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Drought Distribution Dynamics In South-Western Nigeria: A Geospatial Approach To Climate Risk Evaluation

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Abstract
Drought is a natural occurrence which is a natural induce phenomenon and which cannot be, controlled by human being but it can be mitigated during and after its occurrence. It is a phenomenon which occurs after a prolong period of rainfall which brings about fast evapotranspiration as a result of high temperature. Indicator like SPI, SPEI, SMI and PCI are used to estimate the analysis of drought. These methods of analysis can give useful information about drought frequency and magnitude. Soil Moisture Index (SMI) shows that evenly distributed soil moisture was recorded from 1983 to 1992 but the pattern changed during 1993 to 2002 where there is no serious drought condition. The SMI indicated that there was no drought condition in the entire region of South Western Nigeria in the year 2003 – 2006 and year 2015 and 2021 showed that very serious drought occurs. The Plant Condition Index (PCI) indicator agreed with the same explanations given by SMI. The general objective of this paper is to examine the spatia distribution of drought in South Western Nigeria (SWN).
Keywords: *Drought, SWN, Distribution, SMI, PCI, 2083 – 2022.*

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I. Introduction

Drought is one of the most severe natural disasters throughout the world (Igbawua *et al*., 2016; Kalisa *et al.*, 2019). Drought can be defined as an extended period with subnormal or no rainfall (Raposo, 2023). The American Meteorological Society (AMS) in the year 2018 classifies it into four types. These are: the meteorological drought which results from lack of rain in an area during a selected period; hydrological drought which is associated with a lack of surface and underground water; the agricultural drought which refers to a deficiency in water accessibility for plant growth and the social economic drought which is related to insufficient supply of water to meet the demand of various economic goods with the above three mentioned types of drought (Yang, 2010; Du *et al*., 2013; Udmale *et al*., 2014). Among all types of droughts, meteorological drought normally triggers the other three drought types. According to the Intergovernmental Panel on Climate Change (IPCC), drought is set to increase globally in both frequency and severity due to climate change (Raposa, 2023). The aim of this study is to establish the spatial distribution of drought in South Western Nigeria.

II. Concept Of Drought

Authors of the same view (Kalisa *et al.* 2020; Afzali *et al.*, 2016; Asefjah *et al.*, 2014; Nohegar *et al.*, 2014; Bazrafshan and Khalil, 2013) define drought in various ways, pointing toward the same goal. Drought as a creeping hazard and complex natural phenomenon has significant effect on water resource management (Bazrafshan and Khalil, 2013). Generally, drought gives the impression of water scarcity due to insufficient precipitation, high evaporation, and over exploitation of water resources, or a combination of all the above (Afzali *et al.*, 2016; Nohegar *et al.*, 2014; Asefjah *et al*., 2014; Zaire *et al*., 2013; Azarakhshi *et al.*, 2011; Dastorani and Afkhami, 2011). Other authors looked at drought as a "period of insufficient rainfall either in time or in space. "It is caused by low rainfall, often associated with increased evaporation rates. As a result of this, crop failure occurred which cause a severe shortage of food in a rural population (Achugbu and Balogun 2018). The impact of drought on socio-economic and environment affect many sectors of African economy (Olatunde and Aremu, 2013). An encyclopaedia account noted drought as a lack of insufficiency of rain for an extended period that caused a considerable hydrology (water) imbalance and, consequently, water shortage, crop damage, stream flow reduction, and depletion of ground water and soil moisture (Britannica, 2021). It occurs when evaporation and

transpiration (Movement of water in the soil through plants into the air) exceed precipitation for a considerable period. It is the most serious physical hazard to agriculture in nearly every part of the world. Efforts have been made to control it by seeding clouds to induce rainfall, but these experiments have had only limited success (Britannica, 2021). Some authors reasoned that drought is the most severe natural disasters throughout the world (Igbawua *et al.*, 2016; Igbawua *et al.*, 2019 and Kalisa *et al.*, 2020).

