CHAPTER THREE

USE OF GIS AND REMOTE SENSING TECHNIQUES FOR ENVIRONMENTAL MONITORING AND EVALUATION OF THE LOWER QUA IBOE RIVER BASIN

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1.0 INTRODUCTION

The lower Qua Iboe River estuary and its adjoining wetlands (basin) has come into national and international focus partly because of its abundant natural resources and therefore its role in the national economy. The Qua Iboe Terminal (QIT) of Mobil Producing Nigeria Unlimited, MPNU (a subsidiary of ExxonMobil) is located here. MPNU is the second largest crude oil producing company in Nigeria and the largest condensate producer in Africa. Other major oil and gas companies that operate within the lower Qua Iboe River estuary and its adjoining wetlands (basin) include Shell Petroleum Development Company (SPDC), Elf Petroleum Nigeria Limited (EPNL) and Addax Oil Company. Some of these Oil Companies operated within this area from the early 60s. Recently, the lower Qua Iboe River estuary and its adjoining wetlands (basin) has become an area of intense human and industrial activities. These intense activities within the area are not without their attendant negative consequences on agricultural land resources and agricultural development in particular and environment in general (Udotong, 1995, 1999).

Due to its size, peculiar terrain, inaccessibility and other factors, it has been difficult to monitor the rate of environmental problems in general and impact of the intense human and industrial activities in the LQIR basin on agricultural land resources degradation and agricultural development in particular. Moreover, evaluation and management of agricultural land resources within the LQIR and its adjoining wetlands (basin) was difficult. Today, there is paucity of data on the rates of these environmental problems and where available, they are not reliable because methods of assessment were empirical and therefore highly subjective.

Some globally accepted methods for evaluation and management of agricultural land resources are the Geographic Information System (GIS) and Satellite Remote sensing techniques. A GIS is software and hardware able to manage and analyze geo-referenced data and attribute data together. Attribute data refers to any type of descriptive or statistical data linked to geographical features. Geo-referenced data is associated with geographic co-ordinates, which give the data some location in space. Data in a GIS are stored as map layers and output is usually in the form of maps or data tables. Similarly, change detection has been successfully achieved using Satellite Remote Sensing. Vegetation cover-change analysis using Satellite sensors like Landsat Thematic Mapper (TM) offer the advantages of wide spatial coverage while providing land cover information. Change detection using Satellite Remote Sensing implies that different states of an object are identified by observation of the object at different dates. This implies the ability to quantify temporal effects by using multitemporal data. The basic idea behind change detection studies is that changes in land cover must result in changes in radiance. This change in radiance must be larger than the change in radiance due to other reasons like (i) differences in atmosphere conditions, (ii) differences in sun angle, and (iii) differences in soil moisture (Singh, 1989).

These techniques, inspite of the enormous advantages over visual observation (empirical) methods were however, not used in the environmental monitoring and evaluation of the LQIR basin. This paper advocates the need for the use of GIS and Remote sensing techniques for the evaluation and management of the agricultural land resources of the lower Qua Iboe River estuary and its adjoining wetlands (basin). The advantages of the use of these techniques are enormous. Most importantly, it is used globally in recent times for evaluation of agricultural land resources and therefore a potent tool for integrated management of River Basins.

2.1 Study Area

The lower Qua Iboe River estuary and its adjoining wetlands (basin) is an extensive coastal area at the extreme south of Akwa Ibom State (Southern Nigeria) with the Qua Iboe River emptying into the Southern Eastern Atlantic Ocean at the Bight of Bonny at Ibeno Village. The entire area lies between 4 °32' and 4°37'N latitude and 7°50' and 8°02'E longitude (Fig. 1.0). The climate is classified as dry and wet season with a mean annual precipitation of 500mm. The Northeast trade winds blow during the dry season from the Sahara with "Harmattan" dominating the months of December and January. The Southeast trade winds blow across the Atlantic Ocean inland, bringing rains during the months of April to December.

