Hydrology: Current Research
Shefine, Hydrol Current Res 2018, 9:4
DOI: 10.4172/2157-7587.1000307
Research Article Open Access

Analysis of Meteorological Drought Using SPI and Large-Scale Climate Variability (ENSO)-A Case Study in North Shewa Zone, Amhara Regional State, Ethiopia

Bethel Geremew Shefine*

Department of Natural Resources Management, Debre Berhan University, P.O. Box 445, Ethiopia

***Corresponding author:** Bethel Geremew Shefine, Department of Natural Resources Management, Debre Berhan University, P.O. Box 445, Ethiopia, Tel: +251967292745; E-mail: mybethel.y@gmail.com

Received date: Sep 24, 2018; **Accepted date:** Nov 30, 2018; **Published date:** Dec 06, 2018

Abstract

Drought is one of the most complexes and least understood natural disaster that causes loss of life and property destruction. The objective of this study was to analyze meteorological drought using Standardized Precipitation Index (SPI) and climate variability (ENSO) in North Shewa Zone, Amhara Regional State. Spatiotemporal variability or trends of rainfall, and temperature were also analyzed. For the seasonal trend analysis of rainfall, maximum and minimum temperatures the MK test was applied and there have been significant increasing trend in maximum, minimum temperature, mostly in semi-arid district. The rainfall of three agro-ecological zones showed strong variability with negative Sen's slope indicated decreasing signal mostly for Belg season and semi-arid district. The Belg season rainfall showed high variability. Ataye station Belg season (April and May) dry events occurred in 1999, 2000, 2008, and 2011, while the wet events occurred in 1990, and 1993. In the same station, the kiremt season (June and July) wet years occurred in 1990 and 2010, whereas extreme dry events occurred in 1994, 2000, 2008 and 2011. The Kiremt season dry events years were also much higher in Ataye (semi-arid) district as compred to other district, whereas the wet events years were higher in debre berhan (cool, humid, highlands) district. The major El Nino years were in 1982, 1987, 1997 and 2015, whereas the major La Niña years occurred in 1988, 1999, and 2000. In Ataye station the correlation between Kiremt rainfall and Niño 3.4 was -0.43, while in the Belg season it was 0.53. In most of the years the La Nina was associated with rainfall deficiency in Belg season but increase rainfall in Kiremt season. The contrary was true for El Nino events.

Keywords: North shewa zone; Amhara regional state; Meteorological drought; Spi; Climate variability (ENSO)

Introduction

Drought is a prolonged deficiency of rainfall that results in water shortage for some activity or a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious moisture deficit and hydrological imbalance [1]. Drought can be considered as strictly meteorological phenomena and it means various things to various people based on their interest for example to meteorologist drought means below normal rainfall, to agrarian it means shortage of moisture in the root zone, to hydrologist it means below average water level in streams, lakes, reservoirs and the like, to the economist it means a water shortage that adversely affects the established economy [2]. In this study the prominent meteorological drought will be investigated as it has been frequenting in the region. Droughts are natural disaster in the world and affect more people than floods, due to its wider spatial coverage [3]. Drought is a major natural disaster, and, among all-natural disasters, it causes the greatest damage that the global annual economic estimate to be $7 billion [4].

Climate variability refers to the climatic parameter of a region varying from its long-term mean that means in some year or month for a specific time period, the climate of a location might be different from 'normal' [1]. Year to year or month to month climatic element variability, particularly rainfall variability both in amount and distribution is the main cause of drought in most part of Ethiopia. The El Niño and the Southern Oscillation phenomenon (ENSO) is often thought as an irregular interannual oscillator that swings between warm and cold sea surface temperature (SST) and low and high surface pressure over the central and eastern tropical Pacific Ocean [5]. ENSO is the primary driver of climate variability and has a large economic and social impact over the globe [6]. The large scale global El Niño/Southern Oscillation (ENSO) phenomenon is the main cause of climate variability in Ethiopian region [7-10]. Due to the unpredictability of large scale global El Niño/Southern Oscillation (ENSO) and its relation to Ethiopian rainfall drought remains hard to conquer in some part of Ethiopia. Climate variability that is associated with ENSO has been mentioned as a cause of many drought and famines events that occurred in different part of Ethiopia [11-14]. Climate variability is a serious challenge to sustainable food production, food security and overall sustainability in Ethiopia or Africa [15].

Primary market research is tailored to a company's particular needs and is conducted either by you or by a company that you pay to conduct the research for you. Focus groups, surveys, field tests, interviews, and observation are examples of primary market research.

Primary market research lets you investigate an issue of specific interest to your business, get feedback about your website, assess demand for a proposed service, gauge response to various packaging options, find out how much consumers will pay for a new product, and more.

Citation: Shefine BG (2018) Analysis of Meteorological Drought Using SPI and Large-Scale Climate Variability (ENSO)-A Case Study in North Shewa Zone, Amhara Regional State, Ethiopia. Hydrol Current Res 9: 307. doi:10.4172/2157-7587.1000307

Primary research delivers more specific results than secondary research, which is an especially important consideration when you're launching a new product or service. In addition, primary research is usually based on statistical methodologies that involve sampling as little as 1 percent of a target market. This tiny sample can give an accurate representation of a particular market.

The downside of professionally conducted primary market research is that it can be expensive-several thousand dollars or more. Fortunately, a growing number of online tools allow you to conduct primary research such as surveys yourself at very little cost.

Drought is becoming a common yearly problem in some part of Ethiopia including North Shewa Zone due to rainfed agriculture dependency and climate variability as well as low resilience. The main economy in North Shewa Zone, Ethiopia is significantly dependent on rainfed agriculture, and climate variability results decreasing of agricultural productivity, increased risk of food security, water scarcity and droughts [16,17]. Climate change (variability) is likely to intensify rainfall variability or temperature increases during the last three decades in African countries that have witnessed frequent severe water scarcity [1]. Previously the droughts frequency was noticed approximately in every 3-5 and 6-8 years in the arid and semi-arid regions of Ethiopia and every 8-10 years for the whole country [18], but recently the drought frequency is becoming high in every part of the country due the changing climate. According to IPCC, there is significant warming occurring in the Sub-Saharan African countries and warming is not uniform throughout the region so that assessing of climate parameter is quite crucial [1].

