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Incidence of Droughts Vs El Niño : A Case Study of Addis Ababa City, Ethiopia

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Abstract

The research article deals with the incidence of droughts and their relation with El Niño episodes in Ethiopia in general and in Addis Ababa in particular. It is opined by many scientists that climate change is responsible for vanishing glaciers, rising sea levels, frequency in ENSO conditions, incidence of frequent and intensified droughts and occurrence of intensified cyclones and extreme weather conditions. Among these, policy makers in Ethiopia focused on El Niño, which is believed to be one of the causes of drought occurrence in Ethiopia. Keeping that in view, analysis of droughts in Addis Ababa has been carried out with the aid of Thornthwaite's water balance technique. The analysis has revealed that Addis Ababa has experienced a total of 19 droughts during the 39 study period (1970-2008) indicating 48.7 percent of total drought proneness. The study further revealed that Addis Ababa has experienced mostly large types of droughts followed by moderate.

When these drought incidences were correlated with El Niño episodes, it is interesting to note that the disastrous droughts that occurred in Ethiopia (including in Addis Ababa) during 1973/74, 1983/84 coincided with the years of El Niño episode during 1972/73 and 1982/83 respectively. Further, the large drought that have occurred in Addis Ababa during 1997/98, 2002/03 coincided with the years of El Niño episode that occurred during 1997, 2002/03 respectively. Moderate drought that has occurred in Addis Ababa during in 2004 coincided with the year of El Niño episode during 2004/05.

Introduction

It is opined by many scientists that climate change is responsible for vanishing glaciers, rising sea levels, frequency in ENSO conditions, incidence of frequent and intensified droughts and occurrence of intensified cyclones and extreme weather conditions. Among these, policy makers in Ethiopia focused on El Niño, which is believed to be one of the causes of drought occurrence in Ethiopia.

Drought is a physical condition of the environment in which the amount of water available from the precipitation and soil is not sufficient to meet the demands of evapotranspiration (Angur Maiti, 1990). Drought is the absence of precipitation when normally can be expected, and a demand exists for it (Oliver and Hidore, 2002). In meteorological terms, a drought is "a sustained, regionally extensive, deficiency in precipitation" (Ramachandran, 2000).

According to the World Meteorological Organization (1990), drought is a prolonged absence or sparse distribution of precipitation and, a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance.

