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Mining and its Implications on the Rural Peoples' Livelihood and Environment in Etche, South-South Nigeria using Multivariate and Geospatial Analyses

Bridget E. Diagi, Nasir A. Umar, Victor A. Agidi, Ahmed Y. Ameh, Chinwe G. Onwuagba and Chukwudi Nwaogu
Department of Environmental Management, School of Environmental Sciences, Federal University of Technology, Owerri, P.M.B. 1526, Owerri, 460114, Imo State, Nigeria.

Hycienth O. Nwankwoala
Department of Geology,
University of Port-Harcourt,
Port-Harcourt, Rivers State,
Nigeria

Susan I. Ajiere
Department of Geography and
Environmental Management,
University of Port-Harcourt,
Nigeria

Abstract:- The study aimed at assessing the impacts of mining and other anthropogenic activities on the land-use, vegetation and livelihood in the Niger-Delta Region, Nigeria. It is hypothesized that the land use, floristic composition, and livelihood were significantly affected by mineral mining. GIS and Remote sensing were used to collect data, identify, and classify the landuse-landcover. On the other hand, the local people were also interviewed. In addition, reconnaissance survey and field data sampling were used to identify the plant species. GIS analyses tools, regression and RDA analyses where employed to analyze the data. The result revealed that oil mining activities, farming, and logging were the primary socioeconomic activities which have significant impacts on crude-oil spillage. The relationship between oil mining and fishing was significantly high (p = 0.002; R2 = 0.63). The trees were more vulnerable to the effects of the crude-oil spillage when compared with other plant functional groups. A net loss of about 15,500 US dollars per annual was recorded on the impacts of oil spill to the vegetation. However, with fewer grasses, about 50% of the vascular plant species were associated with the 0.5km buffer zone. Integration of geospatial and statistical analyses was very effective and successful in analyzing the impacts of socioeconomic activities on land use-land cover. The use of GIS should be further applied in studying the spatio-temporal pattern of basic facilities and species hotspots in the area as this would consolidate land use-cover conservation against future crude-oil pollution.

Keywords:- *Geospatial, Landuse-landcover, livelihood, socio-economics, Infrastructural facilities, Etche.*

I. INTRODUCTION

Crude-oil exploration and exploitation have been one of the most viable socio-economic activities in Nigeria since it was discovered in 1937. Though crude-oil has greatly contributed to Nigeria's economic boost but, its devastating effects when spilled can neither be underestimated nor ignored. Oil spillage has been known as a re-occurring environmental problem of the host communities, especially the Niger-Delta regions where the crude-oil mining, transportation and marketing is highly concentrated [1]. It is therefore important to examine, assess, predict, and regulate the incidence of oil spillage in the area as to mitigate all the socio-economic and environmental dangers associated with it. Report has confirmed that land use-cover modifications by man or nature can have profound impacts on climate, hydro-biogeochemical cycles, biodiversity, soil quality and human wellbeing [2]. This justified the importance of land use and land cover change research in the context of local and global environmental change and sustainable development.

Over the past two decades, the country recorded about 5400 oil spill incidents and the release of over 2.0 million barrels of oil into the immediate environment. It was documented that about 75% of these oil spill incidents are noted to have occurred in inland areas (including sensitive swamp environments), while about 25% occurred in the offshore areas [3].

However, the Niger Delta environment could not perfectly be restored to its natural state after any oil spill, but for pseudo-natural environment to be put in place, some environmental management plans need be adopted. Sequel to this, it is therefore of necessity to monitor, map and manage the incidence of oil spillage in the Niger Delta area to ameliorate its risks on the environment and peoples' livelihood.

The multi-agent based model integrates Remote sensing, GIS, and the people's knowledge in evaluating the relationships between landuse-cover characteristics and socioeconomic activities [4-8]. This study aimed at assessing the impacts of mining and other socioeconomic activities on the landuse-cover, and peoples' livelihood. It is hypothesized that anthropogenic activities including crude-oil mining have substantial impacts on the landuse, plants composition and the local communities.

II. MATERIALS AND METHODS

A. Study area

Etche Local Government Area (ELGA) is located between longitude 06° 05' E - 07° 14' E and latitude 04° 45' N - 05° 08' N (Fig. 1). It has an annual mean rainfall ranging from 2000 mm to 3000 mm, and annual mean temperature ranging from 26.4°C to 38.6°C [9]. It is a typical rainforest region with traces of mangrove and Fresh water swamp forests towards the

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south and in areas along the major rivers [10]. Etche is a subsistent agrarian ethnic group in Rivers State and is situated within the eastern flank of the Niger Delta Region of Nigeria. The inhabitants engage in farming, palm wine tapping, fishing, logging, hunting, oil and sand mining [1]. Etche has combination of many communities and villages which include Okehi, Ulakwo, Obibi and others (Fig. 1a).