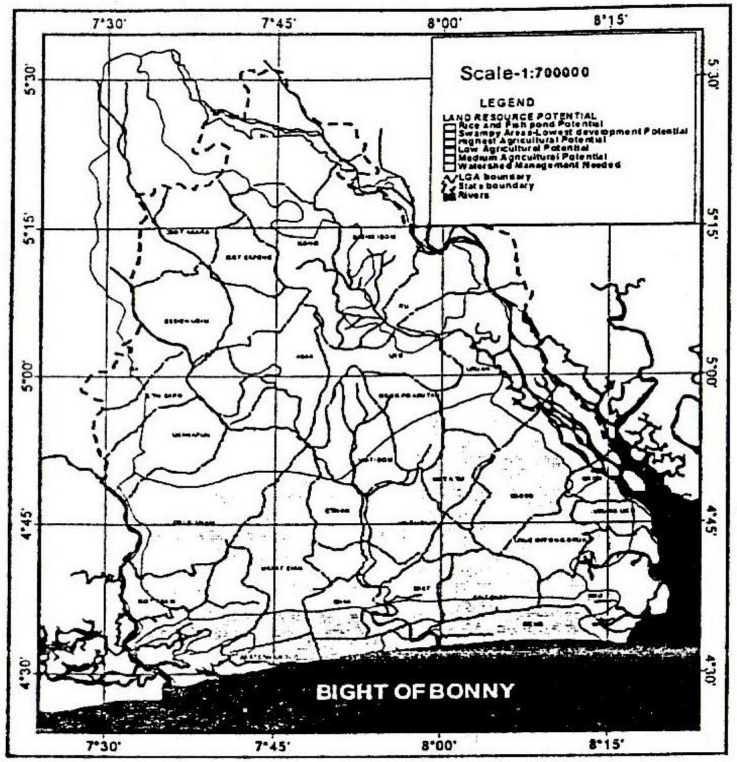

FIG.1 QUA IBOE RIVER BASIN: LAND RESOURCE DEVELOPMENT AREAS; STATE AND LGA BOUNDARIES SUPER-IMPOSED USING GIS

The Qua Iboe River, from where it rises from hills on the outskirt of Umudike (near Amaba Ime) in Abia State to where it empties into the South Eastern Atlantic Ocean at Ibeno in Akwa Ibom State is estimated (from actual measurement from a topographical map) to be approximately 156.60km ((Udotong, 1999; Akpan, 1991). It is one of the major rivers in Akwa Ibom State; infact the State derived its name from the river because of its importance to the residents. It is an important source of water, fish, and livelihood to the people of Akwa Ibom State.

The area was chosen for the study because it is rich in petroleum resources: crude oil and natural gas. Crude oil wells exist both on land and on the continental shelf, with Mobil Producing Nigeria Unlimited, MPNU (the second largest producer of crude oil in Nigeria and the largest producer of condensate in Africa) as the major exploiting company. Other crude oil exploration and production (E&P) companies in the area are Shell Petroleum Development Company (SPDC), Elf, and Ashland. Although the petroleum E&P formation from the offshore production platforms are disposed into the Atlantic ocean, the PPE after oil extraction at the Qua Iboe Terminal is discharged into one of the Qua Iboe River Creeks (Udotong, 1995, 1999). Also, the QIRE was chosen for the study because, like most other tropical rivers, it is still poorly known both in its overall ecology and the effects of petroleum E&P and human activities on it. It has received very little or no scientific attention despite its size and importance. So far there has been no comprehensive study on the river and the present study is the first of such attempt.

2.2 Evaluation of the Environmental Problems of the lower Qua Iboe River estuary and its adjoining wetlands

During the reconnaissance survey of the Qua Iboe River estuary, three major environmental problems were investigated.

(a) Land degradation

Physical examination of the study area for indications/evidences of coastal erosion, flooding and other agents of land degradation was carried out.

(b) Environmental pollution

Biomarkers and other indicators (non-biological markers) for the environmental pollution of the study area were examined. Presence/absence of tar-balls, physical presence of crude oil on water body, faecal materials, indication of waste disposal (e.g. PPE and/or sludge, gas flares, etc) were examined along the lower Qua Iboe River Estuary.

(c) Renewable Resources Degradation

Among the renewable resources considered were the fisheries resources and mangrove ecosystem exploitation. The presence of water hyacinth (*Eichhornia crassipes*) and loss of biodiversity were also examined.

