Lagos Journal of Geo-Information Sciences (LJGIS)

LJGIS Volume 1, Number 1; June 2011

University of Lagos
(www.unilag.edu.ng)

Lagos Journal of Geo-Information Sciences (LJGIS)
Volume 1, Number 1; June 2011

In this Edition:

Lagos Journal of Geo-Information Sciences (LJGIS)

ISSN: 2276-7983

Publisher

LJGIS is an International Journal of:
Department of Geography
University of Lagos
Akoka – Yaba, Lagos, 101017
NIGERIA

Marketing

University of Lagos Press
P.O.Box 132, Unilag Post Office
Akoka-Yaba, Lagos, Nigeria, 101017
Tel: +23417943017
Email: press@unilag.edu.ng

Correspondences

All Correspondences should be directed to:
The Editor-in-Chief
Lagos Journal of Geo-Information Sciences (LJGIS)
Department of Geography, University of Lagos
Akoka-Yaba, Lagos, Nigeria, 101017
Email: ljgis@unilag.edu.ng.

BASELINE ECOSYSTEMS AND SENSITIVITY OF THE OF FORCADOS RIVER, WESTERN NIGER DELTA OF NIGERIA, TO OIL IMPACTS

Mayowa FASONA (Correspondence Author)
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, Nigeria, 101017
Tel: 234-802-312-7998. E-mails: mfasona@unilag.edu.ng; mfasona@yahoo.com

Alabi SONEYE
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, Nigeria, 101017
Tel: +234-802-312-6221. E-mails: asoneye@unilag.edu.ng; asoneye@yahoo.com

Morries NWOKEDI
Department for Petroleum Resources, Victoria Island, Lagos
Tel: +234-805-829-8829. E-mail: morriesjay@yahoo.com

Mosunmola **OLADEINDE**
Airtel Nigeria Limited, Plot L2, Banana Island, Ikoyi, Lagos
Tel: +234-802-222-4799. E-mail: mosunoladeinde@yahoo.com

Received: January 10, 2011 *Accepted: March 21, 2011*

ABSTRACT

Oil exploration has high potential to disrupt socio-ecological systems when not properly managed. Over two-third of producing oil wells in the Niger delta is located in the inland areas. The ecosystems of the inland areas provide the functions and services that support the well-being of the indigenous communities. Yet these areas have not been given considerable attention in ecosystems prioritization and sensitivity mapping to protect them from deleterious effects of oil activities. This study attempts to establish the baseline ecosystems and their sensitivity to oil spill in the lower segment of the Forcados River. Baseline ecosystems was derived from Landsat ETM imagery, and integrated with biological and socio-economic data within GIS to generate sensitivity areas. The classification was done using multi-criteria analysis based on ecosystems productivity, oil-ecosystem interaction, ease of cleanup, importance of inhabiting fauna species to rural livelihood, and human weight including frequency of human interaction with an ecosystem. The result suggests the mangrove ecology as possessing the highest sensitivity to oil activities and paved surfaces have the least.

KEYWORDS: Ecosystem, Oil Exploration, Niger Delta, Nigeria

INTRODUCTION

The environment encompasses everything in a defined region (Eedy 1995, Arms, 1994). It consists of the tangible aspects - air, water, soil and living organisms - and also the less tangible aspects of social, cultural and economic resources. Some of these components took millions of years to develop, but could be damaged in a matter of decades if appropriate safeguard strategies are not adopted (Al Gore, 1997). The environment provides all the essential stuffs of living (MEA, 2005), converted into useful material through resource development and conversion to engender growth and development in human societies. The process of resource development is often accompanied by externalities including disruption and degradation of terrestrial ecosystems. This presents fundamental natural resource challenges to environmental scientists, managers and planners. Some effects of this may be dramatic with impacts occurring within a short time, while some may take longer time to manifest. Some can also remain permanently with the exploitation process thereby altering the overall benefit-cost of resource development (Fasona, 2009). Anthropocentrism and sustainability dictate that any process of development that negates the fulfillment of basic human needs or destroys livelihood of indigenous communities is a travesty of the idea of development (Conyer and Hills, 1995; Arms, 1994). The process of resource exploitation is therefore expected to preserve both intra and inter generational equity by preserving the basic life support systems, and without causing systematic impoverishment and socio-economic dislocation to indigenous communities. Every ecosystem has its limits of resilience and rate of stability. Resilience refers to ability to withstand perturbation while stability refers to ability to regain climax after an impact (Verburg et al., 2002).

Statutory analytical tools for evaluating resource development impacts on socio-ecological systems in Nigeria include environmental impact assessment (EIA) of green projects, environmental evaluation report (EER) of brown projects and commissioned environmental audits (DPR, 1991). The monitoring plans that emanate from these have always been fraught with challenges of lack of quality and systematic data on intrinsic characteristics of places from local to regional levels thereby making the plans ineffective (Fasona, 2003). In addition, the extents to which the reports are implemented suggest that much is still desired for sound environmental management to be achieved in the oil industry (Agha et al., 2002; Nwilo and Badejo (N.D)).Oil exploration in particular has potential to cause maximum and irreparable damage and dislocation to the socio-ecological systems if not well managed. Oil spills, with all their devastating effects on the environment, have remained a regular occurrence in our coastal and marine environment.