Drought Indicator and Indices

Drought indicators and indices are important parameters with which Scientists Meteorologist and hydrologist use as input for drought analysis.

Drought Indicators

Indicators are variables or parameters used to describe drought condition. Example of these includes precipitation, temperature, stream flow, groundwater and reservoir levels, soil moisture and snowpack (WMO, 2016).

Drought indices

Drought indices are typically computed numerically representations of drought severity, assessed using climatic or hydro-meteorological inputs including the indicators listed above. They aim to measure the qualitative state of droughts on the landscape for a given period. Indices are technically indicators as well (WMO, 2016).

Table 2.1: Palmer Classifications (mml)

Palmer Value (mml)	Classification
4.0 or more	Extremely Wet
3.0 to 3.99	Very Wet
2.0 to 2.99	Moderately Wet
1.0 to 1.99	Slightly Wet
0.5 to 0.99	Incipient Wet Spell
0.49 to -0.49	Near Normal
-0.5 to -0.99	Incipient Dry Spell
-1.0 to -1.99	Mild Drought
-2.0 to -2.99	Moderate Drought
-3.0 to -3.99	Severe Drought
-4.0 or less	Extreme Drought

Source: NDMC (2012)

Table 2.2: Classification of drought according to SPI & ZSI value classes (mml)

Value	Classification
2 or more	Extremely wet
1.5 to 1.99	Very wet
1 to 1.49	Moderately wet
0.99 to 0.0	Normal
0.0 to -0.99	Near normal
-1 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2.0 or less	Extremely dry

Source: Afzali *et al.* (2016)

III. Methodology

Satellite imagery data is refers to images captured by satellites orbiting the earth . It provides a view of the earth's surface from space and can be used for various purposes, including monitoring environmental changes , analysing land use pattern and natural disasters. Satellite imagery was access from the website of National Oceanic Atmospheric Administration (NOAA), United State Geological Survey (USGS) and Moderate resolution Imagery Spectroradiometer (MODIS), Earth Observing System Data and Information System (EOSDIS) or purchase data from commercial providers such as Digital Globe. Airbus Defense and Space or Geo IQ. To process and analyze satellite imagery data, software like Google Earth Engine, ESRI ArcGIS, or QGIS was used. These tools allow you to visualize, manipulate and extract useful information from the imagery. This will enable one to detect drought events and classify different levels of severity. Geographic Information System was used to create maps indicating the spatial distribution of drought and to identify areas with lower-than-normal rainfall or higher than normal temperatures. Drought indices (SPI, PDSI) was applied to quantify the severity of drought events and distinguish their characteristics.