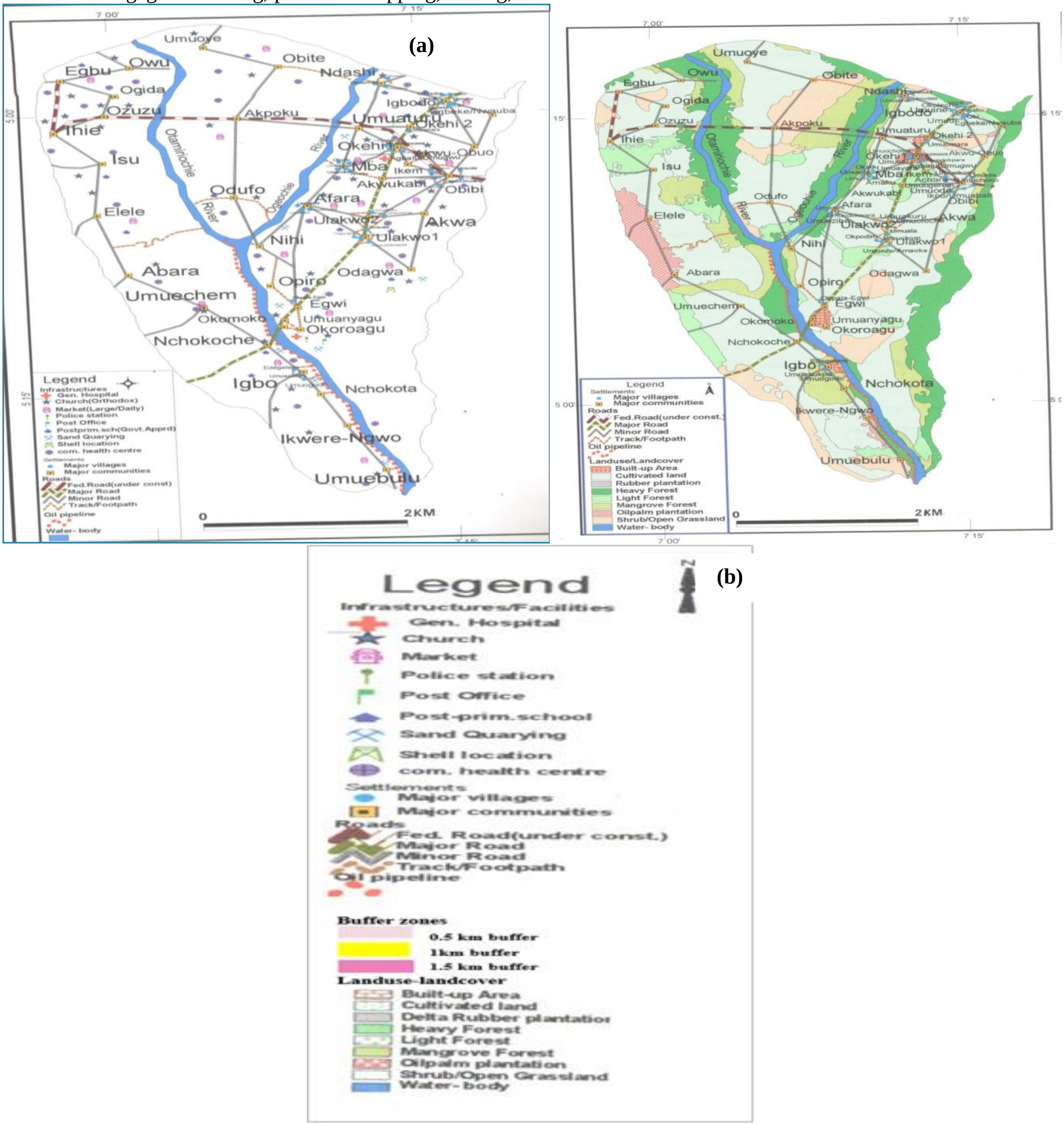

Fig. 1: Study area (a) Facilities distribution (b) Landuse-Landcover. Source: adapted and modified from [11].

