ENVIRONMENTAL IMPACT ASSESSMENT OF LOWER NIGER RIVER (FORCADOS RIVER SEGMENT) DREDGING ON SOUTH WESTERN NIGER DELTA USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM (G1S) TECHNIQUES.

PRESENTED BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, FOR THE AWARD OF MASTERS OF TECHNOLOGY (M.TECH) IN REMOTE SENSING, DEPARTMENT OF GEOGRAPHY.

ABSTRACT

This research is concerned with assessing and predicting the likely environmental impacts of the proposed dredging of the lower Niger river around the lower segment of the Forcados river on the South-Western flank (Forcados area) of the Niger Delta using Remote sensing and Geographic information system (GIS) techniques. The study area covering about 3589.14km2 of Warri South-West, part of Warri North, Burutu, Bomadi, Ughelli South, part of Ughelli North, Uvwie, Udu, and Patani local government areas of Delta state consists of built-up areas, lakes, rivers/creeks, marsh, scrub, palm, vegetation (forest) and sandbar/ beach as the major ecological classes that will be seriously impacted. The actual dredging and straightening of river, movement and disposal of dredge spoil, anticipated movement of vessels on the river and the attendant influx of people will have severe environmental and social impact such as coastal and river bank erosion, oil pollution, ecosystems destruction, loss of farmlands, social tension and settlements and fishing camps displacement. Benefits such as growth of towns, economic and industrial prospects will be enhanced as a result of the opening up of the study area to the rest of the country. Mitigation strategies such as identification and consultation with the affected communities to discuss expectations, adaptation, livelihood loss, compensation, relocation etc; best method of dredge spoil disposal; shoreline hydrology and geology evaluation to protect shoreline etc were discussed. Alternative route with minimal impact was suggested through Forcados-Nikorogha creek- Ramos river entrance. Alternative projects were suggested in the construction of access roads linking the settlements and with the outside settlements after considering the economical and environmental sustainability of the project. Extension of North-South East rail line to the

study area is also a very good alternative project after considering its sustainability both economically and environmentally.

DEDICATION

This research study is dedicated to the ALMIGHTY GOD who in HIS infinite mercy granted me the Grace to accomplish this arduous task; and the entire people of the Niger –Delta area.

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CERTIFICATION

This is to certify that this research work was done under my supervision by Mr. Abbas. I. Innocent (M.Tech/SSSE/99/2000/291).

15-01-2001

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Date

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CHAPTER ONE

1.1 GENERAL BACKGROUND:

A new paradigm that is fast gaining ascendancy the world over is the concept of sustainable development. A brainchild of Gro Harlem Brundtland's World commission on Environment and Development (WCED, 1987). A sustainable use of the natural resources calls for appropriate methods to collect baseline information, to assess environmental impacts and to monitor environmental change.

Adeniyi et al (1992) define a resource as connotes any part of the environment that has a present (or is known to have a future) potential of being developed to satisfy human wants. Every portion of the environment is a neutral stuff until is known to be useful to man. Thus, resources are direct expression of the cultural capability otherwise called the level of technology of a people.

Development can be described as a form of economic process that could result in increase in social and economic well-being (quality of life) of a people. Relating sustainable development to water resources development Oyebande (1998) states that:

- development must not damage or destroy the basic life support systems (air, water, soil biological systems etc)
- development must be economically sustainable to provide a continuous flow of goods and services derived from water and associated land resources.
- It required sustainable social systems at international, national, local and family levels to ensure equitable distribution of the benefit of the goods and services produced and of sustainable life support systems.

The whole life support systems- air, water, soil, fauna, flora, in short, all biophysical and ecological constituent of nature, are useful to man. The actual exploitation or use of a resource during the transformation of neutral stuff into a commodity or service to serve human needs and aspiration is called resource development (Mitchell, 1989).

Water is a resource most vital to man. It is the life-blood of the earth and it is critical to the continued existence (sustainability) of life on earth. Water is useful to man in domestic (urban and rural) water use (irrigation), navigation, tourism and recreation, hydropower generation, waster disposal and management etc. For all these uses of water to be well coordinated, water resources development planning is required. Water resources development involves taking inventory of the actual and potential water resources that are available and balance it with current and future needs and demands for water in the different water required sectors. Water resources development thus involves taking conscious decisions about the use of water resources in coordinated fashion in order to maintain optimal and sustainable use of water resources.

Resource developments are often accompanied by externalities. These deleterious effects, which may be very heavy at the initial stage, may taper off on the long (in some cases) or may remain permanently with the resource exploitation and therefore put the overall benefit-cots analysis in a serious questionable equilibrium. Hence, in resource development (water resources development inclusive), it is required that the overall or aggregate effect of the proposed development on the biophysical basic life support constituents (air, water, soil, biodiversity, wildlife etc) as well as socio-lifestyle, aesthetics, perception, cultural heritage, security etc) be put into consideration in the benefit-cost analysis. However, prior to the recent past, experience had shown that those who have much to gain and loose in resource development (the people) are often excluded in the profit and loss calculation when embarking upon a project.

Environmental impact Assessment (EIA) according to Mitchell, (1989) represents a legislative/ policy based concern for possible positive or negative, short or long term effects on our total environment attributable to proposed or existing projects, programs or policies of a public or private origin. EIA is a process, based on current scientific knowledge, used to predict the environmental consequences of a proposed action, project or programme and to provide decision makers with systematic information presented in such a way that the impacts, as well as mitigating needs, can be assessed in temporal and spatial perspectives (UNEP, 1994; Stromquist and Tatham 1992); EIA focus on the agenda of a resources proposed with regards to impacts upon natural economic efficiency, income redistribution, preservation and aesthetics, political equity and above all, environmental equilibrium and control.

Remote Sensing represents the science and art of obtaining information from a distance object or phenomenon through the use of electromagnetic energy. Campbell (1988) defines Remote Sensing as the science of deriving information about the earth's land and water areas from images acquired at a distance. It usually relies upon measurement of electromagnetic energy reflected or emitted from the features of interest. Sabins, (1987) defines Remote Sensing technology as a technique for collecting information about a target from a distance, which means that the collecting device is mounted on some sort of platform, commonly an aircraft or a satellite. In recent years, environmental remote sensing has emerged as a strong discipline that provides data and techniques that allow us to detect, analyze and classify the natural and human environments in order to evolve better management and planning options. The strength [illegible] of Remote Sensing in EIA studies lies in its ability to provide current and up-to-date data on biophysical and cultural resources. Such data are highly important in impact studies if they are to actually refer to the ground situation as at the time of carrying out a project.

A Geographic Information System (GIS) has been described as a computer-based system for solving spatial problem. It consists of hardware, software, man and data, which interact for a common good to solve spatially referenced problems. Eedy (1995) described

GIS as consisting of spatial database management analysis and display of large multidisciplinary data set. GIS is especially amenable to environmental impact prediction because it has all attributes required for effective and efficient prediction of impacts as well as capability for data management to assess mitigation measures after the project has been decommissioned. Areas where GIS is especially useful include data management and display, data analysis (import, interchange and overlay of attributes on map, site impact predictions, and wide area prediction both in depth and area. It is also amenable to studying cumulative effects and environmental audits for analysis of future projects, trends analysis (long-term impact predictions on real time) data set for mathematical modelling as well as for habitat and aesthetic analysis. Thus, GIS is the only system that can provide a holistic approach to the study of total environmental issues, which still make visible the different processes, or interrelationships that exist within the different biophysical components.

A holistic approach to sustainable environment demands that environmental problems be assessed and tackled from environmental viewpoints and challenges. This equally implies that in environmental decision-making, there is the need to consider the whole value of ecosystem (physical, biological and social components) as well as all those to whom the ecosystems are of values. Only then can a sustainable environmental development be said to have been manifested.

1.2 STATEMENT OF THE PROBLEM

Every development has an impact on the environment. However, while some of these impacts may be readily discernable and remedied, others may not be so obvious at the time of embarking on the project and may take considerable length of time before they become manifested. While some of the impacts can affect physical resources such as surface and groundwater, air, beach and coastal waters, land resources; other impacts can be on biological resources including aquatic and terrestrial biodiversity and wildlife; and yet others, economic resources/human values as they directly affect the people- Their infrastructures, transportation, quality of life, local economy, livelihood, public health, population and ethnic patterns etc.

Jordan et al (1993) describes the use waterways as having the least adverse impact on the environment. It is most advantageous for carrying goods, uses least energy per ton, most economical over long distances and also has the capacity for national and international exchanges. They however noted that hydraulic designs/ activities for waterways could have effect on groundwater elevations and could also induce changes of fauna and flora near rivers. Hence, this research basically focus on integration of planning of water related land resources or coordinating the planning of the flow resources with that of the landscape element (Falkenmark 1983). Thus, the research question is an inquiry into what will be the impacts (positive or negative) of the lower Niger River dredging on the land and land related resources in the Southwestern of the Niger-Delta areas.

1.3 AIM AND OBJECTIVES

Environmental awareness is growing now in every society. There is no justification for a project development unless a substantial degree of minimal interference with the natural environment and socioeconomic, cultural and aesthetics aspects and view point of the expected beneficiaries of the project is adequately guaranteed. Mitchell (1989) submits that we must know much more about what occurs after the bulldozers have withdrawn. However, environmental challenges required that not only do we need to know about the post project but about what happens to the socioeconomic cultural life of people, land resources, water resources, flora, fauna, land etc at the on set of the project and also during the construction stage.

The aim of this research is to conduct an environmental inquiry and assessment (especially as regards land and land related resources) in the South Western area of the Niger Delta to the proposed dredging of lower Niger River. The specific objectives are:

- To establish the baseline ecology and land use and cover conditions of the area that could be affected by the planned dredging.
- To provide guidelines for identifying all activities both during and after the dredging that elicit negative impacts on the environment.
- To identify the probable positive impacts on social economics well being of other inhabitant of this area.
- To predict the probable effects of the proposed dredging on the water and land related resources of the area and
- To identify alternatives as well as develop control strategies to mitigate and ameliorate significant impacts.

1.4 RATIONALE FOR THE STUDY

The planned dredging of the lower Niger, like any project of such magnitude and significance has indeed generated lots of debate. Protagonists of the project have enumerated lots of benefits derivable from the project. Chief among these advantages is the linking of the northern part of Nigeria with poorly accessible southern interior of the Niger delta, which is expected to generate lots of internal trade and exchange benefits. Opponents of the project (mainly environmental groups and NGOS such as NEST, CERACE) argued that the project would cause lots of changes in ecosystem balance in the environment around the Niger River. They also hypothesized that the huge cost neither makes it viable nor sustainable as an economic proposition. However, the Federal Environmental Protection Agency (FEPA) which is the watch dog for environment in the country has requested for a comprehensive EIA for the project; and the EIA is presently under preparation.

This study apart from fulfilling an academic endeavour and contribution to knowledge, serve as a micro study in a localized environment, which aims at predicting impacts of the expected lower Niger River dredging on the southwestern Niger delta. This study is equally very relevant considering the delicate ecosystem of this area.

1.5 THE STUDY AREA

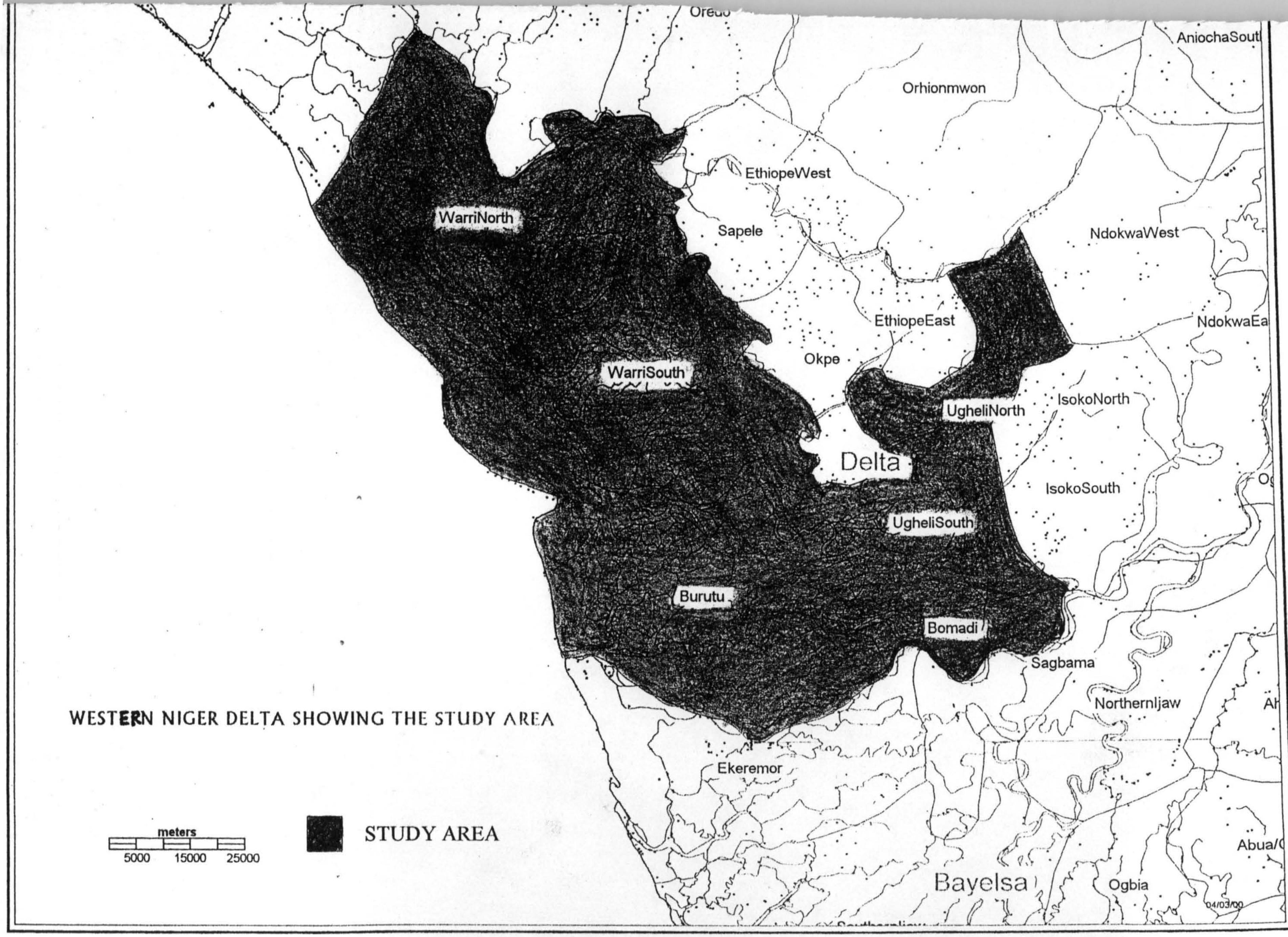
The area being adopted for this study is located approximately between longitudes 5^0E and 6^0E and latitudes 5^0N and $5^0$30'N. The area includes all those along the Forcados river from about 30km from its bifurcation from the Niger river at Ofani to the mouth of the Forcados River at Sea. It therefore covers the following local governments- Warri south West, part of Warri North, Burutu, Bomadi, and Ughelli south, part of Ughelli North, Uvwie Udu and Patami all in Delta State. In total it covers an area of about 3589km^2

1.1.1 PHYSICAL CHARACTERISTICS

RELIEF AND DRAINAGE

One major physical feature that has influenced all other physical and biological constituents of this area is the drainage. The area consists of intricately woven network of rivers, creeks, rivulets, inlets and canals. The Forcados and Escravos and Ramos rivers, which are part of the twenty-two entrances of the Niger into the Atlantic, are the major rivers around the study area. All others, creeks, rivers and canals discharge into these major rivers. A major tributary to the Forcados River is the Warri river. The Warri River is of high significance because the Forcados River is navigable by medium-sized ship from mouth up to Warri, Koko and Sapele river ports through the Warri River.

