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Drought and Flood Occasion under the Influence of El-Nino and La-Nina Phenomena in Gurage Zone

A Senior Research in Partial Fulfillment of the Requirements for the Bachelor of Science Degree in Natural Resource Management

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LIST OF ABBREVIATION

ENSO	El-Nino and La-Nina Oscillation
IPCC	Intergovernmental panel on climate change
ITCZ	Inter Tropical Convergence Zone
NGOs	Non-Governmental Organizations
NMA	National Metrological Agency
SOI	Southern Oscillation Index
SPI	Standardized Precipitation Index
SST	aSea Surface Temperature
WHO	World Health Organization

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ABSTRACT

Drought and flood issues are major problem in Ethiopia as well as hectic at the regional level. It affect the agricultural system and water resources through reduction of soil moisture or insufficient rain fall duringEl-Niño and washing away of soil nutrient, top soiland property destruction during La-Niña condition.In light of this, a study was conducted in Gurage Zone to analyze drought and flood occasion under the influence of El-Nino and La-Nina phenomena. The spatio-temporal variability of droughts and flood in Gurage Zone were analyzed to detect drought and flood events using the standardized precipitation index at SPI12 time scales based on 29 year (1989-2017) rainfall data.The annual rainfall in the four stations showed a significant decreasing and increasing trend at Wolkite station but there was non-significant negative trend at Butajira station. During the period of study, the largest negative deviation was occurred during the year 2017, 1992, 2016, 2012, and 2017 and the highest positive anomalies was registered during year 1993, 2010, 1992, 2010, and 2005 at Mareqo, Cheha, Abeshge, Sodo and Mesikan districts, respectively. In 1992, 2012, 2016 and 2017 an El-Nino event occurred across the entire study area, 5 out of 5 districts experienced drought. In 1993, 2010, 1992, 2010, and 2005 a La-Lina event occurred across the entire study area, 5 out of 5 districts experienced flood condition. In the study area like Cheha, Mesikan and Mareqo recorded extreme drought with risk peak value was above -2 while Abeshge and Sodo districts recorded severe drought with risk peak value was –1.8 and -1.63 respectively. In contrary, Sodo woreda, Abeshge and Mareqo recorded extreme wet condition with risk peak value was above +2 whereas Mesikan and Cheha districts recorded severe wet with risk peak value was +1.92 and +1.94 where they are considered the most abundant rainfall in the area, respectively. The study result indicated that the study area is experienced in unpredictable drought and flood events with different time period. Such research is importantin strategic planningand operational applications like drought and flood monitoring. Therefore, the local government, NGOs and others concerned body should provide platform for early warning preparedness, drought and flood monitoring strategies in the area.

Key words: Drought, flood, El-Niño, La-Nina

1. INTRODUCTION

1.1.Background

In recent years Ethiopia has seen in substantial investments in agriculture through theGovernment of Ethiopia’s Agricultural Growth Program me, the Feed the Future Program of the United States Government, and programs supported by a range of other donors. However, the economy of Ethiopia and the food security of its Population are highly dependent on agriculture which is rain-fed, and therefore, Susceptible to drought. Ethiopia refers to failed or poor rains, which in part relate to El Niño weather events (Meehl,*et a*l 2000).

In earlyJune2015 Ethiopia’s National Meteorological Agency (NMA)reported that the important spring *belg*rains of March to May, had failed. Second, an emerging El Niño episode was associated with the delayed onset of the main summer *kiremt*rains, normally falling in June to September. The last major El-Niño event in 1997 to1998 led to severe droughts in the Sahel and the Indian Subcontinent as well as severe Flooding in parts of East Africa. While difficult to predict, scientists reported that El Niño in2015 would be the strongest on record and in part, this played out in other parts of the World in terms of flooding and above average rainfall.

In Ethiopia a very severe drought took hold in large parts of the Ethiopian highlands, and Afar and northern Somali regions, and a major humanitarian response began The current crisis in Ethiopia is being labeled an ‘El Niño crisis’ or similar, but the drought is More due to a succession of weak or failed rains which in some areas, date back to mid2014. While the El Niño event of 2015 can be associated with the erratic and poor summer Rains in parts of Ethiopia, the impacts of the drought are an accumulation of pre-El-Niño and El-Niño related declines in rainfall. The most important feature of sea surface temperature variability that can cause large scale weather disruptions is El Niño and its counterpart La Niña (Goddard *et al*., 2001).

According to Nicholls (1991) ENSOand local rainfall relationship has been made of correlation and regression methods in attempting to establish evidence of “teleconnections” that affects local rainfall patterns. Accordingto (Korecha and Barnston 2007),in Ethiopia ENSO events have strongly linked with various atmospheric system and rainfall distribution. The principal cause of drought in Ethiopia is asserted to be the fluctuation of the global atmospheric circulation, whichis triggered by SSTa, occurring according to ENSO events. The phenomena have significant impact on displacement and weakening of the rain producing system in the seasons. ENSO episodes and other regional systems have impact on seasonal rainfall performance and rainfall variability over Ethiopia due to remote teleconnectionssystem (Gissila, 2001).

Hence, most of the drought years were recorded during *kiremt*season's El Niño episode. SinceAgriculture is heavily dependent on rainfall productivity and production are strongly influenced by climatic and hydrological variability due to ENSO phases. In Ethiopia, the degree of crop yield variability over time is determined by the amount, pattern, and frequency of rainfall (Lemi, 2005).

1.2. Statement of the problem

Drought and flood issues are major problem in the country as well as at the regional level concern. It affect the agricultural system through reduction of soil moisture or insufficient rainfallduringEl-Niño and washing away of soil nutrient during La-Niña condition. So these conditions are very serious and reduce productivity, affectsall sector including health system.Gurage zone is part of Ethiopian recurrently affected by El-Niño and La-Niña hazard. Therefore, this research try to provide information on temporal and spatial variation of El-Niño and La-Niña condition. The output of the research will important for decision maker in strategic planningand operational applications like drought and flood monitoring in the study area.

