SEASONALITY OF RAINFALL IN SOUTH-WESTERN NIGERIA

BY

Fajemidagba, K.J.[1*], Sawa, B.A.[1], Adeleke, E.A.[2] and Ibrahim, S.O.[3]

[1]Department of Geography and Environmental Management, Ahmadu Bello University, Zaria
[2]Department of Geography and Environmental Management, University of Ilorin, Ilorin
[3]Department of Geography, Bayero University, Kano
*Corresponding Author's Email: joelkolade@gmail.com

ABSTRACT

Climate change seems to be the foremost global challenge facing humans at the moment. One of the challenges posed by change in climate is ascertainment, identification and quantification of rainfall and its implications on human activities. This study aimed at analyzing the effect of climate change on rainfall seasonality in south-western Nigeria. Data used for the study was monthly rainfall records of Lagos, Oyo, Ogun, Osun, Ondo and Ekiti state for the period 1983-2017 which was gotten from NIMET office at Oshodi. Walsh and Lawler (1981) method was adopted to calculate seasonality index while time domain Time Series Analysis and t-test were used to analyze the data of the study. The results of the study revealed that Lagos, Oyo, Osun and Ondo states experienced shortened spread of rainfall during the period of study while Osun and Ekiti experienced increase in spread of rainfall. In general, south-western Nigeria experienced a shortened spread of rainfall with rainfall occurring between 7-9months of the year during the period of study. Furthermore, t-test result showed that there is a significant difference in seasonality of rainfall in the region during the study period. It was concluded that the region experienced shortened spread of rainfall during the period of study. It was therefore recommended that during the periods of excess rainfall, water should be stored by government in dams while farmers and residents should store water in artificial reservoirs to cater for the shortage during the period of deficit.

Key words: Climate, Rainfall, Seasonality, South-western, Time series.

INTRODUCTION

Climate is a global resource which has a direct influence on every aspect of human existence such as natural environment, economies, politics, culture, spatial interactions and development. It has been observed from records and simulation of atmospheric conditions by Intergovernmental Panel on Climate Change (2007a) that the earth's climate for the past 100 years has changed in response to various natural and anthropogenic activities. Climate change threat is a serious setback to development efforts, placing least developed countries particularly sub-Sahara African countries who are already vulnerable even in more precarious position (National Emergency Management Agency, 2013). Climate change is defined as a statistically significant variation in the mean state of the climate occurring for a long period ranging from decades to million years (IPCC, 2007b). One of the challenges posed by change in climate is ascertainment, identification and quantification of rainfall and its implications on human activities (De Luis et al., 2010). Rainfall is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation. Rainfall variability affects water

resources sustainability which includes the availability, management, and utilization. This in turn may affects ecosystems, land productivity, agriculture, food security, water quantity and quality, and human health. Variation in rainfall in south-western Nigeria poses significant risks to human health, forests, agriculture, freshwater supplies, coastlines, and other natural resources that are vital to the region's economy, environment, and quality of life.

The distribution of rainfall throughout the seasonal cycle is as important as the total amount of monthly or annual precipitation. The seasonal distribution of precipitation is the result of revolution of the earth resulting in the unequal heating of the earth's surface over the year. Rainfall seasonality is the distribution pattern of rainfall on monthly basis in a defined geographical area. Seasonality Index (S.I) measures the spread and steadiness of the rainfall during the wet season (Adejuwon, 2012). Rainfall seasonality index is a critical environmental factor affecting the evolution of natural vegetation. The seasonality index classifies the type of climate in relation to water availability, the higher the seasonality index of a region, the greater the water resources variability and scarcity in time, the more vulnerable the area to desertification (Patil, 2015).

Walsh and Lawler (1981 cited in Adejuwon, 2012) linked rainfall seasonality in Africa, to latitude. It was discovered that seasonality is low in equatorial areas but increases rapidly with latitude, particularly towards the Sahara where the highest seasonality index values are found. In like manner, Ayoade (1970 cited in Adejuwon, 2012) noted increasing seasonality in the rainfall of Nigeria with distance from the coast as part of the continental scale latitudinal pattern. Thus, according to Adefolalu (1986) locations north of 8°N latitude in the country received over 90% of the total annual rainfall in April-October while for southern stations the proportion of wet season rainfall was 84-88% of the annual total. From the foregoing, it is clear that climate change has affected rainfall seasonality in the region. Therefore, there is dire need to identify and quantify the changing rainfall to improve knowledge as well as reducing vulnerability thereby lending support to sustainable development of communities in the region. The objective of this study is to analyze rainfall seasonality in south-western Nigeria.

THE STUDY AREA

South-western Nigeria lies between Latitude 6º 00"N and 9º00" North of the equator and longitude 3º 00"E and 6º 00" East of the Greenwich meridian. The South-western part of Nigeria is bordered in the East by Edo and Delta states, in the North by Kwara and Kogi states, in the West by the Republic of Benin and in the South by the Atlantic Ocean (see Figure 1). It has a total land area of 191,843sqkm (Adepitan, Faleyi and Ogunsanwo, 2017).