3.0 RESULTS

3.1 Environmental problems of the Lower Qua Iboe River estuary basin.

The following environmental problems have been identified to plague the study area (the lower Qua Iboe River basin), hence posed some serious challenges to sustainable development

(a) Land Resources Degradation

Four major causes of land resource degradation identified were:

(i) Flooding (ii) Erosion (iii) Land subsidence and (iv) Agricultural land degradation.

(i) Flooding

The lower Qua Iboe River Estuary is a wetland lying within 2m above sea level (Ibe and Awosika, 1989). High water levels in the rivers during the rainy seasons flood extensive areas. More severe flooding regimes may disrupt the lives of several thousands of inhabitants of Mkpanak, Upenekang, and other major fishing settlements along the coast of the lower QIRE.

(ii) Erosion

Coastal and riverbank erosion has been identified as one of the major environmental problems affecting land resource degradation along the lower Qua Iboe River Estuary. Similar riverbank and coastal erosion are encountered at different locations along the lower QIRE.

The construction of breakwater jetties at Mkpanak, Upenekang and Eket (UAC beach) also cause coastal recession per year. Tidal erosion occurs at the mouth of the Qua Iboe River as a result of high tides in combination with

waves. A number of fishing settlements are affected, including Iwopom, Okposso 1 and 11, Akata, Ntafre and others. Other factors found to contribute to coastal erosion along the lower QIRE were sand and gravel mining, dredging, reclamation of land, as well as oil, gas and water abstraction and the removal of vegetation (mangroves) (Udotong, 1995, 1999).

Sheet, rill and gully erosion is serious within the floodplain but most serious primarily outside of the flood plain and in farmlands upstream of the Qua Iboe River but the effects are felt also in the mouth. It is caused by rain or surface run-off, particularly in this area where shifting cultivation is practiced, and is especially severe in areas too steep for sustainable cultivation.

(iii) Land subsidence

Land subsidence is a major feature of environmental problem along the lower QIRE. Several factors, including natural geologic processes and hydrocarbon extraction may be the cause of land subsidence along the lower QIRE.

Land subsidence is a possible factor contributing to coastal flooding within the study area. It may also cause coastal erosion from increased wave penetration inland, forest inundation and salt-water intrusion. There is little or no empirical data on the local land subsidence rate.

(iv) Agricultural land degradation

Increasing population due to population growth and a heavy influx of people into the study area because of oil development and increased economic activities, will require either intensive agriculture on existing farms or an expansion of agricultural areas to feed the additional community members. Intensive agriculture on the already degraded agricultural lands lead to declining yields from reduced soil fertility. Declining yields combined with population pressure result in a cycle which forces farmers to expand into increasingly marginal areas that offer even lower returns to labour leading to further expansion (Udotong, 1999).

(b) Renewable Resources Degradation

The two major cases of renewable resources degradation that constitute environmental problems along the lower QIRE were identified as fisheries exploitation and forest degradation.

23

(i) **Fisheries exploitation:**

The preservation of freshwater and brackish swamp and mangrove ecosystems is crucial for the viability of a large coastal and wetland fishery. Although there are no empirical data to show annual catches and values of sustainable harvesting of fish from the lower QIRE, fluctuations in captures, decreasing sizes of fish, and observations from and oral interviews/personal communications with fishermen however give evidences of declining stocks from over-exploitation and habitat degradation.

The most important commercial species from the fresh water environment of the lower Qua Iboe River include tilapias (*Tilapia* spp); Heterobranchus (*Chrysichthuys* spp); Catfishes (e.g *Clarias* spp.) and moonfishes (*Citharinus* spp). The most important marine and brackish water species are croakers (*Psedolithus* spp), bongafish (*Ethmalosa* spp), Herrings (*Sardinella* spp), Catfish (e.g *Arius* spp), Snappers (*Lutjanus* spp.), mullets (*Liza* spp and *Mugil* spp) and shrimps (*Penaeus* spp)

Apart from the exploitation of the above-mentioned finfishes, mollusks and crustaceans harvesting is widespread and is a critical economic activity along the LQIR basin. Periwinkles, clams, oysters, whelk and shrimps are also over-exploited along the LQIR basin.

(ii) **Forest Exploitation**

The rich mangrove forest of the LQIR basin has been found to be exploited. The mangrove plants are cut down for use as fish drying racks, fish traps, cages, and fuel wood. Other important uses are for house and fence construction.