1.3. General objective

To assess the drought and flood occasion under influence of El-Nino and La-Ninaphenomena inGurage zone

1.4. Specific objectives

- To identifyextreme and peak risk period in the study area
- To assess the spatial and temporal distribution of El-Niño and La-Nina in the region

2. LITERATURE REVIEW

2.1. The concept of El-Niño and La-Nina

El-Nino is a warming of the tropical Pacific that occurs roughly every three to seven years and lasts for12–18 months. It is dynamically linked to the Southern Oscillation, a see-saw in surface atmospheric pressure between the Australian East Asian region and the eastern tropical Pacific. During El Nino, the trade winds weaken along the equator as atmospheric pressure rises in the western Pacific and falls in the eastern Pacific. Weakened trade winds allow warm surface water, normally confined to the western Pacific, to migrate eastward(Glantz, 2001)

Wind-driven upwelling, a process that brings cold water to the surface along the equator and along the west coasts of Northland South America, is also greatly reduced, causing sea surface temperatures to rise. Upwelled waters are rich in nutrients that support biological productivity, so that reduced upwelling adversely affects marine ecosystems and economically valuable fish stocks. The current crisis in Ethiopia is being labeled an 'El Niño crisis' or similar, but the drought isMore due to a succession of weak or failed rains which in some areas, date back to mid2014. While the El Niño event of 2015 can be associated with the erratic and poor summerLa-Nina is the cold phase of the ENSO cycle (Philander, 1990).

It is characterized by stronger than normal trade winds, colder tropical Pacific sea surface temperatures, and positive values of the SOI (southern oscillation index).It represents a situation in which oceanic and atmospheric processes which give rise to normal conditions are exaggerated, with deep convection and heavy rainfall along the equator shifted even further to the west and confined toa narrower range of longitudes. The term La-Nina (*the girl) was* coined in the mid-1980s by scientists investigating the year-to-year oscillations between warm and cold conditions in the tropical Pacific. La Niña has also been referred to as anti-El-Nino, ENSO cold event, and El Viejo (the old man). Like El-Nino, La Nina typically lasts 12-18months(Philander, 1990).

2.2. Cause of El-Niño and La-Nina

El-Nino and La-Nina events are naturaloccurrence in the global climate system resulting from variation in ocean temperature in the equatorial pacific. In turn changes in the atmosphere impact the ocean temperature and current system oscillate between warm El-Nino to neutral or cold La-Ninacondition.El-Nino is the opposite of La-Nina this occur when the easterly trade wind become weaker and some case blow in the opposite direction the pacific ocean during El-Ninobecome warm gain heat and push east ward during La-Nina period the sea surface temperature across the eastern and centralpacific ocean tend to be lower than normal temperature (Michael,2000,)There are many factors that cause floods in Ethiopia, including changes in land use and poor soil permeability when forests and grasslands are removed for the construction of roads and buildings, permeable soil is replaced by hard surfaces such as concrete. This reduces the infiltration of water into the ground and increases run-off, making flooding more likely. Failures of dams and reservoirs can also lead to floods. Many micro-dams have been constructed in Ethiopia for irrigation, water supply and generating hydroelectric power. Increase population, deforestation, agriculture explanationand climate change (El-Niño and La-Nina) are the main cause for drought and flood occurrences (Abaya *et al.*, 2009).

2.3. Effects of El-Nino and La- Niña

El-Niño and La-Niña have opposite effects on the climate. Even though both of these ocean currents occur far away from Ethiopia, they influence the route and speed of major airstreams and alter the pattern of rainfall around the world, so that some regions are wetter than average and others are drier (Waskom *et al*., 2013). The effects of El-Niño and La-Niña in Ethiopia depend on which of our two rainy seasons they occur in the *belg*season is from February to March and the *kirmt* season is from June to September. If El-Niño occurs during *belg*, it can cause above-normal rainfall, whereas if La-Niña occurs during *belg*, it causes below-normal rainfall. In contrast, if El-Niño occurs during *kirmt*, it decreases the seasonal rainfall, whereas La-Niña during *kirmit* increases rainfall above the normal level (NMA, 2006).

2.3.1.Effect on agricultural system

The El Niño impacts differ from region to region based on the sensitivity of agro-ecological zones that could be estimated based on past impacts. The historical assessment of crop production performance during different El-Niño years could give an idea to evolve scenarios of future impacts of El-Niño of various magnitude and duration and projected future impacts. It is not always, the agriculture sector will face negative consequences during El-Niño years. The drought like conditions induced by El-Niño might have different impacts on rain-fed and irrigated crop lands. The crops watered by irrigation are relatively less sensitive to short term precipitation fluctuations. Hence, an assessment has to holistically consider the region's agricultural history, current farming and irrigation practice, and recent climate and crop productivity (Riebsame, 1988).

It would increase rainfall, which could cause more flooding. Floods can contaminate our water resources and destroy the water supply and sanitation facilities pipes (Ethiopia Red Cross/Red Crescent, 2005). And it disrupt the land surface by enhancing soil erosion to wash away the soil nutrient ,top soil and root suffocation as a result of these La-Nina reduce agricultural productivity. So it highlyaffects the economy of the country. La-Niña episode and resulted in a severe food security and nutrition crisis that affected the lives and livelihoods of more than 12.5 million people living in the region's dry lands.

2.3.2. Effect on weather system

One impact of the eastward shift in rainfall along the equator during El-Nino is that drought develops in Australia, Indonesia and neighboring countries. On the other hand, the island states of the central Pacific and the west coast of South America are inundated with heavy rains. Heavy rainfall bands normally situated north and south of the equator in the Intertropical Convergence Zone and the South Pacific Convergence Zone also shift equator ward as surface waters warm. These latitudinal shifts contribute to unusually heavy rains near the equator in the central and eastern Pacific, and to drought conditions at higher latitudes in regions such as New Caledonia and Fiji to the south, and Hawaii to the north.Thus, although El-Nino increases the probability of a particular kind of weather pattern occurring in particular regions of the globe, actual impacts may vary from those expected for any given event(Trenberth*et al.*, 1998).