The climate of south-western Nigeria is tropical in nature and it is characterized by wet and dry seasons. The annual rainfall ranges between 1500mm and 3000mm with a mean of 1875mm. Coastal zones like Lagos show a tendency towards a double maximum separated by a short dry season; while on the other hand, regions close to the savannah zone like Oyo is characterize by two peaks maxima in July and September separated by a more pronounced break in August (Sobowale, Sajo and Ayodele, 2016). The area experiences about 9months of rainfall between March and November and 3months of Dry season between December and February. The temperature ranges between 21ºC and 34ºC with an average of 27.5 ºC. The coldest month of the year is January while the hottest month is August.

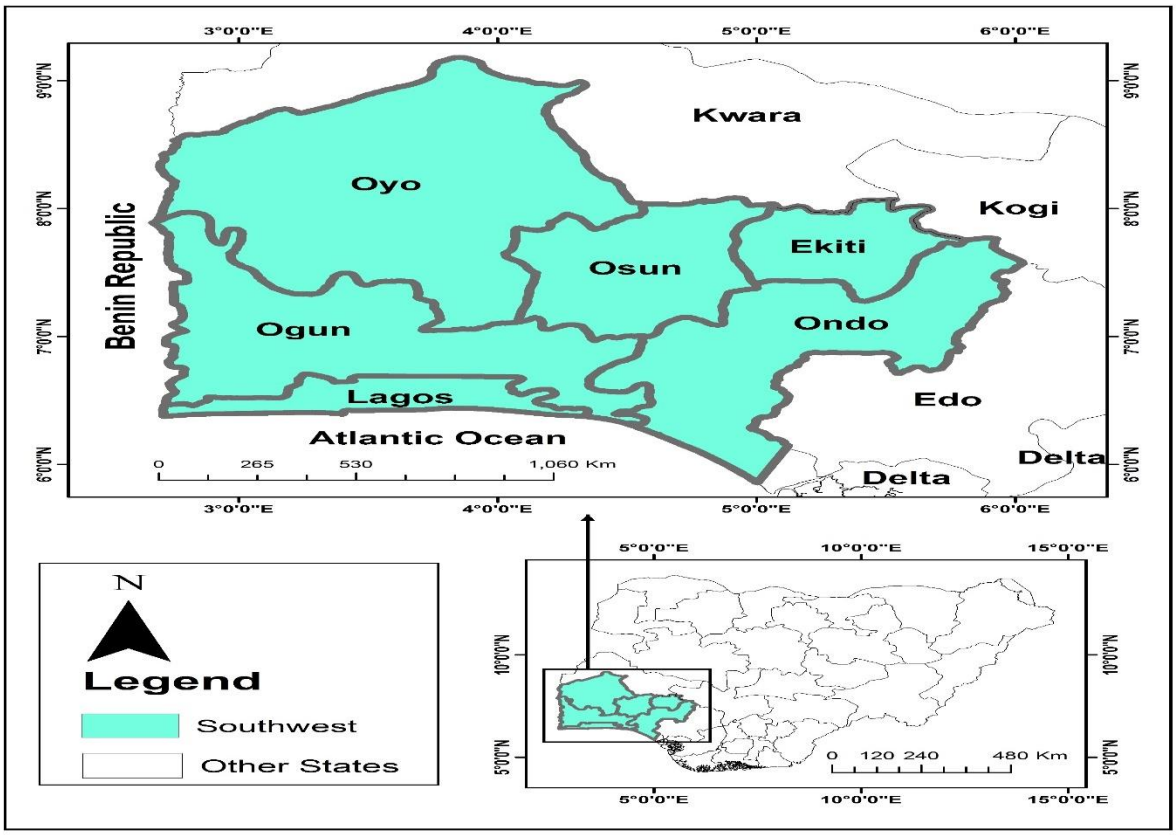

Figure 1: South-western Nigeria
Source: Adapted and Modified from the Administrative Map of Nigeria (2018)

The vegetation of the South-western Nigeria can be broadly termed as a forest community. The forest community is made up of the mangrove, freshwater mangrove, and the rainforest. Some common species of plants in the area include oil palm *(Elaeis guineensis*), Beechwood (G*melina arborea*), Avicennia (*Avicennia marina*), Iroko (*Milicia excelsa*), African white mahogany (*Turraeanthus africana*), Light Bosse (*Guarea cedrata*), kola (*Cola acuminate*), coffee (*Coffea*), rubber (*Havea brasiliensis*), citrus (*Citrus medica*), and cocoa (*Theobroma cacao*) being the most prevalent especially in the rainforest (Iwena, 2007).

The population of south-western Nigeria as at 2006 was 27,581,992 (National Population Commission, 2006). The projected population of the area is 39,003,385 persons (2017). The people of the region are predominately Christians and of the Yoruba ethnic group who make up approximately 21% of the national population.