It is in recognition of this that the Federal government of Nigeria set up the National Oil Spill Detection and Response Agency (NOSDRA). Spill record from NOSDRA shows that during the first half of the year 2007, a total of 424 spill incidents involving 33,799 barrels of oil were reported from the upstream operations. Out of these, 196 incidents occurred due to equipment or operation failure, 143 incidents were due to sabotage, while the source of 85 incidents were in contention. (SEDEC, 2008). The inland areas of the Niger Delta and the contiguous coastal areas are particularly susceptible to oil spill. Some 1045 of the 1665 producing wells in these areas are located in the inland swamp area (FGN, 2000).

All activities in the petroleum industry including exploration, production, terminal operations, hydrocarbon processing, transportation, and marketing possess potentials to impact the life support systems. The quantity of oil lost into the natural environment roughly equates total quantity spilled between 1976 and 1996 (Fig 1) and about 75% of these spill incidents occurred onshore within creeks and swamps and delicate ecosystems that support livelihoods of indigenous communities.

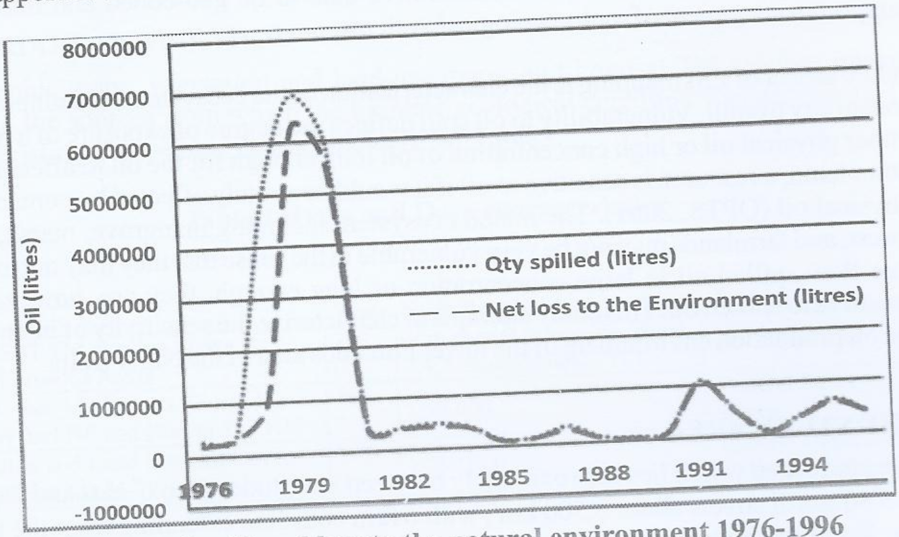

Fig **1: Oil spill and loss to the natural environment 1976-1996**
(Source: Nwokedi, 1999)

This underscores the need for proactive response to spill incidents. Proactive response can be aided by combining geographic information with characterization of spills and the environment where they occur, and it is what environmental sensitivity index (ESI) as impact analysis and response strategy tool seeks to achieve.

ESI mapping is an integral part of oil spill contingency plans. It takes into account an initial identification and prioritization of various aspects of ecosystems in an exploration environment and helps prioritize the placement and allocation of resources during cleanup efforts (Jensen, *et al.*, 1998). It is a mapping system designed to integrate data from various sources with a view to predicting the behavior of spill and its effects on surrounding marine and fresh water habitats (RPI, 1985). It is a cartographic presentation of the environmental attributes of a given area in a ranked scale that distinguishes the type, class and degree of sensitivity to spill as environmental stressor.

When produced at reasonable scale and easily decoded format, ESI map forms a basis for priority response during oil spill incident. It is robust for prerequisite analysis of the likelihood of spill, the expected degree of impacts and effectiveness of protection and clean up exercises. It is predicated on the experience obtained from observatory behaviors of spills in different marine and freshwater habitats. It is developed by employing remote sensing and geographic information systems (GIS) to generate and integrate general and specific variables on the socio-ecological systems to produce spatially-explicit integrated digital database with querying, retrieval and update capabilities. GIS supports integration of data captured from different sources including remote sensing, global positioning systems (GPS), surveying and fieldwork, digital camera, archival attribute and administrative data to be geo-coded and integrated for support management of socio-ecological systems.