Drought has been the main concern in some places of North Shewa Zone or Ethiopia, its recent high frequency and larger area coverage is also becoming scare. The Zone belongs to one of the most vulnerable places to climate variability in the country that a lot of it population is already food insecure. Ethiopia is frequently depicted as a drought-stricken country for so long. Therefore, the estimation of the severity, spatial extent, and frequency of droughts is one of the key elements for food security, resources planning and management. The main objective of this study is to statistically investigate the spatial and temporal change in severity and frequency of meteorological drought and climate variability along with ENSO in North Shewa Zone, Ethiopia. The most reliable and commonly used Standardized Precipitation Index (SPI) indices will be used for meteorological drought analysis. I believe that this study would provide essential information about drought, seasonal rainfall variability that could helpful for agricultural activities, water resources management, agricultural planning and policymaker in the Zone.

Description of Study Area

North Shewa Zone is one of the eleven zones in Amhara Regional State, Ethiopia [19]. The Zone is bordered on the south and the west by the Oromia Region, on the north by Debub Wollo, on the northeast by the Oromia Zone, and on the east by the Afar Region as shown in Figure 1. The highest point in the Zone is Mount Abuye Meda (4012 meters); other prominent peaks include Mount Megezez [20]. The topography comprises uneven and ragged mountainous highlands in the northern and central part of the zone, extensive plains and also deep gorge sand cliffs in the periphery [21] as shown Figure 1.

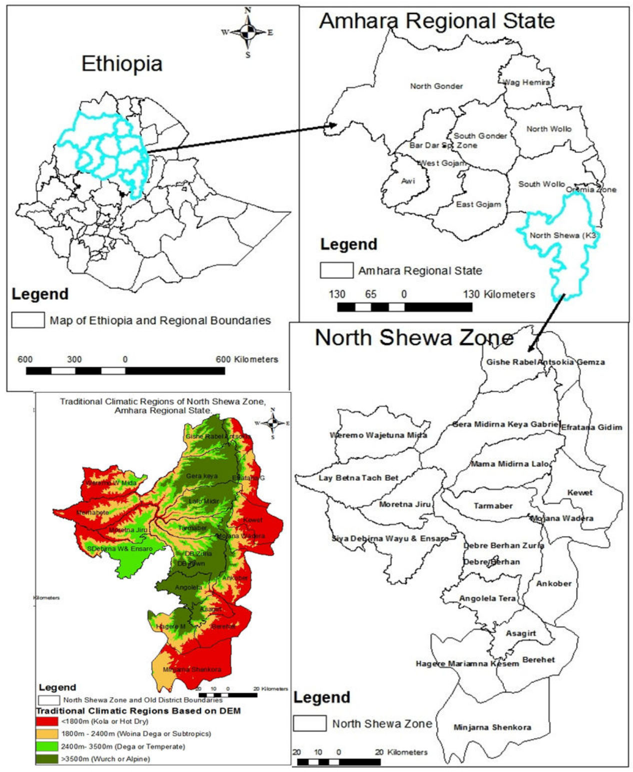

Figure 1: Study area.

The North Shewa Zone climate extends from semi-desert lowlands in the south, west and east periphery to cold high mountainous part in the center with extreme ranges of temperature and rainfall. The movement of the inter-tropical convergence zone (ITCZ) and the influence of the Indian Monsoon throughout the year, mainly determine the climate pattern of the zone [22]. There are three seasons in the zone based on the movement of inter-tropical convergence zone (ITCZ), the amount of rainfall and the rainfall timing. The three seasons are Kiremt, which is the main rainy season (June-September), Bega, which is the dry season (October-January), and Belg, the small rainy season (February-May) [23]. Drought during Kiremt season may lead to food insecurity and starvation since the season is the main rainy provider for most of agricultural activities in the zone. Normal Belg rainfall adds moisture to the soil, enabling land preparation for the Kiremt season planting [24]. The short rainy season, the Belg is the result of moist easterly and southeasterly winds and produces rains in March, April, and May [25].

The annual average rainfall varies between 400-700 mm and the annual average temperature ranges between 8 to 35.7°C [21]. The rainfall pattern is bimodal but often unreliable [26]. High rainfall and low temperature over the Wurch and Dega area in the central area of North Shewa Zone and low rainfall, high temperature over the low land's periphery of south, west and east of the zone as shown in Figure 1. Most parts of the zone are hilly or mountainous, but there are some plains. The topographic feature of the administration is range from 927 m.a.s.l in south, west and east peripheries and 2450 m.a.s.l in the central part of the zone as shown in Figure 1.

Materials and Methods

Monthly or daily temperature and rainfall datasets were collected from National Meteorological Agency, Ethiopia. Three meteorological stations such as Debre Berhan, Alem Ketma and Ataye with the longer year data were selected across the zone based on different agro-ecological zones. These datasets were analyzed in the basis ofmean monthly, seasonally and yearly time scales for the available period. Monthly mean sea surface temperature anomalies (SSTA) of station NINO3.4 was downloaded from National Oceanic and Atmospheric Administration (NOAA).

Standard Precipitation Index (SPI)

The software used: SPI_SL_6.exe (Sources of the software:// drought.unl.edu/Monitoring Tools/DownloadableSPIProgram.aspx National Drought Mitigation Centre University of Nebraska-Lincoln). This SPI software was selected for analysis of drought over the zone because of simple input requirement, wide applicability and easily accessible. Assessment of rainfall is used to identify the pattern and the intensity of drought. SPI developed by by McKee et al. (1993) [27] is the most widely used index for understanding the magnitude and duration of drought events. The data will be fitted to normal distribution and be normalized to a flexible multiple time scale such as 3, 6, 12, 24, 48 and etc. SPI is used to identify the meteorological drought or deficit of precipitation [28].

SPI can provide early warning of drought and its severity because it can specify for each location and is well-suited for risk management. The first and primary advantage is simplicity. The SPI is based solely on rainfall. The SPI is also not affected adversely by topography. It is less complex to use than other indices. The SPI's second advantage is its variable time scale, which allows it to describe drought conditions important for a range of meteorological, agricultural, and hydrological applications. This temporal versatility is also helpful for the analysis of drought dynamics, especially the determination of onset and cessation, which have always been difficult to track with other indices.