MATERIALS AND METHODS

The data used for this study are monthly rainfall data for Lagos, Ogun, Oyo, Osun, Ondo and Ekiti states for the period of 1983-2017. This period was selected in accordance to the report of IPCC (2007a) who indicated that the minimum period for measuring climate change is 35year. The rainfall data was obtained from the headquarters of the Nigerian Meteorological Agency (NIMET) at Oshodi, Lagos. The non-parametric Thom's homogeneity test was used to test the homogeneity. The formulae is given as:

$$Z = \frac{R - E}{\sqrt{S}} \quad \text{(Equation 1)}$$

Where Z= Z Score
R= Number of runs

$$E = \frac{N+2}{2} \quad \text{(Equation 2)}$$

Where E = mean of series
N = number of years
and

$$S = \frac{N(N-2)}{4(N-1)} \quad \text{(Equation 3)}$$

Where S= Variance
N= Number of Years
1, 2 and 4= Constants

For $\alpha = 0.05$ level of significance, if $|Z| \leq 1.96$, the data is homogeneous and if $|Z| > 1.96$, the data is heterogeneous.

Walsh and Lawler (1981 cited in Sawa and Adebayo, 2011) mathematically expressed seasonality index as the sum of the absolute deviations of the mean monthly rainfall from the overall monthly mean multiplied by the exponent of the mean annual rainfall given as:

$$SI = \frac{1}{\bar{R}} \Sigma \left| \overline{x} - \frac{\bar{R}}{12} \right| \quad \text{(Equation 4)}$$

Where;
SI = seasonality index
$\bar{R}$= mean annual rainfall
$\overline{x}$= mean rainfall of the month n
1 and 12 = Constants

Table 1 presents the different class limits of seasonality indices and respective rainfall regimes.

Table 1: **Rainfall Seasonality Indices**

SI	Rainfall Regime
≤ 0.19	Rainfall spread throughout the year
0.20-0.39	Rainfall spread throughout the year but with a definite wetter season
0.40-0.59	Rainfall seasonal with shorter drier season (10-11months of rain)
0.60-0.79	Seasonal (7-9months of rain)
0.80-0.99	Marked seasonal with a long dry season (5-6months of rain)
1.00-1.19	Most rainfall in less than 3months
≥1.20	Extreme seasonality with almost all rainfall in 1-2months

Source: Kanellopoulou, 2002

The calculated seasonality index (S.I) were subjected to time series analysis, where trend lines and linear line equations were fitted to show direction of change in these parameters. Furthermore, crammer's t-test was used to determine if there was a significant variation in seasonality indices in the region for the period of study.

RESULTS AND DISCUSSION

Seasonality index for Lagos state

Figure 2 shows the trend of rainfall seasonality in Lagos state for the study period. The seasonality indices of Lagos state ranged between 0.58 in in 2009 to 0.61 in 1988, 1989, 1990, 1991 and 1995. The mean seasonality index for Lagos state was 0.57s; meaning that wet season in Lagos state occurred within 10-11months during the period of study. The linear trend line equation (Y= -0.0004x + 0.6045) is negative; meaning that there is a decrease in spread of rainfall in Lagos state during the study period. This implies that the steadiness of rainfall in the state was decreasing.