La-Nina, like El-Nino, affects tropical storm frequency, intensity, and geographical distribution through changes in sea surface temperature and atmospheric circulation. Pacific hurricanes, typhoons and cyclones are more restricted in their geographical extent because of colder underlying sea surface temperatures. On the other hand, Atlantic hurricanes tend to increase in number as the subtropical jet stream shifts La-Nina's effects on weather variability are roughly (though not exactly) opposite to those of El-Nino (Ropelewski ,1987). The atmospheric response to weak-to-moderate cold and warm tropical Pacific sea surface temperature anomalies tends to be similar in magnitude, but opposite in sign.

2.3.3. Effecton water resource

The changes in climate and weather characteristics (especially rainfall patterns) has a pronounced impact on runoff and the subsequent effects of changes in runoff on managed water supply systems (Riebsame, 1988). As the agricultural and domestic consumption heavily depend on the water resources, fluctuations in the water availability leads to serious damage.

2.3.4.Effecton health

The El-Niño and La-Nina caused shifting weather patterns such as severe drought, flooding, heavy rains and temperature rises can lead to food insecurity and malnutrition, disease outbreaks, acuteshortages, and disruption of health services (WHO, 2016). The health consequences will be more if the countries are having less capacity to cope with such threats (Table 1).

Table 1: Correlation between El-Nino and La-Nina with drought and flood in Ethiopia(Source: Abebe. 2011 and Kousky et al., 2001)

ENSO			Drought years in Ethiopia	Areasaffected inEthiopia	Severity
Year	Episode	Intensity			
06-07	El-Niño	Weak	2006-07	Southern Eth	6.4 million people wereaffected
07-08	La-Nina	Moderate	2007-08	Southern Eth	
09-10	El-Nino	Moderate	2009-10	Southern Eth	
10-11	La-Nina	Moderate	2010-11	Southern Eth	
11-12	La-Nina	Weak	2011-12	Southern Eth	
15-16	El-Nino	Strong	2015-16	Afar and Sitiizone of Somaliregion	

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study was conducted in Gurage zone south west Ethiopia ,about 155 kilometer south west of Addisabeba,bordering the Awash River in the north ,the gibe river (the tributary of the omo river) to the south west and lake ziway in the east(Figure 1). Geographically located from 7^0 50’ 0’’ - $8^0$40’0’’N to 38^0 0’ 0’’E.

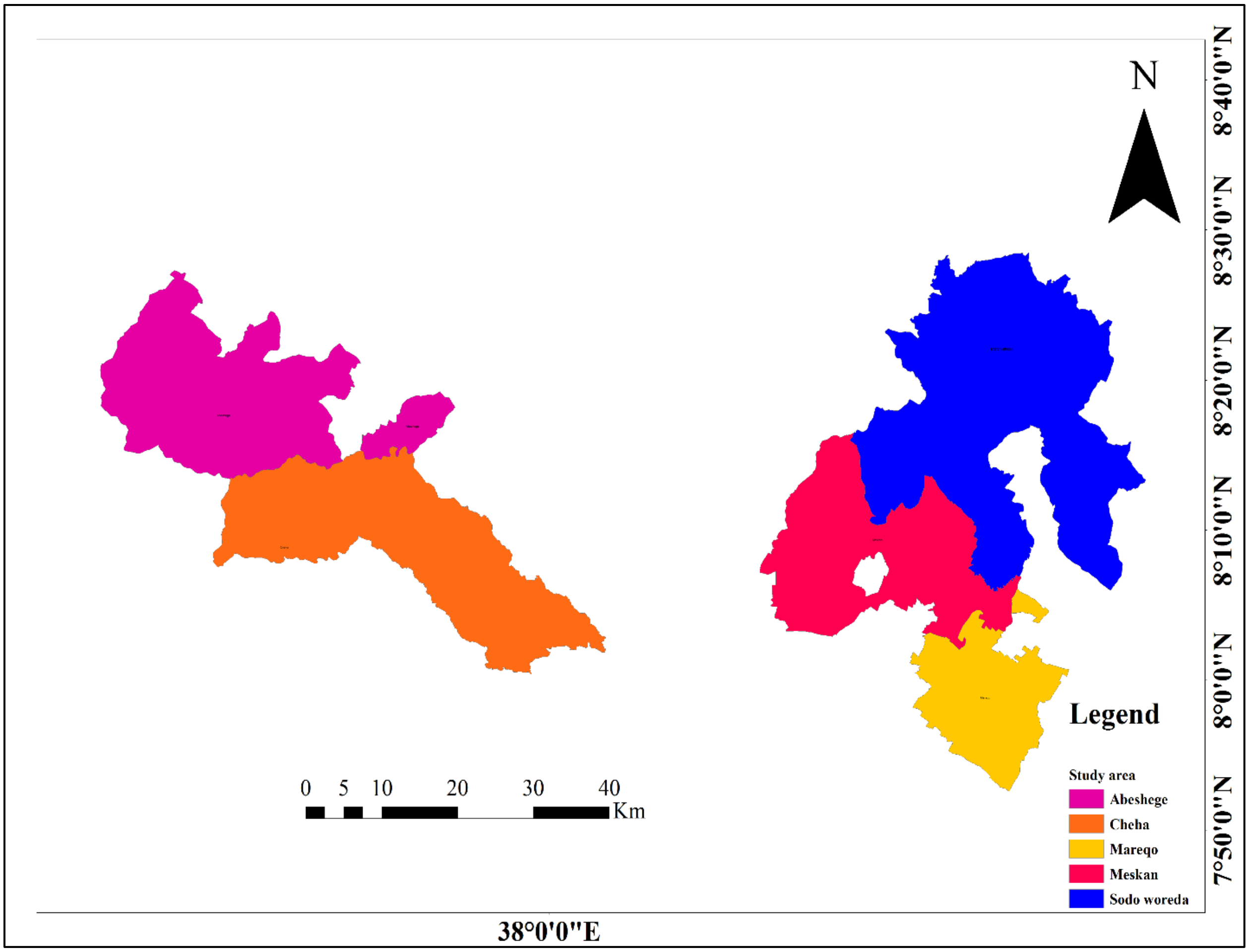

Figure 1: Map of study area

3.1.2. Population

Based on 2007 census conducted by the centralstatically Agency of this zone has total population of 1, 279, 646, of whom 622,078 are men and 655,568 women; with an area of 5,893.40 square kilometer. Gurage has a population density of 217.13.119, 822 are urban inhabitants. Total of