Though relief data on the area and on the Niger-Delta as a whole are hard to come by, more so when none of the 77 maps covering the Niger-Delta is contoured, estimates however put the relief at between less than 0m to about 8-10m above seas level. Most of the areas are low-lying and consist of tidal flats. Most settlements are located on the relatively higher



WESTERN NIGER DELTA SHOWING THE STUDY AREA

SOURCE: AUTHOR

areas near the riverbanks. Tidal information on the Forcados river shows 1.402m, 1.128, 0.152m, 0.823m and 0.427m for means high-water spring (MHWS), mean high-water neap (MHWN) mean low-water spring (MLWS), mean low-water neap (MLWN) and mean-mean seal level (MMSL) respectively (Dublin- Green et al, 1997).

GEOLOGY

The geology belongs to the extensive recent quaternary sedimentary deposits that have undergone metamorphosis over time. They are therefore rich in organic deposit minerals such as crude oil and bitumen.

CLIMATE

The area is located within the tropical coastal mangrove swamp of Nigeria. Mean annual precipitation is about 2768mm, mean number of rainy days of between 160-180, average mean annual temperature is above 27^0C, mean relative humidity is between 70-80% and the net radiation is about 65kcal/$cm^{-2}yr^{-1}$ (National Atlas, 1978).

The area experiences typical equatorial double maximum rainfall with peaks at July and September. Rainfall is experienced all year round though its duration, intensity and frequency are function of season and months of the year.

Humidity is uniformly high all year round with daily average mean of 121.25mm.

Temperature and Insolation:

The study area experiences a mean annual temperature of about 27.8^0C, mean daily temperature of 26.68^0C, mean daily minimum temperature of 22.46^0C, and mean daily maximum temperature of 31.04^0C. The mean annual hour of sunshine calculated between 1901-1970 (70 years) for this study area is 1537. The lowest mean daily hour of bright sunshine is recorded between July and September (at the peak of rainy season) while the highest mean daily sunshine hour occurs between November and February while the lowest are recorded between July and October for mean daily maximum temperature and between

December and February for mean daily minimum temperature. The Net radiation of the area is one of the lowest in the country.

VEGETATION AND SOIL

The area falls in the tropical mangrove forest zone of Nigeria where rainfall is all year round. The vegetation consists mainly of mangrove, palm, swamp, marsh, infact mangrove and swamp forest dominates. Farmlands and cultivation are found along the riverbanks in the areas where soils are of the hydromorphic type.

The soil consists mostly of alluvia floodplain and hydromorphic ferrasols.

HUMAN SETTING

ADMINISTRATION

The study area consists of the following local governments: Warri south-west, part of Warri North, Burutu, Bomadi, Ughelli south, part of Ughelli North, Uvwie, Udu and Patani. The combined population of this area according to the 1991 census figure is 908,562 with total land area of 8421.87km^2. This indicates an average population density of 107 persons per square km.

L.G.A	POPULATION	AREA (sqkm)	DENSITY
BOMADI	108494	377.72	287.23
BURUTU	167648	2007.18	83.52
UGHELLI NORTH(1)**	139748	766.41	182.34
UGHELLI SOUTH	166029	750.92	221.10
WARRI NORTH	90893	3875.11	23.46
WARRI SOUTH(2)**	235750	644.53	365.77
TOTAL	908562	8421.87	107.88

(1)** - include PATANI

(2)** - include Warri South West, Uvwie Udu

Source: NPC (1994)

THE PEOPLE

The major inhabitants of this area are Ijaws, Urhobos and Itsekiris. They are mainly fishermen and peasant farmers. Their occupations have indeed being reinforced by the physio-climatic and edaphic characteristics of the area. Farms and cultivation areas are mainly along the river channels while fishing is done on the rivers, canals, creeks and rivulets that criss-crossed the landscape. Most small settlements and isolated fishing steads are found in the mangrove swamp interior while major settlements are located (along the river banks) in areas where the soil, geology and drainage are relatively favourable. In most parts of the study area, rivers, creeks, canals and inlets form the major accessibility route. Hence, the area is poorly connected to the hinterlands. Roads are virtually unknown and canoes and paddles are the principal means of transport.

1.2 SCOPE OF STUDY

Due to the limitation of time, cost and resources coupled with the fact that this is a partial EIA, aspects about public consultation and opinion sampling, socio-cultural or sociological inquisition will be limited to literatures. Also, ecological examinations will not be to the level of detailed biological physiological investigation of individual species found in the study area. Chemical and laboratory examination of soil and water constituents to test likely impacts will not be embarked upon; land and land related resources will form the core of the analysis.

CHAPTER TWO

LITERATURE REVIEW

Geographers as resource analysts seek to understand the fundamental characteristics of natural resources and the process through which they could be and should be allocated and utilized. This is the core of resource management. Mitchell (1989) defines resource management as a process of decision making whereby resources are allocated over space and time according to the needs, aspirations and decisions of man within the framework of his technological inventiveness, his political and social institutions, his legal and administrative arrangements.

Tolba (1988) identified that water development like any other type of resource development can have both positive and negative impacts. However, in the past, environmental considerations, which are importantly at the receiving end of negative impact of resource development, are rarely given considerations. Hence, the world tends to develop at the expense of the environment. Another dimension is what Head (1988) has described as a situation where too many people place too much demand on too few resources (Water International, pp 194).

Relating this to water resources development, Tolba (1988) posits that the basic answer to how water (and other resources) management should take place is that we must ensure that development of water resources does not contribute to their destruction; the same is true for the rest of the natural resource base on which the long term sustainability of development depends.

Falkenmark (1983), considering holistic planning in the water sector, submits that "there has been a clear tendency during the last decade to broaden water planning from reallocation of water to planning of water and related land resources". Jordan et al (1993) also buttress this when they state that hydraulic engineers today no longer seek to train the river. Rather, they try to work with it to constrain the river only as needed and thereby reduce environmental impacts as well as maintenances cost.

Therivel and Morris (1995) recognized that World commission on Environmental and Development (WCED, 1987) and United Nations Conference on Environment and Development (UNCED, 1992) established objectives to adapt human activities to nature's carrying capacity. They also noted that the European Union (EU) Action Programmes on Environment are concerned that

- Preventive action is better than remedial measures.
- Environmental damage should be rectified at source
- The polluter should pay the costs of measures taken to protect the environment; and
- Environmental policies should form a component of other EU policies

Hence, one sure way of maintaining all these and other issues in development of resources is through the EIA principle.

2.1 ENVIRONMENTAL IMPACT ASSESSMENT

EIA has been defined by Munn (1979) as an activity designed to identify and predict the impact on the biogeochemical environment and on man's health and well being of legislative proposals, policies, programs, projects and operational procedures and to interpret and communicate information about the impact.

Mitchell (1989) opines that EIA represents a legislative or policy based concern for possible positive or negative, short or long term effects on our total environment attributable to proposed or existing projects, programs or policies of a public or private origin. Hence, EIA is a planning tool, a formal study problem used to predict the environmental consequences of a proposed major development project. EIA thus epitomizes the value of holistic approach to studying environmental problems (Mitchell 1989); and a clear example of the emphasis on preventive, holistic, strategic approaches to environmental protection, which acknowledge environmental limits.

Ibe (1989) recognizes that an integrated approach (to environmental management) ensure that all problems at least those known but also those foreseen are put on table at the same time and the linkages established as far as the eye can see before recommending or adopting solutions. Hence, an EIA study agenda of a resource proposal would consider impacts upon natural economic efficiency, income redistribution, preservation and aesthetics, political equity as well as environmental control (Mitchell, 1989).

Various authors have expatiated on what should be the concern of an EIA. A synthesis of Mitchell (1989), Dublin- Green (1997), Morris and Therivel (1995) shows that EIA should be all encompassing. It should consider both the biophysical and socio-cultural environments. Hence, an EIA is designed to concentrate on the problems, conflicts or natural resource constraints that could affect the viability of the project. It examines the impacts of proposed projects on people, homelands, physical and biophysical resources, livelihoods and nearby developments.

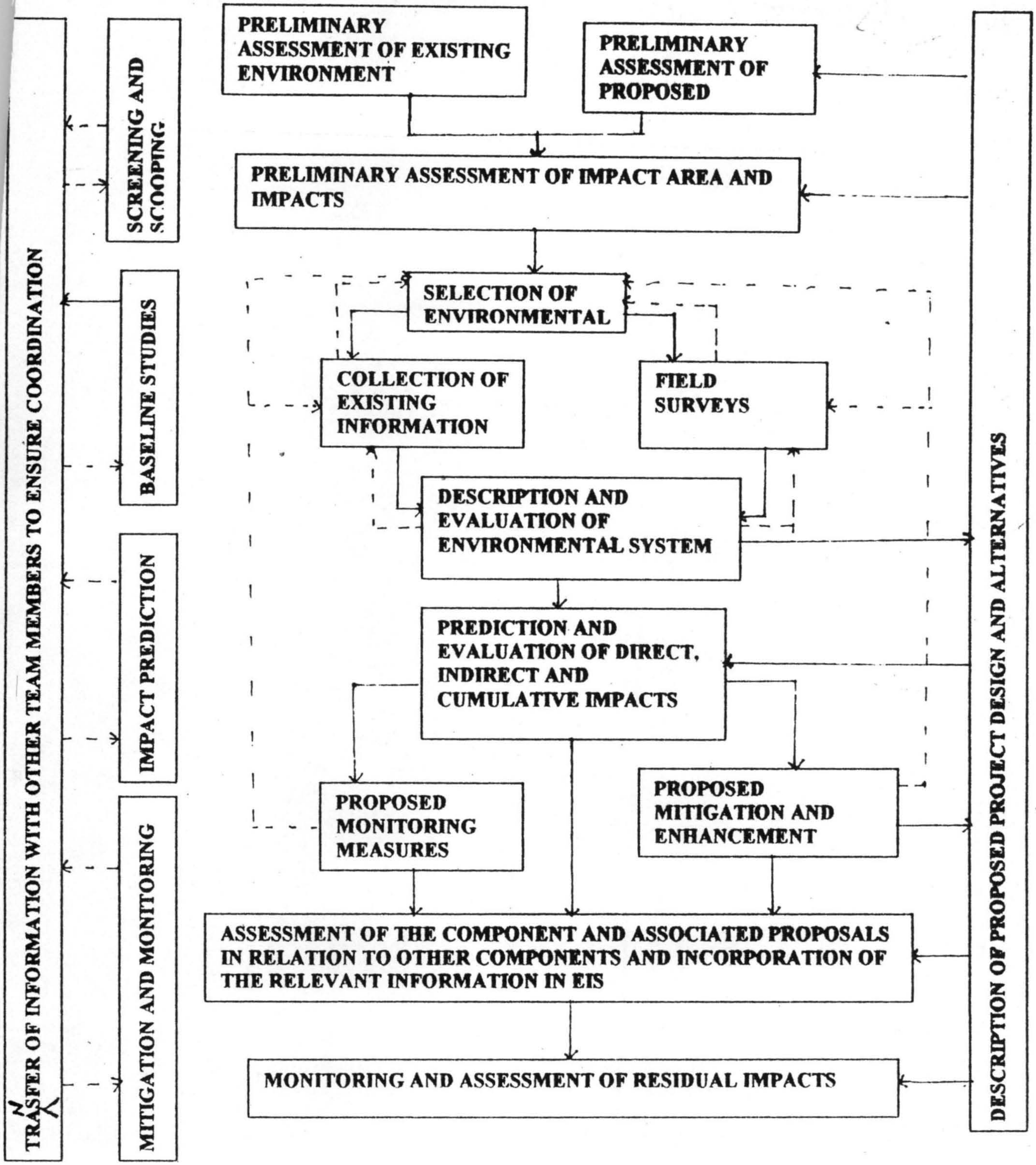
An EIA should consists of analyses of impacts on physical resources, ground and surface water, air, land resources beach and coastal waters, biological resources and aquatic and marine lives, economic development of the people, infrastructure, transportation, quality of life, aesthetics, population and ethnic patterns, perceptions, religions, preferences, public health, local economy, employment, income, and host of other socio-cultural attributes of the inhabitants (Dublin-Green, 1997). It should also describe the proposed action or impact, what changes will occur without intervention, describe alternatives including 'no project' option, describe the nature and magnitude of environmental effects, identify remedial action, identify any positive results that can be developed by direct/indirect spin-off from the project, identify any trade offs necessitated and as well develop a baseline inventory capable of conversion to a monitoring system (Mitchell, 1989).

Therivel and Morris outlined the procedures for carrying out qn EIA as shown in Fig. 2.1.

Omojola (1988) quoting Rau (1980) defines an impact (in EIA) as any alteration of environmental conditions or creation of a new set of environmental conditions adverse/beneficial, caused or induced by the action or set of actions under consideration. Hence, impact simply refers to change in sets of conditions physical, natural, human etc.

Therivel and Morris (1995) have therefore divided these changes or impacts into three direct, indirect and cumulative. Direct impacts are first order and are caused by projects at the same time at the same place (localized). Indirect impacts are second order and they affect the environmental component under consideration as knock-on effects between sub-components or through other components. Cumulative impacts are sum of projects impacts when added to those past, present or future projects. They can be additive (individuals), synergistic (interacts to produce stronger impact), or neutralisms/antagonistic (counteracting). (Therivel and Morris, 1995).

Mitchell (1989) basically divided EIA procedure into two-pre-project Analysis and Post-project Analysis. The pre-project Analysis is a stage of collecting, collating and analyzing baseline environmental data on abiotic, biotic and cultural components of the environment with a view to measure or estimate the magnitude of impact on human, material and cultural values; identify both primary and secondary impacts as well as impacts arising from interactions of two or more separate impacts. Pre-project analysis is carried out using either or combination of checklists, over lay, matrices and network methods. Post-project Analysis deals with the analysis of impacts (intended and unintended), which are function of initial social and environmental objectives. It is an analysis of what the environment would



→ Primary Pathways

- - → Interactive Pathways and feedback loops

Fig 2.1: Procedures in the assessment of an environmental component of an EIA
Source : Riki Therival & Peter Morris (1995)

have been without the project and separating those changes that are due to or attributable to natural and cultural processes (which are project independent) and those that are due to the project; and also examine legislative and administrative structures to determine liability/responsibility and constraints on actions.

Hence, we should know what happens after the bulldozers have withdrawn because heightened historical-temporal perspective in environmental research can only be obtained by monitoring a project throughout its lifetime. This is important because several studies have shown that unintended impacts have in most cases outweighed the intended impacts.

EIA in Nigeria is a recent development. Prior to 1992, it was business as usual. However, the Nigerian National Policy on Environment (1989) aims at ensuring sustainable development based on proper management of the environment in order to meet the needs of the present and future generation. The National Policy on Environment (NPE) was a precursor of the international workshop on the goals and guidelines of the National Environmental Policy for Nigeria held between September 12-16 1988. The historical climax was however reached with the promulgation of EIA decree 86 of 1992. The decree requires EIA for development in nineteen vital sectors. These include Agriculture, Agroforestry, food processing, manufacturing, Mining, Quarrying, Land reclamation, Dams, Drainage, Irrigation, Fisheries and Aquaculture, Petroleum and Petrochemicals infrastructures and installations, (roads, airports, harbours, seaports, housing, transportation, railway), Electric Power generation and transmission, forestry and plantation, Domestic water supply, sanitation, Tourism and Recreation development. The list has since been reviewed as deemed necessary. Therefore, an environmental non-challancy has indeed given way to that of articulate goals and aspirations, for environmental sustainability in Nigeria.