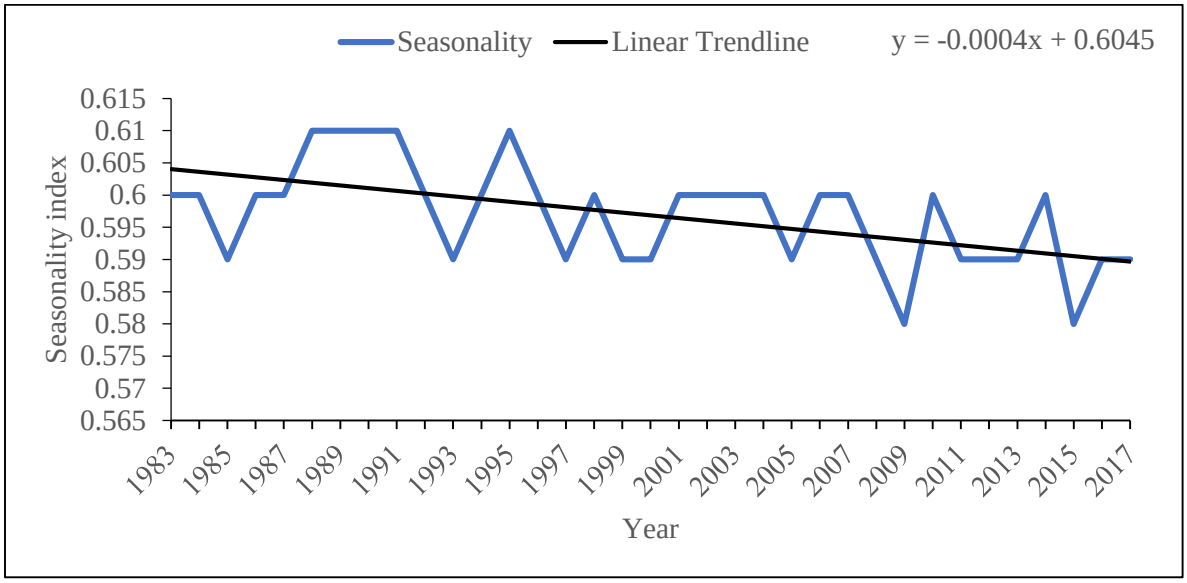

Figure 2: **Trend of Rainfall Seasonality indices in Lagos State (1983-2017)**

Seasonality index for Ogun state

Figure 3 presents the trend of rainfall seasonality in Ogun state for the period of study. The rainfall seasonality of rainfall in Ogun state was characterized by marked variability from year to year. Rainfall seasonality indices in Ogun state ranged between 0.55 in 1990 and 0.78 in 2011. The mean rainfall seasonality index for Ogun state during the period of study was 0.61; implying that wet season in Ogun state occurred within 7-9months during the period of study. The linear trend line equation (Y = 0.0009x + 0.5924) is positive; meaning that the spread of rainfall increased in the state during the study period. This result implies that the spread of rainfall was increasing in the state. This result contradicts the findings of Sawa and Adebayo (2011) in Northern Nigeria who found out that there is a shorting spread of the rainy season in Northern Nigeria.

This is a welcomed development for farmers in the area. Water required by plants for growth will be available in sufficient quantity throughout the planting seasons thus improving the yield of crops in the area. . Farmers may no longer need to use irrigation to supplement shortage of water during the little dry season period in the area and increase in yield of crops will ensure food security in the state.

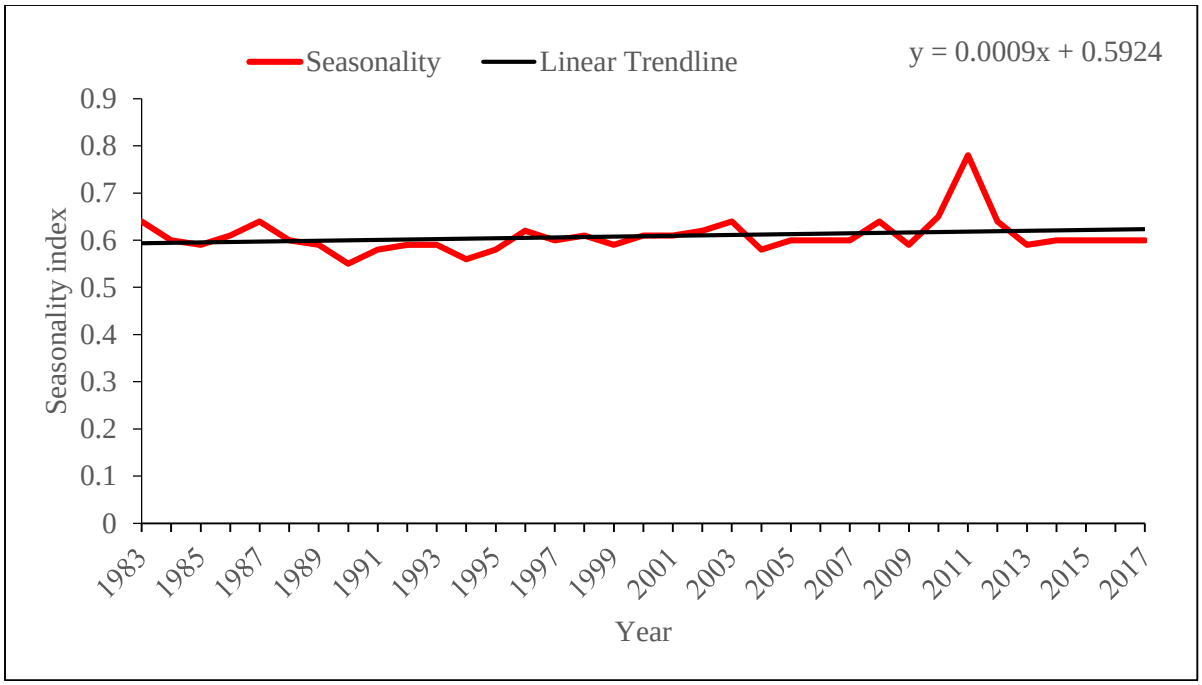

Figure 3: Trend of Rainfall Seasonality indices in Ogun State (1983-2017)

Seasonality index for Oyo state

The spread of rainfall in Oyo state for the study period is presented in Figure 4. The seasonality of rainfall in Oyo state was characterized by marked variation from year to year during the study period. Rainfall seasonality indices for Oyo state ranged between 0.56 in 2016 and 0.69 in 1983. The mean rainfall seasonality index for Oyo state during the study period was 0.61; meaning that wet season in Oyo state occurred within 7-9months during the period of study. Further, the linear trend line equation (Y = -0.0011x + 0.6268) is negative; meaning that the state experienced a shorten spread of rainfall during the study period.