IV. Results And Discussion

Examining spatial distribution of drought in South Western Nigeria

The spatial distribution of drought in South Western Nigeria was studied from 1983- 2022 (40years). The years were compressed into ten years interval from1983-1992, 1993-2002, 2003-2012, 2013-2022 as presented in figs.4.1.1, 4.1.2, 4.1.3, 4.1.4. Viewing closely through the South Western Nigeria fig.4.1.1, the wettest parts of the region cut across the whole states. It was pronounced in the central parts of South Western Nigeria ranging from Ondo to Oyo state in 1983, partly Ondo and Ekiti states in 1984, northern Ekiti, Oyo and Lagos states in 1985 and was well pronounced throughout the South Western Nigeria in 1989. During 1990-1992, the trend in distribution changed. According to Oluwafemi *et.al*,2018, South Western Nigeria experienced spatial distribution of drought and its relationship with climatic variables are increasing in alarming rate. Soil Moisture Index (SMI) shows that these locations have little amount of soil moisture in the soil. Drought might have occurred in these areas. The western part of Lagos,Ogun and passing through northern Oyo state, indicates that the area were moderately wet, with some spots showing normal wetness. On the other hand, the dry area were noticed in Ondo south throughout the year (1983-1992) except in 1992 when the locations were very wet. In 1983,1984,1988,1991 and 1992, normal dryness cut across the states and was pronounced in Oyo states (1992). During 1983, 1984 and 1986, states like Lagos, parts of Oyo, Ogun, Ekiti and Ondo respectively, experienced fairly dry conditions. The dry condition was well pronounced in states like northern Ekiti and Ondo states in 1988, parts of Ogun and Oyo states in 1987, Oyo and Ogun central in 1985 and in 1990, the entire Ondo and Ekiti states to Ogun central axis experienced very dry condition. Prevalence of drought occurs during these years because of the dryness condition. This assertion agreed with the statement about drought assessment by Okoye *et al*,2019. In the year 1994,1995,1999 and 2002 fig 4.1.2, nearly the wet condition cut across the South Western Nigeria and most of the states in the region have normal to moderately dry scenario when compared to 1993-2002. The year where dry spell was pronounced was in 1987, 1998, and 2000 along the axis of Ondo, Ogun, Lagos and northern parts of Oyo states. Here, the prevalence of drought was possible because of the dry environment. This agreed with the findings of Oyesiku, *et al*, 2017. Figure 4.1.3, depicts spatial distribution of drought events between year 2003-2012. The scenario changed, having states with very dry condition in 2007 (northern Osun and Ekiti states), 2008 (northern Osun states), 2010 (central Ogun) and eastern boundary axis between Osun and Oyo states. These area experienced drought condition because it was indicated in the study that they were categorized into the classes of moderately dry to very dry environment. In the year 2003-2011 and partly 2012, it was indicated from the study that the environment were categorized between moderately wet and wet. This shows that drought never occurred in these environment during the identified years. Fig, 4.1.4, depicts the spatial distribution of drought of drought event between 2013-2022 in the study area. In 2015 and 2021, there was drastic changed of drought events in the entire region. The region was categorized into moderately dry to dry environment. This shows that there was drought condition during this period (2015,2021). In 2013-2014, the Soil Moisture Index (SMI), indicates that South Western Nigeria was categorized into moderately dry (0.2-0.4) and moderate (0.4-0.8) condition. This same scenario was repeated in 2017,2018 and 2020 except2019 where most of the locations in South Western Nigeria indicates moderately wet environments. Here, drought may not likely occurred because of the wet condition as indicated by the SMI. Fig. 4.1.4 presented the spatial distribution of drought in South Western Nigeria during the year 2013-2022. In fact , the same scenario happened when compared with the year 2003-2012. In 2015 and 2016, the SMI indicator shows that there was a very dry environment which calls for drought condition and this explained that in any dry environment there would be drought occurrence. The rest of the years also tailored the same spatial distribution as that of 2012-2022.

