

# **Analysis of Oil Pollution Intensity in Niger-Delta, Nigeria Using Normalized Difference Vegetation Index.**

## **Abstract.**

There has been increase in the level of 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 human health but also to the ecosystem at large. Geographic Information System (GIS) and Remote Sensing (RS) are veritable tools in Environmental management. Normalized Difference Vegetation Index was used as GIS and RS tools 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 performed. Five NDVI types were used with the equation  $NDVI = (NIR - Red) / (NIR + Red)$ . The total land mass covered was 109,582 sq.Km. The results showed that in 2010, Healthy Vegetation was 37,352 sq.Km, which was 34 Percent of the total land mass. In 2015, Poor Health vegetation accounted for the highest land mass with a total of 41,976 sq.Km, while Moderate Health Vegetation had the lowest land mass of 12,830 sq.Km. In 2020, Poor Health Vegetation accounted for the highest land mass of 38,324 sq.Km representing 35 Percent of the total land mass while Increasing Vegetation had 13,452 sq.Km with 12 Percent 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. This was an indication of high level of pollution.

There is need to mitigate oil spillage to its barest minimum in the study area.

Keywords: Environmental Management, Niger-Delta, Normalized Difference Vegetation Index, Mitigate, Remote Sensing.

## **INTRODUCTION**

Crude Oil was first discovered on commercial basis in the Niger-Delta of Nigeria at Oloibiri the present day Bayelsa State in 1956 (Mba et al., 2019). Subsequently, there were more discoveries of crude in the region and as years go by, oil exploration activities increased in the region (Oyehan & Baqer, 2014). Crude oil exploration has really enhanced the economy of Nigeria as it accounts for up to 90Percent of the Gross Domestic Product (GDP) of the Nation (Oyehan & Baqer, 2014). As Nigeria is benefiting from crude exploration, there are environmental problems associated with it, one of these problems is oil spillage.

### **1.1. Sources of Oil Pollution**

Oil pollution is the discharge of Petroleum hydrocarbon and petroleum-derived waste into the environment (Ite et al., 2013). Sources of oil spill include; release of crude oil from tanker ship, directly from accidents and indirect from ship operations, offshore platforms, drilling rigs and well as spills from refined products (Fartoosi, 2013). In Nigeria, fifty percent (50 Percent) of oil spills is due to corrosion, twenty-eight percent (28 Percent) to sabotage and twenty-one percent (21 Percent) to oil production operations (O.T. Badejo & P.C Nwilo, 2015). Sabotage is the major cause of oil spillage in Nigeria. Unpatriotic citizens of Nigeria collaborate with people from other country to engage in oil theft and bunkering activities. They damage oil facilities in their bid to steal oil from them. Oil spill has occurred in various parts and at different times. Report from Department of Petroleum Resources (DPR) show that between 1976 and 1996 a total of 4647 incidents of spillage occurred resulting to the spill of approximately 2,369,470 barrels of oil into the environment. Of this quantity, an estimated

1,820,410.5 barrel (77 Percent) were lost to the environment (O.T. Badejo and P.C Nwilo, 2015). Other notable spills include Escravos spill in 1978 of about 300,000 barrels, SPDC's Forcados Terminal tank failure in 1978 of about 580,000 barrels, Texaco Funiwa-5 blowout in 1980 of about 400,000 barrels. Over the years there have been numerous major oil spills in the region, a look at the Oil Spill Monitor (<https://oilspillmonitor.ng/>) give a clear indication that oil spill is a major scourge on the environment.

### 1.2. Effects of Oil Pollution

Oil pollution has detrimental effects on the immediate environment, groundwater, and the ecosystem at large. (Ite et al., 2013). Oil kills plants and animals in the estuarine zone. Oil settles on beaches and kill organisms that live there, it also settles on ocean floor and kills benthic organisms such as crabs (O.T. Badejo and P.C Nwilo, 2015). Oil poisons algae, disrupts major food chains and decreases the yield of edible crustaceans. It coats birds impairing their flight and reducing their insulative property of their feathers, thus making them vulnerable to cold (O.T. Badejo and P.C Nwilo, 2015). Oil spill is also a source of heavy metal contamination of aquatic and surrounding terrestrial environment (Chinedu & Chukwuemeka, 2018). Furthermore, oil spillage decreases agricultural productivity due to farmland degradation, pollute traditional fishing grounds and destroys forest life (Chinedu & Chukwuemeka, 2018).