The SPI was calculated using the following equation: SPI= (Xj-Xm)/σ, Where, Xj= is the seasonal precipitation and, Xm is its long-term seasonal mean and σ is its standard deviation. SPI was used to quantify the precipitation deficit in the growing season and analyze the impact of rainfall deficiency on drought development. SPI (1 month) is probability index looking at the rainfall over the last month compared to the historical rain in the same period. SPI (3 month) is probability index looking at the rainfall over the last 3 months compared to the historical rain in the same period. SPI (6 month) probability index looking at the rainfall over the last 6 months compared to the historical rain in the same period (Tables 1 and 2).

SPI duration	Phenomena reflected	Application
1 month SPI	Short term conditions	Short-term soil moisture and crop stress (especially during the growing season)
3 month SPI	Short and medium term moisture conditions	A seasonal estimation of precipitation
6 month SPI	Medium term trends in precipitation	Potential for effectively showing the precipitation over distinct seasons.
9 month SPI	Precipitation pattern over a medium time scale	If SPI9<-1.5 then it is a good indication that substantial impacts can occur in agriculture (and possibly other sectors)
12 month SPI	Long term precipitation pattern	Possibly tied to streamflows, reservoir levels, and also groundwater levels

Table 1: SPI application adapted from [28].

Index Value	Class	SPI value	Drought severity class
SPI ≥2.0	Extremely wet	Above 0	No drought
1.5≤SPI<2.0	Very wet		
1.0≤SPI≤1.5	Moderately wet		
-1.0<SPI<1.0	Nearly Normal	0.0 to -0.99	Slight drought
-1.5<SPI≤-1.0	Moderate dry	-1.0 to -1.49	Moderate drought
-2.0<SPI≤-1.5	Severely dry	-1.5 to -1.99	Severe drought
SPI≤-2.0	Extremely dry	-2 and less	Very severe drought

Table 2: SPI based drought severity class, adapted from [27,28].

Coefficient of variation (CV) were also computed using CV = (\frac{S}{\Biggl})*100 where, \bar{x} is the long term mean of rainfall over a period of observation, and S is standard deviation. If CV< 20, variability of rainfall will be less, otherwise variability will be moderate when 20 < CV <30, high CV >30, very high CV>40, and CV>70% as extremely high [29,30].

Results and Discussion

Spatial-temporal variability or trends of temperature and rainfall in North Shewa Zone

Maximum and minimum temperature: In this study three agroecological zone such as Woyena Dega (sub-tropical), Kolla (semi-arid) and Dega (cool, humid, highlands) districts were selected using by representative Alem ketema, Ataye, and Debre berhan meteorological stations, respectivly. The maximum temperature Mk trend analysis for Ataye station which is semi-arid indicated significantly increasing for all seasons. In Debre berhan station which is humid or highland the maximum temperature trend anlysis indicated significantly increasing for Belg (FMAM) season, whereas there was no trend for Kiremt (JJAS) or Bega (DJON) plus postive Sen's slope. The maximum temperature trend analysis in Alem ketema station (sub-tropical) indicated significantly decreasing for Kiremt

Citation: Shefine BG (2018) Analysis of Meteorological Drought Using SPI and Large-Scale Climate Variability (ENSO)-A Case Study in North Shewa Zone, Amhara Regional State, Ethiopia. Hydrol Current Res 9: 307. doi:10.4172/2157-7587.1000307

season, while there was significantly increasing for Belg or Bega season.

The minimum temperature trend of Ataye station indicated significantly increasing for Kiremt and Bega seasons, while there was no trend plus +ve Sen's slope for Belg season. The Kiremt season minimum temperature was significantly increasing for three stations. In Debre berhan station there was no significant trend in minimum temperature for Bega and Belg seasons, while the Sen's slope was positive. In addtion to Kiremt Belg also showed significantly increasing trend of minimum temperature in Alem ketema station but there was no trend in bega. In general the Sen's slope was positive for all stations and minimum, maximum temperatures. Most of the seasons in semi-arid station showed significantly increasing trend of maximum and minimum temperatures, whereas the humid or highland district seasons indicated less significantly increasing trend of maximum and minimum temperatures (Figure 2).