2.2 REMOTE SENSING AS A TOOL

Remote Sensing serves as a tool for environmental resources (biotic, abiotic and cultural) assessment and monitoring. Remote Sensing has some fundamental advantages that make it a veritable tool in environmental monitoring and management and impact studies. These have been listed by Barret and Curtis (1976) to include:

- A capacity for recording more permanently detected patterns.
- Play back facility at different speeds
- Opportunity for automatic (Objective) analysis of observations to minimize personal peculiarities of observers.
- Means of enhancing images to reveal or highlighted selected phenomena

To these can be added:

- The synoptic views advantages offered by raised platforms.
- Ability to record data on otherwise inaccessible areas.
- Ability to produce accurate data on large areas at desired time intervals and at relatively lower cost compared to the cost that would be incurred through ground survey methods.
- Ability to record images in multispectral fashion at different stages, scale and spatial resolutions.
- Remote sensing data also posses high geometric precision / detail, consistency, cost effectiveness and adaptation to highly difficult terrain.

All these combine to make Remote Sensing a veritable tool for obtaining baseline information of an area for establishing baseline conditions of an area at the pre-project analysis stage, as well as monitoring changes in the environmental conditions of such after the project has been de-commissioned. This was recognized by Linden (1997) in his classical article: A World Awakens (Times November 1997). He wrote, "Another crucial shift in thinking came courtesy of space programs. Earth bound mortals now have a new perspective from which to interpret their obligations to the biosphere. Lofty images of the home planet, a growing awareness of our power undermine vital systems and concern about pollution and endangered wild lands have combine to make safeguarding natural resources a broadly shared value".

The field of GIS and Remote Sensing has been referred to as the technology of today. Jones (1997) has observed that the largest primary source of digital data for use in GIS is undoubtedly that created by Remote Sensing technology on board of satellites and other aircrafts. The discipline of Remote Sensing is therefore an important relative of GIS and from some point of view regarded as a sub discipline of GIS. The two (RS and GIS) are thus highly amenable to the study and conduct of environmental impact assessment (EIA).

2.3 GEOGRAPHIC INFORMATION SYSTEM (GIS)

Tomlin (1990) defines a GIS as a configuration of a computer hardware and software specially designed for the acquisition, maintenance and use of cartographic data. Burroughs (1986) sees a GIS as a powerful set of tools for collecting, storing and retrieving at will, transforming and displaying spatial data from the real world.

Intera Tydac Tech Inc (1993)- the producer of SPANS GIS defines a GIS as a rapidly advancing computer based technology where information is organized, analyzed and presented with reference to location. The point of note is that a GIS is a computer-assisted system for the acquisition, storage, analysis and display of geographically and spatially referenced data. The power of a GIS lies in its ability to bring both the spatial attribute data within a common framework to form a united database system; and its ability to compare different entities based on their common geographic occurrence through the overlay process.

GIS is indeed a new application-based field that has lend itself to varieties of human endeavours ranging from business, facility management to environmental management and resource application areas. Eedy (1995) has described GIS as a veritable tool in environmental assessment because it:

- Stores large multidisplinary data sets
- Identify complex interrelationship between environmental characteristics
- Evaluate changes over time
- Can be systematically updated and use for more than one project.
- Serve as a data set for a variety of mathematical models.
- Store and manipulate 3D in addition to 2D files.
- Serve the interests of the general public as well as technical analyst.

An important aspect of an EIA is the public consultations and social surveys. This in addition to the biophysical survey results can be imported into a GIS.

GIS also have the capability for site impact prediction (SIP), wider area prediction (WAP), Cumulative Effect Analysis (CEA), Environmental audits and for generating trend analysis within an environment. Jones (1997) observed that GIS is highly indispensable because of its ability to conduct spatial analysis on input data. Rodrique- Bachiller (1995) commenting on its application in EIA studies submits that it is a veritable tool for generating terrain maps for slope and drainage analysis, land resources information system for land management, soil information system, geoscientific modelling of geological formations, disaster planning related to geographically localized catastrophe monitoring development, contamination and pollution monitoring, flora studies, linking of environmental data base and constructing global database for environmental modelling.

Jones (1997) gave overview of the five categories of functions to be found in GIS and the different representations upon which they operate as exemplified in figure 2.2.

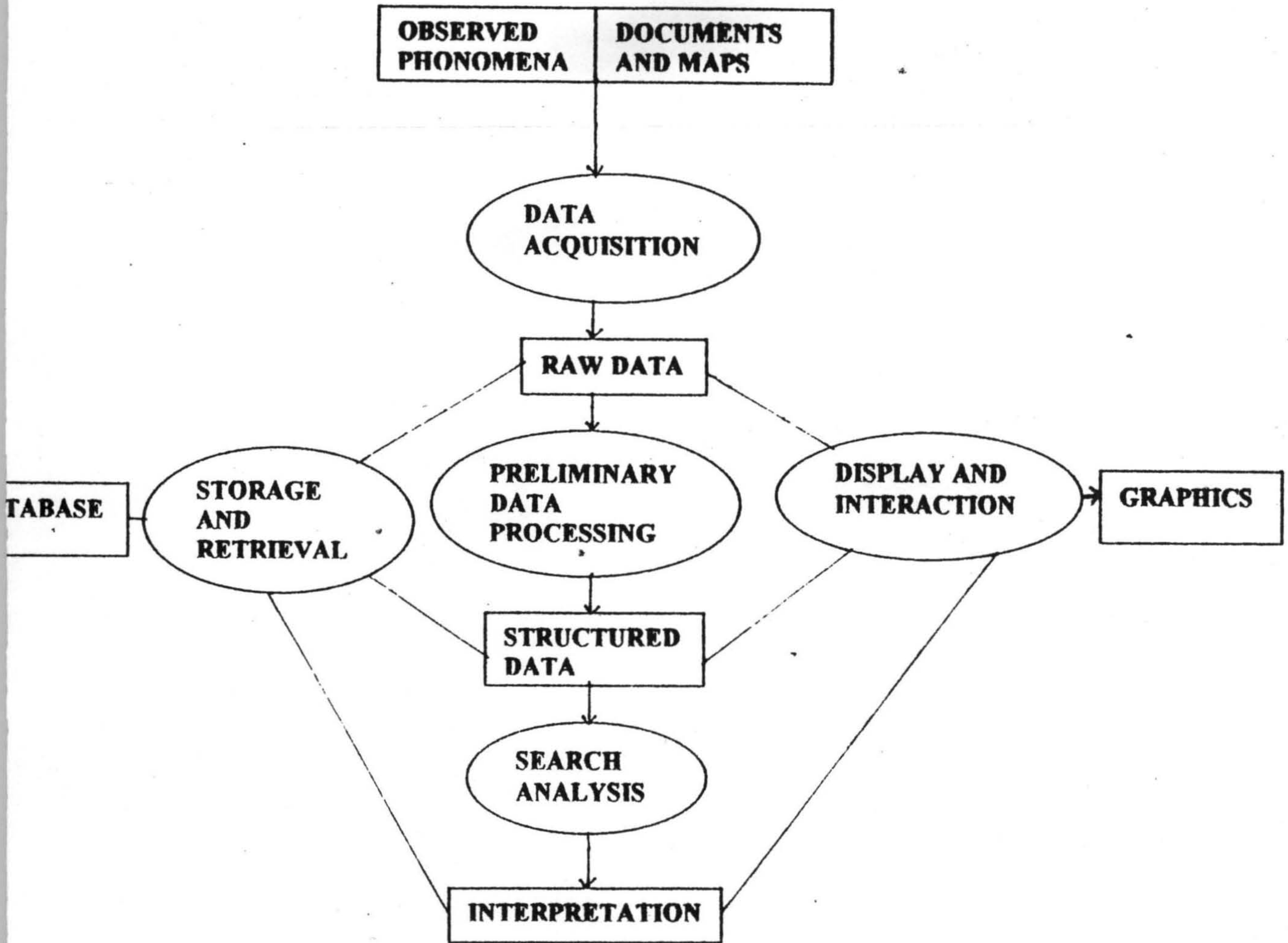


FIG 2.2:Overview of the five categories of functions to be found in GIS (text in ovals) and the different representations (in rectangular boxes) upon which they operate.

Source: Christopher Jones (1997).

2.4 TECHNICAL DETAILS OF THE PROJECT

The project implies the dredging of the lower segment of the Niger River to make it navigable for medium-sized ship of up to about 20000-30000 dead weight. The dredging is expected to be undertaking from Baro in Niger state to Warri in Delta state through the Forcasos-Warri River a total distance of 572km.

Information gathered from various sources including the consultants to the project on EIA shows the following:

- The major client to the project is the Federal Government of Nigeria and it is being sponsored through the Petroleum (special) Trust fund, which is now being wound-up; and the Nigeria inland Waterways Authority is the supervisory Agency.
- The cost of the project is estimated at ₦8.3billion.
- The technical specifications show that the dredging depth is 2.5m and through a median width of 100m.

The consultants have divided the whole length into five segments. These are: Warri-Bifurcation at Ofani, Bifurcation-Onitsha, Onitsha-Idah, Idah-Kotonkarfe; and Kotonkarfe-Baro. Statistics pieced together show the following for the length in kilometer and estimated dredge spoil volume expected from the various segments:

Technical statistics for dredging Table 2.1

Segment	Length (km)	Estimated Dredge Spoil
Warri-Bifurcation	155	3315349
Bifurcation- Onitsha	120	1288514
Onitsha – Idah	115	1162844
Idah-Kotonkarfe	105	2079627
Kotonkarfe- Baro	97	8110520

Total	592	15956854

Depth 2.5m, width 100m

Source: Triple 'E' Associates (1999)

2.4.1 AIMS AND OBJECTIVES OF THE PROPOSED DREDGING

The project aims at carrying out an extensive dredging and river training works on the lower Niger waterway with objective of improving the navigability of this water route. The dredging exercise will extend from the middle parts of the country to the Niger Delta especially areas where there is pronounced water transportation problem. The dredging of the lower Niger will immediately impact the environments of these states; Niger, Kogi, Benue, Anambra, Imo, Delta, Edo, Bayelsa and Rivers, all of which are riparian states of the Niger river.

(Guardian, May 10, 1999) the implementation of the project is expected to achieve the following specific objectives:

- Registering the existence of beneficiaries which include communities, inland water uses and major operators in the lower Niger
- Improving the commercial operations of the lower Niger through continuous studies, research, regular survey, channel patrols and bouyage, water level and discharge measurement.
- Ensuring regular dissemination of information on channel condition for the benefit of navigators.
- Enhancement of maintenance dredging, discharge regulation through reservoirs and free flow river development; and
- Facilitating the sustenance of navigation in riverrine areas through the establishment of a national and eventually regional databanks and operations coordination system.

2.4.2 EXPECTED BENEFITS OF THE PROJECT

Specific benefits of the project include:

- Transportation- a sustainable rivertransport system that would attract cargoes throughout the year and transport them cost-effectively is the best mode of handling large quantities of bulk and irregularly shaped cargoes
- Trade- The use of inland waterways would undoubtedly result in lower total transport cost for movement of low value commodities between the ocean (river) ports of Warri, Port Harcourt and places along the Niger River between Onitsha, Ajaokuta and Lokoja. About one million tons of cargo per annum is expected to be involved, and there is expectation of trade flourish along the Niger in term of commercial and industrial development.
- Improved interactions between people and cultures of the lower Niger Delta, which is expected to lead to better understanding and tolerance.
- Improved levels of livelihood from numerous economic activities that would be generated along the river coast leading to some level of economic self-sufficiency within the host communities.
- Opportunities to develop inland waterways technologies such as navigational aids, terminal operational facilities at the river ports and ferries, small crafts, barges and pontoons.
- Employment opportunities in dockyards, river-ports terminals and repairs yards along the coast.

2.4.2 ADVOCACY FOR THE PROJECT

Glasson (1995) writing on socio-economic impacts and trade-off in EIA opines that "major projects may offer a tempting solution to an areas' problem especially rural economic problems which may have to be offset against more negative impacts such as pressure on local services and social upheaval".

In the same vein, Munn (1979) allude to the pollution of poverty in developing countries where poverty is wide spread and large number of people have no access to adequate food, shelter, health, education, old age security etc. Lack of development may constitute a greater aggregate degradation to life quality than do environmental impacts on development. Hence, the proponents of this project mainly the Federal government have articulated the aims and objectives as well as expected benefits derivable from the project.

2.4.4 OPPONENTS OF THE PROJECT

Expectedly, reactions ranging from credible justifications for oppositions to mere sentiments and rhetoric have come from the opponents of the project which consists mainly of environmental right groups including Nigerian Environmental study and Action Team (NEST) and Centre for Environmental Resources and sustainable Ecosystems (CERASE).

Among the several points raised by these non-governmental environmental groups are:

- Extensive ecological change will accompany dredging of the river, some of which will be detrimental
- Benefits of the river dredging will only be short-lived due to siltation
- Discharge measurements show that the river is only navigable for three months in the year.
- The estimated 16 million-dredge spoil will constitute a nuisance.
- Deepening of the river through dredging will exacerbate the rate of erosion from the tributaries of the lower Niger which run over unconsolidated soil

- There will be depletion in Agriculture along the river banks which will aggravate food security
- There will be displacement of people / communities especially around the Niger delta
- Livelihood, socio-economics and cultural values of peoples especially around the Niger Delta will be seriously affected (Guardian May 1999).

The opponents do not see the economic sense in spending N8.3 billion to dredge the lower Niger especially while the communities that will be mostly affected are loudly and militantly protesting their neglect and deprivation in terms of economic development and provision of infrastructures and amenities. Hence, their consensus of opinion is that rail transport will likely be a better option to the proposed lower Niger dredging.

2.4.2 THE FEPA PERSPECTIVE

The Federal Environmental protection Agency (FEPA) has ordered that a comprehensive EIA be conducted into the project. Within the scope of the EIA, the following issues are to be addressed:

Air, land, soil surface and groundwater quality, flora and fauna composition, human interest including health risk assessment, land and water use, waste management (industrial and human); impacts of the proposed activities to all or some of the above; and relevant legal and administrative framework within which the EIA is based. The scope of work shall include, but not limited to:

- Baseline surveys for the wet and dry seasons
- Laboratory analyses of samples collected during field surveys
- Identifying the sensitivities of the project area, and areas already degraded, if such exist identifying sources of degradation.

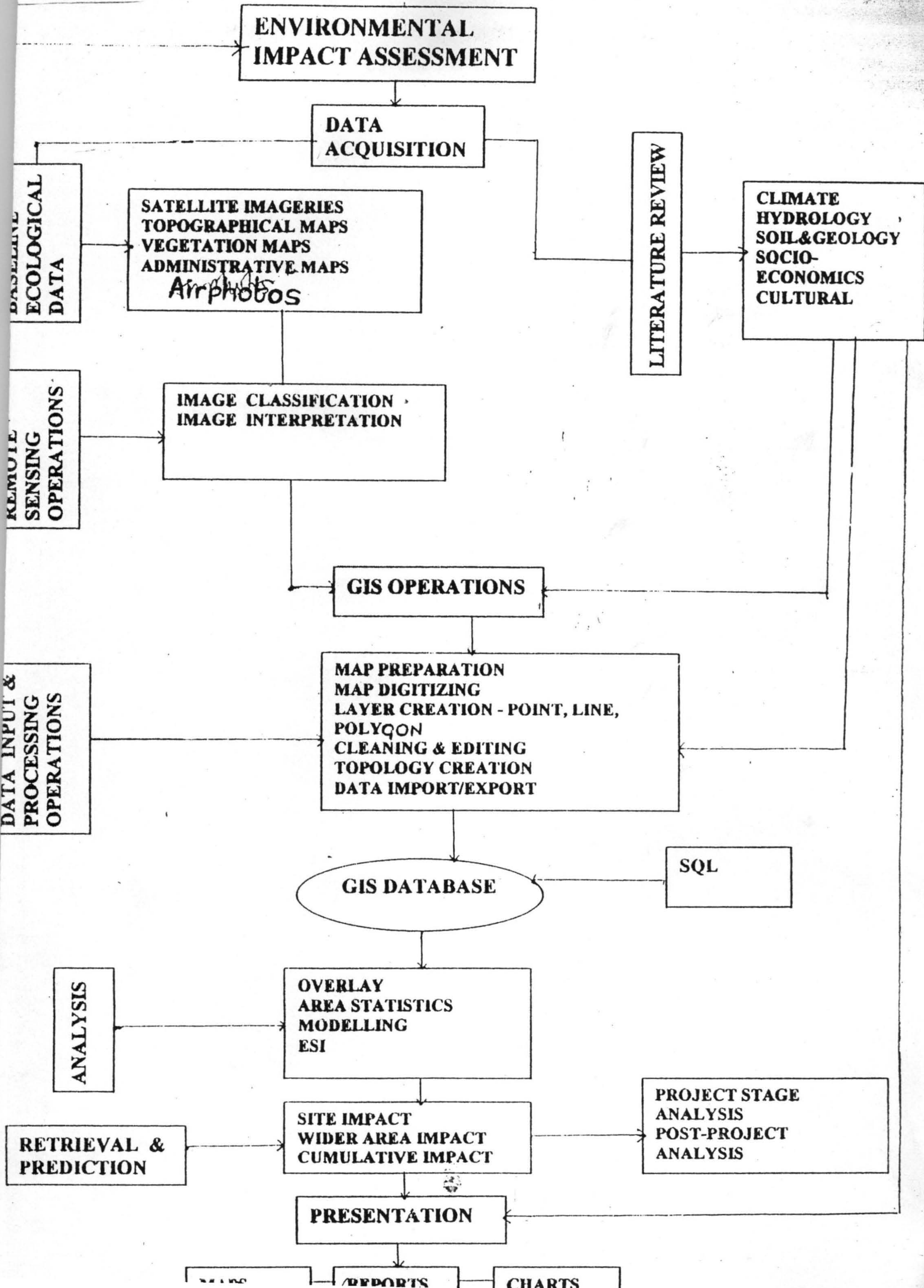
- Prediction of potential environmental management programmes which will include regular monitoring of environmental variables; and
- Preparation of detailed reports presenting clear and concise information on the findings of the EIA study.