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.

### 1.3. Aim and Objectives of the study

The aim of this study was to analyze the oil pollution intensity in Niger-Delta.

The specific Objectives of this study were;

- ❖ To use ENVI Remote Sensing software to analyze multi-temporal land-sat imageries of the study area for the last decade (2010-2020).
- ❖ To perform a Normalized Difference Vegetation Index (NDVI) analysis, as to determine the mass land covered by each NDVI type and subsequently produce NDVI maps of the years in consideration.
- ❖ To use Normalized Difference Vegetative Index (NDVI) analysis to determine the spatio-temporal impact of Oil in the region.

#### 1.4. Related Literature

Remote Sensing and Geographic Information has made way for the geo-spatial, spatiotemporal 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). Vegetative Index through Geographic Information Sensing and Remote Sensing were used to compare fuzzy forest and Random forest methods in detecting and mapping oil-impacted vegetation. The study employed Multispectral optic-I sentinel-2 image and multi-frequency C and X Band Sentinel-1, COSMO Skymed and TanDem-X SAR images to discriminate oil-spill impacted and oil free vegetation in the study area (Ozigis et al., 2020). The result showed that Synthetic Aperture Radar (SAR) based monitoring of petroleum hydrocarbon impacts on vegetation is feasible and has high potential for establishing oil-impacted areas and oil pipeline monitoring (Ozigis et al., 2020). Ochege U.F et al., 2017, used Vegetative Index to perform conservation assessment of Vegetation dynamics under human-induced disturbances. Change detention analysis was done to reveal the change in vegetation over the years in consideration. The results implied that

rates of forest and vegetation recovery are much slower when compared to rates of degradation (Uchenna et al., 2017).

Literature abound that focus either on the spatial or temporal pattern and some focus on analytical assessment of hazardous materials released in the region. (Dutsenwai et al., 2017), monitored the intensity of Oil spillage in Ogoni land which is just a part of Niger-Delta Nigeria. (Eyoh et al., 2019), worked on time-space assessment of Vegetative Health in the Niger-Delta. The work cut across Nine states of the Niger-Delta from 1986-2016. One of the most recent is (Olanrewaju & Chimenwo, 2020), the work monitored the spatio-temporal trend and pattern of oil spill in the region from 2006-2016. The work made use of data from National Oil Spill Detection and Response Agency (NOSRA) to identify oil spill hotspots.

## **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 distributaries before joining the Atlantic Ocean. It lies between longitude 4° 30' - 9° 50'E and Latitude 4° 10' - 8° 0'N. The Political 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 the Political Niger-Delta**

### **Data Collection.**

Raw Landsat Imageries and data of the study area were acquired covering a period of ten years (2010-2020) with a resolution of 30m by 30m from **Global Land Use and Land Cover Facility** ([www.usgs.gov](http://www.usgs.gov)). 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. Imageries acquired also showed the Longitudinal and Latitudinal extend of the area.

### **Data Analysis**

This Pre-Processing and Processing of Data

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

- **Geometric correction and Ground Truthing** was done to register Landsat imageries with ground trothed coordinates prior to processing with the ancillary data. This was done in ArcGIS 10.8 by cross-matching the latitudinal

and longitudinal readings with the imageries acquired to aid interpretation of the land-sat imageries.

- **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. This was done in ENVI4.5 environment by calibrating the pixel values to correct errors in values of each NDVI type. This improved the interpretability and quality of the imageries.
- **Geo-referencing and map registration.** This was done in order to register imageries using reference system. It was done with the geo-referencing tool in ArcGIS 10.8 and it was to register map coordinates and the raster image of the maps to show the spatial location.