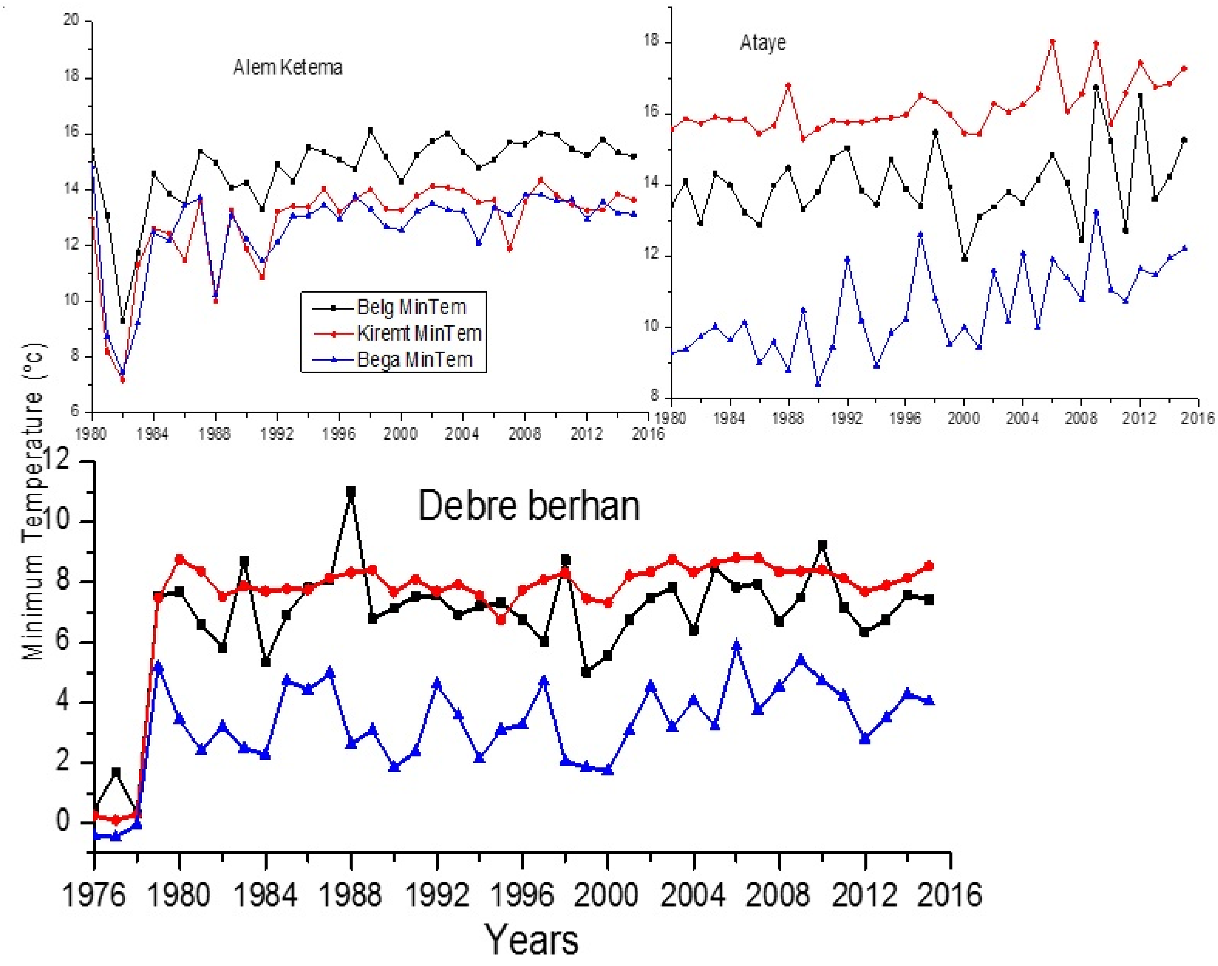

Figure 2: Temperature maximum in the top panels and minimum in the lower panels in three agro-ecological zones of North Shewa Zone.

Variability or trends of rainfall

For trends of rainfall, maximum and minimum temperatures the MK test was applied and there have been significant increasing trends in maximum, minimum temperature as compared to the rainfall. In all of the seasons and agro-ecological zones there were no significant trend of rainfall though the Sen's slope indicated negative or decreasing signal except Bega season in Debre berhan station that showed increasing signal in rainfall. In contrast to the temperature the rainfall trend showed insignificantly decreasing signal in three of the agro-ecological zones. The highest mean monthly Kiremt seasonal rainfall was recorded in Alem ketema station (214.56 mm) that is sub-tropical district and the lowest was registered in Ataye station (152.64 mm) that is semi-arid distric according to the analysis of the present datasets. Standard deviations used to quantify the amount of variation in recorded data so that those two rainfall stations also recorded the maximum (39.03 mm) and minimum (35.02 mm) standard deviations respectively. The highest mean monthly Belg season rainfall was recorded in Ataye station (29.78 mm), whereas the lowest was registered in Debre berhan station (15.71 mm). The coefficients of variation (CV) for Kiremt season were less for Debre berhan (18.76) and Alem ketema (18.18) stations, though the Ataye station (22.95) showed moderate variability. The Belg season rainfall showed high variability as compared to Kiremt season in all stations. The CV for Belg showed high variability for Debre berhan (38.77), and very high variability for Alem ketema (57.20) plus Ataye (41.02) (Figure 3).

Citation: Shefine BG (2018) Analysis of Meteorological Drought Using SPI and Large-Scale Climate Variability (ENSO)-A Case Study in North Shewa Zone, Amhara Regional State, Ethiopia. Hydrol Current Res 9: 307. doi:10.4172/2157-7587.1000307

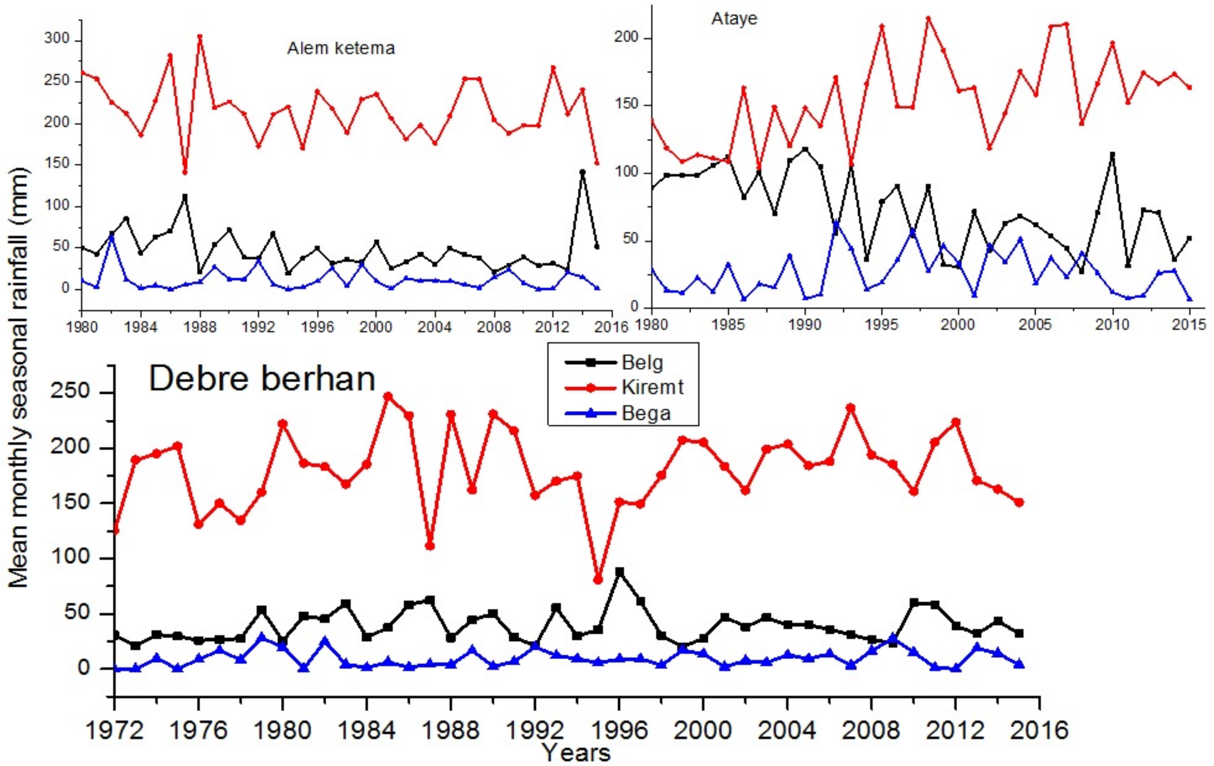

Figure 3: Seasonal rainfall variability and trends of three agro-ecological zones.

