*Journal of Geography, Environment and Earth Science International*

*Volume 26, Issue 11, Page 1-10, 2022; Article no.JGEESI.93697*
*ISSN: 2454-7352*

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

**Peter Chibuike C. [a*], Ezeogu Chibuike M. [b] and Oyintare Brisibe [c]**

[a] *Department of Marine Environment and Pollution Control, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.*
[b] *JD Institute of Health and Safety, Dubai, UAE.*
[c] *Department of Marine Geology; Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/JGEESI/2022/v26i11641

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93697

***Original Research Article***

***Received: 05/09/2022***
***Accepted: 11/11/2022***
***Published: 24/11/2022***

## ABSTRACT

There has been an 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 Systems (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). The land sat imageries of the study area were acquired and NDVI analyses were performed. Five NDVI types were used with the equation NDVI=(NIR-Red)/(NIR+Red). The total land mass covered was

**Corresponding author: E-mail: cipendo4real@gmail.com;*

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 showing of increased Normalized Difference Vegetation Index (NDVI) negative values across the years in the study area. This was an indication of the high level of pollution.
There is a 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.*

## 1. INTRODUCTION

Crude Oil was first discovered on a commercial basis in the Niger Delta of Nigeria at Oloibiri the present-day Bayelsa State in 1956 [1]. Subsequently, there were more discoveries of crude in the region and as years go by, oil exploration activities increased in the region [2]. 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 [2]. 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 [3]. Sources of oil spill include; the release of crude oil from tanker ships, directly from accidents, and indirectly from ship operations, offshore platforms, drilling rigs, and well as spills from refined products [4]. In Nigeria, fifty percent (50 Percent) of oil spills are due to corrosion, twenty-eight percent (28 Percent) to sabotage, and twenty-one percent (21 Percent) to oil production operations [5]. Sabotage is the major cause of oil spillage in Nigeria. Unpatriotic citizens of Nigeria collaborate with people from other countries to engage in oil theft and bunkering activities. They damage oil facilities in their bid to steal oil from them. The oil spill has occurred in various parts and at different times. Reports from the Department of Petroleum Resources (DPR) show that between 1976 and 1996 a total of 4647 incidents of spillage occurred resulting in the spill of approximately 2,369,470 barrels of oil into the environment. Of this quantity, an estimated 1,820,410.5 barrels (77 Percent) were lost to the environment [5]. Other notable spills include the Escravos spill in 1978 of about 300,000 barrels, SPDC's Forcados Terminal tank failure in 1978 of about 580,000 barrels, and 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. [3]. Oil kills plants and animals in the estuarine zone. Oil settles on beaches and kills organisms that live there, it also settles on the ocean floor and kills benthic organisms such as crabs [5]. Oil-poisoning algae disrupt major food chains and decrease the yield of edible crustaceans. It coats birds impairing their flight and reducing the insulative property of their feathers, thus making them vulnerable to cold [5]. The oil spill is also a source of heavy metal contamination of the aquatic and surrounding terrestrial environment [6]. Furthermore, oil spillage decreases agricultural productivity due to farmland degradation, pollutes traditional fishing grounds, and destroys forest life [6].

The Niger Delta region of Nigeria consists of about 8600sqkm of rivers, estuaries, creeks, and stagnant swamps [7]. The Mangrove Swamp found in this region is the largest in Africa covering at least 1900sqkm [7]. 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

This study aimed 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 have made way for the geospatial, spatiotemporal, and interactive Spatio-Temporal analysis of a geographical region. Remote Sensing and Spatial technology have been recognized and used as powerful and effective tools to monitor the environment [8]. 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 [9]. 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 [10]. The result showed that Synthetic Aperture Radar (SAR) based monitoring of petroleum hydrocarbon impacts on vegetation is feasible and has a high potential for establishing oil-impacted areas and oil pipeline monitoring [10]. Ochege U.F et al., 2017, used Vegetative Index to perform a 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 [11].

Literature abounds that focus either on the spatial or temporal pattern and some focus on analytical assessment of hazardous materials released in the region [7], monitored the intensity of Oil spillage in Ogoni land which is just a part of the Niger Delta Nigeria. [9], worked on the 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 [12], the work monitored the Spatio-temporal trend and pattern of the oil spill in the region from 2006-2016. The work made use of data from the National Oil Spill Detection and Response Agency (NOSRA) to identify oil spill hotspots.