### **Processing**

Normalized Difference Vegetation Index (NDVI) Analysis. This was done in order 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:

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red}) \dots (1)$$

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 provided 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.

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

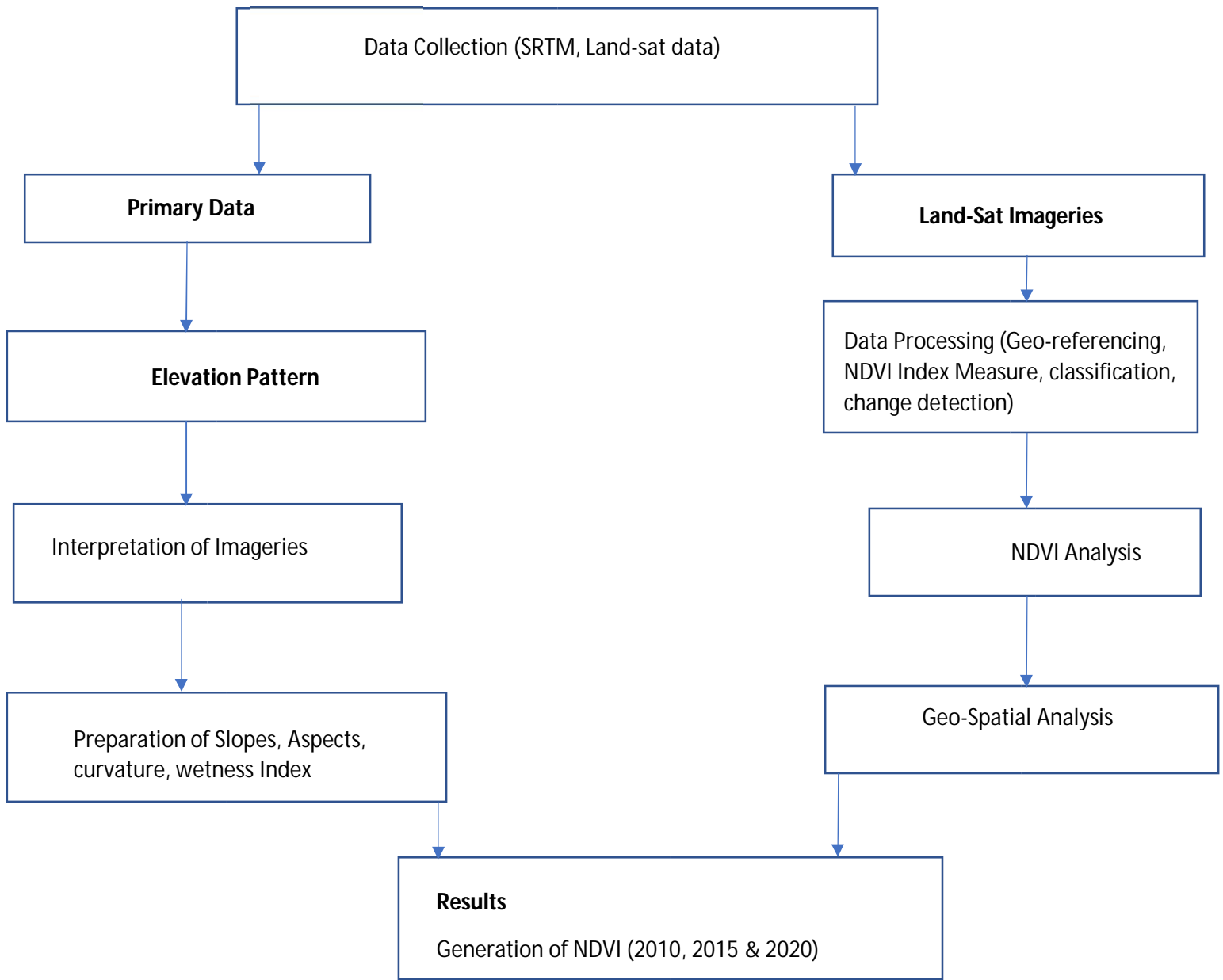
Delta was produced for 2010, 2015 and 2020 respectively as shown in figure 3, 4 and 5 below.