S/N	Class (Level I)	Description (Level II)
1	Built-up Area	Residential, industrial, commercial, Infrastructural facilities such as,
		transportation, communication, recreation, health and education, utilities,
		Mixed urban or built-up land.
2	Agricultural land	Cultivated land, Plantations and orchards, cropland and pasture,
		Shrubs and Open grassland, and other agricultural lands.
3	Forest land	Deciduous- Heavy Forest, Light Forest, Mangrove-evergreen and mixed Forest.
4	Water body	Rivers, streams, ponds, creeks.

Table 1: Landuse-cover classification of the study area

B. Data collection and analyses

Landsat images from NASA, and Topographic maps of scale 1: 50,000 from the Federal office of Survey, Nigeria were used for the landuse-landcover (LULC) and image classification, and oil spill vulnerability studies in the ArcGIS 10.1 environment. The ancillary data were the administrative map of Rivers State, oil spill records, socio-economic activities information, and plant species composition. The geographic corrections (georeferencing) were done using the topo-maps, aerial photographs, and satellite imageries which were registered in accordance with UTM WGS84. The selected ground control points (GCPs) collected via handheld GPS were also used for the validation of the registration. All GCPs were dispersed throughout the scene, yielding a RMS error of less than 0.5 pixels. (Table 1 and Fig. 1b). A hybrid classification scheme was adopted including maximum likelihood. Training sites, ground truth points, and image from Google Earth were employed for further verification and validation. By applying the ArcGIS tools, buffer analyses including the three different buffer zones (0.5 km, 1km, and 1.5 km) were generated with respect to proximity to the oil pipeline and waterbody. The buffer specification was performed in agreement with the Nigerian environmental protection and petroleum regulatory guideline [9,12].

The plant species spatial distribution and composition were measured in the field by integrating GPS, field survey, taxonomy literature and local-based knowledge. The data on the socio-economic attributes were derived by employing questionnaire method. 300 persons from the local communities were administered with structured research questionnaires. 240 completed questionnaires were returned from the sampled population. The sample population characteristics (Table 2) and the sampling type were applied as to cover the working force and the retired because the causes and impacts of oil spills were not sectional restricted.

The socio-economic activities (E) which were significant for crude-oil spillage were generated using the Formula: $E = [(Sr / F) \times (n/N)] \times 100$ [Equ. 1]

where Sr = sum rank, F = rank frequency, n = number of respondents for individual socioeconomic activity, N = total number of all respondents.

On the other hand, likert-scale approach (of 1-4 with ‘1’ as the most significant), regression and correlation analyses were used in integrating livelihood activities and LULC information. This further consolidated the analyses of the data from the peoples’ responses by finding the relationships between oil spill, LULC and socioeconomic activities. Regression analyses, and one-way ANOVA were used to determine the differences between respondents’ mean ranking of the socio-economic activities that could cause oil spillage as well as the observable relationships between the peoples’ occupations. All analyses were done using the IBM SPSS Statistics Version 20 [13] (www.ibm-spss-statistics.soft32.com). A redundancy Analysis (RDA) followed by a Monte Carlo Permutation test with 999 permutations in the Canoco version 5.0 package [14] was used to evaluate the plant species composition and their spatial distribution between the three buffer zones. A biplot ordination diagram was produced by employing the CanoDraw program which enabled the presentation and visualization of the RDA result of the experiment.

III. RESULTS AND DISUSSION

A. Landuse-cover class and basic infrastructural facilities

This study focused on most underlying causes of LULC change by identifying the socio-economic parameters contributing to oil spillage which in turn affect the landscape. The classified landuse-cover classes and their coverage showed that cultivated land (302.8 km2; 47.2%) had the highest area while, rubber plantation (0.6 km2; 0.1%) had the lowest (Table 3 and Fig. 1b). Others were, built-up area (4.5km2; 0.7%), heavy forest (124.9 km2; 19.9%), mangrove forest (67.9 km2; 10.6%), light forest, grassland (56.9 km2; 8.8%), oilpalm plantation (17.2 km2; 2.7%), and water (23.4 km2; 3.2%). General hospitals ranked among the lowest in list of the identified basic facilities in the area given in Table 4.

Parameter	categories	N	%
Gender	Male	130	54.2
	Female	110	45.8
Occupation	*Farmers*	*58*	*24.2*
	Civil Servant/students	*40*	*16.6*
	Fishermen, loggers/hunters	*24*	*10*
	Artesian	*10*	*4.2*
	Technician	*13*	*5.4*
	Business	*23*	*9.6*
	Oil/Gas workers	*45*	*18.7*
	Mixed-jobs	*15*	*6.3*
	Retirees	*12*	*5*

Table 2: Sample Population and Participants Characteristics in the study

The infrastructural facilities in the study area were not only insufficient but were not uniformly distributed across the designated buffer zones (Fig. 2). The shortage of the most essential facilities such as electricity and telecommunication network might have been responsible for the low socio-economic activities in the area [11]. This consequently made farming one of the paramount occupation with cultivated land area covering about 47.2% of the entire landuse-cover (Table 3).