In addition to mangrove exploitation for fuel wood, inhabitants also collect a large variety of non-timber forest products (NTFPs) such as food (crabs, shrimps), honey, medicinal herbs, thatching, dyes and numerous other household products from the mangroves.

(c) **Environmental pollution**

Environmental pollution is one of the major environmental problems affecting the LQIR basin. The major Environmental pollution problems identified to have plagued the LQIR basin are (i) water contamination, (ii) air pollution, and (iii) industrial and domestic wastes disposal.

(i) Water Contamination

Produced water from Qua Iboe Terminal (QIT) is released into the LQIR basin through Douglas Creek. This is the discharge point of the petroleum production effluent and other waste from the QIT. Physical evidences of water contamination along the LQIR basin include presence of crude oil in water bodies, physical presence of debris on the beaches or shoreline after wave actions, human excrement along the beach, presence of tar balls on the water, and abnormalities in the physical properties of the water such as high turbidity as a result of high suspended solids (Udotong, 1995, 1999).

(ii) Air Pollution

A major evidence of air pollution along the LQIR basin is the gas flares at various crude oil production platforms and the gas flare pit at the Qua Iboe Terminal (QIT). These contribute substantial quantities of obnoxious gases into the atmosphere of the LQIR basin.

Also, the intense industrial activities of this area demand increase use of fuels in helicopter, jets, outboard engines and automobiles, by these means, quick anxious working visits and tours to oil platforms and other locations offshore leave ribbons of smoke particulates and obnoxious gases in the atmosphere as physical evidence of air pollution. Another major evidence of air pollution within the study area was the reduced pH (6.1) of rainwater collected at Ibeno (Mkpanak) beach on Feb. 29, 1997, and subsequent reports of corrosion of metal roofs in the area (Udotong, 1995, 1999).

(iii) Industrial and Domestic wastes Disposal

The output of the separation of crude oil and water from the production stream is a heavy oily sludge. The disposal of this oily sludge presents a serious problem. This hazardous sludge is either dumped into the creek or by the shoreline of the LQIR basin.

The turbidity and siltation caused by preliminary E & P activities is one of the most important short-term environmental problems along the LQIR basin. However, long term effect of industrial discharged into the Qua Iboe River includes spent drilling fluids/mud's, drill cuttings and oil well work over fluids.

Although the petroleum industries is by far the largest industrial sub sector in the LQIR basin, household and small industries generate the largest quantities of non-hazardous wastes and are dumped into the river or on the shores which will be washed into the river by tide and wave action (Udotong, 1995, 1999).

(d) Loss of biodiversity

Due to the three environmental problems mentioned above: land resource degradation, renewable resource degradation and environmental pollution, the LQIR basin is seriously threatened with loss of biodiversity. This biodiversity losses range from forest product (timber and non-timber forest products), through mangrove plant species and aquatic resources, to microorganisms. A typical loss of biodiversity is the replacement of usual mangrove plant species (*Rhizophora racemosa*, and *R. mangle*) by Nympa palms (*Nypa fruiticans.).* List of organisms ranging from macro-to microorganisms on the endangered list of the LQIR basin is increasing year in year out (Udotong, 1995, 1999).

4.0 DISCUSSION

The environmental problems of the LQIR basin have been identified in this study and are group into four categories based on the type of resources affected: land resource degradation, renewable resource degradation, environmental pollution, and loss of biodiversity. Though the result obtained in the present study seem to agree with those of other investigators working on defining the environmental development strategy of the Niger Delta (World Bank, 1995) who found that the environmental problem of the Niger Delta could be grouped into four categories, substantial evidence of change detection would have been available if GIS and Satellite Remote sensing techniques were used.

Evidence of coastal erosion abounds along LQIR basin. Studies conducted the Nigerian Institute of Oceanography and Marine Research, NIOMR till date agree with the finding of this study that coastal erosion is a widespread phenomenon along the 800km shoreline/coastline of Nigeria (Ibe and Antia, 1983a, 1983b, Ibe et al, 1985; Ibe 1988). From preliminary measurement during the study period (July 1994 to 1996) and interviews with residents, the annual retreat of the Nigerian shoreline could be put at between 15 and 20 meters. This agrees with the annual retreat of the Nigerian

shoreline of between 20 and 30 meters according to Usoro (1971; 1978) and Ibe (1988), which are some of the highest known in the world.

