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Assessment of the Impact of El Niño-Southern Oscillation (ENSO) Events on Rainfall Amount in South-Western Nigeria

Nze-Esiaga Nnawuike

Department of Engineering and Technical Services, Nigerian Meteorological Agency, Nnamdi Azikiwe International Airport Abuja.Nigerian Meteorological Agency. E-mail: nnawuike@gmail.com.

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ABSTRACT

The need to have a quantitative means of predicting rainfall depth is essential and inevitable for the purposes of planning and policy formulation, as weather varies significantly from one year to another. The different phases of the El Niño Southern Oscillation (El Niño, La Niña and Neutral phase) affect rainfall patterns in different parts of the world in various ways. Hence a better understanding of the impact of these weather phenomena on rainfall amount over a region would improve the quality of rainfall prediction in that region. This study examined the relationship between these weather events and the rainfall amount in South-Western Nigeria. Monthly rainfall data from six meteorological stations in South-Western Nigeria over the period 1985 to 2014 (30 years) were analysed in relation to three El Nino-Southern Oscillation (ENSO) phases. The analysis showed that the ENSO events have no significant relationship with rainfall amount in all the stations of the region, over the period considered. Therefore, based on this study, the use of ENSO phases can be said to be an inadequate tool for rainfall amount prediction over this region.

Key words: Rainfall amount, El Niño-Southern Oscillation (ENSO), El Niño, La Niña and Neutral phase and South-Western Nigeria.

INTRODUCTION

The El Niño-Southern Oscillation (ENSO) is a naturally occurring phenomenon that involves fluctuating ocean temperatures in the equatorial Pacific. Being one of the most important climate occurrences on earth, ENSO has the ability to change the global atmospheric circulation, which consequently, influences temperature and precipitation across the globe. Though ENSO is a single climate phenomenon, it exist in three phases; El Niño, La Niña and Neutral phases.

El Niño: This phase is said to occur when there is warming of the ocean surface, or the sea surface temperatures (SST) rises above the normal, in the central and eastern tropical Pacific Ocean (Figure 1). The low-level surface winds, which normally blow from east to west along the equator (“easterly winds”), instead weakened or, in some cases, start blowing the other direction (from west to east or “westerly winds”) (NOAA, 2014).

La Niña: This phase involves the cooling of the ocean surface, or decrease to below-average SST, in the central and eastern tropical Pacific Ocean. The normal easterly winds along the equator become even stronger (NOAA, 2014).

Neutral (Neither El Niño or La Niña): The ENSO is said to be in the neutral phase when the tropical Pacific SSTs are close to average. However, there are some instances when the ocean can look like it is in an El Niño or La Niña state, but the atmosphere is not playing along (or vice versa) (NOAA, 2014). A variety of tools and techniques are being employed to monitor and forecast changes in the Pacific Ocean and the impact of those changes on global weather patterns. In the tropical Pacific Ocean, *El Niño* is detected by many methods, including satellites, moored buoys, drifting buoys, sea level analysis, and expendable buoys. Hence various indicators are used to monitor episodes of *El Niño* / *La Niña* events (ICCO, 2010).