## 2. METHODOLOGY

### 2.1 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 4º 30' - 9º50'E and Latitude 4º10' - 8º 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 [9]. It is the Oil rich region of Nigeria.

### 2.2 Data Collection

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

### 2.3 Data Analysis

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

- **Geometric correction and Ground Truthing** were done to register Landsat imageries with ground truth coordinate prior to processing with the ancillary data. This was done in ArcGIS 10.8 by crossmatching the latitudinal and longitudinal readings with the imageries acquired to aid the 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 the ENVI4.5 environment by calibrating the pixel values to correct errors in the values of each NDVI type. This improved the interpretability and quality of the images.
- **Geo-referencing and map registration**. This was done in order to register imageries using a 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.

## 2.4 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:

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

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

The NDVI is 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 indicate 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 Figs. 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 Figs. 3,4and 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.

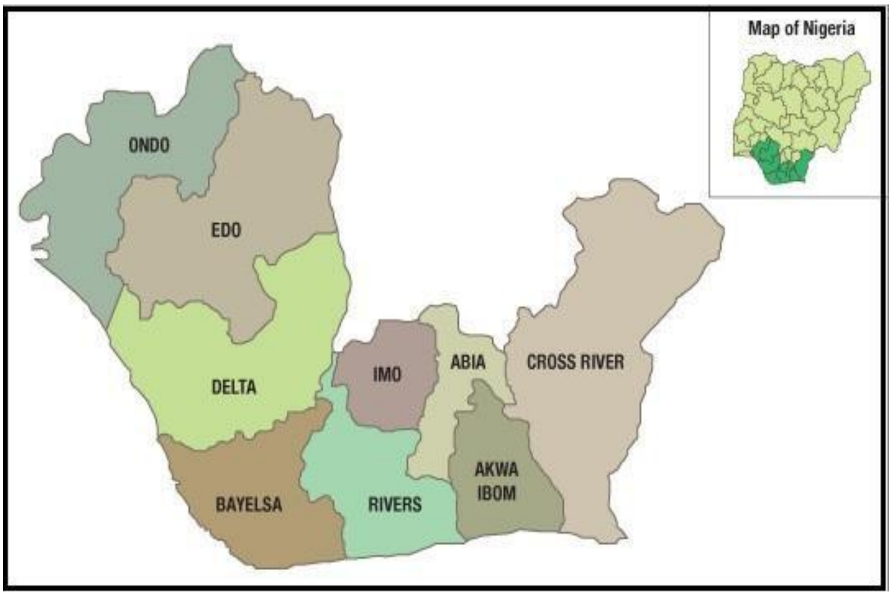


**Fig. 1. Map of the political Niger-Delta**

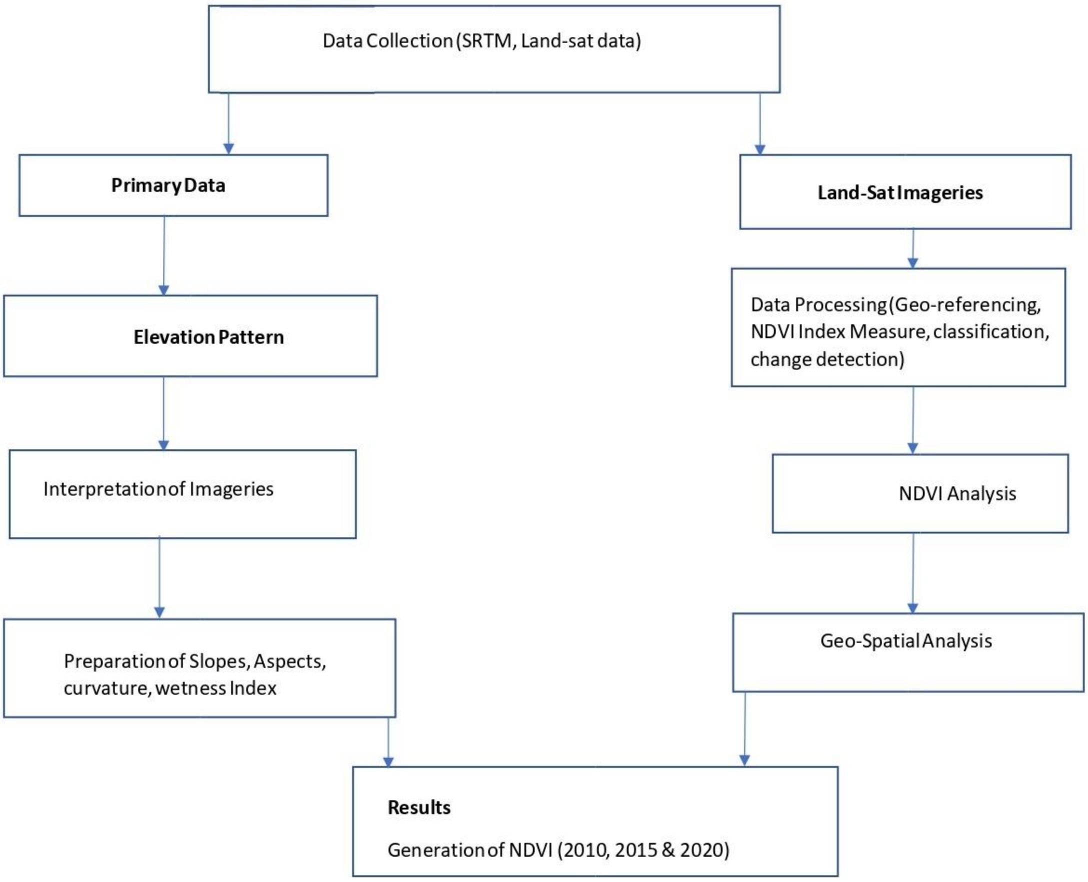


**Fig. 2. Research methodology flow chart**

## 3. RESULTS AND DISCUSSION

As illustrated in the maps, NDVI types were differentiated with different shades of green color 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 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 14,599 sq. 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 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** |

