Original Research Article

Vegetation Change Detection in the Niger Delta Region of Nigeria using Remote Sensing and GIS Techniques from 2000 to 2020

ABSTRACT

Generally, vegetation change through the conversion of the world's forest land to other uses has assumed an increasing scale due to the unprecedented growth of the human population which increases the demand for food and land. Some believed that decrease in vegetation in the area is attributed to oil exploration and exploitation activities only. This study aimed to find out the nature of the vegetation change in the region from 2000 to 2020. The data used was remotely sensed images as Enhanced Vegetation Index (EVI) observed by Terra-MODIS, downloaded via United States Geological Survey (USGS). The Simple Image Differencing was performed on two images (February 18, 2000 and February 18, 2020) using IDRISI software. The result shows that all the states in the Niger Delta region experience both positive and negative change in vegetation cover. The positive change was observed around locations where agricultural plantations exists and within urban areas followed by oil and gas exploration and exploitation that damage the natural forest cover, while negative change was observed around farms where intensive rainy season farming takes place. It was recommended that deforested areas in the region should be reclaimed by planting economic trees as plantation to enhance greenness and maintain balance of the ecosystem. If intensive farming is necessary, it should be practiced sustainably to save the environment.

Keywords: Vegetation, Change Detection, Remote Sensing, GIS

Correspondent Author. walielekwachi@gmail.com

INTRODUCTION

The vegetation of the Niger Delta region according to Udo (1981) is made up of equatorial rainforest. The vegetation could be subdivided into two major groups; the tropical rainforest and swamp forest (which is further sub-divided into fresh water and mangrove swamps).

However, the tropical forest and swamp forest characteristics have been lost to continuous agriculture and urbanization in such a way that the few patches that remain are found in forest reserves (Phil-Eze and Okoro 2009) and shrines (Wali, 2015).The Niger Delta region has several ecosystems that play essential role for the sustenance of the different habitats and life forms in the area. Some of the notable ecosystem includes freshwater swamp forest, lowland rainforest, mangroves forest etc. In recent time, the rate of deforestation, excessive hunting of wildlife and exploitation of non- timber forest products (NTFPs), bush burning, and intensive agricultural practices has increased in the region (Izah *et al.,* 2018).

Generally, vegetation change through the conversion of the world's forest land to other uses is in an increasing scale due to the unprecedented growth of the human population which increases the demand for food and land (FAO, 2016). Many studies have confirmed that several decades ago, forests covered a vast portion of the land area on earth (Jamal *et al*., 2020). According to Food and Agriculture Organization (FAO), (2016), the world's forest decline was estimated at about 129 million ha between 1990 and 2015, approximately the size of South Africa's land mass, representing an annual rate of loss of 1.3%. Regionally, Africa had the largest annual rate of forest loss, estimated at about 0.49%, and reports from African countries documented that about 82 million ha of forest have been converted into other land uses between 1990 and 2015 (FAO, 2016).Deforestation, forest degradation, and their associated environmental problems are the focus of discussion at several environmental fora deliberating on the measures required to mitigate the impact of these global phenomena (Goll *et al*., 2014). The historical linkage between forest cover alterations and economic growth have been outlined by sociologists and forestry scientists about three decades ago (Rudel , 1989, Jamal *et al*., 2020). The industrial development and the accelerated pace and intensity of human activities have greatly altered forest cover with spatio-temporal heterogeneity among nations (Wang *et al.,* 2016). In the United States and Canada, for example, economic growth in the 18th and 19th centuries encouraged investors to clear large areas of forest land for industrial and settlement purposes. Despite this, industrial expansion and urbanization had some positive effects on the vegetation cover, where the rural to urban migration and the rising farming incomes led to the restoration of forests on agricultural fields that were abandoned (Rudel et *al*., 2005, Jamal *et al*., 2020). Some analysts pointed out that despite the main role that inadvertent or spontaneous afforestation played in recovering the forest cover after farmers abandoned their fields (Rudel *et al.,* 1996), the planned

activities for reforestation, whether at the level of plantations or small fields, had the greatest role in forest recovery processes (Marchak, 1995, Jamal *et al*., 2020).