A key aspect of ESI mapping is the characterization of the ecosystems to vulnerability and sensitivity to spill. Vulnerability to oil spill defines the degree of exposure of a resource to either physical oil or high concentration of oil long enough for the oil to affect it. On the other hand, a resource is sensitive to oil if it would be acutely affected by contact with the physical oil (OPTS, 2001). The inland ecosystem including mangrove, marsh, swamp, forest, and farmlands may not be very vulnerable in the sense that they may not experience free flow spilled oil in large concentration or long enough, they are, however, highly sensitive to spilled oil. This study attempts to characterize the sensitivity of inland areas in the oil production environment of the lower Forcados area of the Niger Delta.

THE STUDY AREA

The study area which lies approximately between longitudes 5^0 to 6^0 east and latitudes 5^0 to $5^0 30'$ north covers about 3,500 km^2, with 64km coastline extending from the mouth of the Escravos River up to 15km south of the Ramos River. Mean annual rainfall approaches 3000mm and mean annual temperature is around 27.8^0c. Humidity is high all year round. The area is within the western Niger delta sector of sedimentary basin of West Africa formed from the growth of the delta into the Gulf of Guinea following the gradual retreat of the sea after a short-lived Paleocene transgression onto the late cretaceous coal measures (Wright, at al., 1985). Elevation is low ranging from 0m along the coast to about 12m inland. Soil consists of abandoned beach ridges near the coast and extensive freshwater swamp soils. Vegetation is dominated by freshwater swamps, mangroves, palm bush and tidal flats with some marsh.

Forcados and Ramos rivers which form the main drainage channels are parts of the distributaries of the Niger. According to Dublin Green et al. (1997) the means of high and low water springs for Forcados is 1.402m and 0.152m, high and low water neaps of 1.128m and 0.823m, and mean sea level of 0.427m. The mean high water spring could rise to 4m during violent tides and storm surges and cause back discharge to the distributaries which raise water levels and flood adjoining lands. This makes the area susceptible to oil and hazardous chemical spill both offshore and onshore with devastating impacts on the ecosystems.

The study area covers 9 Local Government Areas within Delta/Bayelsa States with about 261 communities, 31 of which could be regarded as sub-urban settlements located mainly along the river banks and ocean shoreline. The indigenous Ijaw, Itshekiri and Urhobo communities depend on fishing, craft making and some peasant farming along the river bank for livelihoods. Some communities such as Okwagbe, Okwagbe inland, and Burutu are thriving centers of native gin which are produced from raffia palms (Fasona and Anosike, 2002). The natural resource capital therefore contributes significantly to their well-being.

MATERIALS AND METHOD

Topographic maps, vegetation and land-use maps, and Landsat TM satellite imagery provided the sources from which the baseline ecological condition was generated. The characteristics of these base data are indicated on Table 1.

Table 1: Data and Data characteristics

Data	Year	Scale/Resolution	Source
LANDSAT TM satellite image for lower Forcados Areas	2006	25m spatial resolution. Band 2,4,7 enhancement–TCC	www.landcover.org
Topographic Map sheets : Forcados 317 NW and NE and Burutu 318 NW	1963	1:50,000	Federal Surveys, Lagos
Vegetation and Land Use and Cover Maps: Sheet NB 31-12/1	1977	1:250,000	Federal Department of Forestry, Abuja

Data on the dominant fauna species found in each ecosystem was collated through a review of existing works on the study area, while socio-economic and livelihood information were inferred from the base maps, satellite imagery and literature (including existing reports and government register). The image was geo- and ortho-rectified from the source. Image compositing was done to combine bands 2, 4 and 7 and derive a true color composite image. This was analyzed to derive the layers of land-use and land-cover. A land-cover classification derived from the USGS land-use and land-cover schema (Anderson, et al., 1976) was adopted. With this, a semi-automatic visual analysis procedure was used for classifying into land-cover classes.

With the aid of the existing vegetation map, a direct interpretation strategy was adopted for mapping the ecosystems, while inferential and probabilistic strategies was combined with review of existing records to general human activities and livelihood systems. The base maps were also scanned and imported into GIS for extraction of relevant data layers. The semi-automatic approach to image analysis involves detection, recognition, identification and classification of ecosystems using head-up digitization approach. The result is vector data layers for desired classes which can be combined with other data layers generated from the base maps and existing sources without data transformation. This is also important to address the problem of mixing of classes with very similar spectral reflectance characteristics inherent in digital processing.

Effectiveness of oil spill contingency planning is presupposed in identification of spill locations and prioritization of spill-sensitive areas. The considerations necessary for establishing the ranks for the different ecosystems include biological community and productivity of fauna and flora and their ability to recover after a spill incident, social, political and economic significance of each category as means of livelihood for indigenous communities, and ecosystem-oil interaction including persistence and burial which are contingent on exposure and resilience of ecosystems and the property (viscosity, substrate nature and permeability) of spill.

Previous ESI mapping in the study area considered only shoreline areas (Murday, *et al.*, 1988; NDES, 1997). Their categorizations are defined broadly as exposed rocky shores, vertical manmade shelters, tidal flats, mangroves and estuarine wetlands. The different categories are ranked and color-coded according to the US National Oceanic and Atmospheric Administration (NOAA) ESI derived by remote sensing for the shore-lines and near-shore ecosystems (Table 2).