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.



**Figure 2: Research Methodology Flow Chart**



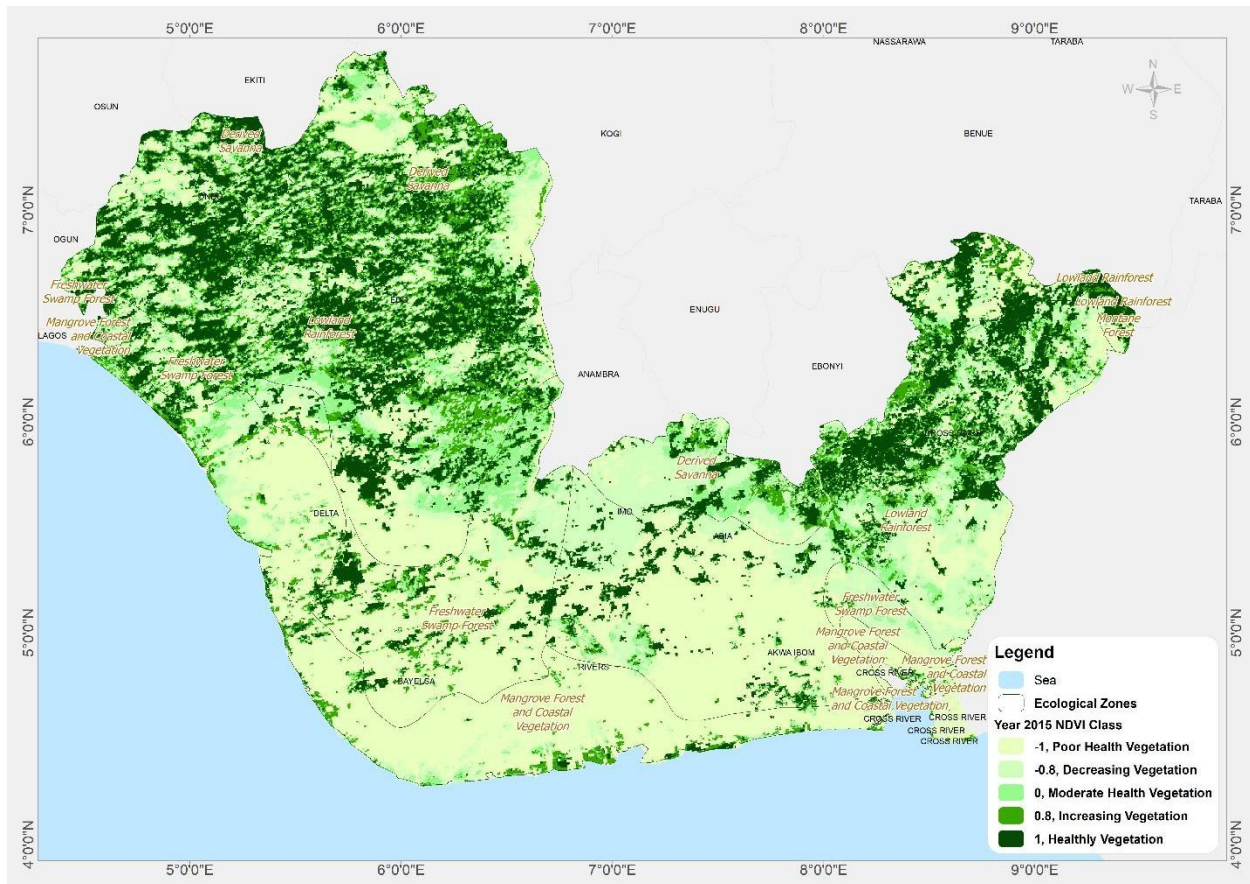


Figure 4: Map showing spatial distribution of NDVI for 2015 of the Study Area.