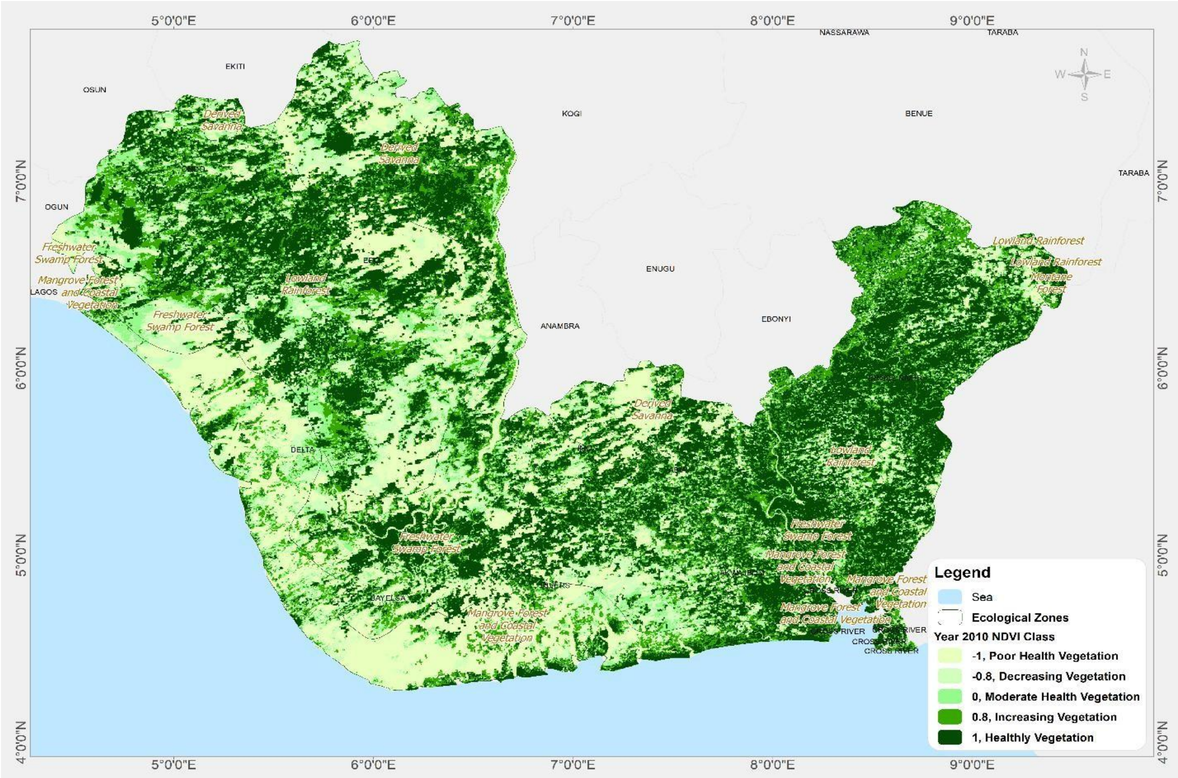


**Fig. 3. Map showing the spatial distribution of NDVI for 2010 in the study area**

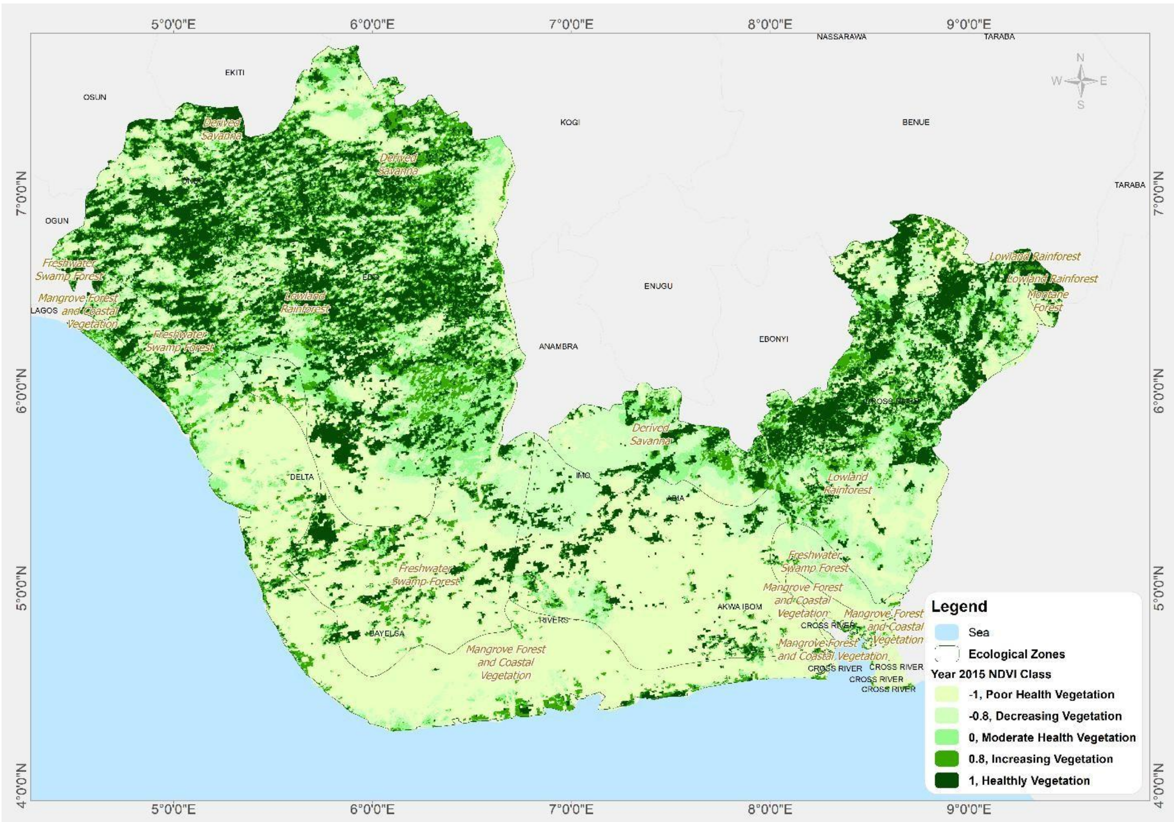


**Fig. 4. Map showing the spatial distribution of NDVI for 2015 in the Study Area**

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