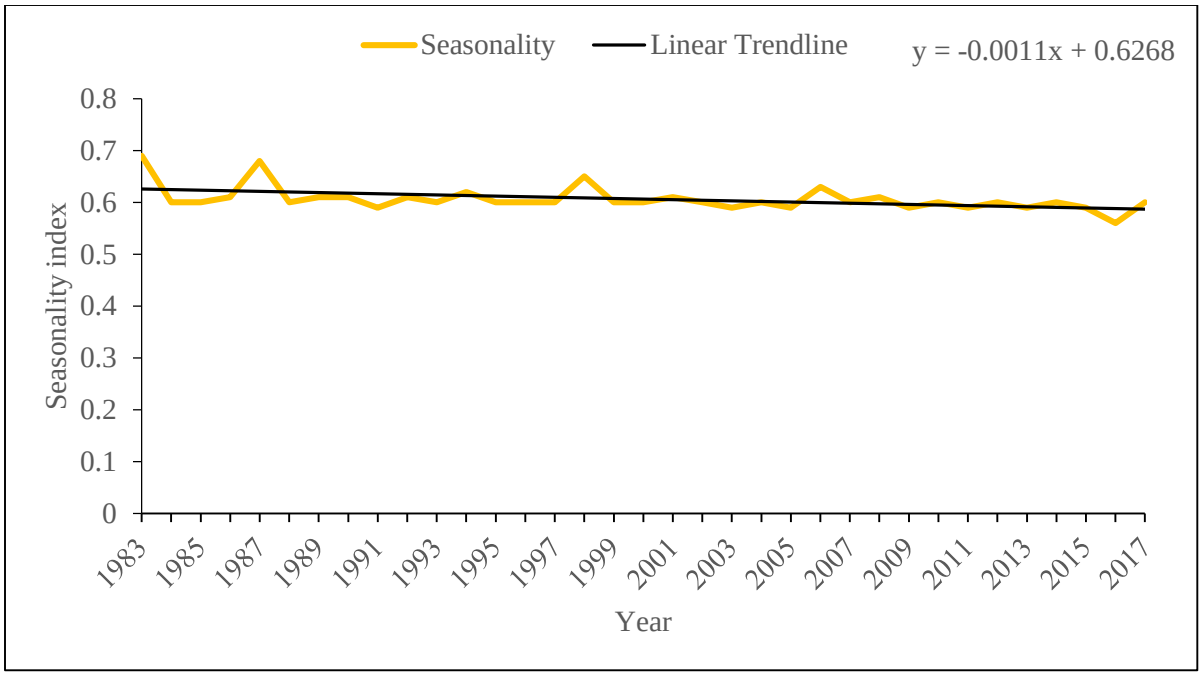

Figure 4: Trend of Rainfall Seasonality Indices in Oyo State (1983-2017)

Seasonality index for Osun state

Figure 5 presents the spread of rainfall in Osun state for the period of study. Rainfall seasonality indices in Osun state for the study period ranged between 0.55 in 1983 and 0.65 in 1993. The mean rainfall seasonality index for Osun state was 0.60; this implies that wet season in Osun state occurred within 7-9months during the period of study. The linear trend line equation (Y = -0.0751x + 0.6042) was negative; implying that the state experienced a decreasing spread of rainfall during the study period.