In addition to these, FEPA insists that:

- the terms of reference should have contained a brief if the project description including information like length, depth and width of the proposed dredging;
- the EIA studies should provide adequate information on the bank stability measures to be adopted including geomorphologic studies;
- under the section, on waste management measures, adequate information should be provided on the management of dredge spoils expected from this project including dumpsite (if any);
- in the discussion of the project alternatives consideration should be given to all aspects of the environment such as economic, social, political. These discussions should include alternative route, alternative technologies, alternative dredge spoil sites etc;
- in the analysis of impacts of the project, emphasis should be given to significant impacts among the envisaged range of impacts e.g, ground water contamination, impacts on fishing, flooding of farmlands, erosion of banks etc;
- the important socio-economic impacts likely to arise from this project were to be mentioned. The influx of workers into the area is not as important as other anticipated socio-economic impacts such as loss of farmlands, loss of fishing grounds and wet lands, etc;

- all relevant laws that affect the project should be cited and reviewed to show their relevance to the project; and
- all mitigation measures should be presented in the EIA report as statement commitment. (Culled from the Guardian May 10, 1999).

FIG 3.1: RESEARCH PROCEDURE FLOW DIAGRAM



CHAPTER THREE

RESEARCH METHODOLOGY AND PROCEDURE

3.1 DATA AND DATA COLLECTION

An EIA is an extensive study that requires interdisciplinary approach- where objectives, method and procedures are interwoven as opposed to multidisciplinary approach where specialists work independently. Hence, extensive data and information are required on biophysical and socio-economic and cultural resources around the project site.

Data are required on such diverse environmental components as:

Human beings (population)- economic impacts, social impacts, noise, traffic etc.

Fauna and Flora (ecology)- Terrestrial, freshwater and coastal,

Soil – soils and geology

Water- freshwater, groundwater, coastal waters

Air- Air, climate and climatic factors

Material assets- economic, architectural, archaeological, cultural etc.

Landscape and interactions between impacts and landscapes.

However, as stated in chapter one, this study is a partial EIA, hence, because of cost, time and material constraints, it will only dwell on impact of the proposed project as it directly and indirectly affects land and land resources of the study area and therefore not all components of the environment will be considered.

In keeping to the aims and objectives of this academic work, the datasets used for this research includes the following:

- Vegetation and land use /cover maps (for land and biotic resources)
- Drainage networks (water resources)
- Soil and geology

- Social and economic characteristics (settlements, social infrastructures and economic infrastructures).

DATA SOURCES:-

The data sources accessed for this research include the following:

Table 3.1: Sources and characteristics of data used.

S/ N	DATA	YEAR	SCALE RESOLUTION	SOURCES
1.	Literature review	Varied		Extensive
2.	LANDSAT TM, Georectified and processed and Resampled satellite imagery for the following areas; FORCADOS NW, NE AND SE, BURUTU NW, NE, SW and SE	1994	1:50,000, 7 spectral bands 25m X 25m spatial resolution	Lab. For RS&GIS courtesy UNILAG consult
3.	Topographic Maps FORCADOS SHEET N0 317 NW, NE AND SE, BURUTU SHEET N0 318 NW, NE SW AND SE	1963	1:50,000	Federal Surveys
4.	Vegetation and Land use and land cover maps: SHEET N0 NB31-12/1	1977	1:250,000	Federal Min of Agric and rural development Federal Dept of Forest

3.2 PROCEDURE

The research methodology applied for this study is as shown in the flow diagram in figures 3.1

The research combines both Remote Sensing and GIS techniques to generate maps and statistics of areas and biophysical resources likely to be impacted by the proposed dredging activities as well as the likely degree of impact.

3.2.1 REMOTE SENSING ACTIVITIES

Remote Sensing activities involve the acquisition of imagery, generation of land cover classes and interpretation of the satellite imageries using the topographic and vegetation maps as base maps and ancillary data. The use of 1994 land sat TM, geo-rectified and re-sampled (25km X 25km) satellite imagery to generate ecological baseline data is especially vital against the background that:

- The available topographic and vegetation maps were produced around 1963 and 1977 respectively,
- The study area is a highly delicate coastal ecology that is very susceptible to natural forces especially those that relate to land and water interaction zone. It composed of the littoral zone, the mixing zone, the maritime zone and the coastal plains
- Anthropogenic changes are very intense in this areas, as is evident from exploration of oil and gas, pipelines and flow lines that crisscross the whole area; numerous flare sites, forest loss to lumbering and logging; mangrove loss for firewood and canoe building and wide scale diversion of creeks and dredging of canals which could greatly impact on the basin hydrology of the area.

Therefore, against the background of the facts reinforced above, the Land-sat TM produced a higher temporal coverage to determine baseline ecological data.

3.2.2 GIS ACTIVITIES

The result of the Remote Sensing activities goes into GIS as a secondary digital data. The operations performed under the GIS include the following:

- Data input and processing: map preparation, map digitizing, layer creation (point line and polygon); cleaning and editing, topology generation, data import and export. By importing point data from topographical maps and social economic data gathered from interactive review, a GIS database was thus created.
- Analysis operation include: overlay of coverages/layers, statistics generation, modelling environmental sensitivity index mapping.
- Retrieval / impact prediction: using the SQL (Structured Query Language) prediction of impact were made on: Site specific impacts (SSI), wider AREA impact (WAI), Cumulative Effect Impacts (CEI); and post project impact analysis (PPIA) were deduced from the results

3.2.3 LITERATURE REVIEW

Several literatures were reviewed as varied topics relating to environment, EIA, sustainable development, hydrology and water resources development, Remote Sensing and Geographic Information System (GIS). Hydroclimatological data were obtained from the National Atlas of Nigeria (1978) while population and social data were obtained from various publications including that of the National Population Commission (NPC). Literatures also provided theoretical background for the study area especially with regards to soil and geology, hydrology, climate and vegetation; landuse as well as economic, social and cultural behaviour of inhabitants. The literature consulted is shown in the references.

3.3 LIST OF EQUIPMENT AND MATERIALS

Equipment and materials used for the study include:

- Pentium II CPU 6.4 GB HDD 64 RAM
- 14" CTX colour Monitor
- Altek Ao digitizer
- HP 890C / HP 1120C coloured printers
- Software – GIS- PC ARC/INFOR 3.5.1, Map info 4.0; Spreadsheet (Microsoft Excel 7.0 on windows 98).
- Transparent overlay (tracing paper)
- Cartographic Pens (0.4 and 0.5)
- Methylated spirit

Transparent overlay was firmly attached to the surface of the imageries and after the classes and minimum mapping units, (MMU) had been determined, delineation of regions / polygons of features were done on the tracing paper using cartographic pen(0.4), whole label identification was assigned to each delineated polygon. The methylated spirit and cottonwool were used for cleaning wrongly delineated (interpreted) polygons. The transparency was then transferred to the digitizer with geographic coordinates (taking from the corresponding topographical maps) assigned to them. Digitizing was done using PC Arc/Infor vers. 3.5.1 software. The minimum accepted root means square error (RMSE) for each coverage was 0.003. Cleaning and topology creation was also done using PC Arc/Info vers 3.5.1 software. The interchange file *200 together with point data captured from the topographical maps were imported into map info 4.0 where the analyses (area statistics generation, ESI mapping, buffering) and final layout and design of the maps were done.

3.4 PROBLEMS ENCOUNTERED

The major problems were in the areas of data collection and in equipment and facilities. Scanty information was available on soil and geology of the area. Hence soil and geology data were obtained by the inferences made on the vegetal cover on satellite imageries.

Furthermore, because of fund and time limitations, extensive public opinion survey into the socio-cultural and economic characteristics of the inhabitants were not possible. Hence, great reliance was placed on literature review and archival data. Lastly, having access to hardware and software facilities has been difficult. However, thanks to the management of the Laboratory for remote sensing and Geographic information system, University of Lagos for giving me the opportunity to make use of the laboratory.

CHAPTER FOUR

PREDICTION, ANALYSIS AND PRESENTATION OF IMPACTS

4.1 INTRODUCTION

The area under investigation in all respects falls into the category that can be described as coastal wetland.

Dugan P.J. (1990) quoting the Ramsar convention, defines wetland as areas of marsh, fen, peatland or water whether natural or artificial, permanent or temporary, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6m.

Pernetta and Milliman (1995) also described coastal zone as extending from the coastal plains to the outer edge of the continental shelves, approximately matching the regions that has been alternatively flooded and exposed during the sea-level fluctuation or the late quaternary period.

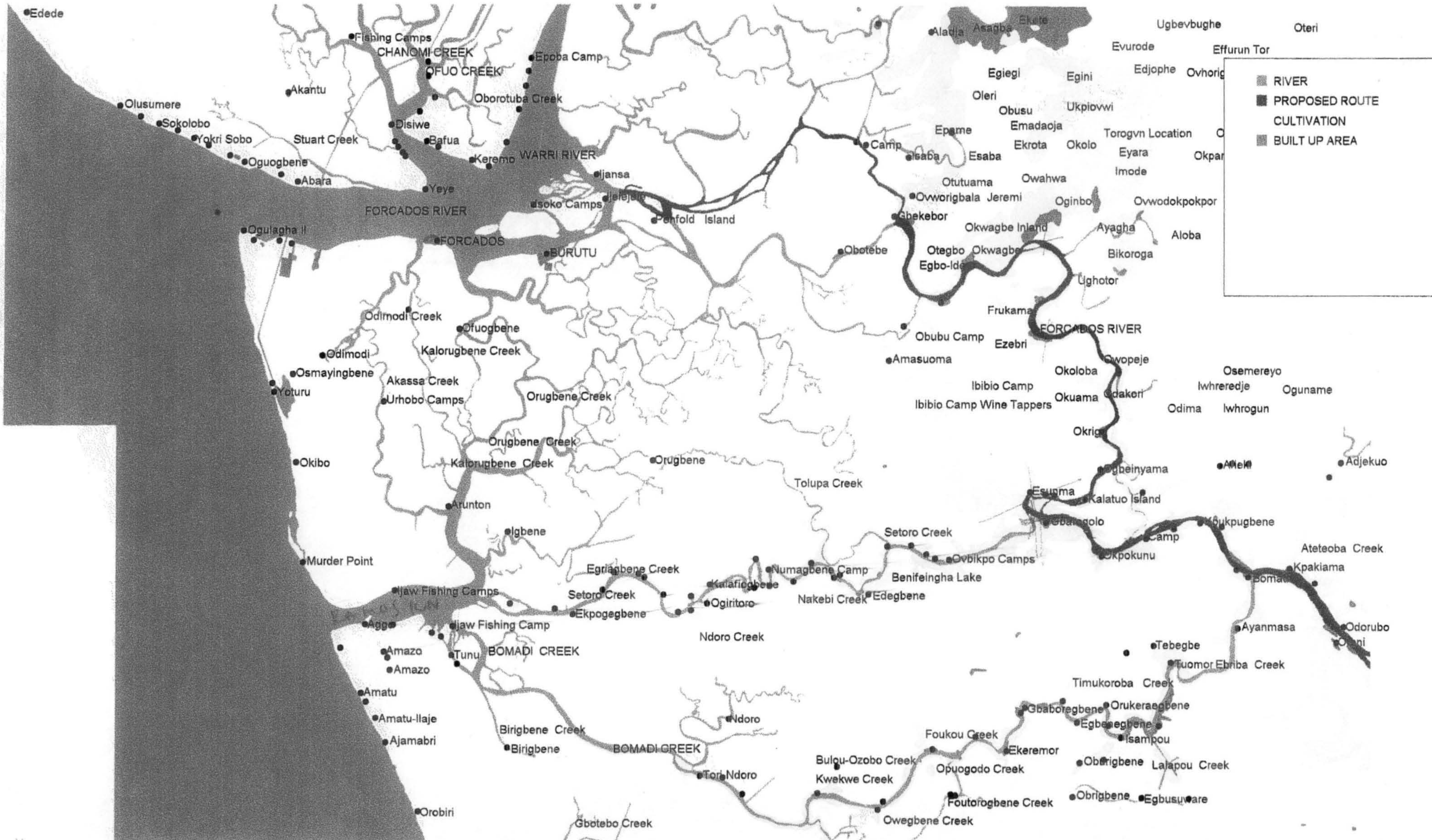
This assessment covers an area of about 3589.14km^2. It covers an area of Forcados river beginning from the town of Ofani about 33km from the bifurcation of the River Niger into the Forcadso river. The total length of the forcados river from the starting (Ofani) to Burutu town is about 107km while the distance from the forcados river going through the Odube creek linking the Warri river in the upper part to Warri town is only 15km.

The Forcados river thus provides the only route or artery for linking the Atlantic coast around the study area. The extent from Atlantic coast via Forcados town through the Warri river up to Warri has been dredged in the past. This accounts for the navigability of this stretch up to Warri port by medium-sized ships.

As shown in map 4.1 (Drainage, Cultivation and built-up areas of the study area), Forcados river bifurcates at Bomadi town one branch flowing North-West ward as the main Forcados river and the other branch flows south-westward into Bomadi creek. Furthermore, at Gbarogalo, the Forcados river also further bifurcates: the main Forcados still flowing

MAP 4.1

DRAINAGE, CLTIVATION AND BUILT UP AREAS OF THE STUDY AREA



North-westward; while the other flows westward and discharges into the Atlantic through the Setoro/Nikorogha creek/Ramos river estuary which is joined by the Bomadi creek about 7.93km before Atlantic ocean.

