Original Research Article

Analysis of Oil Spill Pollution Intensity in Niger-Delta Region of Nigeria Using Normalized Difference Vegetation Index.

Abstract.

There has been increased in the level of pollution cause by oil spillage across the Niger-Delta region of Nigeria since the advent of crude oil exploration. The effects of oil pollution cannot be overemphasized, as it is not only detrimental to the health but also to the ecosystem a large. Geographic Information System (GIS) and Remote Sensing (RS) are veritable tools in Environmental management. They have proved to be vital in monitoring of environment. In this work, Normalized Difference Vegetation Index was used as GIS and RS tool to determine the intensity of pollution caused by oil spillage in the Niger-Delta area for the past decade (2010-2020). Land sat imageries of the study area were acquired and NDVI analysis were preformed to reveal the intensity of oil pollution on the area in space and time. Five NDVI types with different negative and positive values were used with the equation NDVI=(NIR-Red)/(NIR+Red). The total land mass covered was 109,582sq.Km. The results showed that in 2010, Poor Health Vegetation had 21,519sq.Km which accounted for 20% of the total land mass; Decreasing Vegetation had 14,659sq.Km which accounted for 13% of the total land mass; Moderate Health vegetation had 13,115sq.Km which was 12% of the total land mass; Increasing Vegetation had 22,938sq.Km which was 21% of the total land mass and Healthy Vegetation had 37,352sq.Km which was 34% of the total land mass. In 2015, Poor Health vegetation accounted for the highest land mass with a total of 41,976sq.Km representing 38% of the total land mass while Moderate Health Vegetation had the lowest land mass of 12,830sq.Km representing 12% of the total land mass. In 2020, Poor Health Vegetation accounted for the highest land mass of 38,324sq. Km representing 35% of the total land mass while Increasing Vegetation had 13,452sq.Km with 12% making it the lowest NDVI type for the year.

From the results there was evidence show of increased Normalized Difference Vegetation Index (NDVI) negative values across the years in the study area which is an

indication of high level of pollution, it was also evident that NDVI Positive values decreased over the years in the region, which is also an indication of pollution. There is need to mitigate oil spillage to its barest minimum in the study area.

Keywords: Normalized Difference Vegetation Index, Geographic Information System, Remote Sensing, Niger-Delta, Oil spillage

INTRODUCTION

Oil pollution is a common occurrence in the Niger-Delta region of Nigeria since oil exploration started in the nineties. Oil spillage has detrimental effects on the immediate environment, groundwater, and the ecosystem at large.(Ite et al., 2013). In the Niger-Delta where oil is found in abundance, incidence of discharge of Petroleum hydrocarbons and petroleum-derived waste in the aquatic bodies have caused serious environmental pollution which has led to; adverse human health effects, detrimental impact on the region's economy and adverse environmental impacts.(Ite et al., 2013). Oil spillage causes water pollution thereby endangering the health of the local communities; contaminates soil, making it unfit for agricultural purposes and also reduces the aesthetic value of the environment(Nwilo & Badejo, 2005).

The Niger-Delta region of Nigeria consists of about 8600sqkm of rivers, estuaries, creeks and stagnant swamp.(Dutsenwai et al., 2017). The Mangrove Swamp found in this region is the largest in Africa covering at least 1900sqkm (Dutsenwai et al., 2017). It is a tropical rainforest zone with diverse species of floras and faunas which are highly sensitive to pollution. Sequel to this, adequate measures are necessary to be taken to mitigate oil pollution.

Remote Sensing and Geographic Information has made way for the geo-spatial, spatio-temporal and interactive Spatio-Temporal analysis of a geographical region. Remote Sensing and the Spatial technology have been recognized and used as powerful and effective tools to monitor the environment(Peter et al., 2017). Normalized Difference Vegetative Index (NDVI) has been used in different GIS and Remote Sensing studies to determine vegetation phenology, vegetation classification and mapping of continental land cover (Eyoh et al., 2019).