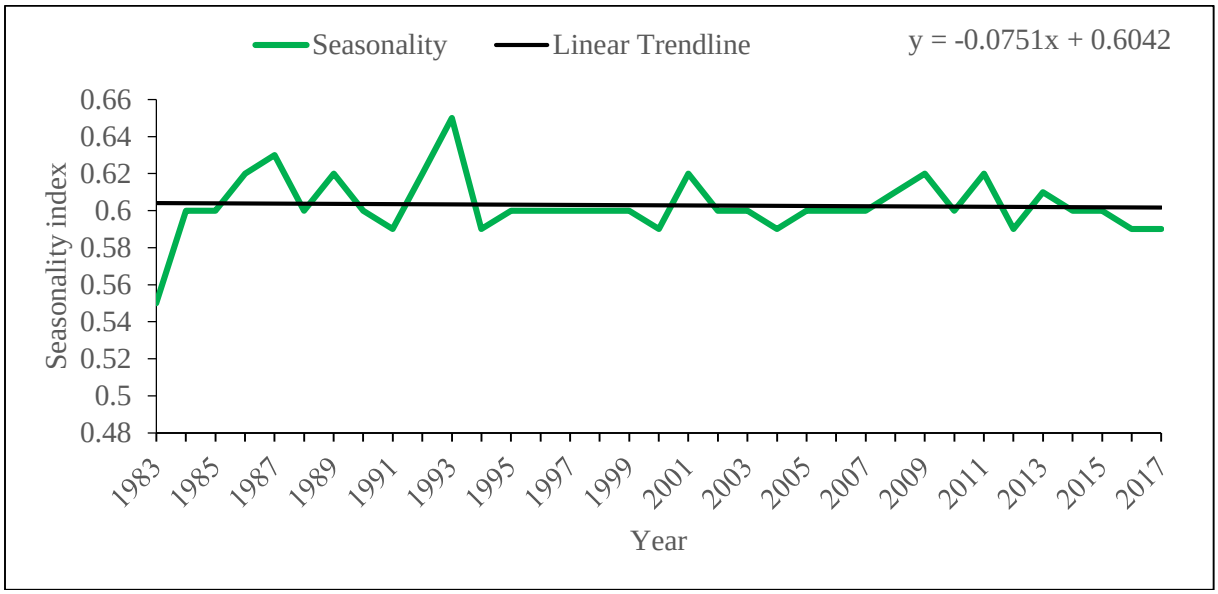

Figure 5: **Trend in Rainfall Seasonality Indices in Osun State (1983-2017)'**

Seasonality index for Ekiti state

Figure 6 presents the trend of rainfall seasonality index for Ekiti state during the study period. The rainfall seasonality indices for Ekiti state ranged between 0.59 in 1998, 1992, 1993, 1994, 1996 and 1999 respectively and 0.67 in 2003. The mean rainfall seasonality index for Ekiti state during the period of study was 0.60; meaning that wet season in Ekiti state occurred within 7-9months during the period of study. The linear trend linear trendline equation (Y = 0.0001x + 0.6009) was positive; meaning that the state experienced a progressive increase in spread of rainfall during the study period. This result contradicts the findings of Sawa and Adebayo (2011) in Northern Nigeria who found out that there is a shorting spread of the rainy season in Northern Nigeria.

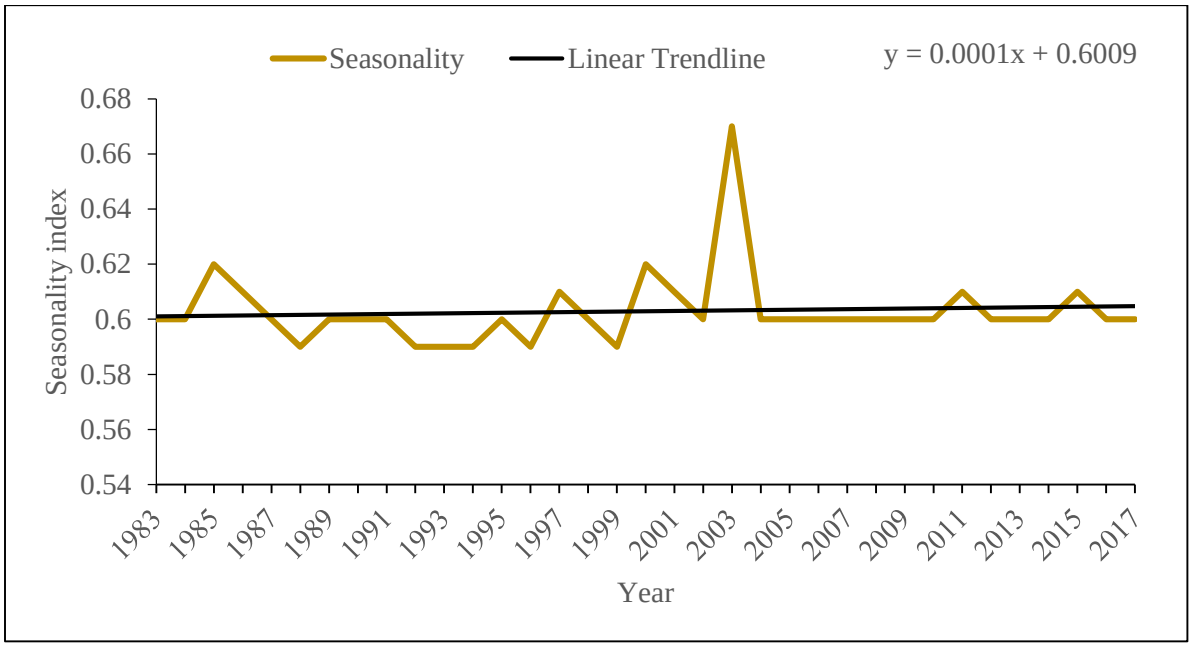

Figure 6: **Trend of Rainfall Seasonality indices in Ekiti State (1983-2017)**

Seasonality index for Ondo state

The spread of rainfall in Ondo state during the study period is presented in Figure 7. The trend of rainfall seasonality in Ondo state is characterized by marked variability from year to year. Rainfall seasonality indices in the Ondo state ranged between 0.59 in 1994 and 2017 and 0.69 in 1992. The mean seasonality in Ondo state during the study period is 0.61; this implies that wet season in Ondo state occurred within 7-9months during the period of study. The linear trendline equation (Y = -0.0003x + 0.6166) was negative; meaning that the Ondo state experienced shortening spread of rainfall during the study period. This result agrees with the findings of Sawa and Adebayo (2011) in Northern Nigeria who found out that there is a shorting spread of the rainy season in Northern Nigeria.

