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Assessment of Climate Variability on Vegetation Phenology Cycle in Wetland Region of Nigeria

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Abstract: *Climate variability and change has been a global problem that is affecting the environment. Therefore, this work assessed the impact of climate variability on vegetation phenology cycle in the wetland region of Niger Delta from 2010 to 2019 using remote sensing and geographical information system. The data used in this study was based on remotely sensed data. The Moderate Resolution Imaging Spectroradiometer (MODIS) data MOD11A1 and MOD13A1 of 2010-2019 downloaded for three (3) years interval from the NASA website. The ArcGIS 10.1 modeler was used to put the parameter of conversion from satellite data to climate data. The mean temperature and Normalized Difference Vegetation Index (NDVI) was extracted using the study area administrative boundary shapefile. The result was computed in a graph. The result shows that from 2010 to 2019 there has been a serious climate variability that has impacted the vegetation phenology cycle. When NDVI was high in Cross River the temperature was low and when NDVI was low the temperature was high in Delta state. Rainfall and NDVI followed the same trend pattern as NDVI increases rainfall increases. The study shows a relationship between vegetation photosynthesis and rainfall; as rainfall increases, vegetation photosynthesis also increases. This study recommends constant monitoring of vegetation phenology to observe the impact of climate variability on the vegetation.*

Keywords: *Climate variability, imagery, temperature, phenology, GIS*

INTRODUCTION

Vegetation phenology is the seasonal growing life cycle of plants. [1] expressed that vegetation phenology depends on seasonal variation of temperature, precipitation, solar insolation, nutrient availability, and photoperiodic signals. Studies explained that vegetation phenology is a fundamental determinant that affects processes such as water, carbon, and energy exchange in wetland ecosystems ([2]; [3]). [4] observed the main drivers of vegetation phenological responses. [5] report that in the high and mid-latitudes, vegetation phenology are controlled by temperature and the duration of daylight but, it is generally accepted that precipitation is also a principal controlling effect of vegetation phenology in the tropics [6]. In Africa, studies of [7] and [8] provide details explaining the vegetation phenological responses. The causes of the inception of vegetation growth and the beginning of dormancy in Africa are poorly understood. Few studies further explained that there exists uncertainty about the environmental drivers of vegetation phenological growth and pattern of plants in Africa ([9]; [10],).In addition, Africa's vegetation has experienced notable change over recent years due to climate change. It has been noted that Africa is vulnerable to climate change impacts.

In Nigeria, several wetlands exist. However, the most significant is the mangrove swamp forests which are in the coastal states in Southern Nigeria such as Edo, Delta, Cross River, Rivers, Akwa-Ibom, Ogun, Ondo and Lagos. The Niger Delta and Cross River wetland ecosystem are of high economic importance to the local dwellers and the nation. The regions are rich in both aquatic and terrestrial biodiversity and serves as a source of livelihood for rural dwellers as well as stabilizing the ecosystem. Remarkable changes have occurred recently in the Niger Delta and Cross Rivers wetlands due to anthropogenic activities leading to climate change and destruction of vegetation. Subsequently the commencement of oil exploration in the Niger Delta region of Nigeria, persistent oil spill has damaged the ecosystem destroying plants on land and in water. Therefore this study assessed the effect of climate variability on vegetation phenology cycle in the wetland region of Niger Delta from 2010 to 2019 using remote sensing and geographical information system.

RESEARCH METHODOLOGY

This study was carried out in the Niger Delta region of Nigeria. Niger Delta comprises nine oil-bearing states; Abia, Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers. The Niger Delta region is situated in the Gulf of Guinea between longitude 5°E to 8°E and latitudes 3°N to 6° N. The Niger Delta occupies 70,000 square kilometers of Southern Nigeria. The ecological zones in the Niger Delta region can be broadly grouped into the tropical rainforest in the northern part of the Delta and mangrove forest in the warm coastlines of Nigeria. The Niger Delta Basin is a major geological feature of significant petroleum exploration and production in Nigeria [11], it is Africa's leading oil province [12]. The Niger Delta accounts for the entire hydrocarbon production at present-day Nigeria. The mean Temperature is 27.5°C, Rainfall is 123.5mm, and Relative Humidity is 78.6% [13]. Farming and fishing are the major livelihood activities of inhabitants of the region but, due to climate change; more households have diversified their livelihoods into the non-farm sector [14].