Table 2: The classification scheme adopted by Murday *et al.* (1988)

Class	Description
ESI-1	Exposed rocky shores and vertical, hard manmade structures (seawalls)
ESI-2	Exposed wave-cut rock platform
ESI-3	Fine grained sand beaches
ESI-4	Medium to coarse grained sand beaches
ESI-5a	Mixed sand and gravel beaches
ESI-5B	Artificial fill containing a range of grain size and materials
ESI-6A	Gravel Beaches
ESI-6B	Exposed Riprap
ESI-7	Exposed tidal flats
ESI-8	Sheltered rocky shores and coastal structures
ESI-9	Sheltered tidal flats
ESI-10A	Mangroves
ESI-10B	Other estuarine wetlands

The study focused on the inland areas. The inland areas have not been adequately covered in oil contingency planning in Nigeria. Even in the OPTS ESI mapping protocols developed in 2001, only 4 inland cover categories - Strand vegetation, farmlands, bush fallow/fallow, palm bush and rainfed deltaic forests were classified. Large percent of oil spill in the Nigerian environment also occur in inland areas which suggest greater possibility for disruption of livelihoods and decimation of ecosystem. It is therefore important that the inland area is given priority consideration in sensitivity modeling.

The Forcados area experiences intense oil activity with several oil fields including Escravos beach, Forcados Yokri, Odidi, Ajuju, and Warri located onshore. Several oil pipelines that criss-cross the ecosystems and human settlements connect several oil wells and flow stations to the Forcados and Escravos oil terminals that together has a nominal storage capacity of about 9.6million barrels (FGN, 2000).

The major criteria considered in determining the degree of sensitivity to oil spill and other stress factors of an ecological category include its biological productivity, oil/ecology interaction and ease of cleanup, and social, economic and human weight (importance). The classes and ranking for the indices was developed to incorporate the delicate ecosystems, creeks, water bodies and human settlements. It also incorporated the vulnerability (likely exposure) of the main fauna found within each ecosystems and their impact on rural livelihood.

Characterization of sites was done through survey procedure using satellite imageries. Actual classification to rank ecologies according to sensitivity to spill was done by combining remote sensing data with reviewed information on the reaction of ecology with oil including degree of likely injury and ease of clean up and socio-economic impact. Map algebra was employed within multi-criteria analysis to combine and analyze the variables. A final sensitivity class range from 1 to 10 in increasing order of sensitivity was generated.

RESULTS AND DISCUSSION

The Ecosystem

Fig. 2 shows the statistics for the respective ecosystem categories and Fig. 3 shows the spatial pattern of the different categories. Waterbodies which consists of rivers, creeks, inlets and canals have the highest coverage of 111,097 ha which represents about 25% of the area. This underscores the nature of the terrain and the importance of fluvial influence on the ecosystems, livelihoods, and cultural life of indigenous communities. Mangroves accounted for 89,217ha or 20% which indicate the delicate nature of the area and its disposition to possible degradation resulting from oil and hazardous chemical spill.