Past studies on the application of Geographic Information System (GIS) and Remote

Sensing (RS) on the region have been done with various methods and outcomes through monitoring the extent, drift and type of oil production. Literatures abound that focus either on the spatial or temporal pattern and some focus on analytical assessment of hazardous materials released. Example is (Dutsenwai et al., 2017), who worked on the intensity of oil spill in Ogoni land, they used GIS and RS tools to monitor the intensity of Oil spillage in the region though the work was limited to Ogoni land which is just a part of South-South Nigeria. This work will look at the Normalized Difference Vegetation Index (NDVI) of the area so as to determine the intensity of oil pollution in the region for the last century (2010-2020).

METHODOLOGY

Study Area

The Niger-Delta Region of Nigeria is located in the southern part of Nigeria. It is located where the river Niger divides into many tributaries before joining the Atlantic Ocean. It lies between longitude 4º 30' - 9º 50'E and Latitude 4º 10' - 8º 0'N. The Niger-Delta Region is made up of nine southern states namely: Cross River, Akwa Ibom, Abia, Imo, River, Bayelsa, Delta, Edo and Ondo state. It has more than 40 ethnic groups with about 250 different dialects(Eyoh et al., 2019). It is the Oil rich region of Nigeria.

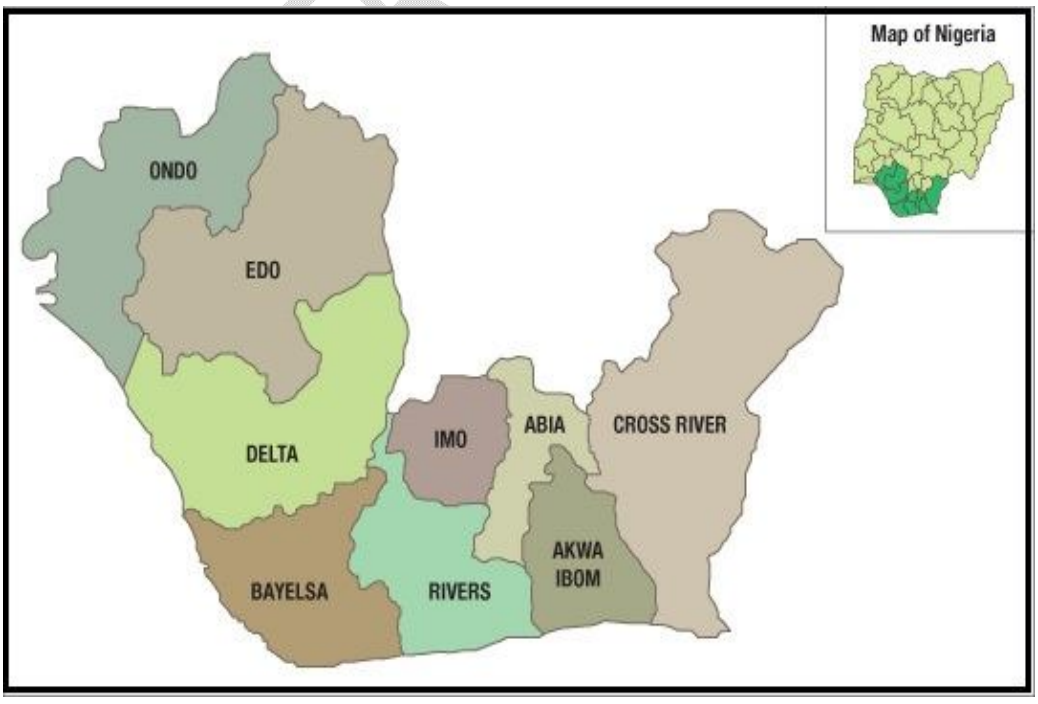

Figure 1: Map of Niger-Delta (Study Area)

Data Collection.

Landsat Imageries and data of the study area were acquired which include Landsat Imageries covering a period of ten years (2010-2020) with a resolution of 30m by 30m from Global Land Use and Land Cover Facility. Imageries acquired covered the entire Niger-Delta region of Nigeria which consists of; Bayelsa, Delta, Edo, Rivers, Cross River, Imo, Abia, Ondo and Akwa Ibom State

Data Analysis

Pre-Processing

Pre-processing was done to enhance the quality of data. Landsat imageries contain errors caused by external and internal factors. Data preprocessing follow the following processes

- **Geometric correction and Ground Truthing**. This is to register the Landsat imageries with ground truth coordinates prior to processing with the ancillary data.
- **Radiometric and atmospheric correction.** In the Landsat images, radiometric and atmospheric correction is done to correct the calibration of radiometry between each of the detectors for each band.
- **Geo-referencing and map registration**. This was done in order to register imageries using reference system.