The environment of the Niger Delta region popularly called the South-South has been witnessing various forms of degradation since the discovery of the crude oil in 1956 (Oseni, 2016). According to the Organization of the Petroleum Exporting Countries (OPEC), Nigeria became a member of OPEC in 1971 among the countries with substantial net export of crude petroleum. According to Collins *et al., (*2008), most of the environmental elements have been affected negatively through oil related pollution which include air, soil and water that subsequently destroy plants and animals in the area and that these negative effects were caused as a result of oil spillage, vandalism, gas flaring and the escape of other chemicals used in the production processes. This study therefore, examines the changes in vegetation cover in the Niger Delta region between 2000 and 2020 using remotely sensed data and geospatial analytical technique.

MATERIALS AND METHODS

The Study Area

The Niger Delta Region is basically a wetland on the Gulf of Guinea on the Atlantic Ocean spanning over 111,020 km^2 (12%) of Nigeria's surface area as shown in Fig. 1. With a population of 36 million in nine states of the Nigerian federation, it spreads across six ecological zones consisting of barrier islands, salt water marshes, mangroves, freshwater swamps, lowland rainforest and derived savanna vegetation. It has the largest and most important mangrove forest in Africa, 3rd largest in the world and habours a high diversity of flora and fauna—including endemic, endangered and threatened species (Phil-Eze and Okoro, 2009; Phil-Eze, 2014).

The Niger Delta is the delta of the River Niger sitting directly on It is politically considered to be located within nine coastal southern Nigerian states, which include: all six states from the South- South geopolitical zone, one state (Ondo) from South West geopolitical zone and two states (Abia and Imo) from South East geopolitical zone. Of all the states that the region covers, only Cross River is not an oil-producing state ("Niger Delta," 2020). The Niger Delta is a very densely populated region sometimes called the Oil Rivers because it was once a major producer of palm oil. The area was the British Oil Rivers Protectorate from 1885 until 1893, when it was expanded and became the Niger Coast Protectorate. The delta is a

petroleum-rich region and has been the center of international controversy over pollution ("Niger Delta," 2020).

This natural vegetation of the study area has been degraded by the activities of man such as bush burning, farming, urbanization, construction, legal and illegal crude oil refining activities. The vegetation consists of various kinds of evergreen trees, including palms trees and a variety of shrubs. More than 70 % of the inhabitants of the study area are engaged in subsistent farming and fishing (Wali *et al.,* 2020).

The mean monthly temperatures are steady throughout the year (about 20^0C) (Hamilton *et al.,* 2020) while the total annual rainfall in the area ranges between 2,000 mm to 3,000 mm (Climate – Nigeria, 2020). The Niger Delta region of Nigeria is geographically located between 4.20^0 and 7.80^0N, and between 4.30^0 and 9.50^0E (Fig. 1).

The geology of the Niger Delta has been described in details by various authors. The formation of the Delta started during Early Paleocene and resulted mainly from the buildup of fine grained sediments eroded and transported by the River Niger and its tributaries. The Tertiary Niger Delta is a sedimentary structure formed as a complex regressive off lap sequence of clastic sediments ranging in thickness from 9,000 - I2, 000 m (Abam, 1999; Wali *et al,* 2020). Starting as separate depocenters, the Niger Delta has coalesced to form a single united system since Miocene. The Niger Delta is a large and ecologically sensitive region, in which various water species including surface and sub-surface water bodies exist in a state of dynamic equilibrium (Abam, I999; Wali *et al,* 2020)

