north, east and central parts of Bale Highlands (78, 75 and 74, respectively). South part of Bale Highland has the shortest mean growing period in Belg season (i.e. 68 days) shown in Table 5.

Length of the growing period (LGP) in Kiremt season over Bale Highlands

The average value of length of growing period during main rainy season over Bale Highlands was 110 days cited in Table 5. The length of growing period has variability with values ranging from 91 to 126 days. Western part of Bale Highland has the longest mean growing season 83 days, followed by north, central and south parts of Bale Highlands (123, 110 and 102 days, respectively). East part of Bale Highland has the shortest mean growing period in Kiremt season (i.e. 91 days) shown in Table 5.

The mean variability of the mean length of growing period in both Belg and Kiremt season were shown in Table 5. Belg season mean LGP standard deviation ranges from 21 to 38 days in Bale Highlands. The mean LGP standard deviation of Belg season over Bale Highland is 26 days. Eastern and Southern portion of Bale Highlands have the lowest variability with standard deviation of 21 and 22 days, respectively, whereas Central, western and northern parts of Bale Highlands have the highest variability (standard deviations of 32, 33 and 38 days, respectively).

Similarly, Kiremt season mean LGP standard deviation ranging from 23 to 30 days in Bale Highlands. The mean LGP standard deviation of Kiremt season over Bale Highland is 19 days. Eastern and Southern portion of Bale Highlands have the highest variability with standard deviation of 30 days, whereas Central, western and northern parts of Bale Highlands have the lowest variability (standard deviations of 24, 23 and 25 days, respectively).

The mean coefficient of variation of mean LGP in both Belg and Kiremt season were shown in Table 5. In Belg season the mean LGP coefficient of variation ranging from 28 to 48% in Bale Highlands. The mean LGP coefficient of variation of Belg season over Bale Highland is 36%. Eastern and Southern portion of Bale Highlands have the lowest variability with coefficient of variation of 28 and 32%, respectively that is from moderate to high variability, whereas Central, western and northern parts of Bale Highlands have the highest variability (coefficient of variation of 43, 40 and 48%, respectively) that is shown in Table 5 as the highest variability.

Likewise, Kiremt season mean LGP coefficient of variation ranging from 18% to 33% in Bale Highlands. The mean LGP coefficient of variation of Kiremt season over Bale Highland is 17%. Eastern and Southern portion of Bale Highlands have the highest variability with coefficient of variation of 33% and 30% that is the highest variability, whereas Central and northern parts of Bale Highlands have the moderate variability (coefficient of variation of 22% and 20%, respectively).

Conclusion

This study presents analysis of latest characteristics of seasons and seasonal distribution for both Belg and Kiremt season over Bale highlands. After a thorough examination of the daily rainfall patterns for 12 stations in the study area, the current study has been able to objectively determine the onset and cessation and LGP of the Belg and Kiremt rainy seasons of Bale Highlands. It was found that there is more variability in the onset of the Belg rains than the cessation of Belg and onset of kiremt rain season.

Analysis of seasonal feature variability is very crucial for planning and management of agricultural practices in Bale Highlands. The mean standard deviation and CV values of onset seasons as 35 days and 38%, respectively in the southern parts of Bale Highlands during Belg season is higher than kiremt seasons mean standard deviation ad CV values 26 days and 13%, respectively over Bale highlands. The high variation was observed in areas with high number of mean standard deviation and CV values of Cessation of seasons in Belg season than Kiremt season. The mean CV value of LGP in Belg season is higher than Kiremt season. Seasons with CV value of >30% was persist in southern parts of Bale Highland for onset of Belg season. The CV value of LGP < 30% in eastern parts of Bale Highland for Belg season and >30% in eastern parts of Bale highlands for Kiremt season. The average onset dates of small rainy season in Bale Highland in DOY was found to be 88 (March 28), with CV of 22%; whereas for end dates of small rainy season was 162 (June 10) with CV of 12%. The mean LGP of Belg and Kiremt seasons were 73 days, 110 days with CV of 36%, 17% for Bale Highlands. The result is also in line with the works reported by Hoefsloot [13].

Recommendations

Belg is less likely to be operational for rain-fed agriculture discretely in Bale Highlands. Hence long-term strategy should be designed to select short cycle and/or drought resistant crops or support the season with additional water resources (irrigation/water harvesting). Mostly, the agricultural activities appropriate the length of the two rainy seasons. Hence, the output of the agricultural activities depends on the performance of these seasons. The small rainy season is used for sowing short and long cycle crops.

Information about the start of the rains is important for appropriate agricultural decision making so that reduction in yield of the crops is avoided by taking appropriate action. During those seasons, over Bale Highlands receives small and large rain lived. But, agriculturally small rainy and main rainy seasons are important over the study area. A delay or deficient Belg or Kiremt rainfall means absence of water and pasture, which may result in deaths of thousands of peoples and animals. Kiremt and Belg season rain is extremely important from agricultural economic point of view.

The short in LGP and the variation of onset and cessation of the seasons will be considered by the concerned body and this body would be assess the local community by aware creation them on the onset and cessation as well as Length of growing period for both seasons. It is more likely to deviate from the traditional rain-fed agricultural practice (using Belg and Kiremt season) to use irrigation system.

The starts of the season, end of the seasons and length of growing periods of the seasons will investigate related with ENSO and IOD phenomenon over Bale Highlands.

