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GEO-SPATIAL TREND MAPPING OF SOME ANNUAL CLIMATE VARIABLE FOR SOUTH WEST NIGERIA

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Abstract: The concept of climate has gained much relevance because of its dynamic and complex nature and the significant influence it has on various aspects of the environment including the increasing threat of global climate change. The varying pattern does not encourage the stable practice of agriculture, thereby causing an increase or decrease in their yield. Data were collected from Nigeria Meteorological Agency (NIMET) for rainfall, temperature and relative humidity data for the period of 38 years and were analyzed in order to generate geo-spatial trend maps of climate variability to aid smart agricultural crop production. The mean temperature, average rainfall and average relative humidity for each year of the study period were calculated. Imagery shape file was also extracted from South West Nigeria maps. The weather data and Imagery shape file were then imported into Arc GIS 9.0 for geo-spatial maps for Rainfall, Temperature and Relative Humidity. The analysis showed prolonged variability in average annual rainfall received over the climatic zone across the three climatic factors. The results indicated a temperature higher than 27°C cause under-development of anthers and loss of viability of pollen. Higher temperature disturbs the photosynthesis and respiration and these may result in low production. Rainfall pattern reveals that rainfall in South West has been highly varied. Relative humidity pattern between the years tends to either increase or decrease in the result by (±3) with a relative stability in the last 5 years of this study period thereby aiding the easy prediction of the shelf life of agricultural products.
Keywords: climate factors; climatic variability; agricultural production; south-west of Nigeria

INTRODUCTION

The last several decades have witnessed warmer temperatures across the globe, with more rapid warming observed during the last half of the 20th century compared with the first (Jones *et al.*, 2001). Agriculture in Nigeria is a branch of the economy in Nigeria providing employment for about 30% of the population as at 2010 (Sanusi, 2010). Heavy rainfall events have increased, longer and more intense droughts have occurred.

The adverse effects of food insecurity have already been felt in the South Western of Nigeria. Currently, and over the next few decades, climate change impacts on agriculture are more likely to arise from increased climate variability and increased frequency and intensity of extreme events, rather than from changes in mean climatic conditions. It has produced several effects on food security thereby resulting in scarcity of some items not produced in this part of the country. With all these adverse effect of climate on agriculture been stated, addressing climate concerns through adaptation will be advantageous to agriculture (FAO, 2006).

The Intergovernmental Panel on Climate Change (IPCC) notes that adaptability through changes in "processes, practices or structures" is a crucial element in reducing potential adverse impacts or enhancing beneficial impacts of Climate change (IPCC 2001). Adaptation is regarded as a vital component of climate change impacts and vulnerability assessment (Skinner *et al.*, 2001). In the context of development, Burton (1996) asserts that a practical response strategy is to improve adaptation to climate variability, including extreme events. Smith (1997) maintains that adaptation is necessary to avoid impacts that can otherwise occur gradually and may be irreversible. That is, increasing the robustness of infrastructure designs and investments can reap immediate benefits through improved resilience to climate variability and extreme atmospheric events. Adaptation is viewed as a crucial step to strengthen local capacity to deal with forecasted and unexpected climatic conditions (Smith *et al.*, 1996).

Nigeria, by virtue of its location, enjoys a warm tropical climate with relatively high temperatures throughout the year and two seasons; the rainy or wet season that lasts from mid-March to November in the south and from May to October in the north; and the dry season that occupies the rest of the year. However in a country where the temperatures do not fluctuate regularly, constant elements such as rainfall and relative humidity are heavily relied on to differentiate between the season and climate zones.

The climate of the country is influenced by the interaction of two air masses: the relatively warm and moist tropical marine mass which originates over the Atlantic ocean and is associated with southwest winds in Nigeria and the relatively cool, dry and relatively stable tropical continental air mass that originates from the Sahara Desert and is associated with the dry, cool and dusty North-East Trades (harmattan).