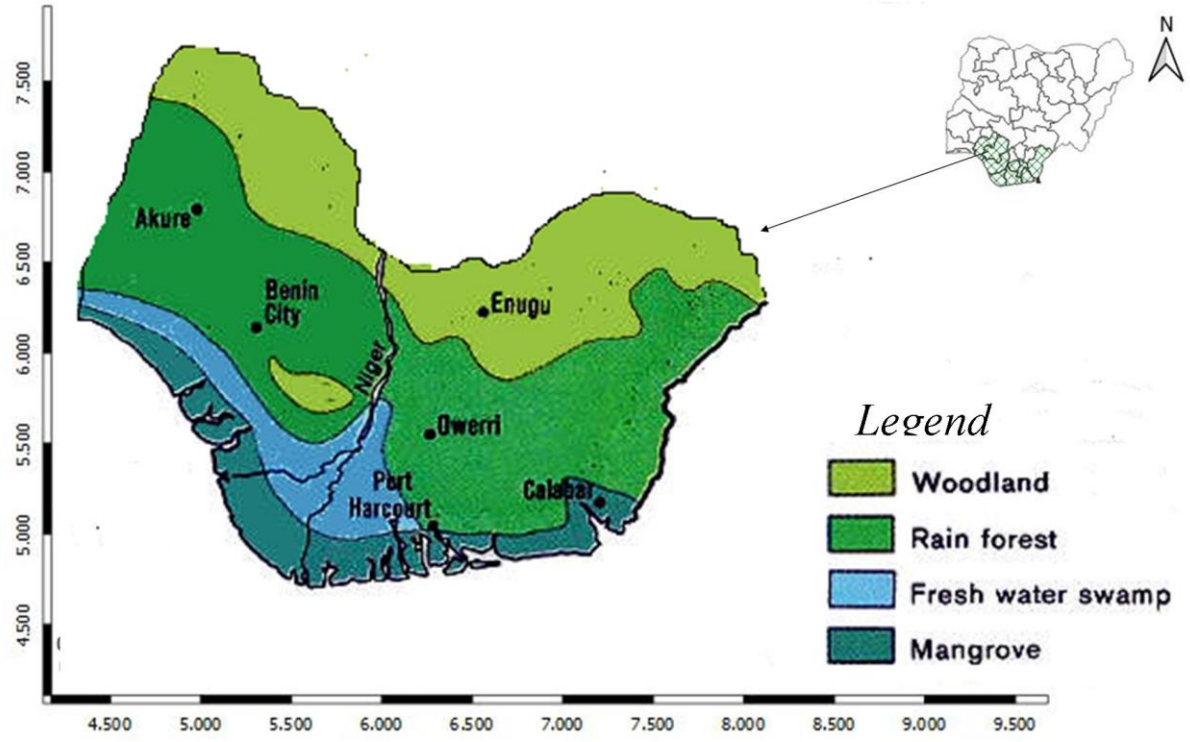

Fig. 1: Map of Nigeria showing the Study Area (Niger Delta States)

Source: NDLink Admin, (2019)

Methodology

The vegetation data used for this research are remotely sensed images called Enhanced Vegetation Index (EVI) obtained by Terra/MODIS, downloaded via Land Processes Distributed Active Archive Center (LP DAAC) collection on the Earth Explorer From the United States Geological Survey website (https://earthexplorer.usgs.gov/). The dates for the observation were February 18, 2000 (MOD13Q1.A2000049.h18v08.006) and February 18, 2020 (MOD13Q1.A2020049.h18v08.006) for earlier and later periods respectively. The Idrisi software was used to convert the downloaded HDF to Idrisi raster file format. The two converted images were windowed to focus on the study area (Niger Delta States). A Simple Image Differencing was performed using Image Calculator. The resulting image was then reclassified to clearly differentiate between positive and negative changes in vegetation cover in the study area. HISTO module was used to calculate area percent covered by each class of change.

RESULTS AND DISCUSSION

The two processed images denoting periods of observation (2000 and 2020) in Figures 2 and 3 shows that the later image (2020) has a pixel with higher EVI value (3.33), while the earlier one (2000) has lower EVI value (3.19). This shows that some locations are greener than previous years. Despite the increase in vegetation cover on some locations, looking at the images holistically, low EVI values (yellow palette) can be observed to be highly distributed on the 2020 image than the 2000 image. It was suggested that locations with the high vegetation value on the later image were areas of human disturbance of vegetation with cocoa and palm plantations.