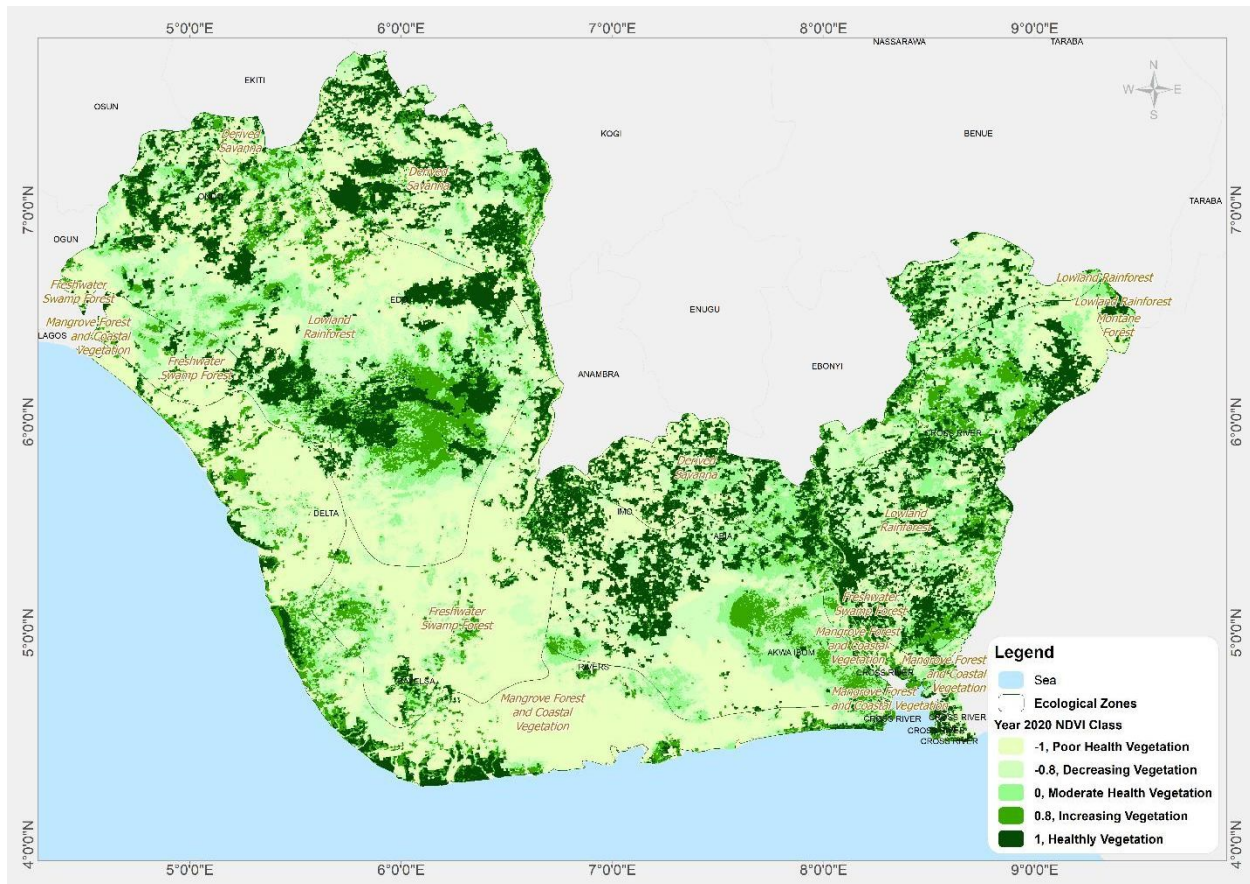


Figure 5: Map showing spatial distribution of NDVI for 2020 of the Study Area.