Processing

Normalized Difference vegetation Index Analysis (NDVI)

Normalized Difference vegetation Index was done to assess the level of degradation as NDVI values are expected. ArcGIS10.8 and ENVI4.5 Software were used to model for spatio-temporal valuation of NDVI based on equation 1:

$$NDVI = (NIR - Red) / (NIR + Red) \quad \ldots (1)$$

Where; NIR is the Near Infrared Band and Red is the Red band.

The NDVI being a normalized transform of the NIR to Red reflectance ratio, is designed to standardize Vegetation Index values to between −1 and +1 and provides the measures of the amount or health of vegetation within a pixel. Values between - 1 -0.3 indicates poor vegetation status; 0.3-0.5 indicates Normal vegetation condition and 0.5-1.0 indicates a healthy condition.

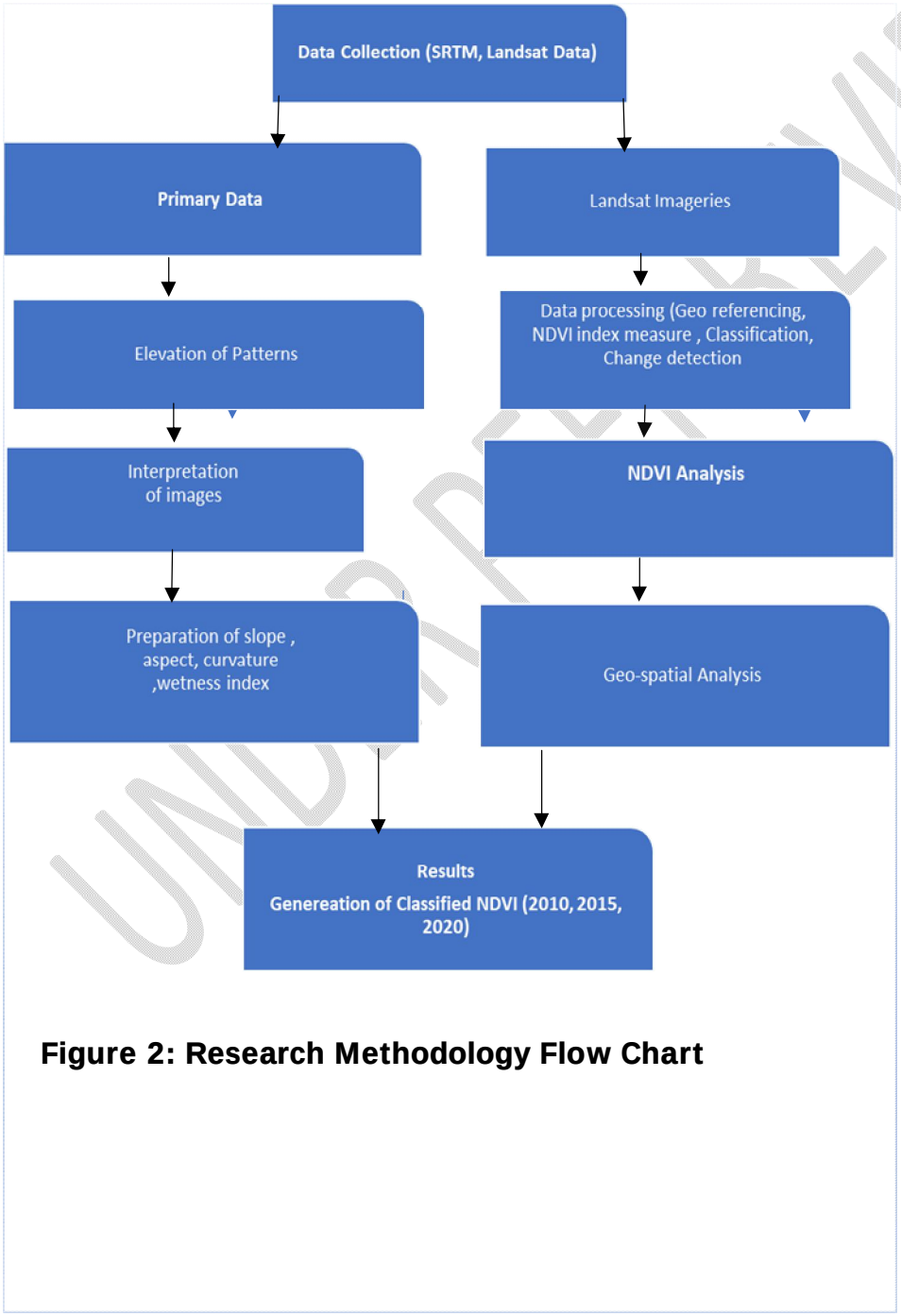

Figure 2: Research Methodology Flow Chart

Results and Discussion

Making use of the model for Normalized Difference Vegetation Index produced in the GIS and Remote Sensing platform, the geo-spatial distribution of NDVI across the Niger Delta was produced for 2010, 2015 and 2020 respectively as shown in figure 3, 4 and 5 below.