Several studies have been done to establish the

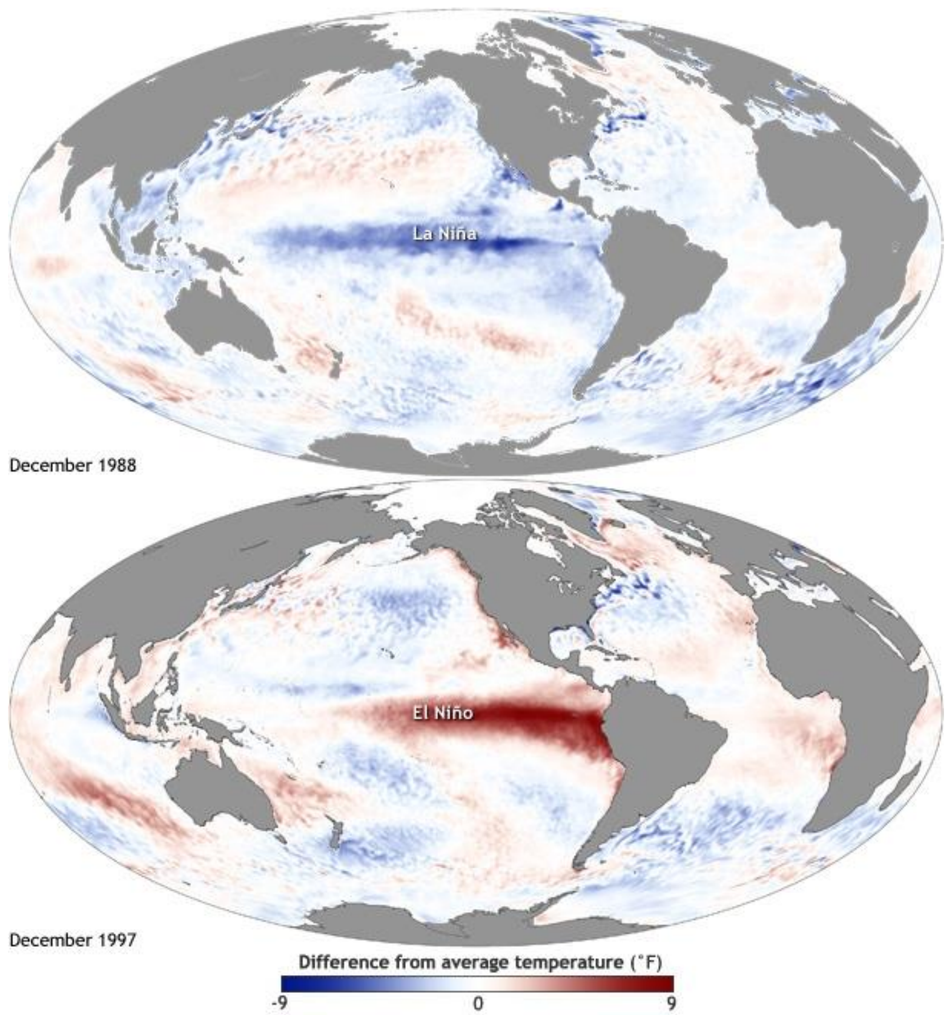


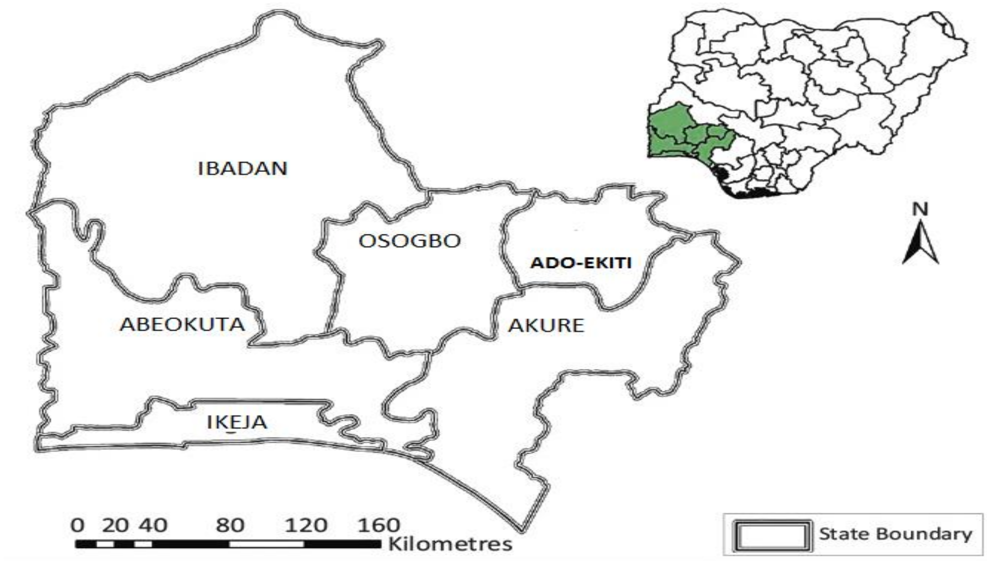
Figure 1. Maps of sea surface temperature anomaly in the Pacific Ocean during a strong La Niña (top, December 1988) and El Niño (bottom, December 1997). Source: (NOAA, 2014).