286,328 house hold were counted in this zone which results in average of 4.47 persons to house hold and 276,570 housing units.

3.1.3. Agricultural practice of the area

The Gurage live a sedentary life based on agriculture involving complex system of crop rotation and Trees planting. Gurage people are known as hardworker and as a model of good workerculture in the whole Ethiopia. Enset is the main stable food, but other cash crops are grown, which include coffee and khat both traditional stimulants animal husbandry is practice, but mainly for milk supply and dung. Other food consumed includes green cabbage, cheese, butter and roasted grains, with meat consumption being very limited also use in rituals and ceremonies.

3.2. Data set

Drought and flood occasion under the influence of El-Nino and La-Nina phenology has received a great deal of attention by researchers worldwide. Many studies have been conducted to illustrate El-Nino and La-Ninaphenomena and becoming comprehensive issue. The study emphases on detecting drought and flood occasion under the influence of El-Nino and La-Nina phonology for the 5 stations or district in the Gurage zone. Therefore, to study this phenomena daily archival rainfall data series for 29 years (1989-2017) of 5 stations were collected from the Ethiopia National Meteorology Agency (Table 2).

Table 2: Average annual rainfall and standard deviation (SD) in the study area

No.	Station name	Years	Meanrainfall(mm)	SD(mm)	Elevation(m)	Long.(E)	Lati.(N)
1	Imdibir	29	1174.11	290.81	2076	8.13	37.93
2	Wolkite	29	1191.89	389.36	2000	8.29	37.78
3	Butajira	29	984.04	402.45	2000	8.12	38.37
4	Bui	29	1063.12	206.62	2020	8.32	38.55
5	Koshe	29	801.86	187.27	1878	8.01	38.53

3.3. Missing data estimation

Missing data may be due to the absence of observer, short disturbances in observations due to breakage, malfunction and calibration problem of instruments during a certain time period, therefore we need to solve this before goingfor further analyses. Therefore, the missing values was patched using first order Markov chain model of In stat version 3.37 software.

3.4. Rainfall data consistency

The consistency of the rainfall data set was checked by the Double mass-curve method and a plot of average cumulative annual rainfall data (as ordinate) against with Abscissa.

3.5. Rainfall trend and model specification

Mann-Kendallmodel was used for the analysis of trend in rainfall from 1989 to 2017 time period. There are two benefits of using Mann-Kendall test. First, it is a non-parametric test and does not require the data to be normally distributed. Second, the test has low sensitivity to abrupt breaks due to inhomogeneous time series. Each data value is likened to all subsequent data values. If a data value from a later time period is higher than a data value from an earlier time, the statistic *S* is increased by 1. On the other hand, if the data value from the later time period is lower than a data value sampled earlier, *S* is decreased by 1. The net result of all such increments and decrements is one that determines the final value of S. The Mann-Kendall S Statistic is mathematically computed as follows:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign\ (T_j - T_i)$$

$$Sign\left(T_j - T_i\right) = \begin{cases} 1\ if\ T_j - T_i > 0 \\ 0\ if\ T_j - T_i = 0 \\ -1\ if\ T_j - T_i < 0 \end{cases}$$

Where T_j and T_i are the annual values in years j and i, j >i respectively.

A positive value of S indicates an increasing trend whereas a negative value indicates a declining trend in the data. At certain probability level H_0 is rejected in favor of H_1 if the absolute value of S equals or exceeds a specified value $S_{\alpha/2,}$where $S_{\alpha/2}$ is the smallest S which has the probability less than α/2 to appear in case of no trend. For n ≥ 10, the statistic *S* is approximately normally distributed with the mean and variance as follows:

$$E(S) = 0$$

The variance (σ^2) for the S-statistic is defined by:

$$\sigma^2 = \frac{n(n-1)(2n+5) - \sum t_i(i)(i-1)(2i+5)}{18}$$

In which t_i denotes the number of ties to extent i. The summation term in the numerator is used only if the data series contains tied values. The standard test statistic Z_s is calculated as follows

$$Z_s = \begin{cases} \frac{S-1}{\sigma} \, for \, S > 0 \\ 0 \, for \, S = 0 \\ \frac{S+1}{\sigma} \, for \, S < 0 \end{cases}$$

The test statistic $Z_s$is used as a measure of significanceof the trend. In fact, this test statistic is used to test the null hypothesis, H_o. If | Z_s| is greater than $Z_{\alpha/2}$, where α represents the chosen significance level then the null hypothesis is rejected implying that the trend is significant.

Another statistic obtained on running the Mann-Kendall test is Kendall's tau, which is a measure of correlation and therefore measures the strength of the relationship between the two variables. In common with other measures of correlation, Kendall's tau will take values between ±1 and +1, with a positive correlation indicating that the ranks of both variables increase together whilst a negative correlation indicates that as the rank of one variable increases, the other decreases.