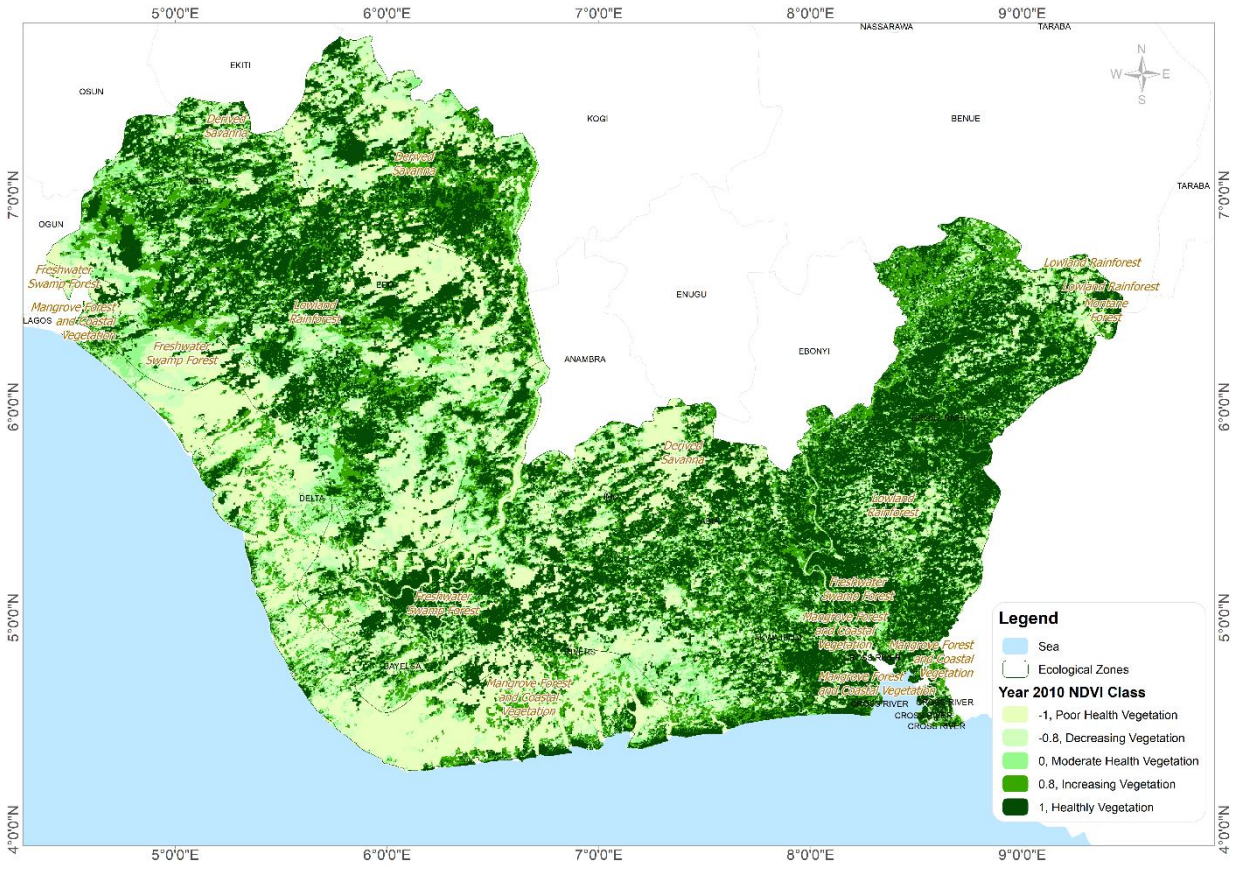

Figure 3: Map showing spatial distribution of NDVI for 2010 of the Study Area.