However, the segment of major concern is the main Forcados river from Ofani, which flows through such settlements as Bomadi, Gbarogalo Esunma, Okwagbe, Gbekebor, Burutu and Forcados among others and several fishing camps. The minimum width of this segment is about 250m at Okwagbe while the maximum width is about 680m at Gbekebor

4.2 ECOLOGICAL BASELINE OF THE STUDY AREA

A Remote sensing and GIS based assessment techniques of the ecological baseline o f the area has been done in order to generate the baseline ecological conditions prior to the commencement of the dredging activities. This is also important at having an overview as well as detailed existing ecological conditions, and in impact prediction and assessments. Map 4.2 shows the ecological baseline of the study area. From the results of the GIS area generation analysis, the areal extent of each ecological class is as shown in Table 4.1

Table 4.1 ECOLOGICAL BASELINE OF THE STUDY AREA

CODE	FEATURES CLASS	AREA(KM^2)	PERCENTAGES
1	Built-up areas	25.71	0.70
2	Lake	0.35	0.01
3	River /creek	905.42	25.22
4	Marshland	2.32	0.07
5	Swamp	319.25	8.90
6	Mangrove	727.03	20.26
7	Cultivation	202.85	5.65
9	Thicket	192.32	5.36
10	Scrub	8.47	0.24

12	Vegetation (forest)	559.48	15.59
14	Sandbar/sand beach	9.21	0.26
33	flare site	0.09	0.00
	Total	3589.14	100.00

Source: GIS Analysis of Map 4.2

From table 4.1 and figure 4.1, the total areal extent of all the features is 3589.14km^2. From map 4.2, 12 major ecological classes are identifiable across the study area. These area built-up areas, Lake, River/creek, Marshland, Swamp, mangrove Cultivations, Thicket, Scrub, palm, Vegetation (forest) and sandbar/sand beach.

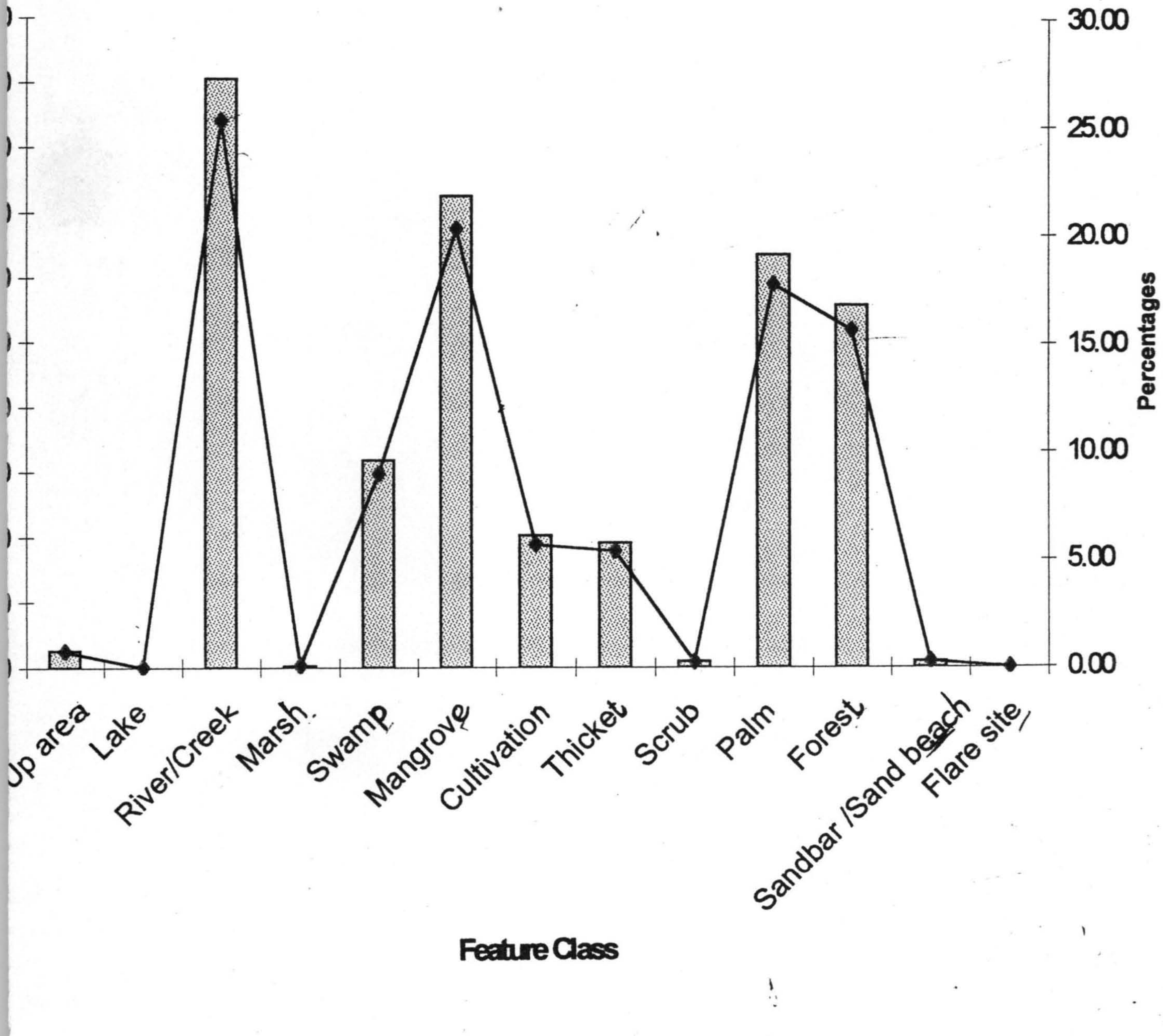
From the result in table 4.1, rivers and creeks has the highest area extent covering 905.42km^2 and representing 25.22% of the total area. This is followed by mangrove with 727.02km^2(20.26%) other land cover ecological classes are palm 636.64km^2 (17.74%); vegetation (forest) 559.48km^2 (15.59%); swamp 319.25(8.9%); cultivation 202.85km^2(5.65%); Thicket 192km^2 (5.36%); Built-up areas 25.71km^2 (0.7%); sandbar /sand beach 9.21km^2(0.020%) and Lake 0.35km^2(0.01%).

4.3 THE DREDGING ACTIVITIES

It has been established that all activities of man have either direct or indirect impact on the environment. In the face of increasing demands upon a diminishing resource base, all governments are faced with the difficult task of selecting investment priorities. Options for conservation as well as sustainable exploitation of resources and for their environmentally sound management therefore need to be given the best possible review based upon the best available information and understanding of potential value of each site.

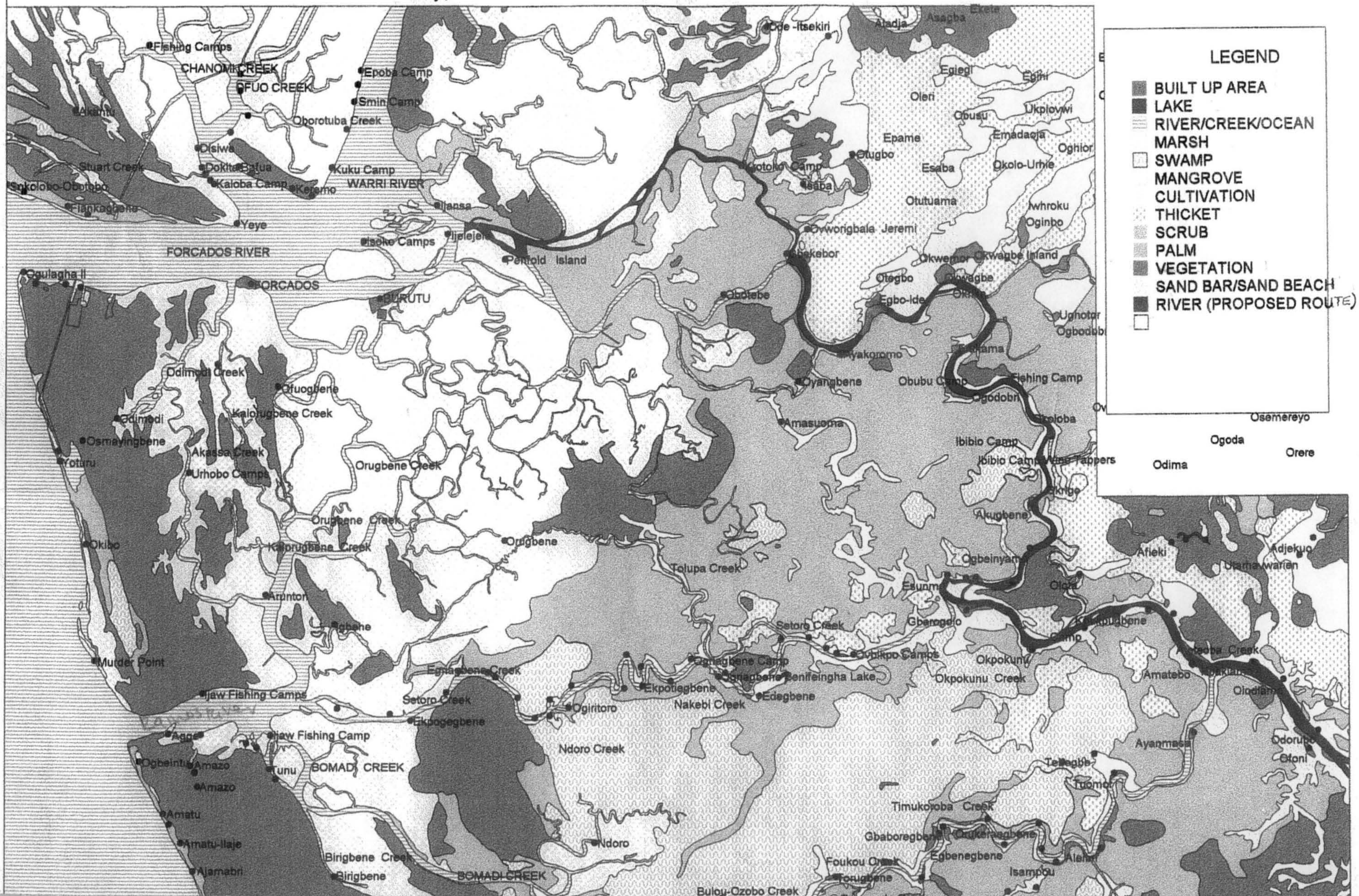
Dugan (1990) has submitted that dredging and channelization for navigation and flood protection is not a significant wetland loss except in estuaries. This is also supported by Jordan et al (1993) in identifying that waterway has the least impact on the environment;

FIG 4.1: ECOLOGICAL BASELINE OF THE STUDY AREA



MAP 4.2

ECOLOGICAL BASELINE OF THE STUDY AREA



in addition to its function of carrying goods and capacity for national and international exchanges.

The dredging activities is to make the Niger river navigable for medium-sized ships from the coast at the Forcados entrance through the Forcados river via the river Niger up to Baro (Niger State) a total distance of about 572km. Specifically, with special reference to the study area adopted, the following activities will be carried out on Forcados River.

DEVELOPMENTAL PHASE

The developmental phase can be divided into the following:

(a) Mobilization stage: This will involve the movement and mobilization of human and material resources as well as equipment-dredgers and earth moving equipment to the project site.

(b) Operational stage: This involves the actual dredging, excavation, removal and disposal of the dredge spoils

The mobilization stage is expected to have a lot of impacts by the influx of migrant and mobile workers.

The social impact is going to be mostly on infrastructures and facilities in town in the study area.

The second stage, which is the operational stage, is expected to cause major impacts on both biophysical as well as the social environment. This stage will involve direct dredging of the riverbed as well as excavation of materials and dredge spoils. The disposal of these dredge spoils is going to pose major problems because of the following:

(1) The area is wholly a wetland zone, which is highly sensitive to ecological alterations in any way.

(2) Most of the major settlements and smaller fishing camps are located at about zero meter along the bank of the river course (which is to be dredged and hence they will be clearly impacted).

(3) The area being typically wetland, hence, most of the cultivation or farmlands are located along the river courses (0-500m) as shown in Map 4.1. Therefore, the dredging, excavation and removal of the dredge spoil (if there is any plan for that) will definitely impact the agricultural lands.

(4) The only roads present in the study area run between Egbe Ide-Okwagbe, Otegbo-Okwagbe-Okwagbe Inland- other places; and Kpakioma-Gbaragolo, Oderubo-Kpatiama- Bomadi. These roads apart from covering less than 1/3 of the study area, run parallel to the river (between 100m-500m). Hence, the practicality of removing/clearing the dredged spoils without impacting the environment will be difficult.

(5) The dredging and excavation will equally cause impact on flora and fauna (especially aquatic species) found around the dredged river.

(c) Post Operational Stages: the post operational stage include all those activities which will come on board after the dredging has been completed, which will include short, medium and long term impacts. Such activities will include:

a. The movement of ships on the river, which is likely to increase river-bank erosions.

b. The influx of people from all parts of the country area into the study area which will possibly lead to pressure on land, facilities in towns and settlements as well as increase in social vices, and demands for accommodation and other necessities.

c. Hydrological changes which will result from increasing mixing of fresh and saline water as well as attendant effects on the ecology of the area which could lead to loss of species

d. Increase influx or discharge from the headwaters, which could lead to increase erosion and flooding around the study area. This will be accompanied by ecological and habitat loss as well as displacement and uprooting of human settlements.

4.4 POSITIVE IMPACTS OF THE DREDGING ON THE STUDY AREA

Major project may offer a tempting solution to area especially rural economic problems, which may have to be offset against the negative impacts such as pressure on local services and social upheaval in addition to possible damage to the physical environment (Glasson, 1995). Hence, in project development, all trade-offs should be recognized and balanced against positive impacts of the project.

Any (resource) development should be anthropocentric. This is identified by the COCOYOC (Mexico) declaration by United Nations Environmental Programme (UNEP) and United Nations Conference on Trade and Development (UNCTAD, 1974) that: development should not be to develop things, but man. Human beings have basic needs-food, shelter, clothing and education. Any process of development / growth that does not lead to their fulfillment or even worse, disrupt them is a travesty of the idea of development (Coyer and Hills, 1995).

The proposed dredging of the lower Niger if it accomplishes the envisaged depth and attracts traffic will have some positive impacts on the people of the study area. These positive impacts include the following:

(1) Accessibility: the study area just like the rest of the Niger-Delta is highly inaccessible by road as shown in Map 4.3 (Niger-Delta-Regions without roads.)

The only means of transportation in the study area remains the rivers and creeks. This has indeed hampered the growth and development and thus, the social and economic retardation of the study area over the years. The total length of road in the area is 54.3616km. This represents a road density of 0.015km of road per square kilometer. Secondly, the available roads are localized around the drier upland areas along the Forcados River course. Hence, extensive areas of marsh land, mangrove, vegetation (forest) and palm with several fishing communities are not connected by road. Thirdly, there is virtually no accessibility route between the Atlantic coast and the interior inland as shown in maps 4.2 and 4.3. Hence, the dredging of the lower Niger River will form the major pioneering effort at opening up the dense interior of this part of the Niger Delta.