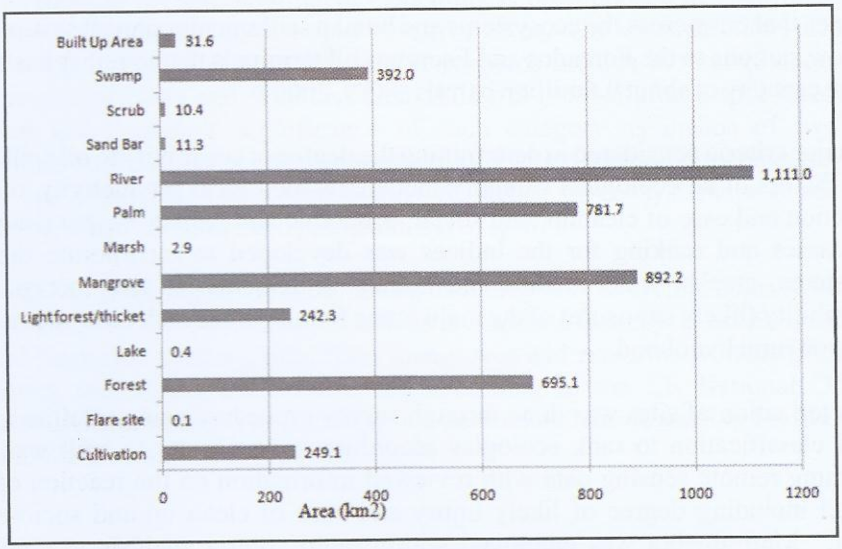

Fig. 2: Area extents of ecological classes

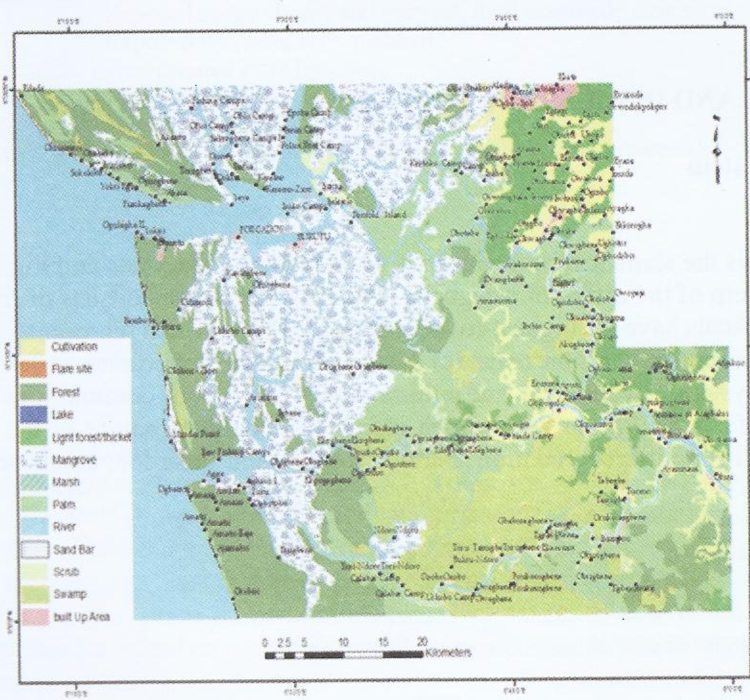

Fig 3: Spatial pattern of ecological baseline of lower Forcados area

Heavy forests which covered about 16% are found at the ocean fringe sheltering the mangrove complexes from the ocean. Raffia palm complexes covered about 18% and are found mainly along the creeks in inland areas. A total of 71built-up areas which account for 3,198ha or 0.71% of the area was mapped. The mapped built-up lands also include oil facilities including flow-stations, terminals, loading and production platforms.

Human communities are also strategically located along the river courses and creeks intersections. This is because the waterbodies provide the only means of transportation between the communities. Some other fishing camps and smaller settlement are also found in the mangrove interior where they depend on collecting mangrove dwelling fauna species to survive.

Cultivation accounts for only 25,000ha but are very strategically located. Cultivation is done in upland areas with some consolidated arable soils and around the river channels especially in dry season when the water recedes. The exposed alluvial during the period is utilized for farming pending the rainy season when the water level rises again. They therefore supplement both the livelihood and food requirements of residents

Sensitivity Index Analysis

The criteria for delineating the ecosystems into sensitivity categories basically include the biological productivity of an ecosystem category (including ability to support various flora and fauna), the oil-ecology interaction including absorption, flow and retention, ease of cleanup, importance of inhabiting fauna species to human livelihood, socio-economic and human weight including the frequency of human interaction with the category. All these were scored and weighted using multi-criteria analysis and rank was assigned according to the final score. The mangrove ecosystems has the highest score and ranked 10, while concreted installations and production facilities has the lowest score and ranked 1. Table 3 shows the sensitivity rankings and Fig. 4 shows the resulting Sensitivity map for the area.

Table 3: The classification scheme adopted for the study

Class	Description
SA-1	Concreted installations and transportation amenities
SA-2	Sand bares/sand beaches
SA-3	Scrubs
SA-4	Thickets
SA-5	Cultivated Lands
SA-6	Built up areas
SA-7	Swamp, Palm and Forests
SA-8	Rivers and Creeks
SA-9	Marshes
SA-10	Mangroves