River bank erosion results in an estimated loss of 400h of land annually (Abam, 1995). With the present trend, about 40% of the current inhabited land in the Niger Delta (the study area inclusive) could be lost within 30yrs. Since riverbanks levees are the most populated areas and are intensively cultivated, riverbank erosion results in the loss of some of the most valuable land in the delta (Ibe and Awosika, 1989). In the present, direct losses from flooding within the study area would include large areas of valuable land, which cannot be cultivated, as well as the destruction of infrastructure and housing. Direct losses (from farm productivity loss as riverbanks are eroded) and indirect losses (from farm decline in fishery productivity because of changes in hydrological conditions) are difficult to estimate, but experience elsewhere within the Niger Delta provides an indication of the potential magnitude of this problem (Moffat and Linden, 1995).

Although agricultural productivity studies were not carried out in the present study, reports of lower yields, the increasingly expanding area under cassava and cocoyam production, the absence of widespread use of agricultural inputs and the expansion of agriculture into marginal areas, all provide evidence that land (resources) degradation is very significant and pervasive within the lower QIRE. According to Moffat and Linden (1995), the degradation of agricultural land has a central roll in causing deforestation and exhausting soil fertility.

Three major environmental problems were identified in this study, to be associated with renewable resources degradation along the lower QIRE. Firstly, fisheries depletion has been reported. This is evidence by the declining annual catch per fisherman (Mr. P. Inyang, Pers. Comm). Also, certain fish stocks are reported to have declined, e.g. sardines, snappers, croakers and mackerels, and average body length of some of the most important commercial fish species has decrease during the last decade (Moffat and Linden, 1995).

A second major environmental problem associated with renewable resources degradation along the study area identified was deforestation

241

and mangrove degradation. Deforestation and mangrove degradation within the study area have not been appreciable; the little is due to urban growth and oil exploitation activities. For instance, since it began operation about 30 years ago, SPDC has removed about 10% of the mangrove forest in Rivers and Bayelsa states (World Bank, 1995). Although the exact proportion of mangrove forest removed in Akwa Ibom State due to crude oil exploitation was not determined in this study, the problem is presumed, to be quite substantial. Mangrove forest degradation is especially problematic because of the very slow generation rates. Seismic lines only a few meters wide that were cut over a decade ago are still visible by air. In addition to the cleared mangroves, a large number of mature *Rhizophora* sp. near flow stations are dead, possibly from oil clogging and suffocating the trees (Moffat and Linden, 1995). Timber resources and especially non-timber forest products (NTFPs) are critical sources of income for the inhabitants of the study area. According to Asthon – Jones and Douglas (1994) the possibility of progressive deforestation and mangrove degradation of the study area with time should not be ignored.

The third major environmental problem associated with renewable resources degradation along the study area was identified to be loss of biodiversity. On a regional basis, Niger Delta (including the study area) being the most extensive and complex lowland forest/aquatic ecosystem in West Africa, its biological diversity is of regional and global importance. A World Bank report (World Bank, 1995) emphasized the importance of Niger Delta as a habitat for a great variety of coastal and estuarine fauna and flora, which lacks any marine or coastal protected area. The Stubbs creek conservation project in Akwa Ibom state is a response to the continued loss of biodiversity within the study area. Two principal threats to biodiversity are habitat destruction, and hunting. Population pressure and agricultural land degradation also exacerbate biodiversity losses as they induce people to extensify agricultural production and emphasize none farming activities, particularly haunting and NTFPs exploitation. Another major threat to biodiversity is the rapid spread of the Nympa palms (*Nypa fruiticans*) was introduced into Calabar in 1906 (RSEPA, 1993) and has expanded slowly,

spreading into the degradable mangrove area from the Cross River estuary to the Bonny estuary (including the study area) over the past 90 years. Considerable environmental concerns over possible negative impacts of *Nypa fruiticans* have been expressed to include mangrove degradation and reduced fishing fields due to the fish spawning habitat degradation (Moffat & Linden, 1995).