relationship between Nigerian rainfall and the ENSO. While Adebayo (1999) disclosed that ENSO has been shown to relate strongly to variations in Nigerian rainfall, analysis by Okere et al (2006) revealed some indication that rainfall in Nigeria is associated with El Nino-related circulation and rainfall anomalies. Data reported by Owen and Ward (1990) and by Adebayo (1999) also confirm the relationship between extra-tropical SST anomaly (for example, SSTAs over the North Atlantic, North Pacific and South Pacific) and rainfall fluctuations in Nigeria. According to Oguntoyinbo (1986), there exists interaction between the atmospheres over large geographical scales, so that climatic anomalies tend to be extensive in space. Thus, it is common to find the variation of one element in one area correlated with its variation in another area that is, an increase in one element in a region will signify an increase in another element, in another region and vice versa. Such linkages as these are called teleconnections. Owen and Ward (1990) established that when the El Nino pattern is strongly positive (that is, positive SSTA pattern in the eastern tropical Pacific) there is a tendency for the Sahel to be dry, but wet when the pattern is strongly negative. Adedoyin (1989) also reported a significant positive correlation between tropical east Pacific SSTA and rainfall intensity at the beginning of the rainfall season in Nigeria. Thus, the aim of this research is to determine the teleconnection between ENSO Events and the rainfall amount in South Western Nigeria.

MATERIALS AND METHODS

South-Western Nigeria, which is the study area of this research, consists of six States and a station was considered in each of these States. The stations' details are presented in Figure 2 and Table 1. Mean monthly rainfall amount data for each of the stations over the period (1985 to 2014) was used for this study and these data was obtained from Nigerian Meteorological Agency (NiMet). Also obtained from NiMet is the yearly ENSO phase for the period under consideration.

Time series analysis of the monthly and annual rainfall



Source: Authors' own creation

Figure 2. Map showing the location of South Western Nigeria.

Table 1. Details of the stations.

Station	NiMet Station ID	Latitude (N)	Longitude (E)	Altitude (m)
Abeokuta	65213	7.10	3.20	104.00
Ado Ekiti	65ADO	7.60	5.20	431.00
Akure	65232	7.17	5.18	375.00
Ibadan	65208	7.26	3.54	227.20
Ikeja	65201	6.35	3.20	39.40
Osogbo	65215	7.47	4.29	302.00

Table 2. Standardized precipitation index (McKee et al., 1993).

SPI	Interpretation
2.00+	Extremely wet
1.50 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
-2.00 and less	Extremely dry

values were used to illustrate the trend in the behaviour of rainfall and in estimating seasonal variation. Microsoft Excel statistical tool was used as it has proven effective in investigating trends in many climatic time series (Hutchinson, 1985; Ayoade, 1973). Also, in computation of the deviation score, the standard precipitation index (Table 2) was used.

Standardized Precipitation Index (SPI)

The SPI which is a drought index developed by McKee et al. (1993), is expressed as standard deviations that the observed precipitation would deviate from the long-term mean. The SPI is used for estimating wet or dry conditions based on precipitation variable. This wet or dry condition can be monitored by the SPI on a variety of time scales from sub seasonal to inter annual scales. Positive SPI values indicate wet condition greater than median precipitation, whereas negative values shows dry condition less than median precipitation. Hence, SPI was used in this study to determine how wet or dry a year is and this was based on Table 1, and this was plotted