In the south, it's a different case as the long wet season that starts in mid-March and last till July is a season of heavy rains and high humidity. Plants and pasture are fresh and green grasses and weeds grow rapidly and look attractive. Plant development depends on high atmospheric humidity in the sense that many plants have the ability to directly absorb moisture from unsaturated air of high humidity.

This percentage tells how close the air is to being saturated. If the relative humidity is 50%, the air contains half the water vapour required for it to be saturated. If the amount of water vapour in the air increases, the relative humidity increases, and if the amount of water vapour in the air decreases, the relative humidity decreases. However, relative humidity is dependent on air temperature, too. If the water vapour content stays the same and the temperature drops, the relative humidity increases. If the water vapour content stays the same and the temperature rises, the relative humidity decreases. This is because colder air doesn't require as much moisture to become saturated as warmer air (Monteith and Unsworth, 2008).

According to 2004 estimate the value of agriculture production constituted 30.8%; industry, 43.8% and services 25.4%, of the nation GDP, respectively. The nation's GDP real growth rate stood at 7.1% (CIA World Factbook, 2004). Temperature rise is likely to result in reduced food production within the next couple of decades in regions already facing food insecurity. To determine the correlating effects of these two climatic factors, a model will be used to study the processes taking place in the soil-plant-atmosphere continuum and carry out scenario testing. This approach permits revisiting of the past, simulating the present and predicting the future, thus, made it flexible in all situations.

With an upgraded capability to environmental parameters, proper management intervention could be done to minimize risk in the future. The rainfall pattern can simply be accessed using simulation models. Another issue is the spatial and temporal dimension of water productivity. A spatio-temporal analysis could broaden the role of models in exploring improved water use in agriculture (Ines *et al.,* 2002). The use of Geographic Information System (GIS) and crop models permits more efficient analysis because the temporal and spatial dimensions could be examined at once.

This study focused on the assessment of climate variation in South Western region of Nigeria based on the variations in rainfall, relative humidity and temperature within the period 1970-2007. The aim is to assess climate change in south-west of Nigeria as it may likely affect agricultural crop production.

This study helps to address the research gap by providing an assessment of the overall effect of climatic variability on agricultural production through analysis of some climatic conditions data associated with crop production.

Rainfall, temperature and relative humidity seems to be the main contributor to agricultural crop production in the south western part of Nigeria. The analysis will help farmers on how to cope with the environmental changes in the context of farm management and precision farming.

DATA AND METHODOLOGY

— Description of study area

South West Nigeria, as shown in Figure 1, constitute of six states namely, Ogun, Oyo, Osun, Ekiti, Ondo and Lagos. The area falls between longitude 2° 31' and 6° 00' East and latitude 6° 21' and 8° 37' North with a total land area of 77,818 Km^2 and a projected population of 28,767,752 in 2002. The states are part of few states that participated in Agricultural production in Nigeria. The study area is bounded 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 Gulf of Guinea (Agboola, 2004). Between March and October, the prevalent winds in the region is the moist maritime South-west monsoon which blows inland from the Atlantic Ocean, this is the period of rainy season. November to February is the period of dry season when the dry laden winds blow from the Sahara desert. The mean annual rainfall of about 1,205 mm, fell within an approximate period of 109 days with two rainfall peaks in June and September.