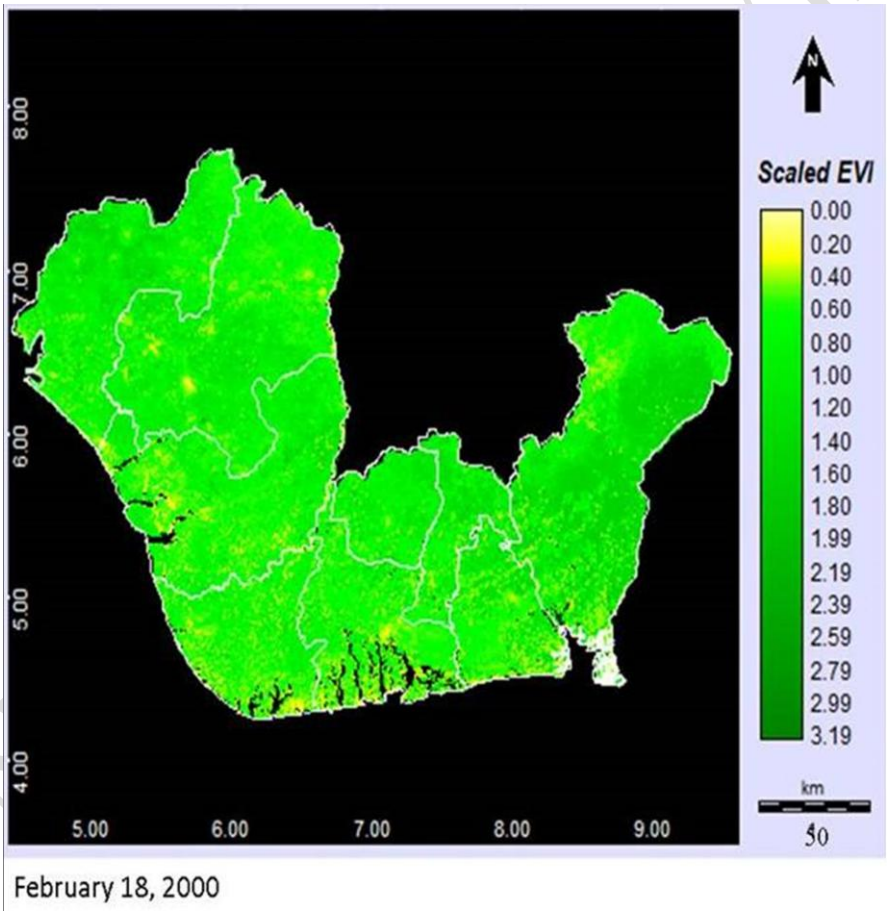

Fig. 2: Vegetation Characteristics in February, 2000

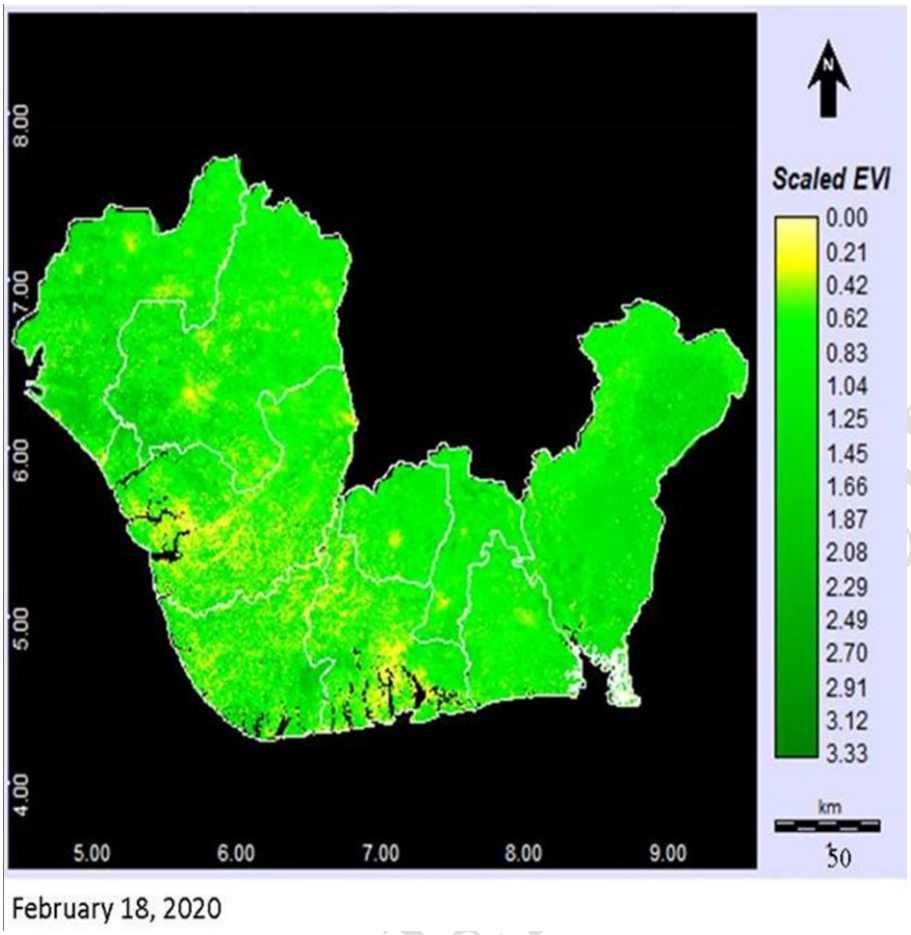

Figure 3 Vegetation Characteristics in February, 2020

Figure 4 shows that the study area has experienced both negative and positive changes in vegetation cover during the periods of observation and corroborates with the findings of Muktar & Yelwa (2020). The analysis shows that about 52.5% of the area experienced an increase in vegetation, while 47.4% of the area experienced a decrease in vegetation. Only 0.1% of the area remains unchanged. These changes cut across all the states in the region where Cross-River, Delta and Akwa Ibom States have pixels with higher negative values compared to other states. This suggested that the decrease in vegetation in the area was not mainly caused by crude oil activities. The Cross-River State that has higher negative values is not an oil producing state. Therefore, it was posited that the oil exploitation causes climate change which consequently affects global vegetation.