Standard Precipitation Index (SPI) analysis

The SPI 6 months of April and May for Belg season as well as June and July for Kiremt seasons were selected to check the medium trends of rainfall condition over distinct seasons. The SPI 6 months used to track the long-term meterological drought pattern in both of the rainy seasons in the three agro-ecolgical zones.

Debre berhan station in upper panel of Figure 4, the six month SPI for Belg season (April and May) showed that, there are dry and wet events happened in the district. The SPI value greater than one meaning that moderately, very or extremely wet years in Belg (April and May) were 1979, 1996, and 2010, but April or May alone Belg season wet years were 1981, 1983, 1987, 1990, and 2003. The Belg season (April and May) severly dry (-2.0<SPI≤-1.5) years were 1973, and 1999, but April alone Belg season severly dry years were 1984, 2008 and 2015. The Belg season (April and May) moderately dry (-1.5<SPI≤-1.0) years were the same to severly dry years. The Kiremt season (June and July) moderately, very or extremely wet years were 1986, 1996, 1997 and 1998 but June or July alone years were 1979, 1990 and 2011. In kiremt season, there was no severly dry year for both June and July but June alone severly dry year were 1973, and 1999. In the same season July alone severly dry years were 1977, 1978, 1987 and 2015. The Kiremt season (June and July) moderately dry years were 1973 and 1992, but June or July alone moderately dry years were 1976, 1977, 1978, 1987, and 2009.

Ataye station in middle panel of Figure 4, the six month SPI for Belg season (April and May) extreme dry events occurred in 2008 but April only occurred in 2000 and 2011. The Belg season (April and May) severly dry years were in 1999, 2000, 2008, and 2011, but April or May alone years were in 1994, 2011, and 2014. The Belg season (April and May) moderately dry events occurred in the same year to severly dry years. The Belg season (April and May) moderately, very or extremely wet years occurred in 1990, and 1993 but April or May alone events occurred in 1987, 1996, 2004, and 2010. The kiremt season (June and July) moderately, very or extremely wet years occurred in 1990 and 2010 but June or July alone events occurred in 1985, 1987, 1989, 1993, 1996, and 1998, whereas extreme dry events occurred for June and July in 2000, plus July alone in 1992. The kiremt season (June and July) severely dry event occurred in 1994 and 2000 but June or July alone events occurred in 1992, 2002, 2008 and 2011. The kiremt season (June and July) moderately dry events occurred in 1994, 2000, 2008 and 2011 but June or July alone events years were in 1999, 2002, 2014, and 2015.

Alem ketema station in lower panel of Figure 5, the Kiremt season (June and July) moderately, very or extremely wet events occurred in 1986, 1996 and 2014 but June or July only events occurred in 1983, 1987, 1988, and 2000. Month of June extremely, severely, and moderately dry events occurred in 1999, 2009, and 1988, respectively. Monthly July severely dry events occurred in 1999 and moderately dry event occurred in 1982, 1992, 1995, 2004, 2010, 2011 and 2015. The Belg season (April and May) moderately, very or extremely wet events occurred in 1983, 1987, 1990, and 2014 but April alone events occurred in 1993. The year 1999 was extremely and severely dry year for Belg season (April and May) along with April severely dry in the year 2008. The Belg season (April and May) moderately dry events occurred in 1994, 1999, and 2008 but April or May only events occurred in 1984, and 2015.

Citation: Shefine BG (2018) Analysis of Meteorological Drought Using SPI and Large-Scale Climate Variability (ENSO)-A Case Study in North Shewa Zone, Amhara Regional State, Ethiopia. Hydrol Current Res 9: 307. doi:10.4172/2157-7587.1000307

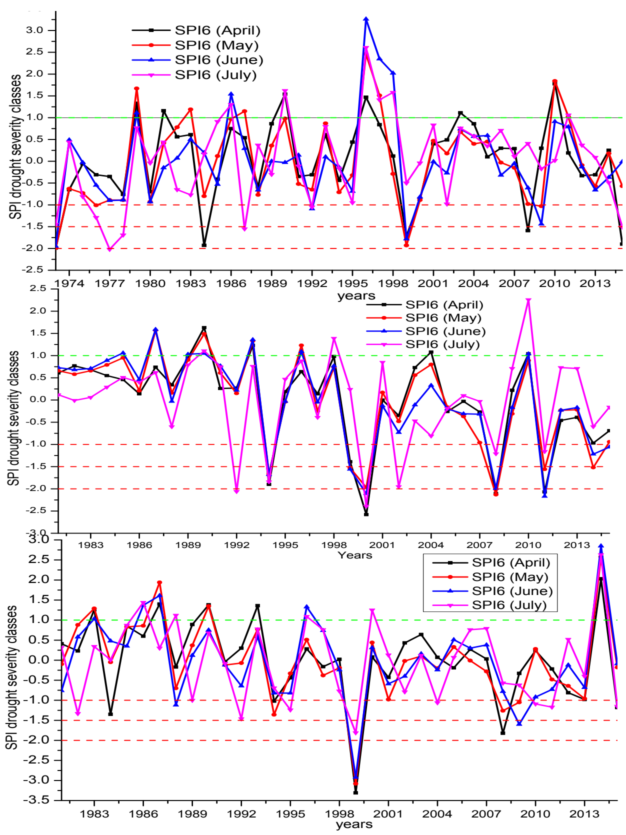

Figure 4: Drought severity classes of Debre berhan in upper panel, Ataye in middle panel and Alem ketema station in the lower panel for two months of Belg and Kiremt seasons.