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Lanuse-cover	Buffer zone/distance from oil spill source (oil pipeline/water)						Total land area within buffer zones		Total land area in entire study site	
class	0.5km	%	1km	%	1.5km	%	km^2	%	km^2	%
Built-up area	1.7	1.3	3.4	1.3	4.3	1.1	9.4	1.2	4.5	0.7
Heavy forest	79.2	58.8	80.1	30	85.5	22	245	31	125	20
Mangrove forest	20.7	15.5	50.9	19	51.8	13	124	16	67.9	11
Light forest	9.9	7.2	21.1	8	23.4	6	54.4	6.8	43.1	6.7
Cultivated land	17.6	13.1	87.2	33	176.5	45	281	36	303	47
Grassland/shrub	1.8	1.3	17.2	6.5	44.8	12	63.7	8	56.9	8.8
Oil-palm plantation	2.1	1.6	3	1.2	3	0.8	8.2	1	17.2	2.7
Rubber plantation	1.7	1.2	1.8	0.6	1.9	0.4	5	1	0.6	0.1
Water	0	0	0	0	0	0	0	0	23.4	3.7
TOTAL	134.7	100	265	100	391.2	100	791	100	641	100

Table 3: Landuse-landcover class and area (in km^2 and %) covered within the buffer zones from the oil spill source, and total area for the entire study site.