(2) Growth of Towns and settlements: As shown in maps 4.1 and 4.2, most of the settlements along the Forcados river are historical settlements that have refused to grow over the years. These settlements include Forcados ,Burutu, Bomadi, Okwagbe, Gbekebor and several others. These settlements have existent since 1900s and settlements like Forcados and Burutu have since been recognized as important points on the Forcado/ warri river. However, comparison of their areas on topographical map of 1963 and landsat Tm satellite imagery of the area in 1994 shows that there is not significant difference in the areal extent. Instead, the better connected and highly accessible Warri town has tend to grow very significantly between the time period. Therefore, the relative retardation of these towns can be substantially attributed to their poor accessibility, which has not encouraged the migration of people into these towns. The dredging of the Forcados river might open up the towns and encourage the movement of people from several parts of the country. This will tend to increase the tempo of activities and thus leads to

MAP 4.3

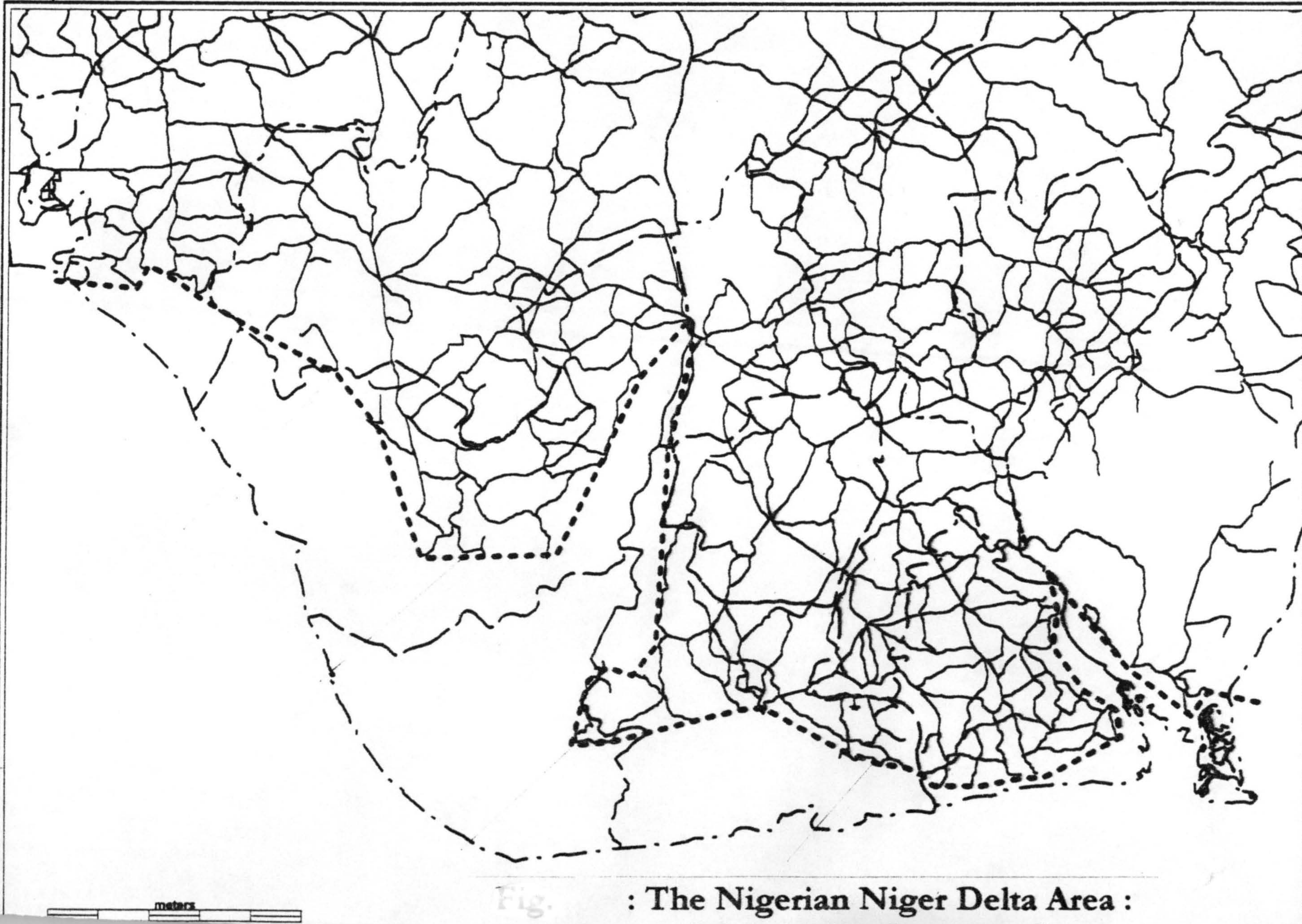


Fig. : The Nigerian Niger Delta Area : *Regions Without Roads* increase in trade, exchanges and provision of infrastructural facilities, as well as enhancing the living standards of the inhabitants.

(3) Social Interaction and tolerance: the opening up of the study area will tend to encourage social interaction of the people with people from other cultures of the other part of the country that will migrate into these coastal area for economic reasons. This will lead to better understanding and mutual, interaction and tolerance especially against the backdrop of resentment and neglect that characterized the study areas.

(4) Economic and Industrial growth: the question about finding the best location for a manufacturing firm has for long been the concern of economic geographers. Hence, the question of location has always been very central to the study of geography. Although, the problem of distance (accessibility) is only one among the many factors affecting location patterns, it nevertheless has its influence everywhere in the world in all location matters. (Chisholm 1962). Talking about economic and industrial growth, Walter Isard (1956) in "Location and space Economy" identified three basic location forces. Two of these, transport (transfer) cost differential and labour cost differential interplay to determine the regional distribution of industries, and he therefore called them the regional factors. The third factor he identified was a local factor, which acts to concentrate industries within a region.

Hence, in summary, the opening up of the Forcados river (lower Niger river dredging) estuary areas to the rest of the country through dredging will definitely facilitate economic growth through the location of industries in the study area. The growth of industries in this area will also enhance the economic well-being of the inhabitants by generating employment and thereby raising the income level and social well-being of the inhabitants.

Dugan (1990) has identified the importance of water transportation through creeks and canals through otherwise inaccessible mangrove dominated ecology of the pacific coast of Nicaragua and in the Zambian's Bangwenlu basin where water transport provides a cheap and readily available means for moving both people and freight in what is otherwise an isolated area.

The regular movement of ship between this area and the hinterland will also allow the growth of markets for the local products- fish and other aquaculture products as well as farm products. This will generate more income, while also allowing access to other project from the hinterland. Hence, economic and trade benefits through exchange is guaranteed. This will surely alleviate the poverty level in the study area through economic multiplier effect.

(5) Tourism: Tourism is an important aspect of life both for economic development, aesthetics, resource and ecological conservation. Tourism encompasses the totality of terrain features as well as social and cultural structures such as architectural, archaeological, religious feature etc. The beauty and uniqueness of the study area could be better appreciated on land than when traveling by air over the area. Hence, the dredging of the Niger river in this area will provide an accessible route to view closely the beauty and complexity of this delicate ecosystem from the Forcados beach to the upland interiors. This will infact generate employment, income source for the people as well as economic growth and foreign exchange for the country.

Landscape is an important national resource- an outstanding natural and cultural inheritance that is widely appreciated for its aesthetics beauty and its important contribution to regional identity and sense of place. Although, it is subject to evolution and change, the landscape is recognized as a resource of value for future generation. Smaller coastal settlements such as Abara, Oguogbene, Iyanawo, Olusemere, Ogulagha and built-up areas like Burutu and Forcados will grow into important tourist centers.

4.5 NEGATIVE IMPACTS PREDICTION AND ANALYSES

There is no physical development without negative impacts on the environment. Hence, the major approach of an EIA is to adopt the benefit-cost analysis function, that is, to identify the overall economic, social and other gains of a proposed development vis-à-vis its likely negative impacts on the environment. This therefore calls for identification of trade-offs (if the negative effects on the environment for outweigh the expected positive impact and or if the mitigation measures proposed will not sufficiently reduce or ameliorate expected negative environmental consequences.

4.5.1 IMPACTS ON LAND AND LAND RELATED RESOURCES

The ecological baseline resources of the study area have been discussed in section two of this chapter. The major land use and land cover found in the study areas are built-up areas, lake, river/creeks, marsh, swamp, mangrove, cultivation, thicket, scrub, palm, vegetation (forest) and sand beaches. In order to ascertain the degree of impact on the different land resources around the preferred route of the Forcados river estuary during and after the dredging activities, environmental sensitivities or buffers were created around the river from the starting point at Ofani up to the point where the dredging is expected to stop (Burutu). The sensitivities or right of way are in the range 100-500m, 500-1000m,1000-2,500, 2500-5000m and 5000-7000m. This is shown in map 4.4.

Table 4.2

Forcados-Forcados entrance route-Ecological Areas that Fall into Different Sensitivity Zones.

Ring	Radius(m)	Area(km^2)	Count of poly
1	100-500	61.94	22
2	500-1000	85.65	31
3	1000-2500	1.989	19
4	2500-5000	88.592	49

5	5000-7000	60.958	61
	Total	299.129	182

Source : GIS Analysis of map 4.4

The result, which is presented in table 4.2 shows that a total of 61.94km^2 covering 22 land features regions (polygons) will be impacted at the first sensitivity zone (100-500m). A total 85.65km^2 and 31 feature regions (polygons) in the second ecological sensitivity zone and 1.989km^2 in 19 feature regions are subjected to impact in the third ecological sensitivity zone. 88.592km^2 in 49 feature regions falls into the fourth sensitivity zone while a total of 60.958km^2 in 61 polygons falls into the fifth sensitivity zone.

On the whole a total of 299.129km^2 covering 182 feature regions (polygons) are susceptible to impact within the different ecological sensitivity zones.

(a) Built-up areas fishing camps and roads.

As shown on map 4.1, the settlement characteristics of the area are such that followed a definite pattern. Settlements followed the major river courses-mainly the Forcados river. Both the major settlements (built-up areas) and fishing area located right along the river bank. Hence, they will be negatively impacted by all activities-excavation; movement and disposal of dredge spoils. They will also be impacted in various ways such as noise from the mechanical equipment, pollution from emission from mechanical equipment as well as pollution from dust.

Hence, a total of seventeen major settlements (built-up areas) as shown in table 4.3 covering a total land area of 6.03km^2 or 25% of the total built up are of the study are will be directly impacted.

Table 4.3 Major Towns to be Impacted by preferred route

S/N	Town	Area(km^2)
1	Bomadi	0.5956
2	Kpatiana	0.0129
3	Ofani	0.6992
4	Ararama (Abgtakiri)	0.0904
5	Obara	0.05709
6	Okpatunu	0.1016
7	Gbaregala	0.4359
8	Aputu Esanma	0.2174
9	Akugbene	0.1526
10	Ezebiri	0.03299
11	Erutama	0.1783
12	Otuwagbe	0.7661
13	Egba ide	0.3749
14	Ayatarama	0.2258
15	Gbetebor	0.1131
16	Burutu	1.278
17	Forcados	0.6986

Source: GIS Analysis

Fishing camps that will be directly impacted in the course of the dredging include the following as displaced in Table 4.4

Table 4.4

Fishing Camps that will be directly impacted by dredging

(1) Okriga

(2) Okurama

(3) Otalata

(4) Okrika

(5) Kratafa

(6) Isata

(7) Ijelegele

Source: GIS analysis

(b) Roads

The roads followed the pattern of settlements. They thus displayed a linear (parallel) pattern around the forcados river within a distance of 0-100m from the river bank. Hence, the following roads will be directly impacted during the dredging activities.

Table 4.5

Roads that will be impacted during dredging

Egbe ide-Otuwagbe	3.11
Otuwagbe-Otuwagbe inland	3.405
Oturogale-Otipatunu	4.73
Otpatunu-Obara	5.169
Obara-Bomadi	6.837
Ararama-abgtakiri	4.128
Bomadi-Kpatiama	8.699
Total	36.078

Total length of road in the study area = 54.3616

Source: GIS Analysis.

From the table, a total of 36.078km of road (67% of the total road) in the study area will be directly impacted by the deposition of dredge spoils around the riverbanks. Considering the fact that the physical characteristics of this area make road construction an arduous and highly expensive venture, this literally will translate to a loss of millions of Naira.

© River and Creeks

The proposed channel or route to be taken by the dredging and river training activities is well indicated in maps 4.1, 4.2 and 4.4.

Two activities are being proposed by the consultants to the project. The first is to embark on 'cutting or canalizing' of all those segments of the river channel that exhibit meandering. Those segments will thus include the stretch between Okpokmu and Kalatuo Island, and also between Frukama and Okwagbe.

The second is to link the route (Forcados river) with the Warri River through the Odube creek via Ode-Itsekiri. The implication of this for ecology is two-fold:

(1) More land resource will thus be impacted by the effort to straighten the river channels. This will also result in loss of more channel and bank habitants, enhanced erosion, and more importantly, wetland habitats around the river channel caused by the widening, deepening and straightening of the channels will be lost.

(ii) The Odube creek is only about 95m at its widest point; hence, attempts to widen the creek will cause more or increased negative impacts on the land use and cover around the area.

Considering the fact that the Forcados river flows and discharges directly into the Atlantic Ocean and also noting that the area generally consists of low-lying mud and tidal flats; the dredging of the river Niger (in its widest sense) and the Forcasos river (a distributary's of the

Niger) is expected to cause the following hydrological changes around the Forcasos river estuary:

(1) Large scale irrigation and water diversion upstream the Niger will cause regional relative sea level changes which could be of an order of magnitude higher than eustatic sea level rise in this predominantly flood plain or tidal flats area.

(ii) Resectioning/ Channelization (widening, deepening, realigning and straightening) or river channel to increase channel capacity for flood or runoff to facilitate navigations will enhance erosion especially river bank erosion at the entry point into the Atlantic. Hence, more portions of the Forcados will be lost to erosion. Undisturbed coastlines counteract such recessions by building beaches, sand spurs or coral platforms and filling lagoons with mangroves, peat or marsh which is the situation in most parts of the study area presently.

(ii) Dredging and deepening to increase the depth and volume of water in the channel will also tend to increase flooding risk while also depriving some numerous other lesser undredged channels of water and this is expected to cause wide spread ecological change and loss of species.

(iv) The dredging and straightening of the Forcasos river and indeed all parts of the Niger River will increase the sediment load and hence turbidity of water. Since land derived carbons, nutrients, freshwater and sediments from all parts of the basin enter the coast at the river mouth, changes in these inputs will have major consequences not only for the mixing zone between freshwater and sea water, the Forcados area in wider sense, but also for the entire sediment, carbon and nutrient balance of the coastal sea down current of the river month especially in the study area.

(v) As shown in map 4.1, the study area is primarily a crude oil producing zone. Large deposits of crude oil abound in the study area because of the geological and geomorphologic nature of sediments found in this area. Hence, oil fields including (1) Escravos beach field (ii) Alfremo field (off shore) (ii) Forcados Yokri filed(iv) Odidi field(v) Ajuju field(vi) Batan field (vii) Bomadi field etc are all located in the study area. Many oil fields / installations and infrastructures such as flow stations, flow line, oil rings and platforms, oil tank farms etc are located in the study area. Hence, oil spill is a regular occurrence on rivers and creeks. Therefore, the dredging of the Forcados River and by extension, the Niger River to increase the water level as well as enhance navigability by medium sized ship will increase the risk of oil spill on water. This will be facilitated by the increase in velocity of river due to increased depth as well as the movement of ships on rivers. Hence, an oil spill that occurs at Forcados may therefore impact areas as far inland as Lokoja and Baro and even beyond depending on some other factors. Dredging can also cause rupture to under water pipelines that criss-cross the study area; and hence will lead to ecosystem destruction.

(vi) The changes in fresh water input to coastal water around the Forcados river esturary will have large effects on salinity distribution, flushing rates, mixing of the water column and other physio-chemical properties of in shore water.

Biggs in P. Morris and R. Therivel (1995) has summarized some impact from direct manipulation or utilization of hydrological systems. This is shown in table 4.6 below:

Table 4.6a

Impacts from direct Manipulation or utilization of Hydrological systems

Activities	Potential impacts
River engineering / manipulation: Resectioning / channelization (widening, deepening, realigning. straightening); usually to increase channel capacity for food defense	Loss of channels and bank habitats in channelized section especially slow flow habitats). Enhanced erosion and hence silt production (especially during construction

and / or land drainage or to facilitate project layout.	phase, when pollution risks also increase). Lowering of water table level and associated loss of wet land habitats in flood plain caused by deepening.
Diking / embarking and bank protection e.g. with concrete, usually for reasons as above.	Natural flood plain inundation prevented with consequence silt deprivation, loss of wetlands and risk of soil drought. Drainage from flood plain prevented unless slices installed with consequence risk of water logging
Clearing bank vegetation usually, associated with the above.	Destruction of vegetation and wildlife habitat. Loss of visual/ amenity value.
Dredging and filling (deposition of dredging) to (a) maintain flood capacity or (b) to improve navigation	Increased suspended sediment load and hence turbidity. Physical damage to channel habitats and biota. Smothering of estuarine ecosystem, e.g marsh and swamps with consequent increased erosion risk.
Diversion: To increase water supply to receptor area. As a relief channel (in flood defense)	Decreases supply in donour area. Usually involves channelization and evaporative loss from open channels. May destroy habitats in main river corridor
Development on the river flood plain	Usually requires (or follows from) flood protection e.g. embarking (often with channelization). Marked increase in flood risk downstream

Source ; Adapted from P.Morris and J. Biggs in P.Morris and R.Therivel (eds 1995).