In this study, physical evidences of environmental pollution of the study area were identified and categorized into water pollution due to oil spills. Oil may be released to the environment as accidental spills (including spill due to sabotage) or in connection with the separation of oil and water either of installations at the terminal (Qua Iboe Terminal). According to the official estimates of the Nigeria National Petroleum Corporation (Moffat and Linden, 1995), a total of approximately 2300m^3 of oil is spilt in 300 separate incidents annually. The number and quantity of recorded spills has not change in the 1990s, although crude oil production today is higher than in the early 1980s (Grevy, 1995). This may be either as a result of improved crude oil spill containment measure by the oil industries or a deliberate underestimation to exonerate themselves. Infact some are reported as mystery spills" like the Akata/Ntafre mystery spill of 1993 within the study area. However, Moffat and Linden (1995) reported that as the oil companies frequently under estimate the quantity of oil split and a large number of other spills go unreported, the total volume of split may be 10 times higher than the official figure.

It is worthy of mention that the most recent case of spill within the study area occurred on January 12, 1998. The volume of oil spilt was estimated to be about 40,000 barrels. This is grossly an underestimation. Although oil leaks and spills as well as poor waste management are common around oil installations within the study area, little or no study has been conducted on the impacts of this spills. This report is probably the first documented impact of the crude oil production activities on the lower QIRE. Ekweozor (1989) reviewed the available research on the environmental impact of oil spills in the Niger Delta.

There are enormous advantages of the use of GIS and Satellite Remote Sensing for change detection over the empirical (visual) method. GIS and Satellite Remote Sensing techniques have been available for the last 30 years, but its percolation into the society is limited, despite its enormous potentials.

Many factors restrain this technology transfer, not least local skills and infrastructure. Today, standard personal computers have the capacity to process data for many of the applications addressed at the advent of Satellite imaging devices, technical and staffing constrains are also decreasing.

The environmental problems of the lower Qua Iboe river basin namely, flooding, erosion, deforestation, pollution etc can be more effectively studied with the aid of the GIS and Remote sensing technologies.

Owing to the diversity and inaccessibility of some of the areas, it is advantageous to make use of remote sensing. Remote sensing is the gathering and processing of information about the earth's environment using photographic and related data acquired from an aircraft or satellite (Robinson et. al; 1995). It has been applied to various land management issues especially in the field of agriculture (Adeniyi, 1986; Bronsveld et al, 1994; Ryden, 1997). In these and other resource fields, remote sensing has been used for resource identification/ recognition in terms of location and composition and for resource assessment with regards to quantity, quality, distribution and change. Satellite remote sensing allows a retrospective, synoptic viewing of large regions and so provides the potential for a geographically and temporally detailed assessment of changes in the environment.

The availability of time-sequence satellite images makes it possible to study changes associated with river banks and basins including areas under flood water, erosion, forest cover, cultivation etc. Quite a number of satellites have the potential for identifying and also monitoring different aspects of the environment. Table 1.0 presents the elements that are possible to identify by visual interpretation of the image material.

Table 1. Elements possible to identify by visual interpretation of the image material

IMAGE TYPE	STUDY FEATURE	INTERPRETATION ELEMENTS
Landsat MSS	Physiography	Major land forms, soil characteristics {origin, type, depth]
	Hydrology	Type and density, major reservoirs, major wetlands, major irrigation canals
	Landuse	Agriculture [irrigated, commercial, subsistence], forest areas, bushland, grassland
	Settlements and infrastructure	Major cities, major roads
Landsat TM	Physiography	Major land forms, soil characteristics {origin, type, depth]
	Hydrology	Type and density, reservoirs, wetlands, major river characteristics [sandbars, spits, down cutting], irrigation canals
	Landuse	Agriculture [irrigated, commercial, subsistence], forest areas, bush land, grassland
	Settlements and infrastructure	Major cities, villages, scattered are as major and secondary roads
SPOT	Physiography	Major land forms, soil characteristics {origin, type, depth], major erosion areas
	Hydrology	Type and density, reservoirs, wetlands, major river characteristics [sandbars, spits, down cutting], irrigation canals
	Landuse	Agriculture [irrigated, commercial, subsistence], agricultural practices [terraced, irrigated], forest areas, bushland, grassland

It is obvious from the table above, that, some properties of land and land use can be directly identified on remotely sensed images. Others [non-detectable e.g. soils, geology etc] can be inferred since detectable and non-detectable properties are often interrelated.