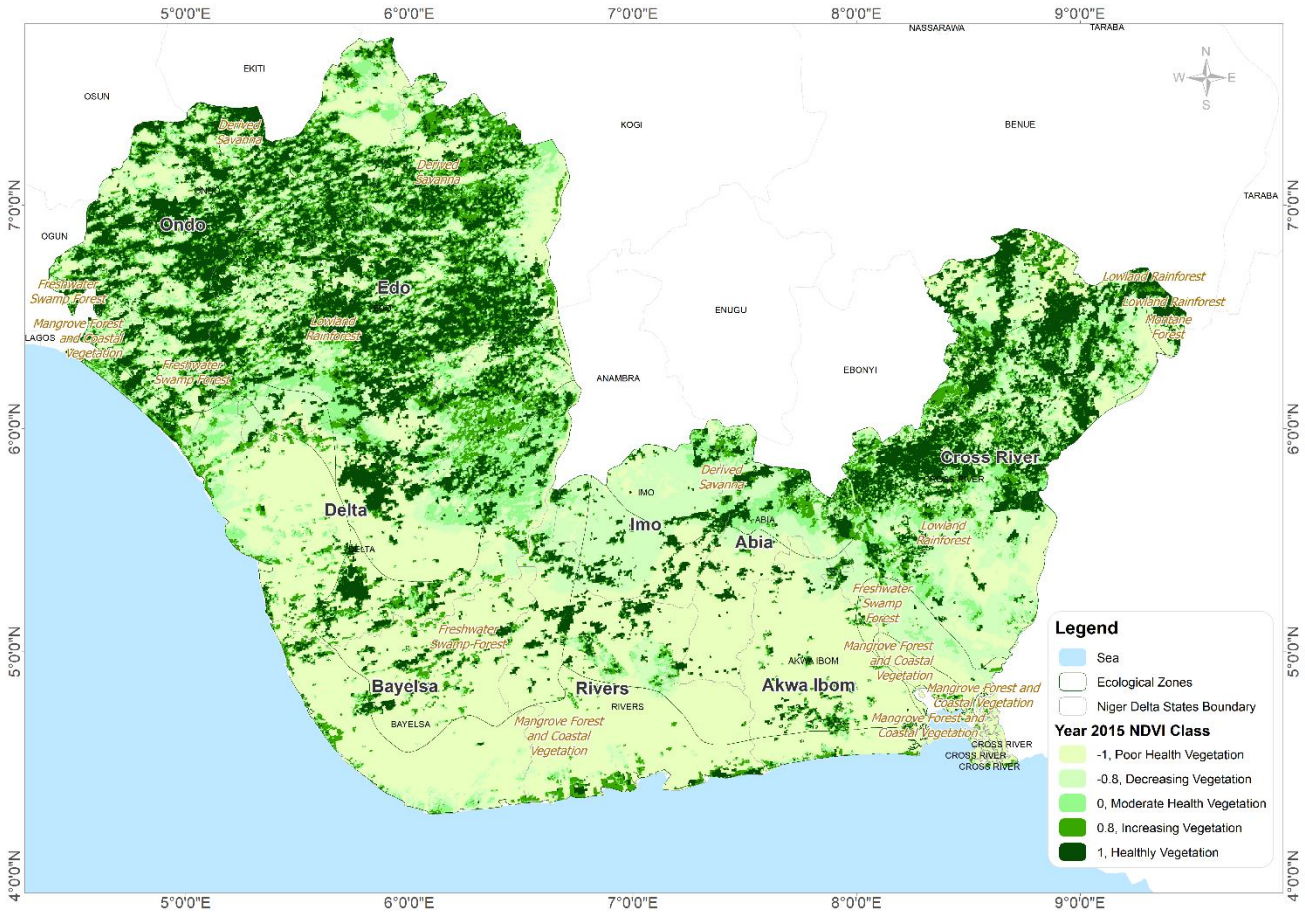

Figure 4: Map showing spatial distribution of NDVI for 2015 of the Study Area.