3.6. Data analysis

The SPI was determined as the difference between the annual totals of a particular year and the long term average rainfall records divided by the standard deviation of the long term data. This index is used to observe the nature of the trends and also enables the determination of the extreme dry and wet years in the record. SPI was plotted against time (in years) to visualize and identify/select the extreme drought and flooding year in the time period for further analysis. In addition to this McKee *et al*. (1993) designed Standardized Precipitation Index for multiple time scales from 1-12 months was used to identify the drought and flooding phenomena of the area. Mathematically computed as:

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

Where, ***SPI*** is Standardized Precipitation Index; ***X*** is the annual rainfall total of a particular year; $\boldsymbol{\mu}$ is mean annual rainfall over a period of observation and$\boldsymbol{\delta}$ is the standard deviation of annual rainfall over the period of observation.

According to the classification scale for Standardized Precipitation Index values, a positive value of the SPI denotes that rainfall at study area is higher than average rainfall whereas a negative value of the SPI indicates that rainfall in the area is lower than normal rainfall (Source: XU *et al.* 2012; Pei *et al.* 2013). A region will be considered as extreme flood if the SPI value of the area greater or equal to +2.00 contrarily region considered as extreme drought if the SPI value of the area less than -2.00 or lesser (Table 3).

Table 3: Classification of SPI values (Source: XU *et al.* 2012; Pei *et al.* 2013)

SPI	Classification
$\geq$ 2.00	Extreme wet
1.50 to 1.99	Severe wet
1.00 to 1.49	Moderate wet
0.50 to 0.99	Mild wet
-0.49 to 0.49	Near normal
-0.99 to -0.50	Mild drought
-1.49 to -1.00	Moderate drought
-1.99 to -1.50	Severe drought
< -2.00	Extreme drought

Software used for performing the temporal variation of El-Niño and La-Nina in the regionwereInstat+v3.37 and DrinC**.**XLSTAT 2019 software was used for analyzing trend in annual rainfall. Software deployed for plottingthe spatial distribution of El-Niño and La-Nina in the region wasArcGIS 10.3.1.

4. RESULTS AND DISCUSSIONS

4.1. Data consistency

The consistency of the rainfall data set was checked by the double mass-curve method and a plot of average cumulative annual rainfall data (as ordinate) against with Abscissa (Figure 2). As you can see form figure the double mass curve assured that all station data were consistence owing that missed and outlier data were filled correctly.

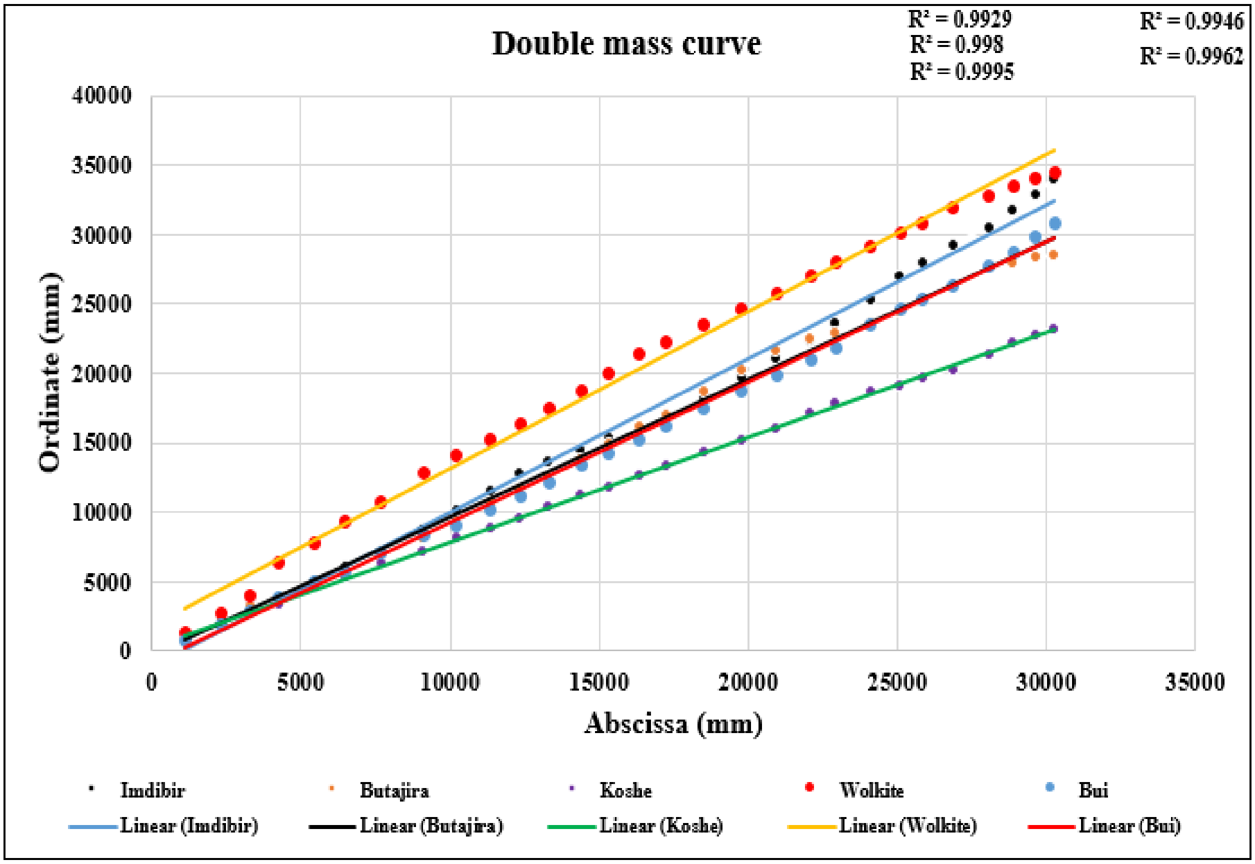

Figure 2: Double mass curve

4.2. Rainfall trend analysis

The annual rainfall in the four stations showed adecreasing trend by a factor of -0.18, -1.01, -0.67 and -0.62 mm per year at Imdibir, Bui,Butajira, and Koshe station respectively but had an increasing trend at Wolkite station (Table 4). The result of annual rainfall probability value showed significant trend atImdibir, Bui,Wolkite, and Koshe station but the negative trend at Butajira station is not statistically significant, which might be associated to large inter annual fluctuation. According to Hulme*et al.* (2001) and IPCC (2001), East Africa rainfall shows an increasing trend.Negash and Eshetu (2016) reported decreasing trendatChidastation (16.08mm/year) andButajira station (6.26mm/year).