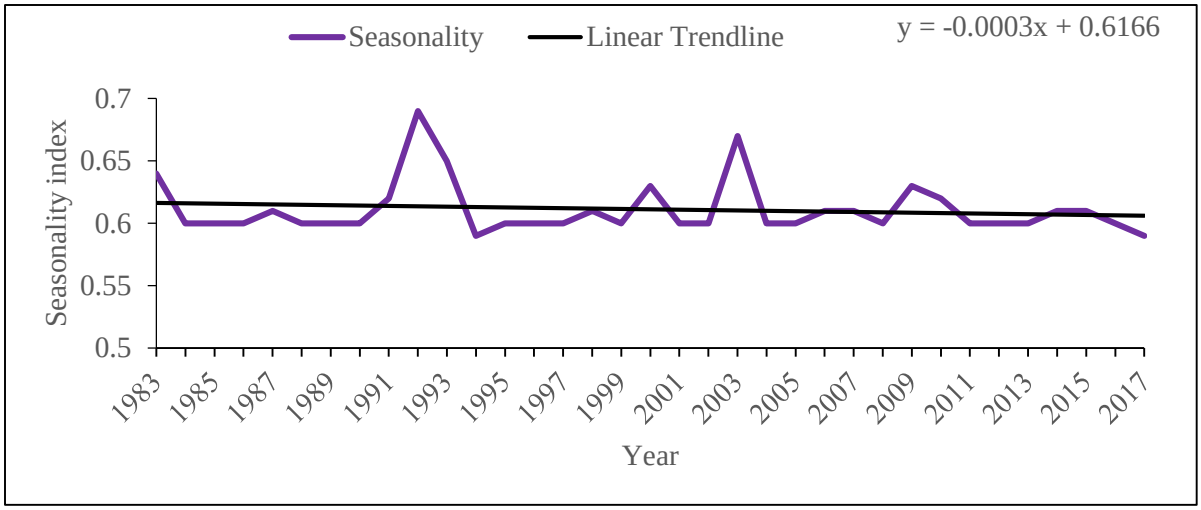

Figure 7: **Trend of Rainfall Seasonality Indices in Ondo State (1983-2017)**

Seasonality index for South-western Nigeria

Figure 8 presents the trend of rainfall seasonality index in south-western Nigeria during the study period. The trend of rainfall seasonality index in south-western Nigeria is characterized by marked variability from year to year during the study period. Rainfall seasonality indices in south-western Nigeria ranged between 0.59 and 0.64 with the mean rainfall seasonality index in the region being 0.60. This result indicates that wet season in south-western Nigeria occurred within 7-9months during the period of study. The linear trend line equation (Y = -0.0003x + 0.6166) was negative; meaning that the region experienced a shortening spread of rainfall during the study period. The equation also shows a predictive decrease rate of 0.0003% per annum.

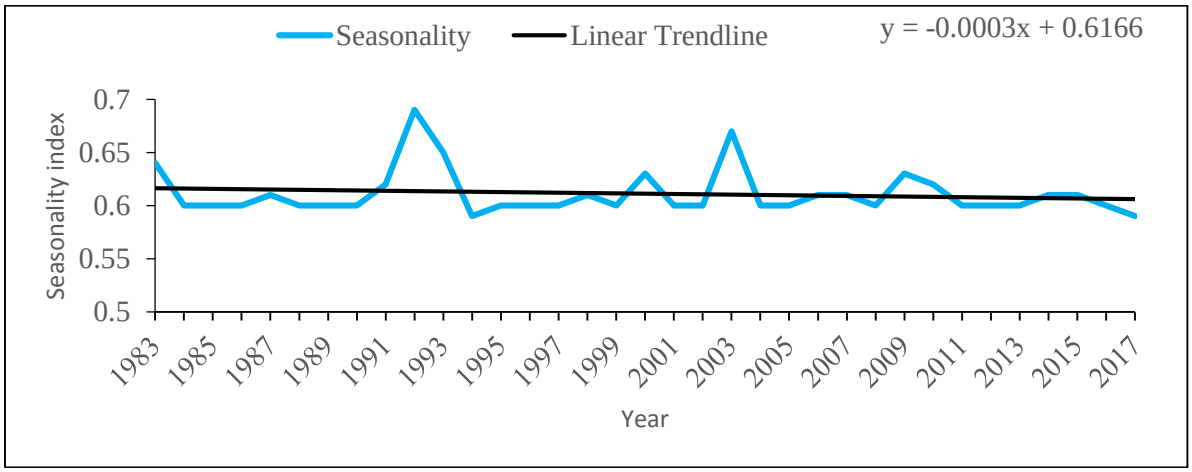

Figure 8: **Trend of Rainfall Seasonality indices in South-western Nigeria (1983-2017)**

The region experienced a phenomenon called little dry season during the rainy season in the months of July and August (Odekunle, 2007), where there was a decline in rainfall. Bello (1998) compared the seasonality of rainfall distribution in Nigeria in two periods, 1930-61 and 1962-1993 and found out that 1930-61 period, the rainfall regime in the forest zone to be equable (i.e.

rainfall was received all the year round) but this changed into one of a rather seasonal rainfall regime (i.e. rainfall was received within 7-9 months of the year) during the 1962-1993 period. It also conforms with the findings of Sawa and Adebayo (2011) in Northern Nigeria who found out that there is a shorting spread of the rainy season in Northern Nigeria. Shorten spread of rainfall in the region will affect agricultural activities in the region. Farmers will have to depend on irrigation to compliment the shorten duration of rainfall to maximize yield of crops.