Table 4.6b

Hydrological impacts particularly Associated with the construction phase of projects.

Category	Potential impacts
Runoff	Appreciable increases often associated with disturbance, vegetation removal, soil compaction, and pumped water (When escavations, e.g. for foundations extend below the water table); can markedly affect stream flows and stream sediment loads
Sediment	Export of large quantities of sediment in runoff, with suspended-sediment loads up to $50g/l^{-1}$ recorded in streams draining from construction sites. Oxidation of organics in sediment can threaten fish and invertebrate population through deoxygenation of water.
Nutrients release	Considerable quantities, especially of Nitrogen, can be released through disturbance of established grassland soils and the effect can persist for several years. Amounts are difficult to predict, but nitrogen release can be in the range of 50-2000 $kgha^{-1}yr^{-1}$. Nitrogen entering streams and ground water may lead to enrichment of water bodies away from the site.

Oils and other pollutants	Water frequently polluted from spillages on construction site, especially when tanks of petroleum products are located near water and vehicle are filled from these can also lead to ground water pollution

Source: P. morris and J. Biggs in P.Morris and R. Therivel (eds. 1995).

Dredging tends to increase the channel capacity and may therefore reduce flood risk. Indeed, former flood plains may be starved of water. There may be some flood risk in downstream areas not dredged.

(b) Land/ Ecological Resources

Using the created GIS database for the study area, the Structured Querry Languages (SQL) was used to calculate the area of each land use / land cover features that falls within the sensitivity zones 1 – 5 of the preferred route as shown on map 4.4. The generated result is shown in Table 4.7

Table 4.7

Preferred route: likely impacted ecology

S/N	Feature class	Site impact(km^2)	Wider impact (km^2)	Total (km^2)
1.	Built up areas	6.03048		6.0348
2	Cultivation	215.13124		215.13124
3	Vegetation(forest)	27.079	82.23	104.309
4	Thicket	24.301	118.1	142.401
5	Scrub	4.244		4.244
6	Marsh	0.2335		0.2335

7	Palm	65.6074	175.04	240.6474
8	Mangrove	118.41418	24.358	142.77218
	Total	456.0498	199.398	855.7688

Source: GIS Analysis

The wider impact represents those feature class regions that did not fall entirely within the sensitivity zones. A total of 199.3km^2 will be affected by wider area impact while 456.0408km^2 will be impacted at the site.

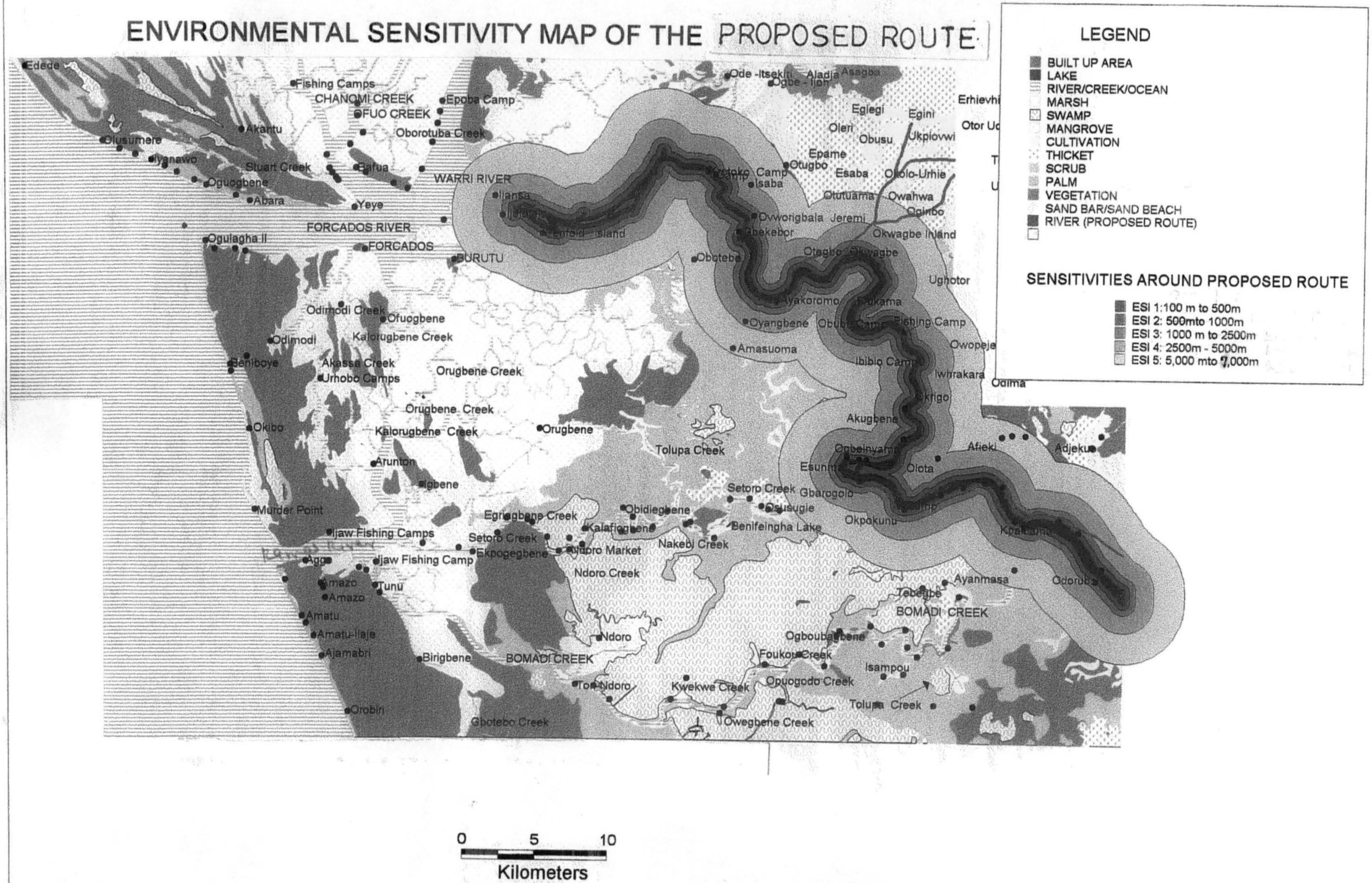
DISCUSSIONS

(I) Built-up Areas: - This has been fully discussed elsewhere in this section. The impact will be severe and most large settlements at riverbank will have to move back (economic loss) while smaller fishing camps will be entirely displaced

(ii)Cultivation: - As shown on map 4.1, the pattern of cultivation follow riverbank. This is especially so because of the edaphic nature of the area. In most places immediately after the cultivated lands, the other adjoining lands are covered by palms, marsh and swamps, which do not support cultivation. Hence, in only few areas are there forest and thickets that can be cleared for the growing of crops. The analysis on table 4.7 shows that a total 215.13km^2 of cultivated land will be impacted by the planned dredging activities. This is especially significant in the difficult, delicate and non-workable terrain found in other parts of the study area. This also indicates that the source of subsistence and livelihood of the people will be severely impacted. In monetary terms, when the real values of the land in absolute terms are considered, millions of Naira will be lost and this will surely be a highly significant impact.

(ii) Vegetation (forest): About 22.079km^2 of forest will be affected by site area analysis [illegible] while a further 82.23km^2 will be impacted on the wider area analysis. This sum up to a total of 104.309km^2

MAP 4.4


ENVIRONMENTAL SENSITIVITY MAP OF THE PROPOSED ROUTE
LEGEND
BUILT UP AREA
LAKE
RIVER/CREEK/OCEAN
MARSH
SWAMP
MANGROVE
CULTIVATION
THICKET
SCRUB
PALM
VEGETATION
SAND BAR/SAND BEACH
RIVER (PROPOSED ROUTE)
SENSITIVITIES AROUND PROPOSED ROUTE
ESI 1:100 m to 500m
ESI 2: 500mto 1000m
ESI 3: 1000 m to 2500m
ESI 4: 2500m - 5000m
ESI 5: 5,000 mto 7,000m
WARRI RIVER
FORCADOS RIVER
FORCADOS
BURUTU
CHANOMI CREEK
FUO CREEK
BOMADI CREEK
0
5
10
Kilometers

of forest vegetation. The high accessibility of the area after the dredging activities might have been completed and the expected river traffic flow will lead to a significant impacts on the forest resources. Lumbering activities and tree felling and logging will increase and this will lead to further deforestation and loss of species as well as loss of habitats, and also lost in the atmosphere since forest serves as sink for carbon dioxide.

(v) Thicket: - 24.301km^2 of thicket growth will be directly impacted while another 118.1km^2 will be affected by wider area impact. This is especially significant because of the fact that the displacement and dislocation of settlement and cultivation around the riverbanks will cause the people to move further away from the riverbanks. This will force them to use any other available relatively habitable and cultivable lands. Thickets will be highly impacted as a result of this as some of them will be cleared for farmlands and settlements.

(v) Scrub:- Scrub land will face the same impact as thickets. About 4.244km^2 of scrubland will be directly impacted by the proposed dredging activities.

(vi) Marshland :- Marsh land will be least impacted among the categories, only 0.2335km^2 will be impacted.

(vii) Palm: About 65.607km^2 will be affected while another 175.04km^2 will be affected by wider impact prediction. This brings the total area that will be impacted by the dredging activities to 240.647km^2. The influx of the people to the study area expected to be triggered by the improved accessibility of the area is expected to have more wider area on palms especially as more people are likely to engage in crafts and occupations that depends mostly on palms and palm products.

(vii) Mangrove:- mangrove is one of the most significant wetland ecology resources, and it has indeed been one of the most affected by accelerating habitat loss. Pernetta and Milliman (1985) identified that in 1987, only 13.9million hectares of mangroves were estimated to remain in 22 countries containing the world's mangrove forest, with 90% of those in the developing countries and therefore stand higher risk of being lost. They also submit that the change in the use of mangrove systems has been undertaken with inadequate consideration for the goods and services such as shoreline protection provided by the natural (mangrove) ecosystem.

From the analysis in Table 4.7 118.41km^2 of mangrove will be directly impacted through the dredging and other activities and if the route is dredged through the Odube creek to Warri river as is being considered, another 24.358km^2 of mangrove will be severely impacted this is expected to bring the total mangrove stand at immediate risk to 142.772km^2.

The loss of mangrove in the study areas will trigger off other reactions and set back because of the role mangrove stands play in ecological balance and on shoreline protection. Hence, more areas will be opened to inundation by tide, and more habitats will be lost and this will also lead to loss of fauna species that live around the mangroves. Mangroves roots also help in soil compaction exercise and also acts as buffers for pollution and oil spill on waters. Hence, the removal of these mangroves will provide for easy and fast movement of pollution and oil spills on water, which aided by wind and navigating ships could reach several kilometers inland before containment / mop-up action is mobilized.

(e) Impacts on other resources

(a)Air:- air pollution will result from emission o f hydrocarbon compounds by mechanical equipment.

(b) Noise:- Settlements around the river will experience high increase in noise level due to movement and working of heavy duty vehicles and other mechanical equipment from and to the project site.

© Biodiversity: - The degree of impacts on biodiversity, which is a precious natural resource, a resource essential to human existence and commerce, will depends on individual species. This requires more scientific and detailed studies of the morphological and biological constituents of the different species. However, generally, many inland water dwelling species of fishes will be impacted as well s their migration for spawning between the coast and inland water since breeding and nursery ground for the species will be negatively impacted.

(d) Groundwater:- groundwater around the study area will be negatively impacted especially by the disposal of dredge spoils. Considering the delicate nature of the ecology of the study area, attempts at disposing off dredge spoils will negatively impact groundwater source due to leaching of substances. This area composed mostly of high water table level. Hence, an in-depth study at dete4rmining the chemical components of the spoils as well as boundary conditions and acquifer characteristics of the area is required before embarking on the project

(e) Beaches and Recreation:- The study area consists of extensive beaches at the mouth of the Forcados River. These will be affected in two ways. Any measure that increases flow velocity, (such as river dredging) has the propensity to increase the erosive capacity of water, and also increase flood peak downstream. Thus, the dredging of the river will increase coastal erosion especially around Burutu, forcados and other smaller coastal settlements. Ibe (1988) reported that the rate of erosion at the Forcados river mouth (coastline) is between 20-22m per annum. However, a simple GIS assessment (analysis) carried out by this author by overlaying the coastline from topographical map sheet (prepared from 1:40000) aerial photograph flown between 1961 and 1963) and the coastline from the 1994 landsat Tm satellite imagery shows a difference (recession) of 250m during the period. This translates to an erosion rate of 8.33m per annum at Forcados. A similar exercise shows 7.16m per annum for Opobo river and 2.6m per annum for new Calabar river.

The second way is through the influx of people to the Forcados beach area, which will be triggered by improved accessibility that results from inland navigations. Settlements will increase in size and beaches will be increasingly polluted with human and domestic wastes.

4.6 MITIGATION STRATEGIES

From the analysis, it is clear that the categories of natural and human resources that will likely be mostly impacted by the proposed dredging activities are:

Built up areas (settlements and fishing camps), road networks, farmlands, river / creeks, mangroves, beaches, biodiversity, palm, thickets and scrubs.

Hence, the following mitigation measures are suggested:

For immediate impacts:

(i) Identification, and immediate consultation with all affected communities both small and large to discuss the projects and its impacts on them (e.g. expectations, adaptation, livelihood /loss and relocation) to avoid confrontation (physical) during the operational phase.

(ii) Identification and documentation of all farmlands and cultivation beside the river in order to facilitate cost-benefits calculations before the project is embarked upon.

(ii) Dredging of the river by following its course and discouraging channeling and cutting to straightening the river course.

(iv) Efficient and Environmental friendly (low noise, high performance and less carbon emission from) mechanical equipment at site.

(v) Safety consciousness and restriction signals at the dredging site especially where settlements are present to forestall accidents.

(vii) Scientific research into the best method of disposal for the dredge spoils as well as their chemical and biological composition.

(vii) Evaluation of the shoreline hydrology and geology and best method of shoreline protection before embarking on operation.

(viii) Considerations of local labour within the affected communities to reduce social stress and pressure on available facilities and infrastructures by migrant workers.

(ix) Evaluate socio-cultural environment of involved communities to measure expected stress on local cultures, values, aesthetics and livelihoods.

For long-term impacts, mitigating measures should include:

(1) The enactment of legislation making all parts of the study area to be categorized as Natural ecology Reservation Area. This with proper monitoring and enforcement will help protect the ecology (plants, animals, microorganisms) as well as the different land cover characteristics of this highly sensitive wetland –wild land area.

(ii) An efficient and effective Remote sensing and GIS based monitoring system of the Forcados river estuary areas for shoreline erosion, flooding and inundation, beach and river bank erosion.

(iii) A more technically efficient and environment friendly crude oil exploitation / exploration methods to be recommended and enforced for oil prospecting companies in the study area to prevent oil and chemical spillages as well as effective clean up operations of oil spills.

4.7 SUGGESTED ALTERNATIVE ROUTE

Considering the magnitude of negative impacts on communities and resources involved in dredging and straightening the Forcados river through forcados- Gbarogalo- Burutu-Forcados entrance (map 4.1), an alternative route being proposed is the forcados-Nikorogha creek – Ramos

The arguments for the proposition of this alternative route lies on the following facts from the GIS and Remote Sensing assessment of the study area:

(a) The forcados-Nikorogha-Ramos entrance as shown on maps 4.1 and 4.5 from Ofani is 87.6km to the Atlantic as opposed to the Forcados-forcados entrance which is about 107km from Ofani to Burutu. The Ramos mouth is only 27.1km to the Forcados entrance, hence, navigation from Warri port to the hinterland upstream the Niger is equally easy.

(b) The Forcados-Nikorogha-Ramos entrance has a width of 220m (minimum) and 500m maximum hence it can equally be dredged as opposed to the Forcados- through the Odube creek) which is only 95m wide. The former meandered less and this required less straightening and cutting.