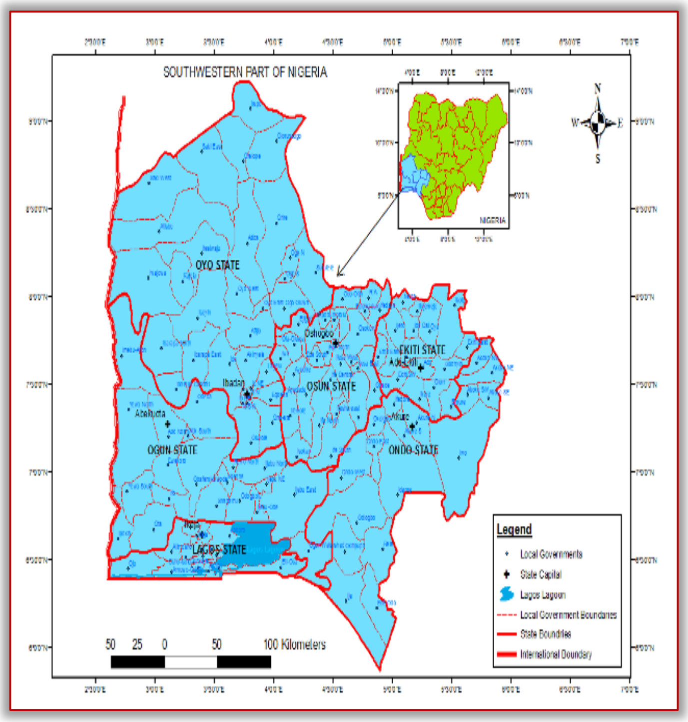

Figure 1: Map of the study area (Southwest, Nigeria).
Adapted from Ojo and Olawale, 2014

— Data collection and analysis

The data used for this project were secondary and were collected from Nigeria Meteorological Agency (NIMET). The data cover relative humidity, temperature and rainfall of the south-west of Nigeria from 1970 to 2007. The data were recorded on monthly basis, that is, from January to December. Imagery shape file was also extracted for the study area. Rainfall data was subjected to various statistical techniques to arrive at valuable result.

The correlation analysis was used to determine the pattern in total rainfall over time for the weather station in the study area. The data were processed using Microsoft Excel software. Microsoft Excel was used to calculate mean of maximum and minimum temperature, average rainfall and average relative humidity for each year from 1970 to 2007 respectively. Imagery shape file was also imported into Arc GIS 9.0 for map productions for rainfall, temperature and relative humidity.

Correlation analysis was also carried out using temperature data of 38 years to determine the variations in temperature and establish the temperature trend in the study area.

RESULTS AND DISCUSSION

— Variations in rainfall, temperature and relative humidity in South West Nigeria

The impact of climate change on crop yield is generally estimated from a combination of the effects of climate models on the physical crop growth pattern (Müller *et al*., 2011). Climate change, if not properly assessed, will obviously jeopardize farming sustenance of the rural people in Africa, particularly where inadequate access to agricultural knowledge and technology of climate will hamper their ability to adapt and plan (Lobell *et al*., 2008, Salami and Matthew, 2009).

Trend analysis of the data set over the study time was therefore obtained to determine the recent and current trend in temperature as it provides indication of the increase or decrease of good climatic conditions.

— Rainfall Pattern

The result of this study show that rainfall variations and pattern in South west is worthy of close examination, as its variations over time is remarkable.

The results showed that there was a high variation of precipitation in the Southwest. The trend of total annual rainfall for the periods is shown in Figure 2a.