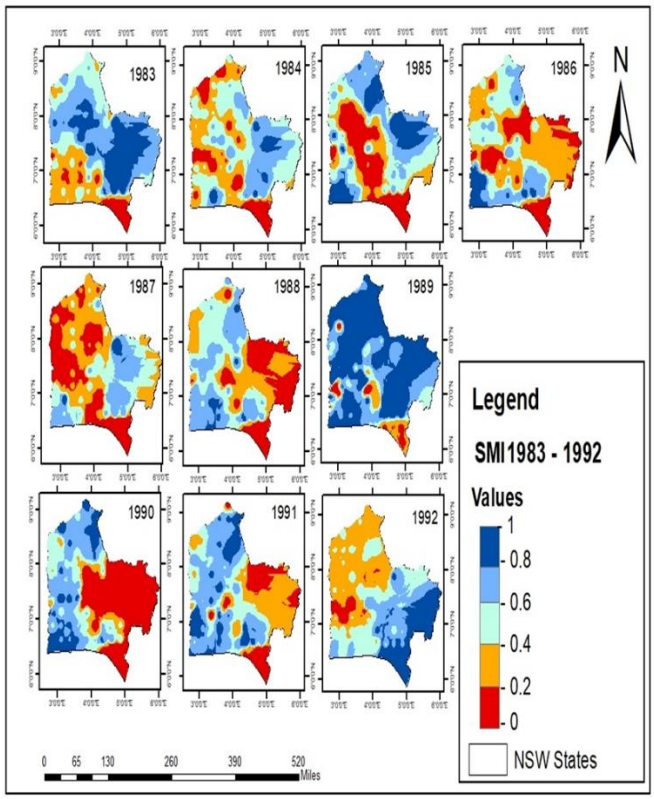

Fig. 4.1.1: 1983-1992 SMI over South Western Nigeria

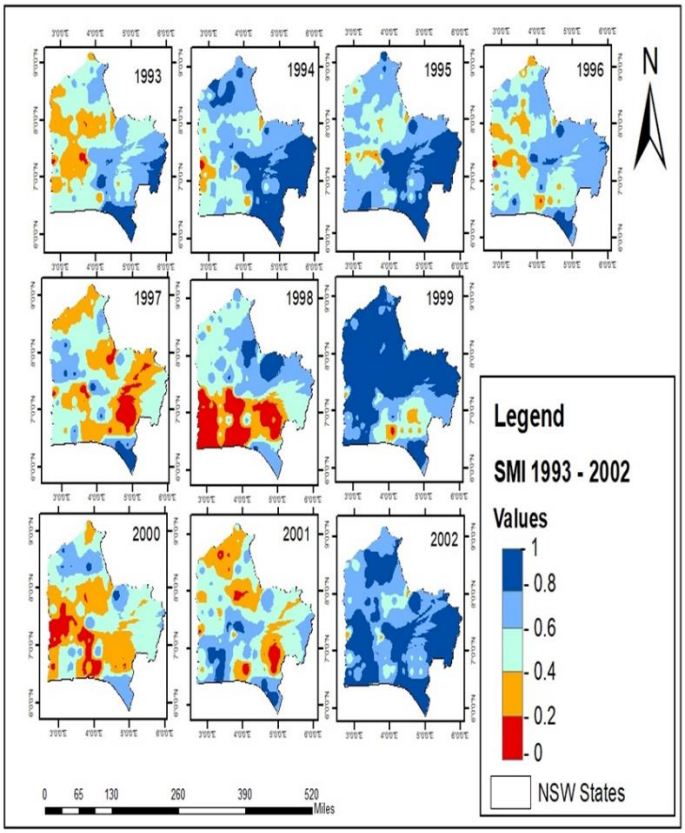

Fig. 4.1.2: 1993-2002 SIM over South Western Nigeria

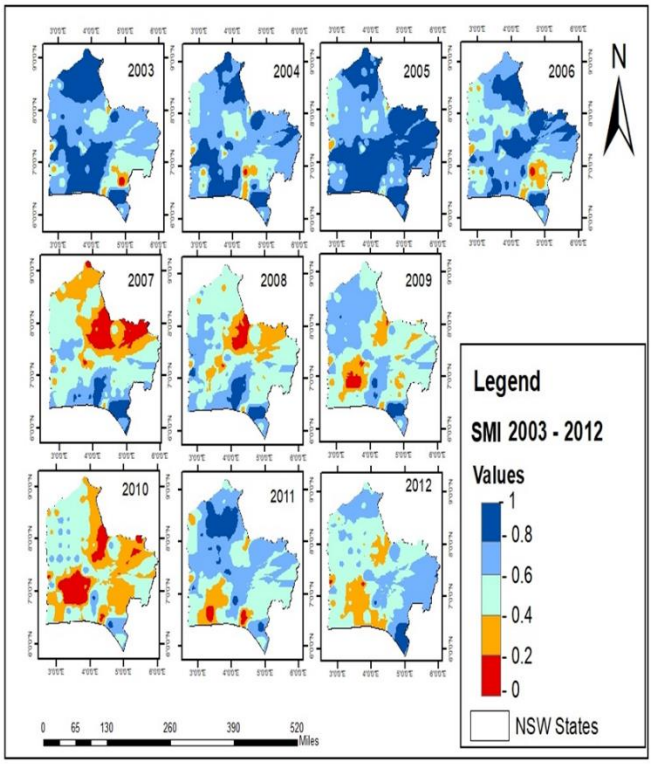

Fig. 4.1.3. 2003-2012 SIM over South Western Nigeria

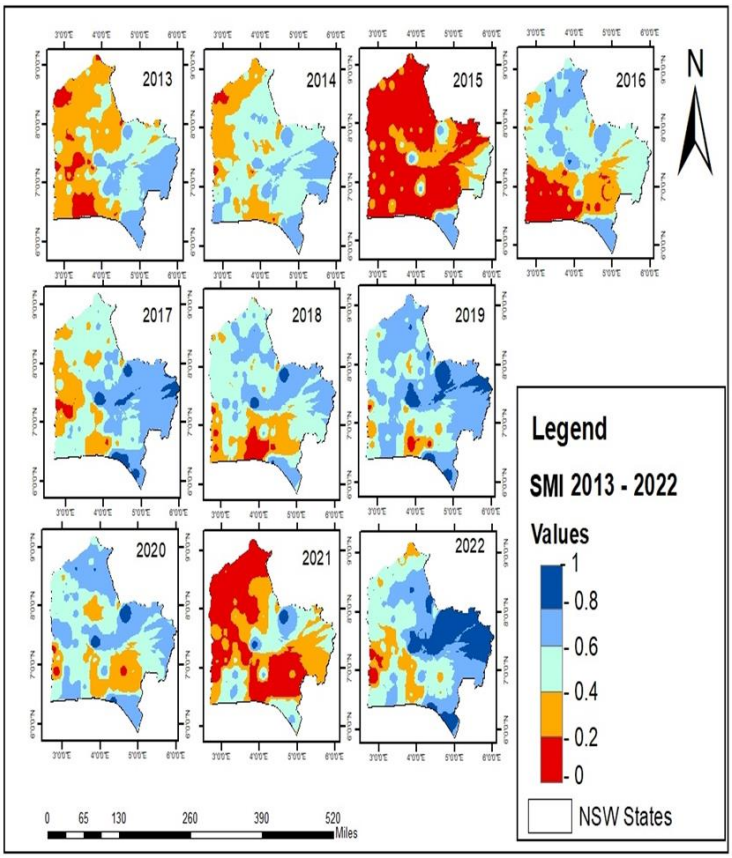

Fig. 4.1.4: 2013-2022 SMI over South Western Nigeria

Fig.4.1.5. presented the Plant Condition index (PCI) drought in South Western Nigeria from 1983-1992 which is equally suitable to describe drought occurrence in a locality. This index enable a researcher to know the drought condition and its distribution in a place. A lower value of PCI indicates severe drought stress, while a higher value indicates healthier plant. Moderately wet (1.2-1.4)was recorded for Ondo north in 1983 and this indicates that the plant are not prone to drought. The rest states of the region experienced very dry to near normal (0.4-1.0) except in 1988 when PCI value was slightly wet (1.0-12) for the entire region.

Fig. 4.1.6 depicts PCI values in the year 1993-2002. In 1995, the entire region except Lagos experienced PCI values of 1.0 -1.4 which indicates that drought might have not been well pronounced. Year 1999 shows very low values (0.0-0.4) for Ekiti and northern Ondo state which indicates the presents of drought stress on plants. The region largely experienced drought stress on plant in the year 1998-2002 as low values was recorded (0,6-0.8) except 1997 which had a higher value (0.8-1.0)In the year 2003-2012 (fig.4.1.7), the drought stress was highly pronounced throughout the region (0.4-1.4) except in 2005 (0.0-0.2) where Ondo, Ekiti and northern part of Osun and Oyo states axis experienced drought.

Fig.4.1.8 depicts, the PCI values from 2013-2022. In the year 2013-2017, the PCI values ranges from 0.4-0.8, Here, the drought stress on plant was minimal. It is only the vegetation of northern Ondo that experienced drought stress on plant (0.2-0.4). Year 2019 and 2021 have high values of PCI (1.2-1.8).