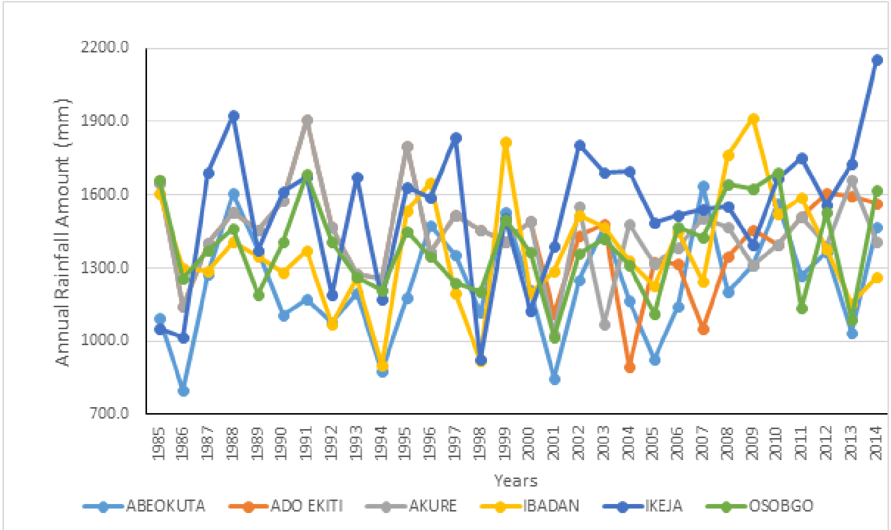


Figure 3. Plot of the annual rainfall amount over the stations for the period 1985 to 2014.

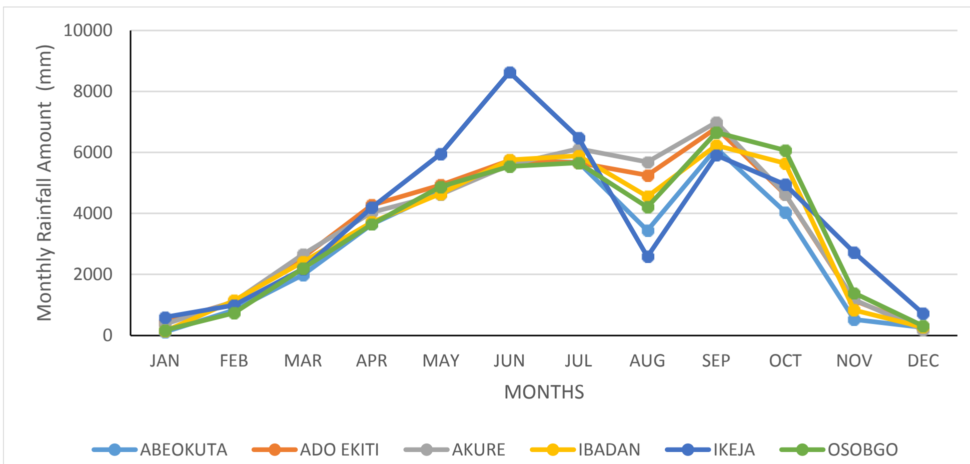


Figure 4. Plot of the monthly rainfall amount over the stations for the period 1985 to 2014.

against the ENSO phase of the year. SPI: = $\frac{(x-\bar{x})}{S}$ (McKee et al. 1993), Where x the annual rainfall is totals, $\bar{x}$ is the mean of the entire series and S is the standard deviation from the mean of the series.

RESULTS AND DISCUSSION

Figure 3 illustrates the inter-annual rainfall variability over the Stations during the period 1985 to 2014. The trend shows that Ikeja has the highest annual rainfall amount (2155.3 mm) in 2014, while Abeokuta with 796.8 mm in 1986 and from Figure 4, Ikeja was found to experience its rainfall peak in June while the other station recorded their peaks in September. It was also observed from the study that the August break affects all the stations in August but it differs in magnitude across the stations with Ikeja having the highest impact.