The effect of ENSO to regional rainfall variability: The influence of El Niño Southern Oscillation (ENSO) events to the zone rainfall was assessed. If NINO3.4 SSA >2, b/n 1 and 2, b/n 0.7 and 1, and b/n 0.5 and 0.7, the ENSO events were classified as super, major, moderate and minor El Nino, respectively. The converse was true for La Niña events. Considering the annual NINO3.4, the major El Nino years were in 1982, 1987, 1997 and 2015, whereas the major La Niña years occurred in 1988, 1999, and 2000. The moderate El Nino years occurred in 2002, but the moderate La Niña years were in 2008 and 2011. The minor El Nino years were in 1991, 1992, 1997 and 2015, whereas the minor La Niña years occurred in 1984, and 1985.

When we consider the Kiremt season NINO3.4, the major or moderate El Nino years are similar to the annul consideration, but the major La Niña years occurred 1988, 1998, and 1999. There was no moderate La Niña year when we consider the Kiremt season NINO3.4. The minor El Nino years were in 1991, 2004, 2009 and 2012, whereas the minor La Niña years occurred in the same year to that of annual consideration including 2007.

The Belg season NINO3.4 consideration indicated 1983, 1987, 1992, and 1998 as major El Nino years, while major La Niña years were in 1989, 1999, 2000 and 2008. The moderate El Nino year was 2015, whereas the moderate La Niña years occurred in 1985, and 2011. The minor El Nino and La Niña years occurred in 2010 and 1996, respectively. In Debre berhan station in Kiremt season correlation between rainfall and Niño 3.4 SSTA was -0.37, while in the Belg season the correlation was 0.42. In Alem ketema station the correlation between Kiremt rainfall and Niño 3.4 SSTA was -0.33, while in the Belg season it was 0.41.

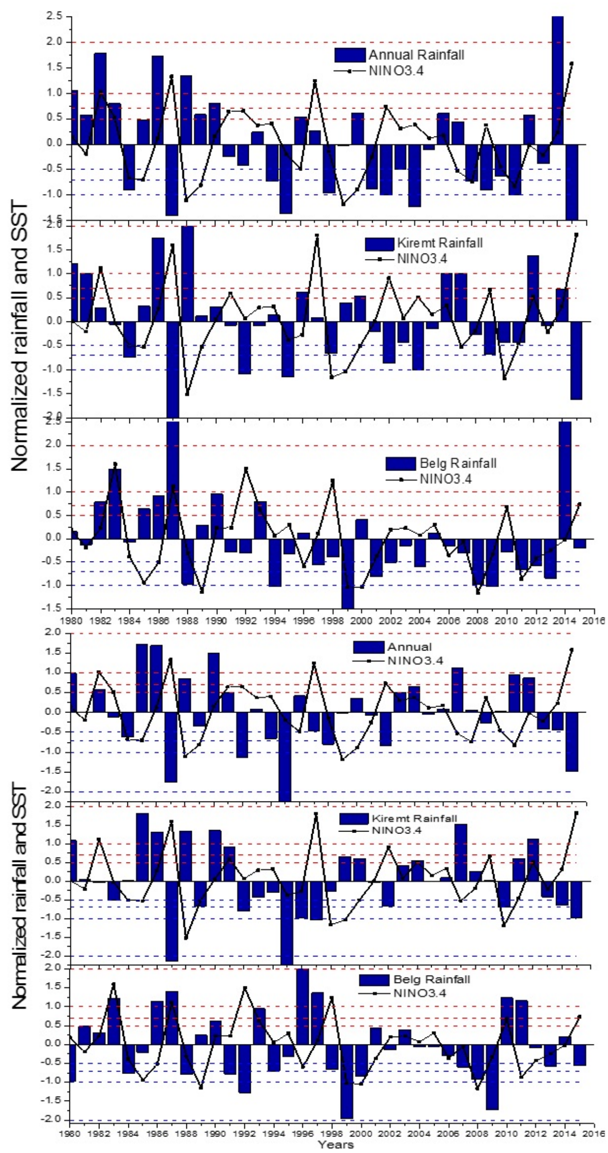

Figure 5: normalized rainfall from Debre berhan station in the lower panel and Alem ketema station in upper panel associates with SSTA.

In Ataye station the correlation between Kiremt rainfall and Niño 3.4 SSTA was -0.43, while in the Belg season it was 0.53. The correlation result indicated that influence of ENSO was a little bit higher in semi-arid district as compared to other agro-ecological zones. In most of the years a negative SSTA, La Nina (cooling) was associated with rainfall deficiency in Belg season but increase rainfall in Kiremt season. Similar to other studies a positive SSTA, El Nino (warming) was mostly associated with normal and above-normal rainfall amounts in Belg season and low rainfall in Kiremt season [7-9]. The decreasing of rainfall associated stronger El Nino (warming) events was higher in Ataye (semi-arid) district as compared to other agro-ecological zones. In some of the years there have been high rainfalls, although the years were considered as El Nino (warming) and vice versa, particularly that might be due to the complex relationship or interaction of ocean-atmosphere and land along with other components and other rainfall bearing systems in the region (Figure 6). In general, most of the results are similar to the previous studies in the region except higher or lower degree of variability and correlation variation from place to place [11-13].