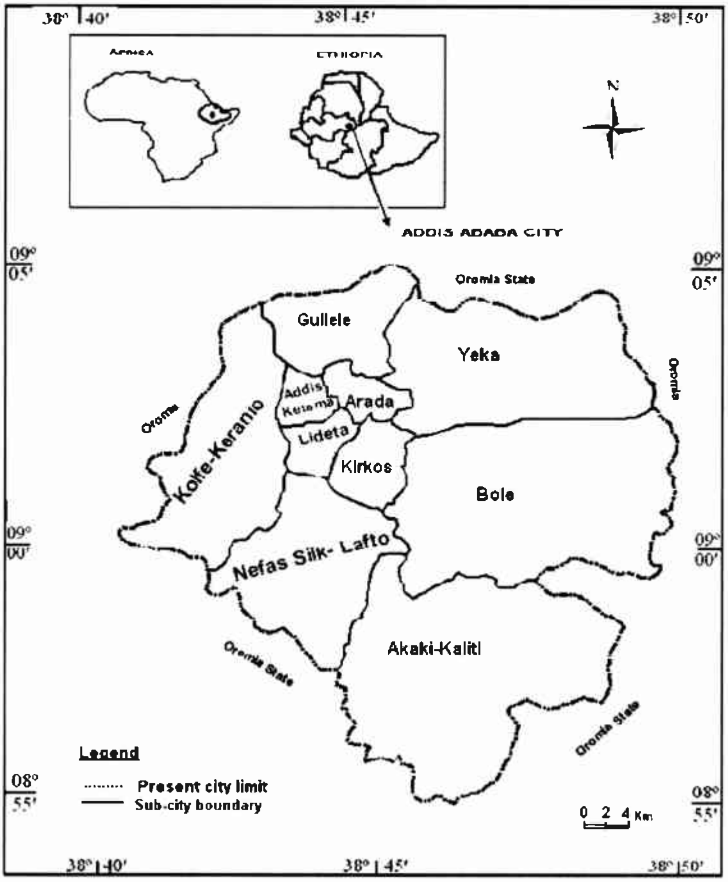

Fig. 1: Location map of Addis Ababa city and its sub-cities

El Nino is a shift in ocean temperatures and atmospheric conditions in the tropical Pacific that disrupts weather around the world. Several studies indicated that Warm Sea Surface Temperature (SST) is believed to be associated with widespread drought in Ethiopia. Ethiopia has used El Nino information for early warning systems on 1987, 1992 and 1997 droughts.

The main objective of the present study is to analyze the incidence of droughts and their correlation with El Niño in Addis Ababa

Study Area

Addis Ababa, the capital of Ethiopia, is an elevated city (2440 m) in the world and is located in the central highlands of Ethiopia (Admasu, 1997). Geographically, the city is located at 9° 03' N Latitude and 38° 43' E Longitude (Fig.1). According to Central Statistical Agency Report (1998) the city covers a total area of 540 Km^2. Administratively the city is divided into 10 Sub-Cities (Kifle-Ketemas) and further subdivided into 99 kebelles (Demelash, 2007; Addis Ababa City Administration, 2008). According to 2007 census the population of the city is 0.3million (Central Statistical Agency of Ethiopia ,2008).

Data and methodology

Data on temperature and rainfall on monthly basis for drought analysis have been collected for 39 years (1970-2008) from the two existing weather recording stations namely Bole and Addis Ababa Observatory maintained by the National Meteorological Agency (NMA) of Ethiopia Water balance approach developed by Thornthwaite (1955) and his associates (1957) has been used in this study to assess the drought condition in and around Addis Ababa city. Statistical techniques such as index of Aridity (Ia) and standard deviation has been used to categorize the droughts based on intensity.

Drought- a climatic extremity of Addis Ababa city

Analysis of droughts in Addis Ababa

For the analytical study of droughts with special emphasis on their intensity and frequency, the aridity index (Ia) of Thornthwaite has been found to be very useful parameter (Subrahmanyam et al., 1965). Drought years may be easily identified and their intensities assessed from the study of departures of the index of aridity (Ia) from the median value for the corresponding station. Aridity Indices for all the years were computed for the study area.

Yearly departures of aridity indices at a station from the median values expressed as a percentage of the average of the study period can thus show diverse drought conditions experienced by the station. When these departures graphically plotted against the successive years will yield not only the information about the years of drought, but also the intensity of drought situation. Subrahmanyam and Subramaniam (1965) have categorized the droughts according to their intensities by using standard deviation technique. Table1, shows the scheme proposed by Subrahmanyam and Subramaniam (1965).

Table 1: General scheme of drought classification

Departure of Ia from the median	Drought Category
0 - 1/2	Moderate Drought
1/2 to	Large Drought
to 2	Severe Drought
above 2	Disastrous Drought

Table 2: Categorization of drought years of Addis Ababa city (1970-2008)

Drought Category	Departure of Index of aridity from the median	Years of Drought	No. of Years
Moderate	0 - 2.36 (0 - 1/2)	1971,1985,1996, 2001, 2004	5
Large	2.36-4.72 (1/2 to)	1988,1991,1992, 1994, 1997,2000,2002, 2003	8
Severe	4.72-9.44 (to 2)	1974,1975, 2008	3
Disastrous	above 9.44	1973,1984,1999	3
		Total	19

For the present study, categorization of droughts that have occurred in Addis Ababa city has been attempted based on the climatic data of about 39 years (1970-2008), by considering the standard deviation of the aridity indices. The median was used as the base of reference for measuring the departures Figure 2 depicts the trends in departure of values of Aridity Index (Ia), from normal index of aridity. The figure clearly shows frequency and intensity of different drought situations. Years of drought in Addis Ababa along with their intensities are presented in Table 2.