Assessment of the Impact of ENSO Events on Rainfall Amount

The results of the statistical analysis are presented in the Figures 5 to 10 and it can be deduced from the plots that there are no direct relationships between ENSO events and rainfall amounts in all the stations considered, due to very dry and very wet conditions in all the three ENSO phases. For instance, in Figure 5, years 1996, 1999 and 2003 which are Neutral, La Nina and El Nino years, respectively, have SPI of 1.06, 1.32 and 1.05, respectively and these indicates that moderately wet conditions prevailed over the three years. Also, Figure 6 shows that Ado-Ekiti, in El Nino years (1987, 1988, 1992,

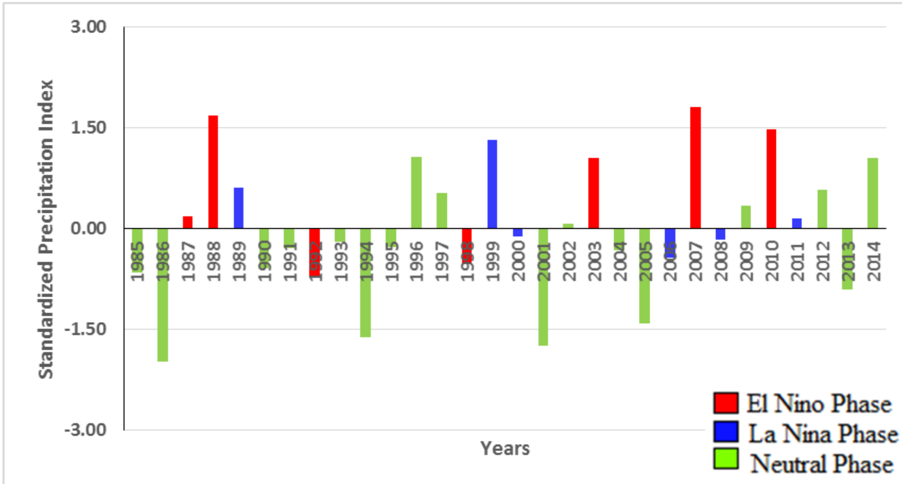


Figure 5. Plot of the annual SPI and the corresponding ENSO phase for Abeokuta.

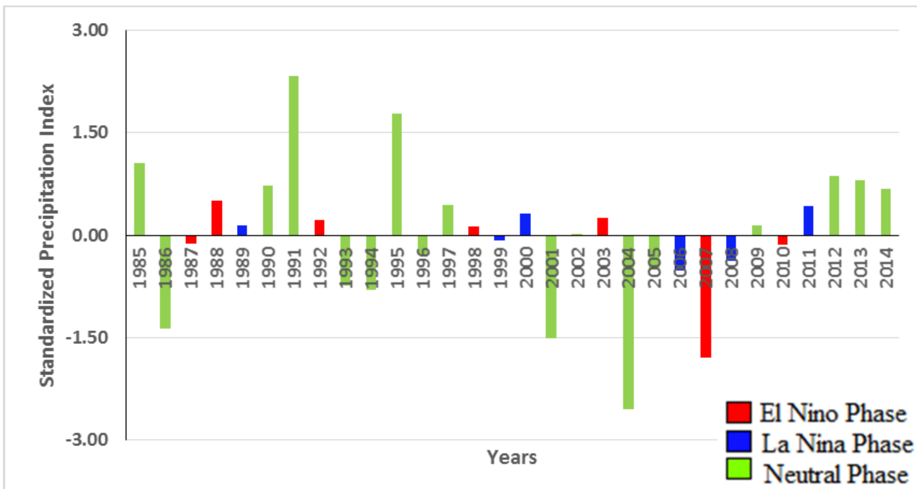


Figure 6. Plot of the annual SPI and the corresponding ENSO phase for Ado-Ekiti.