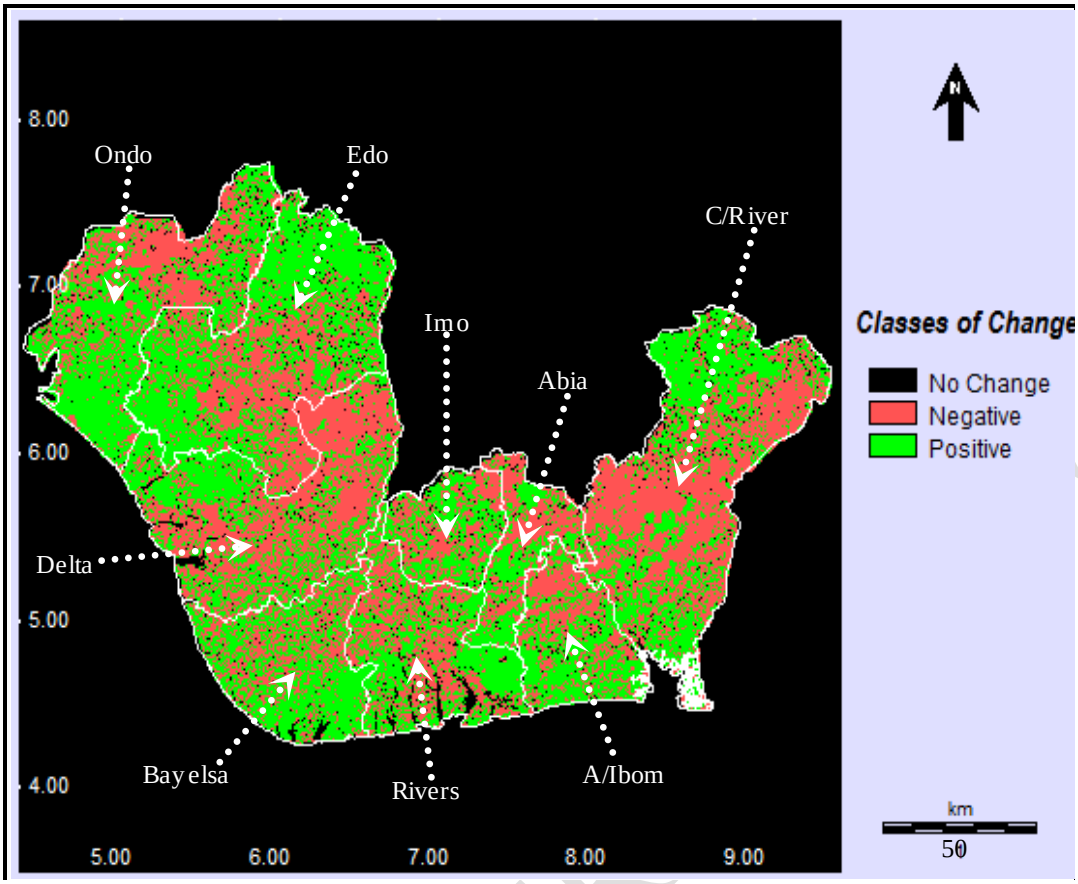

Fig. 4: Classes of Vegetation Change

The increases in vegetation in some locations were as a result of mass economic tree plantations by the local populace across the region and also government effort to combat deforestation. Some selected locations with increase in vegetation can be seen on image *a*, *b* and *c* on Plate 1 as Ondo (6.985987N, 4.953092E), Edo (6.342179N, 5.280259E) and Bayelsa (4.658136N, 6.422837E) respectively. The increase in vegetation in these locations was attributed to plantation agriculture which includes oil palm, cocoa, and rubber trees. Some locations with decrease in vegetation are on images *d, e* and *f* on Plate 1 which shows Delta (5.522624N, 6.005357E), Akwa Ibom (5.314817N, 7.730210E) and Cross River (6.022698N, 8.427842E) respectively. These are places where large scale rainy season farming is being practiced which includes Maize, Cassava and Yam. This shows that plantation agriculture helps in maintaining the ecosystem of the environment.

Plate 1: Vegetation Characteristics on some Strategic Locations

CONCLUSION AND RECOMMENDATIONS

It is observed that all the states in the Niger Delta region experience both positive and negative changes in vegetation cover. Invariably, there is also a decrease in vegetation which is not directly linked to oil exploitation activities but rather climate change which affects vegetation in the long run. The changes in vegetation in some locations are attributed to agricultural activities within the areas, which are as follows lumbering, shifting cultivation and bush fallowing. It was recommended that deforested areas in the region should be

reclaimed by planting economic trees as plantation to enhance greenness and maintain balance of the ecosystem. If intensive farming is necessary, it should be practiced sustainably to save the environment.

ACKNOWLEDGMENT

A great thank goes to United States Geological Survey (USGS) for providing us with the MODIS-EVI data as archived in the LP DAAC collections by NASA.

COMPETING INTERESTS DISCLAIMER

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

Abam, T .K. S (1999), "Dynamics and Quality of Water Resources in the Niger Delta Proceedings of IUGG 99 Symposium HSS Birmingham", *IAHS Publ*, Vol. 259: 429-437.

Climate – Nigeria, (2020). World Climate Guide. Accessed October 03 2020. Retrieved: https://www.climatestotravel.com/climate/nigeria

Collins, N. C. Ugochukwu, & Jürgen, E. (2008). Negative impacts of oil exploration on biodiversity management in the Niger Delta area of Nigeria. *Impact Assessment and Project Appraisal, 26* (2): 139-147. Accessed 20th April, 2020. Retrieved from: https://www.tandfonline.com/doi/pdf/10.3152/146155108X316397A

FAO (2016). Global Forest Resources Assessment 2015: How are the World's Forests Changing? 2nd ed.; Food and Agriculture Organization of the United Nations: Rome, Italy, 2016.

Goll, I.I.; Nick, B.; Li, J.; McKay, J.; John, S (2014). Analysis on the causes of deforestation and forest degradation in Liberia: Application of the DPSIR framework. Res. J. Agric. For. Sci. 2014, 2, 20–30.