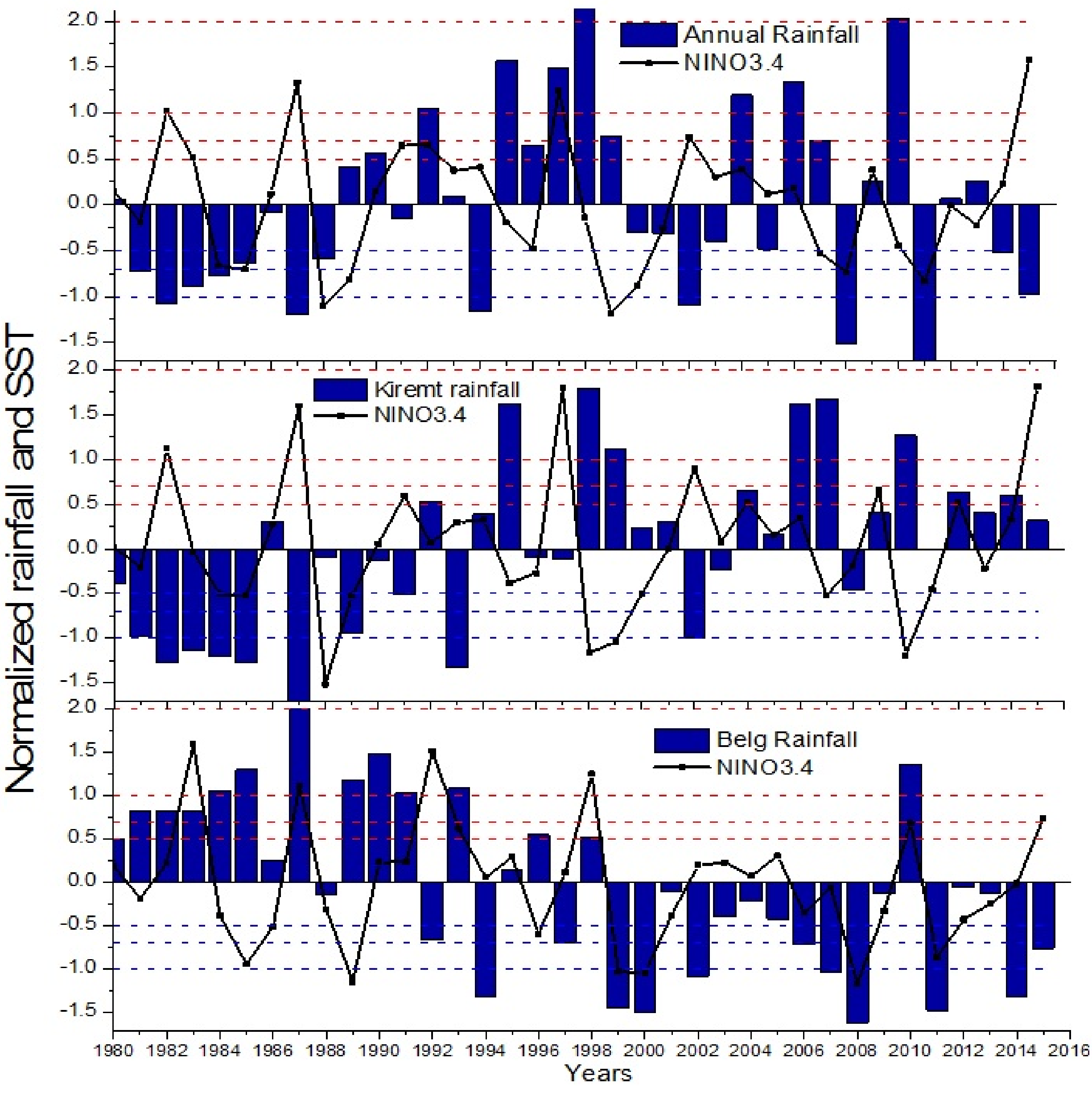

Figure 6: Normalized rainfall from Ataye station associates with SSTA.

Conclusions

In this study the spatiotemporal variability or trends of rainfall, maximum and minimum temperatures from three different agro-ecological zones of North Shewa zone such as Woyena Dega (sub-tropical), Kolla (semi-arid) and Dega (cool, humid, highlands) districts were presented. Moreover, the SPI 6 months of April and May for Belg season as well as June and July for Kiremt seasons were analyized to track the long-term meterological drought pattern in both of the rainy seasons in the three agro-ecolgical zones. The three meteorological stations such as Alem ketema (sub-tropical), Ataye (semi-arid), and Debre berhan (cool, humid, highlands) were selected to analyis both the SPI and spatiotemporal variability or trends of rainfall, maximum and minimum temperatures. The influence of El Niño Southern Oscillation (ENSO) events to the North Shewa zone rainfall was assessed.

For trends of rainfall, maximum and minimum temperatures the MK test was applied and there have been significant increasing trends in maximum, minimum temperature as compared to the rainfall. The mean seasonal maximum and minimum temperatures showed warming trends in most of the seasons, particularly in sub-tropical and semi-arid districts for the period 1980-2015. The Sen's slope was positive for all stations and minimum, maximum temperatures though there has been no trend especially in humi or highlands district. The mean Belg season maximum and minimum temperatures showed warming trends for three agro-ecolgical zones, whereas the other seasons indicated either warimg or no trend in one of the districts. The Kiremt season minimum temperature was significantly increasing for three stations. In all of the seasons and agro-ecological zones there were no significant trend of rainfall though the Sen's slope indicated negative or decreasing signal except Bega season in Debre berhan station that showed increasing signal in rainfall. The coefficients of variation (CV) for Kiremt season were less for Debre berhan (18.76) and Alem ketema (18.18) stations, though the Ataye station (22.95) showed moderate variability. The Belg season rainfall showed high variability as compared to Kiremt season in all stations. The semi-arid district rainfall was highly inconstant as compared to sub-tropical and humid districts.

The debre berhan (cool, humid, highlands) station Belg seaon (April and May) SPI 6 month result indicated that 1979, 1996, and 2010 were wet years, while the year 1973 and 1999 were dry. Simialrly in Kiremt season (June and July) dry events occurred in 1973 and 1992, but the wet event occurred in 1986, 1996, 1997 and 1998. Alem ketema station (sub-tropical) Kiremt season (June and July) wet events occurred in 1986, 1996 and 2014 but there was no dry event year for both months. In the same station, the Belg season (April and May) wet events occurred in 1983, 1987, 1990, and 2014, while dry events occurred in 1994, 1999, and 2008. Ataye station (semi-arid) Belg season (April and May) dry events occurred in 1999, 2000, 2008, and 2011, while the wet events occurred in 1990, and 1993. In the same station, the kiremt season (June and July) wet years occurred in 1990 and 2010, whereas extreme dry events occurred in 1994, 2000, 2008 and 2011. In all stations, if one month alone SPI were considred such April, May, June or July, there would have been few more years with either dry or wet events. The Belg season wet events years were higher in Alem ketema station (sub-tropical) district as compared to humid and semi-arid districts, whereas the dry event years were higher in Ataye (semi-arid) district. The Kiremt season dry events years were also much higher in Ataye (semi-arid) district as compred to other district, whereas the wet events yeasr were higher in debre berhan (cool, humid, highlands) district.