Table 1: Summary of NDVI Types and Land Mass covered

S/N	Type	NDVI Value	Area (sq. km)		
			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



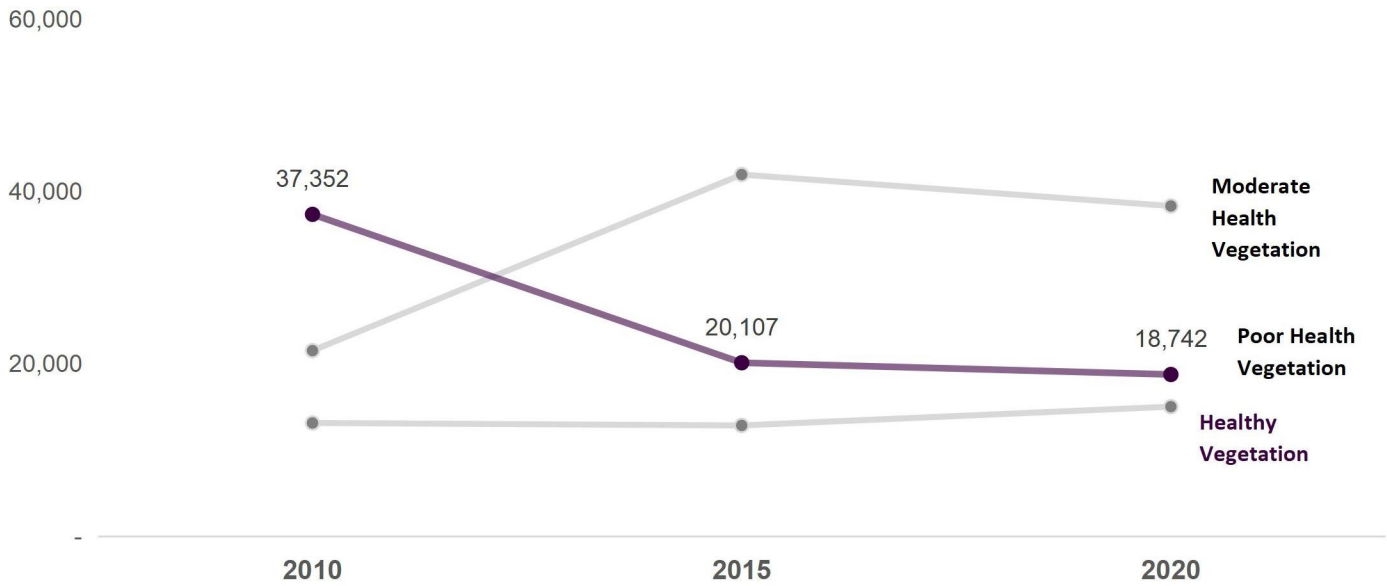
1	<b>Poor Health Vegetation</b>	-1	21,519	41,976	38,324	20Percent	38Percent	35Percent
2	<b>Decreasing Vegetation</b>	-0.8	14,659	20,070	24,058	13Percent	18Percent	22Percent
3	<b>Moderate Health Vegetation</b>	0	13,115	12,830	15,005	12Percent	12Percent	14Percent
4	<b>Increasing Vegetation</b>	0.8	22,938	14,599	13,452	21Percent	13Percent	12Percent
5	<b>Healthy Vegetation</b>	1	37,352	20,107	18,742	34Percent	18Percent	17Percent
<b>Total</b>			<b>109,582</b>	<b>109,582</b>	<b>109,582</b>	<b>100Percent</b>	<b>100Percent</b>	<b>100Percent</b>

In 2010, Poor health Vegetation accounted for 20Percent of the total land mass, it increased to 38Percent in 2015 which is an indication of increased level of pollution.

However, from 2015 to 2020, Poor Health Vegetation reduced from 38Percent to 35Percent. 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 13Percent of the total land mass in 2010, it increased to 18Percent and 22Percent in the year 2015 and 2020 respectively. Moderate Health Vegetation accounted for 12Percent of the total land mass for the year 2010 and 2015, in 2020, it increased to 14Percent. Increasing Vegetation type decreased from 21Percent in 2010 to 13Percent in 2015.

This was expected as negative NDVI value increased over the years. In 2020, the later also decreased. Healthy Vegetation decreased accounted for 34Percent of the total land mass in 2010, it decreased to 18Percent in 2015 and 17Percent 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.



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 affected 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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