The analysis revealed that Addis Ababa has experienced a total of 19 droughts during the study period (1970-2008) with different intensities. The city has experienced three disastrous droughts (15.8 percent), three severe droughts (15.8 percent), eight large type of droughts (42.1 percent) and five moderate nature of droughts (26.3 percent). The study further revealed that Addis Ababa has experienced mostly large intensity droughts followed by moderate.

Table 3 : Drought proneness of Addis Ababa

Category of drought	Number of droughts	%
Overall drought proneness	19	48.7
Disastrous	3	7.7
Severe	3	7.7
Large	8	20.5
Moderate	5	12.8

Table 2, also depicts annual variations in the occurrences and nature of droughts in Addis Ababa city. It is clearly shown that three disastrous droughts(1973,1984 and 1999), large drought (2002 and 2003) experienced by Addis Ababa coincided with the major drought periods of the country as a whole which occurred in 1972-73, 1983-84, 1999-2000 and 2002-03 (Teshome Erkineh,2006).

Drought proneness

The study of the vulnerability of particular place to droughts is important for planning especially for agriculture. The percentage ratio of the number of drought years to the total number of years under study provides the overall drought proneness of the area (Hema Malini and Nageswara Rao, 1998). The drought proneness for Addis Ababa city has been computed and the results presented in Table 3.

The analysis of droughts in Addis Ababa indicated 48.7 percent of drought proneness (Table 3). The category-wise proneness revealed that the city is vulnerable to 7.7 percent of disastrous, 7.7 percent of severe, 20.5 percent of large and 12.8 percent of moderate droughts. The analysis indicated that the city is more prone to large type of droughts. Thus from the analysis it is evident that though Addis Ababa has a humid type of climate and receives high rainfall, drought is a recurring phenomenon.

Drought Vs El Niño

Ethiopian policy makers focused on El Niño, which is believed to be one of the causes of droughts in Ethiopia. Warm Sea Surface

Table 4: El Nino Vs Drought Incidence in Ethiopia (1539 - 2005)

S#	Years of El Niño	Drought/Famine	Regions affected
1	1539-41	1543-1562	Hararghe, Eastern Ethiopia
2	1618-19	1618	Northern Ethiopia
3	1828	1828-29	Shewa (including Addis Ababa)
4	1864	1864-66	Tigray and Gondar, Northern Ethiopia
5	1874	1876-78	Tigray and Afar, Northern Ethiopia
6	1880	1880	Tigray and Gondar, Northern Ethiopia
7	1887-89	1888-1892*	Ethiopia (including Addis Ababa)
8	1899-1900	1899-1900	Ethiopia (including Addis Ababa)
9	1911-1912	1913-1914	Northern Ethiopia
10	1918-19	1920-22	Ethiopia
11	1930-32	1932-1934	Ethiopia
12	1953	1953	Tigray and Wollo
13	1957-1958	1957-1958	Tigray and Wollo
14	1965	1964-66	Tigray and Wollo
15	1972-1973	1973-1974	Tigray and Wollo (including Addis Ababa)
16	1982-1983	1983-1984	Ethiopia (including Addis Ababa)
17	1986-87**	1987-1988**	Ethiopia (including Addis Ababa)
18	1991-92	1990-92	Ethiopia (including Addis Ababa)
19	1993	1993-94	Tigray, Wollo (including Addis Ababa)
20	1997	1997-98	Addis Ababa
21	2002-2003	2002 - 2003	Addis Ababa
22	2004-2005	2004	Addis Ababa

Sources: Quinn and Neal (1987); Degefu (1987, 30-31); *Nicholls (1993); Webb and Braun (1994) ; **Ayalew 1996 cited in Tsegaye(1997).