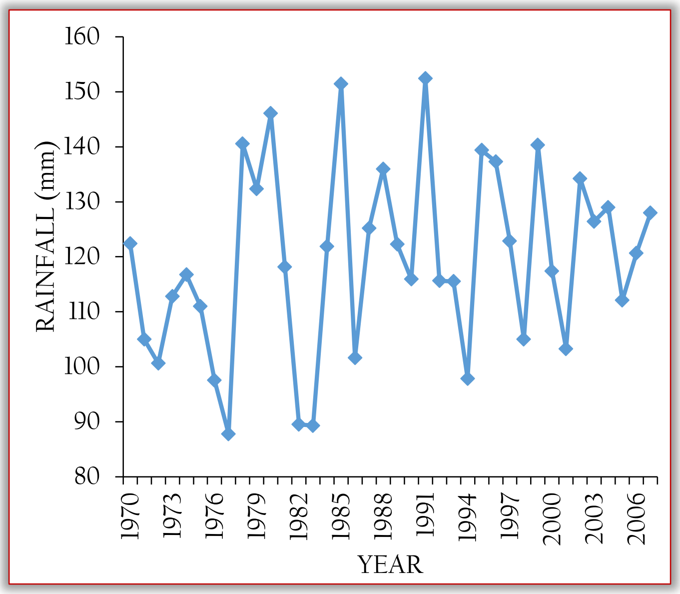

Figure 2a: Trend line for yearly mean rainfall variation

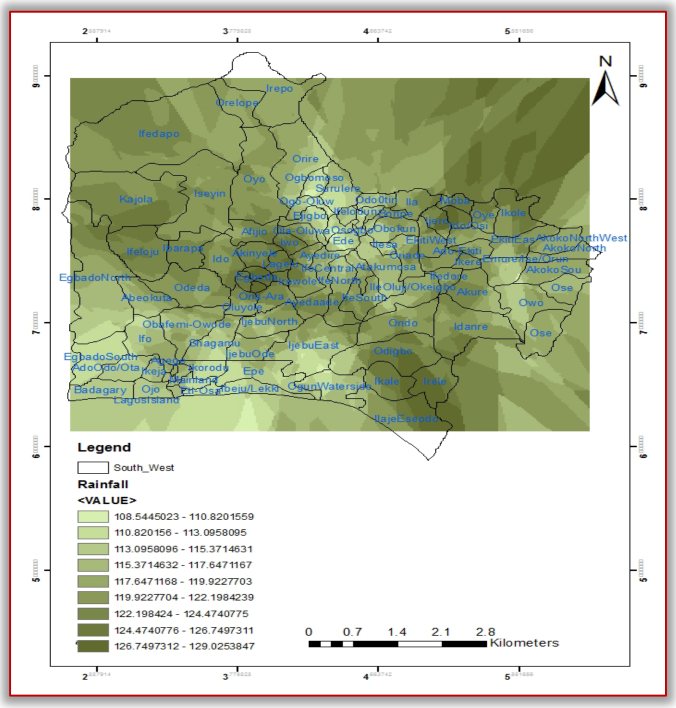

Figure 2b: Geo-spatial variation map of annual Rainfall for South West of Nigeria

Total rainfall of the area was characterized by two distinct peaks: one in 1985 and the other (highest) peak in 1991. This shows that these years were the wettest year within the period under study.

Generally, the total rainfall of the area decreased in the period 1970-1973 and increase in year 1974. There was also slight decline in years 1976, 1977, 1982, 1983 and 1994. There was a sharp increase after year 1978; this was more experienced in year 1985 till about year 1992 with a sharp decline in year 1993. Within this period there was an interesting variation of rainfall as it experienced a rise and fall. The total rainfall continued to increase and decline in the period 1994-2007.

The geo-spatial variation map of annual rainfall for the study area is shown in Figure 2b. The mean total annual rainfall is highest for year 1991 (152 mm) while it is lowest for year 1977 (88 mm). The implication of this is that rainfall in South west varies in amount from year 1970-2007. Therefore, it is not expected that equal amount of rainfall can fall from one year to another. Annual rainfall range indicates the variability of annual rainfall and hence denotes how reliable the rainfall is in terms of its persistence as a constant and stable replenishing source of water in south western region. It was also observed that there was decreased crop production in the years with less precipitation.

Agricultural produce were very scarce and the yields were reduced as compared to the years with high precipitation rates. Agricultural production in South Western part of Nigeria is largely fed by rainfall; any decrease in precipitation rate will have unfavourable impact on agricultural production and largely reduce the crop yields as relatively reported by Chikezie *et al*., 2015).

— Temperature Pattern

The mean yearly temperature variation is shown in Figure 3a. The lowest average temperature value of 23°C was recorded within the period under study in year 2007. The minimum value of 26°C was recorded in years 1971, 1974, 1975, 1976, 1978 and 1980, which shows that these years were relatively cooler.