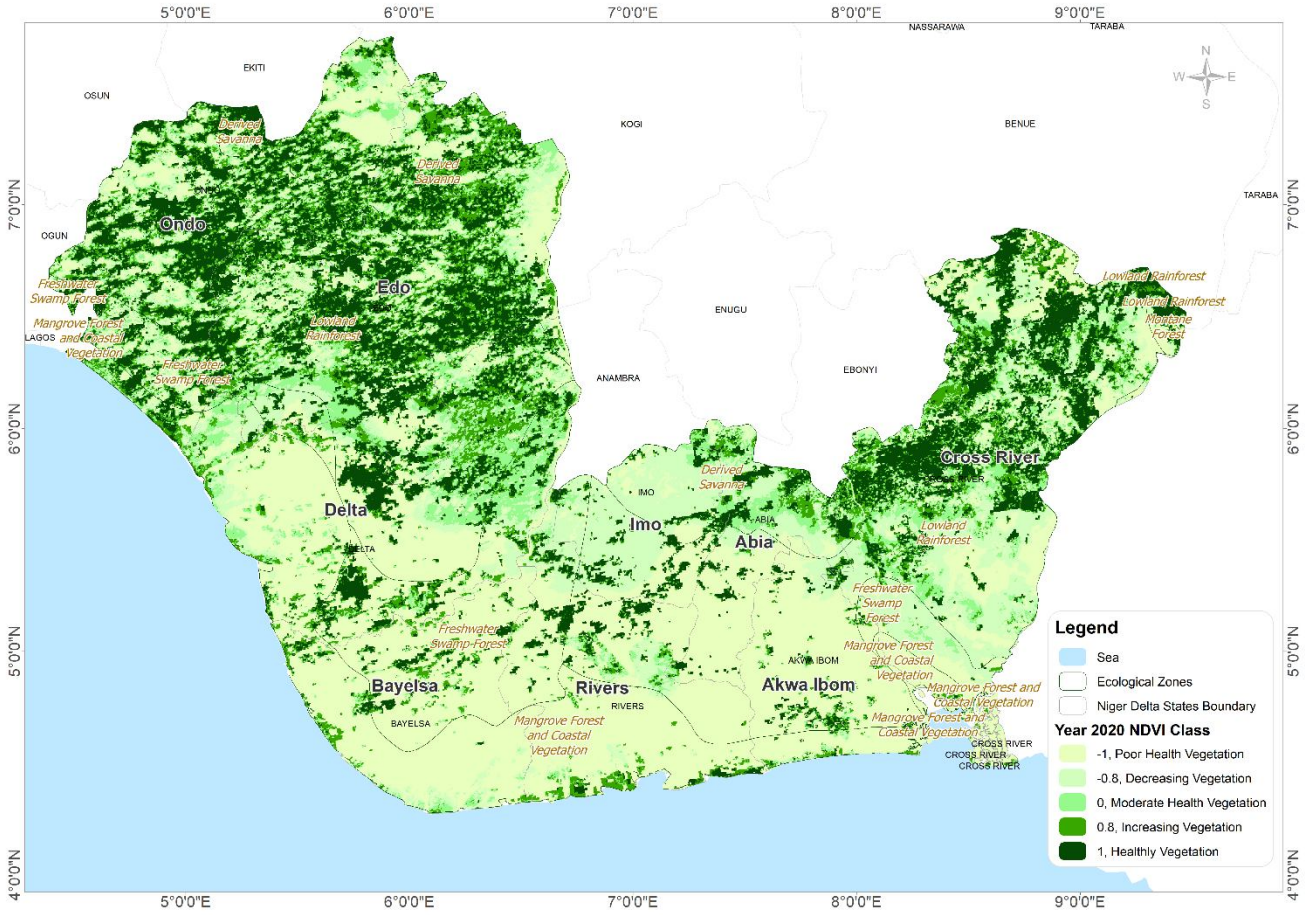

Figure 5: Map showing spatial distribution of NDVI for 2020 of the Study Area.

The study area was characterized and the NDVI Map was produced for 2010, 2015 and 2020 to reveal the Spatio-Temporal NDVI changes as shown in figures 3, 4 and 5 respectively.

In the NDVI Maps, every NDVI type has its corresponding value.

a) Poor Health Vegetation -1
b) Decreasing Vegetation -0.8
c) Moderate Health Vegetation 0
d) Increasing Vegetation 0.8
e) Healthy Vegetation 1

The NDVI was used to examine the relation between the spectral variability and the changes in vegetation growth rate. The result of the NDVI also showed the area covered by vegetation type as shown the table 1 below.

Table 1: Summary of NDVI Types and Land Mass covered

			Area (sq. km)		
S/N	**Type**	**NDVI Value**	**2010**	**2015**	**2020**
1	**Poor Health Vegetation**	-1	21,519	41,976	38,324
2	**Decreasing Vegetation**	-0.8	14,659	20,070	24,058
3	**Moderate Health Vegetation**	0	13,115	12,830	15,005
4	**Increasing Vegetation**	0.8	22,938	14,599	13,452
5	**Healthy Vegetation**	1	37,352	20,107	18,742
	Total		**109,582**	**109,582**	**109,582**

As illustrated in the maps, NDVI types were differentiated with different shades of green colour to show Poor Health Vegetation, Decreasing Vegetation, Moderate Health Vegetation, Increasing Vegetation and Healthy Vegetation.