Table 2 shows the t-test results that test for significance difference in seasonality indices in the states and the region at large

Table 2: **Variation in Rainfall Seasonality for the period of study**

	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lagos	443.601	34	3.601	.59686	.5941	.5996
Ogun	96.080	34	3.601	.60829	.5954	.6212
Oyo	148.570	34	3.601	.60629	.5980	.6146
Osun	220.265	34	3.601	.60286	.5973	.6084
Ekiti	257.664	34	3.601	.60286	.5981	.6076
Ondo	165.872	34	3.601	.61114	.6037	.6186
Southwest	268.097	34	3.601	.60400	.5994	.6086

Source: Authors' Analysis, 2018

Table 2 showed that the observed 't' for all the states and region at larges is greater than critical 't' = 3.60. This shows that there is a significant difference in seasonality indices in the states and the region during the study of study. This result showed that climate change has led to differences in seasonality of rainfall in the region. In some years, seasonality of rainfall is high while in some years it is low. This changes in seasonality will affect agriculture activities in the area, it would also have effect on water resources in the region

CONCLUSION

Based on the findings of the study, it could be concluded that climate change has led to shortened spread of rainfall in Lagos, Oyo, Osun and Ondo state while Ogun and Ekiti states experienced an increase in spread of rainfall during the period of study. In south-western Nigeria generally, climate change has led to shortened spread of rainfall and this could have effect on agriculture and water resources in the area.

It was therefore recommended that during the periods of excess rainfall, water should be stored by government in dams while farmers and residents should store in artificial reservoirs to cater for the shortage during the period of deficit. It can also be used to monitor the water table of the area, well and boreholes can be dug during the dry season so that it can supply water all through the year. Similarly, timely communication of rainfall prediction is important for planning of agricultural activities thus NIMET should communicate this information to farmers on time to avoid loss of yield in the region.

REFERENCES

Adefolalu. D.O. (1986). Rainfall Trends in Nigeria. *Theoretical and Applied Climatology*. 37, 205-219

Adejuwon, J.O. (2012). Rainfall Seasonality in the Niger Delta Belt, Nigeria. *Journal of Geography and Regional Planning.* 5(2), 51-60

Adepitan, J.O., Falayi, E.O. and Ogunsanwo, F.O. (2017). Confirmation of Climate Change in South-western Nigerian through Analysis of Rainfall and Temperature Variations over the Region. *Covenant Journal of Physical and Life Sciences.* 5(1), 37-51

De Luis, M., Hidalgo, J.C.G., Longares, L.A. and Vide, J.M. (2010). Changes in Seasonal Precipitation in the Iberian Peninsula during 1946-2005. *Article in Global and Planetary Change*. 74(1), 27-33

IPCC, (2007a). *Regional climate projections*. In *Climate Change 2007*. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, New York, US: Cambridge University Press pp 8 – 19.

IPCC, (2007b). *Climate change: Synthesis Report. Summary for policy makers*. pp. 1-22. Retrieved from http://www.ipcc-wg1-ucar.edu/wg1/wg1-report.htm on February 2017.

Iwena, O.A (2007). *Essential Geography*, 6th Ed, Tonad publishers limited. Pp. 229-266.

Kanellopoulou, E.A. (2002). Spatial Distribution of Rainfall Seasonality in Greece. *Weather.* 57(3), 215-219

National Emergency Management Agency (2013). 2012 Flood Disaster cost Nigeria N2.6tn. *The Punch*, 20th July, 2013. Available at www.punchng.com.

National Population Commission (NPC) (2006). Nigerian Population Census- State Population. http://www.population.gov.ng/index.php?option=com_content&view=aticle&id=89.

Odekunle, T.O. (2007). Predicting the Variability and the Severity of the Little Dry Season in South-western Nigeria. *Ife Journal of Science*. 9 (1), 82-95

Patil, M.K. (2015). Change in Seasonality Index of Rainfall in Sangli District, India. *Indian Streams Research Journal.* 5(1), 1-7

Sawa, B.A. and Adebayo, A.A. (2011). The Impact of Climate Change on Precipitation Effectiveness Indices in Northern Nigeria. *Research Journal of Environmental and Earth Science.* 3(5), 481-486

Sobowale, A., Sajo, S.O. and Ayodele, O.E. (2016). Analysis of Onset and Cessation of Rainfall in Southwest Nigeria: Food Security Impact of Variability in the Length of Growing Season. *Hungarian Agricultural Engineering.* 30, 23-30.