Table 4. Mann-Kendall trend statistics of annual rainfall for representative station in Gurage zone

Station	Years	Sen's Slope	Z value	Mk statistic (S)	*P*-value
Imdibir	29	-0.18	-0.04	-17	0.001
Bui	29	-1.01	-0.38	-164	0.04
Butajira	29	-0.67	-0.11	-46	0.67
Koshe	29	-0.62	-0.09	-37	0.01
Wolkite	29	3.17	0.27	117	0.01

4.3. Temporal distribution of drought and flood events

Year-to-year variation of SPI is presented in terms of normalized anomaly index as shown in Figure 3. The study districts are experienced both wet and dry years over the study period. Of the observed 29 years, 51.7, 48.3, 44.83, and 55.17% recorded rainfall above long term average, but about 48.3, 51.7, 55.17, 55.17 and 44.83%was recorded below the long term average annual rainfall at Mareqo, Cheha, Abeshge, Sodo and Mesikan districts, respectively (Figure 3). The largest negative deviation was occurred during the year 2017, 1992, 2016, 2012, and 2017 and the highest positive anomalies was registered during year 1993, 2010, 1992, 2010, and 2005 at Mareqo, Cheha, Abeshge, Sodo and Mesikan districts, respectively (Figure 3). These findings were in conformity with study carried out by Kidane*et al*. (2010) about years of drought and floods in Ethiopia.

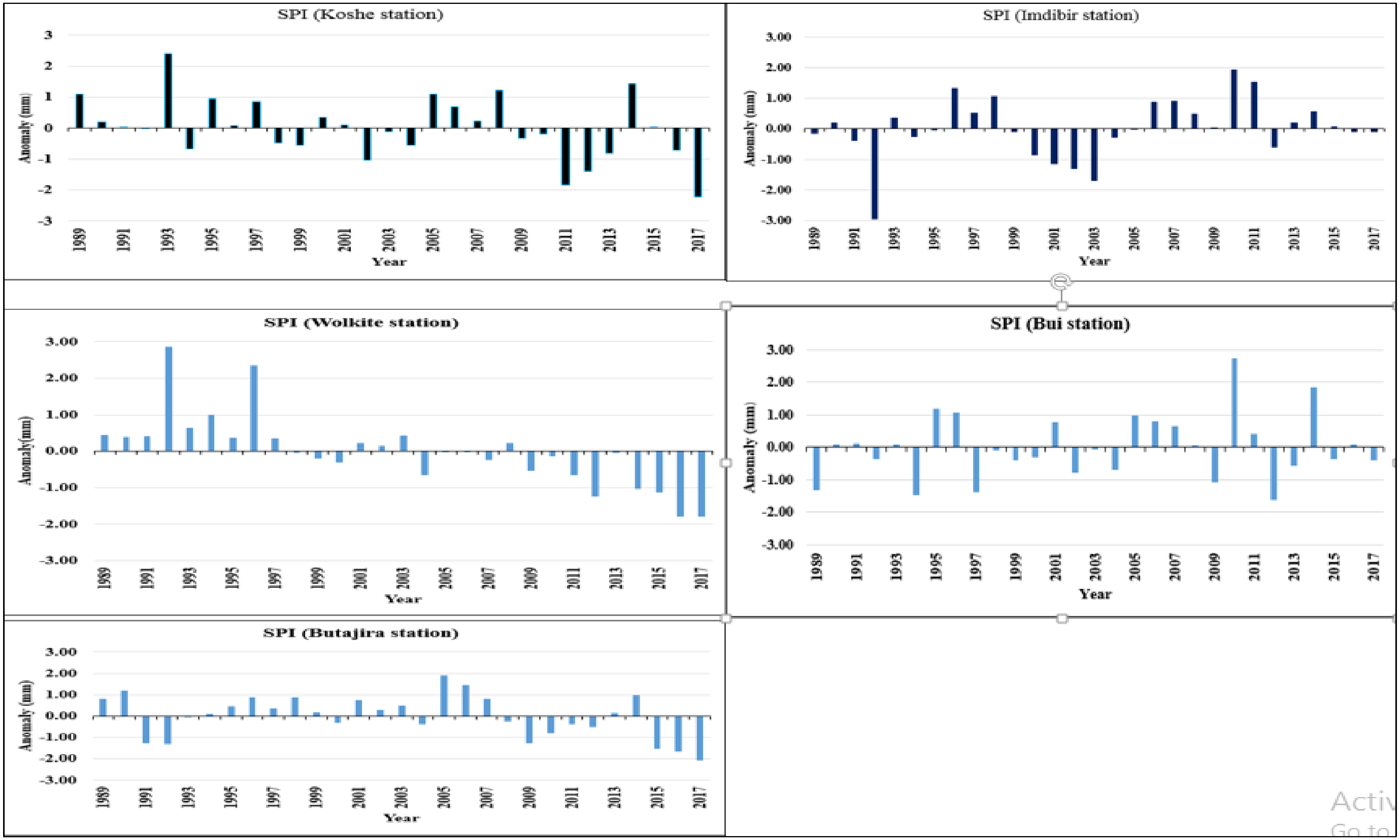

Figure 3: Temporal distribution of drought and flood events

4.4. Spatial distribution of drought and flood events in relation to El-Nino and La-Lina phenology

The spatial distributions of SPI12 drought time scales under the influence of the years of El-Nino and La-Lina phenomena (1989-2017) is presented in Figure 4 and Appendix Table 1. In 1992, 2012, 2016 and 2017 an El-Nino event occurred across the entire study area, 5 out of 5 districts experienced drought. In 1993, 2010, 1992, 2010, and 2005 a La-Lina event occurred across the entire study area, 5 out of 5 districts experienced flood condition.