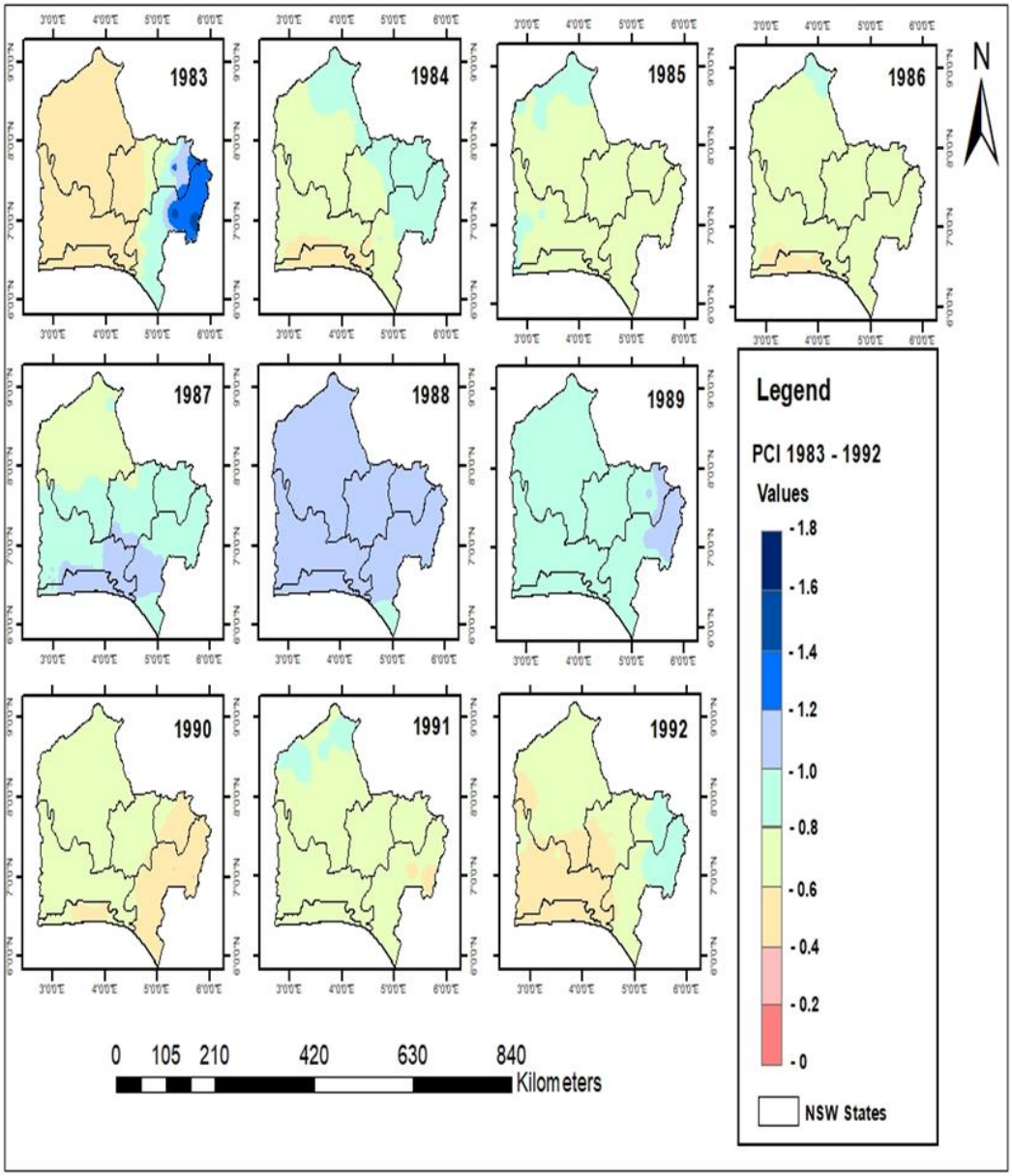

Fig.4.1.5:1983-1992 PCI over South Western Nigeria

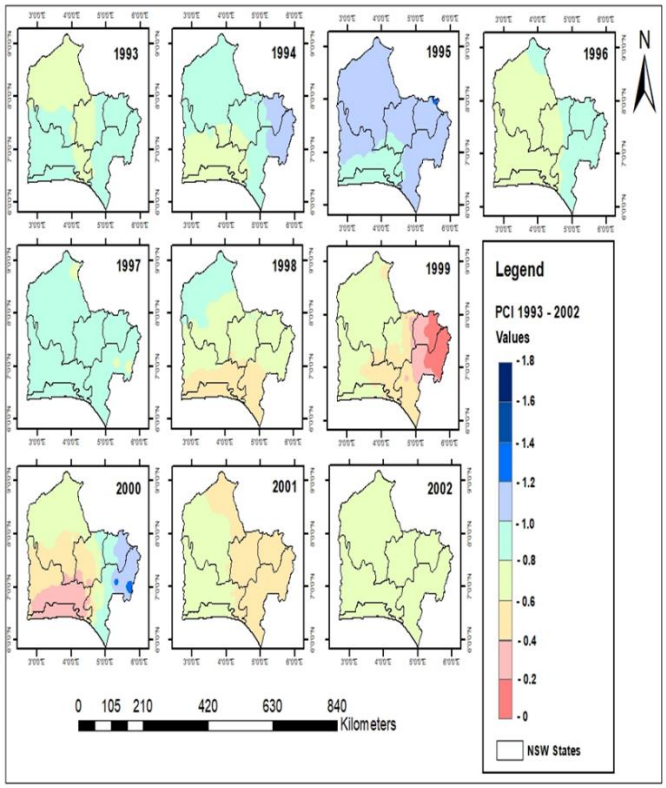

Fig. 4.1.6:1993-2002 PCI over South Western Nigeria.