**SA means sensitivity area*

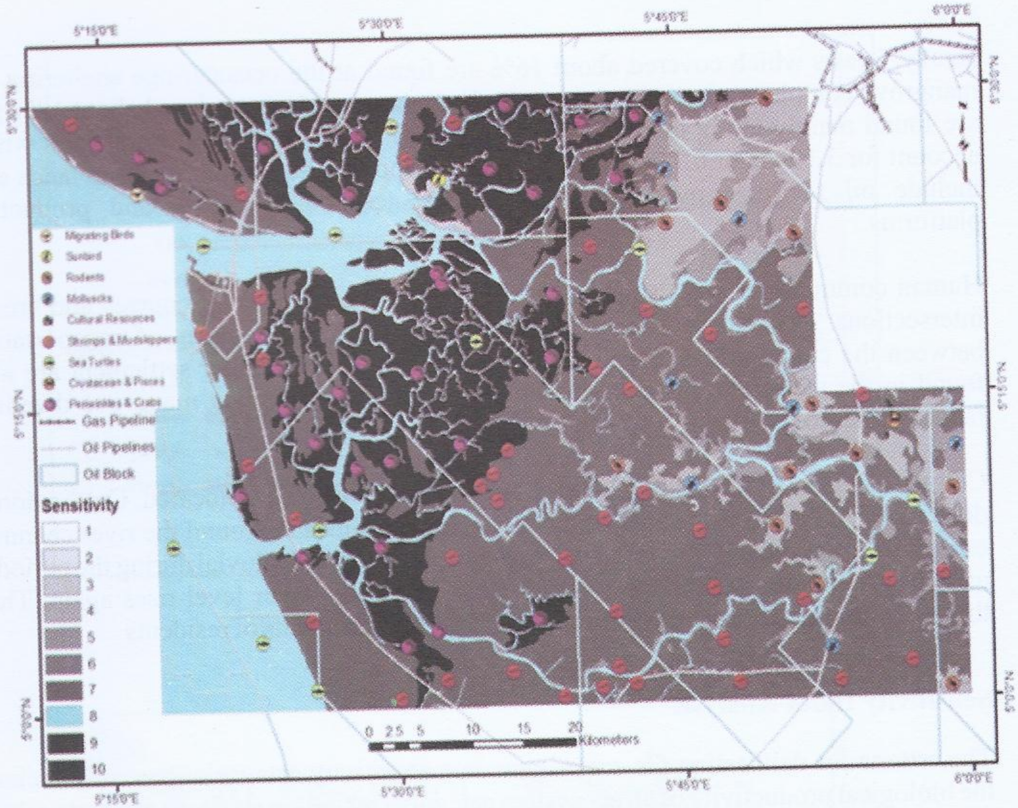

Fig. 4: Generated Sensitivity Area map of lower Forcados area

The descriptions of basic characteristics and sensitivities and ease of cleanup for the different classes are summarized as follow:

SA-10 (Mangroves)

Mangroves are the most productive of the flora ecosystem in the area. They serve as abode for species of crabs, shrimp, periwinkles, mudskippers and crustacean which support rural livelihood. Resident fish species include mudskippers, eleotrids, gobbies and eels while tidal fishes such as tilapia, mullet, young bonga and adult topminnows are common visitors. Mangroves grow below tidal level on sediments of mixed mud, organic litter and peat. Dominant species include *rhizophora* (red mangrove) and *avicenia* (white mangrove). Other plants of *phoenix* and *nypa* palms grow in less saline axis.

Their productivity makes the ecosystem a most fragile to oil and hazardous chemicals spillage. The associated stilt roots serve as barriers against spill flow on adjoining creeks thereby causing accumulation, sticks to roots, and deposit on creek bends and front banks. Deep penetration into substrate also occurs. It is an ecosystem of immense use to riverine communities. It supports rural livelihood by providing breeding space for fauna species and also used extensively for boat and shelter construction among the riverine dwellers. Mangrove also shelters communities from violent ocean waves and tide and reduces flooding of adjoining lands. Biological damage to the ecosystem by spillage is lethal. Beyond death of the mangrove trees, several inhabiting fauna also risk being destroyed. Mangrove regeneration rate is slow. Feasible clean up operations include absorbents and booms at the mangrove fringes to prevent spread of spill.

SA-9 (Marshes)

Marshes are short vegetation of grasses and shrubs around tidal flats and sediments of soft mud and organic litters in areas of high salinity and mangrove fringes. They also serve as habitat to a variety and species of crustacean and fishes especially mudskippers, and mullets, crabs and snapping shrimps. Spills over a long time have the potential to seep into surrounding aquifers. They also indirectly support rural livelihoods. The potential biological damages include loss of associated fauna and flora species and inhibited microbial activities. They are slow in regeneration and re-colonization. Usually, cleanup operation is through bio-remediation.

SA-8(Rivers and Creeks)

The rivers and creeks range from very large rivers such as Forcados and Ramos to tiny rivulets. They are intricately interwoven and serve as access route for marine traffic and pipeline right-of-ways (ROWs). The creeks are the only access route between settlements in over 95% of the area. Their biological productivity rests on the fact that they are the main habitats for fishes, aquatic birds and reptiles such as turtles, hippopotamus and manatees some of which are migratory species in search of breeding space.

They are of appreciable socio-economic and cultural importance to the communities which depend entirely on them for domestic water consumption, fishing, transportation and religious activities. Virtually every community is located by banks for easy accessibility. Behaviorally, spilled oil floats on water because it is lighter. Under normal environmental conditions, oil forms slicks on water and cuts off atmosphere-water interaction. This can lead to loss of aquatic fauna and flora. It can also impair birds and contaminate domestic water. Feasible cleanup approaches include use of sorbent booms and skimmers, chemical sprays and foams.

SA-7 (Swamp, Palm and Forests)

These are riparian freshwater vegetation. Swamps separate pure mangrove stands from freshwater forests and palms. They predominate on flat terrains with inter tidal fine-grained sediment of silt, clay and poorly decomposed organic matters. Tropical forests are found on upper stretches of beaches and well-drained interior soils while palms are found more on brown clayey soils and fairly higher water table interiors.