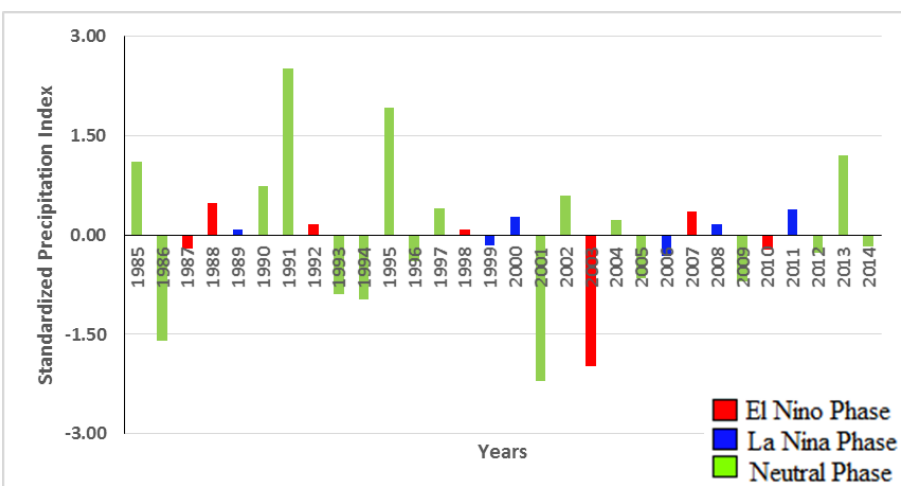


Figure 7. Plot of the annual SPI and the corresponding ENSO phase for Akure.

1998, 2003 and 2010), moderate wet to moderate dry conditions were experienced. Neutral years (1991 and 1995) were very wet and 2004 which is also a neutral year experienced less than normal rainfall. Figure 7

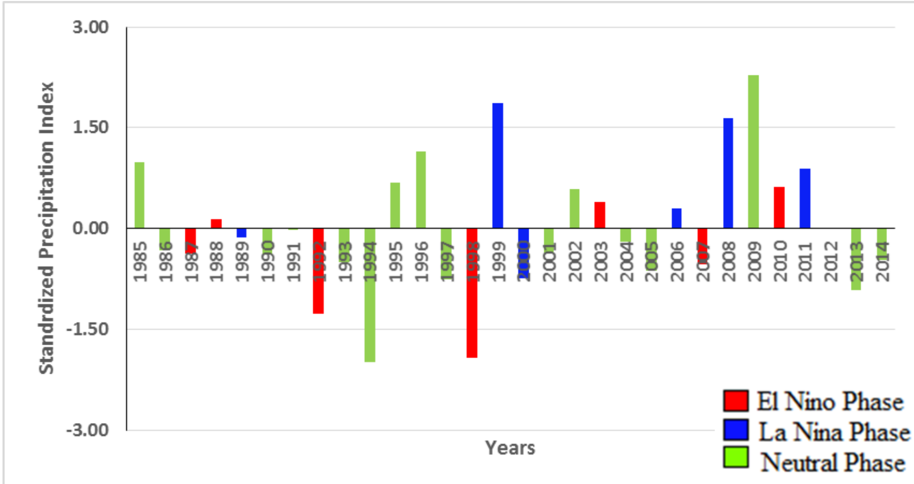


Figure 8. Plot of the Annual SPI and the corresponding ENSO phase for Ibadan.