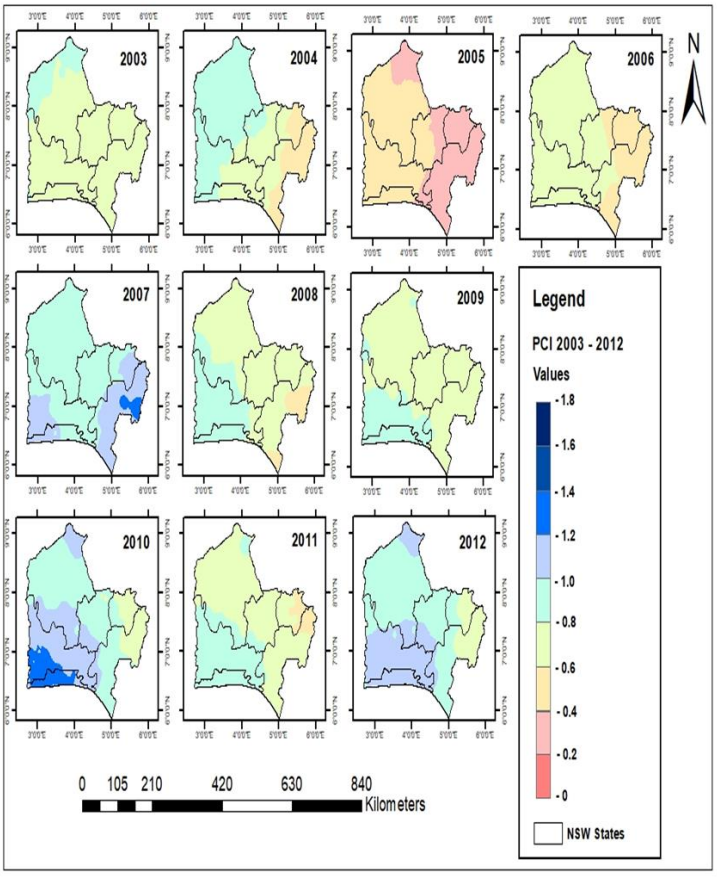

Fig.4.1.7: 2003-2012 PCI over South Western Nigeria

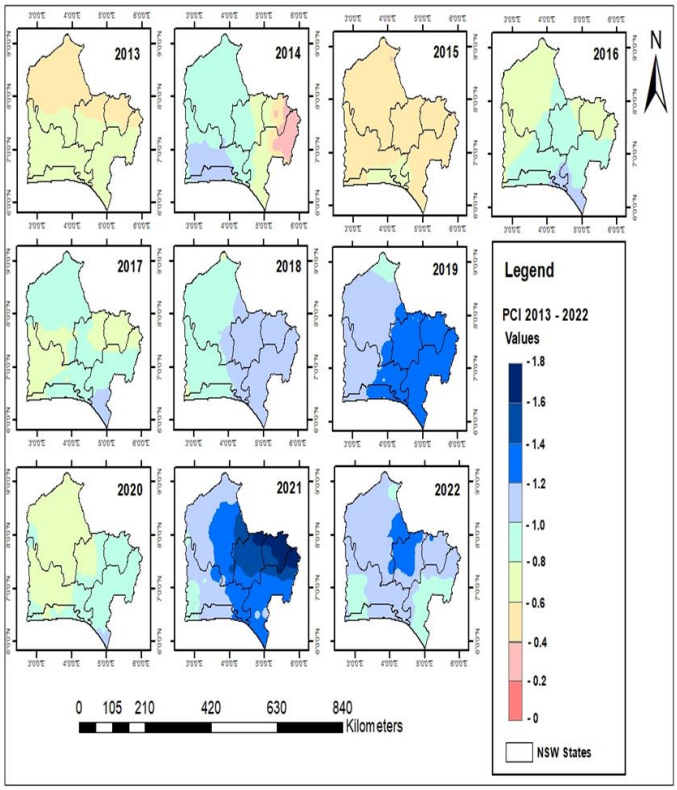

Fig. 4.1.8 :2013-2022 PCI over South Western Nigeria

V. Conclusion And Recommendation

The following conclusions were made after studying and examine the trend of spatial drought distribution in South Western Nigeria:

i. The Soil Moisture Index (SMI) indicated that the moisture present in the soil of South Western Nigeria was evenly distributed throughout the year (1983-1992), except in 1989 where the soil of the entire region was almost wet as presented in fig.4.1.1.This shows that drought can not occur during these periods. This also favors the healthy condition of the plant as presented by Plant Condition Index (PCI) Fig.4.1.5

ii. Ten years interval (1993-2002), the distribution pattern changed and most of the years (1993,1995,1999,2002) did not experienced pronounced drought condition except 1998 where the indicator (SMI) shows dryness along central Lagos, Ogun and Ondo states axis. Fig. 4.1.2 . This explanation agreed with that of PCI indicator as presented in fig.4.1.6

iii. The trend of distribution of wet condition for the four years from the beginning of 2003-2012, shows that there was no drought throughout these years (2002 – 2006) in the entire region of South Western Nigeria. Fig.4.1.3. From 2007-2012, the region experienced mixed distribution between dry and wet condition. This explanation was true for PCI as presented in fig 4.1.6.

iv. There was well pronounced drought in the year 2015 and 2021 as shown by the indicator (SMI) while the rest of the year showed a mixed mild drought and wet condition.Fig.4.1.4.

v. The blue sign on the legend indicated that the environment is wet and the red sign indicated dry condition.

VI. Recommendation

Having under studied the trend of drought distribution in South Western Nigeria, the following recommendations were presented:

i. Climate change is the change in the climate of a place. This change occurs as a result of the global warming. The ozone layer had been depleted and as such the intensity of the sun heated the surface of the soil directly. To prevent this, alternative source of energy to fossil fuel is recommended to reduced the global atmospheric gas emission that contribute to global warming.

ii. Farmers in South Western Nigeria should be advised to take into account yearly rainfall for-cast from relevant agencies such as NIMET for effective planning to maximize crop production given the seasonal and annual rainfall variation and distribution in the region.

iii. The Government at all levels should invest in the studying of drought, how it can be controlled, prevented and to educate the masses about this menace.

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