In the study area like Cheha, Mesikan and Mareqo recorded extreme drought with risk peak value was above -2 while Abeshge and Sodo woredas recorded severe drought with risk peak value was -1.8 and -1.63 respectively (Figure 4 B). In contrary, Sodo woreda, Abeshge and Mareqo recorded extreme wet condition with risk peak value was above +2 whereas mesikan and Cheha districts recorded severe wet with risk peak value was +1.92 and +1.94 where they are considered the most abundant rainfall in the area, respectively (Figure 4 A). In general, during El-Nino phenomenon the area were experienced with water shortage whereas in La-Lina condition some part of Gurage zone was affected by flooding hazard.

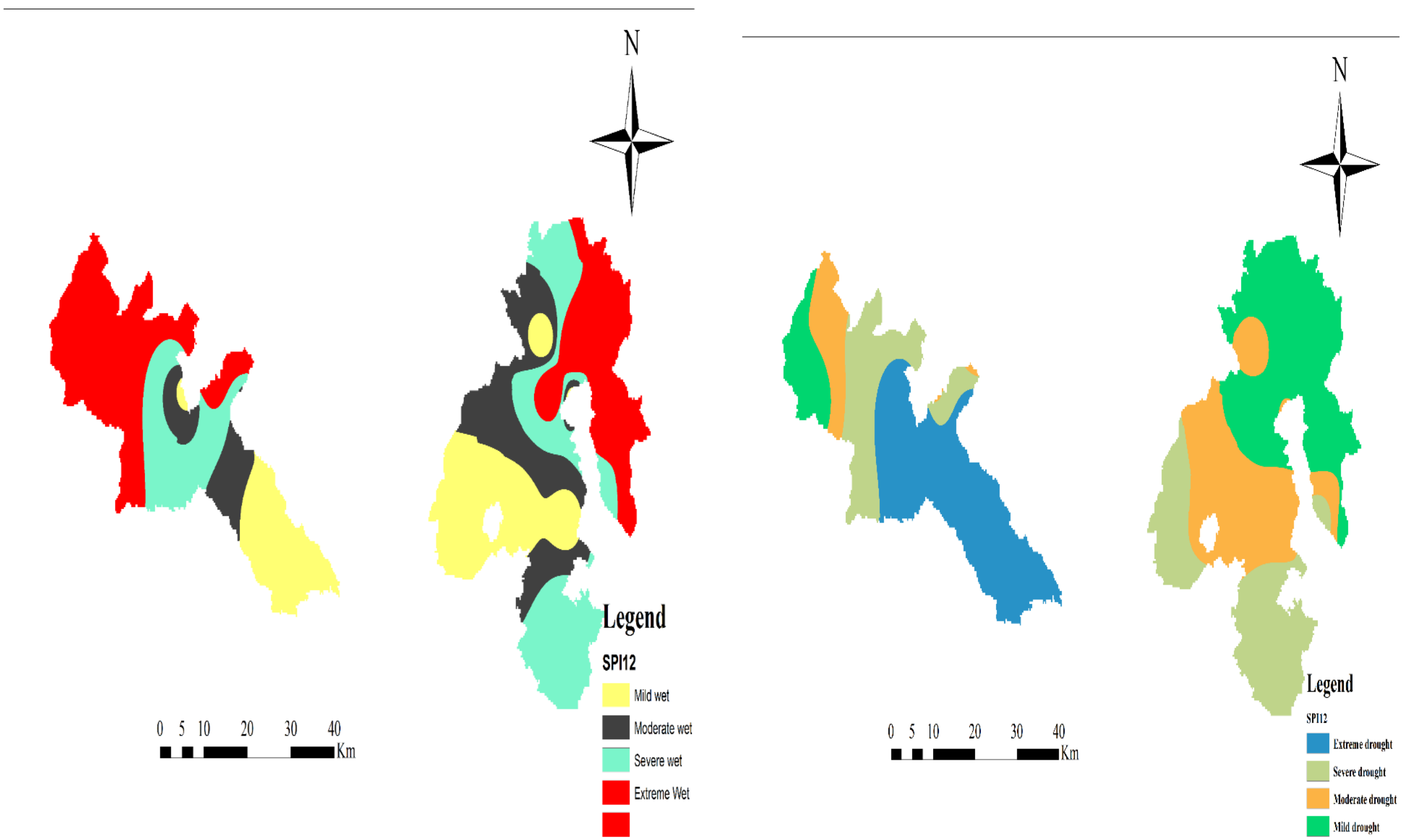

Figure 4: Spatial distribution of flood (A) and drought (B) events in the study area

5. CONCLUSION AND RECOMMENDATIONS

The annual rainfall in the four stations showed a significant decreasing and increasing trend at Wolkite station but there was non-significant negative trend at Butajira station. During the period of study, the largest negative deviation was occurred during the year 2017, 1992, 2016, 2012, and 2017 and the highest positive anomalies was registered during year 1993, 2010, 1992, 2010, and 2005 at Mareqo, Cheha, Abeshge, Sodo and Mesikan districts, respectively.

In 1992, 2012, 2016 and 2017 an El-Nino event occurred across the entire study area, 5 out of 5 districts experienced drought. In 1993, 2010, 1992, 2010, and 2005 a La-Lina event occurred across the entire study area, 5 out of 5 districts experienced flood condition. In the study area comparable Cheha, Mesikan and Mareqo recorded extreme drought with risk peak value was above -2 while Abeshge and Sodo districts recorded severe drought with risk peak value was -1.8 and -1.63 respectively. In contrary, Sodo woreda, Abeshge and Mareqo recorded extreme wet condition with risk peak value was above +2 whereas Mesikan and Cheha districts recorded severe wet with risk peak value was +1.92 and +1.94 where they are considered the most abundant rainfall in the area, respectively.