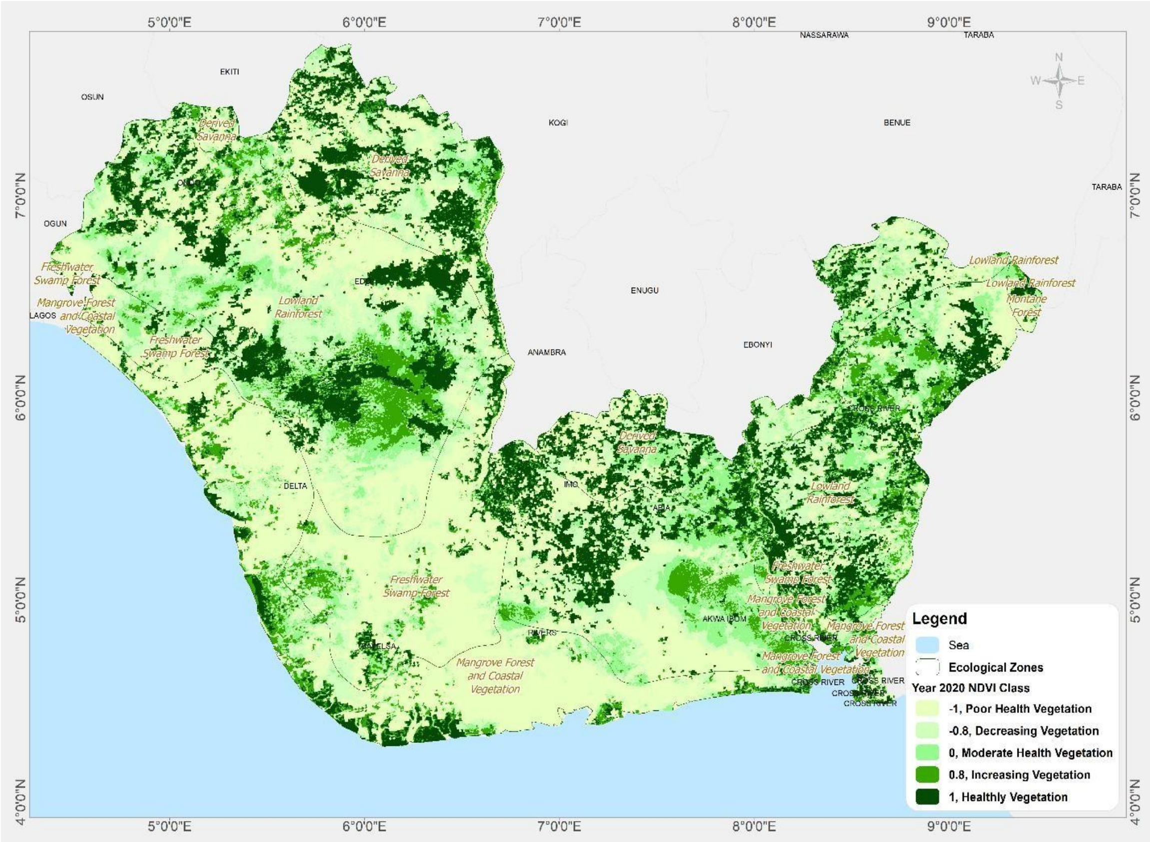


**Fig. 5. Map showing the spatial distribution of NDVI for 2020 in the study area**

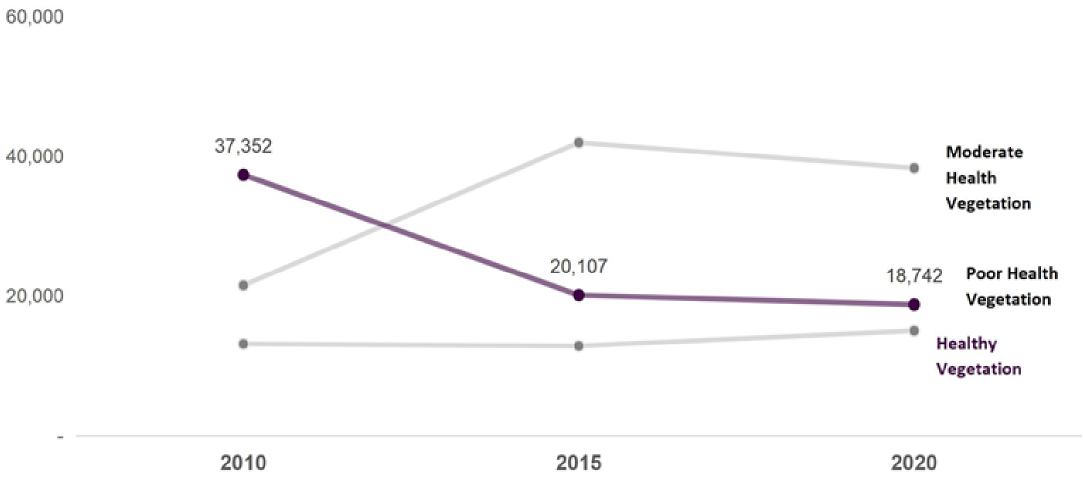


**Fig. 6. Normalized Difference Vegetation Index distribution**

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

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

This was expected as the negative NDVI value increased over the years. In 2020, the latter 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 a positive value decreased, this is an indication of low productive of green plants in the region which could be a result of oil pollution from oil exploration in the region.