The total land mass covered was 109,582sq.km. For the first year (2010), it was found out that Poor Health Vegetation has a total of 21,519sq.km; Decreasing Vegetation has a total of 14,659sq.km; Moderate Health Vegetation has a total of 13,115sq.km; Increasing Vegetation has a total of 22,938sq.km and Healthy Vegetation has a total of 37,352sq.km. In 2015, Poor Health Vegetation has a total of 41,976sq.km; Decreasing

Vegetation has a total of 20,070sq.km; Moderate Health Vegetation has a total of 12,830sq.km; Increasing Vegetation has a total of 14,599sq.Km; and Healthy Vegetation has a total of 20,107sq.Km. In 2020, Poor Health Vegetation has a total of 38,324sq.km; Decreasing Vegetation has a total of 24,058sq.km; Moderate Health Vegetation has a total of 15,005sq.km; Increasing Vegetation has a total of 13,452sq.km and Healthy Vegetation has a total of 18,742sq.km.

Table 2: Percentage of Land Mass Covered by NDVI Type

			Area (sq. km)			Percentage		
S/N	**Type**	**NDVI Value**	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**
1	**Poor Health Vegetation**	-1	21,519	41,976	38,324	20%	38%	35%
2	**Decreasing Vegetation**	-0.8	14,659	20,070	24,058	13%	18%	22%
3	**Moderate Health Vegetation**	0	13,115	12,830	15,005	12%	12%	14%
4	**Increasing Vegetation**	0.8	22,938	14,599	13,452	21%	13%	12%
5	**Healthy Vegetation**	1	37,352	20,107	18,742	34%	18%	17%
	Total		**109,582**	**109,582**	**109,582**	**100%**	**100%**	**100%**