Hamilton, A., Millard Kirk-Greene, Reuben Kenrick Udo…… (2020). Nigeri *Encyclopædia Britannica, Inc.* Accessed October 02 2020. Retrieved: https://www.britannica.com/place/Nigeria/Climate

Iza, S.C (2018): Ecosystem of the Niger Delta Region of Nigeria: Potentials and Threats Biodiversity International Journal.2018; 2(4): 338345.DOI:10.15406/bij.2018.02.00084

Jamal, S.A; Siva, K.B; Ahmed, H.M.H; and Christopher, T.B.S (2020). Detecting and Analyzing Land Use and Land Cover Changes in the Region of Al-Jabal Al-Akhdar, Libya Using Time-Series Landsat Data from 1985 to 2017. Sustainability 2020, 12, 4490; doi: 10.3390/su12114490 www.mdpi.com/journal/sustainability

Marchak, M.P (1995). Logging the Globe. Montreal and Kingston; Mcgill-Queens University Press: Montreal, QC, Canada, 1995.

Muktar, A. & Yelwa S.A. (2020). Application of MODIS-NDVI for Vegetation Change Detection Across Nigeria from 2000 to 2019. *Kaduna State University Environmental Science Journal (1)*1: 40-47.

NDLink Admin, (2019). Rivers, Delta lead South-South 2018 IGR gainers list. Accessed September 26 2020. Available: https://ndlink.org/

Niger Delta, (2020, October 02). In *Wikipedia.* Retrieved from https://en.wikipedia.org/wiki/Niger_Delta

Organization of the Petroleum Exporting Countries (OPEC), (2020). Member Countries. Accessed 20th April, 2020. https://www.opec.org/opec_web/en/about_us/25.htm

Oseni, O. (2016). Effects of Oil Spillage on Vegetation, Land and Water Odu-Gboro Sagamu, Ogun State, South-Western Nigeria) Using Remote Sensing and GIS Techniques. *American Geophysical Union, Fall Meeting, abstract #NH23A-1858.* Accessed 20th

April, 2020. Retrieved from https://ui.adsabs.harvard.edu/abs/2016AGUFMNH23A1858O/abstract.

Phil-Eze, P. O. (2014). Biogeographical implications of the size of PAs in the Niger Delta Region of Nigeria for species conservation. Paper presented at *UNDP/GEF Niger Delta Biodiversity Conservation Project* Workshop held at Golden Tulip Hotel in Port Harcourt, Rivers State, Nigeria.

Phil-Eze, P. O. and Okoro, I. C. (2009): "Sustainable Biodiversity Conservation in the Niger Delta: A Practical Approach to Conservation Site Selection" ***Biodiversity and Conservation,*** Vol. 18 (5), pp 1247 – 1257. [http://dx.doi.org/10.1007/s10531-008-9451-z]

Rudel, T.; Fu, C (1996). A requiem for the southern regionalists: Reforestation in the South and the uses of regional social science. Soc. Sci. Q. 1996, 77, 804–820.

Rudel, T.K (1989). Is there a forest transition? Deforestation, reforestation, and development 1. Rural Sociol. 1989, 63, 533–552.

Rudel, T.K.; Coomes, O.T.; Moran, E.; Achard, F.; Angelsen, A.; Xu, J.; Lambin, E (2005) Forest transitions: Towards a global understanding of land use change. Global.Environ. Chang. 2005, 15, 23–31.

Udo, R. K., (1981): *The Human Geography of Tropical Africa.* Heinemann, London.

Wali, E (2015): Urbanization and loss of wetland in Port –Harcourt metropolis, Nigeria. (Unpublished Master's Thesis) University of Nigeria, Nsukka, Enugu State. Unn institutional repository.

Wali, E; Muktar, A; Nwankwoala H.O; Ekwezuo, C; Hemba, S; and Ocheje, J.F (2020). Analysis of Temperature and Rainfall Variability over two Coastal States in the Niger Delta, Nigeria. *Annals of Geographical Studies, 3(2), 2020, pp. 1-6. ISSN 2642-9136.*

Wang, C.; Gao, Q.; Wang, X.; Yu, M (2016). Spatially differentiated trends in urbanization, agricultural land abandonment and reclamation, and woodland recovery in Northern China. Sci. Rep. 2016, 6, 37658