Also, NDVI Types with negative values increased across the row as the year increased. It is expected to keep increasing if activities that lead to oil pollution are unabated.

## 4. CONCLUSION

To determine the intensity of oil pollution in the study area for the last decade, Normalized Difference Vegetation Index was conducted. From the results there was evidence showing 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 a 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 a need to mitigate oil spillage to its barest minimum in the study area.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Mba, Ifeoma & Mba, Emmanuel & Ogbuabor, Jonathan & Arazu, Winnie. Causes and Terrain of Oil Spillage in Niger Delta Region of Nigeria: The Analysis of Variance Approach. International Journal of Energy Economics and Policy. 2019;9:283-287. DOI:10.32479/ijeep.7332.
2. Oyehan TA, Baqer ARM. A GIS approach to the management of oil spill in Nigeria. The 9th National GIS Symposium, Dammam, Saudi Arabia. 2014;1–14.
3. Ite, Aniefiok & Ibok, Udo & Ite, Margaret & Petters, Sunday. Petroleum Exploration and Production: Past and Present Environmental Issues in the Nigeria's Niger Delta. American Journal of Environmental Protection. 2013;1:78-90. DOI:10.12691/env-1-4-2.
4. Fartoosi FM. Al. The Maritime Commons: Digital Repository of the World The impact of maritime oil pollution in the marine environment: case study of maritime oil pollution in the navigational channel of Shatt Al-Arab. World Maritime University; 2013.
5. Nwilo, Peter & Badejo, Badejo OT. Oil Spill Problems and Management in the Niger Delta. International Oil Spill Conference Proceedings. 2005;2005:567-570. DOI:10.7901/2169-3358-2005-1-567.
6. Chinedu, Enegide & Chukwuemeka, Chukwuma. Oil Spillage and Heavy Metals Toxicity Risk in the Niger Delta, Nigeria. Journal of Health and Pollution. 2018;8:180905. DOI:10.5696/2156-9614-8.19.180905
7. Dutsenwai HS, Ahmad BB, Tanko AI, Mijinyawa A. Spatio-temporal analysis of vegetation and oil spill intensity in Ogoniland. International Journal of Advanced and Applied Sciences. 2017;4(4):81-90.
8. Peter CC, Alozie M, Azubuine C, Oti U. Change Approach in determining the rate of Urban Expansion Dynamics and Changes in Land Use/Land Cover: A Case Study of Owerri Municipal, Imo State, Nigeria. Sky Journal of Soil Science and Environmental Management; 2017.
9. Eyoh, Aniekan & Ekpa, Akwaowo. Temporal appraisal of land surface temperature dynamics across the nine states of Niger delta region of Nigeria from 2004-2016 using remote sensing dataset of Modis. International Journal of Research in Engineering and Applied Sciences (IJREAS). 2017;7:53-62. Available online at http://euroasiapub.org/journals.php.

10. Ozigis, Mohammed & Kaduk, Jörg & Jarvis, Claire & Bispo, Polyanna & Balzter, Heiko. Detection of oil pollution impacts on vegetation using multifrequency SAR, multispectral images with fuzzy forest and random forest methods. Environmental Pollution. 2019;113360. DOI: 10.1016/j.envpol.2019.113360.
11. Uchenna F, Timipre R, Chigozie E, Okpala-okaka C. The Egyptian Journal of Remote Sensing and Space Sciences Geospatial assessment of vegetation status in Sagbama oilfield environment in the Niger Delta region, Nigeria. The Egyptian Journal of Remote Sensing and Space Sciences. 2017;20(2):211–221.
12. Olanrewaju, L & Chimenwo, Roland. Analysis of oil spill risk using space-time pattern of incidents in the Niger delta, Nigeria; 2020.



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*The peer review history for this paper can be accessed here:*
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