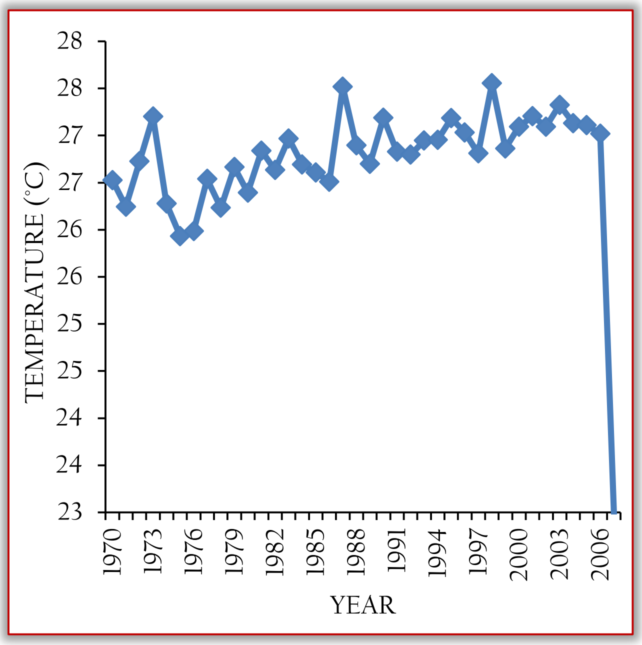

Figure 3a: Trend line for mean yearly temperature variation

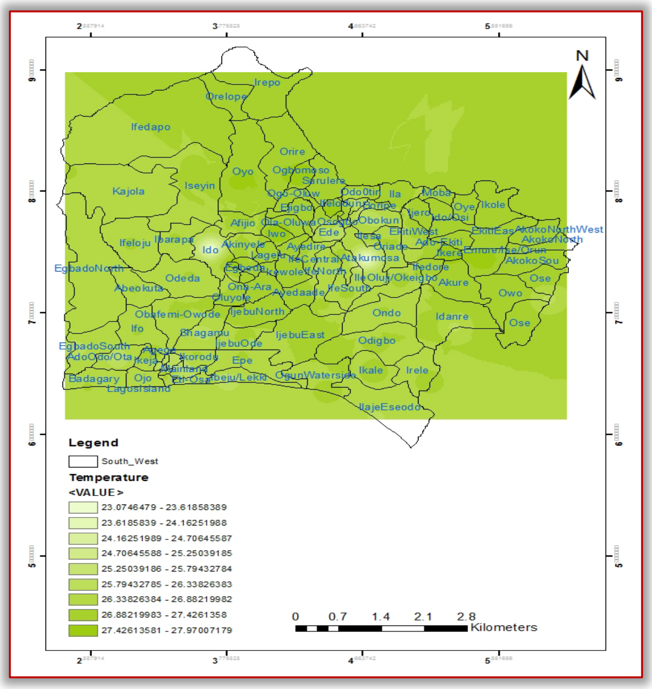

Figure 3b: Geo-spatial variation map of annual temperature for South West Nigeria

The maximum value of 28°C was however recorded in years 1987 and 1998, indicating that it was a relatively warmer years. Temperature in south west has been slightly varied. The varying period was the early years of the study period 1970-1980. The geo-spatial variation map of annual temperature for South West Nigeria is shown in Figure 3b. In general, the mean annual temperature of the study area was stable with slight fluctuations in years 1987, 1998 and 2007 within the period.

— Relative humidity pattern

The relative humidity trend is shown in Figure 4a. It can be observed that there is a slight difference in the trend pattern from year to year. However, the trend of relative humidity varies at the early stage of the study period 1970-1972. There was a stable trend over the period 1973-1975. The (highest) peak relative humidity was in year 1979, with other high values recorded in the year 1976 and 1978. Also the lowest years were years 1983, 1992, 1993, 1998, 2000 and 2002 relatively 79%. Other varies trend falls within the highest value and the lowest. This shows the variation of relative humidity within a predictable range for agricultural practices. The geo-spatial variation of map of annual relative humidity for South West is shown in Figure 4b.