Acknowledgment

First and foremost, thanks to almighty God for granting me His limitless care, love and blessings all along the way. I would like to thank NMA Bale robe branch Directorate and Cordex African regions for providing me Meteorological GCM data for my study area. I would like to acknowledge the invaluable input of all individuals and organizations, in particular those who provided materials and information and who helped me a lot during the data entry, quality control period: Mr. Fitsum

Bekele, Mr. LaekmariamYohanes. I am highly indebted to all staff members of Bale robe Meteorology directorate for their ideal and technical supports. Thanks are also to all my friends who give me their comments, ideas, shared love and happiness.

References

1. Asnani G (2005) Tropical Meteorology. Revised (1st edn).
2. Australian Bureau of Meteorology, 2010. Rainfall variability in Australia. http://www.bom.gov.au/climate/data/index.shtml. Accessed on 23/12/2010
3. Bale Zone Finance and Economic Development Office (2010) Physical and socio Economic profile of Bale zone,
4. Beltrando G, Camberlin P (1993) Inter-annual variability of rainfall in the eastern Horn of Africa and indicators of atmospheric circulation. Int J Climatol 13 533-546.
5. Camberlin P (1997) Rainfall anomalies in the Source Region of the Nile and their connection with the Indian Summer Monsoon. J Clim 10: 1380- 1392.
6. Central Statistical Agency (2008) Statistical abstract of Ethiopia. Central Statistical Authority. Addis Ababa, Ethiopia.
7. Camberlin P, Philippon N (2002) The East African March-May Rainy season: Associated Atmospheric dynamics and predictability over the 1968-97 period. J Climate 15: 1002-1019.
8. Chow Ven T (1988) Applied Hydrology.McGRAW-HILL Book Company. New York, USA.
9. Workineh D (1987) 'Some aspects of meteorological drought in Ethiopia.' In: Glantz MH (ed), Drought and Hunger in Africa. Cambridge: Cambridge University Press, UK.
10. FARM Africa and SOS Sahel (2007) Bale Eco-Region Sustainable Management Programme (BERSMP): Annual report.
11. Gebreeyesus YG (2006) Constructing a homogeneous rainfall data set to study the climate of Ethiopia. Msc Thesis in Applied Meteorology. University of Reading. UK.
12. Attlee G (1968) Weather and climate at Addis Ababa, Asmara. Ethiopia.
13. Haile T (1986) Climatic variability and support feedback mechanism in relation to the Sahelo-Ethiopian droughts. pp. 119-137
14. Hoefsloot P (2009) LEAP (Livelihood Early Assessment Protection) version 2.1 for Ethiopia. By collaborative action of FAO, World Bank and World food programme. The Netherlands.
15. Jember G (2007) Change in the frequency and intensity of extremes over Northeastern Africa. MSc. Thesis in Meteorology.Wageningen University, The Netherlands.
16. Kassahun B (1987) Large scale features associated with kiremt rainfall anomaly. African Climate and climate change: Physical social and political perspectives. In: Charles JR, Kniveton DR (eds).
17. Bokretsion K (1999) Ye'ayerMezabat'natinbi'yak'ItiopiaAntsar (Climate Change and Forecast in Ethiopia, in Amharic). Paper Presented at a Meeting organized by the DPPC on Climate Change, Drought and Disaster Prevention in Ethiopia, Addis Ababa, Ethiopia, August 1999.
18. Korecha D, Barnston AG (2007) Predictability of June-September Rainfall in Ethiopia. Monthly Weather Review. V. 135: 628-650
19. Tsidu MG, Bayable E (2011) Evidences of climate change signal at local scales of Ethiopia; proceedings of the Global Conference on Global warming, Portugal.
20. øAbebe (2006) The onset, cessation and dry spells of the small rainy season (Belg) of Ethiopia. National Meteorological Agency, Addis Ababa, Ethiopia.
21. Muleta D, Desalegn O, BikilaZ A (2015) Using NDVI for prediction of yield for specific crop type: Case Study of Sinana District in Bale Zone.
22. NMA (National Meteorological Agency) (2015) Guide to the use of weather and climate information (WCI) for agricultural practices over selected district of Tigray, Ethiopia. National Meteorological Agency (NMA) of Ethiopia.
23. NMSA (National Meteorological Service Agency) (1996) Climatic and Agro-climatic resources of Ethiopia. Meteorological research report series, 1:1, January. Addis Ababa, Ethiopia.
24. NMSA (National Meteorological Services Agency) (1996b) Assessment of drought inEthiopia: Meteorological Research Report Series. Vol.1, No.2, Addis Ababa. pp. 259.
25. NMSA (National Meteorological Services Agency) (2001) Initial national communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC), Addis Ababa, Ethiopia.
26. Pedreros D, Korecha D, Funk C (2017) real-time monitoring of current belg season in Ethiopia. http://blog.chg.ucsb.edu/?p=221
27. Segele ZT, Lamb PJ (2005) Characterization and variability of Kiremt rainy season over Ethiopia. Meteor Atmos Phys 89: 153-180.
28. Seleshi Y, Zanke U (2004) Recent changes in rainfall and rainy days in Ethiopia. Int J Climatology 24 : 973-983.
29. Shanko D, Camberlin P (1998) The effect of the southwest Indian Ocean tropical cyclones on Ethiopian drought. Int J Climatol 18 : 1373-1378.
30. Stern R, Rijks D, Dale I, Knock J (2006) INSTAT Climatic Guide.
31. WBISPP (Woody Biomass Inventory and Strategic Planning Project, 1995): Socio-cultural and Economic aspects of crop, livestock and tree production. The Woody Biomass Inventory and Strategic Planning Project. Ministry of Mines and Energy. Ethiopian Energy studies and Research Center.