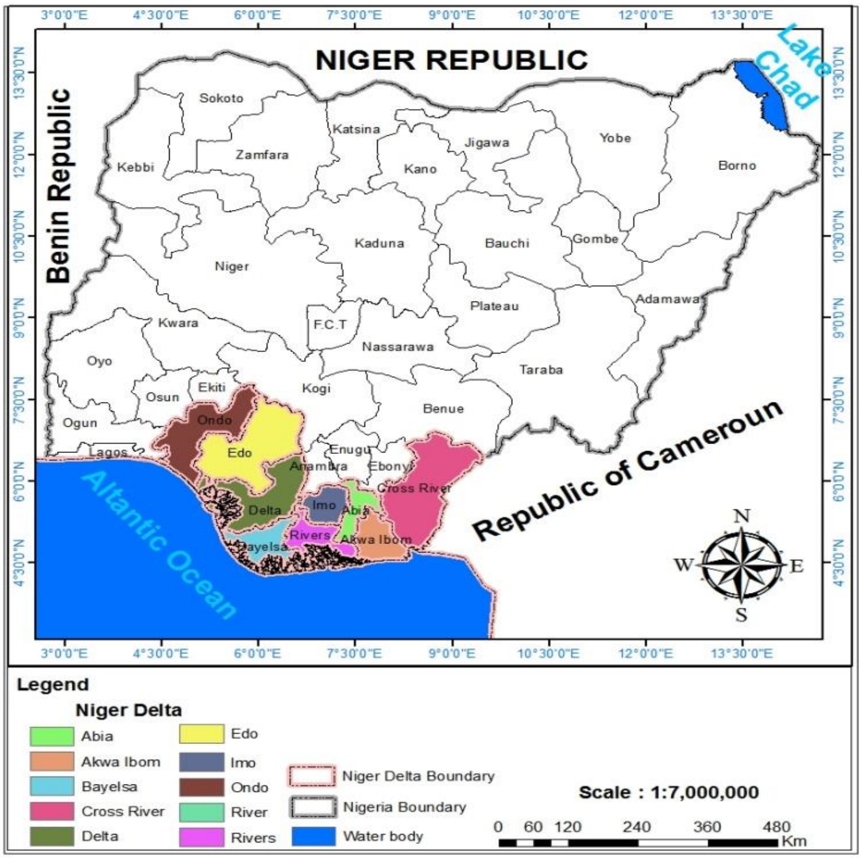

Figure.1: Map of Nigeria showing the Niger Delta Region [Source: Authors' GIS Lab 2020 (extracted using LST and NDVi for the states)]

The data used for the study was based on remote sensing. The monthly Moderate Resolution Imaging Spectroradiometer (MODIS) data MOD11A1, and MOD13A1 of 2010-2019 downloaded for three (3) years interval from NASA web site. The MOD11A1 for land surface temperature, and the MOD13A1 for vegetation indices composite product produced at 1 km meter pixel resolution. The algorithm used for the MOD11A1 and MOD13A1 data product collection is based on the logic of the Penman-Monteith equation, which includes inputs of daily meteorological data. The Data were imported into ArcGIS 10.1 software for processing. The MOD11A1 and MOD13A1 datasets are estimated using [15] improved algorithm. The MOD11A1 was multiply by Scale facture and converted to the Modis Digital number to land surface temperature (LST) in Kelvin (K). The data was processed into ARCGIS Modeler. To obtain the NDVI, the MOD13A1 was multiply by Scale facture

(0.0001) and converted to the Modis Digital number to Normalized Difference Vegetation Index (NDVI). The data was process in ARCGIS Modeler.

The computed data from satellite base were organized in tabular format. The administrative map of Niger Delta region was extracted using LST and NDVi for the states. The ArcGIS 10.1 was used to generate the mean of LST and NDVI value for each state. The table was analysed and compare using graph and histogram. The temperature T in degrees Celsius (°C) is equal to the temperature T in Kelvin (K) minus 273.15:

$$T_{(°C)} = T_{(K)} - 273.15 \quad ... \quad (3.1)$$

RESULT AND DISCUSSION

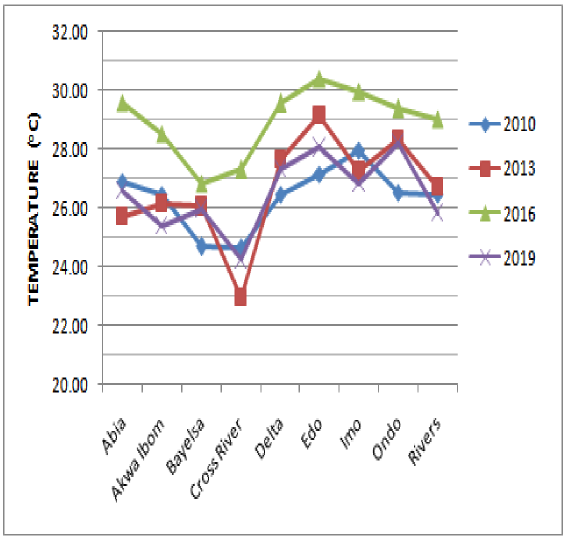

Figure 2: Graph of temperature variation of the study area from 2010 to 2019 (Source: Authors work, 2020)

Figure 2 above shows the temperature variation of the study area from 2010 – 2019. From the graph, 2010 recorded the lowest temperature while 2016 was the highest. From 2010 to 2013, the temperature decreased in Abia, Cross River, Imo, and Akwa Ibom while there was an increase in other states. From 2013 to 2016, the temperature was high in all the States except for Cross River. We observed that Cross River always has the lowest temperature within the year while Delta and Edo States have the highest temperature. In 2019, the temperature dropped in all the states. This variation of temperature is evidence of climate variation in the Niger Delta.

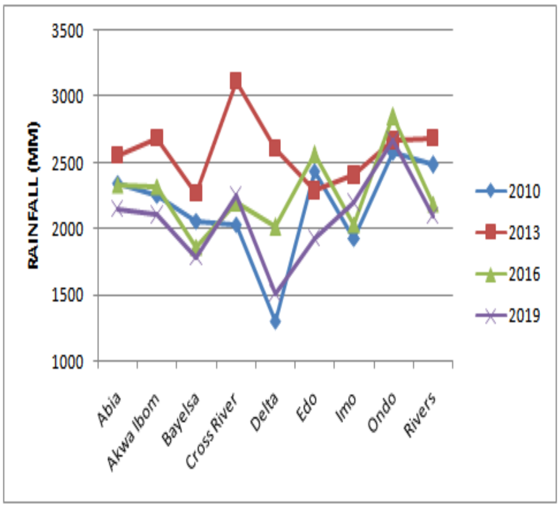

Figure 3: Graph of Rainfall variation in the study area from 2010 to 2019 (Source: Authors work, 2020)

Figure 3 above shows the total annual rainfall variation of the Niger Delta region from 2010 to 2019. Rainfall varied from one location to another. From 2010 to 2013, the rainfall increased in the Niger Delta region. From 2013 to 2016, the rainfall decreased in Abia, Akwa Ibom, Cross River, Delta, Imo, and Rivers states but, in Edo, and Ondo there was an increase. We observed that Cross River recorded the highest rainfall in 2013 while Delta recorded the lowest rainfall in 2010 and 2019. From 2016 to 2019, the rainfall decreased in all regions except the Cross River and Imo state. The result shows a climate variation of rainfall in the Niger Delta region.

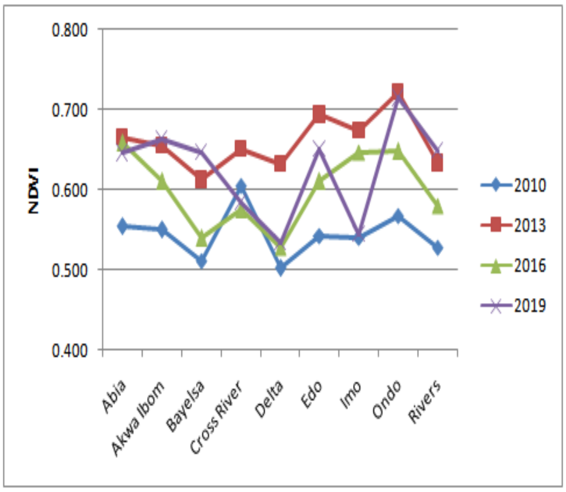

Figure 4: Graph of NDVI variation in the study area from 2010 to 2019 (Source: Authors work, 2020)

The variation of vegetation photosynthetic was estimated using NDVI. The graph above shows the NDVI values. In 2010, the NDVI was low while it increased from 2010 to 2013, after which it started decrease till 2016. In 2019, the values increased in some states, and others decreased. Ondo state has the highest NDVI value in 2013 and 2019, Edo and Abia in 2013 and 2016. From 2010 to 2013, the NDVI value highly increased. From 2013 to 2016, it decreased except for Abia State that maintained almost the same value. From 2016 to 2019, the values increased in all the states except in Delta that remain almost the same but decreased in Imo.