243

The use of AVHRR satellite data to monitor vegetation cover is becoming increasingly important. AVHRR has the advantage of being available on approximately daily basis for the whole globe and thus the chances of obtaining cloud free images are much greater than for higher resolution data. The data is also much cheaper per square km. compared with the Landsat TM or SPOT (Martin, 1999).

Beside the well-known advantages of digital image analysis such as cost effectiveness, repetitive coverage, independence of data, expediency in retrieving spectral information, digital image analysis provides a sound basis for enhancing the framework for spatial sampling thereby reducing considerable effort during fieldwork. The procedure comprises image acquisition, image processing, production of maps and associated statistics (Kufogbe et.al; 1999).

The use of the remote sensing technology involves large amount of spatial data management and requires an efficient system to handle such data. GIS provides tools and technologies that are needed to synthesize disparate forms of data about the environment and make meaning out of them and draw useful conclusions. It is a system of computer hardware, software and procedures designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced data for solving complex planning and management problems (Robinson et. al, 1995; Kraak and Ormeling, 1996).

The use of GIS eliminates data integration problems caused by the different geographic units to which different datasets are related. It allows the overlaying of maps with different map units (e.g. agro climate, soil, land use, watershed and district/village maps) and facilitates map integration.

The full benefits of the GIS and remote sensing technologies are obtained when they are used in combination as functional components of integrated information systems. Such systems enable the assessment and comparison of the ecologic, social and economic effects of continuing existing land use and/or introducing improve land uses.

An integrated information system that includes a GIS with remote sensing image processing capabilities, a relational database and modeling techniques is a powerful tool for the evaluation of the sustainability of land use systems. Such an information system makes it possible to:

1. Update the existing land cover and land use information using remote sensing data {present land use information is essential for the evaluation of current sustainability problems]
2. Integrate data that are related to different map units; e.g. terrain and soil data, present land use data and social/economic data of villages can be combined to determine the percentage of the village income obtained by the existing agricultural system on different soil units within the river basin.
3. Predict ecologic and economic consequences of the introduction of alternative land uses in areas with sustainability problems.
4. Present the results of the evaluation in a clear and attractive way
5. Give answers to questions such as:
    - What are the rates of erosion of different tracts of land under existing land use?
    - What area of land is flooded, eroded, under cultivation, polluted, deforested? (Vasile et al, 1989; Kimerling, 1995; Robinson et. al, 1995; Kraak & Ormeling, 1996; Ayeni, 1997).

In the field of land evaluation, remote sensing is frequently associated with GIS technologies. The former provides information on actual land use/ cover, while the latter enables an integrated evaluation of land potentialities to be made. This integration of GIS and remote sensing methods is widely recognized as mutually beneficial

5.0 CONCLUSION

In this article, we have presented the environmental problems of the LQIR basin obtained through visual observation (empirical) methods. The results may be considered subjective due to inherent errors associated with this method of data gathering. In our opinion, use of GIS and Satellite Remote sensing would be the method of choice for reliable data gathering on change detection within the LQIR basin.

REFERENCES

Abam, T. K. S (1995).State of Erosion and Flooding in the Niger Delta. Report prepared for World Bank, Washington DC.

Adeniyi, P. O. (1986) "the role of Remote Sensing in land use planning" Application of Remote Sensing Techniques in Nigeria Musisi Nkambwe [Ed] Nigerian Society of Remote Sensing Publication, number 2. Pp.19 – 31.

Akpan, A. W. (1991): A Limnological Survey of Qua Iboe River in south-eastern Nigerian. Ph.D thesis, University of Jos, Nigeria. 447pp

Asthon-Jones, N. J. and Douglas, O. N. (1994). Baseline Ecological Survey of the Niger Delta. A report to Statoil (Nig.) Ltd., Lagos.

Ayeni, O. O. (1997) "Digital Mapping and GIS Education in Developing Countries" Cartography and Geographical Information Systems for Sustainable Development ed. Isi A. Ikhuoria. Benin City: Nigerian Cartographic Association. Pp. 25 – 36.

Bronsveld, k, et al (1994) "Improving land evaluation and land use planning" ITC Journal Number 4. pp. 359 –365.

Ekweozor, I. K. E. (1989). A Review of the effects of oil pollution in a West African Environments Discovery and Innovation 1: 27-37.