The result indicated that study area is experienced unpredictable drought and flood events with different time period. Such research is importantin strategic planningand operational applications like drought and flood monitoring. Therefore, the local government, NGOs and others concerned body should provide platform for early warning preparedness, drought and flood monitoring approaches, strategies and policies direction in the area.

6. REFERENCE

Abaya. (2009). *Extrem weather event.*

Abebe,. D. 2011. Unpublished notes on interviews of Borana oral historians June-September, 2011.

Michael C MacCracken and John S Perry. *The Earth system: physical and chemical dimensions of global environmental change.* pp 353–370.

Fraisse, C. W., N. W. Breuer, D. Zierden, J. G. Bellow, J. Paz, V. E. Cabrera, A. Garcia y Garcia, K. T. Ingram,. 2006. *A Climate ForecastInformation system for Agricultural Risk Management in the South-eastern USA.* Computational andElectron Agriculture, 53, 13-27.

Gissila, T. 2001. *Rainfall Variability and Teleconnections over Ethiopia. MSc thesis (Meteorology*. Universityof Reading, U.K. pp109.

Glantz. 2001. Currents of Change: El Ni˜no's Impact on Climate and Society, Cambridge University Press, Cambridge,.

Goddard, L. A. 2001. *Evaluation of the IRI'S "Net Assessment" seasonal climateforecasts, Bulletin of American Meteorological Society.*

Hulme, M., Doherty, R., Ngara, T., New, M. and Lister, D. 2001. African climate change: 1900-2100. *Climate Research 17*: 145-168.

IPCC. 2001. Climate Change 2001: The scientific basis. Contribution of working group i to the third assessment report of the intergovernmental panel on climate change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp

KidaneGeorgis, AlemnehDejene and MeshackMalo. 2010. Agricultural based livelihood systems in drylands in the context of climate change. Inventory of adaptation practices and technologies of Ethiopian Institute of Agricultural Research in collaboration with environmental sustainability, 131p

Korecha, D. A. 2002. *Seasonal rainfall Prediction of Ethiopia for the Periods of September-December.* Predictability of June-September Rainfall in Ethiopia, International.

Kousky E.V., a. B. 2001. Causes, predictions and outcome of El Niño 1997–1998. In: Chagnon, S.A.

Lemi, A. 2005. *Rainfall Probability and Agricultural Yield in Ethiopia.* Journal of Eastern Africa Social.

Meehl, G. A. 2000. Trends in Extreme Weather and Climate Events: Issues Related to Modelling Extremes in Projections of Future Climate Change, Bull. Am. Meteorl. Soc., 81,.

NMA. 2006. National Adaptation Programme of Action of Ethiopia (NAPA). National MeteorologiAgency, Addis Ababa.

NegashWagesho and EshetuYohannes. 2016. Analysis of rainfall variability and farmers' perception towards it in agrarian community of Southern Ethiopia.*Journal of Environment and Earth Science*. 6(4).

Philander. 1990. El Ni˜no, La Ni˜na, and the Southern Oscillation, Academic Press, San Diego, CA, 293.

Riebsame W . 1988. *Assessing the social implications of climate fluctuations- A guide to climate impact studies.* University of Colorado, Boulder, USA.

Ropelewski, C F and Halpert, M. 1987. *Global and RegionalScale Precipitation Patterns Associated with the El Ni˜no/Southern.*

Trenberth, K E and Shea, D J. 1987. *On the Evolution of theSouthern Oscillation, Mon. Weather Rev., 115, 3078–3096.*

WHO. 2016. *El Niño and Health, Global Overview as of 30 October 2015.*

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7. APPENDICES

Appendix Table 1. Summary SPIfor Koshe, Imdibir, Wolkite, Butajira and Bui stations

Years of occurrence	*Station SPI value*				
	Koshe	**Imdibir**	**Wolkite**	**Butajira**	**Bui**
1989	1.09	*-0.16*	0.45	0.81	-1.30
1990	0.20	*0.19*	0.40	1.20	0.10
1991	0.04	*-0.40*	0.40	-1.28	0.11
1992	-0.02	*-2.97*	2.86	-1.32	-0.36
1993	2.41	*0.36*	0.64	-0.04	0.08
1994	-0.67	*-0.28*	0.99	0.12	-1.47
1995	0.97	*-0.05*	0.38	0.46	1.18
1996	0.09	*1.34*	2.36	0.87	1.06
1997	0.86	*0.51*	0.35	0.36	-1.38
1998	-0.47	*1.08*	-0.05	0.89	-0.08
1999	-0.55	*-0.11*	-0.20	0.17	-0.38
2000	0.35	*-0.86*	-0.31	-0.29	-0.31
2001	0.11	*-1.17*	0.22	0.76	0.76
2002	-1.03	*-1.31*	0.15	0.31	-0.78
2003	-0.10	*-1.70*	0.43	0.48	-0.05
2004	-0.56	*-0.29*	-0.64	-0.36	-0.69
2005	1.09	*-0.03*	-0.01	1.92	0.98
2006	0.69	*0.89*	-0.01	1.45	0.80
2007	0.23	*0.91*	-0.23	0.82	0.65
2008	1.23	*0.50*	0.23	-0.25	0.05
2009	-0.32	*0.05*	-0.55	-1.28	-1.09
2010	-0.17	*1.94*	-0.14	-0.80	2.75
2011	-1.84	*1.53*	-0.66	-0.36	0.42

2012	-1.39	*-0.60*	-1.25	-0.51	-1.63
2013	-0.80	*0.21*	-0.05	0.14	-0.59
2014	1.43	*0.56*	-1.03	0.96	1.86
2015	0.03	*0.07*	-1.13	-1.54	-0.38
2016	-0.71	*-0.12*	-1.80	-1.65	0.09
2017	-2.21	*-0.11*	-1.80	-2.06	-0.38