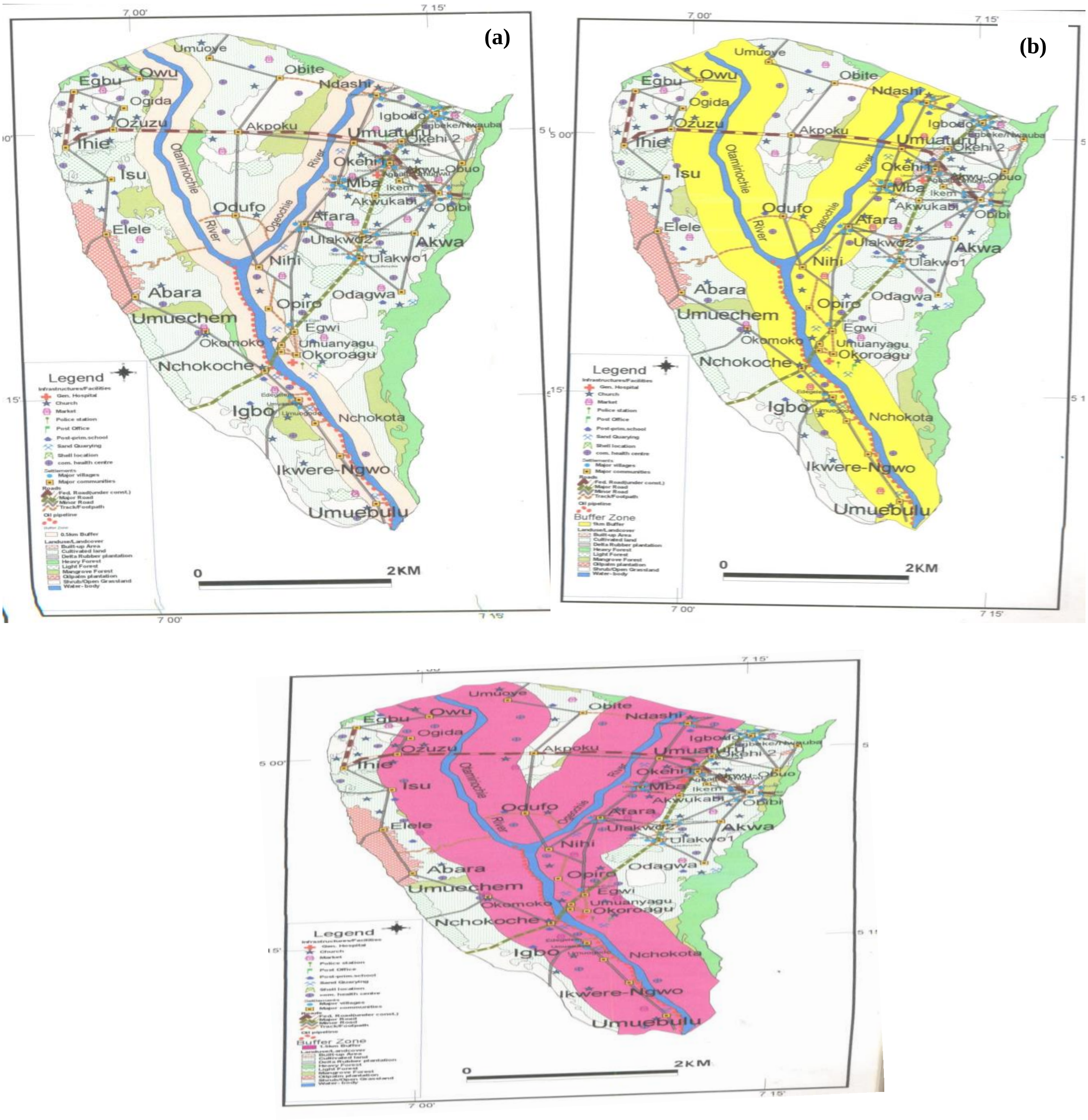

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Fig. 2. Buffer zones around the water body/oil pipeline (a) 0.5km buffer (b) 1km buffer (c) 1.5km buffer.

Source: adapted and modified from [11].

*Value in bracket are the road types: Federal Road (Fed.), Major Roads, Minor Roads, & Track/Footpaths.

B. Buffer zones, landuse-cover, and facilities distribution

Buffer zone 0.5km

The buffer zone 0.5km (500m) covered 134.7km2 of the entire study area. It is the closest to the waterbody/oil pipeline which is the source of the oil spillage. Though it has the highest number of sand quarry depots, it accounted for the lowest frequency of the basic land use facilities (Table 3). This zone was most predominated by the Heavy Forest while, Grassland was the lowest. The zone recorded the highest species of trees, lianas, ferns, and epiphytes as compared with the 1km and 1.5 km zones (Fig. 3).

a) Buffer zone 1km

The 1km buffer distance from the waterbody/oil pipeline covered a total of 264.7km2 (Table 3). It has no records of sand quarry but has the highest number of roads, markets, community health centers and religious worship centers as compared with buffer zones 0.5km and 1.5km (Table 4). In terms of landcover, the cultivated area (arable land) had the largest areal extent. The study also revealed that Heavy Forest and mangrove forest were among the largest landcover in this zone. On the contrary, the rubber plantation recorded the least (1.8km2; 0.6%) in this buffer zone (Table 3). Furthermore, herbs and shrub species were dominant in this zone though with fewer trees and grasses (Fig. 3).

1Facilities	Buffer zones (in km)			Total Within Total Number	Total Number
	0.5	1	1.5	buffer zones	in the area
General hospital	1	0	1	2	2
Church (Orthodox)	5	8	9	22	36
Market	0	6	5	11	17
Police Station	1	0	1	2	2
Post office	0	1	1	2	2
Post-prim. School					
(Govt. aprovd.)	0	3	7	10	15
Shell location	0	0	0	0	1
Sand quarry depot	7	0	0	7	8
Comm. Health Centre 3	10	6	19	28	
Number of Roads					
[*different types*]*	10[4]	18[4]	17[4]	45[4]	222[4]
Railway	0	0	0	0	0
Electric lines/poles	0	0	0	0	0
Telecom mast	0	0	0	0	0

Table 4: Major socio-economic & basic infrastructural facilities and their distribution within the Buffer Zones.

b) Buffer zone 1.5km

Buffer zone 1.5 km occupied a total land area of 391.2km2 with cultivated (arable) area having the largest cover. The built-up area was among the least landuse-cover in this zone (Table 3). This is because farming was the main socioeconomic activities, and people refrain from building in this vast land but for agriculture. The study discovered that the 1.5 km buffer zone has the highest number of schools and churches (Table 4). This could be explained by the ministry of education regulations which mandates any school location to have large hectares of land and must be far from the built-up areas. This zone was also dominated with legumes and grasses with scanty trees and shrubs (Fig. 3). Intensive cultivation and

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slash-burn agriculture prevalent in this zone favor the legumes and grasses as compared with the trees.

The three buffer zones were developed to assess the impacts of oil spills and vulnerability with each landuse-cover. Besides, the buffer zones also helped to identify, rank and predict the various anthropogenic activities that could trigger oil spillage in the area [11,12,15]. Buffer zone 0.5 km and 1.5km were discovered to have more of the man-made resources as compared with the buffer zone 1.5km (Fig. 2). This might possibly be explained because of the closeness of the rivers to the 0.5km buffer and large arable land within the 1.5km buffer which promote farming instead.