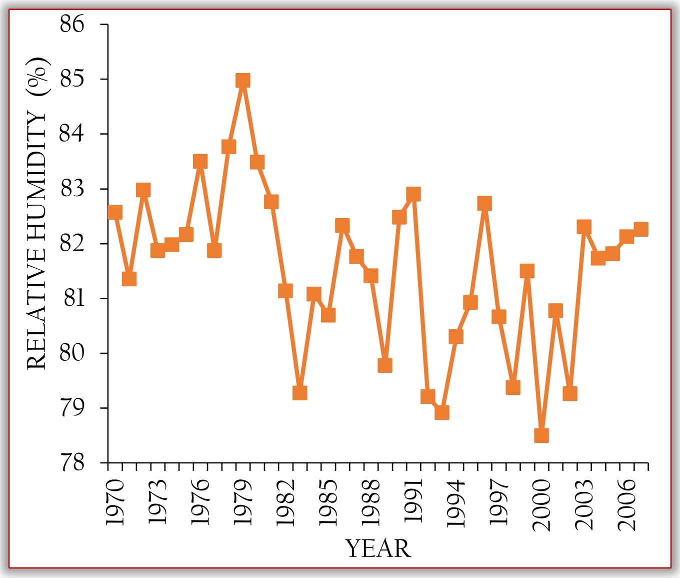

Figure 4a: Trend line for mean yearly relative humidity variation

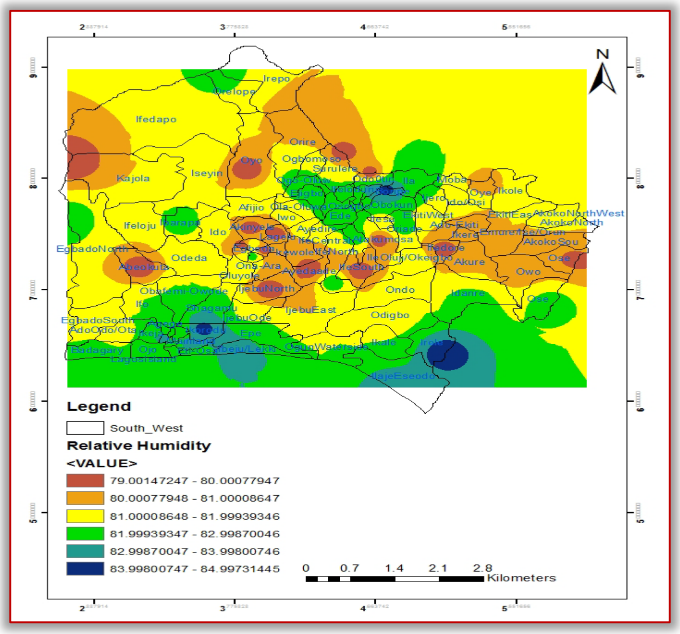

Figure 4b: Geo-spatial variation of map of annual relative humidity for South West

CONCLUSION AND RECOMMENDATION

The results establish variability and change in zonal rainfall, temperature and relative humidity experienced in agricultural production in Nigeria.

The study has revealed the effects that climatic variables, such as rainfall, relative humidity, temperature have on agriculture in the study area. The analyses have shown prolonged variability in average annual rainfall received over the climatic zone across the three climatic factors considered and such variation and changes were statistically established. Such prolong variability also extend its socioeconomic importance to the ground water resources and hydrological sector.

Rainfall, temperature and relative humidity showed transitions from dry to wet conditions in the change point analyses between 1970 and 2007 as there were observed jumps with no imbalance in averaged zonal rainfall distribution, temperature and relative humidity across the climatic periods.

The results will assist in planning ahead in order to avert problems such as early drought associated with climatic variables in the study area. Besides reducing over dependence on rain-fed agriculture, it is recommended that farmers should plant drought resistant crops or early maturing crop varieties especially in the extremely southern zone. The farmer should be tutored on how to cope with the environmental changes in the context of farm management and precision farming.

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