Swamps accommodate sparse rooted macrophytes such as aquatic lily (*crinum natans),* pure stands of crew pine pandanus, some raffia palms and mixed species of *cleistopholis, symphonia* and *mitragyna* (abura). The tropical forest ecosystem has varieties of economic lumber trees such as Iroko, Abura, Walnut and Gmelina. Oil palms (*elaesis guineesis*) dominate the palm forests and Raffia palms (*raffia spp*) dominate in areas of high water table. Swamp fauna include intertidal fish species such as electric fish, burrowing fish, species of shrimps, mudskippers, crabs and invertebrates including insects. In the palm forests are varieties of mammals including rodents, monkeys and squirrels as well as birds. At the ground level are mollusks such as giant tropical land snails (*achatina*), reptiles especially snakes, some burrowing animals and biologically important insects.

Spilled oil floats on fringing floating vegetation mats of swamp forest and also accumulate in surrounding small inlets. Recovery is severely limited while impacts tend to be long term as bottom sediments are heavily soaked usually and surface flow is limited because poor driving current. Often, the affected soils are buried which increases the potential for ground water contamination. In some other instances, potential damage includes death of slow moving aquatic macrophytes, crustacean and some fish species. Clean-up strategies include natural recovery, vacuum sorbents, low pressure flushing, booms and skimmers around wetland fringes.

SA-6 (Built up Areas)

The main towns are Warri, Burutu, Okwagbe and Forcados located either on shoreline or beach ridges. Many of the villages and fishing camps are found around sandy beaches, shorelines, and close to oil exploration sites. The settlements are inhabited by both indigenous communities and ethnic nationalities whose identity, culture, religions need be preserved. Spilled oil has direct and indirect impacts on these communities. They also have some unusually sensitive area including drinking water and cultural resources (Jensen *et al.*, 998). Some of them are at high risk of oil-related accidents and hazards from pipelines. The major containment strategy is preventive. Hence, adequate precautions should be designed for town-based production infrastructure such as refineries to prevent spills, while smaller settlements can be 'lured' away from oil infrastructures through creation of "development centers."

SA-5 (Cultivated Lands)

Cultivated lands are restricted to upland areas with consolidated beach ridges, peat and silt sediments along river banks. Ecosystem productivity is limited to planted crops such as pineapple, bananas and vegetables amongst others. The fauna include species of insects, mollusks and other invertebrates. The lands supplement other livelihoods such as fishing. Large spillage normally forms shinning slippery soil surface layer over cultivated areas. This leads to pollution of subsurface fresh water, wilting of crops and mortality of insects, burrowing animals, and mollusks. The feasible clean up strategies include deployment of skimmers and booms at banks to prevent flow, removal of polluted debris, re-vegetation and natural flora regeneration.

SA-4 (Thickets)
Thickets are mixture of tall grasses and short trees in uplands and well drained areas around major settlements. Its biological resources include flora of different trees species, scattered palms, elephant grasses and creepers. The fauna are small mammals especially rodents, squirrels, giant rats and a variety of birds. Spilled oil will flow over some distance before reaching thickets. Hence, the sensitivity especially from offshore locations is minimal. Otherwise it behaves as SA-5. The potential biological damages are on associated fauna and flora mortality. They regenerate naturally.

SA-3(Scrubs)
Scrubs are found in well-drained upland soils of old beach ridges and ferruginous soil materials. They are associated with limited flora varieties of shrubs, grasses and some creepers; and fauna species of rodents and sunbirds. Spilled oil will not flow over a long distance on scrubs but will form slivery surface and infiltrate the top soil. The potential biological risk is limited to plants and animals including soil micro fauna mortality. Clean up strategy is through bioremediation and natural regrowth.

SA-2 (Sand bars and Sandy Beaches)
Sand bars and sandy beaches are associated with the ocean and river mouths. They accommodate smaller settlements coastline. Some are usually exposed to high waves and strong currents. Except for few arthropods, land crabs (*cardisoma*) and domestic animals, the biological productivity is otherwise low due to its high salt content and low vegetal cover. Large accumulation of spilled oil would cover a beach face; accumulate on debris and compact sediment to a shallow depth. The biological damage is limited to skin disease on domestic animals and mortality of associated fauna. The clean up strategies is through removal of oil and oily debris.

SA-1 Concreted installations and transportation amenities
These include production platforms, flow stations, tank-farms, jetties, airstrips and artificial embankments. They are devoid of any appreciable ecosystem at risk. They allow rapid flow of spilled oil without percolation. Hence they are of least risks to spills and require only thorough cleaning.