C. Socioeconomic activities and oil spillage

The major occupations were classified into nine (9) categories based on the information from the local people, field records, and literature [10,11]. The categories and their percentages were Farmers (24.2%), Oil workers (18.7%), Government and NGOs including white-collar jobs & students (16.6%), Fishermen, Loggers, & Hunters (10%) and others (Table 2). The ranked values and percentages of the livelihood activities that caused or are affected by oil spill in the area were examined (Table 5). Some occupations were either highly vulnerable to oil spill or contributed to oil spillage. The study evaluated the position of each socioeconomic activity with respect to oil spill. It was discovered that oil mining and transportation, logging, farming, sand quarry, construction works, fishing, and water collection were significantly linked to oil spillage. Though construction works, fishing, and water collection were lowly ranked by the people yet our analysis indicated that they were also significant factors for the oil spillage. Oil mining and transportation, farming, sand quarry and logging were significantly ranked and rated by all the respondents as a causative activity for oil spills (Table 5).

Although school was among the infrastructural facilities dominating the area yet, information gathered from the people revealed that the existing number of schools was inadequate. Similarly, the need for security in the area was highlighted. All the participants indicated that more police stations be established in all the three buffer zones. Meanwhile, only one police post was in existence in each of the zones as at the time of the study posing security challenges [11].

Similar to schools and police station, report revealed that community health centers were indispensable and critically needed by the people. The inhabitants opted for the reduction in the number of the churches. Moreover, electricity, recreational sites and telecommunications were among the limiting infrastructures. These were obviously none in existence in the buffer zones as at the time of this research. Establishing these needed infrastructures will not only solve the problems of poor social facilities [16], but will reduce youths' restiveness and unwholesome acts because many will find better paying jobs for themselves [17].