Grevy, P. (1995). The Nigeria Delta, Nigeria: Draft Pollution assessment Study., Submitted to the World Bank. Carl Bro. International. Glosrtup, Denmark.

Ibe, A. C. (1988). A Collective Response to Coastline Erosion Hazards. In: Environmental Issues and Management in Nigerian Development (Sada, P. O. and Odemerbo, F. O, eds). Evans Brothers (Nigeria Publishers) LTD, Ibadan. Pp252-262.

Ibe, A. C. and Antia, E. E. (1983a). Preliminary Assessment of the Impact of Erosion along the Nigerian Shoreline. Paper presented at the International Conference on Desertification, Erosion and Flooding in Africa at the Rivers State Univ of Sc. & Technology, PH. 3-6. May, 1983.

Ibe, A. C. and Antia, E.E. (1983b). Preliminary Assessment of the Impact of Erosion along, the Nigerian Shoreline. NIOMR Technical paper No. 13, 19p.

Ibe, A. C. and Awosika, L. F. (1989). National Assessment and Effects of Sea level rise on the Nigerian Coastal Zone. Report to the University of Maryland. 31pp.

Ibe, A. C., Awosika, L. F., Ihenye, A. E., Ibe C. E., Okonya, E. C. and Tiamiyu, A. I. (1985). Coastal Erosion in Awoye and Molume, Ondo State. A report for Gulf Oil Company Nigeria Ltd. 123p.

Kimerling, A. J. (1995) "Geographical Information Systems and Cartography" Proceedings of conference on Digital) Map Production Lines held at Istanbul, Turkey April 11 – 15, 10994. pp. 35 – 47.

Kraak, M.J. & Ormeling, F.J. (1996) Cartography: Visualization of Spatial Data Essex: Addison Wesley Longman Ltd. Pp132-171.

Kufogbe, S. K et.al (1999) " Remote Sensing Evaluation of Urban Encroachment on the Sakumo Coastal Wetland in the Accra-Tema Metropolitan area in Ghana" Geoinformation Technology Applications for Resource and Environmental Management in Africa (Peter O. Adeniyi, ed). African Association of Remote Sensing of the Environment [AARSE].

Martin, S. M et.al (1999) " towards Regional and Global Vegetation Cover Mapping: Application of Low Spatial Resolution Satellite Data in Vegetation Mapping Over Fragmented Landscapes" Geoinformation Technology Applications for Resource and Environmental Management in Africa (Peter O. Adeniyi, ed). African Association of Remote Sensing of the Environment [AARSE].

2

Moffat, D. and Linden, O. (1995) Perception and Reality: Assessing Priorities for sustainable Development in the Niger River Delta, Ambio 24(7-8): 527-538.

Robinson, A. H et. Al (1995) Elements of Cartography New York: John Wiley

Ryden, A (1997) "Approaches to practical remote sensing for environmental studies: Experiences from a case study in Swaziland and southern Mozambique" ITC Journal Number 2. pp. 136-145.

Singh, A. (1989). Digital change detection techniques using remotely-sensed data. Int. J. Remote Sens. 10, 989-1003.

Udotong, I. R. (1995) Petroleum Exploration and Production (E&P) – waste stream management in the Nigerian Oil Industry. Journal of Science, Engineering & Technology 2(2): 201 – 217.

Udotong, I. R. (1999) Environmental Monitoring and effect of Petroleum Production Effluent on some biota of the Lower Qua Iboe River Estuary. Ph.D Thesis. Rivers State University of Science & Technology, Nkpolu, Port Harcourt, Nigeria, 295 + xxv pp

Usoro, E. J. (1971). Recent rates of shoreline retreat at Victoria beach, Lagos. Nig Geog. J. 14(1): 49-58.

Usoro, E. J. (1978). Coastal Development in Lagos Area. Ph. D Thesis. University of Ibadan.

Vasile, C. et al (1989) "The Development and State of the Art of GIS in Romania" International Journal of Geographical Information Systems. Vol. 3, Number 2. pp. 185 – 190.

World Bank (1995). Defining and Environmental Development Strategy for the Niger Delta. Report No. 14266-UNI to West Central Africa Department, World Bank, Washington, D.C.

2