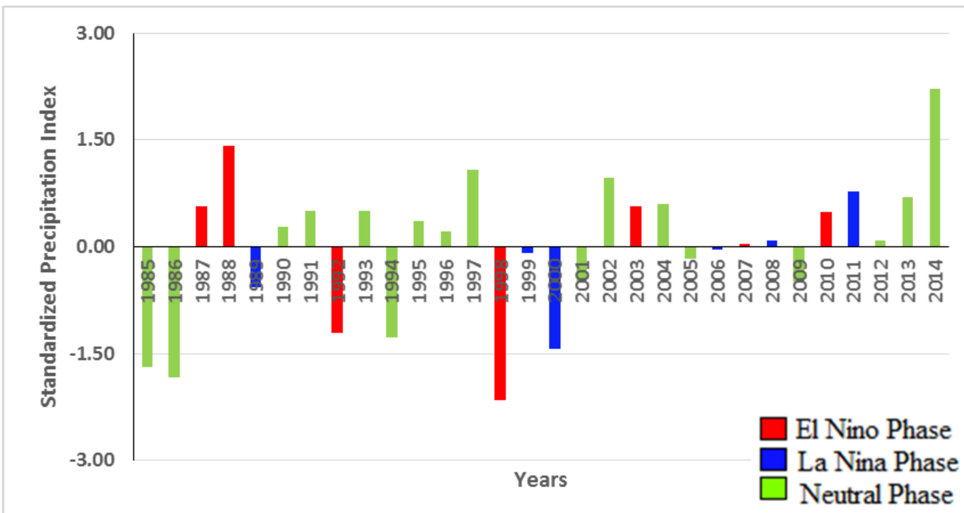


Figure 9. Plot of the annual SPI and the corresponding ENSO phase for Ikeja.

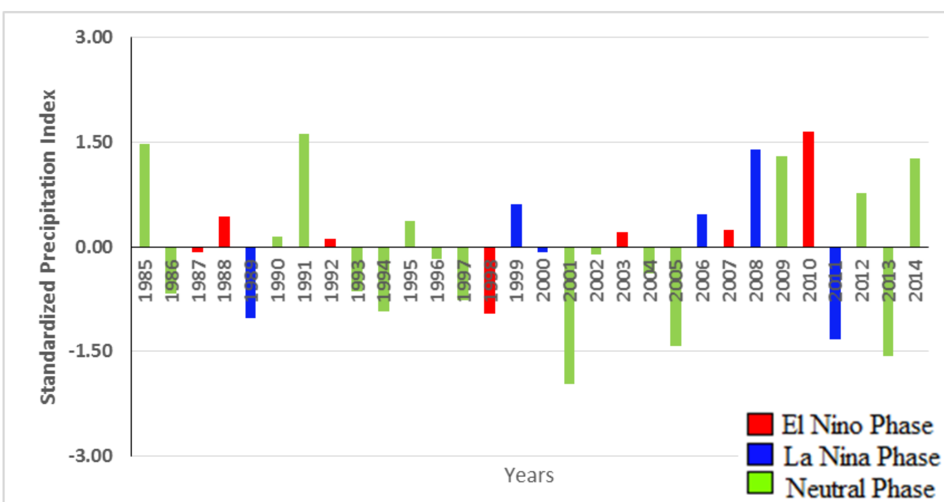


Figure 10. Plot of the annual SPI and the corresponding ENSO phase for Osogbo.

reveals similar situation for Akure, with 1991 and 1995 being neutral years but experienced greater than normal rainfall with SPI values of 2.52 and 1.92, respectively. Also, all the La Nina years (Figure 7) has SPI values ranging from -0.5 to +0.5 which depicts Neutral phase. However, in Ibadan, except for 1998 which is an El Nino year with SPI of -1.92, all other El Nino years experienced Neutral phase conditions (Figure 8). Likewise, moderate wet to moderate dry condition prevailed in every other La Nina year in Ibadan except for 1999 and 2008, which has SPI values of 1.86 and 1.65, respectively. Similarly, all the La Nina years from Figure 9, has SPI value from 0.77 to -1.44 which indicates moderate wet to moderate dry in Ikeja. In Osogbo (Figure 10), moderate dry conditions were observed in 1989, 1994 and 1998, which are La Nina, Neutral and El Nino years, respectively, with SPI values of -1.02, -0.93 and -0.92 correspondingly.

CONCLUSION

The core question of this study is to assess whether ENSO events influence the amount of rainfall in the south-western region of Nigeria. The statistical analyses show that ENSO events have no significant relationship and influence on rainfall amount in all the station over the period considered. With any of the ENSO phases, cities of South Western Nigeria can witness either excess, moderate or less rainfall amount.

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