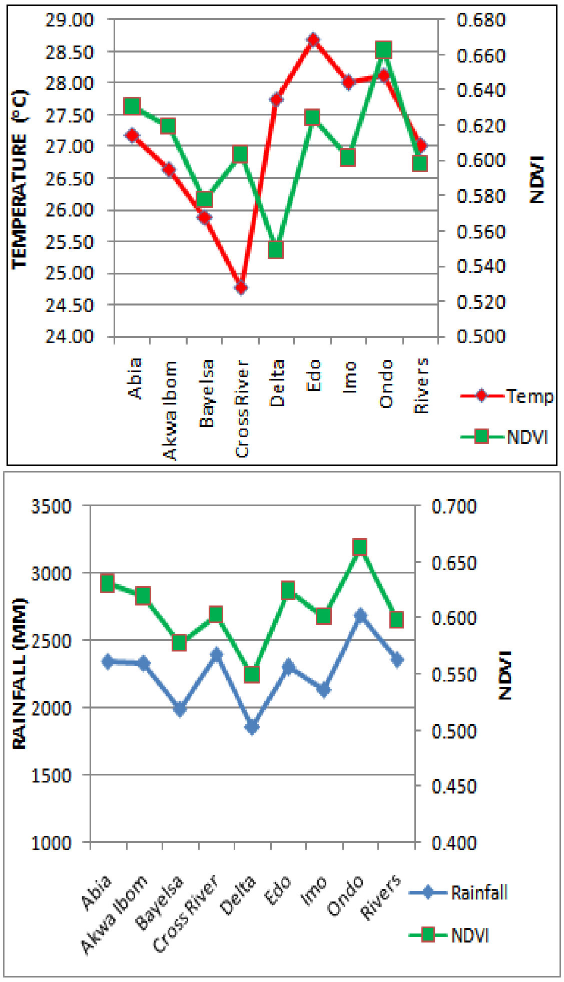

Figure 5: (a): Graph of Temperature and NDVI (b): Graph and Rainfall and NDVI (Source: Authors work, 2020)

Figure 5 revealed the variation of Rainfall, Temperature, and NDVI in the Niger Delta Region. NDVI and temperature followed the same trend pattern except in Cross River and Delta. When NDVI was high in Cross River the temperature was low and when NDVI was the low temperature was high in Delta state.Rainfall and NDVI followed the same trend pattern as NDVI increases rainfall increases. When NDVI decreases rainfall decreases. It shows a perfect relationship between NDVI and rainfall. From the study, we observed that rainfall has an impact on the vegetation phenology cycle.

[16] opined that the strongest inter-annual correlation between climatic variables and NDVI was precipitation and the highest temperature. They observed that the months with the lowest temperature had the most pronounced impact on land cover change. The months with the highest temperature and precipitation also have a remarkable effect on NDVI value. Another study proved that the NDVI was affected by temperature and rainfall in the area, showing periodic change especially when NDVI had a high value within-growing season [17].

Studies by [18] and [19] further confirm that climate is the primary factor of vegetation change, especially temperature and precipitation. They have influences on vegetation growth, carbon budget functions, and distribution. NDVI reflects the state of surface vegetation to a large extent and is generally used at present ([20]; [21]). This is in line with this study. NDVI is significantly affected by temperature in the Northern Hemisphere and the increase of vegetation activities [5]. Furthermore, precipitation also has an influence on NDVI at the regional scale, particularly in arid and semi-arid areas [22]. However, some areas are affected differently by climate factors at different times.

CONCLUSIONS AND RECOMMENDATION

We examined vegetation phenology by assessing the impact temperature and rainfall using NDVI from 2010 to 2019. We observed that the temperature impacts the vegetation phenology in some states within the Niger Delta region. The rainfall analysis shows a good relationship between vegetation phenology as rainfall increases, the vegetation phenology increased, and when rainfall decreases NDVI decreases. The study concluded that rainfall impacts the vegetation phenology cycle more than the temperature within the Niger Delta region of Nigeria.

The study therefore recommends that Agriculturalist and farmers alike should utilize the finding and more of such studies conducted in a non wetland region to understand Climate variability and vegetation phenology on a non wetland Environment.

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