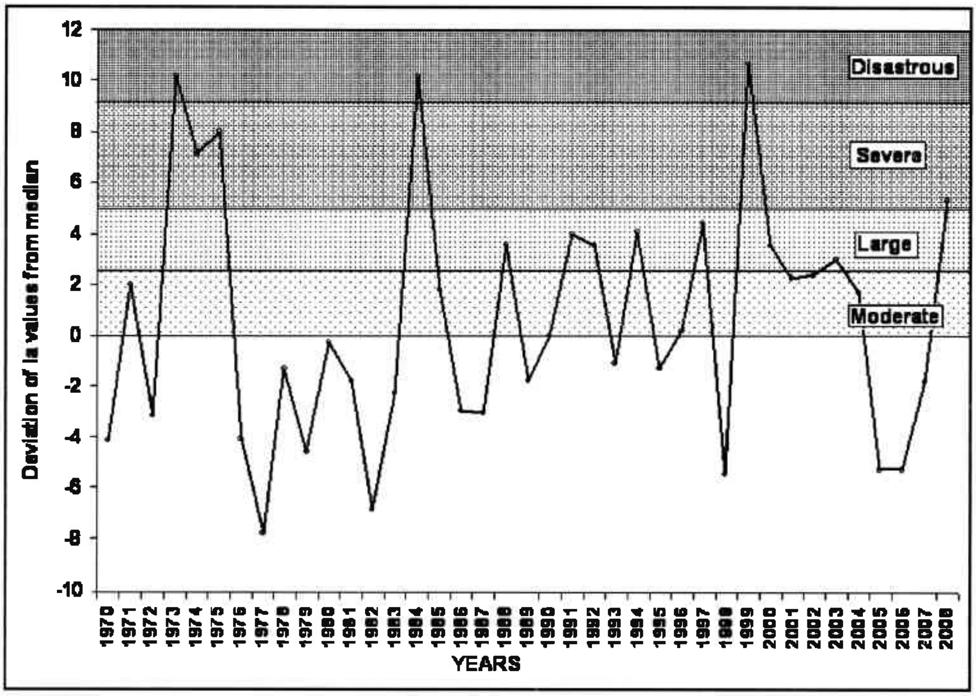

Fig. 2: Categorization of droughts in Addis Ababa city (1970-2008)

Temperatures (SST) are believed to be associated with widespread meteorological drought. Tsegaye (1997) indicated that there is an association between Ethiopian droughts and El Niño. He related seasonal anomalies of the region to the major El Niño of 1997(NMSA, 1997). While, La Niña phenomena are responsible for the occurrence of heavy rainfall and flooding in Ethiopia, Ethiopia used El Niño information as an early warning for the 1987, 1992 and 1997 droughts (Tsegaye, 2002). Table 4 indicates the chronology of droughts and famines in Ethiopia.

The historical record of droughts (Table 4) indicates that drought is a common and more frequent weather hazard that occurs in Ethiopia since time immemorial. As a part of Ethiopia, Addis Ababa has experienced drought during 1828-1829, 1888-1892, 1899-1900, 1973-1974, 1983-84, 1987-1988, 1990-92, 1993-94, 1997-98, 2002 – 2003 and 2004. All these years are mostly coinciding with the El Nino episodes.

By the analysis of Thornthwaite's the years which were identified as drought are coinciding with the list of droughts in Addis Ababa (Table 4). This shows the validity of water balance technique in drought analysis.

Conclusions

For categorization of droughts parametric index namely aridity index was used to carry out analysis of droughts. The study revealed that Addis Ababa has experienced four types of droughts namely disastrous, severe, large and moderate..Further it is revealed that on an average Addis Ababa has experienced 19 droughts in 39 years in the two stations. The dominate drought type in Addis Ababa is 'large' followed by 'moderate'.

The drought occurrence during the four decades revealed that the maximum number of droughts occurred during 1990-1999 and 2000-2008 decades and the minimum number of droughts in 1980-1989 decade. When these drought incidences were correlated with El Niño episodes, it is interesting to note that the disastrous droughts that occurred in Ethiopia (including in Addis Ababa) during 1973/74, 1983/84 coincided with the years of El Niño episode during 1972/73 and 1982/83 respectively. Further, the large drought that have occurred in Addis Ababa during 1979/98, 2002/03 coincided with the years of El Niño episode that occurred during 1997, 2002/03 respectively. Moderate drought that has occurred in Addis Ababa during in 2004 coincided with the year of El Niño episode during 2004/05. The study is an evidence that incidence of droughts in Ethiopia is a result of El Niño occurrences in the same period.

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