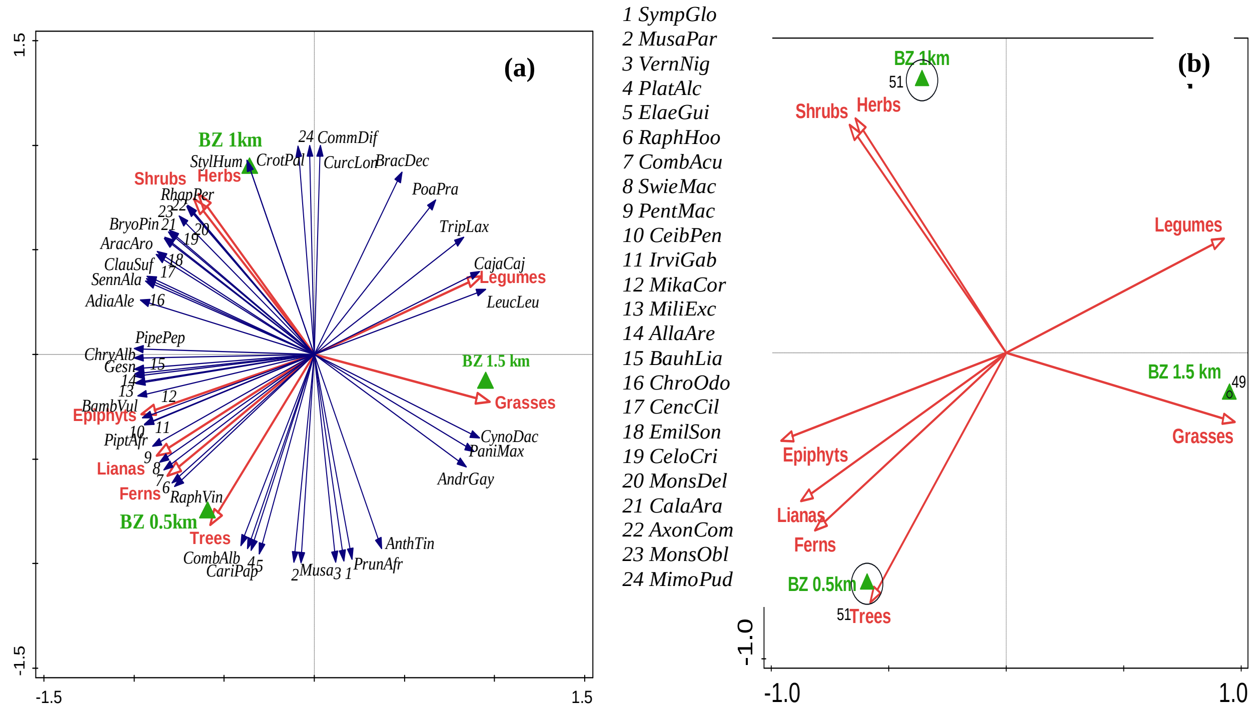

Fig. 3: Ordination diagram showing the results of RDA analysis of (a) plant species composition (b) the abundance and distribution of the functional groups of the major vascular plant species within the 0.5km, 1km and 1.5 km buffer zones from the waterbody/oil pipeline. Species abbreviations are as follows: *AntiTox=Antiaris toxicaria, MiliExc=Milicia excels, CeibPen=Ceiba pentandra, PiptAfri=Piptadeniastrum africanum, PentMac=Pentaclethra macrophylla, ChryAlb=Chrysophyllum albidum, IrviGab=Irvingia gabonenesis, ElaeGui=Elaeis guineesis, RaphHoo= Raphia hookerii, RaphVin=Raphia vinifera, AllaAre=Allagoptera arenaria, MusaPar=Musa paradisiaca, MusaAcu=Musa acuminate, CariPap=Carica papaya, PrunAfr= Prunus Africana, SympGlo=Symphonia globulifera, BambVul=Bambusa Vulgaris, SwieMac=Swietenia macrophylla, BauhLia=Bauhinia liana, CombAcu=Combretum aculeatum, CombAlb=Combretum albidum, PipePep=Piperaceae peperomias, AracAro=Araceae aroids, Gesn=Gesneriaceae, AdiaAle=Adiantum aleuticum, PlatAlc=Platycerium alcicorne, BryoPin=Bryophyllum pinnatum, CeloCri=Celosia cristata, ClauSuf=Clausena suffruticosa, SennAla=Senna alata,*

MonsDel=Monstera deliciosa, MonsObl=Monstera obliqua, RhapPer=Rhaphidophora pertusa, ChroOdo=Chromolaena odorata, CalaAra=Caladium Araceae, CommDif=Commelina diffusa, CrotPal=Crotalaria pallida, CurcLon=Curcuma longa, EmilSon=Emilia sonchifolia, MikaCor=Mikania cordata, MimoPud=Mimosa pudica, AndrGay=Andropogon gayanus, BracDec=Brachiaria decumbens, CencCil=Cenchrus ciliaris, CynoDac=Cynodon dactylon, PaniMax=Panicum maximum, AxonCom=Axonopus compressus, PoaPra=Poa pratensis, TripLax=Tripsacum laxum, CajaCaj=Cajanus cajan, LeucLeu=Leucaena leucocephala, StylHum=Stylosanthes humilis, AnthTin=Anthemis tinctoria (cota), VernNig=Vernonia nigritiana.

Source: Authors' data collection and analysis.

Socio-economic Activities	Sum of Respondents Ranking	%	Sig.
OilMining& Transportation(OMT)	241	99.60[a]	< 0.001**
Sand Quarry (SQ)	251	95.60[a]	0.005**
Construction works (C)	409	58.70	0.038*
Fishing (F)	638	57.60	0.044*
Water Transport & Boat Carvers (WTBC)	744	52.30	0.069
Religious Rituals (RR)	802	29.90	1.00
Logging of Trees (L)	252	95.20[a]	< 0.001**
Hunting (H)	759	31.60	0.342
Swimming & Recreational (SRA)	672	35.70	0.703
Palm-Wine Tapping (PWT)	684	55.10	0.886
Farming (FM)	247	97.20[a]	< 0.001**
Water Collection (WC) +	743	50.30	0.047*

Table 5: Results of the ranking values and significance of the socioeconomic activities that cause or are affected by oil spill in the area

Source: Authors' data collection and analysis.

*Significant at P<0.05; **Significant at P<0.01
+ =Water Collection and uses for industrial, commercial and domestic purposes
a = most significant socioeconomic activities with highest role in oil spillage.

The poor status of electricity and telecommunication in the area partly accounted for the choice of socio-economic activities where little or no power or telecommunication services were required such as oil mining and transportation, sand quarry, construction, fishing, boat transport and making. Due to the socio-economic activities and extraction of natural resources, LULC suffered several threats, and changes [16]. In comparing the problems of socio-economic activities and natural resources exploitation on the LULC, our study area has high record because of the low land topography of the area [1,10]. Several scientists in temperate and tropical regions have also revealed that places with low altitude have more human activities and higher threats to the landscape as compared with the high-altitude belts [11,18].