© Only thirteen major settlements with total built up areas of 3.63861km^2 and fishing camps and small settlements will be directly impacted as shown in tables 4.8 and 4.9 as opposed to the Forcados-forcados entrance with predicted direct impact on seventeen major towns with total surface area of 6.03048km^2 and seven fishing camps.

Table 4.8

Likely impacted settlements by the Setoro-Nikorogha creek – Ramos entrance proposed alternative route.

S/N	Settlements	Area(km^2)
1	Nikorogha	0.7452
2	Benifeingha	0.04901
3	Gbaragale	0.4359
4	Okpatunu	0.1016
5	Obara	0.05709
6	Kputugbene	0.0904
7	Bomadi	0.5956
8	Kpatiama	0.0129
9	Edegbene	0.06331
10	Ogriagbene	0.1421
11	Ekpogbene	0.02672
12	Ekugbene	0.61958

13	Ofani	0.6992
Total		3.63861

Source:GIS Analysis

Table 4.9

Fishing camps likely to be impacted by the proposed alternative route.

1.Opufia

2.Akpatigbene

3.Bibiregbene

4.Ogriagbene

5. Osusugie

6.Ogirikana

7. Edemogbene

8. Obidiegbene

9. Kabiogbene

10. Ebeberegbene

11. Ortikpa camp

12. Olugbene

13 Ekpogbene

14. ijaw fishing camp

15. Ilaje fishing camp

16 Agge

17. Aghara

Source GIS analysis

In any case, it is easier for fishing camps to relocate than for larger / major built-up settlements. No road will be impacted by the proposed alternative route.

(d) The sensitivities (buffer zones) around the proposed alternative route shown in map 4.5 shows that a total of about 338.99km^2 consisting of 149 feature regions of land resources features as shown in table 4.10 falls into the five sensitivity zones as opposed to 299.19km^2 of 182 feature regions in the Forcados-Forcados entrance

Table 4.10

Environmental Sensitivity of the proposed alternative route.

Ring	Radius(m)	Area(km^2	Count of poly
1	100-500	64.27	26
2	500-1000	73.41	23
3	1000-2500	88.35	19
4	2500-5000	63.31	36
5	5000-7000	49.65	45
		338.99	149

Source: GIS Analysis of map 4.3

(e) A total f357.27km2 of land resources and ecological features (as shown in table 4.11) are likely to be directly impacted by the dredging activities through the alternative route-Nikorogha-Ramos entrance as opposed to 45.604km2 for the Forcados – Forcados entrance proposed preferred route (table 4.7)

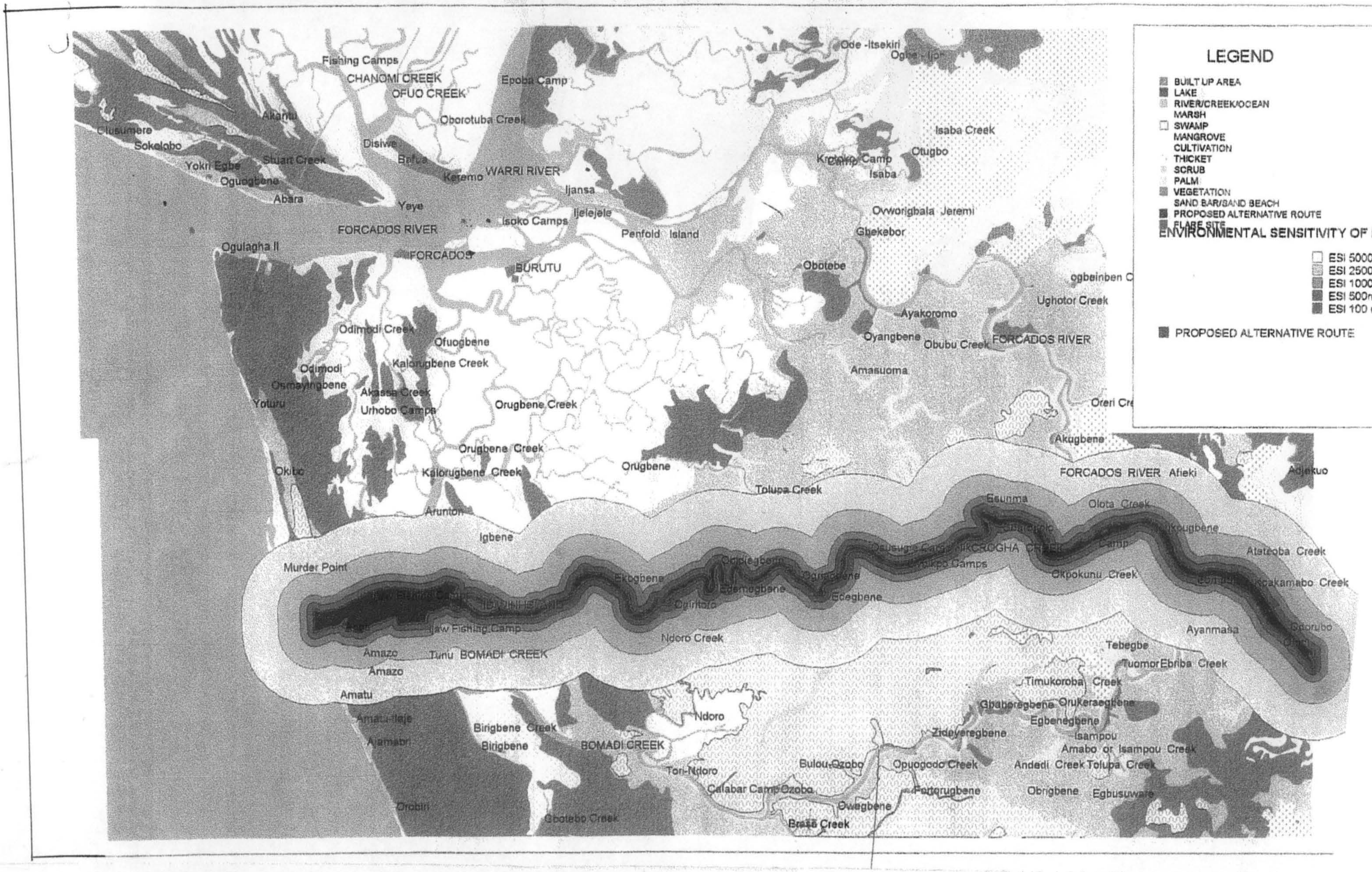
Of importance is that 76.105km2 of farmlands will be directly impacted by the proposed alternative route as opposed to 215.13km2 of farmland likely to be impacted by the proposed preferred route

Table 4.11

Proposed Alternative route: Likely impacted ecology

AP 4.5

ENVIRONMENTAL SENSITIVITY OF PROPOSED ALTERNATIVE ROUTE



S/N	Feature class	Site impact 9km)	Wider impact (km^2)	Total
1	Built-up Areas	3.63861		3.63861
2	Cultivation	76.015		76.015
3	Vegetation(forest)	56.05	221.18	277.23
4	Thicket	5.04	4.01	9.05
5	Swamp	11.52	277.44	288.96
6	Palm	86.4	54.38	140.78
7	Mangrove	118.47	7.12	125.59
8	Lake	0.14		0.14
		357.27361	564.13	921.40361

Source: GIS Analysis

4.8 ALTERNATIVE PROJECTS

One of the cardinal objectives of the proposed dredging of the Niger river (through the Forcados river) is to make the lower Niger (Niger-Delta in general) more accessible. As indicated on the study area (chapter one) and as also shown in map 4.3, the Niger-Delta is the least accessible part of the country. Therefore, any accessibility project that can open-up this western part of the Niger-Delta will be of a tremendous economy, social and political significance.

The two most important alternative accessibility routes to the study area are by:

(i) Constructing access roads from the coastal settlements of Forcados-Burutu to link Warri as well as Forcados-Burutu to link other important settlements such as Gbekebor, Egbo-Ide, Okwagbe inland , Bomadi and to Patani and Aboh outside the study area to link other road networks, Only 54,36km of road presently exist in the study area. While road networks, are socially and politically desirable in these areas, it is not economically feasible and more importantly environmental considerations, aspirations, and challenges does not a bit support such project. Because of the delicate ecological and edaphic nature of the area as well as the sensitive, fragile and delicate nature of this largely wild land, road construction will neither be economically viable nor environmentally sustainable.

(ii) The second alternative is by construction or expanding the railway line to the study area. The rail system is another mass-carrier that can match the carrying capacity of the ship. Trains from colonial time was designed in Nigeria to run from hinterland to the coast. It is equally a mass-transits system that can be employed to freight low value bulky commodities and imports from the river port of Warri and Burutu to the towns and cities inland and also carry export goods from hinterland to the ports.

Commenting on train and land demand, Duncan (1992) quoting Jakpa (1977) said " The superiority of a rail mass transit system in terms of land occupation is seen from the fact that a single tract requires space as little as 5m in width and can handle trains with only a few minutes headway in between them each carrying over 1000 passengers at a time. This represents output of 10000 passengers an hour per 5m width of land, a performance no other mode of transport can match". Modern trains are equally fast, safe, comfortable and do not pollute the air because they are now run on light hydrocarbons as opposed to the old coal-driven locomotive engines.

Railway in Nigeria has especially been of historic significance in their North-south vertical runs and in the creation and growth of some important urban centers. However, apart from the latest efforts at linking the iron-ore triangle of Ajaokuta, Itakpe and Aladja to the National rail system, no effort has been made since independence to extent the rail system to other parts of Nigerian that had no access to rail routes.

However, the extension of the North-South East rail line (Kafancha-Portharcourt) to the study area will equally serve the purpose being proposed by the planned dredging. As in the case for road, social and political considerations will definitely favour this option. However, research into economic (financial) feasibility of this option; considering the state of the Nigeria economy need to be undertaken.

Another important issue is also that of sustainable environment. While issues of changes in surface and groundwater hydrology may not be a major issue in extension of rail line to the study area, ecological sensitivities and habitat, species and resources impacts will also be of great concern.

Secondly, all major socio-economic and cultural impacts as well as cumulative impacts expected for river dredging will also accompany rail-line development in the study area.

However, weighing all impacts, rail line construction from Forcados to Warri and to other urban centers may be a better (environment-friendly) option to dredging the Forcados river. This, however, calls for more research on its feasibility especially as regards financial implications as well as ecological considerations.

CHAPTER FIVE

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

Every development aims at increasing the well being of man also has potentials for both direct and indirect, immediate or later negative impacts on the environment. Hence, as stated elsewhere in this report, the immediate/remote, direct/indirect, negative impacts, must be balanced with the expected or envisaged positive impacts on the physical, mental, social, aesthetic and economic well being of man.

Commenting on the impacts of the development on the Nile on the economy of Egypt, Tolba (1988) said that the real question is rather what should have been done to deal with the potential adverse impacts and to ensure that they were kept to an acceptable minimum and not whether the project should have been embarked upon in the first instance.

5.2 SUMMARY OF FINDINGS

This research has been concerned with attempt at assessing and predicting the likely environmental impacts of the proposed dredging of the lower Niger river on the south western flank of the Niger Delta areas around the lower segment of the Forcados river i.e Forcados area using Remote Sensing and GIS analysis /techniques. It has been carried out according to the set out aims and objectives as highlighted in chapter one.

The result of the Remote Sensing and GIS analyses have shown that the area (study area) covering about 3589.141 km^2 consisting of built-up areas, lakes, rivers/creeks, marsh, swamp, mangrove, cultivation, thicket, scrub, palm, vegetation (forest); and sandbar /beach as the major ecological classes present. There is also 54.36km of road. It has also been established that the actual dredging and straightening of rivers, the movement and disposal of dredge spoils, the movement of vessels on the rivers and the anticipated movement or migration of people from different parts of the country to the towns and settlements such as

Forcados, Burutu, Bomadi, Gbarogalo and others will have severe environmental and social impacts on the study area. These impacts will include increased coastal and river-bank erosion, oil pollution, destruction of ecosystems, likely pollution of ground water source, loss of farmlands, increase in crime and social tension as well as pressure on available infrastructure and loss of livelihoods.

The results of the analyses have also shown that lots of benefits including growth of towns, economic and industrial prospects that will enhance the economic social well being of the poverty-stricken inhabitants of these areas will be triggered off by increased accessibility. Hence, for the very first time, the southwestern Niger- Delta will be "open up" to the rest of the country.

However, land and land related resources will suffer severely as a result of combine effects of direct, indirect and cumulative effects of all activities. The results, which are presented, in section 4.5 of chapter four shows that built-up areas, road and cultivation (farmlands) will be mostly affected. Seventeen built-up settlements with a total area of $6.03km^2$, 36.078km of road and a minimum of seven fishing camps as well as about $215.13km^2$ of cultivated lands will be directly and indirectly impacted. Other land resources such as vegetation (forest), thicket scrub, marsh, palm and mangrove will also be directly and indirectly impacted. The cumulative effect of these is expected to cause ecological and habitat loss as well as aggravate other impacts such as erosion, pollution and disappearance of biological diversities, loss of livelihood as well as social dislocation, resettlement and tension.

Mitigation strategies against impacts as well as alternative route and alternative projects were considered in sections 4.6, 4.7 and 4.8 of chapter four. Several mitigation measures were suggested which could be summarized in adopting environmentally sustainable methods and practices for the dredging as well, especially in the disposal of dredge spoils.

The Forcados- Nikorogha creek- Ramos route has also been analyzed in section 4.8 of chapter four as a better alternative route environmentally to the Forcados-forcados entrance or Forcados-Odube creek – Warri river route.

Finally, while road construction cannot be environmentally justifiable as an alternative project, this research called for more examination and inquiry into the possibility of extending the rail system to the Forcados area (study area) as alternative to the proposed project (dredging).

5.3 RECOMMENDATIONS AND CONCLUSION

Having conducted an environmental impact inquiry into the proposed dredging of the lower Niger river through the Forcados river in the south western axis of the highly precious, fragile and delicate ecosystems of the Niger delta, and considering the magnitudes of both positive and negative likely impacts of the proposed dredging activities on both short/long term, direct/indirect and cumulative effects; the following recommendations are put forward:

(1) The dredging of the Forcados river through the Forcados-Forcados entrance should be replaced by the alternative route, Forcados / Nikorogha creek – Ramos route. More research and assessment should be carried out on the land-oceans interaction in this axis before embarking on the project especially as regards land-ocean mixing boundary.

(2) If however, for other reasons (social-political) The Forcados-Forcados river is to be followed, the Odube creek- Warri river route should be dropped for reasons stated elsewhere in this report. In its place, a straight Forcados-forcados river entrance (estuary) which link Warri river around Burutu should be followed.

(3) An extensive comparative assessment should be instituted for a rail system alternative to the proposed dredging.

(4) All communities and settlements that will likely be impacted by the proposed dredging must be contacted early and brought into negotiation so as to agree on trade-off before the project is embarked upon.

(5) Considering the likely attendant or anticipated deforestation and habitats and biodiversity and species loss that are likely to accompany the dredging through improved accessibility of this delicate and fragile ecosystem, adequate legislation to protect the land resources of the study area should be put in place

(6) Oil prospecting and exploration companies in the study area should be prevailed upon to put in place modern environment- friendly methods of petroleum exploration and also intensity efforts at devising more optimal strategies for oil spill containment.

(7) Large GIS-based data bank for the study area as regards ecology and other environmental components generated from real time spatial and temporary resolution techniques of Remote Sensing should be created. This will enable easy monitoring and modelling of the environment at point and local basin scales.

In conclusion, the World Bank (1991) identified that transportation projects such as canals, river dredging and others make areas more accessible and induce development and may directly eliminate wild lands. Yet, towns, settlements and people cannot effectively develop without accessibility. How then do we resolve this quandary? This has been the objective of this research and solution has simply been described by Falkenmark (1983) as Eco-development, and balance environment by Tolba (1988).

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