The major El Nino years were in 1982, 1987, 1997 and 2015, whereas the major La Niña years occurred in 1988, 1999, and 2000. The moderate El Nino years occurred in 2002, but the moderate La Niña years were in 2008 and 2011. The minor El Nino years were in 1991, 1992, 1997 and 2015, whereas the minor La Niña years occurred in 1984, and 1985. In Debre berhan station in Kiremt season correlation between rainfall and Niño 3.4 SSTA was -0.37, while in the Belg season the correlation was 0.42. In Ataye station the correlation between Kiremt rainfall and Niño 3.4 SSTA was -0.43, while in the Belg season it was 0.53. In most of the years a negative SSTA, La Nina (cooling) was associated with rainfall deficiency in Belg season but increase rainfall in Kiremt season. The decreasing of rainfall associated stronger El Nino (warming) events was higher in Ataye (semi-arid) district as compared to other agro-ecological zones. The higher decreasing of Belg rainfall in semi-arid district or Kiremt rainfall have strong association with ENSO, so at least rough prediction of ENSO would be helpful for the region agricultural activities and water management.

Acknowledgement

The author gratefully appreciates to groups producing SST dataset (the oceanic ENSO indices by NOAA/NWS/CPC) and the Ethiopian National Meteorology Agency for providing observed meteorological datasets.

References

1. IPCC (2014) Climate Change: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Edenhofer O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner S, et al. (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
2. Palmer WC (1965) Meteorological droughts. US Department of Commerce, Weather Bureau Research Paper, pp: 45-58.
3. Gebre SL, Getahun YS (2016) Analysis of Climate Variability and Drought Frequency Events on Limpopo River Basin, South Africa. Hydrol Current Res 7: 249.
4. Kwak J, Kim S, Jung J, Singh V, Lee D, et al. (2016) Assessment of Meteorological Drought in Korea under Climate Change. Advances in Meteorology.
5. Philander SG (1990) El Niño, La Niña, and the Southern Oscillations. Academic Press, p: 293.
6. Glantz MH, Katz RW, Nicholls N (1991) Teleconnections Linking Worldwide Climate Anomalies, Cambridge University Press, p:535.
7. Seleshi Y, Zanke U (2004) Recent changes in rainfall and rainy days in Ethiopia. Int J Climatol 24: 973-983.
8. Korecha D, Barnston AG (2007) Predictability of June-September Rainfall in Ethiopia. Monthly Weather Review 135: 628-650.
9. Zaroug M (2010) The connections of Pacific SST and drought over East Africa.DEWFORA meeting at ECMWF, Improved Drought Early Warning and FORecasting to strengthen preparedness and adaptation to droughts in Africa (DEWFORA), United Kingdom, October 4-5.
10. Degefu MA, Rowell DP, Bewket W (2017) Teleconnections between Ethiopian rainfall variability and global SSTs: Observations and methods for model evaluation. Meteorol Atmos Phys 129: 173-186.
11. National Meterological Service Agency (NMSA) (1996) Assessment of drought in Ethiopia. In: Meterological Research Report Series, Addis Ababa.
12. Woldegeorgis T (1998) Reducing the Impacts of Environmental Emergencies through Early Warning and Preparedness: The Case of the 1997-98 El Niño.
13. The Impact of Cold Events on Ethiopia.
14. Legesse G (2010) Agricultural drought assessment using remote sensing and GIS techniques. Addis Ababa University, Department of Earth Science.
15. FAO (2010) Africa: Climate change challenges agriculture.
16. ICPAC (2012) Climate Variability, Early Warning and Food Security:Icpac Experinces in The Greater Horn of Africa (Gha). IGAD Climate Prediction and Applications Centre (ICPAC).
17. Borgomeo E, Vadheim B, Woldeyes FB, Alamirew T, Tamru S, et al. (2017) The Distributional and Multi-Sectoral Impacts of Rainfall Shocks: Evidence From Computable General Equilibrium Modelling for the Awash Basin, Ethiopia.
18. Tilahun H, Teklu E, Michael M, Fitsum H, Awulachew AB (2011) Comparative Performance of Irrigated and Rainfed Agriculture in Ethiopia. World Applied Sciences Journal 14: 235-244.
19. Haile T (1988) Causes and characteristics of drought in Ethiopia. Ethiopian Journal of Agricultural Science 10: 85-97.

20. Aregay W (1999) Exploratory Study of two regions in Ethiopia to Identify target areas and partners for intervention. Drylands Coordination Group.
21. NSHSB (2007) North Shewa Highland Sheep and Barley, livelihood profile Amahra, region, Ethiopia.
22. Tilahun A, Terefe H, Soromessa T (2015) The Contribution of Ethiopian Orthodox Tewahido Church in Forest Management and Its Best Practices to be Scaled up in North Shewa Zone of Amhara Region, Ethiopia. Agriculture, Forestry and Fisheries.
23. Romilly, Gebremichael (2010) Evaluation of satellite rainfall estimates over Ethiopian river basins. Hydrol. Earth Syst Sci 15: 1505-1514.
24. Degefu W (1987) some aspects of meteorological drought in Ethiopia, Cambridge University Press.
25. NMSA (1990) Seasonal Weather Outlook of Kiremt. NMSA mimeograph. Addis Ababa, Ethiopia: NMSA.
26. Sileshi Y, Demarée GR (1995) Rainfall variability in the Ethiopian and Eritrean highlands and its links with the Southern Oscillation Index. J Biogeogr 22: 945-952.
27. Teferra B (2007) Investigating production, processing, and market opportunities of pulse crops in north Shewa of Amhara region. Debre Birhan Agricultural Research Center. Debre Birhan, Ethiopia. Proceedings of the 2m annual regional conference on completed crop research activities.
28. McKee TB, Doesken NJ, Kleist J (1993) The relationship of drought frequency and duration to time scales. In Proceedings of the 8th Conference on Applied Climatology, Anaheim, Calif, January 17-22. American Meterological Society.
29. WMO (2012) Standardized Precipitation Index User Guide.
30. Asfaw A, Simane B, Hassen A, Bantider A (2017) Variability and time series trend analysis of rainfall and temperature in north central Ethiopia: A case study in Woleka sub-basin.