D. Plant species composition and spatial distribution within the buffer zones (BZ)

Most trees, ferns, lianas and epiphyte species such as Prunus Africana, Carica papaya, Musa acuminate, Musa paradisiaca, Elaeis guineesis, Piptadeniastrum africanum, Bauhinia liana, Araceae aroids and Platycerium alcicorne tend to show higher concentrations within the 0.5km buffer zone (BZ) from the waterbody/oil pipeline (Fig. 3). On the other hand, the 1km buffer zone was dominated by the herbs and shrubs species such as Bryophyllum pinnatum, Celosia cristata, Crotalaria pallida, Curcuma longa, Chromolaena odorata, Rhaphidophora pertusa, Monstera deliciosa and others. In constrast, the legumes and grass species such as Cajanus cajan, Leucaena leucocephala, Andropogon gayanus, Brachiaria decumbens, Tripsacum laxum, Cynodon dactylon and others were commonly found within the 1.5km buffer zone which is farther from the source of oil spill (oil pipeline/waterbody). It could be therefore explained that the trees, lianas and epiphytes are more vulnerable to the impacts of oil spill in comparison with the grasses or legumes.

The plants are of diverse socio-economic benefits to the rural communities (Table 6) especially as sources of timber products, domestic energy (firewood), building materials, canoe and boat makings, traditional medicines and so on [19,20]. Similarly, some lianas and epiphytes are important sources of ropes and crafts productions which support the peoples' livelihood [20-22]. The vegetation provides ecosystem services to man, animal, mico-organisms and the entire habitats [23-26]. It is therefore imperative to protect these floristic species for the sustenance of the rural peoples' livelihood and economy. For example, our study revealed that more than 12, 800 US dollars was lost annually from timber products alone while, more than 72,000 US dollars were lost annually from all vegetation types because of oil spill (Table 6). Several studies have documented the impacts of oil spill on the vegetation and ecosystem services and the need for sustainable development in Nigeria [20,22,27-30].

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Item	Uses/benefits	Monetary equivalent/estimate		Net gain	Net loss
		gain in zero oil spill	loss to oil spill		
	Timber products	20,545.3	12,848.3	7697	-
	furniture (home & offices)	6,123.9	4,067.6	2056.3	-
	house building & roofing	6,847.4	3,792.2	3055.2	-
	bridges construction	5,305.7	3,014.1	2291.6	-
	Arts (sculpture/carving)	2,268.3	1,974.4	293.9	-
	Sources of food	4,418.6	6,395.2	-	1,976.6
	Canoe & boat making	1,267.9	865.1	402.8	-
	Firewood for rural cooking/heating	5,325.3	3,110.7	2214.6	-
	saw dust for livestock	967.4	509.2	458.2	-
	traditional medicine	2,816.6	5,018.1	-	2,201.5
	nutrient cycling	3,730.5	4,185.9	-	455.4
	air & water purification	2,497.0	3,761.4	-	1,264.4
	Animal & their habitats	4,611.8	6,624.3	-	2,012.5
Trees, shrubs & herbs	Local-crude tools for agric.	597.3	862.0	-	264.7
Lianas & epiphytes	Local robes & crafts	2,551.7	3,996.1	-	1,444.4
	soil mineral enrichment/conservation	3,093.2	7,144.6	-	4,051.4
Legumes & grasses	herbivores' feed/nutrition	1,942.8	3,866.7	-	1,923.9
Total		**74,910.7**	**72,035.9**	**18,469.6**	**15,594.8**

Table 6: Socio-economic gain & loss (in US$/year) from the plant species in the study area. Source: Authors' data collection and analysis

IV. CONCLUSION

The 1.5 km buffer zone has the highest number of schools and churches which was due to order by government regulations mandating schools sites at large hectares of land far from the built-up areas. Thus, the 1.5 km zone became dominant with legumes and grasses with scanty trees and shrubs because intensive and poor farming practices such as slash and burn was a tradition in this zone. Hence, the legumes and grasses were favoured when compared with the trees. The livelihood of the rural communities depends on the luxurious vegetation and recently, substantial amount has been lost economically through oil spillage which has impoverished the people. The trees are more vulnerable to the oil spill effects because they are closer to the oil spill source in comparison with other plant functional groups. Oil mining, tree logging, sand quarry, and river-side farming were the most socioeconomic activities with significant contribution to the oil spillage. The roles of vegetation in provision of ecosystem services was truncated through the various anthropogenic activities. The study recommends a decisive policies and measures that will support the conservation of the trees since their benefits to the rural peoples' livelihood cannot be underestimated. In addition, the local government lost substantial amount of money through the destruction of the vegetation by the oil spillage. GIS has proved to be an effective scientific and technological innovation in the management of oil spill in the Niger Delta. Continuous application of geospatial tools will help to explore and conserve the rich plant-species diversity in the area.

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