CONCLUSION

This study establishes the ecological characterization of the Forcados area and the likelihood of being impacted by oil exploratory activities based on their respective biological productivity, the oil/ecology interaction, potential biological damage, ease of cleanup and contribution to human survival and livelihood. Losses to oil spills are often total and irreversible in some cases or take a very long time for natural regeneration. Sensitivity area classification is a pro-active response strategy to contain oil spill and minimize impacts on people and natural environment. It provides information to spill managers on incident-ecosystems and possible response strategies ahead of actual spill. The automation advantage of GIS and data access through space technologies makes updating easier and allows direct spatial assessment of ecological and other attributes of the environment as demonstrated by this study before stepping into the field. The lower Forcados area contributes a lot to oil exploration and Federal earning from oil. Cases of disastrous impacts of spills on the natural environment and livelihoods of communities have been rampant for too long in the area. Oil companies and environmental regulatory agencies should step-up contingency planning to respond to oil spill in near real time and with adequate information on the total environment at risk. The present arrangement in which oil spill is left for the oil companies to manage need to be revisited. Federal agencies should be equipped to become on-scene coordinator during spill emergencies. Digital SA maps offer a veritable tool for both oil companies and Federal agencies to protect the environment from deleterious effects of oil exploration

REFERENCES

Agha, G.U, Irrechukwu, D.O, Zagi, M.M (2002): Environmental Impact Assessment and the Nigerian Oil Industry: A Review of Experiences and Learnings. SPE 74074, Society for Petroleum Engineers, Richardson, Texas, USA.

Al Gore (1997): Respect the Land, *Time Magazine*, 150, (17A), November, 1997, Time Inc. Rockefeller Center, N.Y

Anderson, J.R., Hardy, E.E., Roach, J.T., and Witmer, R.E. (1976): A Land use and Land cover Classification System for use with Remote Sensor Data. *Geological Survey Professional Paper 964*, Washington D.C: USGS.

Arms, K (1994): Environmental Science, 2nd Edition, Saunders College Publishing

Conyer, D & Hills, P (1995): An Introduction to Development Planning in Third World Countries. John Wiley & Sons Ltd

Department of Petroleum Resources (1991): Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, DPR, Lagos

Dublin-Green, C. O., Awobamise, A., Ajao E. A. (1997): Large Marine Ecosystem Project for the Gulf of Guinea- Coastal Profile of Nigeria, GEF/UNIDO, 1997

Eedy, Wilson (1995): The Use of GIS in Environmental Assessment, *Impact Assessment*, 13, 199-206.

Fasona, M (2009): Global Environmental Change: People, oil and ecosystems – a case study. LAP Academic Publishers, Saarbrucken, Germany

Fasona M.J (2003): The Challenge of Spatial Data Infrastructure for Effective Planning in Developing Countries – The Nigeria Example, Proceedings of the *21st International Cartographic Conference,* Durban, South Africa, 10-16 August, http://cartography.tuwien.ac.at/ica/documents/ICC_proceedings

Fasona, M and Anosike, V (2002): GIS based assessment of the potential benefits of dredging the River Niger: A Case study of western Niger Delta, N.O Uluocha and F.

Dada (ed): *Maps and Resource Management*, Nigerian Cartographic Association.

Federal Government of Nigeria (2000): National oil spill Contingency Plan for Nigeria. Retrieved www.Nosdra.org.pdf last accessed 12 September 2011.

Jensen, J.R, Halls, J.N and Michel, J (1998): A systems approach to environmental sensitivity index mapping for oil spill contingency planning and response, *Photogrammetric Engineering and Remote Sensing*, 64 (10) 1003-1014.

Millennium Ecosystems Assessment. (2005): Ecosystems and Human Well-being: Framework for Assessment:
http://www.maweb.org/documents/document.299.aspx.pdf. Accessed 23 October 2009.

Murday, M., *et al* (1988), Atlas of Environmental Sensitivity to spilled oil for Operational Areas of NNPC/GOCON OML 49 including the outer coastline from Molume to Escravos, Benin and Ecsravos River/Creek Complex

Niger Delta Environmental Surveys (1997): Niger Delta Environmental Survey Phase 1 Report Vol.1: Environment and Social-Economic Characteristics, ERML

Nigeria OPTS/NNPC (2001): ESI Mapping Standards and Protocols. OPTS, Nigeria

Nwilo, P.C and Badejo O.T. (ND): Oil spill problem and management in the Niger Delta. www.iosc.org/papers/IOSC2005a432.pdf. Accessed December 5, 2010.

Nwokedi, M (1999) Environmental Sensitivity Index Mapping of Lower Forcados Areas, M.Sc. Thesis (unpublished), University of Lagos

Research Planning Institute (1985): Environmental Baseline Studies for the Establishment of Control Criteria and Standards against Petroleum related Pollution in Nigeria, NNPC (1985).

SEDEC Associates (2008): State of the Nigerian Environment Report. Federal Ministry of Environment/UNDP.

Verburg, P.H., Veldkamp, A., Espaldon, R.L., and Mastura, S.S. (2002): Modeling the spatial dynamics of regional land use: the CLUE-S Model. *Environmental Management*, 30(3), 301-405.

Wright, J.B, Hastings, D.A, Jones, W.B & Williams, H.R (1985): Geology and Mineral Resources of West Africa, George Allen & Unwin, London