In 2010, Poor health Vegetation accounted for 20% of the total land mass, it increased to 38% in 2015 which is an indication of increased level of pollution. However, from 2015 to 2020, Poor Health Vegetation reduced from 38% to 35%. This could be as result of the

time of the year which the imageries were captured as it is expected to be on the increase. NDVI type 2 (Decreasing Vegetation -0.8) accounted for 13% of the total land mass in 2010, it increased to 18% and 22% in the year 2015 and 2020 respectively. Moderate Health Vegetation accounted for 12% of the total land mass for the year 2010 and 2015, in 2020, it increased to 14%. Increasing Vegetation type decreased from 21% in 2010 to 13% in 2015. This was expected as negative NDVI value increased over the years. In 2020, the later also decreased. Healthy Vegetation decreased accounted for 34% of the total land mass in 2010, it decreased to 18% in 2015 and 17% in 2020. From the analysis as shown in table 2, as the NDVI Type with Negative value increases, the NDVI type with positive value decreased, this is an indication of low productive of green plants in the region which could be as a result of oil pollution from oil exploration in the region. Also, NDVI Types with negative values increased across the row as the year increases. It is expected to keep increasing if activities that lead to oil pollution is unabated.

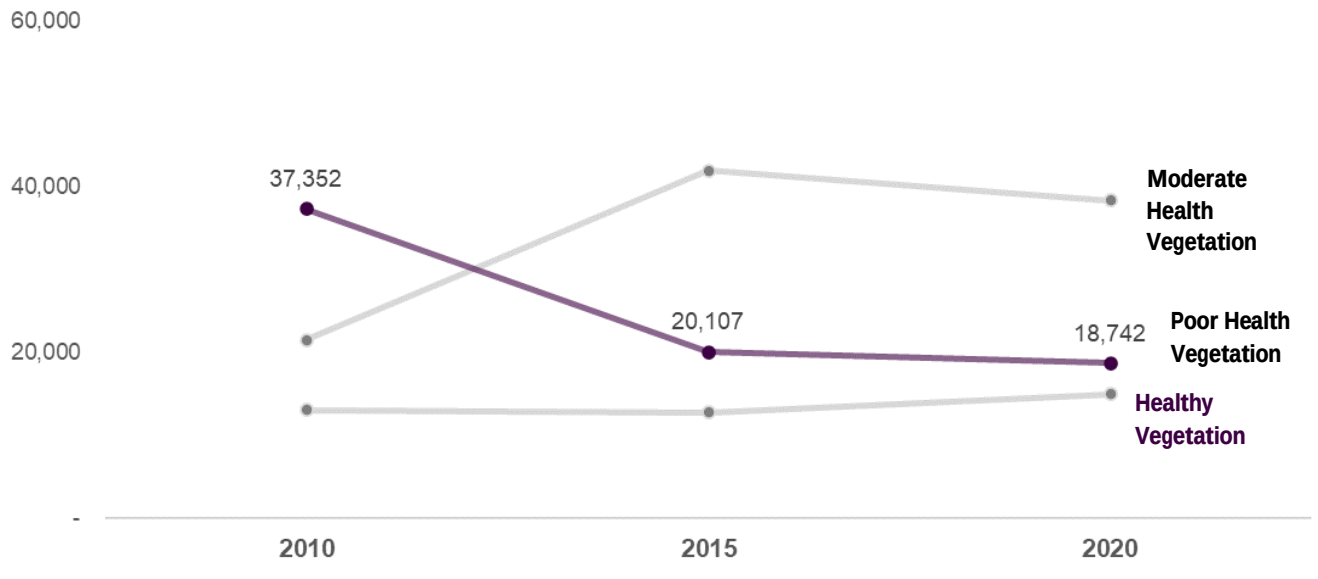

Fig 6: Normalized Difference Vegetation Index distribution

Conclusion.

To determine the intensity of oil pollution on the study area for the last decade, Normalized Difference Vegetation Index was conducted. From the results there was evidence show of increased Normalized Difference Vegetation Index (NDVI) negative values across the years in the study area which is an indication of pollution, it was also evident that NDVI Positive values decreased over the years in the region, which is also an indication of pollution. The results showed that there was pollution across the region which increased as the years go by. Also, the pollution increased in space and time to indicate that there was high intensity of pollution in the region was has adversely effected vegetative life.

Niger-Delta is home to diverse floras and faunas found in the creeks and water shores, therefore there is need to mitigate oil spillage to its barest minimum in the study area.

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